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Evaluation of Orthodontic Positioners

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A thesis submitted in partial requirement for the degree of Master of Dental Science.

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1986
DEDICATION
To my wife, Rosalind, whose very considerable assistance under difficult circumstances enabled me to undertake and complete the M.D.Sc. course.
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INTRODUCTION

Tooth positioners are held in high regard by many prominent orthodontists. The literature has many references to the excellent results produced by tooth positioners. For the Begg lightwire technique, tooth positioners are considered the best form of retention (Begg & Kesling, 1977). However, there has been no clinical evaluation of the tooth positioner in comparison to conventional retainers.

The aim of this thesis is to present a method of evaluating post orthodontic treatment occlusal changes in patients who wore either a tooth positioner or a conventional retainer. The conventional retainer used in this study is of the form recommended by Begg and has come to be known in Australia as the “Begg retainer”. I have therefore used the term “Begg retainer” in this thesis.

Post orthodontic treatment changes were evaluated by assessing the number of inter-occlusal contacts when the jaws where clenched together in maximum intercuspation.

I considered that if the Begg retainer and tooth positioner had differing effects, then it would be reflected in assessing the change in the number of occlusal contacts.
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Chapter 1 —

POSTTREATMENT CHANGES

INTRODUCTION

This thesis examines posttreatment changes in one aspect only, viz., the changes in the number of occlusal contacts. However, to understand how and why these posttreatment changes occur, it is important to understand the elements of posttreatment change. Therefore, the literature review of this thesis covers much of the published literature on posttreatment changes.

For clarity the important terms used are defined. These terms have been given a range of definitions in the literature, and some orthodontists have suggested alternative terms (Horowitz & Hixon, 1969). Simple terms with simple definitions are preferred here.

Retention: Retention is a passive stage of orthodontic treatment where we endeavour to retain or hold the corrections achieved by active treatment. Passive appliances such as the Begg or Hawley retainers are typical retention devices.

There are other forms of retention that do not fit into this category, such as active retention and functional retention.

Active retention: Active retention infers that further change, albeit small, is being implemented. We are not retaining tooth position but we aim to alter it. Examples of active retention are tooth positioners, in most cases, and Begg or Hawley retainers if they are made active by tightening the labial bow (or similar strategy). We use the word “retention” with these appliances as once the correction is achieved, the same appliance becomes a passive retainer.

There is, in reality, a fine line between active and passive retainers. However, as retainers vary in their potential for being active, and to achieve desired aims in their use, we must ensure we consider this facet.
Functional retention: Functional retention is the use of the oral environment to give stability and positional retention to the teeth. It infers that the combined forces acting on the tooth, whether from the periodontal fibres, the muscles, the occlusion, or elsewhere, are all in balance and this balance will hold the position of the teeth. Functional retention is certainly a reality. Every stable dentition utilise functional retention. However, as a form of posttreatment retention it is not true "retention" as there is no real control over the teeth. The teeth are allowed to settle and move according to the forces acting upon them.

Relapse: Relapse is a return of the tooth’s position, back towards the position it occupied prior to treatment. For my purposes here, relapse is every movement, irrespective of magnitude, which is a reversal of the treatment.

Settling: The Concise Oxford Dictionary (1964) defines “settle” as becoming established in a more or less permanent position. This definition suits our purposes very well. The stage of settling of the dentition can, therefore, be considered as all movements that occur after removal of fixed appliances. I have included relapse as part of settling as not all relapse is unfavorable. Dr Begg realised that in most cases a certain amount of relapse was unavoidable. Through his use of overcorrections, he has made some relapse an important part of the settling of the dentition.

If we want a time limit for settling, we must go back to our dictionary definition. Settling is completed when the teeth are in their “more or less’ permanent positions. Just when this has occurred is difficult to define, especially with the Begg technique in which there has been little quantitative measurement of settling correlated against the time factor. I classify unfavorable posttreatment changes also as settling. If a maxillary midline diastema appears posttreatment where it was not present prior to treatment, then it cannot be considered relapse. Therefore, settling may be beneficial, or deleterious.

ETIOLOGY OF RELAPSE

Although we do not know all the reasons for relapse, we understand many of them. The magnitude of the contribution of each factor is very difficult to determine. However, with experience and knowledge of these factors, total relapse may be limited.
The origin of relapse can be covered by the following (Carriere, 1975; McLean, 1965; Williams, 1985):

1. Forces produced in the periodontal and gingival tissues.
2. Functional forces produced by the oral environment, i.e. the occlusion, tongue and lips.
3. The position of the root of the tooth in the basal bone, in relation to the tooth crown, the cortical bone and other factors.

Relapse of all forms can usually be attributed back to these three factors. The relapse forces of the periodontium are basically controlled by the duration of the retention. The other relapse factors are basically controlled by tooth positioning. For a better understanding we must discuss these in more detail.

1. **Forces Produced in the Periodontum**

As soon as the dental profession started to orthodontically move teeth, they would have noticed relapse. Forces inside the gingiva and periodontal membrane were accused more than once.

Skogsborg (1927) attributed relapse entirely to periodontal fibres, and to the remodelling process of the bone. Erikson and co-workers (1945) found that in humans transseptal fibres still had not remodelled almost one year after all tooth movement had stopped.

1958 became the year that periodontal fibres came to the fore as a cause of relapse. Reitan (1958) published the first of his papers showing the delayed re-organisation of the periodontal fibres of dogs following orthodontic treatment. He rotated the teeth and then retained them for varying periods. He then examined the periodontal and gingival tissues histologically. The periods that Reitan found that were required for re-organisation of the fibres have had a very significant impact on current thinking about retention. Unfortunately, two very important facts are usually forgotten. These facts are:

(i) Reitan’s research was on dogs. Reitan (1958 & 1969a) considered the fibres of the dog’s periodontal membrane to be coarser and stronger than the periodontal fibres in humans. The different forms of the fibres may affect their remodelling capacity.

In orthodontic text books, Reitan (1969b, 1985) presents the results of his research, but does not mention the research was using dogs. Although the general findings may be transferred to humans, I consider that more evidence is required before the quantitative measurements are accepted.
(ii) After 232 days, Reitan found that only some of the marginal fibres had remodelled. He considered the amount of remodelling to be less than "fairly well". Therefore, considerably more remodelling was required before completion, perhaps two to three times as long. Reitan (1985) infers that 232 days retention is sufficient time for remodelling of most of the supraalveolar fibres.

Thompson (1958) produced his results the same year. To determine the effects of the supraalveolar fibres on relapse he orthodontically moved teeth in monkeys. Immediately after space closure he carried out a complete and thorough gingivectomy on his experimental group. Twenty one days later the appliances were removed and relapse was observed. The control group had relapse of 44%, the experimental group only had 10%. From this Thompson concluded that the supraalveolar fibres contribute to relapse.

It was also in 1958 that oxytalan fibres were described (Fullmer & Lillie, 1958). Oxytalan fibres were found in the periodontal membrane, tendons of muscle attachments, and in other areas of stress.

Oxytalan fibres are, in many respects, similar to elastic fibres (Fullmer & Associates, 1974). Sims (1976) has also observed physical changes of oxytalan fibres, when prepared histologically, that suggests an elastic nature. However, the function of these fibres, and any elastic purpose which they may serve, is uncertain.

Edwards (1968) found oxytalan fibres were definitely more numerous and more clearly defined in the periodontium of teeth that had undergone orthodontic movement, than in the periodontium of control teeth. The preponderance of oxytalan fibres was still present after one year of retention (Edwards, 1971). Boese (1969) and Campbell & Associates (1975) have made similar initial findings.

Edwards (1968) found that oxytalan varied in its distribution in the periodontal tissues. Among the transseptal fibres of the gingiva he found the oxytalan fibres ran parallel with the free gingival collagen fibres.

Edwards found that oxytalan did not extend from one tooth to the next, nor did it insert into the alveolar bone. In the middle third of the periodontal ligament, the oxytalan fibres were numerous. They were observed to run in the same direction as the collagen fibres of the ligament, this infers they ran at an oblique angle to the tooth surface.

Boese (1969) reported the oxytalan and collagen fibres as forming dense bands of tissue extending between teeth. He also found oxytalan extending from
cementum to bone. In contrast to Boese (1969) other
investigators, Edwards (1968, 1970, 1971), Parker (1972), Sims (1975), have not
reported oxytalan inserting into the alveolar bone. Boese is the only investigator to
consider that oxytalan extends from tooth to tooth. Boese describes the strands as
oxytalan and collagen bundles. He did not determine the relative density of each
component in the bundle.

Parker (1972) examined the fibrous component of the periodontal and
gingival tissues in monkeys. He extracted the first molars of the monkeys, closed
the spaces and then examined the soft tissues. Parker found oxytalan fibres most
common in the transseptal fibres of the gingival tissues, but were also found in the
periodontal ligament. The oxytalan fibres did not attach to the bone or cross the
interdental alveolar crest of bone. Parker could not determine the function of the
oxytalan fibres but suggests that their function is secondary to that of collagen.

Sims (1975, 1979) has carried out very comprehensive research on
oxytalan. Although Sims considers oxytalan to be elastic in nature, he does not
consider that it maintains tooth position or contributes to relapse. After examining
"several thousand sections", Sims concludes that oxytalan is more closely
associated with the vascular elements of the periodontal ligament, than the collagen
fibres. Being associated with the blood vessels would explain why oxytalan fibres
are more readily observed during remodelling. When Edwards (1971) noted the
preponderance of oxytalan fibres in the gingiva about 12 months after space
closure, he also noted that inflammation was present.

Sims also found oxytalan capable of fairly rapid turnover. In 28 days the
oxytalan network was observed to have developed anew with the old fibres being
broken down and lost as the blood vessels became embedded in the new alveolar
bone. Sims also found the oxytalan attached to the cementum, and its orientation is
basically vertically along and near the root surface. The research by Sims clearly
shows that the oxytalan of the periodontal ligament does not contribute to tooth
position. Unfortunately, the role of oxytalan is still undetermined. However, it
appears to be closely related to the vascular components of the periodontal
ligaments.

Elastic fibres have been attributed as playing a role in relapse of tooth
position (Reitan, 1985). However, Fullmer & Associates (1974) and Sims (1976)
have only found elastic fibres to be associated with the vascular structures of the
in his own research.
Histologically, attached gingiva may be differentiated from unattached gingiva by the absence of elastic fibres in attached gingiva. Therefore it is very unlikely that elastic fibres have any role in tooth position or movement.

In conclusion, fibres of the periodontal ligament and gingival tissues do contribute to relapse. The only fibres that have been shown to be closely associated with relapse are the collagen fibres. Although elastic and oxytalan fibres appear well suited, structurally, to produce relapse, it does not appear that this is their biological function.

2. Functional Forces

The forces directed onto the teeth during function are important. If they are in harmony with the positions of the teeth, the teeth will be stable. However, if the forces are not balanced, tooth movement may occur towards a position of balance or equilibrium.

Angle (1907) claimed that if correct form and function were reproduced, then stability would follow. To Angle, correct function was the correct occlusal relationship. To later workers, the term functional forces also included muscular forces. Muscular forces were considered the dominant cause of relapse.

The functional muscular forces: Tweed (1944) presented 100 consecutively treated cases to a conference in Chicago. Tweed explained that these cases had been treated originally without extractions. After serious relapse had occurred, Tweed retreated these cases and he was now presenting them up to ten years out of retention. Tweed’s cases were so well presented that extracton became a more accepted adjunct to treatment. The functional forces, produced by the oral and facial muscles, became an important consideration in treatment planning.

Two leading orthodontists who published papers on retention that are just as valid today as they were when first published are Hahn (1944) and Strang (1946 & 1949). The main points of their presentations were:

(i) Every malocclusion presents a denture that is in balance with all associated structures.

(ii) The balanced muscular forces cannot be changed. Therefore, treatment must work to preserve this balance.

(iii) Irrespective of the duration of retention, upon release each tooth will seek a position where it is in balance with the forces acting upon it.
It is interesting to note that these authors advocated a period of settling after removal of fixed appliances. Dr Begg (1965) also advocated this and hence his method consistently produces a result in harmony with the functional forces.

Weinstein & Associates (1963) tested muscle forces on teeth by a number of ingenious methods. The results of their studies were:

1. The tongue exerts the dominant force on the buccal teeth. The forces exerted by the buccinator muscle was found to be considerably less.
2. A definite range of stable positions for the incisors was shown. This range was from 50 to 73° (the angle produced by the labial surface of the central incisor and the occlusal plane).
3. Very small forces are capable of moving teeth.

Unfortunately their tests had very small numbers of patients and were carried out with a limited range of muscular movements over a short period. However, within these limitations, the experiments proved quite valuable.

**The functional forces of occlusion:** Dreyer & Gavron (1975) attribute considerable retentive influence to be associated with favorable tooth position and occlusal function. They list the important factors as:

1. Tooth angulation
2. Tooth articulation
3. Occlusal contacts
4. Interproximal contacts.

The use and effect of these forces for retention may be termed "functional retention".

Functional retention has wide applications. It may be utilised to retain incisors corrected from a crossbite, provided adequate overbite is established. If it cannot be established, incisor relapse is notoriously frequent unless other retention is used.

Miles (1985) utilises functional retention in many of his cases. He stresses that functional retention is not a matter of removing fixed appliances and waiting to see what happens. Functional retention requires careful treatment procedures, more detailed than what is normally required. Miles has found that to make functional retention successful, the third stage of Begg therapy must be lengthened and finished with the teeth in specific positions and angulations. Any settling that may occur should be anticipated and allowed for with tooth positioning.
With growth, we may also see a form of the functional forces of occlusion aiding to retain the occlusal relationships of the teeth. The studies of Bjork (1953), Bjork & Palling (1954), and Schudy (1964 & 1974) have all found that when forward mandibular growth exceeds maxillary growth, the maxillary teeth migrate forward so the maxillary dental arch becomes positioned further forward relative to its basal bone. The origin of the forces to move the maxillary teeth forward can only be surmised.

3. The Position of the root of the tooth.

Angle (1907) did not consider the relationship of the roots of the teeth to be significant for retention or stability. Sved (1953) considered that if arch expansion was maintained, new bone would form labial and buccal to the roots of the teeth.

In contrast, Lundstrom (1925), Riedel (1960) and Williams (1985) consider the roots of the teeth must be centrally placed in the alveolar bone. If they are positioned in or against cortical bone they will move, usually with deleterious results, once fixation is removed.

Riedel points out that we must be careful when positioning lower incisors. Lower incisor angulation is inadequate by itself as with arch expansion the lower incisors may be angled correctly but be positioned against cortical bone. This position is not stable. It was to reduce this type of problem that Williams (1969) encouraged the use of the A-P line to aid incisor positioning.

Conclusion

Tooth movement is the result of a force. Posttreatment movements may be the result of any of three sets of forces. Treatment planning and procedures must anticipate these forces so their effects will not be deleterious posttreatment.

CLINICAL STUDIES ON RELAPSE

This thesis is concerned with the initial six months of retention. But to fully understand the movements during that period in relation to the grand scale of things, we must understand tooth movements for the years that follow. Therefore this review covers a broad range of the more recently published papers on relapse.

Each form of relapse is discussed individually, presenting its occurrence, possible causes and methods of reducing its incidence. The forms of relapse to be discussed relate to:
1. Overbite
2. Overjet and incisor angulations
3. Intercanine width and lower incisor alignment
4. Spacing
5. Rotations

**Overbite**

Relapse of the overbite is a major form of relapse that is potentially very troublesome. Begg (1965) and Begg & Kesling (1977) stressed that overbites should be overcorrected to positions of openbite, so that the impending relapse is in the operator’s favor.

Some overbite relapse does appear to be unavoidable. The following studies review the amount of relapse recorded. As treatment philosophy has a large bearing on the method and degree of overbite correction, I will specify the treatment form if recorded.

Litowitz (1948) reported that teeth intruded during treatment regained their original height posttreatment, and in some cases exceeded it. He found that overbite had a strong relapse tendency.

Stackler (1958) reviewed 20 Class II Division 1 patients at least five years posttreatment. All had their four first premolars removed as part of their treatment. Stackler found three cases had a return of excessive overbite. He attributes this relapse to elongation of intruded maxillary incisors, and mesial tipping of the buccal segments. In this study cephalometric radiographs were not used and the results were not quantified.

Magill (1960) examined 63 edgewise cases, between 1.5 and 7.5 years out of retention. All patients had extractions. He found that 50% of the overbite relapse occurred in the first two years postretention. The mean overbite relapse was 1mm and it did tend to increase with time. Only two patients had a deeper overbite at the final examination than they had before treatment. Both of these patients had a minimal overbite prior to treatment.

Ludwig (1966 & 1967) tried to find, using cephalometrics, a relationship between overbite relapse and other dental or skeletal factors. In 114 edgewise patients, examined up to six years postretention, he found a mean relapse of 1.5mm, or 33%. Only three cases relapsed to their original depth. Ludwig considered the relapse to occur mostly in the first year or two.
The method of expressing relapse is important. In Ludwig’s deep bite cases, relapse averaged 3.9mm, or 30% of pre-treatment overbite.

In the shallow bite of the pre-treatment overbite cases, relapse averaged 2.6mm, or 41%. Therefore, if expressed as a linear measurement, the deeper bites relapsed more. But if we use percentages, the opposite is true. This fact is very important as Shudy (1974) quotes the unpublished thesis of Urban which finds overbite relapse is less in cases with larger initial overbites. However, Schudy does not say in what form Urban expressed the amount of relapse. Riedel (1960) and Joondeph & Reidel (1985) consider that the further a tooth is moved during treatment, the more stable it is. I would expect that Urban, Riedel and Joondeph & Reidel are considering relapse as a percentage of total tooth movement achieved.

Ludwig was unable to find a correlation between the facial height to facial depth ratio and the amount of overbite before or after treatment. He found that a correlation may exist between overbite and interincisal angle, but there was no correlation between the overbite and the incisal angulations when considered alone. Ludwig’s papers were well presented with a good number of patients.

Leff (1969) in his unpublished thesis, as described in Schudy (1974), found a correlation between posttreatment eruption of the teeth and overbite relapse. Leff found posttreatment eruption of the lower incisors was associated with overbite relapse. However, vertical growth, due to eruption of the maxillary molars, was important as it could offset the eruption of the incisors and prevent the overbite from increasing.

Bishara & Associates (1973) studied 30 edgewise patients. All had had premolar extractions; the average period postretention was 15 months. These workers found the overbite had relapsed an average of 45% of the overbite correction.

Simons & Joondeph (1973) managed to recall 70 patients treated with the Tweed technique, who had been out of retention for more than 10 years. They found that the overbites that were deepest initially, tended to be deeper later. However, deep overbites still had the greatest net correction after 10 years. The patients who had the greatest mandibular growth posttreatment, had the least relapse, but they found no correlation between mandibular plane changes and the depth of the bite. Posttreatment eruption of molars, as part of growth, was associated with increased vertical stability. Due to the greater amounts of mandibular growth remaining after treatment in males, they were found to have less overbite relapse than females.
Bresonis & Grewe (1974) reviewed 53 patients, three to five years postretention. The patients included both extraction and non-extraction edgewise treatments. All cases were treated to a good result. At the follow-up they found the average change was towards an opening of the bite. However, the Angle's class II cases tended to close. The class II division 1 cases closed an average of 30%, the division 2 cases closed an average of 16%. The authors concluded that as relapse averaged less than 2mm, an edge-to-edge incisal positioning was desirable at the end of treatment.

Nemeth & Isaacson (1974) examined growth form in relation to overbite relapse. They examined 26 patients, one to six years posttreatment. They found that the relationship between anterior facial height increase and posterior facial height increase determined the overbite relapse. If anterior facial height growth predominated, the bite depth decreased and an open bite may even develop. If posterior facial height dominated, the bite depth increased.

Nemeth & Isaacson observed the posttreatment molar changes as these teeth affect the anterior facial height. They found no molar depression posttreatment, in fact all maxillary molars continued to erupt as did 80% of the mandibular molars.

Johnson (1977) examined 11 edgewise cases, at least six years postretention. His finding was that the overbite deepened by an average of one millimetre.

El-Mangoury (1979) selected 50 patients with initial overbites greater than 4mm. They were assessed more than 2 years out of retention. Twenty-five of the cases were found to be stable, 25 had relapsed, the average relapse being 1.74mm. He concluded that the degree of relapse could not be determined from the treatment records. The presence or not of extractions did not effect the overbite relapse.

Ronnerman & Larsson (1981) recalled patients three years and then ten years posttreatment. Twenty three were included in their study. Some patients were treated with an activator, the remainder with the edgewise techniques, with or without headgear. They found that at the three years follow-up, about 50% overbite relapse had occurred. At the ten year follow-up there was very little residual bite opening remaining.
Little & Associates (1981) examined 65 edgewise cases who had been out of retention for more than 10 years. The patients were all treated by traditional edgewise mechanics with extractions. The authors found no significant relationship between the Angle's classification of the malocclusion and the degree of relapse. The average relapse of overbite was .76mm.

Shields & Associates (1985) followed up the study of Little & Associates (1981). The same patients were evaluated. These authors found incisors intruded during treatment tended to extrude during retention. This association was fairly strong and accounted for a significant amount of the overbite relapse. They also found that overbite relapse was unrelated to the angulation of the incisors, to the interincisal angle, or to the growth pattern.

Berg (1983) examined 26 cases, five to nine years postretention. A light wire edgewise technique was used. Nineteen patients had an Angle's Class II Division 1 malocclusion, 7 were Division 2. In these cases the overbite averaged less than 20%. Only one case had a serious relapse of the overbite.

Wood (1983) examined 60 cases with an Angle's Class II Division 1 malocclusion. Thirty of these cases were retained and 30 had no form of retention. Cases treated to an overcorrection were excluded from the study, otherwise there was no discrimination on grounds of the form of treatment. The cases were reviewed three years posttreatment. The retained cases wore their retainers for an average period of 8 months. Wood found the retained cases had more overbite relapse than the unretained cases. Measurable relapse had occurred during retention. However, the retained cases also had greater initial overbites and greater overbite reduction was achieved than for the controls, during treatment. Wood's control group, therefore, lacks some validity as it differed from the experimental group in important aspects. Therefore Wood's conclusion that the need for retention may be considered doubtful, is in itself doubtful. Further details are discussed under the heading "Overjet".

The following papers are grouped together as they all pertain to the Begg technique.

Bijlstra (1969) observed 21 patients all out of treatment at least two years. He found the bite opening was produced by elevation of the mandibular molars, but there was some intrusion of lower incisors. The molar movements did not relapse posttreatment and so the overbite was stable. However, the level of the lower incisors did relapse and they erupted to within 1mm of their original positions.
Grano (1971) examined 30 patients, all more than two years postretention. The cases were selected for initial overbites greater than 4mm. The average pretreatment overbite was 6mm. After treatment the average overbite was 2.6mm, and at the review appointment the average was 3.2mm. This is 17% relapse. The overbite correction during treatment was found to be due to eruption of the molars, particularly the mandibular first molar. Posttreatment all teeth continued to erupt, but the lower incisors erupted further and accounted for most of the deepening of the bite.

Barton (1972) compared the results of 30 patients treated with the edgewise technique, to 30 patients treated with Begg philosophy by W. Thompson of Florida. All patients had extractions and pretreatment overbites of 3mm or more. Barton found that bite opening was achieved by molar extrusion in both techniques. However, he found that edgewise treatment did not open the mandibular plane angle but the Begg treatment did. I noticed that extrusion of the upper incisors occurred during treatment. This suggests the Class II elastics were too strong. This is considered incorrect technique and a complication of this fault is that the mandibular plane will rotate open and not move bodily (Gildea, 1982).

Levin (1977) analysed the results of 30 patients, one to three years, postretention. He found considerable individual variation among patients. He did conclude that a large decrease during treatment, tended to be associated with a large increase in the postretention period. Levin also found that a backward rotating mandibular plane during treatment assisted overbite reduction, and a forward rotating mandible posttreatment was associated with a deepening of the bite. However, he also found that a low significant correlation was found between treatment changes and the final overbite.

O’Reilly’s (1979) is the final study of overbite relapse that I am reviewing. She studied 24 patients, all retained with tooth positioners for 12 to 18 months. All patients had extractions of four first premolars, followed by Begg therapy. Only one case did not have a deep bite originally. They were observed for an average of ten years postretention. O’Reilly found bite opening was due to extrusion of the mandibular first permanent molar. She noted some relapse of the height of this tooth posttreatment but she does not say if this affected the overbite.

**Conclusion:** Relapse of the overbite is quite variable. I do not attribute much of the variation to the time factor as the longest studies, Simons & Joondeph (1973), Johnson (1977) and Little & Associates (1981) had less relapse than some of the shorter studies. Therefore, there is not a consistent change with time.
Two more variables are growth and treatment method. Both are equally important but it is normally difficult to ascertain how each has contributed to relapse. Therefore, we should not consider the posttreatment changes in overbite as following a set pattern. We must ensure our treatment is mechanically correct, and we should take heed of the recommendations of Begg (1965), Bresonis & Grewé (1974) and Rocke (1964), to allow for settling due to oral forces, by overcorrecting. In this way the final result is not only close to ideal tooth positioning, but there is harmony between the oral muscles and tooth supporting structures.

**Prevention of overbite relapse:** In the Begg technique we normally do not want to prevent relapse, as this is part of the settling of the occlusion. Our retainer, whether it is a tooth positioner or an acrylic plate, should only limit the settling process.

If we have a case where the bite was not opened adequately during the treatment, we may want to prevent all relapse of the vertical dimension. It is doubtful if this can be achieved. However, it may be attempted by using a tooth positioner, made with the dental setup with the overbite reduced, or we may use an acrylic plate with a bite platform for the lower incisors, the Sved retainer was developed for this purpose (Sved, 1944), but a Hawley retainer with a bite platform is also very suitable. The success of retention of the overbite reduction with these appliances depends on the hours per day the appliance is worn, and on the number of months or years its use is continued.

**Overjet and Incisor Angulations**

Relapse of the overjet and incisal angulations are discussed together as they are both directly related to each other. Relapse of the incisor angulation is also related to overbite changes. However, few studies have noted the relationship and none were found which measured the degree of the effect.

Begg (1965) stresses that the overjet should be treated to an edge-to-edge relationship, or if it was severe initially, it must be overcorrected. His philosophy was that some relapse was normal and should be anticipated in the treatment. There has never been any evidence to show that this philosophy is incorrect.

**Incisor Angulation:** Mills (1964, 1966, 1967 & 1968) has presented the evidence on which to base all discussions of lower incisor position. He examined 35 children almost five years after extraction of the lower first premolars and no further
treatment to the lower arch (Mills, 1964). He showed, by using cephalometric recordings, that the angulations and positions of the lower incisors had negligible change in most cases. He concluded, therefore, that the lower incisor position is a response to the balance of forces between the tongue and the mentalis muscle. With mandibular growth, the intact arch carried the incisors bodily forward. In the cases where the first premolars were extracted, the roots of the lower incisors moved forward but the crown remained in its same relationship and position between the oral muscles. This produced a retroclination of the lower incisors.

His next study was on lower incisors that had been proclined considerably during treatment of 56 patients (Mills, 1966). He found that in some cases the lower incisors could be proclined considerably and yet remain stable. These cases are where a muscle balance has been altered during treatment.

The examples are:
1. Angle's Class II Division 2 cases,
2. Thumbsuckers where the habit has been stopped, and
3. Angle's Class II Division 1 cases where the lower lip is no longer trapped behind the upper incisors.

In the 56 cases Mills examined, where the muscle patterns were not changed, he recorded the following relapse twelve months after retention was ceased.

For cases with proclination during treatment of 5 to 10° (average 7.2°) after twelve months the average remaining proclination was 4.8°.

For cases with proclination during treatment of greater than 10° (average 14.4°), after twelve months the average remaining proclination was 8.6°.

The relapse was due mainly to crown movement, root movement only being a minor factor. Even in the group that had the greatest proclination during treatment, after twelve months the incisal edge of the lower incisors was on average only 1mm further forward than it would have been in the absence of treatment.

Mills (1967) then evaluated mandibular incisors retroclined more than 7° during treatment. Again he found most relapse occurred in the first twelve months. Relapse occurred by movement of the crown and not the root, Mills attributes this to the fact that the forces of relapse, the oral musculature, directly affect the tooth crown. Of the retroclination remaining after twelve months, half of it would have
been achieved with extractions alone and no mechanical assistance. Only 1.3mm additional retroclination was gained. In the patients who had a considerable retroclination that remained stable (i.e. 10° or greater) all except one had remodelling of point B that allowed the tooth to move bodily forward.

Mills (1968) next assessed 150 patients. He divided these into four groups, i.e. the controls, patients with the lower first premolar extraction but no lower arch treatment, cases that had more than 7° proclination of the lower incisors during treatment, and cases that had more than 7° retroclination of incisors during treatment. His results were that lower incisor positions were surprisingly close irrespective of treatment, non-treatment, Angle’s classifications, proclination or retroclination.

In the extractions with no further treatment, Mills found the incisors tended to slowly tilt lingually until the extraction spaces closed, then almost all slowly returned labially.

Mills concludes that the lower incisors lie within a narrow zone of stability and unless we alter the muscular balance, we must accept that position.

Reitan (1967) assessed the stability of maxillary incisors in monkeys following tipping movements. Following tipping, the appliances were removed and relapse assessed. Reitan found most relapse occurred in the first five hours. However, this was then followed by six days of no relapse or tooth movement due to the development of a hyalinised area against the root of the tooth. This suggests the tipping force on the tooth was quite strong, stronger than the forces recommended by Begg & Kesling (1977). Reitan also applied root torque to teeth, moving some roots through the cortical plate. Again he found that if no retention was applied, considerable relapse occurred within hours.

However, these results have little application to our clinical work, as we usually retain corrections for many months. In the Begg technique, crown tipping is achieved early in treatment, and the position is held for the duration of the treatment. Root torque and uprighting are the final tooth movements prior to removal of appliances. However, these are overcorrected to allow for limited relapse. Also the rate of root movement is quite slow and rearrangement of the bone and fibrous tissues occurs after as little as 8 to 10 weeks (Reitan 1967).

Reitan concludes that it is only when retention is omitted, that any appreciable relapse tendency exists in the bone in the apical root area. Antérieur
teeth that have been tipped, will remain fairly stable, with little relapse tendency, provided they have been uprighted and retained.

Other workers have tended to concentrate on the overjet, with incisor angulation being a lesser consideration. Martin (1962) examined 32 cases at least 12 months out of retention. He found that in the non-extraction cases, the maxillary incisors tended to move labially, whereas in extraction cases they moved lingually posttreatment.

Huggins & Birch (1964) examined 82 Class II Division 1 cases six months, then one, two and three years after treatment. They found that 70% of their cases had relapse of 1mm or more and nearly all the relapse occurred in the first six months. Unfortunately, their evaluation technique had a few flaws. All their measurements were made on lateral cephalometric radiographs and only the upper incisor relapse was considered. ANS was used as the stationary point for horizontal measurements. As the patients were 10 to 13 years old, ANS would be still growing forward (Bjork & Skieller, 1972). Huggins & Birch did not evaluate lower incisor movement or position.

Bijlstra (1969), when evaluating the results of 21 patients treated with the Begg philosophy, at least two years posttreatment found the interincisal angle, as well as the individual incisor angles, all changed less than 1%. The overjet had relapsed between 1 and 2mm.

Fastlicht (1970) compared 28 patients who had had Class II Division 1 malocclusions prior to treatment, to an equal number of controls with good occlusions. The treated patients were up to 10 years postretention. He found the overjet was almost identical in both groups.

Barton (1972) found the relapse of the overjet was minimal, and the same for both the Begg and edgewise techniques.

Berset (1972), studying a mixed group of 43 children, mostly treated with edgewise, found lower incisor positions quite stable one to five years posttreatment. In the patients with extractions the incisors tended to be uprighted, in the non-extraction cases they were proclined.

Bishara & Associates (1973) examined 30 cases treated with edgewise treatment and extractions. The cases were examined 6 to 48 months postretention. The overjets were found to have relapsed 13% during the study.

Bresonis & Grewel (1974) examined a mixture of extraction and non-extraction orthodontic patients, three to five years postretention. In the Angle’s
Class II Division 1 cases, the mean overjet correction was 5.1mm, the mean relapse of the cases was 0.6mm. The Class I cases had minimal relapse; only 5% of the Class I cases exhibited relapse. The authors considered the overjet to be a stable relationship posttreatment. However, some cases did relapse but they found it impossible to predict what cases would do so.

Johnson (1977) reviewed 11 edgewise treated cases, all more than six years postretention. He found that the overjet of all the patients stayed within the range considered by Rocky Mountain Inc. to be normal (i.e. not greater than 2.5mm). Johnson found the anterior Bolton analysis to be not very specific in indicating a clinically apparent tooth size disharmony in this sample. Johnson considered the interincisal angle to be frequently too large at the end of fixed appliances, but this corrected itself posttreatment. However, as the average posttreatment change was only 1.2%, I wonder if this change is really significant.

Levin (1977), with 30 Begg patients examined one to three years postretention, found the posttreatment changes quite variable and less predictable. However, the correct occlusions were relatively stable. He found the relationship between changes in overbite and overjet to be of low significance, due to the stability of the overjet.

El-Mangoury (1979) used 50 "well-treated" edgewise cases, all with an initial overjet greater than 4mm for his study. He assessed these patients more than two years postretention. He considered 25 patients to have a stable result. The overjet relapse for these patients averaged 0.34mm. He also considered 25 patients to have relapsed. These patients had an average overjet relapse of 0.93mm. Based on these figures, I do not consider the level of relapse to be functionally or aesthetically disturbing.

Ronnerman & Larsson (1981), in their study of 23 patients at three and ten year posttreatment examinations, found the overjet relapsed up to 3mm at the three year point. After ten years the overjet had increased slightly more but was still quite acceptable. The Class I bimaxillary protrusion cases were found to have the largest percentage relapse, i.e. for an average correction of 1.9mm there was 0.7mm or 36% relapse.

Little & Associates (1981), in their study of 65 edgewise cases all more than ten years postretention, found the overjet to be stable posttreatment. They also looked for a relationship between overjet changes posttreatment and the development of lower anterior crowding. They found no relationship. Shields &
Associates (1985) reassessed the same patients. They found a weak association between the distance the incisors were moved and the relapse tendency. Sixty-five per cent of the upper and lower incisors tended to move back in the direction they came from. From the patients with an overjet relapse of 3mm or more, no pre or posttreatment cephalometric measurements could be used to predict this relapse. However, these authors did find that the posttreatment interincisal angle was not an indication of stability. An interincisal angle of 135° is often considered favorable for stability (Schudy, 1963), but this study showed no angle was more stable.

Wood (1983), in his study of 60 patients who originally had Class II Division 1 malocclusions, came to the conclusion that the importance of retention is in doubt. He found that the overjet relapse was greater in the group of patients who wore retainers, than it was in the group of patients who did not wear retainers. However Wood found that the retained group —
1. Had greater initial overjets (almost 2mm greater) than the control group, and
2. Had greater interincisal angles at the end of treatment than the control group.

Schudy (1963) and Ricketts (1982) advocate correct angulation of the incisors for stability. Wood does not specify what the treatment form was and lack of root torque during treatment suggests removable appliances may have been used. Greater relapse may be expected in cases where the incisors have been given inadequate palatal root torque.

Therefore, due to the differences between the experimental and control groups that Wood used, his results should be treated with some reservations.

Miles (1985) utilises functional retention to control the overjet once the fixed appliances are removed. He finds clinically, that if the teeth are torqued correctly, and the interincisal relationship is suitable, relapse of the overjet is not a problem. This is a clinical evaluation however.

Prevention of overjet relapse: Relapse of the overjet appears to be a problem in very few cases. Where relapse does occur, it may be due to the lower incisors re-establishing their original positions, as determined by Mills, or by proclination of the maxillary incisors.

The maxillary retainers designed by Hawley (1919) and Begg (1965) have labial wires which function to prevent proclination of the maxillary incisors. If relapse does occur, the acrylic base palatal to the incisors should be removed and the labial bow made firmer.
For the mandibular teeth, a mandibular version of the maxillary retainers may be made. Alternatively, a fixed cuspid to cuspid or premolar to premolar retainer may be placed. However, the effectiveness of these is doubtful as they have been shown to allow some retroclination of the lower anterior teeth (Lee, 1981).

If worn correctly, tooth positioners would be very good in retaining relapse of the overjet. Only very little movement would be allowed.

**Conclusion:** It appears, therefore, that relapse of the overjet is very infrequent. Unfortunately the cases in which it will occur cannot be predicted at any stage during or posttreatment. Most of the relapse of the overjet occurs in the first six months and very little occurs after three years.

**Intercanine Width and Lower Incisor Alignment**

Relapse of arch width is well documented. However, it is still open to discussion as to how much of a certainty it is. Arch width may be measured between the canines, premolars or molars. As the Begg philosophy is contrary to arch expansion, I will not discuss all aspects of arch width. Instead I will restrict this discussion to the intercanine width, mainly the lower intercanine width, as relapse in this dimension is a major problem that frequently occurs.

Closely associated with the lower canines are the lower anterior teeth. These teeth are also a major problem due to the frequency and severity of the relapse of their alignment. In fact lower anterior crowding is so frequent irrespective of whether orthodontic treatment has been performed, that many orthodontists consider it normal.

The review of the literature illustrates the problems orthodontists face with these teeth.

Begg & Kesling (1977) express concern over the lower canine positioning. In extraction cases the canines are moved distally along the arch. This is contrary to attritional occlusion which is the natural condition. Attritional occlusion allows the canines to migrate mesially. Begg & Kesling do not discuss the consequences of distal movement.

Begg (1965) advocates the need for the placement of lower incisors over the basal bone. This is a position of functional harmony and posttreatment changes will be minimised. However, there is mesial migration of the teeth for much of our life. This is a physiological adaptation to Stone Age Man's attritional occlusion. In civilised man's mouth, the mesial migration still occurs with crowding of the anterior
teeth as a consequence. Begg & Kesling (1977), Barrer (1975) and Williams (1985) recommend interproximal stripping of the anterior teeth to reduce or prevent imbrication of these teeth.

Strang (1949) emphasises the balance that maintains teeth in stable positions, even if they are in malocclusions. During and after treatment this balance must be maintained. As part of this balance, the arch form of the lower incisors must be kept, as must the lower intercanine distance. If these teeth are crowded, extractions are necessary and the teeth must be distalised along the arch.

Walter (1953) produced a study that is often quoted as evidence of the success of arch expansion. Walter examined 102 cases, all non-extraction. He examined these cases between one and thirteen years postretention. However, the average time lapsed was only two and one half years. Of these 102 cases, only 34 had models for pretreatment, end of fixed appliances, and recall for the study. The remaining 68 cases did not have the end of fixed appliances models, but did have the initial and recall models. From measurements from these models, Walter concluded that lower intercanine widths may be maintained if the increase is moderate and is in balance with muscular function and growth. I find the conclusion is a sensible comment. However, I cannot see how he arrived at the conclusion from his study. If he does not have the lower intercanine distance at the end of fixed appliances, he cannot conclude that the distance is stable.

Walter carried out further studies (Walter, 1962) which involved 100 patients. Fifty had extractions as part of their treatment, 50 did not. They were examined, on average, almost three years postretention. This study was better controlled and produced more valid results. Walter found the greatest retained widths where the teeth canines were overexpanded and allowed to settle into what he assumed to be functional positions. Fifty-two per cent of the canine widths were overexpanded during treatment. After settling they all maintained some expansion, the average expansion remaining being 62%.

Two questions to be raised with Walter’s work are:

1. What was the relationship of the canines to the basal bone? Walter did not relate the canine positions to the basal bone at any stage. I feel this is an important aspect of canine width relapse.

2. Is his posttreatment time period adequate? These patients were two years and nine months postretention. There is no evidence to suggest that the teeth were stable at this stage. Conclusive results cannot be reached until the canine positions are stable.
Martin (1962), in the same year, published the results of his study of 32 cases. Twelve of his cases had extractions as part of treatment, 20 did not. They were examined one year postretention. Martin found a reduction in the intercanine distance of both the non-extraction and the extraction groups of patients.

Fastlicht (1970) examined the inter-relationships between different occlusal factors in 28 treated class II division 1 cases, comparing them to 28 untreated controls with good occlusions. He found more lower anterior crowding in his control group than in the treated group (examined 1½ to 10 years postretention). He also found that males had wider lower incisors, and that wider lower incisors showed a stronger tendency to become imbricated. Fastlicht found that larger overbites and reducing intercanine distances were associated with more lower anterior crowding.

Berset (1972), in a study of 43 children, mostly treated with edgewise mechanics, found a general posttreatment reduction in intercanine width, with a net loss being the result. However, Berset quotes two references (Brockman, 1968; Graf & Associates, 1970), published in German. Berset summarises these papers as concluding that a great degree of stability of lower canine width is possible with longer retention.

Schwarze (1972) examined the records of 110 patients, 85% nine years or longer posttreatment, and some up to 20 years posttreatment. He found that arch expansion achieved during orthodontic treatment had relapsed considerably, with associated crowding of the anterior teeth. Schwarze could not evaluate intercanine distances as many of the canines were not erupted at the start of treatment. However, through assessment with the aid of photodocumentation, Schwarze assessed contraction and found it greater than 50% of the expansion achieved. He found no relationship between length of retention and the amount of relapse. Schwarze recommends extractions instead of arch expansion to increase the stability of our orthodontically treated cases.

Lombardi (1972) examined the canine position in relation to the basal bone, in 30 cases. His cases included both extraction and non-extraction. However, he found no difference between the two groups. Lombardi found maxillary intercanine width increases more stable than increases in the mandible. He found the cases with stable lower intercanine widths were only increased 0.33mm during treatment, whereas those with unstable intercanine widths were increased on average 1.9mm during treatment. The unstable group had a lower intercanine width
gain of 0.6mm at the follow-up which was defined as “years” after treatment. A high correlation was found between crowding in the maxilla, and crowding in the mandible, both tended to occur together. A correlation was not found between relapse of lower anterior crowding and tooth size or overbite changes.

Lewis (1973) considers the lower intercanine width should not be expanded during treatment. If it is expanded, lower retention should not be used until the settling or relapse of the intercanine width has been allowed to occur. Once the lower canines are in stable positions, or close to their original positions, a lower fixed lingual retainer, from canine to canine, should be inserted. This increases the stability of the lower anterior segment which in turn increases the stability of the maxillary incisors. Lewis also recommends extractions instead of arch expansion.

Bishara & Associates (1973) examined 30 extraction cases, an average of 15 months postretention. Treatment was with the edgewise technique. Mandibular intercanine width increase was found to have relapsed by 71%, but the maxillary intercanine widths had only relapsed by 2%.

Barrer & Barrish (1975) evaluated 74 cases five to ten years posttreatment. The cases were treated with the Begg technique. They found the maxillary intercanine distance was increased during treatment and most of the increase was retained. However, the lower intercanine width decreased posttreatment. At the observation appointments there was a net decrease of 0.6mm in the lower intercanine widths. This is an interesting observation as the lower intercanine widths were kept almost stable during treatment (an average increase of 0.2mm). Barrer & Barrish found a strong correlation between intercanine width reduction and return of lower anterior crowding.

Kuftinec (1975) examined 50 cases four months postretention. Thirty of these cases had the four first premolars extracted as part of edgewise treatment. He found that the lower anterior crowding relapsed more in the non-extraction group than in the extraction group, despite the extraction group having significantly more initial crowding. The frequency of the relapse of slight anterior crowding made Kuftinec question the wisdom of treating cases whose only problem is slight anterior crowding. Kuftinec found the lower intercanine width increased in both the extraction and non-extraction cases. In the non-extraction cases it was due to arch expansion, in the extraction cases it was due to distalisation of the canines along the tapered arch. On an individual basis it was found that the more expansion of the intercanine width achieved, the greater the relapse. Kuftinec evaluated the Peck &
Peck ratio as an indicator of the likelihood of imbrication of the lower incisors. He considered the ratio not reliable enough.

Riedel (1976) discusses lower intercanine distance. He supports the practice of serial extractions as the canines will erupt more distal in the arch, therefore, with a greater intercanine width. He gives this the expression “using a natural cuspid retractor”. Riedel considers the lower intercanine width may be increased and maintained only in exceptional cases. He lists these exceptional cases as:
1. When they are instanding prior to treatment
2. In Class II Division 1 cases where extractions are performed
3. In some Class I cases with Class II Division 2 incisor relationships.

Riedel refutes the idea that extractions increase stability. He claims there is a swing to non-extraction treatment due to the lack of increased stability. I have reviewed much of the earlier literature and although few authors find stability better in extraction cases, none find stability worse. This is an indication of the success of treatment with extractions, as extractions are only used in the more severe cases. These cases would have required the greatest expansion of intercanine widths and, therefore, if treated without extractions, would have relapsed even more than the non-extraction cases.

Riedel suggests the extraction of one lower incisor in cases with severely crowded lower incisors. He believes this is the only logical way to stability. This is interesting as it is what Begg (1965) also suggested. However, both of these men express caution as a tooth-size discrepancy will usually develop with the occluding maxillary dental arch. Riedel routinely has pericisions and interproximal stripping around severely crowded lower incisors.

Gardner & Chaconas (1976) examined 103 cases treated with bioprogressive edgewise treatment. Extractions of four first premolars were performed in 29 patients, the rest were non-extraction. They found at the review appointment (an average of 5.2 years postretention) that the relapse of the lower intercanine width was 58% in both the extraction and non-extraction groups. These authors, and Kuftinec (1975), found a greater increase of the intercanine width during treatment in the extraction cases than in non-extraction cases.

Johnson (1977), in his study of eleven edgewise cases greater than six years postretention, found the lower intercanine distance to be highly individual. The average change was a 1mm decrease. However, some cases had held a 1.5mm increase.
Levin (1977) analysed 30 patients treated with the Begg philosophy. He recalled the patients one to three years postretention. He found that the lower intercanine width steadily decreased for all patients, except one, irrespective of the treatment change, i.e. the amount of increase or of decrease. The one case that expanded postretention had the width decreased during treatment. Levin found lower anterior crowding recurred in most cases. He does not believe the contraction of the intercanine width is the force that imbricates the incisors, but rather it is a case of the canines following the incisors.

Levin found that uprighting of the lower incisors was related to crowding of these teeth. He looked for a relationship between diastemas at the extraction space but found the presence or absence of such a space is unrelated to later crowding of the incisors.

Shapiro & Kokich (1981) quote the unpublished thesis of Gallerana. Gallerana found the duration of retention was unrelated to the maintenance of incisor alignment following retention. Shapiro & Kokich consider the original mandibular intercanine distance should be maintained.

Ronnerman & Larsson (1981) reviewed 23 edgewise patients three years, then ten years posttreatment. During treatment some of the patients had a reduction of the mandibular intercanine width, others had an increase. After three years most had a net contraction and this continued to reduce slightly up to ten years. After ten years they found secondary crowding in 50% of the patients.

Little & Associates (1981) assessed 65 edgewise cases more than ten years postretention. All had their four first premolars removed as part of the treatment. The authors found that approximately 66% of the original crowding had returned. There did not appear to be a relationship between the length of wear of a lower removable retainer and crowding. However, the duration of wear of the retainers was determined using the patient’s estimates at the ten year recall visit. The Angle’s Class II malocclusions, Divisions 1 & 2, had slightly less lower incisor crowding develop posttreatment.

Little & Associates found there was a poor relationship between changes in the lower intercanine width and the secondary crowding of the mandibular incisors. Some cases that had expansion of the intercanine width posttreatment still developed crowding. Therefore, the amount of increase of the lower intercanine width during treatment cannot be used as an indicator of long term crowding.
The intercanine widths from this study tended to constrict, but many still retained some expansion. Some cases reduced to less than the original width whilst others expanded. It is possible that retention did not reduce the posttreatment changes.

Shields & Associates (1985) assessed the patients from the study of Little & Associates (1981) using cephalometrics. They found no cephalometric factors that could indicate the likelihood of relapse. With lower incisor irregularities a few weak and doubtful associations were found. A possible association between the uprighting of the maxillary incisors, as well as retrognathic maxillas, and lower anterior crowding was found.

Discussion: There is no doubt that it is usual for the mandibular intercanine width to decrease posttreatment. However, this seems to occur whether the width is maintained or increased during treatment. The unpredictable nature of the relapse indicates other factors are involved. Four such factors may be:
1. The relationship of the root of the canine to the crown, or to the cortical bone,
2. The effect of the musculature on the canines,
3. The effect of the other teeth on the canines, and
4. The effect of the periodontium on the canines.

It is important to ensure the root of the canines are in cancellous bone (Williams, 1985). The effect of the musculature on the mandibular canines is difficult to assess. The overbite of the maxillary canine often affords some protection. The muscle forces, although of longer duration, must be small in relation to the occlusal forces.

The relationship of the canines to the other teeth is important. It is uncertain if occlusal forces produced by the maxillary canines, can produce constriction of the intercanine width. I would not expect so as the lower canines are capable of withstanding the forces of function and even severe parafunction without changing their position. However, if the canines lose their mesial contact with the incisors, this may just allow some tipping and contraction of the distance. If the incisors move mesially bodily, the interdental fibres would exert a force pulling the canine mesially. This group migration has been observed with wisdom teeth and shown experimentally in animals (Moss & Picton, 1975). Therefore, even the periodontium may be the cause of relapse.
Retention

The retention of the lower incisor alignment is an enigma. From these studies we must accept that return of lower anterior crowding is a fairly common feature. Fixed lower retainers are used routinely by many orthodontists today, and Barrer (1975) found 33% of the orthodontists he surveyed used mandibular fixed lingual retainers from canine to canine. In the literature there are many reports on how to construct these retainers (Crawford, 1981; Knierim, 1973; Lee, 1981; Meyers & Vogel, 1982; Hiddens, 1983). Each of these reports represents a different technique. Only two of these studies presented clinical results:

Zachrisson (1977) found failure of bonded lingual retainers in about 10% of his cases in the one to three year follow-up. He feels, however, that with experience this problem can be reduced. Zachrisson lists the advantages of lower fixed lingual retainers as:

(i) Aesthetically very acceptable
(ii) If they are bonded to the canines there is no risk of demineralisation as there may be under bands
(iii) Bonded retainers can be inserted when the bands are removed, or before.

The disadvantages of these retainers are:

(i) The incisors may rotate. Each incisor may be bonded to the retainer but problems would develop when these bonds separated.
(ii) If dislodged, the retainer may be swallowed or aspirated. However, not one operator reported a case where both bonds failed together, which is necessary for such an accident. Zachrisson suggests leaving a ligature holding the retainer to a tooth as a third point of contact.

Indications for a fixed lingual retainer are (Lee, 1981; Zachrisson, 1977):
1. Severe pretreatment lower incisor crowding or rotation.
2. Deliberate alteration of lower intercanine width.
3. Following advancement of the lower incisors during active treatment.
4. After non-extraction treatment in mildly crowded cases.
5. Following correction of a deep overbite.
6. Where anterior spacing was present pretreatment.
7. Where the canines have been extensively torqued, e.g. from impacted positions.

Lee (1981) in a study of eight patients wearing retainers for more than one year, found that even with a lower fixed canine to canine retainer in place,
considerable change in the axial inclination of the incisors is discernible on the cephalometric radiographs. The alignment of the incisors was maintained but the overbite increased during the study.

Interproximal stripping is a method of reducing or delaying relapse of lower incisor crowding. In the Begg technique lower anterior stripping is approved (Begg & Kesling 1977) as it replicates, to a limited extent, interproximal attrition of Stone Age Man, as well as reducing the requirement to increase the intercanine width.

Peck & Peck (1972 & 1973) presented ratios for the anterior teeth that allowed the operator to assess the stability or instability of the lower incisors. The ratios were the mesio-distal widths of each incisor, over its labio-lingual thickness, and this figure was multiplied by 100 to express it as a percentage. For mandibular central incisors the desired Peck & Peck ratio is 88-92%, for the lateral incisors it is 90-95%. If the ratios for the teeth were in the desired range, the teeth were claimed to be more stable. Peck & Peck recommended the interproximal stripping of incisors to bring them into the desired range.

Later studies (Kuftinec, 1975; Little & Associates, 1981; Smith & Associates 1982) have not supported an association between the Peck & Peck ratio and an increase or decrease in stability of incisor position.

Neff (1949) and Bolton (1958 & 1962) both assessed widths of the anterior teeth. Neff mainly relates the ratio of the maxillary teeth to the mandibular teeth and how this ratio affected the overbite. Bolton assessed the ratio of the width of the six mandibular anterior teeth, expressed as a percentage of the width of the six maxillary anterior teeth. This was presented as an aid to treatment planning. The ratios of Neff and Bolton are very similar. Since their introduction these ratios have been used as an indication of the stability of the teeth posttreatment (Godfrey, 1985). If the ratios point to an excess of mandibular tooth structure, we may complete the case with less overbite than normal. However, if the bite deepens during the posttreatment phase, we would find there is a tendency towards crowding in the mandibular arch, or spacing in the maxillary arch. As overbite is a difficult form of relapse to control, and is in fact considered normal settling, we may try to ease the teeth into a favorable relationship with interproximal stripping to create a more suitable Bolton’s, or Neff’s ratio, i.e. an inter-arch relationship that is compatible to the overbite present. Therefore, interproximal stripping can aid stability by improving the inter-arch tooth mass relationship.
Begg (1965), Paskow (1970), Boese (1980 a & b), Vickers (1982) and Sheridan (1985) all recommend interproximal stripping to flatten the interproximal surfaces of the incisors to increase their stability. Common sense suggests that flat surfaces are less likely to rotate than round ones. Unfortunately this point has not been proven.

Barrer (1975) has proceeded one step further than interproximal stripping. Barrer suggests stripping at an angle so the forces of relapse are strongly resisted. He has termed this procedure “keystoning”. This is not true keystoning in a stabilising architectural sense. This form of interproximal stripping may create unstable contacts. Due to lack of further mention of “keystoning” in the literature, I suspect it is not used to any great extent.

If lower anterior crowding recurs following treatment, lower anterior stripping alone may correct it (Paskow, 1970). If an active appliance is required, a “retainer splint” or “lower spring aligner” (Deal, 1967; Barrer, 1975) may be used in conjunction with stripping.

Reidel (1976) considers conventional treatment is incapable of creating a lower anterior segment that is stable in the long term. He considers that extraction of one lower incisor and/or pericisions on all the teeth of the lower anterior segment, is the best way to produce a stable segment. However, even some of these will recrowd. This is also the disadvantage of developing tooth to bone discrepancies.

Conclusion

Lower anterior crowding is such a frequent occurrence that it may be considered normal. When treating our patients we have an obligation to correct the alignment of the lower incisors, and to try to develop stability. What is done to ensure stability depends on:

1. The patient’s concerns and expectations.
2. The orthodontist’s concerns and expectations.
3. The patient’s willingness to undergo further treatment and/or prolonged retention.

These are all highly individual matters that must be decided for each case. It appears, though, that if the patient wants perfect alignment of the lower incisors, he or she must be prepared to have long term retention.
Spacing

Spacing of the teeth is often overlooked as an undesirable change that may occur following treatment. Nevertheless it is important and spacing may develop irrespective of its presence or absence pre-treatment.

It is an accepted principle that at the end of fixed appliance therapy, all teeth must contact each other. Of course, teeth that had bands will have slight spacing, but the design of the retainers should encourage this space to close. In some exceptional cases, for example in tooth size discrepancy cases, some spacing may be deliberately retained to enable better buccal intercuspation with a good anterior relationship. The main problem of recurring spacing develops from diastemas that were present pretreatment, or at the extraction sites.

Begg (1965) advocated overtipping of the roots of the teeth adjacent to extraction sites. If this is achieved the natural tendency of the teeth to upright over their roots will hold the space closed. Begg also drew our attention to the mesial drifting of teeth, which is a natural physiological change which has, as one of its functions, the closing of spaces and maintaining their closure.

Stackler (1958) noted that spaces open at the end of treatment had an overwhelming tendency to close. He found no evidence of space opening at the extraction sites.

Erikson & Associates (1945) produced valuable results from a study of the periodontal tissues after space closure in two patients. Each had two first premolars extracted. The space was closed orthodontically. The teeth were then kept in retention for 11 months in one case and 6 months in the other. After this period the canine and second premolar were removed, with their supporting alveolar bone and periodontal tissues. In the case with only six months retention, the lateral incisors were also removed.

Histological examination of the periodontal tissues revealed that the transseptal fibres are remarkably persistent, and that there is no physiological process that shortens or removes the excess fibres. They found that the transseptal fibres developed across extraction spaces, and as the spaces close the fibres relax, coil, and then finally become compressed. The compressed fibres remain and if they press on the bone, cementum or dentine, they will bring about resorption of that substance.

Erikson & Associates conclude that it is biologically unsound to expect good proximal contact between dental units approximated into an extraction site.
For the same reasons teeth fail to drift together completely after extractions, and extraction spaces tend to re-open after they have been orthodontically closed.

These authors also noted the ability of the transseptal fibres to stretch and pull the teeth in the direction of the force exerted upon the fibres.

Thompson (1958, 1959), in experiments with 40 monkeys, assessed the effects of the gingival tissues on relapse of teeth over an extraction site. His experiment involved extractions of anterior teeth in monkeys. The spaces were closed. He then performed thorough gingivectomies on the experimental group. A control group was also used. Three weeks later the appliances were removed from all monkeys and relapse was assessed.

Thompson found 44% relapse in the control group, 10% relapse in the experimental group. He concludes that the supraalveolar fibres are important contributors to relapse, but other factors are also present.

Parker (1972) assessed the effect of gingivectomies on preventing spaces from re-opening posttreatment. In seven monkeys he had the first molars removed and the premolars retracted to close the spaces. In each monkey one side had a gingivectomy, and became the experimental side, the other side was the control. Retention was for 30 days postsurgery.

Parker observed relapse on the control sides. However, relapse did not occur on the experimental side. In some cases, on the experimental side, if complete closure was not achieved during treatment, it tended to close posttreatment.

Parker found that the control teeth in this study relapsed only 13%. In Thompson’s study (1958, 1959) relapse was found to be 44%. Parker attributes Thompson’s higher relapse to the fact that he only tipped the teeth to close the spaces. Parker ensured the roots were parallel in his study.

Parker found that after appliance removal, about 50% of the relapse occurred in the first 12 hours.

Moss & Picton (1975) also demonstrated the importance of the gingival fibres to tooth position and movement. Moss & Picton do not consider that the anterior component of occlusal force, the soft tissues or the angulation of the teeth, contribute to the mesial migration of the teeth of monkeys. Their experiment was designed to demonstrate the effect of the transseptal fibres.

The gingiva of the monkeys was selectively cut and/or removed. Some molars were divided into mesial and distal halves. All interproximal contacts were opened with a diamond disc and were kept open during the experiment by adjustments.
The animals were observed from 2 to 9 months each.

Moss & Picton found that with divided molars, if the gingival fibres were scraped away, no movement occurred. However, if the fibres were left intact, the two halves were pulled apart. This is because there are no collagen fibres between the mesial and distal roots of the molars. It is interesting to note that Sims (1979) found oxytalan fibres forming a figure of 8 around the molar roots of mice. If these fibres also existed in the monkey, then they failed to prevent the segments from separating.

With the other teeth, if the gingiva was incised, then allowed to repair, the teeth were pulled together simulating mesial drift. The controls, which were not treated surgically, had the same response. However, if percisions were repeated weekly, or the tissue scraped away, little movement occurred.

The experiments of Moss & Picton have shown that intact gingival fibres will hold the teeth together. However, if the fibres are absent such as between the roots of the divided molars, the teeth may be separated. A clinical corollary to the latter situation would be over closed extraction sites. Although gingival fibres are present, their coiled and twisted nature prevents them functioning correctly to hold the adjacent teeth in contact. Therefore, re-opening of the space is possible.

Crossman & Reed (1978) assessed the spaces remaining eight to nine years after extractions and limited orthodontic treatment. They examined 44 patients who had all first or second premolars extracted to assist tooth alignment. The main orthodontic treatment given was upper removable appliances only. They found space closure was more frequent in the maxilla than the mandible, and was more often associated with second than first premolar extractions. In the upper arch almost 80% of the contacts were satisfactory.

In the lower arch, Crossman & Reed considered 20% of the first premolar extraction cases to have satisfactory contacts and 41% of the second premolar extraction to have satisfactory contacts. 40% of both extraction types had unsatisfactory contacts. These contacts were judged to be unsatisfactory by taking into account the relative height of the contact, the axial inclination, and the rotation of the adjacent teeth. The remaining cases had open contacts.

Although Cross & Reed found spacing still existed eight or nine years posttreatment, they do not discount natural space closing tendencies. In fact they found only 6.5% of maxillary spaces still open and 12.7% of mandibular spaces still
open at their reassessment. They consider that teeth remaining tipped to close spaces, i.e. not later uprighted, are detrimental due to hygiene difficulties. For our purposes, the most important conclusion drawn from this study is that mesial drift is an important factor contributing to space closure, even in the mandibular arch.

Offedal & Wisth (1982a, 1982b, 1982c) assessed spacing in 90 edgewise patients. Spaces were assessed at debanding (1982a), at the end of retention (1982b) and at periods of up to one year, 1 to 2 years, or more than 2 years postretention (1982c). Offedal & Wisth found that constriction of the alveolar process at extraction sites did not affect space closure, whether during treatment or retention. However, space opening was a related feature during the postretention period. Therefore, constriction of the alveolar bone does not affect space closing but predisposes to re-opening of the spaces.

Of their cases, spacing at debanding was a frequent observation. All cases that have bands removed will have some spacing. However, 62.5% had spacing greater than .5mm in each arch. Hawley retainers were used to enable a space closing action to be utilised, and space closing was observed during retention. However, the authors found mandibular spaces had a greater tendency to close and these did not have a retainer to influence them. They suggest that occlusal forces may have supplied the impetus to close spaces and the reaction force may have reduced maxillary space closing.

Offedal & Wisth found that cases that took longer to treat usually had more space closure at debanding, but a greater tendency to have spacing postretention. This is attributed to the longer treatment reflecting the greater difficulties, with similar factors that cause the treatment difficulties, encouraging relapse. A long period of retention was positively correlated with small spaces and this is attributed to the stabilising effect of the retention period.

Angle's Class II Division 1 cases pretreatment were found to have more maxillary spacing posttreatment. This was attributed to the tissue build-up distal to the canines because they required further movement.

An increasing of the overbite postretention was found to be associated with mandibular space closure.

Overall, the factors Offedal & Wisth found associated with spacing posttreatment were postretention changes in overjet and overbite, spacing pretreatment, size of the extraction spaces at debanding, and the duration of the treatment and retention.
Edwards (1971) studied the influence of the gingiva on the relapse of spacing. He closed bilateral extraction spaces in ten patients. Heavy forces were used and Atherton's red patch (Atherton, 1970) was a common finding. When the spaces were closed an accumulation or "pile-up" of excess gingival tissue developed between the teeth closing the extraction site. Each patient had one extraction site used as a control. On the other side the excess gingival tissue was removed by a surgical procedure. The details of the surgical procedure are:

1. No attempt was made to remove the trans-septal fibres.
2. In no case was the entire papillae resected.
3. A horizontal excision of the excess gingiva is performed. Only the excess gingival tissue is removed.
4. In many cases local anaesthesia was not required.

On the control side, at 17 months after space closure, there was still accumulation of the excess gingival tissue in every case. At 28 months after space closure, seven out of ten extraction sites still had an abnormal gingival contour, or space opening, or both.

On the experimental side, prior to the surgery the appliances were detached from the teeth and a relapse tendency was assessed. All extraction sites opened 1 to 3mm in 3 months. The teeth were again approximated and the surgery performed. These cases were then observed for 12 to 18 months. Four cases retained an abnormal gingival contour, but to a much lesser extent than previously. In all cases re-opening of the extraction spaces was eliminated or diminished.

Edwards observations confirmed the previous observations of Atherton (1970) and Edwards (1968) in the respect that a moving tooth displaces the gingiva, rather than moving through it. It is this displacing or pushing of the gingiva that produces the accumulation of excess tissue.

When Edwards studied the surgically excised tissue histologically, he produced unexpected results. The collagenous fibres of the transseptal group were normal, and not coiled up as previously described by Erikson & Associates (1945). However, oxytalan fibres had increased in the unattached gingival papillae. Normally oxytalan fibres are relatively scarce. But in these sections dense aggregations of oxytalan fibres were present. An increase in oxytalan fibres was not observed among the normal transseptal fibres closer to the alveolar crest. The increase in oxytalan fibres may be associated with the increased vascularity also noted in this area. The increased vascularity is possibly due to a chronic inflammatory response.
Due to the unattached gingiva being the slowest tissue to adapt to orthodontic movement, Edwards considers that such tissues are probably the most persistent relapse force in the periodontium.

During this study it was observed that severe gingival inflammation, due to poor oral hygiene, also reduced relapse. This was attributed to the damaging and repair of the gingival fibre groups. In this way more re-organisation occurred than otherwise would have. This observation is in contrast to Boese (1969) and Thompson (1958). Both parties found, in a very limited number of experimental animals, that there was a greater tendency for relapse in area of marked gingival inflammation.

Edwards' study has limited relevance to cases treated by the Begg technique, as he used heavy forces for rapid space closure. Begg & Kesling (1977) stress that light forces only must be used. With light forces it is unusual for the accumulation of gingival tissues to develop. However, Edwards conclusion concerning the relapse potential of the gingival tissues is significant.

Hatasaka (1976) examined the effect of the root angulation and position, of the teeth adjacent to extraction sites, to see if this affected space re-opening posttreatment. Hatasaka quotes Rocke (1972) as recommending that radiographs be taken prior to debanding to ensure that the roots of the teeth adjacent to extraction sites are parallel, or even converging. Hatasaka examined 110 extraction sites from 1 to 13 years postretention. All were edgewise treatments and the majority had four first premolars extracted. Hatasaka's findings were:
1. Where the roots touched over the extraction site, they stayed touching. The spaces stayed open.
2. Where the roots converged but didn't touch, the root angulation of 28 improved, 20 stayed the same and only one root worsened to touch its adjacent tooth.
3. Where the roots were parallel and the crowns upright, 25 remained parallel, four improved and Hatasaka does not state how the four cases improved. Three worsened. He considers parallel roots to be the best. Perhaps the improvement he noted is a reference to space closing. Spaces of 1 to 2mm at the end of treatment generally closed.
4. In underuprighted cases, three improved, seven remained the same and six worsened.
Hatasaka does not present figures for the frequency of space reopening. He concludes, though, that the best positioning for the crowns and roots are normal upright, parallel positions. In these cases, slight spaces were consistently found to close posttreatment.

Riedel (1976) discusses the problem of anterior spacing posttreatment. Riedel's experience has shown that if a mandibular incisor is extracted for treatment, space re-opening posttreatment is not normally a problem. However, if maxillary lateral incisors are extracted, recurrent spacing between the central incisors and canines is a problem. Riedel advises caution before having maxillary lateral incisors extracted.

Where diastemas were present pretreatment, Riedel tries conventional retention. If this is unsuccessful, he then considers inlays in the teeth approximated as a form of permanent retention.

Huggins (1963) advocates functional retention for routine cases, but he lists diastemas and rotated teeth as the two conditions that must be retained with appliances.

Bishara (1972) and Sperry & Abdulla (1982) consider the aetiology of diastemas to be morphogenetic space, tooth size discrepancy, labial frenum position, tooth rotations and inclinations, supernumary teeth, pathological conditions such as cysts, orodigital habits, and traumatic occlusion. These authors consider that if the aetiological factor can be recognised, it may be eliminated and retention will be easier. Unfortunately the aetiology is often idiopathic or multifactorial and in these cases space closure is followed by a difficult retention period.

To overcome the retention problem for retention of a maxillary midline diastema, Sperry & Abdulla present a design for a permanent fixed palatal retainer that holds the central incisors together, yet allows some individual movement between the teeth, as well as allowing dental flossing. Other, more or less permanent fixed retainers, have been presented by Kaswiner (1973), Chan & Andreasen (1975), Reinhardt & Associates (1979) and Jones (1982).

The superior labial frenum has been blamed for the recurrent spacing between many maxillary central incisors.

Bell (1970) and Spilka & Mathews (1979) present a method of surgically closing maxillary diastemas. Although the principle advantage of this method is
speed of treatment, a considerable secondary advantage presented is posttreatment stability. However, at present, orthodontic closure of diastemas is still the main method practised.

Bishara (1972), in his comprehensive paper on diastemas, considers diastemas normal until all permanent teeth are fully erupted. This is usually at about 12 years of age. Bishara stresses that the cause of the diastema must be looked for and corrected if possible. It is important that the arch size is not constricted to reduce generalised spacing as the functioning tongue will produce relapse.

Edwards recommended a treatment of frenums that greatly reduced the relapse tendency. An advantage of his technique is its conservative nature. The retention of the frenum produces a greater zone of attached gingiva, retention of the interdental gingiva and retaining better gingival contour.

Popovich & Associates (1977) examined the relationship between midline diastemas and frenums. They concluded that the main cause of persistence of the midline diastema is generalised spacing, with secondary factors being a low thick frenum.

Discussion

Different forms of diastemas may develop following orthodontic treatment. At extraction sites postretention diastemas may be due to the angulation of the tooth and root, an accumulation of excess gingival tissue, or due to failure to achieve initial space closure. All of these factors must be considered and can be greatly reduced by correct treatment. Constriction of the alveolar bone is another factor with which it is more difficult to deal, but again correct mechanics and treatment should allow tooth movement to be rapid but biologically safe to the supporting structures, and so maximum bone is retained.

Maxillary midline diastemas should not be treated until all the permanent anterior teeth have erupted. Even then, if surgical intervention is desired, it should coincide with orthodontic treatment and be conservative.

Finally, we must be prepared for maxillary midline diastemas that don’t appear until after treatment. In the malocclusion, the teeth, tongue and lip are in a state of balance. If we retract the maxillary segment, we may impinge on the tongue’s functional space resulting in a posttreatment forward movement of the teeth and spacing. If the transseptal fibres between the incisors and canine are stronger than the fibres between the two central incisors, the space will open between the central incisors (Campbell & Associates, 1975).
Prevention of Relapse

Spacing is an important form of relapse and most retainers are designed to prevent it. The tooth positioner, Begg retainer or Hawley retainer are all quite capable of closing spaces during the retention period. These three also function very well preventing the re-opening of spaces, although maxillary midline diastemas will often open slightly during retention. It is very unusual to use a Hawley or Begg retainer on the lower arch. However, this may be done to control spacing. The tooth positioner has the advantage of routinely retaining both arches.

Following closure of maxillary midline diastemas, fixed retention is often used.

Rotations

Rotations are perhaps the biggest retention problem in orthodontics. There is still no general agreement on how to retain rotations, for how long, whether they should be overcorrected, and to what degree, at what age they should be treated, or whether surgical separation of the supraalveolar fibres is of benefit.

The work of Reitan enabled orthodontists to understand the causes of rotational relapse. Reitan (1958) experimented with dogs and assessed the degree of remodelling of the bone and periodontal fibres. It should be remembered that this work was in dogs and Reitan notes that the periodontal fibre bundles are coarser and the bone structure is denser in dogs than it is in man. Therefore, Retain's results cannot be transferred directly to clinical practice with people. However, Retain's finding that the principal fibres, i.e. connecting the tooth root to the alveolar bone, rearrange fairly rapidly, and that the supraalveolar fibres rearrange extremely slowly, is borne out by studies on humans. Later papers from Retain (1959, 1960) repeat the information from this study on dogs.

Reitan (1967) recommends over-rotating teeth, followed by retention that allows physiological tooth movement. Reitan does not recommend percisions, as he feels over-rotation is the best form of preventing relapse and this would make the percision unnecessary.

"Immediate torsion" was a method tested to reduce rotations, in the hope of reducing relapse (Hallet, 1956; Haryett, 1962). "Immediate torsion" is the use of dental exodontia forceps to hold the tooth, and then to twist it to correct its position in the socket. Haryett lists the problems with immediate torsion as:
1. Relapse of the rotation.
2. Pulp pathology.
3. Apical root resorption.
It is very interesting that relapse occurred in these cases. However, it may have been due to the lack of retention allowing the ovoid tooth root to rotate back into a better fit into the ovoid socket.

Wiser (1966) assessed the effects of gingivectomies on relapse of orthodontically produced rotations in dogs. Wiser found 44% relapse of the rotations in his control group, but only 11% relapse in the surgically treated incisors.

Edwards (1968) produced some of the most valuable results in the study of rotations. To demonstrate the response of the gingiva to orthodontic rotations, he placed tattoos on the gingiva of six dogs. The tattoos consisted of three spots in a straight vertical line, level with the tooth. The teeth were then rotated, and the deviation in the alignment of the tattoos was recorded. In all cases a moderate to severe movement of the tattoos in the direction of the rotation was observed. This experiment was then repeated with four human subjects, with similar results.

Edwards found that even after a retention period of five months, the tattoos, and consequently the gingiva, had not re-orientated.

Histologically, the most obvious displacement of the supracrestal fibres appeared to be located on the lingual and labial surfaces of the roots. The transseptal fibres had an unexpected arrangement. Where they joined the control tooth, adjacent to the rotated tooth, they ran in a normal perpendicular direction from the surface of the control tooth. However, as these same fibres reached the rotated tooth, they extended obliquely to its surface.

After 5 months, Edwards found that the periodontal ligament had a normal histological appearance. The principal fibres no longer ran around the root surface but were perpendicular to the cementum surface. The connective tissue fibres had a normal wavy appearance. However, the supracrestal transseptal fibres and gingival connective tissue fibres were still disorientated.

Edwards allowed the rotated tooth, of one dog, two weeks to relapse. Some relapse was noted. Associated with this was a tendency for the tattoos to realign themselves, and histologically, the periodontal fibres looked much more normal.

Edwards (1970) followed up his experiments by repeating them on 12 human patients. Again a line of tattoos were placed. However, he introduced a surgical procedure to allow the gingival fibres to reorganise. Edwards does not give the surgical procedure a title. However, it later became known as “Circumferential supracrestal fiberotomy” (Kaplan, 1976) in the American literature, or as a
“Pericision” (Walsh, 1974) in the English literature, or as the “Sulcus slice” to various cynical Americans. In Australia it is generally known as “pericision” and that is the term I will use, irrespective of the terminology in the original paper.

Edwards (1970) describes the pericision as an incision through the supraalveolar fibres, to a level 2 to 3mm below the alveolar crest.

Edwards found that following the pericision, the tattoos realigned themselves. If realignment did not occur, as was the case with one out of the 12 cases, the pericision was repeated and alignment then occurred.

The experimental procedure was to correct the rotations of the teeth. They were retained for eight weeks. They then had all appliances removed and pericisions carried out. Relapse was observed over the next three months. No teeth were over-rotated. Eight teeth were used as a control study.

Edwards’ results showed that the amount of gingival displacement was related to the amount of rotation carried out. In the controls, Edwards found little correlation between the amount of relapse to the amount of orthodontic rotation. Once the pericision was performed, the gingiva realigned within 20 to 40 hours. The depth of the gingival sulcus was found to be unchanged prior to and following the pericision, as was the zone of attached gingiva. Most importantly, during the three months postretention period, relapse was found to be negligible.

Schultz (1968) also demonstrated, by experiments on dogs, the effect of the supra-alveolar fibres on relapse. Schultz rotated left and right maxillary second incisors in six young dogs. Retention varied from four to eight weeks. One side, arbitrarily selected as the control, had the incisor reduced in height to gingival level. The other side, the experimental side, had the incisor reduced to the level of the alveolar bone. By reducing the tooth to this level, the influence of the gingival and transseptal fibres was removed. The relapse of the experimental and control teeth was monitored.

The mean relapse tendency of the control teeth of 35%, whereas the mean relapse of the experimental teeth was only 12%. These experiments demonstrated the importance of the gingival and transseptal fibres of the periodontal ligament in relapse.

Boose (1969) assessed rotational relapse in monkeys with and without gingivectomies. He found that if the teeth were retained for only four weeks, then the experimental teeth relapsed half as much as the control teeth. However, if the teeth were retained for nine weeks, the ratio of relapse of the experimental group, to
the control group, was 1.64. Therefore, gingivectomies considerably reduced relapse, particularly if sufficient time was allowed for remodelling of the periodontal fibres.

Boese also found that relapse continued longer in the control group. After nine weeks retention, relapse continued to occur throughout the 8 week postretention observation period. However, in the gingivectomised group, relapse was completed in the first two to four weeks postretention.

Boese concludes that there are two forces of relapse. The principal periodontal fibres, and the supra-alveolar gingival fibres. In monkeys the principal fibres were active for about eight weeks, therefore retention should always be for at least this long.

Boese concludes that over-rotation would be ineffective in preventing rotational relapse. However, this is not supported by his experimental findings.

Brain (1969) assessed rotational relapse in the dog. Using 5 experimental teeth, and five controls, he rotated the teeth between 16 and 95 degrees. Once rotation was completed, a pericision was performed labially and lingually on the experimental teeth. All teeth were retained for 148 days.

Relapse of the experimental side was 1%, for the control side 27%.

Brain points out that it is the stability of the pericised teeth that is significant, not the amount of relapse of the control teeth.

Brain did not find a correlation between the degree of initial rotation and the degree of relapse that occurred.

Pinson & Strahan (1973) assessed orthodontically corrected rotations one year postretention. Twenty-one teeth had pericisions, 10 did not. These became the controls. They found that the average rotational relapse of the pericised group was 25%, and in the controls was 56%.

More importantly though, Pinson & Strahan assessed the degree of relapse against retention time. Although they considered their groups too small for conclusive results, their findings are interesting.

In the pericised group, for cases retained less than 16 weeks, relapse averaged 17°. For cases retained more than 16 weeks, relapse averaged 4.6°, and for those retained more than 28 weeks, relapse averaged 4.2°.
In the control group, for cases retained less than 16 weeks, relapse averaged 33°. For cases retained more than 16 weeks, relapse averaged 23°, and for cases retained more than 28 weeks, relapse averaged 21°.

From this evidence it appears as though the periodontal fibres, in humans, take at least 16 weeks to remodel. Therefore, this should be the minimum retention period.

Walsh (1974) also compared rotational relapse with the period of retention. He performed pericisions on 31 teeth at debanding. Two cases were not retained and after three weeks 75% relapse was recorded. Retention for these was started immediately. The teeth retained from two to 12 weeks had an average rotational relapse of 27%. Those retained from 13 to 20 weeks had an average rotational relapse of 9%. Walsh concludes that 12 weeks is the minimum period for retention.

The most comprehensive study of relapse of rotated incisors was carried out by Swanson & Associates (1975). They examined 116 patients, or 167 orthodontically corrected rotations, all more than 10 years out of retention. None of the patients had pericisions, most were retained for over a year, some for over three years with fixed retainers. These researchers found that the degree of relapse was related to the amount of orthodontic correction achieved. They found that age, sex, class of malocclusion, extractions and growth had no effect on rotational relapse. Their overall finding was that after 10 years most teeth were mildly rotated. Cuspids were the teeth most frequently corrected, and they relapsed the most. Some teeth were more severely rotated at the follow-up than they were initially. Mesial drift is suggested as the cause of this. Finally, there was a high incidence of relapse even amongst the mandibular canines retained with lower fixed retainers for a minimum of three years.

Bellardie (1985) reviewed 84 patients 16 months and 5½ years postretention. In all, there were 95 pericised incisors and 81 non-pericised or control incisors. Bellardie found that most relapse occurred during retention. After 16 months postretention, virtually all relapse had occurred. The amount of relapse was related to the amount of orthodontic correction achieved.

The control teeth were found to relapse only 2–4° more than the experimental group. Bellardie concluded that pericision was of little value in greatly reducing rotational relapse. He similarly found removable retainers of little value.
Bellardie also found that where the intercanine width was expanded by 2mm or more, the width relapsed and there was no difference between the rotational relapse.

Discussion

From the information presented, it appears as though rotational relapse nearly always occurs. Therefore we must do something about it.

Curiously, few studies have been carried out examining the benefit of over-correcting rotations. Begg (1965, 1977) has always strongly advocated over-corrections. Strahan & Mills (1970) and Boese (1980a & b) found over-corrections very suitable. In contrast Reitan (1985) considers over-corrections to be of no value whatsoever. However, not one of Reitan’s experiments assesses the effect of over-corrections and he does not give any reason as to why he comes to this conclusion.

Pericisions may be also used to reduce rotational relapse. I have listed many studies here supporting the effect of pericisions. Kaplan (1976) found that of 846 American orthodontists who responded to a survey on the use of pericisions, 25% do use, or have used pericisions as part of their treatment. Of those that use pericisions, only 9% used them for more than 50% of their patients. Unfortunately it was not determined how many patients had appreciable rotations, i.e. pericisions may be used on 100% of the patients with severe rotations, but this may be only 20% of the patients overall.

Reasons given for not using pericisions included the lack of long term studies and the risk of periodontal damage.

Of the respondents, almost 90% had not experienced any problems with pericisions. The problems listed by the others were:
1. Six orthodontists reported loss of gingival attachment and that gingival recession had occurred in some of their cases.
2. Two orthodontists found that the oral surgeons performed gingivectomies and not pericisions.
3. One orthodontist reported problems with postoperative infection in patients who had poor oral hygiene.
4. Only eight orthodontists considered pericision not to help at all in reducing relapse.
5. Four reported excessive postoperative pain as a problem with the procedure.
6. Other problems reported by only one or two orthodontists are patient apprehension, difficulty in convincing the patient of the need for the procedure, and oedema and slow healing in adults.

In all, there are surprisingly few problems. As there were 208 respondents who use percisions, the infrequent problems may be attributed to surgical technique or timing. Only further testing would determine if other factors are relevant.

Pericisions must be used within certain guidelines. Suitable guidelines are (Crum & Andreasen, 1974; Boese, 1980 a & b):

1. The teeth must be in ideal alignment or over-corrected prior to the percision.
2. Gingival inflammation and bacterial plaque must be eliminated.
3. Retention for 50–80 days must be allowed for re-organisation of the principal fibres and remodelling of the alveolar bone.
4. Areas with little attached gingiva should be avoided.
5. If post-operative infection occurs, it should be treated by local debridement and saline rinses.

Boese (1980a) reports that following percision there is usually a marked mobility of the teeth. This mobility reduces in two to four weeks. If it persists, other factors, such as occlusal prematurities, should be looked for. He has also found that some spacing may occur immediately after the percision. This is attributed to oedema of the interpapillary tissues and is only of a temporary nature.

Strahan & Mills (1970) sum up the consensus of published opinion when they describe percisions as:

"This small operation is safe, causes the minimum of discomfort, and very probably reduces the amount of relapse and/or the length of retention".

**Conclusion**

My conclusion is that rotational relapse will occur when retention is stopped, if not before. Treatment should allow for some relapse. This is achieved by over-correction of the rotations. Unfortunately there is not an accepted agreement on the level of over-correction, or whether such should be maintained until debanding, or removed just prior to debanding.

Percisions are also a useful adjunct to reduce rotational relapse. However, they must be performed carefully, correctly, and in the absence of infection.
The Hawley or Begg retainers are not well designed to control this form of relapse. The Sved plate or retainer (Sved, 1944) and the tooth positioner, in theory, are both well designed to control rotations of maxillary anterior teeth for the Sved retainer, and all the teeth for the positioner. The alternative is fixed retention, either permanent or semi-permanent. Any of the bonded retainers capable of holding a midline diastema closed would be equally successful retaining corrected rotations.

Considerable changes may occur following orthodontic treatment. Some corrections, such as overjet, are very stable, whilst others, such as rotations, invariably undergo some relapse. The relapse potential of all movements must be understood and the retainer must be selected for its ability to give the desired control. If the teeth are debanded in positions of overcorrection, the retainer must also be selected for its ability to allow, or perhaps to actively produce, the final corrections.

Note: Since the final preparation of this chapter a report of vertical settling has been received at the Sydney University Dental Library (Gazit & Lieberman, 1985). This study found a 56% increase in the number of occlusal contacts in the first year following edgewise orthodontic treatment. The year covered a retention and non-retention period. The method used by the authors is termed "Photocclusion technique". It appears very accurate.
Chapter 2

TYPES OF REMOVABLE RETAINERS

There are many removable appliances currently used for retention. New products are regularly being developed. Few gain wide usage. However, some appliances do, producing a supply of different forms that is quite broad in their actions, advantages and disadvantages.

Products that were developed, but failed to win widespread or consistent use are:

1. The “Adjustor” (Sved, 1953).
2. The “Labiobuccal retainer” (Lewis, 1959).
3. The “Kaswiner lower retainer” (Kaswiner, 1973).

Failure to gain popular usage is not necessarily an indication of the low value of these retainers. The problem is the importance orthodontists place on the retention phase of treatment, and most are unwilling to change from an appliance with which they already achieve good results.

The Sved Plate was designed as a retainer (Sved, 1944). In contrast to its original intent it is now used as a bite opening appliance often prior to orthodontic fixed appliances (Rapaport, 1979). The Sved plate is not well suited to function as a retainer as:

1. It has no control of space opening distal to the upper canines.
2. It requires a layer of acrylic between the upper and lower incisors. This prevents an ideal relationship in which the incisors are only a fraction of a millimetre out of contact (Ramfjord & Ash, 1983).

Also, if the patient neglected to wear the Sved plate for a few days, it may no longer fit and would require remaking.

Removable retainers that have gained acceptance and now enjoy wide use are:

1. The Hawley retainer.
2. The tooth positioner.
3. The Begg retainer.
4. The invisible retainer.
5. The spring aligner.
The most important difference between these retainers is their method of action. All but the tooth positioner retain one arch only; some have better control of rotations, others control the overbite. It is also significant that most may be worn full time, whilst others, mainly the tooth positioner, can be worn only for a limited period each day.

In order to realise the advantages and disadvantages of the tooth positioner as a retainer, I will discuss the other removable retainers. As the Hawley & Begg retainers are similar I will refer from one to the other. As the Begg retainer was used during my research, I will discuss it first.

The Begg Retainer

The Begg retainer was developed by Dr Begg specifically for his technique (Begg, 1965). However, the retainer is similar to one used by Professor Ponitz of the University of Michigan in 1945 (Ponitz, 1985). The Begg retainer is different from other forms of retention as the teeth are less restricted, and more settling is permitted.

The Begg retainer may be made to either of two designs. Begg designed the retainer with vertical loops in the labial wire (fig. 1). These were placed distal to either the canines or first molars. It is not indicated why either position was preferred, perhaps for patient comfort.

The vertical loops are adjusting or activating loops. If spacing develops in the arch during retention, slight closing of these loops will make the retainer active, enabling the spaces to be closed and held so.

Alternatively, the Begg retainer may be designed without vertical loops (fig. 2). To allow adjustment a posterior arm is added to the labial wire. The labial wire, for this design, must exit the acrylic base at the posterior border, near the centre. This retainer may still be adjusted to close spaces. In fact, adjustment is easier as it may be achieved without the use of instruments.

The labial wire for a Begg retainer should be of 0.032 inch diameter wire. It need not have high tensility, as long as some resilience is present.

The labial wire, once it leaves the acrylic base, should pass around the most distal tooth in the arch, contacting it slightly on its distal and buccal surface. At this stage the wire should be level with the middle of the crown, therefore engaging the slight undercut present. The engagement of the undercut is possible as the level of greatest convexity on the maxillary molars is approximately one third
Fig. 1: The Begg retainer illustrated in "The Begg Book", 1965.

Fig. 2: An Alternative design for the Begg retainer.
the tooth's height, from the occlusal surface. If we wish to increase retention, we may place the wire further gingivally.

Begg designed his retainer to avoid the necessity for wires to pass over the occlusal surfaces of the teeth. He realised that wires passing over interproximal contacts may open, or hold open, interproximal contacts.

Begg also avoided the use of clasps. The Begg philosophy requires the teeth to be free to settle into a functional relationship with the other teeth. Clasps may interfere with settling and are better avoided. Retention of the Begg retainer is achieved by adjustment of the labial wire. To increase anterior retention, the labial wire is tightened. To increase posterior retention, the width of the posterior wires is reduced to produce better engagement of the undercuts.

Added retention may be gained by bending indentations into the labial wire as they will engage undercuts. Three beaked pliers are very suitable for this procedure. These indentations are normally most successful if placed between the central incisors or the first and second molars.

As the labial wire progresses anteriorly, it should be positioned higher on the teeth so that on the incisors it is one third of the height of the crown, from the incisal edge. If the wire is placed too far gingivally, there may be a decrease in control over labial tipping of the incisors. If the wire is placed too far incisally, it may annoy the lip, or dislodge over the incisal edges. We must also remember that the entire labial surfaces of the incisors are, in effect, in undercuts. Therefore, if the wire is positioned too far gingivally, the patient may have difficulty inserting the appliance.

The acrylic base is constructed to closely fit the teeth, even into the interproximal areas. The palatal undercuts should be blocked out prior to manufacturing the retainer. The lower teeth should not occlude onto the acrylic.

To prevent tooth rotations, an accurately fitting acrylic base, with a firm contacting labial wire, is required.

The presence of the retainer is sufficient to prevent lingual, buccal or mesiodistal movement of the teeth.

The fitting of the Begg retainer is very important. Begg (1965) says that the retainer should be fitted on the day of debanding. To achieve this he would deband his patients in the morning and insert the retainer the same afternoon. In contrast, in many orthodontic practices, insertion of the retainer frequently takes up to a week, and in some cases even longer. During this period some settling of tooth
positions has occurred. The teeth have also become firmer in their sockets. As the Begg retainer is rigid, it may no longer fit. In these cases the appliances must be adjusted or remade.

Once the retainer is fitted, and the patient is wearing it well, we must determine what tooth movements we desire. Forms of tooth movement desired during the retention phase include:
1. Correction of all overcorrections.
2. Eruption and vertical settling of the teeth into good occlusion.
3. Closing of band spaces, reduction of overjet.
4. Reduction of arch widths where the intermolar distance was expanded and/or overexpanded during treatment. A more frequent form is reduction of the inter premolar width.

During Stage III, if lateral molar step outs were not used, the premolars may have been expanded slightly. In this expanded position their buccal surface is level with the buccal surface of the molar, and their roots abut cortical bone. During retention these teeth have a strong relapse tendency.

The methods of achieving the desired movements are:
To allow or bring about palatal movement of a tooth, or groups of teeth the acrylic base must be reduced to allow the lingual movement. The labial wire is then adjusted to apply extra tension to the teeth to encourage the movement. If a specific one point contact is desired, such as for correction of an over-rotated incisor, three beaked pliers may be used for ease of adjustment.

To allow a rotation to occur, we selectively remove the acrylic base to allow only the desired part of the tooth to move lingually.

Settling of the premolar width is important. As the mandibular premolars are usually not retained, they may move lingually during settling. The maxillary premolars should be allowed to follow these teeth to retain good occlusal contact. Normally the labial archwire would not require adjustment. If it does, a lateral molar step should be incorporated.

The Begg retainer does not effect the vertical movements of the teeth during settling. This is desirable. If the treatment was carried out according to Begg’s philosophy of overtreatment, then vertical settling is catered for.

Band spaces are not as great a problem today as they were when bands were used on all the teeth. If band spaces are to be closed, then the acrylic should
be removed to allow mesiodistal tooth movement to occur. The spaces will usually close by themselves, perhaps assisted by molar uprighting. If extra assistance is required the labial wire may be tightened.

**Duration of wearing Begg retainers.**

The period for which the teeth must be retained is a highly individual concern. Some occlusions require no static retention, while others would benefit from permanent retention. In general, Class III skeletal cases, and cases which originally had severe malpositions of teeth, require longer retention.

Initially the patient is instructed to wear the retainer all the time, except when eating, cleaning the teeth or participating in active sport. The retainer is removed whilst eating to prevent the food bolus from entangling and bending the labial wire. It is also much more pleasant and comfortable for the patient to feel the stimulation of the bolus of food and the tongue against the palate whilst eating.

During active sport, the retainer may fracture if being worn. Therefore, for the patient's safety, it should be removed.

Full time wear of the retainer is recommended for six months (Begg & Kesling, 1977). However, this is only an indication, some orthodontists believe three months full time wear is adequate (Reading, 1985).

In theory, the best retention should be maintained until all the fibres connected to the tooth have rearranged. The principal fibres of the periodontal ligament rearrange after 9 to 16 weeks (Boese, 1969; Pinson & Strahan, 1973). The time required for the rearrangement of free gingival fibres has not been determined, but is thought to be in excess of one year. But we do not have to retain teeth for this length of time. At the commencement of Begg therapy, the teeth are corrected, and then over-corrected. This is the end of Stage I. The spaces are then closed, this is the end of Stage II. The Third Stage is usually as long as Stages I and II combined. The Third Stage involves root torquing, the crowns of the teeth do not move significantly. Therefore, the free gingival fibres have the opportunity to rearrange during the seven to twelve months required for Stage III of treatment. This is a significant consideration as the free gingival fibres have been proven to be a major cause of relapse (Boese, 1969; Pinson & Strachan, 1973).

The root apical fibres also have a strong influence on relapse. As these are the final movements of fixed appliance therapy, these fibres will not have had
time to reorganise. This is why over-movement of the root apices is part of the Begg treatment philosophy. The corrected positions are not held for as long and relapse is more likely.

The Begg retainer has little control over the tipping movements of the teeth. Therefore, control of the angulation of the teeth should be achieved with fixed appliances.

After three to six months, the wearing of the retainer may be reduced from full-time to night-time wear only. When this is first started, the patient should be instructed to return to the orthodontist should the fit of the retainer alter significantly. The importance of continuing routine observation should be realised by the orthodontist and patient. The teeth may make significant movements at this stage and it is important that these movements are known and understood.

After three months of night-time only wear, the patient is told to wear the retainer every second night for one month, then three nights per week for another month, then only twice a week for the third month. The teeth and occlusion are then reviewed and if they are satisfactory, retainer wear can be stopped.

If at any stage of retention a tooth moves into an unsatisfactory position, re-treatment must be considered.

The treatment options are:

1. **Fixed appliances**: Fixed appliances would rarely be full bands, often it is just a few bonded brackets and a segmented arch for six to nine months. The time is not for treatment, but once the tooth is corrected it must be held long enough for all the fibres to rearrange. Some orthodontists may prefer a shorter period of fixed banding followed by prolonged fixed retention. In these cases the fixed retention may be left for two or three years.

2. **Removable appliances**: A wide range of removable appliances may be used, with varying success. Perhaps the most popular is the lower spring aligner.

   The Begg retainer may also be manufactured to fit the lower arch. However, Begg (1965) does not recommend the use of lower retainers except in special circumstances.
The Hawley Retainer

Introduced in 1919 (Hawley, 1919), the Hawley retainer has certainly withstood the test of time. Today, the labial wire is no longer gold, nor is the base rubber. However, little else has changed.

When reading Hawley’s paper, I am surprised by the similarities to the present use of retainers. Hawley recommended a bite platform behind the maxillary incisors, if required, to retain overbite correction. He recommended full-time wear for two to six months, followed by night-time wear only. If patients were travelling away for a holiday, Hawley would issue a second retainer, to be used in case of loss or breakage of the first.

It is ironic that Hawley should conclude his paper by saying “I have no idea that it (his retainer) is perfect or cannot be improved”, (Hawley, 1919, p455), as this is one of the few developments in orthodontics that, apart from using more modern materials, has not been improved.

The Hawley retainer is basically adjusted and worn like the Begg retainer. If we compare the two, we realise each has its individual advantages.

Advantages of the Begg retainer are:
1. The teeth are not held by clasps, and so more settling, especially of the molars, is allowed.
2. There are no wires crossing the interproximal contacts. Therefore, the contacts cannot be forced or held open.
3. The labial wire may be adjusted to deliver a palatally directed force on the buccal teeth.
4. The labial wire passes distal to, and in contact with, the last tooth in the arch. Therefore, by adjusting the tension, spaces can be closed and held closed even if they occur between the molars.
5. The Begg retainer may be easily adjusted to allow constriction of the intermolar width. It is more difficult to do this with the Hawley retainer due to the presence of the Adams clasps.

Advantages of the Hawley retainer:
1. Retention of the retainer in the mouth is more positive. This is due to the clasps on the molars.
2. The force of the labial wire on the incisors can be made more positive. This is because the wire is shorter, with its attachment closer to the point of application of the force.
3. The Hawley retainer may be fitted with a bite platform. The bite platform will assist the control of the overbite. Whether a bite platform is desirable on a Begg retainer is questionable anyway. Dr Begg considered there was no requirement for one. However, if we are unable to reduce the overbite sufficiently during treatment, we may want to ensure no settling and relapse of the overbite occurs.

In conclusion, the differences between the Begg and Hawley retainers are not great. Orthodontists appear to favour the Begg retainer as it allows better settling, or they favour the Hawley retainer, due to its better retention in the mouth.

The Invisible Retainer

The invisible retainer was developed by Ponitz (1971). Ponitz does not reveal what material he uses, he describes it as "a relatively hard space age plastic that the Federal Drug Administration opposes" (Ponitz, 1985). He sells the material for $1 per sheet. It is almost certainly polycarbonate.

An indication of the material is given by its properties and method of moulding. It is a clear plastic that is firm, but not too rigid. When formed, it is less than 0.04 of an inch thick (Ponitz, 1985). To mould the plastic, it is placed in an oven at 250°F for 15 minutes. This is followed by placing it between two heating coils where the temperature is between 370-390°F. The plastic may then be vacuum adapted to the models, with assistance from gloved hands for a close fitting retainer.

Excess plastic may be removed with tin snips, a Joe Dandy disc or a pear shaped stone in a handpiece. The patient’s name may be carved into the retainer with a small round bur.

The invisible retainer basically retains the teeth by acting as a firm, plastic glove. Minor corrections of one tooth per quadrant may be achieved by repositioning the teeth on the models, as with a tooth positioner (McNamara & Associates, 1985).

The advantages of invisible retainers are (McNamara and Associates, 1985):

1. Very good aesthetics and patient acceptance.
2. Minor changes to tooth position can be made.
3. The retainer is simple to construct, easy to deliver and inexpensive.
The disadvantages of invisible retainers are:

1. Durability. Invisible retainers are of a very thin material that is not particularly hardwearing. Therefore, for long term retention, conventional retainers are more suitable (McNamara & Associates, 1985).

2. Occlusal contact. Due to the even thickness of the retainer covering the occlusal surfaces of the molars and incisors, when the patient closes his or her jaws, the bite is propped open posteriorly. This effect would be doubled if upper and lower invisible retainers are used.

   Invisible retainers are regularly used in the United States and appear to be increasing in popularity (Waselesky, 1985).

**The Spring Aligner**

The lower spring aligner was developed by Drs Jarrett, Hopkins & Martin in 1963 (Deal, 1967). It was designed as a cuspid to cuspid retainer that may be extended posteriorly to hold buccal expansion.

Deal notes that the retainer is capable of accomplishing minor tooth movement, provided the tooth is reset on the model prior to the manufacture of the retainer.

Barrer (1975) presented the upper and lower spring aligners which he uses in conjunction with interproximal stripping. The upper spring aligner is an adaptation to the basic Hawley retainer.

The advantages of spring aligners are:

1. They are accurately fitting retainers. Their ability to hold the position of anterior teeth is improved over the conventional Hawley or Begg retainer (Taylor, 1985; Godfrey, 1985).

2. The spring aligners may be used as active appliances to correct minor irregularities in alignment (Deal, 1967; Barrer, 1975). To achieve this, prior to manufacture of the appliance, the relevant teeth are reset on the models in their corrected positions. It must be ascertained that there is sufficient space for the corrections to be achieved. For space requirements the spring aligners often require interproximal stripping.

3. They are aesthetically very pleasing. Although stability of the teeth is better than a Hawley retainer, the aesthetics is similar.
4. They are comfortable and convenient. The upper and lower spring aligners allow the patient to wear the retainer whilst doing most activities.

The disadvantages of the spring aligners are:

1. They are more difficult to manufacture than the standard Begg or Hawley retainers.

2. There is general concern that a lower spring aligner, extending from canine to canine, may be dislodged and swallowed by the patient (Godfrey, 1985). Although I have never heard of this occurring, the possibility appears very real. For this reason these retainers should be extended to the molars which also adds to retention.

3. Unlike the similar Hawley retainer, the upper spring aligner cannot be given a bite platform. A “hybrid” of the Hawley retainer and the upper spring aligner may be made with a bite platform. However, due to the rigidity of the palatal fitting surface, this retainer cannot be made active.

The Tooth Positioner

The tooth positioner was developed to be more than a retainer (Kesling, 1944). It was originally envisaged as being capable of the many movements carried out when finishing off cases. The aim of the tooth positioner was to allow cases to be debanded earlier than they otherwise would.

The tooth positioner has not lived up to its original expectations as an active appliance. The final tooth movements, in both the Begg & Edgewise techniques, usually involves torquing or uprighting of the roots of some teeth. Tooth positioners cannot position the roots of the teeth (Vorhies, 1960), and so are unsuitable in this role. However, if the roots of the teeth are well placed, then a tooth positioner is very well suited for achieving minor movements of the crowns. Examples of active movements frequently achieved with tooth positioners are:

1. Alignment of teeth in overcorrected positions.
2. Closing of band spaces.
3. Canine crown positioning. The position of the canines, particularly the lower canines is very important. Detailed positioning of these teeth is usually one of our aims when using tooth positioners.

Some doubts have also been raised about the effects of the tooth positioner as a long term retainer (Elsasser, 1950). It was considered that the elastic nature of the positioner may allow it to exert forces on the teeth whenever it is worn,
i.e. the teeth may not necessarily find a position where all the forces are in equilibrium. This would be contributed to by not wearing the positioner during the day. During the day a completely different set of forces operate on the teeth. If this was the case jiggling forces may be set up. The effect of this would mobilize teeth which would be readily discernible.

Due to the concern of the tooth positioner producing mobility of the teeth, its use is often restricted to 6 to 8 weeks (Elsasser, 1950; McNamara and Associates, 1985). In effect, the tooth positioner is used for precision positioning of the teeth.

Elsasser (1950) considered that tooth positioners produced a deepening of the overbite. A bite deepening action of the tooth positioner is not supported by other research workers. Elsasser recommends placing an open bite of one to two millimetres in the setup models for the tooth positioner manufacture. This may not be successful as it may produce too much occlusal pressure on the incisors, leading to discomfort and patient co-operation problems.

Vorhies (1960) also considers tooth positioners to be most suitable for short term use. He evaluated the movements he achieved with the use of tooth positioners. Unfortunately, Vorhies' experiment lacks specific and desirable information. Information that should have been given:

1. Are the movements he achieved in the direction of relapse, or do they complement the movements achieved during the fixed therapy treatment?
2. How would a control group have reacted? Were many of the movements assisted by normal posttreatment relapse?
3. How soon after debanding was the tooth positioner inserted? Vorhies does not state the period between debanding and tooth positioner insertion. He inserted a conventional retainer 24 hours after debanding. This was worn until the tooth positioner arrived from the laboratory.
4. How did the movements he achieved compare with the tooth positioner setup models? It would have been very informative to have known how successful the positioner was in achieving each form of tooth movement.

In spite of the lack of information, Vorhies study is interesting. The study involved 10 patients who wore tooth positioners for an average of 32 days. Their wearing time averaged 17.3 hours per day.

Vorhies found the positioners generally did not torque the roots of the teeth, but usually tipped the crowns instead. He also found that he was not able to
selectively depress or erupt teeth. In the study, mandibular opening was either hinge like, in a parallel manner, or not at all.

Vorhies concludes from his study that tooth positions should be overcorrected in the setup of the models. This infers that only part of intended corrections were achieved.

Vorhies considers the tooth positioners to be an excellent device for finishing well treated cases.

Holden (1962) evaluated cephalometrically the changes that occurred in extraction cases where retention was with Hawley retainers or tooth positioners. He had 16 patients use each retainer. The patients were reassessed 6 to 9 months after issue of the retainer. Holden found there were:
1. No significant differences between the groups regarding the type of retention appliance used.
2. No significant difference between patients as a result of the class of the original malocclusion.
3. No significant differences between the patients radiographs taken at the end of fixed appliances and repeated after retention.

Significance of these factors was determined by using student’s “t” test.

Unfortunately, Holden’s measurements are not presented, this reference only being an extract of a paper he presented before the American Association of Orthodontists. Holden’s finding that no significant change was detectable radiographically after 6 to 9 months of retention suggests that the observation period may have been too short. Holden does not specify what orthodontic treatment technique was used to treat the patients. I believe it would have been edgewise as in the Begg technique more posttreatment movements would usually be discernible.

Cottingham (1969) introduced the material “Impak” for the manufacture of tooth positioners. By varying the ratio of the powder and liquid of the materials, he could vary the firmness of the “Impak”. The properties of “Impak” are discussed in more detail elsewhere.

Cottingham considers tooth positioners to be finishing appliances only. He would not use tooth positioners for retention, but as active appliances for 3 to 6 months. The tooth positioners were designed to:
2. Correct the occlusal plane angle if it was tipped during treatment. It is uncertain, though, if the movements of the occlusal plane are affected to a significant degree by tooth positioners.

3. Correct balancing side occlusal interferences. These are most common with second molars.

4. Correct the vertical and horizontal slant of the incisors.

5. Change the canine-premolar relationship, so the premolars are not too obvious when the patient smiles.

6. Reduce overcorrected teeth to their correct positions. With the use of a tooth positioner, overcorrections may be maintained until debanding, yet the teeth will be correctly positioned when the conventional retainer is inserted.

   Cottingham considers tooth positioners not suitable for retaining rotations.

   When the conventional retainer is issued, he stresses that the tooth positioner and other retainers must not be used together, i.e. a Hawley retainer must not be worn during the day and a tooth positioner at night. This may produce a jiggling effect on the teeth.

   Cottingham mounts his casts on an articulator for the construction set up for the tooth positioner. He condemns the practice of manufacturing tooth positioners on hand held or improperly mounted casts. He attributes these poor laboratory techniques to the vertical problems that have been associated with tooth positioner use. Cottingham had found both deep bites and open bites developing during tooth positioner wear. These problems may be overcome by mounting the models on an articulator, using a face-bow and interocclusal recording.

   Wells (1970) assessed the success of tooth positioner therapy in 29 patients. The patients were divided into five groups, i.e:

   Group 1 — Tooth positioner used as total therapy (3 patients).

   Group 2 — Tooth positioner used following therapy by a removable appliance (8 patients).

   Group 3 — Tooth positioner used following minimal edgewise banded therapy (11 patients).

   Group 4 — Tooth positioners used following full edgewise banded therapy (5 patients).
Group 5 — Tooth positioners used following full Begg therapy (2 patients).

As Group 1 will be discussed in Chapter 7, I will not discuss it here.

In Group 2 cases, the tooth positioner was used where treatment with fixed appliances was declined. The major problem with treatment in these patients was found to be lack of co-operation. It is apparent that, if the patients are not sufficiently motivated to wear fixed appliances, then they are unlikely to find the motivation to wear a tooth positioner correctly. In spite of co-operation problems, Wells found a generally favorable improvement with long term non-intensive use of tooth positioners. The tooth positioners were quite successful in guiding the eruption of premolars.

In Group 3 cases, the minimal edgewise therapy was often only the use of headgear. The tooth positioner was then offered as an alternative to full fixed appliances. Co-operation was better in these cases. The tooth positioner was inserted as the premolars started to erupt and they were basically used to guide their eruption. Other corrections achieved were:
1. A favorable improvement of the axial inclination of incisors.
2. Alignment of crowded incisors. In one case, slight spacing developed. I relate this change to the above correction.
3. Improvement of an excessive curve of Spee to a gentle curve only.
4. Correction of a posterior open-bite. Wells was pleased with his results from the use of the tooth positioner in this role.

In Group 4 cases, Wells observed some of the problems that may occur with the use of tooth positioners. He lists the problems reported as being associated with tooth positioners, as opening or closing bites, appearance of diastemas, anterior protrusions may recur, rotations may relapse, and so on. However, Wells did not note any of these problems developing in his cases.

In a severe open bite case, a tooth positioner was worn as a retainer for 18 months. There was only slight relapse of openbite and overjet during retention.

In another case, a tooth positioner corrected a midline discrepancy and held all corrections very well for 10 months.

Wells discusses the effects of the tooth positioner in all the patients. He suggests that many of the changes are normal occlusal changes. Not all movements are attributable to the positioner. Wells assessed overbite changes during positioner wear. Of the 29 cases, 9 had an improvement in the overbite and only 3 had a relapse. The overbite in the remainder was maintained.
The overjet was found to relapse in only 2 of the 29 cases. The remainder were improved or maintained.

Midline discrepancies were also corrected where possible. In 5 cases the midlines were improved, at least 1mm, whilst in 1 case there was 1mm relapse.

The tooth positioner was found helpful in effecting correction of the alignment and rotational position of the anterior teeth. Significant rotational improvement was observed in lower canines. The lower canines are the teeth that are most frequently rotated (Swanson & Associates, 1975) and Wells’ observations are pleasing. Wells considers rotations of premolars to be difficult for tooth positioners to retain, due to the circular nature of these teeth presenting less tooth surface for the positioner to push against. In spite of this Wells achieved a $45^\circ$ correction of an erupting premolar, with a tooth positioner guiding its eruption. From Wells’ comments, I must conclude that tooth positioners are capable of correcting, and holding, rotations on most teeth.

Correction of the sagittal relationships was achieved, in 6 cases, during the wearing of the tooth positioners. Five other cases showed improvement but not full correction. Relapse in the sagittal direction did not occur during tooth positioner wear. Other authors (Kesling, 1945) have noted the same improvements as well.

Wells corrected a posterior crossbite and successfully maintained this and another posterior crossbite that was corrected with fixed appliances. One case did, however, exhibit relapse tendencies in buccal width.

Tooth positioners were found to close spaces. However they could not upright severely tipped teeth. Wells does not specify if he was attempting uprighting of the crown or root torquing.

Wells limits the movements possible from tooth positioners to:
1. Tipping of the crown of the tooth up to 3mm.
2. Rotational correction of incisors, canines and premolars in some instances. Rotational correction of premolars was more successful in the cases treated during tooth eruption.
3. Correction in the anteroposterior direction of the molar and canine relationship, and the intercuspation.
4. Correction of canines, premolar and molar relationships in the bucco-lingual direction.
5. Correction of the overbite and overjet.
7. Improvement of midline deviations.

Significantly, Wells considers tooth positioners to be suitable retainers for all of these movements. He varied positioner wear between 21 days and 3 years in these patients, yet he found no adverse effects developing with time. Wells believes the problems that are attributed to tooth positioners are due to the teeth being placed in positions which are not in harmony with the oral environment. No retainer could be successful under these circumstances.

McBride & Mellor (1971) advocate the use of tooth positioners. They consider tooth positioners the best way to close the band spaces, which may be almost 4mm per arch. For the success of positioner treatment, the authors stress that particular attention should be paid to the following points:
1. Tooth positioners are not substitutes for good primary treatment.
2. Only slight changes in tooth position should be attempted.
3. The cuspid positions are important. These teeth should not be elongated nor their width increased.
4. All the molars should be included where possible. It is important to prevent overeruption of the second molars.
5. Patient co-operation is paramount.

McBride & Mellor suggest a tooth positioner for the upper arch only if the patient must breath through his or her mouth. They consider tooth positioners to be quite suitable for retaining rotations achieved during fixed appliance therapy.

Smart, McKinnon & Grave (1975) issue tooth positioners to all of their patients. The positioners are issued on the day of debanding (Smart, 1985). The advantages they attribute to tooth positioners include:
1. Occlusal details are more readily perfected. The need for occlusal equilibration is greatly reduced.
2. Both arches are retained by one unit.
3. Soft tissue forces are eliminated while the tooth positioner is being worn.
4. Tooth positioners facilitate some corrections.

They also list restrictions on the use of tooth positioners. These are:
1. Their limited ability to close extraction spaces.
2. Their limited ability to hold difficult rotations.
3. The elimination of mouth breathing is not tolerated by some patients.
Smart, McKinson & Grave are very pleased with the results of tooth positioners. However, they have occasional problems. If interproximal contacts slip, spring aligners may be used to regain the contact (Smart, 1985). Chronic nasal obstruction is the only reason why a tooth positioner is not inserted as the retainer following fixed appliances.

In conclusion, Smart, McKinnon & Grave consider that the tooth positioners have had a very significant positive influence on the quality of treatment in their practice.

Manning (1985) also retains with tooth positioners. His treatment technique is similar to Ricketts edgewise technique. Manning usually has the patients wear a tooth positioner for two months. Then he will switch to a more conventional retainer. Manning considers tooth positioners to be the best appliance for fine positioning of the teeth. However, the orthodontist must also do as much as possible with the fixed appliances.

From my research and correspondence with orthodontists, it appears that the tooth positioner is considered highly by those that use it. All believe that they are able to obtain better positioning of the teeth with a tooth positioner, than they could with fixed appliances alone. This is praise for tooth positioners. As a retainer it appears that although they have some limitations, tooth positioners are also very suitable.

**Post-retention changes**

We must also consider postretention changes. Postretention changes are partly due to growth. However, settling of the occlusion may also proceed for many years. If these movements are undesirable we must consider whether treatment is desirable. Treatment may not be desirable as soft tissue forces cannot be overcome, if they are the cause of the change. If we do decide to intervene again, and if the patient still has the tooth positioner that was made as a retention appliance, then this may be used again to correct the change (Cottingham, 1969; Fricker, 1985; Sandilands & Edwards, 1985). There are disadvantages with this form of retreatment though, they are:

1. It is questionable if the tooth positioner is active enough to achieve corrections at this stage. Vorhies (1960) suggested that if movements were desired, the tooth position would have to be overcorrected in the setup prior to manufacturing the tooth positioner.
2. Is the old tooth positioner the best appliance, as it will also attempt to undo all of the favorable postretention changes?

3. The teeth are firm in their sockets. Therefore the tooth positioner would be very uncomfortable to use. The patient would have to show considerable determination to be able to wear the tooth positioner continuously again. If the patient was unable to wear the tooth positioner, the orthodontist may use this as a means of shedding the responsibility of retreatment, from his or her shoulders onto the patient's. Some may view this as an advantage of tooth positioners.

**Conclusion**

It may be seen that each retainer has a different function. Many orthodontists will take advantage of this and use up to three different retainers routinely. The tooth positioner appears to be favored due to its ability to accurately position the teeth. Many orthodontists will then change to a conventional retainer. However, many orthodontists will continue the tooth positioner as the sole retainer and they are very pleased with the results.

Therefore, the tooth positioner is very beneficial when used as an active appliance or as a passive retainer.
Chapter 3 —

TOOTH POSITIONERS: HOW TO USE & USES

INTRODUCTION

To assist people reading this thesis who may plan to use tooth positioners, I have included this chapter on the clinical use of a tooth positioner. I will also discuss the various uses of tooth positioners.

I believe this is a very important chapter — if the tooth positioner is not handled correctly by the orthodontist, then patient co-operation wanes. Even co-operative patients may fail if not instructed correctly. Therefore, this chapter is very relevant and although it will not replace clinical experience, it will give the orthodontist some confidence before he or she confronts the first patient.

METHOD OF USE

T.P. Laboratories Inc. and Professional Positioners provide comprehensive instructions to the patients and orthodontists on how to use tooth positioners. T.P. Laboratories Inc. provide the best information and I have included much of it here. The routine I am advocating is very similar to that recommended by most of the manufacturers and users of tooth positions. As the methods are universally recommended I will not give credit to individuals unless the idea is theirs alone.

Initial Patient Introduction

The idea of using a tooth positioner as a retainer, should be introduced to the patient early in the treatment, perhaps even at the treatment planning appointment. The tooth positioner should be shown to the patient and its use clearly explained. I consider it very important that the following points are also discussed:
1. The use of the tooth positioner is not automatic, but the patient must show his or her ability to co-operate during the fixed banding treatment. Co-operation is necessary for success of the positioner treatment.
2. Co-operation must be maintained during retention. Unlike treatment, where some benefit still occurs if the patient does not co-operate, during the retention phase no benefit and perhaps deleterious changes may occur if there is no co-operation. The treatment results are placed wholly in the patient’s hands. A short period of co-operation, at this stage, will give very good results. Lack of co-operation may lose some of the benefit previously gained.

3. The tooth positioner is capable of achieving the best finish. The fixed appliances can achieve a very good result. However, a tooth positioner will hold and improve on the tooth positioning at debanding. A tooth positioner is, in the operator’s mind, the best form of retainer for the case in hand.

4. The differences between a tooth positioner and a conventional Begg or Hawley retainer should be explained to the patient, preferably with examples of each for the patient to examine.

5. The initial discomfort of the tooth positioner should be mentioned. However, this discomfort is transient and the tooth positioner is quite comfortable to wear after a few days, to a week.

It has been suggested to warn patients that a complete collapse of the treated case may occur unless the positioner is worn correctly (Kiser, 1974). This may be a bit extreme.

The Decision to use a Tooth Positioner

After this initial discussion with the patient, the tooth positioner should be occasionally mentioned to the patient, perhaps when discussing co-operation. I believe that the final decision, as to whether a tooth positioner is to be used as a retainer or not, should not be made until the decision has been made to remove the fixed appliances. At this stage the orthodontist should ask:

1. Has co-operation been of a sufficiently high standard?

2. Is fine adjustment of tooth movements required?

3. Has the treatment been so long, or the appliances so demanding, that conventional retainers, that are simpler to use, are more suitable?

4. Is a tooth positioner suitable, or would a conventional retainer with or without lower retention be more suitable?

From answers to these questions a decision may be made to use a tooth positioner for retention. The reasons for the latter two questions may not be clear so I will explain them.

The duration of treatment, or the appliances used, are important. If treatment has been a prolonged ordeal, the patients may co-operate very well until debanding. However, once freed from their burden, they are so overwhelmed by the
release that they will not become enslaved to the "new master", being the tooth positioner. This problem has been found in cases of long duration, especially where headgear has been used (Bennett 1984).

Tooth positioners are not always the most suitable form of retention. Occasionally settling may be desired. A tooth positioner guides "settling" and the teeth do not necessarily end up in a position of harmony between all of the forces of the environment. However, over a period of time one force, namely the pull of the periodontal fibres, reduces and so a different position may eventually also be in harmony with the forces operating on the tooth. It is conceivable that in some cases it is more desirable to let the teeth settle, than it is to insert a tooth positioner to control them.

Preparations & Insertion of the Positioner

When the decision is made to insert a tooth positioner, the patient is commended and informed of the decision. Arrangements are now made for the tooth positioner to be inserted at the same appointment that the fixed appliances are removed.

At the appointment prior to debanding, the archwires are removed and impressions taken. A wax interocclusal record and a facebow mounting should also be obtained. At this appointment a leaflet produced by T.P. Laboratories Inc. (fig. 3) may be given to the patient to read. I consider this leaflet to be a very good method of maintaining or improving patient interest.

The records obtained are sent to the laboratory for the manufacture of the tooth positioner. Suitable detailed instructions for the laboratory should be included. The prescription forms from specialist laboratories are very detailed to ensure the tooth positioner is most suitable for the case. I have included the prescription forms, with instructions, from T.P. Laboratories Inc. (fig. 4), Professional Positioners (fig. 5) and Frankham Laboratories (fig. 6).

When the tooth positioner is returned, the models and the tooth positioner should be examined to ensure they are of a satisfactory quality. If they are not, repairs may not be suitable and a remake of the appliance, perhaps with a resetting of the teeth, is often the safest course.

If the tooth positioner is suitable the patient may be debanded. The tooth positioner is again explained to the patient and he or she is shown their personal tooth positioner. They are then shown how to insert the appliance.

To insert the appliance, the following steps should be followed.
1. It is fitted over the maxillary arch first.
SECOND PHASE—HERE WE COME!

Very soon, the active phase of your treatment will end and your "braces" will be removed. You will then enter the most IMPORTANT SECOND PHASE of treatment—the final positioning and retention (holding) of your teeth. We are going to have a custom Tooth Positioner made for you so this final positioning can be done without wearing the braces any longer.

More impressions of your teeth will be made, and the plaster models will be sent to a lab. At the lab, your plaster teeth will be repositioned in a wax base into final, detailed positions. This "preview" of how your teeth will look is called a set-up. For example, small spaces can be closed, teeth can be rotated and all teeth will be leveled to the proper height.

The Set-up

Your Positioner is then made over these set-up teeth. As you bite firmly into your Positioner, the flexible material "stretches" around your teeth. The gentle force from the stretched Positioner moves your teeth into their ideal positions. Any improvements that may be necessary to make your teeth ideal can be accomplished by wearing your Positioner.

REMEMBER: These improvements were made on the set-up, and the Positioner was made to fit the set-up...so, the only way your teeth will move into the best positions possible, is by YOU wearing your Positioner as directed. It is really fortunate that this convenient, and exacting way of completing treatment is available.

I HOPE YOU ARE EXCITED ABOUT GETTING YOUR "BRACES" OFF, AND THAT YOU WILL ENTER THIS NEXT PHASE OF TREATMENT WITH ENTHUSIASM! IT IS JUST AS IMPORTANT AS THE BRACES HAVE BEEN UP TO NOW.

You will need to wear the Positioner 12-13 hours per day for the first month. This is 4 hours of ACTIVE wearing plus 8 or 9 hours of sleeping time. During ACTIVE wear, you will be instructed to do a CLENCHING EXERCISE which will actively move your teeth. This is most important! The sleeping time retains (holds) the teeth straight which is also very important until the gum and bone "settle and mature."

As we go through the next months, ACTIVE wearing time will gradually be reduced by approximately 1/2 hour per month (assuming you give full cooperation) until you're only wearing the Positioner while sleeping. Although the Positioner may feel awkward at first, it will become your best friend as it settles your teeth and holds them straight.

PLEASE NOTE: THE FIRST FEW MONTHS OF ACTIVE WEARING ARE CRITICAL. YOU MAY FAIL TO ACHIEVE A FINE RESULT IF YOU DO NOT WEAR AS DIRECTED.

More instructions on your finishing appliance will be given next time.

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Fig. 3: TP Laboratories Inc. leaflet, to be given to patients at visit prior to debanding.
SET-UP & POSITIONER RX SHEET

APPLIANCE
☐ YES ☐ NO
☐ POSITIONER
☐ POSITION-ETTE®
☐ VARSITY GUARD®
☐ GINGIVAL CONDITIONER
☐ BRUXISM APPLIANCE

MATERIAL
☐ crystal-Flex™ ☐ Black Rubber ☐ White Rubber

SEATING SPRINGS
☐ Yes, at Arrows ☐ No

HINGE-AXIS
☐ Tracing Enclosed ☐ Headplate Enclosed
☐ Use Average Hinge-Axis

SOCKET LINERS
☐ Yes, on Teeth Marked ☐ No

HEIGHT
☐ Normal ☐ Low ☐ High

THICKNESS
☐ Normal ☐ Thick ☐ Thin

MOLDED AIRWAYS (Included if not marked)
☐ No

END POSITIONER DISTAL TO
☐ 1st Molars ☐ 2nd Molars ☐ Other

OCCCLUSAL PLANE
☐ Flat ☐ Curve of Spee

ARCH FORM
☐ Ideal ☐ Approximately Same

ARCH WIDTH
☐ Upper ☐ Lower
☐ Expand mm ☐ Constrict mm

SPACES
☐ Close All ☐ Compromise ☐ Leave Space Between

OVERBITE
☐ Ideal (1-2 mm) ☐ Other

OVERJET
☐ Ideal (0 mm) ☐ Other

UPPER ANTERIOR TOQUE
☐ Ideal ☐ Other

LOWER ANTERIOR TOQUE
☐ Ideal ☐ Other

ACCOUNT NO. ☐ PHONE NO.

DATE SHIPPED TO TP ☐ DATE REQUIRED

PATIENT

Patient Name
Address
City
State
Zip

 PLEASE DO NOT WRITE IN THIS SPACE

SU | POSITIONERS
---|---
500-100 | 400-100 | 400-600 | 406-100 | 406-200
501-100 | 400-200 | 400-700 | 406-200 | 406-500
500-300 | 400-500 | 400-800 | 407-100 | 407-200
500-105 | 401-100 | 400-900 | 407-500
500-105 | 401-200 | 400-500 | 407-200 | 407-500

PLEASE SEND ADDITIONAL SUPPLIES
(Fill in address label only if additional material requested)

Dr.
Address
City
State
Zip

☐ Hinge-Axis Analysis Sheets ☐ 2 ☐ 4 ☐ 6
☐ Shipping Bags ☐ 2 ☐ 4 ☐ 6
☐ Shipping Boxes ☐ 2 ☐ 4 ☐ 6
☐ Shipping Labels ☐ 2 ☐ 4 ☐ 6
☐ Other

SPECIAL INSTRUCTIONS

MODELS ENCLOSED:
☐ Recent, Bands-Off
☐ Original □ Banded
☐ Set-Up (Complete)

IMPRESSIONS ENCLOSED
☐ Recent, Bands-Off
☐ Backs Parallel
☐ Wax Bite
☐ Lines on Buccal Surfaces of Molars

CENTRIC OCCLUSION BY
☐ U.P.S.
☐ Airmail
☐ Airmail Special Delivery

SHIP APPLIANCE
☐ First Class
☐ Parcel Post
☐ With Appliance as Indicated at Left

SHIP MODELS
☐ 2nd Molars
☐ 1st Molars
☐ Other

No carbon required. Return white and yellow copies. Keep pink copy.
FORM NO. 5019 REV. 9/83
Copyright 1982, TP Laboratories, Inc
EXPLANATION OF PRESCRIPTION SHEET—

Separations to aid in filling out the prescription on the reverse
side to provide the most personalized set-up and/or appliance

SET-UP

□ ESOTRICAL—This is the rearranging (setting-up) of the teeth of a patient after fixed appliances have been removed. Complete set-up is required to achieve the finest occlusion possible. Recent “bands off” model or impression are required.

□ DIAGN 00 —This is a set-up made before the fixed appliances are removed. Models made from impressions taken over the bands near the end of treatment are required. Overbite are also helpful to determine actual tooth shape and size.

□ DIAGNOSTIC—This is a set-up usually made prior to treatment, as an aid in diagnosis and a case presentation. Original model with well-trimmed bases required. Advise which teeth are to be extracted (if any), and desired positions of lower anterior teeth, treatments relative to their locations before treatment. Please give all details in “Special instructions” section at bottom of sheet.

FABRIC FOR SET-UP

□ Use TP Bases—TP will furnish bases for set-up. Your required control model will be returned with set-up.

□ Use Bases from Enclosed Model—Teeth will be removed from, and re-set on bases of model sent by orthodontist. TP will duplicate anatomical portions only, as a control, and return with set-up.

OVERRIDE

□ Ideal—(1-2 mm)—This is the usual distance the upper anterior teeth pass vertically over the lower. If the original malocclusion had a Class III anterior relationship, or an open bite, the amount of vertical override is usually increased to 2-3 mm. It is not advisable to increase or decrease the amount of override more than 2 mm when making the set-up; otherwise, the resulting appliance will not fit properly and/or may be unduly uncomfortable.

□ VENETO

□ Ideal—(0 mm)—This is the horizontal distance between the incisal surfaces of the upper anterior teeth and the labial surfaces of the lower anterior teeth. In an ideal occlusion, i.e. “veneto”, these surfaces are in contact.

□ PEDIC ANTERIOR TOE

□ Ideal—This refers to the labiobuccal inclinations of the upper anterior teeth. In most instances the inclinations of these teeth will be nearly ideal on the “bands off” model, and they will be reset with approximately the same inclinations. Upper anterior tooth should not be changed more than 3° to 5° in a set-up, or the resulting appliance will not seat properly and/or may be uncomfortable.

□ LOWER ANTERIOR TOE

□ Ideal—Torque refers to the labiobuccal axial inclinations of the lower anterior teeth. The ideal is usually an upright position. Often the crowns are inclined somewhat labially on the "bands off" model. The inclination of band spaces usually upright them properly; however, changes in inclinations should be kept within a 5° range.

SPACES

□ Close All—Normally all spaces are closed in the set-up.

□ Compromise—When spaces are too large to be closed with one appliance (over 3 mm in one arch), an initial set-up is made with all spaces closed 50%. After these corrections have been achieved in the mouth, spaces on the set-up are completely closed and a second appliance constructed.

□ Leave Space Between—if for some reason it is desired to leave space(s) between teeth in the set-up (as for a future artificial replacement), indicate here. Elaborate under “Special Instructions,” if required.

OCCLUSAL PLANE

□ Flat—This refers to the lower occlusal plane, as viewed from the buccal. If the incisal edges and cusp tips through the lower first molars are on a flat plane. Second and third molars (if present) are tipped up slightly. The upper occlusal plane is then crowded by setting the upper teeth to the lower teeth. Most set-ups for tooth positioning appliances are set in this manner, if the preliminary treatment has approximated that condition in the mouth.

□ Curve of Spee—The incisal edges and cusp tips of all the teeth in the lower arch are seen in contact with a curved template. Upper teeth are then set to curve of 0.2 mm Seldom used by orthodontists.

ARCH FORM

□ Ideal—Both upper and lower arches will be set with ideal arch form.

□ Approximate—Same—General shape of arches (tapering, oval, or round) are taken from “bands off” model.

□ Same □ Expand □ Contract—Check the appropriate square for each arch, to achieve corrections desired. If no posterior crossbites are present, and worn out anterior crossbites are proper, check “same” for both. If crossbites exist, indicate which arch should be expanded or contracted by checking the appropriate squares.

APPLIANCE

□ POSITIONER—A resilient appliance fabricated over a set-up, which covers all surfaces of both the upper and lower teeth. Flanges extend 2 to 3.5 mm beyond the gingival margin. Usually has Precision Seating Springs in one (or both) arches.

□ POSITION-ETTE—A resilient appliance fabricated over a set-up. Flanges are trimmed even with the gingival margin for maximum flexibility and comfort. Has Precision Seating Springs in the upper (and usually also in the lower) arch. Indicated when there is only one removable (2 mm or more) space to close in one (or both) arches.

□ VARIETY GUARD—A custom-made, mouthpiece, fabricated over both dental arches, that provides maximum protection and comfort during all contact sports. Has a high upper flange and none on the lower flange. One size fits all.

□ GINGIVAL CONDITIONER—A “positive-pressure” appliance that is worn to provide gingival massage. It covers all the teeth, and extends 2 mm to 3 mm beyond the gingival margins. Normally the “set-up” involves recontouring of proliferated gingiva, but no movement of teeth.

□ BRUXISM APPLIANCE—The Bruxism Appliance is worn while sleeping, to prevent the lateral jaw movements of the mandible and "grinding" of teeth. It covers all maxillary teeth and approximately one-third of the mandibular crowns.

MATERIAL

□ crystal-Flex™—A transparent, soft, resilient material that permits visual examination of tooth-socket relationships. Aesthetically most acceptable of all positioner materials to increase patient cooperation.

□ Black Rubber—The Tooth Positioner material having the proper combination of strength, resilience, softness and flexibility.

□ Clear Rubber—Aesthetically more acceptable.

SEATING SPRINGS

□ Yes—Indicate with an arrow the desired locations of the seating springs. Usually springs are placed mesial to the upper first molars. Often used in the lower arch, either mesial or distal to the first molars. Always try to locate springs distal to extraction sites for maximum space closure.

□ No—Appliance will be made without seating springs. It is recommended that flange height be either normal, or high, to increase retention of appliance in the absence of springs.

HINGE-AXIS

□ Tracing Enclosed—A cephalometric tracing of the condylar head, occlusal plane, and the lower anterior teeth, enables TP to determine if the appliance with the arches in the rest position is correct for the patient. A recent lateral head x-ray should be used. Printed Hinge-Axis Tracing Sheets (with instructions) are available to facilitate tracings.

□ Headplate Enclosed—A plaster, lateral head x-ray taken near the end of treatment, is sent to TP. A tracing is made to determine the patient’s individual hinge-axis. The unaltered headplate is returned to the orthodontist with the appliance.

□ Use Average—Hinge-Axis—TP Laboratories will construct the appliance with the dental arches in normal rest position. An average hinge-axis will be used—recommended in patients with large or small mandibulars.

SOCKET LINERS

□ Yes—Indicate with an “X” the tooth sockets to receive metal liners. Recommended for anterior teeth that may tend to rotate.

□ No—Appliance will be made without socket liners.

HEIGHT

□ Normal—Flanges are trimmed to extend approximately 2 mm beyond the gingival margin.

□ Low—Flanges stop at, or slightly short of, the gingival margin. Reduces bulkiness of appliance, and increases stretchability. Should only be used when seating springs are utilized for retention. (This is the flange height used on all Position-ettes).

□ High—Flanges are extended 4 to 5 mm beyond the gingival margins, except where prevented by muscle attachments. Provides maximum gingival massage, and is indicated in posterior cross-bite cases.

THICKNESS

□ Normal—Thickness refers to the amount of material surrounding the labial and buccal surfaces of the teeth. Normally this is approximately 1 mm. (This is the thickness utilized in position-ettes)

□ Thick—Approximately 5 mm of material over the labial and buccal surfaces of the sockets.

□ Thin—Approximately 2 mm of material over the labial and buccal surfaces of the sockets.

MOLDED ANATOMICAL

□ No—Appliance will be made without air passages through the anterior freeway space. If box is not marked appliance will be made with three rectangular airways, each approximately 4.5 mm x 1.5 mm, placed through the anterior freeway space. Always allows breathing and aids psychological acceptance of the appliance.
Set-Up and PROsitioner® PRESCRIPTION SHEET

Doctor
Address
Telephone
Patient's Name
Original Malocclusion—Class Division
Date shipped by Doctor
PROsitioner Placement Date

(Please print or type above information)

SET-UP INSTRUCTIONS

SET-UP MODELS
☐ Construct the set-up on our enclosed models
☐ Duplicate our models for set-up—return both sets
☐ Other

☐ Do not reset teeth — fabricate PROsitioner as specified on reverse side.
☐ Construct standard set-up as prescribed below — fabricate PROsitioner as specified.
☐ Construct adjustable articulator set-up using my mounted models as prescribed below — fabricate PROsitioner as specified.
☐ Construct pre-treatment DIAGNOSTIC SET-UP only as prescribed below.

MODELS WITH BANDS FOR INSTANT PROSITIONER
☐ Carve off all brackets and bands
☐ Do not remove upper first molar bands
☐ Retain lower lingual 3-3 arch on set-up

☐ RESET ONLY TEETH MARKED

SPACE CLOSURE
☐ Close all spaces completely
☐ Close spaces as feasible
☐ Leave space between

ANTERIOR AXIAL INCLINATION
Upper
☐ Maintain
☐ Torque roots:
☐ Upper
☐ Lingual
☐ Labial

Lower
☐ Maintain
☐ Lateral
☐ Lingual
☐ Labial

VERTICAL OVERBITE
☐ No change
☐ Edge to edge
☐ Reduce to mm
☐ Increase to mm

ARCH WIDTH
Upper
☐ Maintain
☐ Constrict
☐ Widen

Lower
☐ Maintain
☐ Constrict
☐ Widen

LOWER OCCLUSAL PLANE
☐ Flat
☐ Flatter
☐ Curve of Spee
☐ Approx. as is

HORIZONTAL OVERJET
☐ No change
☐ Ideal
☐ Reduce
☐ Increase

SPECIAL INSTRUCTIONS

PLEASE MARK ABOVE DRAWINGS TO ILLUSTRATE ANY ADDITIONAL INFORMATION

Fig. 5: Professional Positioners prescription form for use when ordering tooth positioners.
PROSITIONER® INSTRUCTIONS

- STANDARD PROSITIONER
- SLIM-LINE PROSITIONER
- ATHLETIC PRO-GUARD
- PRO/BOW™

Our PROsitioners are routinely trimmed to the standard flange height and thickness as shown below, unless alternate specifications are checked.

Materials Available

- White Plain
- White Cinnamon
- Pink Plain
- Pink Mint
- Black Plain
- Black Licorice
- PRO-Vision® - Transparent Urethane Rubber
- PRO-Ducer™ - Transparent Urethane Rubber (posterior sections are flamed)
- Vanguard - Translucent Thermoplastic Vinyl (softens slightly in the mouth)
- Impak - Transparent Elastic Acrylic (must be heated in hot water to soften before placement)

Trimming Instructions

- Standard
- Short
- High
- Thin
- Thick

Options Available

- STRETCH GRIP SERRATIONS
- AIR HOLES

BITE OPENING
- Use average bite opening
- Hinge Axis Tracing is enclosed
- Sending Headplate for Tracing under separate cover
- Set-up to be made on Adjustable Articulator

ANTERIOR SOCKETTE® CLIPS

Fabricated from flat wire, Sockette clips deliver additional controlled force to assist in rotating, tipping or depressing anterior crowns.

- Upper arch
- Lower arch

LIMITED TO CENTRAIS AND LATERALS — place "X" above teeth where Sockette clips are desired.

TENSION STRIPS

- Internally molded into Urethane Pro-Visioners or PRO-Ducers only (not available in other materials). These 1mm x 4mm labial elastic strips provide additional pressure to close spaces and increase retention.

CLASPS

Two different types of clasps can be molded into PROsitioners. When ordering, please specify your choice and mark the location of the clasps.

- GRIP-CLIP® CLASPS
  Grip-Clips® are made from .025" stainless wire with continuous tight loops that engage in the interproximal areas.

- BALL CLASPS
  Ball Clasps are made from .035" stainless wire with .040" ball ends for clamping in the interproximal areas.

Shipping Information

PROsitioners and sets-ups are normally returned together, via United Parcel Service (which we recommend); however, we also utilize First Class and Parcel Post service. Please include special mailing requests below.

PROFESSIONAL POSITIONERS, INC.
Post Office Box 239, Racine, Wisconsin 53401 AC (414) 639-6517
Post Office Box 15725, Santa Ana, California 92725 AC (714) 751-4442
Post Office Box 1300, Enfield, Connecticut 06023 AC (203) 741-2513

PLEASE SEND ADDITIONAL

- Shipping Boxes
- Hinge Axis Sheets
- Shipping Bags
- Poly Bags
- Catalog
- Price List

RX Sheets for:
- PROsitioners
- Retainers
- Spring Retainers
- Metals
- Frameworks
- Functional
- Adaptors

Dr. ______________________

Copyright 1982 PROFESSIONAL POSITIONERS, Inc.
Please construct from enclosed well-extended models (cast in stone) for:

**Patient:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
</tr>
</thead>
</table>

**Prior to treatment case was:**

<table>
<thead>
<tr>
<th>Class</th>
<th>Div.</th>
<th>(Angle)</th>
</tr>
</thead>
</table>

**Colour:**

- [ ] White Rubber
- [ ] Pink Rubber

**Construct Set Up:**

- [ ] A Set Up and Tooth Positioner *
- [ ] A Positioner only (No tooth movement required)

**COLOUR:**

- [ ] White Rubber
- [ ] Pink Rubber

**Overmove teeth as original models indicate.**

**General occlusal plain is approx. [nnn] degrees above the horizontal.**

**SET UP:**

- [ ] To most practical and functional position
- [ ] Reposition only
- [ ] R—L as indicated
- [ ] R—L have been extracted
- [ ] To Present plane
- [ ] Flat plane
- [ ] Functional Curve of Spee
- [ ] Close all spaces
- [ ] Compromise space closure

**THE CORRECT OCCLUSION IS INDICATED BY:**

- [ ] Pencil marks
- [ ] Backs of models trimmed flat
- [ ] Wax bite
- [ ] Included also wax bite indicating open relaxed position

**OVERBITE:**

- [ ] Maintain
- [ ] Increase
- [ ] Decrease

**OVERJET:**

- [ ] Maintain
- [ ] Increase
- [ ] Decrease

**ARCHFORM:**

- [ ] Use present form to assimilate upper and lower
- [ ] Ideal

**IF NOT MARKED ON CHART, MOVE FURTHER TEETH AS PRACTICAL TO OBTAIN CORRECT ARCHFORM, SPACE CLOSURE AND MORE DESIRABLE ALIGNMENT OF TEETH.**

How long since bands were removed

<table>
<thead>
<tr>
<th>Date</th>
</tr>
</thead>
</table>

**SPECIAL INSTRUCTIONS:**

- [ ] Upper centre correct
- [ ] Lower centre correct

**FROM:**

<table>
<thead>
<tr>
<th>Name</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Address</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Signed</th>
<th>Date</th>
</tr>
</thead>
</table>

- [ ] Please send more forms

* Pat. Ref. No. 282285

---

**Fig. 6:** Frankham's Laboratory prescription form for use when ordering tooth positioners.
Please complete an appliance for:

Name

SPECIAL INSTRUCTIONS:

FROM: Name
Address
Signed Date

(cont)

Fig. 6 Frankham's Laboratory prescription form for use when ordering tooth positioners.
2. It is fitted over the incisors and pressed into place firmly. The distal segments are then pressed over the buccal teeth. If this method of insertion is difficult, it may be easier to fit the tooth positioner over one buccal segment first, followed by the incisors, then the other buccal segment.

3. The patient then slowly closes into the tooth positioner. If the patient closes correctly, the mandibular teeth should fit into their stalls in the appliance. The orthodontist must instruct the patient to bite into either centric relation or intercuspal position, depending on which relationship was used for the construction of the tooth positioner. It is important the jaw closing is first practised with a mirror as I have had a number of patients bite incorrectly until they are familiar with the positioner.

Once the patient has closed correctly, he or she is then instructed to clench into the tooth positioner. This must be a clenching action, with no lateral forces. If patients chew into the positioner it will rapidly develop splits and disintegrate.

The fit of the tooth positioner is now assessed. All teeth should be close to filling the stalls, in the tooth positioner. Any spacing must be on the side to which tooth movement is desired. The gingival tissues should not blanch when the jaws are clenched. If blanching occurs the tooth positioner should be relieved at that point.

The patient is then given written and verbal instructions on how to use the tooth positioner. The written instructions may be a booklet, such as that supplied by Professional Positioners (Appendix 4), or a single sheet as provided by T.P. Laboratories Inc. (fig. 7), Smart & Associates (fig. 8) or Frankham (fig. 9).

The verbal instructions must cover the points:

1. How to insert the tooth positioner.
2. How long it must be worn for.
3. How to clench into it and for how long.
4. How to clean the tooth positioner.
5. How to care for the positioner when it is not being worn.
6. What to do if the teeth or gums develop soreness.

I have already covered most of these points, I will complete them now.

Clenching should be done for about 30 seconds, followed by one or two minute rest. This cycle is repeated ten to fifteen times. The patient then rests for thirty to sixty minutes before repeating the procedure. Initially patients will tire very
COMING DOWN THE HOME STRETCH

CONGRATULATIONS on completing the active phase of treatment! The Positioner represents the final lap of an important achievement—the final straightening of your teeth. As in any race, you must finish strong to win. The individual runner either achieves the victory or suffers the loss. By the same token, only YOU can successfully wear your Positioner.

Think of how your Positioner was made—impressions of your teeth were taken, your plaster teeth were set-up in wax into perfect positions, and the Positioner was made over the perfectly positioned teeth. So the Positioner has the ability to finish your case beautifully, moving your teeth to detailed perfection and holding them there.

WEAR EXACTLY AS INSTRUCTED: 4 hours EXERCISING (clench, relax, etc.) each day, plus 8–9 hours while sleeping every night. If not in 12 hours per day this first month, call the office—you have a problem.

Clench  Relax
15–20 seconds then clench again
(Relax, but do not open—keep your teeth in the sockets)

This first month is the most important for positioning and settling teeth correctly! Teeth will settle right...or wrong, and we want them to settle correctly. If you don't take this first month seriously, it will be very hard to change tooth positions next month. TEETH ARE MOST RESPONSIVE THE FIRST MONTH.

If the Positioner ever falls out at night, the usual reason is you subconsciously removed it while sleeping. This is a rare problem because the Positioner is made to hold your jaws and teeth in "rest position." However, should this problem occur, you must:

1) Wear your Positioner extra to make-up time the following day.
2) Tell yourself over and over again as you go to sleep that you will keep it in all night. This will help avoid subconscious removal. Don't give up!

You will soon be able to keep the Positioner in all night, every night. If the problem continues, call the office. A Positioner's worst enemy is laziness and carelessness.

You can expect soreness the first few days as the teeth settle into their detailed positions. Take aspirin as needed and/or rinse your mouth with warm salt water.

Keep your Positioner CLEAN! Scrubbing with a stiff handbrush, soap and water restores the lustrous appearance of the Positioner and keeps it fresh and pleasing to the taste. A good scrubbing with baking soda and water should remove any calcium deposits.

Study the accompanying Positioner booklet several times. It contains important information.

Try very hard this first month! Your efforts will be rewarded with a beautiful result and your wearing time will be reduced. Your Positioner is the finest orthodontic appliance to finish and retain your case. It will become more comfortable as your teeth move into their final positions. It also can serve as a retainer for years to come to KEEP your teeth perfect.

Fig. 7: T.P. Laboratories Inc. leaflet given to patients with the tooth positioner.
POSITIONER SHEET

The Positioner is to finish off your orthodontic treatment. It is a very important appliance as it will move your teeth into their final position and hold them until the surrounding bone becomes calcified.

HOW TO POSITION THE APPLIANCE:
The top of the positioner has a 'V-shape' cut out in the centre. This section should be lined up with the centre of your mouth. Gently push it completely over the upper teeth and bite into it with the lower teeth.

EXERCISING:
This refers to the action of alternately biting and relaxing with your positioner in place. Make sure your lower teeth are firmly in position at all times. It is easier to make your positioner fit well when you first have your bands off as your teeth are more mobile, so try to wear it as many hours in the early days as possible. The positioner should be worn for at least 4 hours when you are awake plus through the night. There isn't a chart for you to keep your record so you have to make your own timetable if you feel you need one.

EARLY DIFFICULTIES:
Don't be too concerned if your positioner falls out a lot. When it is first placed the fit is poor; however, by the end of the first week it becomes snug as the teeth begin to move towards their final position. Also there will be some difficulty with breathing, increased flow of saliva and sore teeth. These difficulties are all normal and will soon disappear — so persevere.

CARE:
Good care of the appliance is needed by you. It should be cleaned carefully each time you take it out of your mouth. Use only cold water when cleaning as any contact with heat will cause it to warp. During the time when you are not wearing the positioner it should be stored in a jar of cold water (changed daily). Bring your positioner each time you come — that way we can check your progress.

MODELS:
Great care is also needed with your models. They are given to you to look after and brought in only when your positioner needs replacing (lost or damaged). They are particularly fragile and should be kept in a safe place away from younger brothers and sisters.

PLEASE REPORT ANY DIFFICULTIES YOU HAVE AS IT IS MOST IMPORTANT THAT NOTHING HINDERS THE WEARING OF THIS APPLIANCE.

Fig. 8: Instruction sheet for tooth positioner wear issued by Smart, McKinnon & Grave.
CARE AND USE OF TOOTH POSITIONERS

1. Before inserting the Positioner, ensure that it is wet with water.

2. Place the positioner on the upper teeth first, then close into the lower section. (The area with the "y" is the front upper section.)

3. The Positioner is to be worn all night, and as many hours during the day as practical. The more it is worn, the quicker the repositioning of your teeth will be accomplished.

4. To further aid the repositioning, the patient should exercise gently into the Positioner from time to time. There may possibly be soreness for a day or two, but on no account should the Positioner be left out during this period.

5. Oral hygiene and gum massage are to be maintained at all times.

Your positioner is a highly refined appliance, made especially for you, of the best materials available. To obtain the maximum results and life from your positioner, store in water when not in use. Clean regularly with warm soapy water, mild detergent or tooth paste. DO NOT use denture cleaners or antiseptic such as Jasol, Solyptol etc.

R. FRANKHAM,
ADELAIDE.

Fig. 9: Instruction Sheet for tooth positioner wear issued by Frankham’s Laboratory.
quickly and are not expected to push themselves too far. However, within three or four weeks the patients should be able to keep the teeth clenched for much longer periods.

The tooth positioner must be cleaned when the teeth are cleaned. Cold water with a mild detergent, toothpaste or soap is suitable. Rubber tooth positioners may be washed in warm water but thermoplastic tooth positioners must not. Other cleaning agents must not be used.

When not being worn, the tooth positioner must be stored in a safe place. A sealed container is preferable, and the positioner must be protected from dogs, who have shown their fondness of tooth positioners all too frequently. The positioner must not be left where it can become warm as it may distort.

If the teeth become sore, it is generally a normal response. However, if the pain becomes acute or interferes with the wearing of the appliance, then the wearing should be stopped temporarily, or better still, the socket for the tooth adjusted so less pressure is exerted on the tooth. This sensitivity may be due to too much tooth movement being attempted with the tooth positioner. If it is, a remake of the positioner may be indicated. If it is the gingiva that has developed soreness, the tooth positioner should be relieved at the site.

Once verbal instructions are complete, the patient is left by his or herself. They should have the tooth positioner in place. They are given time to read and understand the instructions, as well as becoming accustomed to the use and feel of the tooth positioner, and to allow any questions a chance to be formulated. Figs. 4 and 5 are the instructions for the patient produced by Professional Positioners and T.P. Laboratories Inc., both are simple, clear and appear easy to understand.

Once the patient is familiar with the tooth positioner and its use, the accompanying parent(s) should be brought in and the explanations repeated to them. When the patient and parent are discharged there should be no unanswered questions.

Recall Visits

At recall visits a routine should be followed, otherwise something may be overlooked. The routine I follow has proved suitable. It consists of the following questions asked to either the patient or myself:

1. Has the patient experienced any problems or discomfort. At the first recall some discomfort should be reported. It is also common for the tooth positioner
to have fallen out during the first few nights. If the patient does not report these problems, co-operation is probably lacking. If these problems exist for more than one or two weeks, the patient is wearing the tooth positioner, but not for long enough. It must be stressed to the patient to wear the tooth positioner at least four hours during the day and even more for a week to overcome the initial problems. Once the initial problems are overcome, and this normally takes four to seven days, then the tooth positioner is quite comfortable.

If the patient has experienced any gingival trauma, the tooth positioner should be adjusted.

2. The orthodontist should ask him or herself what dental changes are occurring. Are the desired changes occurring? Are any undesirable changes occurring? I have had one case where a maxillary midline diastema regularly developed overnight, whilst the tooth positioner was worn, but would disappear during the day. Adjustment of the tooth positioner to remove the material near this interproximal contact was all that was required to stop the nightly opening of the diastema. Examination of the setup models showed firm contact of the central incisors. This is the only adjustment affecting tooth position that I have had to make to tooth positioners.

3. The patient should be asked if any changes have occurred. Within a few weeks the tooth positioner should become a looser fit as the teeth move into the desired positions (McBride & Mellor, 1971). If the tooth positioner is still a tight fit over the teeth, co-operation should be assessed.

After a month or two, the patient should have settled into a routine so the wearing of the tooth positioner is no longer a task. For the patient to arrive at this stage, he or she must have co-operated well. The tooth positioner will not be a tight fit and the desired tooth movements should have occurred. The wearing of the tooth positioner can now be reduced.

To reduce the wearing of the tooth positioner, the first option is to reduce the clenching activities, or to reduce the total time. The purpose of the clenching is to supply the force for tooth movement. As tooth movements have been achieved, we may reduce the clenching considerably.

Our next step is to reduce the total wearing time. After six to eight weeks I generally tell patients that two hours evening wear, plus all night, is adequate. After 12 weeks I reduce it to “in bed only”. These reductions in time are faster than recommended by T.P. Laboratories and Professional Positioners.
However, they are more likely to be cautious, being uncertain of the level of patient monitoring. It is important that the patients are recalled regularly and if favourable change does not occur, the tooth positioner wear should be increased. The first recall visit should be after a fortnight, to ensure no patient problems, then monthly for a few months, then bi-monthly. However, this is open to operator change depending on the individual circumstances.

I have often made my tooth positioners with liberal gingival flanges. I feel these may assist initial retention at night. At the recall visits I reduce the gingival flange a few millimetres. I consider this helps as:

1. The patient feels that favourable change is occurring, thus allowing for the reduction.
2. The patients feel the need to attend appointments, as “something” is required to be done.
3. The tooth positioner is a bit more comfortable after each appointment.

By using this approach I have found patient attendance to be pleasing in its regularity. There is no need to be concerned about too much trimming, as after 12 months or so the mandibular fitting surface can be reduced to indentations only and the tooth positioner may be used as a sporting mouthguard.

In cases where semi-permanent use of the tooth positioner is desired, for example, with corrected Class III or open bite malocclusions, it would be better to keep adjustments to an absolute minimum.

**How to Adjust Tooth Positioners**

A disadvantage of tooth positioners is the difficulty in achieving specific adjustments. Reduction of the peripheries is relatively simple with some materials, but cannot be satisfactorily achieved with others.

Theremoplastic PVC materials, similar to mouthguard material, is easily adjusted. I have found a large acrylic bur most suitable. The bur should have coarse teeth. When rotating at medium speed, these burs cut clean. If rotated too slow it will not cut as clean, if rotated too fast the material tends to melt, however a smooth finish is still produced. The bur must be sharp to enable a smooth surface to be left. If used correctly, no further surface finishing is required.

To adjust the tooth sockets is more difficult. A round bur, of the largest size that will fit into the space, is the instrument of choice. It is difficult to obtain a
smooth finish, even with PVC materials. Fortunately it is not important for these surfaces to be finely finished.

Tooth positioners cannot be added to if they are deficient, have cracked, or need extensive alteration. They should be remade.

Problems and Failures with Tooth Positioners

Tooth positioners should not be prone to many problems and failures. Gottlieb (1968) reported on the reasons for failure in 100 consecutive cases he actively retained with tooth positioners. He listed the following reasons for failure:

1. **Co-operation:** To an inexperienced clinician, lack of co-operation may be a serious problem. However with time, he learns which patients to reject prior to tooth positioner therapy. A poor co-operator should not be expected to suddenly reform just because the treatment has changed. Lack of co-operation was the only cause of complete failure of tooth positioner therapy for Gottlieb. I have found that lack of co-operation can often be detected by patients' remarks. If the patient still salivates excessively, or if the positioner falls out at night, they are not wearing it enough. These problems will be overcome if the patient wears the tooth positioner for longer periods during the day. Patients will also comment that they only wear the positioner "some nights". I have yet to find a patient who can wear the positioner alternate nights. I believe it is too uncomfortable to do so. Every patient who has told me that they wore the tooth positioner "some nights" had later admitted those nights are a long way apart!

2. **Inadequate fixed appliance therapy:** Gottlieb found that the basic fixed appliance therapy must be completed as there is a limit as to what may be achieved with a tooth positioner. Schrems and Schrems-Adam (1982) take this point further and state that if a properly made positioner, with good patient co-operation, cannot achieve a good and stable result then there must be an error in either the treatment planning or insufficient fixed appliance therapy. The only way to correct the situation is to use a "cool head" and recommence from the point where the error occurred. Gottlieb lists antero-posterior discrepancies, excess spacing and deep bites as examples of procedures that cannot be corrected with tooth positioners. These should be corrected during the fixed appliance therapy.
3. **Tooth sizes:** Gottlieb found that tooth positioners are not very successful with unusually small teeth. I am surprised by this as I have found tooth positioners to be very good for maintaining lower anterior incisor alignment. Gottlieb also found the tooth positioner was unable to achieve an ideal result where inter-arch tooth size discrepancies existed. This statement is clear cut. Gottlieb suggests overcoming the discrepancy with the careful positioning of spacing at the end of treatment. He considers this to be achieving a compromise result.

4. **Rotations:** Gottlieb found tooth positioners could only correct some rotations. He does not mention if any rotational relapse occurred from which I assume it was minimal.

Gottlieb does not mention any other factors, but Schrems and Schrems-Adam (1982) and myself have another, i.e.:

5. **Error in tooth positioner manufacture:** Schrems and Schrems-Adams state that the positioner must be properly made if it is to succeed. I can foresee error being in a number of forms. Firstly, there is technician error. This is a fairly obvious form of error that is virtually always kept within acceptable limits. With experience this form of error reduces. Another form of error is in the record taking. If a facebow record is not obtained, and even if it is, if an arbitrary condyle position is used; then a small but important error is introduced. For many patients, the error will be within acceptable limits. However there will be some patients where the error leads to failure, complete or partial, of the treatment. This is an insidious form of failure and it's reason would not be realised normally.

Allied to operator error I would like to add more reasons for failure. A patient may have the best intentions of being co-operative, but if the tooth movements attempted with the positioner are too great then the discomfort will not allow the patient to wear the appliance.

Similarly, if the tooth positioner is not given to the patient at debanding, but is issued seven to ten days later, then there will be much greater initial discomfort. Failure in both of these cases may be attributed to lack of co-operation. However, an equally good case could be made for operator error. It is up to the operator to ensure that this does not occur.
Dogs

Dogs and tooth positioners do not go together (Smart, McKinnon and Grave, 1975; Mackie, 1985; Kesling, 1985). Dogs have a fascination for these objects that is well known to all clinicians who issue them. As Kesling (1985) expresses it “Once a dog gets a hold of one (a tooth positioner), it’s life is just a matter of minutes”. Kesling then qualifies this statement to say it is the life of the tooth positioner he is discussing!

Length of Retention

How long should a tooth positioner be used for retention? Elsasser (1950) recommends six to eight weeks and then followed by a conventional retainer. This is followed by Tuverson (1980) and McNamara and Associates (1985).

I am concerned with tooth positioners as the only form of retention. Therefore it is basically a question of how long should any retention be maintained. The answer depends on patient expectations and willingness to co-operate. Ricketts (1979) believes complete retention with tooth positioners, to be very beneficial, but he does not give a time limit.

Kesling (1969) suggests that the positioner should be worn for as long as possible and that even six years is not unreasonable. Whilst the tooth positioner is worn at night, their teeth should remain exactly as they are on the set-up models. An unidentified source in the Begg Newsletter (1983) quotes an American practice as “not exactly telling the patients when to stop wearing the positioners”.

Alternative Uses for Tooth Positioners

Although primarily a retainer, the tooth positioner has been tested in other roles. Their use is not presently established for other functions. However, this may not be so in the future. Other uses of tooth positioners are:

1. For stabilisation during orthopaedic treatment of Scoliosis: The use of tooth positioners for stabilisation and correction of the dentition during the orthopaedic treatment of scoliotics was developed by Bunch (1961). These were then followed by other workers. This is discussed in detail in Chapter 8.

2. As the sole treatment appliance: The use of tooth positioners, as the sole appliance for treatment was developed largely by Schuchard (Lorentz, 1973).
He treated many cases with quite satisfactory results. Today some patients are still treated solely with tooth positioners. This is discussed in more detail in Chapters 7 and 9.

3. **For treatment of the gingival tissues:** Remensnyder (1926) developed the forerunner of the tooth positioner as a gum massaging appliance for the treatment of pyorrhea. Although this use would not be sanctioned today, tooth positioners are used by periodontists. Baer and Associates (1961) advocated the use of “Positive Pressure Appliances” to treat hypertrophic conditions of the gingiva. The positive pressure appliances are the same as tooth positioners. This use of tooth positioners is discussed in Chapter 6.

4. **For home fluoride treatments:** Trask (1975) advocates the use of tooth positioners for home fluoride treatments. Trask suggests the use of 1.25% acidulated phosphate fluoride gel. A small amount is placed in the tooth positioner nightly or weekly.

   The tooth positioner is then seated over the tooth for 5 minutes or longer. The patient then expectorates the material and saliva. The patient should neither swallow nor rinse the mouth after treatment.

   Trask believes this treatment could become routine for all patients. Immediately following orthodontic treatment it is especially valuable as some demineralisation may have occurred. Also many of the proximal contacts will be open in the “band space”. This slight spacing will allow better infiltration of the fluoride. Cooke and Wreakes (1978) use preformed positioners as retainers and fluoride applicators following fixed appliance therapy. Any white spot lesions present after debanding were clamped with a cavitron scaler. This possibly also removed any unsupported enamel. The patient was then given acidulated phosphate fluoride gel which was placed in the tooth positioner which was then worn for as long as possible. This was repeated a number of times a day. There is usually a considerable improvement within five weeks, after which period I presume, the treatment is usually stopped.

5. **As a sporting mouthguard:** A tooth positioner may be adjusted to eventually become a sporting mouthguard (Smart, McKinnon and Grave, 1975). It should be a quality mouthguard due to its close fit. However tooth positioners may vary from mouthguards in two respects:

   (a) Mouthguards often have extensive buccal gingival coverage. This is to aid retention whilst the patient is breathing heavily through the mouth. If a tooth positioner is to be used for this role it must not dislodge accidentally.
(b) Mouthguards do not have sockets or stalls for the lower teeth. This allows the mandible greater freedom during sport, and more importantly, the patient may mouth breathe. For a tooth positioner to be used as a mouthguard, I feel that no more than 50% of the height of the lower teeth should be covered. There is no reason why a tooth positioner could not be reduced so that only one-third of the lower teeth are held. The anatomy of the lower teeth suggests that the canines are the only teeth that are more easily controlled by grasping the gingival two-thirds compared to the occlusal one-third.

An important question concerning the use of a tooth positioner as a mouthguard is "what is the effect of gripping the teeth?" Taking the example of a blow to the jaw such as in boxing. Will the posterior teeth disclude from the positioner rapidly leaving the lower incisors to take a much greater force? This may occur and for this reason I would not like to see mouth-guards with more than slight indentations for the lower teeth.

If we remove the bulk of the mandibular fitting surface, how valuable is the tooth positioner as a retainer? This depends on which teeth we wish to retain. The maxillary teeth will be retained as good as ever. Unfortunately, the lower teeth, and in particular, the lower incisors are not retained. Therefore, our retention requirements would decide if we can alter the tooth positioner to become a mouthguard.

**Material**

The material also affects the possibility of converting a tooth positioner to a mouthguard. The thermoplastic materials, silicones and rubber, are all used for mouthguards (Godwin and Craig, 1968; American Dental Association, 1972). However, rubber is not easily altered (Sandlards and Edwards, 1985). It would be difficult to alter a rubber tooth positioner into a mouthguard.

Godwin and Craig (1968) also found rubber mouthguards to be only just suitable as the rubber tended to be too soft. Therefore the property of rubber that makes it best for tooth positioners, limits its use as a mouthguard material.
Other Uses of Tooth Positioners.

It is difficult to foresee other uses for tooth positioners. Kesling (1945) found tooth positioners suitable for immobilising fractured jaws whilst they repaired. However there are better ways to do this and so the practice has not continued. I expect that tooth positioners have been tried in other roles, but have been unable to replace the specialised appliances otherwise being used. In the future, further testing and experimenting will go on. In spite of this, I cannot see tooth positioners being used for anything other than active or passive retainers, a role in which they are extremely well suited.
Chapter 4 —
THE MANUFACTURE OF TOOTH POSITIONERS

INTRODUCTION

It is important that the manufacture of tooth positioners is understood by orthodontists who use them. Poor manufacture has been attributed as being a major cause of failure of tooth positioners (Elsasser, 1950). Anyone who prescribes positioners for patients must be confident they can request, and receive, a tooth positioner that is best suited to the patient.

The manufacture of a tooth positioner involves three stages. Each is prone to errors that may jeopardise the success of the positioner treatment. The three stages are:

1. Clinical records,
2. Model preparation, and
3. Construction of the tooth positioner.

CLINICAL RECORDS

The clinical records taken for the manufacture of a tooth positioner vary. These are taken in addition to normal end of treatment records. They should consist of:

(i) Upper and lower impressions.
(ii) A facebow record to allow the mounting of the maxillary cast accurately onto an articulator.
(iii) An interocclusal record. This may be of wax and may be with the jaws in either centric relation or intercuspial position. The choice of the interocclusal relation registered is discussed in more detail later.

Additional records may be taken to assist tooth positioning. These could include a lateral cephalometric radiograph to assist incisor positioning, or further interocclusal records to allow reproduction of the lateral movements of the mandible by the articulator. Photographs or other radiographs may also be desired.
(i) Impressions

Impressions of the maxillary and mandibular teeth are required. These should extend beyond the most distal teeth in the arch, as well as into the gingival sulcus. McBride & Mellor, (1971) attributed the failure of a patients' treatment to be due to the positioner not being extended onto the second molars.

The second molars are very important teeth. They may be involved in occlusal interferences (Brabant, 1982; Klineberg, 1985) and consequently should be controlled. As second molars are often not banded during Begg treatment, these teeth should be incorporated into the tooth positioner.

The impression must extend into the labial, buccal and lingual tissue folds, so that:

(a) the basal bone can be visualized to assist the repositioning of teeth.
(b) the gingival contour can be restored with wax so the positioner will not impinge onto the gingiva and perhaps it may even have a beneficial massaging effect (Kesling, 1945).

(ii) Articulator mounting record

The maxillary model can be mounted on the articulator by three methods, i.e:

(a) Using a facebow record.
(b) Using a recent lateral cephalometric radiograph of the patient.
(c) Using average mounting settings.

The method and advantages of each of these are:

Facebow record: The accuracy of the facebow record is potentially very variable, depending on the facebow used (Klineberg, 1985). Denar produce a facebow which is very popular due to its convenience of use, compact nature for transporting the record and its accuracy.

The Denar facebow was used during the experimental part of this thesis. All of the laboratories I contacted will use Denars if requested. The Denar equipment has a considerable advantage in that the whole facebow does not have to be sent to the laboratory, just a small mounting jig.

The use of a Denar facebow and articulator does not guarantee accuracy, however. The only Denar facebows I have seen in use are the ones that use ear-rods as an approximation of condylar position. This is always about five
millimetres too far distal. Therefore the path of opening is slightly incorrect. Klineberg (1985) does not consider this to be an accurate method of mounting the maxillary cast, but to be an approximate positioning only.

**Lateral cephalometric radiographs**: A recent lateral cephalometric radiograph may be used to position the casts on the articulator. For this, a recent lateral cephalometric radiograph may be sent to the laboratory, or instead, a tracing sheet (fig. 13) may be sent.

Lateral cephalometric radiographs have the advantage that the condyle can be accurately positioned providing it is visible on the radiograph. The condyle is often not visible and this is a problem.

There is potentially less antero-posterior discrepancy with the use of radiographs, than with a facebow that uses ear-rods. However, a lateral cephalometric radiograph cannot give transverse positioning of the maxillary cast.

Whether a facebow utilising ear-rods is more accurate overall, than a lateral cephalometric radiograph, is questionable. Due to the softness of the ears, the ear-rods are not always placed as accurately as desired.

Another disadvantage of the use of a lateral cephalometric radiograph is that it requires irradiation of the patient. Many orthodontic practices do not routinely use cephalometric radiographs for all patients. The procedure of obtaining a radiograph for the manufacture of the tooth positioner only may also be considered unnecessary and average facebow or mounting settings are often used.

**Average mounting settings**: Average mounting settings are used by most orthodontists who use tooth positioners (Kesling, 1985). Two studies have been carried out to determine the accuracy of average mounting settings (Williamson & Associates, 1984; Grosse & Hofmann, 1985). Unfortunately I do not consider the study by Williamson & Associates to be accurate. I present my reason in Appendix 3. The latter study also lacks important details.

It would appear that using average mounting settings is not as accurate as the use of a lateral cephalometric radiograph, or a facebow. However, the difference in accuracy should be assessed to see how often it is significant. This has not been done to date.

**(iii) The interocclusal record**

The interocclusal record may be taken in centric relation (CR) or intercuspal position (IP). To date there has been an emphasis on using centric relation (Cottingham, 1969; Barnett, 1978; Chiappone, 1975; Roth & Gordon, 1981; Williamson & Associates, 1984). However, I consider intercuspal position to be as
TRACING SHEET FOR HINGE AXIS PROSITIONER

Place this sheet over headplate or tracing so that the printed line at the right corresponds to the Frankfort horizontal plane and the circle matches the ear hole plug. Then trace on this sheet:

1. Condyle outline
2. Lower central crown
3. Lower first molar crown

EXAMPLE

We will transfer this data to articulate your set-up and thus produce the proper PROsitioner bite relationship.

DOCTOR ____________________________

PATIENT __________________________

DATE ____________________________
suitable. The argument for this is long and complex, so I will present the basics of it here. For this, I assume that centric relation and intercuspal position do not coincide.

**Centric Relation:** The argument for setting the teeth up in centric relation is that we do not want occlusal interferences in this position. Therefore, if the models are mounted on the articulator in centric relation we may ensure occlusal interferences are not present. But we must remember that occlusal interferences also occur during function. For our articulator to accurately duplicate function we must also set the condylar guidance plane, the intercondylar distance, the Bennett shift and the incisal guide plane. All these should be set for every patient. This is a slow and laborious task and I cannot imagine that many orthodontists would do it. The reason for not following these steps would include lack of skill on the operator’s behalf, lack of equipment to obtain the recordings, and unwillingness to spend the time taking these records and checking them. It must also be kept in mind that for these records to be effective, the technician positioning the teeth must also be trained to transfer the records to his articulator and then be able to position the teeth to the best functional occlusal relationships.

It is apparent then, that to set the teeth into positions where occlusal interferences are absent, the procedure is complex.

Therefore, if our models are mounted in centric relation, we can ensure there are no occlusal interferences if our patient is as average as the settings on the articulator.

It should also be kept in mind that the teeth are not being set into intercuspating positions, and under these circumstances it may be difficult to ensure optimal intercuspation during function.

**Intercuspal Position:** Intercuspal position, that is, where the teeth are in their position of best intercuspation and maximum contact, is used widely for the manufacture of tooth positioners (Kesling, 1985).

When setting the teeth up in this position it is much easier to produce tidy and efficient tooth positioning. Specific philosophies, such as Andrew’s six keys to good occlusion (Andrews, 1972), are more readily followed.

It has been said to me, and I interpret some of the literature as also stating it, that a centric relation maxillo-mandibular record can be taken, and the teeth can then be set in maximum intercuspation. This cannot be done unless centric relation and maximum intercuspation coincide. It must be remembered that
once the mandibular cast is mounted, the antero-posterior positioning of the teeth, especially the molars, cannot be changed, except to close spaces. If the mandibular molars are moved forward, it is the equivalent to moving the mandible forward and therefore the maxillo-mandibular record obtained is altered.

Therefore, a good policy when positioning the teeth on the models is to reset the molars first, ensuring their antero-posterior relationship is maintained.

If all the teeth are cut off the models, as is done in many cases, there is little point in taking a maxillo-mandibular bite record at all. Therefore, only the minimum number of teeth should be reset.

My preferred procedure is to use an intercuspal position bite recording. The models are mounted on an articulator and they are then examined to see what teeth require resetting. In most cases only some of the teeth are involved.

For the tooth positioners used in conjunction with this thesis, the teeth were set up in positions of maximum intercuspation.

This completes the clinical records obtained.

MODEL PREPARATION

Model preparation includes all stages up to where the tooth positioner can be manufactured. Model preparation has a number of stages and these would vary according to the material from which the positioner is manufactured. The stages used for the tooth positioners in this thesis were:

(a) Mounting of the models onto an anatomical articulator.
(b) Resetting the required teeth.
(c) Duplication of the reset models.
(d) Mounting of the duplicate models on a plane line articulator with a transfer bite from the articulator wax set-up.

If the material to be used for the tooth positioner does not require, or produce, heat in its forming (e.g. silicone rubbers), the latter two stages are not necessary. The purpose of these two steps is to produce models with no wax involved so the models can be subjected to considerable heat. Alternatively, cold cure acrylic may be used in place of wax (Schinhammer, 1983).

The stages involved in model preparation must be carried through correctly. The finer points will be discussed in detail.

(a) **Mounting the models onto an anatomical articulator.** The mounting of the models is a straightforward procedure providing it is carefully executed. Errors should not occur during this stage.
(b) **Resetting the required teeth.** The positioning of the teeth on the models is the most critical phase in tooth positioner construction. If the teeth are not positioned correctly the treatment cannot be a success.

The repositioning is also one of the most difficult phases. Kesling (1944, p104) noted there were problems. He said:

"Invariably an operator first attempting to make a setup finds it very difficult to finish it to his satisfaction . . . . It is only with experience that an operator develops ease in positioning the plaster teeth to his satisfaction in a reasonable length of time."

My own experience is also sufficient to prove to myself that the repositioning is slow and requires much care. Each step must be rechecked many times and it is not infrequent that one has to restart from the beginning.

Kesling (1946) states that the teeth should be placed in the desired arch form, axial positioning and interdigitation. The teeth should be placed over basal bone and intended movements should be in accordance with anchorage available, the biological limits of tooth movements and the possibilities and limitations of the material used.

Later, Kesling (1956) describes his diagnostic setup. Kesling was resetting the teeth on the models after treatment to make the positioners. In about 1943 he started doing the setups before treatment. These then became a diagnostic aid. At the end of treatment he would use the same diagnostic setup as the models for the tooth positioner. The diagnostic setup is now often termed the Kesling setup.

Kesling advocated starting the setups at the incisors, utilising the Tweed triangle. This is not necessarily the best technique. As the molars and canines are important for the occlusion, it is advantageous to position them at the start.

A concept of tooth positioning must be formulated to produce optimal setups consistently. The concept followed may be based on various static guides, such as Andrew’s six keys to good occlusion (Andrews, 1972), or Ricketts’ guide (Ricketts, 1985). Alternatively, it may be based on functional occlusal patterns. These are discussed by Brabant (1982) in detail. These generally include rules such as:

(i) No balancing side interferences.
(ii) Canine disclusion in lateral movements.
(iii) Bilaterally balanced contacts in centric relation.
(iv) No interferences in the centric relation to intercuspal position slide.
When positioning the teeth in harmonious functional positions, it must be kept in mind that the articulator settings are mostly averages. Chiappone (1980) is the only person who recommends full facebow records to measure exact hinge axis, immediate side shift and the paths of the protrusive and orbiting condyles. For workers who do not record these measurements, there are limitations to the effectiveness of the teeth repositioning.

As well as occlusal considerations for the setup of the teeth, there are also orthodontic considerations. These are mainly concerned with stability of teeth moved, or to allow specific teeth to be moved.

The stability of the teeth is especially pertinent with the mandibular canines. The pretreatment and end of treatment canine widths must be assessed and the setup intercanine width decided upon. Once established, this intercanine width must be maintained.

If teeth are to be moved, they should be setup in positions of overmovement (or overcorrection) as the tooth positioner is not totally effective in tooth movement (Vorhies, 1960). If relapse is considered a problem, small overcorrections should be maintained in the setup models.

Once the appropriate teeth have been reset, wax is used to restore the gingival contour. If the gingiva is undercontoured, the tooth positioner may impinge on it resulting in discomfort and poor patient co-operation. Therefore, it is better to slightly overcontour the gingival margins and surface.

(c) **Duplication of the reset models.** The duplication of the models is a basic procedure using either alginate or hydrocolloid material. It is important that this is done accurately and full extensions are obtained.

(d) **Mounting of the duplicate models.** The duplicate models are now mounted on an articulator. This may be a plane line articulator as no movements of the articulator are required. It is important that the wax bite record for this mounting is taken accurately. The procedure is:

(i) **Determine the amount of jaw opening to be used for the tooth positioner.** This is generally about three millimetres. The anatomical articulator is adjusted so the reset models will be held at this predetermined separation. A wax bite record is then taken.

When the duplicate models are mounted on the second articulator, the jaw opening must be set at the distance determined on the anatomical articulator. It is at this opening that the tooth positioner must be manufactured.

The remainder of the mounting procedure is basic and will not be covered.
3. CONSTRUCTION OF THE TOOTH POSITIONER

The construction technique described here is that used for the tooth positioners for this thesis. Different materials require different techniques. I will not try to cover the range of techniques used for the different materials. If more information is required in this respect, the manufacturer of the material should be consulted for the optimal working technique. Some information may be gathered from published papers. Prescott & Fertman (1968) and McBride & Mellor (1974) describe how to manufacture tooth positioners from heat vulcanising silastic. Nishiyama, Kamada & Horiuchi (1977) describe how to use room temperature vulcanising rubber for tooth positioners. Roth & Gordon (1981) use a new material, developed by Gordon. They term this material “Orolastic II”. This is a heat curing material that is quite different to the others. Roth & Gordon have patented the material and tooth positioner manufacturing process.

Thermoplastic materials seem to have been the most popular. One reason would be their convenience. They can be purchased as flat pieces and once heated may be shaped, worked and joined. PVC and EVA are two thermoplastics widely used. Techniques using thermoplastics have been described by McBride & Mellor (1971); Smart, McKinnon & Grave (1975); Andersen & Schramm (1976); and Rakosi, Jonas & Burgert, (1981). All of these workers had techniques similar to the technique described here.

Construction Method Using PVC

Mouthguard blanks are heated and adapted over each duplicated model. If these were adapted over the setup models the heat and force would ruin the tooth positioning. Therefore, the duplicate models must be used.

Adaptation may be by utilising a真空 frame, or can be by hand (an expression only, due to the heat a glove would be more effective). Hand finishing is required to ensure an accurate fit against the teeth and into the interproximal areas.

Once a “mouthguard” is made to accurately fit each arch they can be joined. The parts are tried on the models on the articulator and the amount of filling required between the “mouthguards” is assessed. The articulator is then opened, the “mouthguards” heated on their occlusal surfaces, any necessary fill is placed and softened, then the articulator is closed to the predetermined position. Heat is
still applied to keep the material soft so it may be smoothed over. A smooth finish should be obtained.

When cooled, the tooth positioner is removed from the models. The buccal, lingual and distal extensions may be trimmed with scissors or a large burr.

The positioner is then replaced on the models and its accuracy of fit is checked. The best surface finish for PVC materials is achieved with gentle brushing strokes from a small flame. If the material is overheated it will discolour to a brownish tone. However, this is basically a surface change and can largely be removed with a burr.

The most suitable degree of gingival coverage is about three millimetres. A greater coverage may produce patient discomfort, whilst less coverage reduces retention of the positioner in the mouth. The amount of gingival coverage may be varied according to patient needs or preferences.

If airholes are desired, coarse round wire, or dental burrs, may be placed between the two “mouthguards” prior to joining. Once joined and cooled, the wire can be removed leaving clear airways.

**Conclusion**

Tooth positioners are not difficult to manufacture. They require some skill, but more importantly, care and attention to detail. There appears to be an equal division of orthodontists using tooth positioners, where the tooth positioner is manufactured in a specialist tooth positioner laboratory, or a small general orthodontic laboratory.
Chapter 5 —

MATERIALS

INTRODUCTION

Over time, the tooth positioner has been constructed from a range of materials. Unfortunately the components used have been poorly documented and even today some supply companies will not disclose the types of materials they use.

The original gum massaging and tooth moving appliance of Remensnyder (Remensnyder, 1926) was made with black rubber, as was the first tooth positioner of Kesling (1944). Today, black rubber is still considered the best material, but its poor acceptance due to taste, smell and aesthetic considerations, has allowed the extensive use of other materials.

White rubber is utilised to gain patient acceptance, with the advantages of rubber. However a wide range of synthetic materials such as elastomers, thermoplastic polymers and synthetic rubbers are widely used. Their use is mainly due to ease of handling and even greater patient acceptance.

Rubber

Natural rubber is the material of choice for tooth positioners (Kesling, 1944; Vorhies, 1960; Bunch, 1961; Davies & Associates, 1963; Babcock, 1965; Gottlieb, 1968; Wells, 1970; Bekeny and De Marco, 1971; Kiser, 1974; Kesling (1969).

Rubber has one great advantage. This is the property we call “rubbery”. It will undergo large deformation under light forces and still have almost complete elastic recovery. This true rubbery behaviour is very difficult to reproduce with synthetic compounds, silicone rubbers being the synthetic material most similar in properties.

Production

The precursor of rubber is collected by tapping the flow of sap of the rubber tree (Hevea brasiliensis). The sap is collected, dried and sent in thin white sheets to the processing plant.
Compounding

Rubber is then compounded. This is the mixing in of all the additives for later processing. The additives used vary greatly, as these vary the properties of the end product. The range of additives that are compounded into the rubber includes carbon black, oil, sulphur, fatty acids, wax, zinc compounds, vulcanisation accelerators, pigments and fillers.

The compounding process involves the feeding of raw rubber and additives into a mill which mixes them with compressive and shearing forces. This action bring about a change to the structure of the macromolecules of rubber. Their molecular weight is reduced by direct breaking of bonds. This increases the plasticity of the compounded rubber. This process is termed “mastication”.

The compounded rubber is produced in sheets which may be baled and are then sent to factories or dental laboratories for final processing.

Vulcanisation

The most important treatment of rubber is vulcanisation. This procedure was discovered by Charles Goodyear in 1839. Vulcanisation is a chemical reaction which induces extensive changes in the physical properties of a rubber or elastomer. It is brought about by reacting the material with the vulcanising agent. For rubber, sulphur is a suitable agent. The changes produced are decreased plastic flow, reduced surface tackiness, increased elasticity, much greater tensile strength and considerably less solubility. The important chemical change of vulcanisation is the cross-linking of polymer chains. Raw rubber has frequent double bonds along the polymer chains and reduction of these produces extensive cross-linking.

Four types of vulcanising agents may be used, namely:

1. Peroxide and other oxidizing agents.
2. Unaccelerated sulphur (the classical method).
3. Accelerated sulphur.
4. Accelerated organosulphur.

None of these treatments alone maximises the desirable properties and a combination is generally used.

To vulcanise the rubber, the compounded rubber is inserted into the mould and the mould is heated to 130-150°C. The method of
packing the rubber in the mould to fill the mould and yet not produce flash, as well as the design of the moulds themselves, are secrets that dental laboratories are not willing to disclose. It appears that some methods are very laborious, whilst others have developed simplified techniques that give the operator a significant advantage in efficiency.

**Fillers**

Two types of fillers may be used for rubber, i.e. reinforcing fillers, which increase the stiffness without impairing the strength or the rubbery character; or nonreinforcing fillers.

**Reinforcing Fillers:** Tensile strength, stiffness, abrasion resistance and tear resistance can be enhanced by the use of reinforcing fillers such as carbon black. Carbon black is the prime reinforcing agent for rubber. Despite its use since 1904, the reason for its effectiveness has not been satisfactorily explained. The improvement in the physical properties of the rubber is presently thought to be a result of physical bonding of the rubber into the aggregations of carbon nodules, as well as chemical bonding of the rubber to the carbon, hydrogen, oxygen and sulphur, all present on the surface of carbon black granules.

The chemical bond formed between the rubber and the reinforcing filler is another form of cross-linking. Consequently we have improvements in properties similar to those brought about by vulcanisation.

**Inert Fillers:** Inert fillers may also be used. These include clay, whiting, barytes (barium sulphate) and magnesium carbonate. The function of these is to improve handling during processing. They do not assist strength in any way. White and pink rubber, as used for tooth positioners, are coloured by using coloured clay as an inert filler, and less carbon black (Kesling, 1969). It can be seen then, why the coloured positioners do not have the same properties as the black positioners. T.P. Laboratories Inc. explain this is why they recommend the black positioners. However “Professional Positioners” claim that their white, pink and black positioners all have the same properties (Professional Positioners, 1985).

**Disadvantages**

There are a number of disadvantage of rubber as the material for tooth positioner construction. The weight given to each problem is quite subjective. Many operators do not consider them disadvantages at all. However, they have all been presented to me as problems and consequently are mentioned here:
1. **Processing:** From the processing method we can see a major disadvantage of rubber. That is, it is difficult to process in the laboratory (Mackie, 1985). The processing time is also much slower than for synthetic materials.

2. **Level of Skill:** The processing skill for rubber is required. Lack of the ability to process rubber prevents orthodontists and laboratories producing rubber positioners without an appreciable investment in equipment and operator’s time in learning the technique (Mackie, 1985).

3. **Colour and Opacity:** The colour and opacity of rubber is not readily accepted by the patient on grounds of aesthetics. T.P. Laboratories Inc. (1985) consider black rubber is the best for positioners. Their black rubber is stronger, has more elasticity and wears longer than white or pink rubber. They stress that a positioner is not meant to be a thing of beauty.

4. **Taste and Smell:** The taste and smell of rubber. Rubber does have a taste. Do patients accept this? For how long does the taste linger? Rubber has a taste that is generally accepted as unpleasant. The taste is not strong, however, it is still capable of causing annoyance. Professional Positioners add a flavoring to their rubber positioners, which will partially overcome the rubber flavor. T.P. Laboratories Inc. (1985) find that after a few days “the offensive taste, if any, will leave the appliance”. They also state that the positioner “acquires the tastes of the wearer and is not offensive”, by this they must mean that the patient can no longer taste the positioners as being different. T.P. Laboratories Inc. say that if the patient complains of the taste of the positioner after two weeks of wearing, one could be almost positive the patient had not worn it as directed.

   Cottingham (1969) found rubber developed unpleasant odours after a period of use. For this reason he did not use this material. I have also noticed this smell in a positioner which had been used for two years. The odour was quite strong and is associated with degradation.

5. **Deterioration:** Rubber deteriorates with time, mainly by oxidation. This can occur in the absence of external initiators and is largely initiated by the hydroperoxides formed along the rubber chain. It is an aging process which affects the properties of rubber adversely. In familiar terms, the rubber perishes, rots or cracks. There are various aspects to the degradation, any one of which can lead to loss of usefulness of the positioner. The aspects are:

   (a) Loss of rubbery characteristics. The rubber does not exhibit complete
elastic recovery. After one or two years use, some distortion of rubber is discernible, as is some loss of flexibility. However, rubber is such an ideal material initially, that even after there has been a noticeable deterioration, it is still very effective.

(b) Taste. After one or two years of normal use, degradation of the rubber produces an unpleasant taste and odour. This may not be noticed by the patients as they are so accustomed to the positioner. However, it may also be a reason for stopping use.

In spite of the deterioration of the rubber in tooth positioners, there are many documented cases where patients have happily worn them for three to five or more years (Kesling, 1969; Mackie, 1985).

Conclusion

Rubber is considered the best material for tooth positioners. A rubber positioner will have considerable flexibility and yet deliver light forces. Rubber is long lasting, maintaining its desirable properties even after discernible deterioration has occurred.

The significant disadvantages of rubber are its difficulty of manufacture as well as the patients’ expectations for aesthetics.

SYNTHETIC MATERIALS

A number of synthetic materials are used for tooth positioners. Unfortunately, in published articles trade names such as “Impak” are used (Professional Positioners, 1985). The companies are usually unwilling to reveal details of their materials.

To date, seven different synthetic materials are, or have been, used. The degree that each is favoured can only be assessed by figures representing sales supplied by the manufacturing and sales companies. The materials used in the literature are:

1. Polyvinyl Chloride: This is a thermoplastic material and was used in the studies published by Nahoum (1964), Eastham (1971), Godfrey & Spence (1971), and McBride & Mellor (1971). It is currently still in regular usage.

2. “Vangard”: Used by Luedtke (1970), Smart and Associates (1975) and Chiappone (1980) and is currently used by Professional Positioners. It appears to be
very similar to polyvinyl chloride. I suspect it is either a copolymer, using PVC, or else PVC with less plasticisers.

3. "Orolastic II". Another trade name. It was presented by Roth and Gordon (1981). Again no details of its chemistry or structure are available.

4. "Impak" Plastic. "Impak" plastic is an unusual thermoplastic that was introduced by Cottingham (1962) and later used by Eastham (1971). "Impak" positioners are today made by Professional Positioners (1984).

5. Ethylene vinyl acetate. Ethylene vinyl acetate is recommended by McBride & Mellor (1971) and Anderson & Mellor (1971) and Anderson & Schramm (1976). It does not appear to be used by the larger laboratories at present.

6. Polyurethane rubber. Polyurethane rubber is considered one of the best synthetic rubbers. For positioners it is recommended by Yoshii (1973) and is currently used by Professional Positioners (1985).

7. Silicone rubbers: Silicone rubbers are a material unlike all others. For positioners they are, or were, used by Prescott & Fertman (1968), Eastham (1971), Nishiyama & Associates (1977), Barnett (1978), and Kamada & Nishiyama (1982).

Comparison

With the very little information available, it is impossible to determine if any materials are better than others. Extensive clinical tests would be required. Unfortunately, even then the big variables, patient co-operation and variability, would possibly have more influence than the material.

The individual properties of each material are important though. Considerations when selecting a material are cost, ease of manufacture, patient acceptance, level of forces delivered and ease of adjusting and polishing and period of use required or anticipated.

Not all of this information is available. Few authors have been prepared to look at their appliance critically. However, they do comment on alternative materials and although a bias appears present, a guarded judgement can be made. Eastham (1971) is the only person to present a fair comparison of materials and his findings will be presented under the individual materials.
Polyvinyl chloride (PVC)

PVC was developed in 1835 by the French chemist Regnault. It initially did not gain wide usage. However, in 1930 it was discovered that it could be plasticised. Its use then became very considerable so that now it has the largest plastics material usage in the world. It is used for pipes and hoses, coating and insulating wires, phonogram records, floor coverings, rainwear, upholstery and as a film and sheet material.

PVC is a thermoplastic material composed of polymers of vinyl chloride. (A vinyl resin is one formed by the polymerisation of chemical compounds containing the group CH—CH—).

PVC is a colorless solid obtainable in the form of granules, solutions, lattices and pastes.

Plasticisers

“Straight” PVC is a tough and rigid material, of very limited use. To make it more suitable, it may be compounded with plasticisers to yield a flexible material superior to rubber in aging properties.

The product of plasticising PVC is a thermoplastic, i.e. a plastic that may be repeatedly softened by heating and hardened by cooling. It is an amorphous plastic so that the softening is gradual, with the rise in temperature. It is not an “elastic plastic” or more correctly, an “elastomer”. Plasticised PVC is used as a rubber substitute in the construction of tooth positioners. However there are considerable important differences between PVC’s and rubber.

(i) Plasticised PVC does not show the snappy elongation and retraction of vulcanised natural rubber.

(ii) PVC, being thermoplastic, will yield relatively slowly under force.

(iii) the elastic limits of PVC’s are not very definite.

(iv) PVC stress recovery is slow and incomplete.

(v) permanent set is much greater for PVC’s than for rubber.

(vi) with an increase in plasticisers, the percent elongation at break of PVC’s increases and the tensile strength decreases.
Function of Plasticisers

The function of plasticisers are:

1. Good low temperature flexibility.
2. Increased temperature resistance.
3. Decreased modulus of hardness.
4. Good flow.
5. High extensibility.
6. Good impact strength.
7. Other specific individual properties.

Not all plasticisers affect each property similarly. For optimal working properties, a blend of plasticisers are usually used.

Plasticisers can make up 15-60% of the volume of the plastic though around 30% is normal for use in tooth positioners. They are added after polymerisation, the addition process being with hot rollers or heated mixers.

Internal Plasticisation

There is another, very important way to plasticise a polymer. This is to use internal plasticisation. Internal plasticisation is the adding of an agent to the resin during polymerisation, as opposed to a plasticiser being added to the polymer after polymerisation and during compounding. The agent is usually another polymer, vinyl acetate often being the copolymer to internally plasticise vinyl chloride.

The mechanism allowing the mixing of two polymers to produce a softer copolymer is well known. The two polymers are generally incompatible. Therefore we do not get even mixing but instead a multiphase system develops. One phase tends to be dispersed in the other as zones. It is this irregularity of molecular separation that produces the change in properties. There is a reduction in intramolecular or Van Der Waal’s forces, permitting the macromolecules to slide over one another more freely. The size of the unmixed phases or zones decrease with mixing time but will reach a minimum value, after which more mixing will not influence it.

Internal plasticising has the considerable advantage of permanence.
Permanence of the Plasticiser

As stated, internal plasticising has an advantage over the addition of a plasticiser as internal plasticising is a permanent feature. However, to gain optimal properties we usually require plastics with internal plasticising, as well as an added plasticiser. We need, therefore, to look at the permanence of the plasticiser.

The permanence of the plasticiser is the ability of the plasticiser to remain as a useful constituent of a polymer/plasticiser system under use. It is normally a physical attribute as physical loss of the plasticiser occurs under conditions which are not so severe as to cause chemical changes in the plasticiser.

The loss of the plasticiser involves three steps:
1. Diffusion of the plasticiser to the surface of the plastic.
2. Transfer across the interface.
3. Diffusion away from the surface, i.e. removal and loss of the plasticiser.

One of these factors must be slower than the others and so becomes the limiting factor.

With tooth positioners, the plasticiser would be readily removed from the surface by rubbing and washing with saliva. As the surface of the plastic has the same structure as the internal mass, the transfer across the interface would not be the limiting factor. Therefore the limiting factor is diffusion. The plasticiser is lost from the surface layer. The plasticiser from the deeper layers diffuses to the surface to equalise the concentration, and this in turn is also lost. In this way the plasticiser is steadily lost.

In water, the loss of plasticiser is linear, dependent on time. However, in the mouth, with tooth positioners, we have a very different situation. The plastic is not passively immersed in saliva in the mouth, it is normally actively chewed on. This biting action may increase the mobility, and perhaps loss, of the plasticiser.

Stabilisers

PVC polymers will deteriorate when acted upon by a wide range of factors. The more damaging of these are ozone, ultra-violet light, heat and reactive chemicals. In the usage of PVC's that concerns us, the influence of all these factors is minor.
However, there is an autocatalytic degradation in PVC. This is where the breakdown products produced accelerate the rate at which subsequent degradation proceeds. The manner in which this occurs is complex.

**Other Additives**

For specific functions, other additives may be incorporated into plastics. The main additives would be fillers, dyes or anti-bacterial or anti-fungal agents.

**Fillers.** A filler is a relatively inert substance added to a plastic compound to reduce its cost and/or to improve its physical properties, particularly hardness, stiffness and impact strength. The particular properties fillers influence, are not desired in tooth positioners and so no advantage is gained. More importantly though, fillers affect the translucency of the PVC and this removes one of the main advantages of using this material.

**Dyes.** Dyes are added to the plastic of some positioners, for example T.P. Laboratories Prefinisher has a blue tinge through it. The dye is not dense enough to affect the translucency of the material, it is added solely for aesthetics. The dye has no influence on the physical properties of the material.

**Bacteriostats & Fungostats.** Bacteria and fungi require special conditions for growth and therefore to attack materials. These are moisture, suitable temperature, organic carbon, and certain other elements including nitrogen. Some plasticised PVC’s can be attacked, the likelihood depending on the plasticiser.

Bacteriostats and fungostats may be required in these PVC’s where they are exposed to high humidity and temperatures of 25-30°C.

For tooth positioners, we do not use plastics with bacteriostats and fungostats for two reasons:

1. These substances are highly toxic and potentially dangerous.
2. The tooth positioner is regularly cleaned and this should reduce microbial growth.

**Color Changes**

The plasticised PVC used for tooth positioners is originally clear. The manufacturer may add a dye but that does not concern us here. There are three other ways the colour may change, these are:

1. As a result of use: The change from a clear material to a milky opaque
material is readily observed in a correctly used tooth positioner. The cause of this is moisture uptake by the material.

2. As a result of heating or light: Clear PVC discolours on heating over 80°C. This first evidence of instability of PVC, as a result of heating or light, is a yellow or brownish discoloration. If the heat or light is continued, the colour change continues until the material is quite brown or black. Normally the mechanical properties are not impaired until an advanced stage of dehydrochlorination is reached, this is signified by a dark coloring of the material.

3. Staining: Pure PVC does not stain. However, the plasticisers will stain and so the greater the concentration of the plasticiser, the more likely the material is to be stained. Staining should not be a problem with tooth positioners. However if we select a PVC for aesthetic reasons, we should endeavour to maintain the appearance of the material. The more inventive patients should be warned to be careful of eating or smoking while wearing the tooth positioner as tomato sauce, mustard and tobacco smoke (and even lipstick) have all been recorded as staining plasticised PVC.

"Vangard"

"Vangard" is a trade name. I am unable to find out further details of its polymer composition. "Vangard" has been used in published trials in the past (Luedtke, 1970; Smart, McKinnon & Grave, 1975; and Chiappone, 1980) and is currently used in tooth positioners by Professional Positioners. "Vangard" is clear thermoplastic vinyl. It is probably either a PVC or an EVA material. From my work I have found it is firmer than PVC materials such as "Stay-guard" and has a higher softening and melting temperature. My experience has shown that "Vangard" hardens considerably with use. I suspect this hardening is a result of the loss of plasticisers.

Clinical Results

Luedtke (1970) found "Vangard" withstood twelve months usage, ten to fourteen hours per day, very well, provided it was adequately cared for. He had no experience with gingival trauma. His experimental group were scoliotic patients and he found the "Vangard" appliance was very successful in maintaining dental relationships. Smart, McKinnon & Grave (1975) favor "Vangard" positioners. They
have the positioners constructed in their own laboratory and so ease of manufacture was undoubtedly one of the factors why they selected "Vangard". Thermoplastics would be the easiest positioner materials to use. Chiappone (1980) also uses "Vangard" for the construction of his positioners. He does not discuss the desired properties or why he favors the material, however his use of the material can be taken as his condoning it as being suitable for tooth positioner manufacture.

Professional Positioners (1985) currently produce a positioner constructed from "Vangard". They attribute the following advantages to "Vangard".

1. Excellent clarity.
2. Very light in weight.
3. Extremely resistant to "bite-through".
4. Taste is not unpleasant.
5. It is quite firm. It is rated between rubber (natural and polyurethane) and "Impak" for firmness.

Professional Positioners suggest care with heating "Vangard" positioners. For comfort the positioner may be run under warm to hot water before insertion. However it will distort if heated to 150° F. Once distorted it cannot be reshaped.

My observations agree with those of Professional Positioners. "Vangard" would, therefore, be used as a tooth positioner material where a material was required that was firmer than rubber, but softer than "Impak".

"Orolastic II"

"Orolastic II" is the material preferred by Roth & Gordon (1981) for the construction of tooth positioners.

"Orolastic II" was developed by Mr Gordon specifically for positioners. Unfortunately no details of the properties, advantages or disadvantages or indications for its use are provided.

"Impak"

"Impak" is considerably different. It is the firmest of all materials used for tooth positioner construction.

As "Impak" is a trade name, the polymer composition will not be revealed. It was first used by Cottingham (1969) and is currently used by Professional Positioners (1985).
The physical properties of "Impak" are interesting. At 70° F, it is so firm that it resists bending. At 98° F (body temperature) it is still quite firm and may be very difficult to insert. If placed in hot water (about 140° F) it softens so it can easily be inserted. "Impak" can even be placed in boiling water without risking deformation (Cottingham, 1969).

Cottingham (1969) lists the following advantages for "Impak":

1. It withstands abusive wear without deformation.
2. It maintains its rigidity over months of use.
3. It is easily shaped or cut.
4. Its shape can be modified by the addition of cold-cure plastics.
5. It is translucent.
6. It is flexible enough to adapt over irregular surfaces.
7. It is firm enough to move the teeth well and control rotations.
8. It is thermoplastic. To insert, it is heated in water. It then takes on the texture of wet leather. It can be flexible and with enough stretch to be inserted over irregular teeth. It then cools and becomes strong.
9. It is non-irritant, non-porous and non-corruptible. It does not absorb foods and become foetid: It does not degenerate.
10. It is a good stimulant to the gingiva.
11. It is readily cleansed with detergents or in an ultrasonic cleaner.

Professional Positioners currently produce a positioner made from "Impak". I understand it is a recent introduction, as their advertising booklet of 1982 does not include "Impak" positioners. However during 1984 they regularly advertised the material (fig. 11).

Professional Positioners (1984) list the advantages of "Impak" as:

1. Clarity.
2. Thermoplasticity.
3. Durability.

Professional Positioners consider "Impak" material to have the elasticity of rubber, whilst it is firmer. These are not contradicting each other if "elasticity" is referring to elastic range and not to the gentle forces produced by rubber. Professional Positioners recommend minimal gingival coverage with "Impak" positioners. I suspect this may be to prevent gingival trauma should the positioner impinge.
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VANGARD PROsitioner™
VANGARD is a thermoplastic vinyl that if properly used functions very well as a PROsitioner material. It has excellent clarity, is very light in weight and is extremely resistant to “bite-through.” Although often not necessary, a VANGARD can be slightly softened in hot tap water for ease in early placement. However care must be exercised with higher temperatures — 150° - 160° will probably distort vinyl material — boiling water would quickly ruin a VANGARD PROsitioner. Once a tooth socket or arch shape is deformed, they will not return to their original shapes. If care is taken to limit the temperature and stress exposure, a VANGARD PROsitioner will combine great function, appearance and toughness.

IMPAK PROsitioner™
IMPAK is a clear thermoplastic acrylic — heat it and it softens, cool it and it firms up. These unique characteristics can be used to advantage in PROsitioner therapy. At 70° room temperature an IMPAK is quite hard and even resists bending. Place it in hot 140° tap or heated water and it quickly becomes very soft and pliable — easily stretched over the teeth. In the mouth at 98° an IMPAK firms up and has the elastic qualities of a typical rubber PROsitioner. As the patients' teeth move into their desired positions, there is less need for preheating the appliance. An IMPAK is water clear, very durable and easy to maintain. This material is also well suited to our Slim-line trim which has very little tissue coverage.

URETHANE PROvisioner™
PRO's special URETHANE formulas produce transparent appliances that are very “rubber-like” in form and function. The standard PROvisioner has a firmness similiar to that of our white PROsitioner rubber; the unique PROdeucer has the same frontal section, but the posterior section is made from Urethane approximately 10% harder. The later combination results in a PROdeucer that is very efficient in effecting bicuspid and molar corrections, and also very resistant to posterior breakdown. Our URETHANE material is a “permanent set” elastomer — you can place a PROdeuer or PROvisioner appliance in boiling water for hours with no resulting damage or distortion to the appliance.

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Fig. 11: Three different tooth positioners available from Professional Positioners (1984).
In contrast to these published results and claims, Eastham (1971) found “Impak” unsatisfactory as a tooth positioner material. Over the short period of time he had patients use the material (average time three months) he obtained the following results:

1. “Impak” was easier to grind and polish than processed acrylic.
2. “Impak” is much more rigid than PVC at room temperature.
3. “Impak” was quite porous. Due to its porosity, odour and discoloration were problems generally encountered. The patients complained that it was difficult to clean.
4. The material was quite bulky and required a great deal of adjustment before it was well received by the patient. This may have been the laboratories fault and not that of the material, however ease of manipulating of the material by the laboratory must be considered. The same laboratory also constructed the silastic and PVC positioners with no problems. The design of all the positioners was the same.

The high porosity of the “Impak” may be the result of the adjustments after curing of the material. If so, it is a serious problem.

Eastham considered “Impak” to require improvement as it was not well accepted by patients after three months of use. This is a serious consideration with tooth positioners as patient co-operation is vital for success.

Professional Positioners (1985) have now introduced a new material, “Elast-Acryl”, which appears to be a softer form of “Impak”.

ETHYLENE VINYL ACETATE COPOLYMERS

Introduction

Ethylene vinyl acetate copolymers, often abbreviated to EVA, are copolymers consisting mainly of polyethylene, with minor amounts of vinyl acetate. The copolymer retains many of the properties of polyethylene, but has increased flexibility, elongation and impact resistance. EVA resembles elastomers in many ways, but can be processed like thermoplastics.

EVA is, by its copolymer nature, an example of internal plasticising.

Advantages

The advantages of EVA as a tooth positioner material are:

1. It is transparent and so its fit over the teeth can be observed. Patients also accept transparent positioners more readily due to aesthetic considerations.
2. It is sufficiently rigid to enable it to be of small bulk but still have good form stability (Andersen & Schramm, 1976).
3. Its taste is less objectionable, though the authors do not say to what it is compared (Andersen & Schramm, 1976).
4. It is resistant to salivation (Andersen & Schramm, 1976).
5. It is easily adjusted with an acrylic bur (Andersen & Schramm, 1976).
6. It is pressure moulded and this provides detailed tooth adaptation (Andersen & Schramm, 1976).
7. Its raw materials and manufacture is very inexpensive.
8. The use of internal plasticising instead of addition of plasticisers produces a longer lasting flexibility. This is an important consideration for tooth positioners.
9. Processing is simpler and faster than PVC and rubber.
10. Tensile strength is close to that of PVC.
11. Stress cracking resistance is superior to PVC.
12. EVA has very good flexibility, toughness and chemical resistance.

Disadvantages

It is enlightening to read a paper in which the disadvantages of the material are discussed along with the advantages. Andersen & Schramm (1976) do so and this must greatly assist any orthodontist considering using this material. The disadvantages they list are:

1. Production of the positioner is time consuming.
2. The rigidity of the material requires accurate gingival fitting to avoid ulcers.
3. The relatively high elastic modulus of the material produces considerable pressure on the teeth when the positioner is inserted.
4. The material requires care if produced in two pieces and then joined. If the join is not sufficiently strong, the parts may separate during function.

These disadvantages are considered to be far outweighed by the advantages by some orthodontists (Andersen & Schramm, 1976; McBride & Mellor, 1971).

EVA polymers are also used for mouth protectors and have been found to be one of the better materials in this role (American Dental Assoc., 1972; Godwin & Craig, 1968).
POLYURETHANES

Introduction

Polyurethanes are a relatively new material on the market. They were developed by German chemists looking for a nylon 66 substitute, as they were not permitted to manufacture this specific nylon due to patents. It is not a large volume production plastic, as the vinyl are. However it has found a number of specialised roles which it fills very well. The present use for polyurethanes are:

1. Osmotic membranes.


3. Maxillofacial prothesis: A mixture of polyurethane, acrylate and other plastics is a recent addition to maxillofacial prosthesis. The result has a lifelike feel and appearance and better color stability than PVC. However it is subject to deterioration.

4. Rigid polyurethane foams for insulation and reinforcing hollow structures. This use accounts for 25% of polyurethane produced.

5. Flexible Polyurethane foams. The hardness of the foam is determined by the molecular weight of the polyol used. The lower the molecular weight, the more rigid the foam. This use accounts for 50% of the polyurethane produced.

6. Urethane coatings for wood, rubber, leather, wire. They show very good resistance to chemicals, abrasion and corrosion.

7. Elastomeric fibres.

8. Elastomers.

For tooth positioners, the elastomeric form of the polyurethane plastic is utilised.

Polymerisation

Polyurethane elastomers are made in several steps. A basic intermediate is first prepared in the form of a low molecular weight (1,000–2,000) polymer with hydroxyl end groups. This may be a polyester, such as
that made from ethylene glycol and adipic acid, a polyether, or a mixed polyester-polyamide.

The basic intermediate is then reacted with an aromatic diisocyanate to give a prepolymer.

The prepolymer is then vulcanised through the isocyanate groups with reactants such as glycols, diamines, diacids or amino alcohols. An elastomer is the result.

Considerable care must be used during manufacture due to the very high toxicities of the cyanate group of compounds.

If water is added during the vulcanisation, carbon dioxide is produced as a product of cross-linking. The carbon dioxide bubbles are held in the elastomer and flexible urethane foams are produced.

The liquid polyurethane rubber is generally cured, during vulcanisation, by reactions involving both chain extension and cross-linking.

Polyurethane is convenient to use as it is a liquid prepolymer. This is easier to handle and it is mixed with the cross-linking agent and catalyst just prior to pouring into the mould.

Thermoplastic & Elastomeric Rubbers

The thermoplastic and the elastomeric polyurethane rubbers have similar properties and both may be suitable for construction of tooth positioners. Unfortunately few authors state what form of polyurethane rubber they utilise.

The significant difference between the two is the absence of covalent cross-links in the thermoplastic rubbers. This gives them an appreciable higher compression set, an undesirable feature for tooth positioner material.

The difference in these materials is the most likely cause of the discrepancies in the reported performances of polyurethanes.

Reports on the Clinical Use of Polyurethanes

Polyurethane mouth protectors were found to perform poorly (Godwin & Craig, 1968). However it was suggested that thickening the material may assist. Mouth protectors are normally manufactured from thermoplastic materials, and as compressive recovery is not really significant in this role, the thermoplastic form of polyurethane was most likely utilised.
In contrast to these results, polyurethane elastomers are noted for extremely good abrasion resistance and hardness, combined with good elasticity and resistance to greases, oils and solvents. Their toughness is reflected by their use as a rubber substitute for tyre treads. The high tensile strength even when not reinforced, is valuable for tooth positioner construction. It is also very resistant to oxidation.

Pressure vulcanisation of the polyurethane may be an advantage (Yoshii, 1973), the physical characteristics of the elastomer being improved. Polyurethane elastomer does not discolour, it is resistant to mechanical failure, and it has no unpleasant taste or odour. The clarity of polyurethane elastomer is not as high as polyvinyl chloride elastomers. The teeth can still be viewed to ensure they are seated correctly, however the material is certainly "foggy". Professional Positioners accept the loss of clarity and do not consider it is any problem. Surface coating materials may be used to increase the clarity (Yoshii, 1973), however I cannot comment on the use of this procedure or if it affects the physical properties in any other ways.

Polyurethane positioners are tolerant of heat. They may be placed in boiling water for hours with no damage or distortion (Professional Positioners, 1984). This would allow patients to clean the appliance in boiling water. Maintenance of a clean appliance is difficult due to calculus deposits and debris. Between 20–47% of athletes wearing mouth protectors complained of difficulties in keeping the appliances clean and this resulted in a reluctance to wear the appliance (Bureau of Dental Health Educ., 1964).

Professional Positioners have produced from polyurethane what may be considered the most advanced tooth positioner (Professional Positioners, 1985). The tooth positioner is constructed from polyurethane of two different grades of hardness. The softer polyurethane is used for the anterior region, whilst a polyurethane approximately ten per cent harder is used for the posterior teeth. This allows a softer material to be used in the anterior region, while the durability of the appliance is increased.

Professional Positioners find the "Pro-vision-er" tooth positioner is their most popular positioner. They find the polyurethane is softer than rubber and is, therefore, more comfortable when first inserted.

Kamada & Nishiyama (1982) consider polyurethanes to be one of the best materials for tooth positioners due to its lack of taste and odour and its superiority in elasticity.
Disadvantages

The only disadvantage of polyurethane I could find is it's difficulty in processing it (Nishiyama and associates, 1977). Polyurethanes must be produced under pressure (5 kgms/cm²) at 120° C. Methacrylate resin must be used as the mould. Nishiyama and associates attribute this factor as limiting the wider use of polyurethanes in tooth positioner construction.

Polyurethane may stain and cannot be cleaned (Professional Positioners, 1985). However, there is no list of staining agents. There is no comment either, as to whether surface coating reduces the staining potential (Yoshii, 1973), but this would be expected.

The polyurethane appears to require a minimum thickness. Polyurethane mouth protectors fail due to inadequate thickness (American Dental Assoc., 1972) and Professional Positioners require at least two millimetres for polyurethane material between the opposing dental arches for construction of the tooth positioner (Professional Positioners, 1985).

Finally, achieving compatibility between flexibility and resistance to wear must be difficult with polyurethane. Professional Positioners' "Pro-vision-er" may deteriorate after six months. This is a relatively short life for a tooth positioner. Although Professional Positioners may be able to overcome this disadvantage, other laboratories may have difficulties.

SILICONE RUBBER

History

Silicon was a largely unknown agent in chemistry when Alfred Stock, of Germany, attempted to reproduce Hydrocarbons by using silica to replace the carbon atoms. In 1912 he produced silane (SiH₄), the equivalent of methane. Stock was unable to develop long silicone chains as they were very unstable.

In the following decades intensive work was carried out on silicones. It was during the second world war that silicones were first produced commercially and since then their uses and usage have continued to increase considerably.
Chemistry:

Definitions:
Silica, SiO₂, is a natural substance found in sand, quartz and opals.
Silicon, Si, is the pure element.
Silicones are a family of semi-organic polymers comprised of chains of alternating silicon and oxygen atoms.

Preparation of Silicones
The starting material is silicon tetra-chloride, SiCl₄, made from heating sand with chloride gas to about 1,000° celcius. Long chain silicones can be produced. Polydimethyl-siloxane being the silicone rubber in general use.

Silicone Rubber
Silicone rubber is replacing natural rubber in industry due to its much greater operational temperature range and its chemical resistance. An analogy that would appeal to dentists, is that silicone rubbers may be given increased resistance to chemical attack and dissolution by incorporation of fluorine.

Silicone rubber may be prepared in several ways:

1. By free-radical cross-linking with substances such as benzoyl peroxide at high temperatures (480° F). This produces high temperature vulcanising (HTV) silicone rubber. It is a condensation reaction and therefore involves shrinkage of the material.

2. By cross-linking of vinyl or allyl groups attached to silicon at medium temperatures.

3. By cross-linking linear or slightly branched siloxane chains to form Si–O–Si cross-links. This reaction occurs at around 100° C and due to the fact that it will occur very slowly at room temperature, it is called room temperature vulcanising (RTV) silicone rubber. This is a condensation reaction but shrinkage is hardly discernible (Kamada & Nishiyama, 1982).

RTV silicone rubbers are available as a two part mix. One part is the polymer with the added catalyst, the second part is the siloxane cross-linker. The vulcanising reaction is activated by atmospheric moisture. This is the material currently used for domestic purposes under the trade name “Silastic”. “Silastic” has the two parts pre-mixed and only requires moisture to activate the setting reaction.
Properties

Some of the physical properties of silicone rubbers are considered inferior to other rubbers and elastomers at room temperature. The properties of silicone rubbers that concern us are:

**Tensile Strength** — Silicone rubbers have quite low tensile strengths (Kamada & Nishiyama, 1982). The tensile strength of natural rubbers is 1,500 to 3,000 psi. The tensile strength of silicone rubbers may be increased to 1,000 psi with the use of finely divided silica reinforcement. This reduces the elongation potential considerably but does not effect the flexibility and compressibility. Silicone rubbers, with silica reinforcing, appear to be very applicable to tooth positioner construction. Rocky Mountain Orthodontics Inc. introduced this material about 20 years ago, however, it did not remain on the market (Godfrey, 1985). The Dow Corning Corporation presently produce silica reinforced silicone rubber elastomers. They are available in three grades, according to the hardness and strength required. Unfortunately the shelf life of the unreacted material is one to six months. Therefore the Dow Corning Corporation only manufactures the materials when orders are received. From the ordering time, four weeks delivery should be allowed. This could be an impediment to the use of this material.

Without silica as a filler, silicone rubber has very little strength.

**Compressive Set** — Silicone rubbers have substantially the same compression set as natural rubbers at body temperature. Silicone rubbers are considerably better than natural rubbers at most other temperatures, but these do not concern us.

**Effect of Water** — Silicone rubbers are unaffected by water. It is highly repellent to water due to its low surface tension. This lowered surface tension should make this material easier to clean and keep clean.

**Abrasion and Tear Resistance** — Silicone rubbers are inferior to natural rubbers with respect to abrasion and tear resistance. Silica reinforcement increases the resistance but these materials are still not as strong.

**Shrinkage on Curing** — HTV Silicone rubbers shrink more than natural rubbers during processing. A total shrinkage of five to eight per cent may be experienced. This is of concern in the manufacture of tooth positioners which are a precision appliances. Due to this, RTV silicone rubbers should be used.

**Chemical Resistance** — The chemical resistance of silicone rubbers is excellent for the purpose of tooth positioners.
Surface finishing — It is difficult to give silicone rubber a smooth finish as it cannot be readily polished. However it normally will not require smoothing unless adjustments are made.

Identification — Silicone rubber may be very difficult to distinguish from natural rubber. Both have similar stretch and bounce, both shed water and both can be treated similarly. The simplest way to distinguish between the two is to burn the sample. Organic rubber burns with a black smoky flame and leaves about five per cent ash. Silicone rubber burns with difficulty, with a white smoky flame, and leaves about ninety per cent ash.

Cost — Silicone rubbers have the disadvantage of appreciably higher cost compared to other materials.

Reports on Clinical Use of Silicone Rubber

Silicone rubber has been used by a number of researchers (Prescott & Fertman, 1968; Eastham, 1971; Nishiyama and associates, 1977; Barnett, 1978; and Kamada & Nishiyama, 1982).

Only one study compares silicone rubber to other materials (Eastham, 1971). In this study the tooth positioner had a wire screen incorporated into the palate to improve resilience and stability. The results were:

Advantages

1. Splints are resilient and stable.
2. This appliance was easier than the others to place in cases of severe malocclusion. The more rigid appliances (thermoplastic PVC and "Impak" plastic) could not be easily inserted over badly aligned teeth.
3. This appliance was effective as a minor tooth moving appliance.
4. The material was very durable, odour and discoloration were only minor problems.
5. The silicone rubber positioner was successful in controlling tooth movement during Milwaukee Brace therapy in a very limited number of patients. However there was probably very little pressure on the teeth as the patients had no facial skeletal changes during the orthopaedic treatment.

Disadvantages

1. This appliance required the support of a wire screen in the palate to reduce flexibility.
2. Silicone rubber is difficult to trim or adjust. The material is very tough and is not easily ground or adjusted.
3. Due to its flexibility, the silicone rubber had to be thicker than the other appliances. This created some patient discomfort and is attributed to difficulties with night-time wear.

Eastham (1971) recommendations for Milwaukee Brace treatment to stabilise the arch was that if a tooth positioner was required to correct tooth alignment whilst splinting the teeth, then the silicone rubber tooth positioner was recommended. The silicone rubber positioner was also recommended where the malocclusion was so severe that other appliances could not be inserted. Eastham did not specify what form of silicone rubber he used for his positioners.

Barnett (1978) favours the use of silicone rubber due to its colour, transparency, acceptable taste and smell and the fact that light forces are applied, producing less soreness and discomfort for the patient and so improving cooperation. Barnett uses the high temperature vulcanising (HTV) silicone rubber.

Prescott & Fertman (1968) also use HTV silicone rubber. They consider the best attributes of silicone rubber to be its considerable flexibility and transparency. The flexibility produces lighter forces than more rigid materials. This will produce a greater range of tooth movement with less discomfort to the patient than other positioners, including natural rubber.

Nishiyama, Kamada & Horiuchi (1977) describe a method of producing tooth positioners from room temperature vulcanising (RTV) silicone rubber. Again silicone rubber is preferred as it is:

(a) tasteless and odourless
(b) easy in moulding
(c) has excellent elasticity which allows the operator to move the teeth greater distances without having to remake the appliance, compared to other tooth positioner materials.

Kamada & Nishiyama (1982) present another paper which is very much like the Nishiyama and associates paper of 1977. Again RTV silicone rubber is described as a new material for tooth positioner construction. Many of the photographs presented are the same as in the earlier paper. However new information is presented.

Kamada & Nishiyama (1982) have overcome the shrinkage of the silicone rubber during processing. The reaction they use is an addition polymerisation which produces no byproducts. Consequently shrinkage due to vulcanisation can hardly be seen.
They have also produced two grades of the silicone rubber, i.e. regular and hard. The two grades may be incorporated into one positioner for desired variation in flexibility, i.e. the hard grade rubber for the buccal teeth and the regular grade for the anterior teeth.

**Conclusion**

Tooth positioners can be made to have considerably different properties by varying the material from which it is manufactured. The orthodontist must decide what material he wishes his tooth positioners to be made from. His concerns should be patient acceptance, intensity and range of forces to be delivered, ease of manufacture and expected life of the positioner. Due to the range of properties of the different materials, most requirements can be fulfilled within reasonable limits.
Chapter 6 —

THE EFFECT OF TOOTH POSITIONERS ON THE GINGIVA

INTRODUCTION

The forerunner of the tooth positioner was an appliance to treat "Pyorrhea" (Remensnyder, 1926). When Kesling (1944) introduced the tooth positioner, he considered it to have beneficial effects on the gingiva. Other workers have supported the view that there is a significant beneficial effect on the gingiva (Bunch, 1961; Cottingham, 1969; Cooke & Wreakes, 1978). Current users of custom made tooth positioners, to whom I have spoken, also feel there is a significant healing effect on the gingival tissues. However, these reports are subjective, not the results of controlled clinical trials. The healing of the gingival tissues following debanding is normally rapid in the presence of good oral hygiene alone.

When manufacturing tooth positioners, the gingival margins should be carved to the desired form. Bevelling and stippling is also considered beneficial (Cottingham, 1969). When the tooth positioner is held passively in place, there should be no pressure on the gingiva. However, when the patient clenches into the positioner, the gingiva is gently pressed with a massaging action (Kesling, 1944).

During Milwaukee Brace Therapy

When using tooth positioners in conjunction with Milwaukee Brace therapy, Bunch (1961) noted an improvement in gingival health. He attributes the improvement solely to the massaging action of the tooth positioner on the gingiva. If food or debris become interposed between the positioner and the gingival tissue, irritation resulted.

I have hesitation in attributing the improved gingival health to the gingival massaging effect of the tooth positioner alone, because:

1. Bunch issued tooth positioners for only the most co-operative patients. These patients would be more likely to have better oral hygiene.

2. Poor gingival health was considered a common finding in Milwaukee Brace patients (Bunch, 1961). This is believed to be partly due to the rapid tooth
movements occurring. The tooth positioner, by controlling tooth movements, would improve the gingival health.

Therefore, in Bunch's study, the tooth positioners were most likely part of a complex set of factors resulting in improved gingival condition.

Alexander (1966) was concerned about the gingival health of his patients. Alexander found no consistency in the patients' gingival conditions initially. The control and experimental groups both had inflammation. However, once the patients had adapted to the positioners, which had been adjusted, they no longer had any problems. The control group continued to experience gingival bleeding during toothbrushing.

**Following Fixed Orthodontic Appliances**

Bekeney & De Marco (1971) studied the effects of tooth positioners on the periodontium as it recovered after removal of fixed appliances. Tooth positioners, also known as "positive pressure appliances" (Baer & Associates, 1961), had been used to treat dilantin gingival hyperplasia and gingival haemangioma (Baer & Associates, 1961; Davis & Associates, 1963; Babcock, 1965).

Bekeney & De Marco randomly selected 13 patients from a group of patients considered co-operative and ready for removal of fixed appliances. Black rubber tooth positioners were manufactured by T.P. Laboratories Inc. Prior to insertion of the positioners, half of the maxillary and mandibular gingival fitting surfaces were removed with scissors. The edges were smoothed. This was a double blind study, neither the operator who issued the tooth positioner, nor the operator who assessed gingival inflammation, knew which gingival areas were the control or experimental areas. The gingival inflammation was assessed using the Gingival Index of Loe. The patients were instructed to wear the positioners for four hours during the day and all night. They were to exercise into it in the conventional manner.

These authors found that there was a significant improvement in the health of the gingival tissue during the first week. The improvement in the covered quadrant was similar to the uncovered quadrant. During the second week the covered quadrant continued to slowly recover, whilst the health of the uncovered quadrant did not improve significantly. In the following weeks improvement of the gingival condition was not significant statistically. Overall, Bekeney & De Marco considered the difference in periodontal healing to be insignificant between the covered and uncovered sides. They consider it difficult for any appliance to enhance the healing, as the periodontium already possesses such a high potential for healing.
Bekeny & De Marco concluded that:

1. The tooth positioner does not significantly enhance tissue recovery after orthodontic treatment.

2. The tooth positioner does not hinder recovery of the gingival tissue when used as a retention appliance.

3. There was no difference in the rate or degree of recovery of the gingival tissue in the covered or uncovered quadrants.

4. Young, healthy patients in the age group of 12–17 years have a very great inherent ability to heal, signified by the rapid rate and degree of recovery of the gingival tissues after removal of orthodontic appliances.

Therefore we must be cautious before attributing beneficial healing effects to the tooth positioner.

A tooth positioner may work in other ways besides being a gingival massager. It may aid by preventing mouth breathing, which may have a detrimental effect on the gingiva. Or the tooth positioner may function as a reminder. If the patient remembers to wear the tooth positioner every night, it is likely that they will clean their teeth just as regularly.

In contrast to the findings of Bekeny & De Marco (1971), Cooke & Wreakes (1978) attribute a significant healing effect to the tooth positioner. Cooke & Wreakes used "Orthotain" preformed positioners. In the case they describe, fixed appliances were removed early due to poor oral hygiene. The gingiva was very inflamed and hypertrophic. When the preformed positioner was initially seated, blanching was observed in the hypertrophic gingiva. There was very rapid healing of the gingiva and the authors attribute the healing, retraction and reshaping of the gingiva to be due to the massaging effect of the preformed positioner.

My examination of T.P. Laboratories Inc. "Prefinishers" shows them not to be manufactured to be close fitting in the gingival margin area. I attribute this to the necessity of the "Prefinisher" to fit a variable range of patients. The manufacturers would certainly want to avoid gingival impingement that may result in ulceration. Due to the poor fit of "Prefinishers" in this area, I would not expect any preformed positioners to have more influence on gingival healing than custom made tooth positioners.

Of the many orthodontists I questioned on their use of preformed positioners for this thesis, only one felt that preformed positioners had a beneficial effect on the gingiva.
To Control Gingival Hyperplasia

Baer & Associates (1961) present the use of a tooth positioner to control gingival hypertrophy. Due to its different function, they term the tooth positioner a “positive pressure appliance”. However, it does not differ in any respects from the conventional tooth positioner. Baer & Associates used silicone rubber as their material.

The case they treated was a ten-year-old girl suffering from Sturge-Weber syndrome. The patient had a gingival haemangioma as a complication. The gingival haemangioma had been surgically removed twice but had regrown within a few months.

Impressions were taken for the positive pressure appliance. The hypertrophic tissue was then reduced slightly on the models. It was felt that if the reduction was too great ulceration or discomfort may result. A silicone rubber appliance was then made over the casts. The positive pressure appliance was given to the patient who was to wear it as much as possible.

The patient was recalled weekly and further impressions were taken. At each visit the hypertrophic area on the models were reduced and these models were used to allow addition of new silicone rubber to the positive pressure appliance. At the weekly visits the gingival tissues of the patient were also curetted. The tissues were normal by the end of the first month.

Once the tissues became normal, the wearing of the positive pressure appliance was reduced to nights only. There was no regrowth during the next 18 months. The authors illustrate another case that is seven years posttreatment and there is still no recurrence of the hypertrophic gingiva.

If would appear then, that the “positive pressure appliance” contributed significantly to the reduction of the gingival hypertrophy.

Baer & Associates use of silicone rubber for the appliances would be for clinical convenience. It is a simple procedure to add to the appliance with silicone rubber. This is due to the low viscosity of the unset silicones, as well as the property of setting by a chemical reaction and not by heat, though heat setting silicones are also easy to use.

Baer & Associates did not record the oral hygiene changes in the patients studied. Gingival hyperplasia associated with Sturge Weber syndrome may be very successfully controlled by a high standard of oral hygiene (Highfield, 1985).
Unfortunately this important variable was not discussed. Oral hygiene training and maintenance would appear to be a simpler and more convenient method of controlling the gingival hyperplasia.

**Dilantin Gingival Hyperplasia**

Gingival hyperplasia occurs in 21–57% of patients undergoing dilantin therapy. If it occurs, treatment may be changed to another medication. However, dilantin is the drug of choice for epilepsy. Alternatively, the hyperplastic tissue may be surgically removed.

Surgical removal is, however, subject to recurrence. In an effort to reduce the recurrence of hyperplastic tissues, Davis & Associates (1963) evaluated positive pressure appliances to see if they could control the hyperplastic tissue. Two groups of patients, the control and experimental groups, were selected. Each group had nine patients. The experimental group had the hyperplastic tissue removed and after a week a positive pressure appliance inserted, to be worn at night only. The control group had the hyperplastic tissue removed but no pressure appliance was worn.

Two different appliances were used. One was a tooth positioner of natural rubber, the other was a cast chrome-cobalt framework lined with soft plastic.

In the control group, five patients had complete or almost complete recurrence of the gingival hyperplasia. Two patients had a slight recurrence and two patients had no recurrence. In the experimental group, seven members had no recurrence of the gingival hyperplasia. One member had a slight recurrence and one member had a moderate recurrence.

The patient in the experimental group who had a moderate recurrence had an extreme malocclusion and a marked open bite. These factors were considered to contribute to the recurrence of the hyperplasia. Also the appliance did not fit well in the area of recurrence. Davis & Associates suspect that the patient with a slight recurrence did not wear his appliance.

Of the control group. It is considered that in time, all patients would have complete recurrence.

In comparing the cast chrome appliance to the tooth positioner, they were found to be equally effective. However, the chrome appliance was easier to relix and had better aesthetics.
Babcock (1965) repeated Davis & Associates experiment. He used an experimental group of six patients and a control group of four. This positive pressure appliance was similar to a black rubber tooth positioner, but was made to fit the maxillary arch only. His observations were over a six month period.

Of the appliance group, five patients had no regrowth of gingival hyperplasia, and one member had a slight regrowth.

Of the control group, two had complete recurrence, one had moderate occurrence and one had only slight occurrence.

These results agree with Davis & Associates’ results. However, Babcock cautions the reader and suggests there may be other factors involved.

Oral hygiene has been shown to affect the growth of dilantin hyperplasia. The control group patient who had only slight occurrence markedly improved his/her toothbrushing when the study started. Once the oral hygiene had improved, the hyperplasia growth is expected to be slowed.

The appliance group patient who had a slight regrowth of hyperplastic tissue was also a less co-operative patient. Reduction of the quality of personal oral hygiene would be expected to coincide with poor appliance wear. Babcock did not measure the co-operation and toothbrushing levels.

The oral hygiene of the control group was noted as being definitely improved. It was also stressed to the patients (of both groups) that attention to toothbrushing was required to prevent regrowth. Babcock considered the appliance served as a focus of attention and a constant reminder for the patients to keep their teeth clean. It should be noted that Babcock’s and Davis & Associates’ groups consisted of mentally handicapped patients from nursing homes. These patients were chosen as they could be monitored more closely. However, these patients would also be more likely to neglect oral hygiene and a reminder, such as an oral appliance, could be very effective, in fact more effective than it would be for a normal person who, when not in a nursing home routine, is likely to forget either, or both, actions, i.e. toothbrushing and wearing the appliance. Therefore, the appliance may not have this reminder effect in other situations.

There is another effect the appliance may have. Babcock & Nelson (1964) examined the dilantin concentration of saliva. They found the dilantin concentration was highest during the night when saliva flow was lowest. They suggest that the hyperplasia may be due to the direct action of the dilantin on the gingival crevice. The positive pressure on the gingival tissues would prevent the saliva from reaching the gingival crevice and thus an isolation effect is achieved.
Therefore, Babcock is uncertain of the specific action, but he does conclude that the "positive pressure appliance" is effective. He only used rubber appliances as he considers their ease of manufacture and low cost to outweigh any disadvantages.

I would have liked to have had Babcock comment on appliance design. Davis & Associates used a normal tooth positioner as they treated maxillary and mandibular arches. Babcock only treated the maxillary arch, even though treatment for the mandibular arch was indicated. He does not comment on why he did this but I suggest it was for experimental convenience. I prefer Davis & Associates' method of treating both arches together and insertion of a conventional tooth positioner.

Conclusion:

From all of these studies it is difficult to draw conclusions. The experiments of Babcock (1965) and Davis & Associates (1963) should be repeated with more patients who are all capable of good oral hygiene and recording their routine. The experiments need to be better controlled.

From these studies we can see that there is a possible use for tooth positioners in treating gingival conditions. However, as the gingival conditions arise as a result of poor oral hygiene, tooth positioners are not really indicated. It is best if we consider this to be a field that is open to further research.
Chapter 7 —

THE TOOTH POSITIONER AS THE SOLE TREATMENT APPLIANCE

INTRODUCTION

When Kesling formulated the idea of the tooth positioner, he was wanting to produce an appliance that would replace fixed appliances. He developed the tooth positioner, as we know it today. He only considered it capable of finishing cases, that is, completing the final detailed positioning of the teeth. Other workers have tried the tooth positioner as the sole appliance during treatment, many reporting success (Bunch, 1961; Wells, 1970; Clifford, 1971; Lorentz, 1973; Bergston, 1984).

It appears as though tooth positioners do have a limited role in orthodontics as the sole appliance for treatment.

Advantages

The advantages of being able to complete treatment with tooth positioners are varied. They include:

1. **Reduced cost.** If treatment can be completed with three tooth positioners, the cost would be about $200 for materials plus clinical time. This may be substantially cheaper than full banding. Unfortunately the results are also different from full banding as root torque cannot be consistently achieved with positioners (Vorhies, 1960).

2. **Simplicity for treatment planning.** For treatment planning for a tooth positioner, a Kesling setup is carried out. The Kesling setup is an excellent form of visual treatment objective and any potential problems should become apparent. Also only minor movements may be achieved with tooth positioners. Therefore, treatment planning should be simple.

3. **Simplicity of treatment.** The issuing of a tooth positioner to a co-operative patient and getting him or her to wear it is a potentially simple procedure. There is no great need for regular calls and adjustments. Tooth positioners are virtually indestructible and, if the patients co-operate, no harm can be done if the patients miss an appointment or two.
4. **Success is in the control of the patient.** With tooth positioners, success or failure is almost entirely determined by the patient. The greater the patient co-operation, the better the results, and visa versa. This is not necessarily an advantage, but it is a way of treating unco-operative patients without wasting a considerable proportion of the orthodontists clinical time. If the patient is very keen, there is also the possibility of him or her achieving a very good result comparable to the effort.

In contrast to these advantages, there are some disadvantages. These restrict the use of tooth positioners, as the sole appliance, to very few cases.

**Disadvantages**

1. **Discomfort.** If the teeth have not developed mobility, as is present following fixed appliances, then there will be pain and pressure associated with the initial wearing of the tooth positioner. Following fixed appliances this discomfort, if it occurs, will only last up to 3 or 4 days. However, if the teeth have not been moved, the discomfort will last a week or so. It may be difficult getting patients to persevere and overcome the initial soreness.

2. **Inability to consistently achieve certain movements.** Tooth positioners are unable to consistently achieve certain movements. The most important of these is root movement (torque or uprighting) and rotations in some teeth (Vorhies, 1960). This may make tooth positioners unsuitable for a large range of malocclusions.

3. **Limitation of distance moved.** The distance a tooth can be moved by a single tooth positioner is determined by the flexibility of the positioner material, as well as the biological limits imposed by the periodontal ligament. Silicones are more flexible than PVC materials, and therefore, more movement may be attempted. The force exerted on the periodontal ligament may cause pain sufficient to prevent wearing of the positioner (Bunch, 1961).

The limitation of distance is normally overcome by making a number of tooth positioners. Each successive positioner moving the relevant teeth a bit further.
Literature Review

Tooth positioners have been used, in the past, as a preventive, and corrective, orthodontic appliance during the treatment of scoliosis with the Milwaukee Brace. Bunch (1961) pioneered this work and his results, and those of fellow workers, are covered in chapter 8, on the treatment of scoliosis, in this thesis.

The ability of tooth positioners to move teeth was best assessed by Vorhies (1960). He examined ten cases. The patients wore rubber tooth positioners for an average of 31.8 days, averaging 17.3 hours wear per day. Vorhies inserted the tooth positioners following fixed appliance orthodontic treatment. Therefore, a degree of tooth mobility would have been present. The movements he measures are listed in Table 1. He measured the changes from lateral cephalometric radiographs and study models.

Vorhies realised his small study group and the short duration of the study would limit the conclusions he could draw. It is also important that he did not use a control group. With these factors in mind, we can consider Vorhies conclusions. They are:
1. A tooth positioner does not establish a definite pattern in the selective depression or eruption of teeth, i.e., from his examination of overbite changes, Vorhies found no set pattern;
2. Demonstrable quantitative changes may be accomplished with a tooth positioner in a short period of time;
3. Tooth torque improvement of anterior teeth is possible, but apparent success in some cases is an illusion and a resultant of other movements;
4. The axial changes of anterior teeth are primarily due to tipping when using positioners; and
5. The mandible may open in a hinge, or parallel manner, or not open at all when using a positioner.

Due to the exceptional co-operation that Vorhies received, and the fact that he used teeth with some mobility, Vorhies’ results would be the optimal we could expect.

In contrast to the excellent co-operation Vorhies obtained, Wells (1970) reported on tooth positioner patients who had co-operation ranging from fair to excellent.
<table>
<thead>
<tr>
<th>Movements</th>
<th>Maximum Reduction Achieved</th>
<th>Maximum Increase Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. intercanine distance</td>
<td>3mm</td>
<td>0.5mm</td>
</tr>
<tr>
<td>Mand. intercanine distance</td>
<td>1.5mm</td>
<td>0.5mm</td>
</tr>
<tr>
<td>Max. intermolar distance</td>
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<td>1.5mm</td>
</tr>
<tr>
<td>Mand. intermolar distance</td>
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</tr>
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</tr>
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<td>Max. incisor to NA</td>
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<td>11°</td>
</tr>
<tr>
<td>Mand. incisor to NA</td>
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<td>5.2°</td>
</tr>
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</tr>
<tr>
<td>Occlusal plane to NA</td>
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</tr>
<tr>
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<td>3.8mm</td>
</tr>
<tr>
<td>Anteroposterior movement mand. incisor</td>
<td>0</td>
<td>3mm</td>
</tr>
<tr>
<td>Vertical height of max. incisor</td>
<td>1.3mm</td>
<td>3mm</td>
</tr>
<tr>
<td>Vertical height of mand. incisor</td>
<td>1mm</td>
<td>2mm</td>
</tr>
<tr>
<td>Vertical height of max. molar</td>
<td>1.8mm</td>
<td>4mm</td>
</tr>
<tr>
<td>Vertical height of mand. molar</td>
<td>1.4mm</td>
<td>0.5mm</td>
</tr>
</tbody>
</table>

Table 1
The dental changes accomplished with short term intensive use of tooth positioners (Vorhies, 1960).
Wells considered only three patients, out of more than 1,000 he had treated, to be best suited to treatment by a tooth positioner alone. These three showed excellent co-operation. In these patients he corrected an anterior cross-bite, a buccal cross-bite, and an open bite case with 45° incisor rotations. Wells was able to correct lower incisor alignment and rotations of mandibular canines. He does not state if overcorrection of tooth positioning was used for the tooth positioner models.

Wells also discusses "long term non-intensive use" of tooth positioners. This positioner use followed minimal treatment that involved either a Hawley bite plate or extra oral traction. The positioner would again be expected to function as "more than a retainer". Wells found the tooth positioners effective, but rarely achieved full correction. An example of "long term non-intensive use" was night time wear only, or with occasional day-time wear.

Clifford (1971) utilised a tooth positioner to correct a severe anterior cross-bite in a 4 ½ year old child. He found co-operation very good and correction took less than six weeks. Jaw posturing appears, in the photographs, to have increased the severity of the cross-bite. I would be hesitant in using a tooth positioner to correct severe discrepancies.

Lorentz (1973) reported on the success of preformed positioners when used as the sole treatment appliance. The treatment was carried out up to 15 years prior to the assessment. Schuchard had developed a range of 15 different preformed positioners, varying in size, interocclusal space and molar relationship. These were the style used for treatment. On average, treatment was carried out by two positioners, though it may be more or less. I am uncertain how the two positioners issued varied. As it was malocclusions and antero-posterior discrepancies that were being corrected, perhaps a larger positioner is issued initially, with the latter ones being a more accurate fit.

Lorentz found that the treatment of 47 patients had been stable whilst 2 had relapsed. He concludes that a standardised positioner is suitable to treat some malocclusions if the patients are suitable.

Bunch (1961) was able to improve the occlusion of ten out of twelve patients who wore tooth positioners during Milwaukee Brace treatment of scoliosis. Bunch stressed that only small corrections could be achieved with each positioner and he used up to five consecutive positioners per patient.
Hitchcock (1969) also used tooth positioners to stabilise the teeth and achieving minor corrections during Milwaukee brace treatment. Hitchcock found devitalisation of two molars. This may have been due to deep carious lesions alone. However, Hitchcock considers the added pressures from the tooth positioners may have also been an important contribution. Hitchcock’s patients were able to correct antero-posterior discrepancies with the tooth positioners.

In 1984, on the television program “That’s Incredible”, tooth positioners were presented as a sole form of treatment. The clinician is Dr Bergeston. He terms his positioners “Occluso-guides”. The “occluso-guides” have been used to treat about 70 cases per year. He can only achieve small movements with the appliance, an example he gives is correcting an overjet of ¼ of an inch. From close study of his pretreatment and post treatment presentations, his main treatment success is from closing anterior spaces that are present whilst the maxillary canines are unerupted. The closing of these spaces is a natural procedure anyway so the “occluso-guides” cannot take all the credit.

Other Uses of Tooth Positioners

Tooth positioners have found other uses. These are not necessarily in the orthodontic field. Trask (1975) and Cooke & Wreakes (1978) both suggest using positioners as fluoride vessels for application of high concentrations of topical fluoride. As this topical application is normally practised following orthodontic treatment, the positioner issued as a retainer or active appliance is very suitable. The patient is therefore able to do his or her own home fluoride applications.

Tooth positioners have also been used for treatment of patients with temporo-mandibular joint disturbance. The treatment of these patients is controversial (Berry & Harris, 1985) and I follow the teachings of Klineberg (1985) that a bite plate is more beneficial. The patients must be allowed to move the lower jaw with anterior contact and canine disclusion.

Conclusion

To sum up the use of tooth positioners, as the sole treatment appliance, is difficult. They are used in this capacity, but their use is very restricted. The tooth positioners can also be utilised for related functions, however, their value is limited if used in this capacity alone. However, if a tooth positioner is to be used as the retainer following orthodontic treatment, it may be used as a fluoride applicator in conjunction to its retention function.
Chapter 8 —

THE USE OF TOOTH POSITIONERS DURING THE ORTHOPAEDIC TREATMENT OF SCOLIOSIS

INTRODUCTION

Scoliosis is the term applied to a lateral curvature of the spine. There is a wide range of causes, but treatment is basically the same for all cases.

Treatment is generally instituted with the Milwaukee brace and is timed to coincide with skeletal growth, and may be over a period of many years. Today, due to brace modifications, few orthodontic problems develop as a result of treatment. However, in the past the Milwaukee brace was the cause of severe occlusal disharmony and loss of facial height. This, as will be reviewed shortly, prompted use of stabilising devices, including tooth positioners.

The design of the Milwaukee brace incorporated a mandibular pad. Whilst the brace was worn, pressure may be exerted between a pad against the iliac crest of the pelvis, at the inferior end, and against the lower border of the mandible and the occiput at the superior end. Logan (1962) measured the forces and found them to average 2,000 gms. These forces are applied for about 23 hours per day. Due to the intensity and duration of these forces, especially during active skeletal growth, it is not surprising that considerable orthopaedic changes occur.

However, the deleterious effects need not occur. It is stressed to patients to hold their heads so the mandible does not rest on the chin pad. If this is done, there are no forces exerted and, therefore, no abnormal changes. But it is very convenient, and presumably comfortable, for the patients to rest their chins on the chin pad. If patients do this, undesirable changes invariably occur. Unfortunately, in the studies discussed here, the authors do not mention the patients’ head posture during each study. A tooth positioner, as could any appliance, may act as a reminder for correct head posture. In this way it may prevent undesirable changes. Each author believed greater changes would have occurred if the appliance examined was not worn.

O’Meara (1972) examined the problems associated with the Milwaukee brace therapy of scoliosis. He listed the changes as:
Dental changes:

(a) Increase in the overbite, closing of open bites.
(b) Protrusion of upper and lower teeth with concomitant spacing.
(c) Movement of molars buccally, and premolars buccally and mesially.
(d) Depression of maxillary and mandibular molars and premolars, with resorption of the alveolar process.

Considerable skeletal changes occurred. However, as these were not significantly effected by the wearing of tooth positioners, they will not be discussed here. The more important skeletal changes are:

(a) A forward and upward rotation of the maxilla and mandible.
(b) Reduction in facial height.
(c) Elevation of the palatal vault and flattening of the palatal plane.

Logan (1962) examined the overbite changes associated with Milwaukee brace therapy. He came to the conclusion that the increase in overbite is due to depression of the molar teeth into the alveolar bore.

The skeletal changes are more serious, mainly because they are more difficult to correct following treatment. The pressure exerted on the mandible is in the reverse direction to normal growth.

Eastham (1971) considered the loss of vertical dimension to be due to:

(a) A closing rotation of the maxilla and mandible.
(b) Partial inhibition of the vertical growth of the condyle.
(c) Resorption on the lower border of the mandible due to chin pad pressure.

Alexander (1966) examined the change in the gonial angle during Milwaukee brace treatment. He found a mean decrease of 4.5° with a range from 1.5-7°. Alexander attributes this to inhibition of growth along much of the lower border of the mand.

The cranial changes were examined by Cutler & Associates (1972) who found a reversal of normal downward and forward growth of the maxilla and mandible. The entire dento-facial complex was displaced in a superior direction. They recorded a loss in anterior and posterior facial height.

The problem of the dental and skeletal effects of the Milwaukee brace on the face, is clear.

Many techniques have been tried, including the use of tooth positioners, in an attempt to limit the side-effects. I will now discuss the details and results of the studies involving tooth positioners.
Howard (1926) was the first person to attempt stabilisation of the teeth during treatment of scoliosis. He used intra-oral splints, but was unsuccessful.

**Bunch**

Bunch (1961) was the first to publish the results of the use of a tooth positioner to stabilise the teeth and the maxillofacial complex. Bunch found, early in his study, that minor malocclusions, such as spacing, rotations and flared incisors, could also be corrected with the positioner and this became one of the aims of his treatments. He treated forty patients with tooth positioners during Milwaukee brace therapy. Treatment time varied from seven to thirty four months. One or more, and up to five, tooth positioners were worn successively during treatment. The treatment objectives were to maintain existing dental and maxillomandibular relationships during orthopaedic treatment. Where required, dental irregularities were corrected.

The positioners were made of vulcanised rubber with a rest position of two to three millimetres jaw opening.

When the positioner is inserted the maxillomandibular cranial complex, with integrated dental components, was stabilised against placement of the orthopaedic cast or brace. The force supplied by the weight of the head resting on the brace’s mandibular pad was supported by the teeth so that use of a positioner ensured that it was active in tooth alignment.

The patients were instructed to actively bite into the positioner for four or more hours a day. The active bite was to last for fifteen seconds and was followed by a one minute rest, with the teeth remaining in the positioner. Exercise periods were of 30 minutes or longer. The patients were instructed to wear the positioner during sleep and all wakeful hours except while eating, talking and cleaning the teeth.

Bunch found patient co-operation was the key to successful positioner treatment. Patients were encouraged but not complimented. He stressed to patients that progress lost through failure to wear the appliance was harder to regain a second time. Appointments for positioner patients were made to coincide so they could support and encourage each other, as well as, in some instances, compete with each other. Hospital staff were also instructed in the use and advantages of the positioner so the patients could be encouraged during hospital visits.

He considered that the positioner should feel like a cushion between the patients teeth within five to ten days. If it did not, the tooth movements in the
positioner set-up were not within the patients limit of comfort and within the positioner's corrective range. This can be restated as: if the tooth movements are too great, patient discomfort will result and the likely result of this is lack of co-operation.

Once the patient was accustomed to the positioner, lip exercises were introduced. Bunch does not describe the exercises except to say they were orbicularis oris exercises, repeated 30 times, 3 sessions a day. He considered the exercises developed maxillary lip tone and length. The combination of orbicularis oris and temporomasseter (i.e. clenching) exercises produced an interplay with the suprahyoid group of muscles. Circulatory stimulation attendant to this muscular activity appeared to be constructive in maintaining skin tone under the cervical portion of the cast.

Periodontal Health

Improved periodontal health was also evident. Although the patients maintained a high standard of oral hygiene, Bunch attributed the improved tissue tone to be the result of gingival massage due to the tooth positioner. The effect of the tooth positioner on the gingiva is an important aspect that will be discussed in Chapter 6. However, Bekeny and DeMarco (1971) showed there is no real effect. Bunch does not explain how he came to his conclusion concerning gingival health. He may have compared the positioner patients to the control patients. In this case the controls would be experiencing rapid and uncontrolled tooth movement labially and buccally. Therefore, their gingiva would be expected to be pathologically involved. If this was the case the positioner would be credited for the gingival health. However, its method of achieving this is by tooth control, not by gingival massage.

Alternatively Bunch may have examined the gingival health in each patient before and during positioner treatment. If this was the case the improved gingival health may be the result of improved oral hygiene by the patients who virtually all showed they were very co-operative.

Bunch found that if food material or debris became trapped between the gingiva and the positioner, gingival irritation did result. Therefore good oral hygiene was stressed.
Difficulties:

Bunch found the only difficulties with positioner wear was during periods of nasal obstruction. He considered this more of a problem at night as during the day the patient could remove and re-insert the positioner as required.

Bunch did record problems occurring due to the eruption of teeth. As each tooth erupted, it took extra pressure from the positioner and consequently became sensitive. As a result the patients stopped biting firmly into the positioner. To overcome this the positioners were trimmed. I could envisage trouble arising if too much material was removed, allowing over-eruption of the tooth. Bunch does not mention this as a problem. A remake of the positioner is one way of avoiding this problem.

Examination of Patients Undergoing Positioner Therapy:

Bunch listed his method and order of procedures when examining patients. This is a valuable list due to its completeness and is a good guide when examining any patients wearing positioners.

His list is:
1. Proper insertion and complete seating of positioner in mouth.
2. Force of biting into positioner.
4. Keeping teeth engaged in positioner during relaxation period after exercise.
5. Evidence of local soreness.
6. Evidence of tooth soreness.
7. Tooth mobility.
8. Tooth movement.
10. Vertical dimension.
12. Cleanliness of positioner.
15. Lip position and development.
16. Time that positioner is being worn.
17. Attitude and co-operation of patient.
18. Encouragement of patient.
Patients should be informed at the time of insertion of the positioner, that the teeth will be sore for four to six days. There will also be a mobility of the teeth that may or may not be noticeable.

For patient comfort, Bunch preferred to insert the positioner a week or so prior to the placement of the orthopaedic cast. This allowed the patient to overcome one hurdle at a time as well as stabilising the facial complex for cast processing.

Results:

In thirty five of the forty cases satisfactory maintenance or improvement of the dental occlusion was possible by wearing positioners in conjunction with orthopaedic casts and braces.

In two of the unsuccessful cases, later co-operation allowed an improvement of the deteriorated occlusion. In the three remaining unsuccessful cases co-operation was completely lacking. Therefore co-operation was a positive factor and appears to be the most important consideration leading to success or failure of tooth positioner therapy.

A limitation in the extent of tooth movement possible with a dental positioner was recognised in the study.

The patient’s comfort is seemingly improved by the wearing of a positioner during placement of a body cast and brace.

Conclusions:

Bunch came to the following conclusions:

1. Tooth positioners appear to play a valuable role during the orthopaedic treatment of spinal scoliosis by maintaining or improving dental and craniofacial relationships and by preventing dental malocclusion during such orthopaedic treatment.

2. Stability of orthopaedic casts or braces in treatment of scoliosis is enhanced by constant wearing of tooth positioners.

3. Repositioning of the teeth, within physiological limits, and within the positioner’s range of action, was shown to be possible in treated clinical cases.

4. Tooth positioners were well tolerated by patients.

5. Tooth positioner treatment is directly under the patient’s control, which must be recognised as being disadvantageous in principle.
The conclusions are straightforward and as expected. However, the final point is very important and very well expressed. Bunch found co-operation and success went together.

Later Studies:

Bunch's results must have been a stimulus to many orthodontists. This appeared the most successful method of preventing a malocclusion over which they previously had little control.

Alexander

Alexander (1966) commenced a long term study. From this he produced one set of results after an average of 6-7 months of Milwaukee brace and tooth positioner wear.

Alexander's methods differed from Bunch's. He felt that to expect patients to wear the positioner for 23 hours per day was impractical. However, his patients were still instructed to wear the positioner all the time except when eating or brushing the teeth. This was especially stressed for the first 48 hours. From Alexander's experimental group of seven, one patient did not wear the positioner, one averaged 12 hours per day, and the remaining five averaged 16 to 22 hours per day. Alexander had the positioners constructed without palatal coverage. This allowed the patients to speak and be understood whilst wearing the positioner.

Alexander also used seven controls in his experiment. Bunch did not, he considered the results of the orthopaedic brace on the dentition was well documented and accepted. Bunch did use his unco-operative patients as a small control group for some comparison. Alexander's study consisted of seven experimental subjects and seven controls.

The tooth positioners were made from sheets of opaque copolymer vinyl thermoplastic material. The positioner was manufactured on casts mounted on an articulator in centric occlusion. It was adjusted so that there would be no interference with normal movement of erupting teeth. The palate and labial gingiva were not covered. Alexander felt this allowed the patient to speak, and be understood, with the positioner in place. It is not explained how this differed from other designs and neither myself nor Kesling (1985) are able to understand why the patients were able to speak more clearly. Alexander later found that full palatal coverage was necessary.
The positioner was constructed with the mouth open two to three millimetres to rest position.

It was inserted when the Milwaukee Brace was first placed and the patient was instructed to wear it at all times except when eating and brushing the teeth.

The patients were instructed in oral hygiene procedures, an electric toothbrush being recommended as they usually had trouble keeping their mouth open. When the teeth became sore they were to gargle with hot salt water and continue to do so until the soreness had gone. Patients were allowed to relieve sore spots by cutting away the irritating spot on the positioner with cuticle scissors. Recall of the patients was at three-month intervals.

Alexander’s results cannot be considered conclusive, because his period of observation averaged only 6–7 months. Milwaukee Brace therapy is frequently for three years or more. Fairleigh followed up Alexander’s research but his full results were never published. However, Eastham (1971) refers to Fairleigh’s thesis and presents some of the results. Importantly these results are different from Alexander’s short term study.

Alexander’s experimental group wore the positioner for between four and eight months, averaging 6–7 months. His control group were observed between three and eight months, averaging 5–4 months. Only one experimental group patient failed to co-operate, the rest wore the positioner for an average time per day of 12 hours (one patient), 16 hours (two patients), 20 hours (one patient) and 22 hours (two patients).

Alexander’s results were:-

1. Proclination of the anterior teeth was controlled. In the control group the average increase in the upper incisor to SN plane was 12°, for the lower incisor to mandibular plane, 10.5°. In the tooth positioner group, the average increase in the upper incisor to SN plane was only 3.6°, and for the lower incisor to mandibular plane, 2.6°.

2. The tooth positioner did not significantly prevent loss of facial height, nor molar depression. The lower molars were found to be depressed more than the upper molar. The loss of facial height was attributed to this. Vertical growth was also affected. Cephalometric radiographic evaluations demonstrated a change in the direction of growth from the normal. However, no inhibition of growth could be found.
3. Alexander found that patients were capable of speaking with the positioner in place. He found that some of the patients from the control group had more difficulties with speech than the tooth positioner patients had whilst wearing the positioner. He attributes the speech problems of the control group patients to proclination of the anterior teeth. To assist speech, tooth positioner patients were instructed to talk or sing aloud as often as possible during the first few days after receiving the appliance.

4. The pattern of patient discomfort was similar in all positioner patients. The teeth began to get sore 4-5 hours after the Milwaukee brace and positioner were placed. For the next 48 hours the gingiva and tongue were hypersensitive. Pressure point ulcers appeared during this period and were relieved by proper adjustment of the positioner. By the end of three days, the mouth and teeth were no longer sensitive. Alexander achieved tooth movements with the positioner. Once patients were accustomed to the positioner they found it quite comfortable, some patients even considered the positioner made wearing of the Milwaukee brace more comfortable. One patient, however, considered the positioner more uncomfortable to wear than the brace. This patient did not wear the positioner for long.

5. Discoloration of the positioner became a problem. A rust coloured film also collected on the appliance and unpleasant odours were produced. It was difficult to clean the positioner when like this. On occasions it was necessary to make a new appliance.

6. In two cases the positioners failed as they were chewed through. In both cases the patients had developed nocturnal bruxism. My work has shown that any lateral chewing action will lead to fairly rapid breakdown of tooth positioners. Kesling (1969) stresses that biting forces must be vertical only.

7. Alexander comments on the design of his positioners. He considers the labial bulk necessary for strength. This is clear as one of the main movements being countered in his patients is proclination of the anterior teeth. Alexander raises the relevant question “how far gingivally must the material reach?” As it is a retentive device, and not an active device, half way up the tooth may be adequate. Alexander tried such a positioner but the results are not recorded. I suggest caution here as the teeth may be prevented from proclining labially but may instead move bodily labially. This is potentially a more damaging situation. Initially the positioners did not have palates in them, this assisted speech. However, the study showed decrease in
palatal height during the experiment so it was decided to place palates in all positioners. Alexander does not comment whether this alters the ability of the patients to talk and be understood.

8. Alexander was able to achieve a degree of correction of tooth position during positioner use. He achieved this by using a series of positioners with the corrections built into them. He does not give detailed results of what was achieved.

9. The palatal vault decreased in ten of the fourteen patients. There is no significant difference between the two groups of patients, probably as the positioners did not have palatal coverage. Alexander suggests that coverage of the palate may have prevented the decrease in palatal vault depth, but may have displaced the palatal plane superiorly.

Farleigh

Farleigh never published the results of his study. Fortunately Eastham (1971) refers to it and gives some of the results. Farleigh’s study was a continuation of Alexander’s study, and so we may assume the method was identical; in fact many of the patients must be the same. Farleigh looked at his patients after wearing the positioner for 525 days, i.e. one year and five months. Farleigh found that extreme collapse of vertical facial height and large increases in incisor proclination had occurred in the experimental group. It was concluded that the positioner had limited long term value as a stabilising appliance.

Eastham

Eastham (1971) compared a range of materials and methods for stabilisation during Milwaukee Brace therapy. He evaluated growth by the use of metallic implants, using Bjork’s technique. The materials studied included:

1. Thermoplastic vinyl tooth positioners. This is from the study of Alexander and Farleigh.

2. Impak plastic tooth positioners:

3. Silastic tooth positioners, with a metal frame.

The performance of these positioners were then compared to a control group, as well as patients treated with multibanded therapy, a vitallium splint and a processed acrylic splint, similar to a tooth positioner.
Findings:

1. Control Group. These patients were observed for an average of 9.7 months. The findings agreed with previous studies but the radiographic assessment demonstrated an upward and forward rotation of the maxilla and the mandible.

2. Processed acrylic appliance. There were ten patients in this group observed for an average of 9-9 months. The appliance is similar to a tooth positioner but on the labial and buccal surface it does not go further gingivally than the height of the line of greatest convexity.

This material was successful in stabilising the occlusion and possessed many advantages. However, if it was not worn at least eight hours each day it would not fit properly. If left out for 24 hours, it would produce pain on reinsertion.

3. Vitallium splint. The vitallium splint consisted of a labial and lingual bow, with reinforcement where required. All teeth were held firmly, though only by a cast bow a few millimetres wide. The maxillary and mandibular splint were separate. This splint also provided good stabilisation. However, it also did not fit correctly if not worn for at least eight hours per day.

4. Multibanded therapy. Three patients were treated for an average of 14-3 months. Full orthodontic banding was performed and a heavy stabilisation arch was inserted. This was not considered suitable due to oral hygiene problems. Some movement and mobility of the teeth was noted, but this may have been because the stabilising arch was not completely passive.

5. Thermoplastic vinyl tooth positioner. The thermoplastic vinyl used in this experiment was similar to that used by Alexander and Farleigh. Eastham also found the thermoplastic vinyl had limited long term value as a stabilising appliance in conjunction with the Milwaukee brace. It did have the advantage, though, that the positioner was relatively inexpensive, easy to fabricate, could be used on patients during the mixed dentition, and would fit patients with a severe malocclusion. The material did fail periodically. After four or five months it lost its form, resiliency and retentive properties, requiring it to be remade. Odour and discoloration were also major problems.

6. Silastic with a metal frame. Four patients wore silastic positioners over an average period of 5-3 months. A wire screen was incorporated into the palate for rigidity. Silastic is softer than the impak plastic and this appliance was the one of choice for cases of severe malocclusion. Unfortunately its softer nature required a
greater bulk to be used and this was uncomfortable for patients. Minor tooth movements were achieved with this positioner. Eastham found silastic very tough and not easily ground or adjusted, this could be a significant problem. The material was very durable and odour and discoloration were only minor problems.

7. Impak plastic Tooth Positioners. Three patients were studied with impak plastic positioners, for an average period of three months. It is quite bulky and required considerable adjustment before it was accepted by the patient. It is also very porous and odour and discoloration were serious problems. Eastham attributes laboratory technique to the high porosity and suggests that if they were manufactured better, the porosity may be negligible.

Method:

Eastham instructed his patients to wear the removeable appliances during sleep as well as two to three hours after school. This may not be the ideal duration for positioners. However, patient comfort is considered as an important factor and that is why the positioners time was not extended.

Results:

Eastham considers processed acrylic and silastic appliances the best, followed by, in order, vitallium, Impak plastic, multi-banded therapy and thermoplastic vinyl appliances.

The more rigid appliances reduced the amount of vertical facial loss by reducing intrusion and tipping of the teeth. However, downward and forward growth was still a rare form of growth of these patients. Radiographic assessment showed the vertical loss was partly sutural and partly by dental intrusion.

Eastham noted that some appliances unseated the condyle from the fossa. He does not conclude whether this is favorable or not, but suggests that if the brace pressure conducted via the ramus onto the condyle into the fossa, is damaging, then unseating of the condyle may be beneficial.

Recommendations:

Eastham recommends intra-oral stabilising appliances for all patients. The hard processed acrylic splint is the appliance of choice. However, if minor tooth movement is indicated, the hard silastic tooth positioner is recommended.

Other Studies

Only two other reports of tooth positioner use, as an adjunct to Milwaukee Brace therapy, are available. Hitchcock (1969) describes a successful case, the positioner being inserted some time after Milwaukee Brace treatment had
started. Initially there is considerable protrusion of the anterior teeth. After only four months of positioner wear (a black rubber positioner worn 21 hours per day), during which time the positioner was remade once, the teeth were corrected. This is very considerable improvement for only two positioners within four months. The forces were probably quite high and it is interesting to note that two molars had to be extracted due to loss of vitality. However, one of these did have a deep restoration.

Luedtke (1970) used positioners made of "Vangard" material. Ten patients, wearing the appliances for fourteen hours per day for one year, were studied. His results were consistent with other findings. There was a slight decrease in vertical dimension, attributable to slight intrusion of posterior teeth and proclination of the anterior teeth. Dental arch width, palatal vault height and horizontal and vertical overlap remain stable under the influence of the "Vangard" appliance used 14 hours per day.

Summary

Tooth positioners, made of various materials, are effective in retaining the tooth positions and occlusion against the severe effects of the Milwaukee Brace. Rigidity appears to be the most important factor and the material used should be selected with this in mind. Other appliances are also effective and they too should be considered.

Application:

Today, the Milwaukee Brace is of a different design. There is no longer a mandibular support, which was the cause of the problems. Now a throat pad is utilised and occlusal problems are very rare. Consequently, there is no longer any requirement to utilise tooth stabilisers of any form.

However, the lessons learnt during this treatment are important. We cannot predict future problems and possible uses for the positioners. A possible use could be as a post-surgical splint. Kesling (1945) used positioners for reduction of fractures of the mandible and maxilla, even in severe cases. He considers the positioner has tremendous possibilities in this capacity. For jaw stabilisation, the positioner is worn in conjunction with a rigid headgear connected by elastic force to a chin cup. Although the positioner is not used in this role today, we cannot rule out a widening of its present uses into this field. At present full banding therapy or vitallium splints are used to stabilise jaws. Both have similar problems to those experienced during Milwaukee brace therapy. Tooth positioners are not ready to take over their function. However, they would appear to be an excellent adjunct to restoring function, retraining muscles and settling tooth positions once fixation of the jaws is no longer required.
Chapter 9 —

PREFORMED POSITIONERS

Introduction

Preformed positioners were first produced by Orthotain Inc., in 1972 or 1973. T.P. Laboratories Inc. were reluctant to produce a similar appliance, but decided to do so due to requests from orthodontists (Kesling, 1985). The reluctance of T.P. Laboratories was due to their belief that custom-made tooth positioners were better. This is true. However, the preformed positioner has found a role that varies in some ways from the manner in which the custom-made tooth positioner is used. This should become apparent by the end of this chapter.

Although preformed positioners were first produced by Orthotain Laboratories, two patents had already been taken out for them. One patent was taken out by a Frenchman, Andre Tornier, in 1955 (T.P. Laboratories Inc., 1978). The other patent was taken out by Theodor Schuchard in 1952 (Lorentz, 1973). Schuchard manufactured and used preformed positioners for many years.

The only preformed positioner that is available in Australia is the T.P. Laboratories "Prefinisher". "Prefinishers" are available from A.J. Wilcock. Due to the generosity and assistance given to me by T.P. Laboratories Inc. and A.J. Wilcock, I can present considerable information on their products.

"Orthotain Inc." still produce preformed positioners, but as they did not reply to my enquiries I cannot supply information on their preformed positioners. The only orthodontist I found who had used Orthotain preformed positioners has changed to "Prefinishers". He found the larger range of sizes in the "Prefinisher" allowed him a more accurately fitting appliance (Fricker, 1985).

Prefinishers"

"Prefinishers" are available in 21 sizes. They are produced in one millimetre size increments, from 40 to 60 millimetres, inclusive. The measurement is the distance from the distal edge of one canine, around the labial surface, to the distal edge of the contralateral canine. T.P. provide a special ruler to measure the distance (fig. 12).
Using Special Millimeter Ruler

Designed to help determine proper Pre-Finisher sizes by measuring either six or three anterior teeth.

Ruler may be used on patient's right or left side, according to operator's preference. A reading may be obtained in one of two ways:

1. For quick, easy measurement in the mouth, use the condensed scale in the center of the ruler. Place the point distal to either the right or left upper cuspids, curve the ruler along the incisal edges. Reading at midline indicates total mesiodistal width of upper anterior teeth. (Note—Each mark on condensed scale equals two millimeters).

2. For more accurate measurement in the mouth, or when measuring a model, use the full-length scale at the end of the ruler. Place the point distal to either the upper right or left cuspids, bend the ruler along the incisal edges, and take reading distal to opposite cuspids.

Select an appliance from the proper series having a part number ending in two digits the same as the millimeter measurement. If there are band spaces, select a Pre-Finisher one size tone millimeter smaller.

Fig. 12: The ruler supplied with "Prefinishers".

Fig. 13: "Prefinishers" before (clear) and after (white) use.
PLACEMENT
Use a mirror when learning to place your Pre-Finisher. Fit it to the upper teeth first, following the procedure suggested by your orthodontist. It may be necessary to stretch and hold it in place with your fingers, until your lower teeth are closed into it. Soaking the appliance in hot (not boiling) water for 30 to 40 seconds will make it softer and facilitate placing. As your teeth move, and you become more familiar with it, it will become much easier to place.

WEARING
Once you have learned to place your Pre-Finisher properly, you must practice exercise wearing. Bite firmly into the appliance, and hold it under pressure as long as possible. At first you may only be able to exercise for periods of 10 to 20 seconds before your muscles become tired. Then relax—but don't open your mouth. The Pre-Finisher can help your teeth even when you aren't biting into it—but, of course, it has much more effect and moves your teeth more quickly, when you force your teeth into it.

Usually the Pre-Finisher is worn while sleeping. This is called night-time, or relaxed, wearing. Of course, the benefits are not as great as from exercise wearing, but it does help maintain corrections achieved during the day.

SCORECARD
The numbered areas of each letter represent a day's wearing of your Pre-Finisher. If you wear it exactly as required the first day, fill in with a marking pen or pencil the entire No. 1 area.

If you only wear it two-thirds of the prescribed time, fill in only two-thirds of the area. REMEMBER—night-time wearing only equals one hour of exercise wearing.

KEEP WORKING FOR A WIDE SMILE

POSSIBLE PROBLEMS

Congratulations—you finally got your braces off! However, as your orthodontist has told you, the job is not complete. There may be spaces between some of your teeth, and other slight adjustments to be done.
To help finish your orthodontic treatment, he has just given you something to "sink your teeth into"—a Pre-Finisher.
The Pre-Finisher is a soft, resilient finishing appliance in which the tooth impressions are in perfect positions. As you exercise (bite) it into, it stretches and pushes back against your teeth. The pressures applied will be in just the right directions to help finish your treatment.

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“Prefinishers” are available in three models. Each model accommodates a different treatment form, i.e., non-extraction, four bicuspid extraction, and extraction of upper bicuspids only. They may also have seating springs to assist retention in the molar region.

When worn, “Prefinishers” absorb moisture, producing a dramatic loss in their translucency (fig. 13). The “Prefinisher” is initially very clear, but as moisture is absorbed the appliance turns an opaque milky white. If the appliance is put out to dry it will become clear again. Many orthodontists, (and I agree with them) consider the colour change to be an indication of patient co-operation. If the “Prefinisher” has not been in the mouth it will not have taken up moisture and so remains clear. Fortunately patients do not realise the colour change is due to moisture uptake, and I have not heard of any cases of patients leaving the appliance in a glass of water. Unfortunately, in a dry climate, the “Prefinisher” may be able to lose, by evaporation during the day, the moisture it absorbs during use. T.P. provide a container to store the appliance in during the day. If this is done then evaporation would probably be negligible. John Fricker (1985) reports no problems of this kind even through the hot, dry summers of Canberra. In contrast, Peter Kesling (1985) feels the chance of daily moisture loss is too high and so the colour change “can in no way be considered to be an indication of the degree of co-operation by the patient”.

I consider the colour change is an excellent indicator of patient co-operation. However, the patient must store their “Prefinishers” in the container supplied when it is not being worn.

The risk of falsely accusing a co-operative patient of being unco-operative does exist. Therefore colour change must not be used as an absolute indicator of co-operation. Orthodontists who use “Prefinishers” have found that once the colour change starts to occur, patients realise that co-operation may be accurately assessed. The patients will virtually always become very co-operative (Fricker, 1985; McLachlan, 1985). It is very rare for a patient to cease co-operating once they have done so for a few weeks, particularly as the wearing of “Prefinishers” is reduced or even stopped after a short period.
Method of Use of Prefinishers

T.P. Laboratories have produced a very good booklet titled "Congratulations - You Have Selected Prefinisher". This booklet introduces the "Prefinisher", describes its functions and operator's expectations, and the method of use. I have not followed the recommended method of use here as I have been guided by the clinical experience of others (Fricker, 1985; Rapaport, 1985). It is important that the patients are completed to a normal orthodontic finish. Inadequate treatment is the main cause of failure of these appliances and, as I stress later, the preformed positioner is a passive appliance that guides settling. It is not active. The booklet from T.P. Laboratories Inc. is reproduced in Appendix 5.

The "Prefinisher" is inserted following the removal of fixed appliances. Immediate insertion is a considerable advantage of the "Prefinisher" over other retainers.

To select the correct size, the distance from the distal of one canine to the distal of the contralateral canine is measured using the T.P. supplied ruler. The midline of this length is shown by examining the same measurement on the half scale readings at the centre of the ruler. The dental midline should coincide with the ruler-determined midline. If these do not agree there is a size discrepancy between the right and left side and the "Prefinisher" may not fit. The desired size "Prefinisher" of the correct model or series, according to the extraction regime, is then selected. If band spaces, or other spaces are to be closed a slightly smaller sized appliance may be selected.

The "Prefinisher" is once again demonstrated and explained to the patient. It is then inserted. As with other positioners it is usually easier to insert the maxillary anterior segment first, followed by the maxillary buccal segments, and the patient then occluding the mandibular arch into its position of best fit. If the "Prefinisher" is too stiff to insert easily, it may be soaked in lukewarm water for 15-30 seconds. If fit is still unsatisfactory another size should be tried.

If extra retention is desired, or more than one millimetre of space closure is desired, a "Prefinisher" with seating springs should be used. I was unable to find an orthodontist who uses "Prefinishers" with seating springs so I cannot comment on their effectiveness.

The T.P. booklet suggests adjusting the seating springs, to increase retention, by bending their arms to the mesial. When inserting "Prefinishers" with seating springs, one buccal segment should be seated first, then the anterior segment followed by the other buccal segment.
The fit of the "Prefinisher" may be assessed, due to the transparency of the material. The fit should be examined with the jaws relaxed and then clenched. When assessing the fit, we should examine the distal surfaces of the teeth, especially the canines. There should not be space to the distal of any tooth, otherwise spaces may open in the arch.

It is rare for the appliance not to fit due to a dental non-conformity, apart from ones such as over-corrections, we want corrected. If there is a dental factor preventing satisfactory seating, for instance considerably shovel shaped incisors, or a palatal cusp on the canines, the "Prefinisher" may be adjusted with a large acrylic bur.

Unfortunately, adjustments to the tooth sockets is difficult. Poor fit due to tooth morphology will, if present, normally prevent the use of "Prefinishers". However, this is very rare.

The impingement onto the gingiva should also be assessed. This should be done whilst the jaws are clenched. If the "Prefinisher" impinges onto the gingiva there will be blanching of the gingiva in the area. The appliance should be relieved with an acrylic bur until there is no more blanching.

Once the fit of the "Prefinisher" is satisfactory, the wearing instructions are given. These are the same as for custom-fitted tooth positioners and so will not be repeated here. However, if the "Prefinisher" is used as a short term appliance, it should be stressed to the patient that excellent co-operation is required so that he or she can progress to the next stage. It is also important to tell the patient to store the "Prefinisher" in the container supplied, when it is not being worn.

The patient should be recalled after one week to ensure there are no problems, and co-operation is satisfactory. The appliance will usually have started its colour change. The following visit could be two or three weeks later.

If the "Prefinisher" is to be followed by a standard retainer, the impressions should be taken at one of the follow-up appointments. The impression must not be taken at the same appointment that the bands are removed as this would negate the movements achieved by the "Prefinisher". At best the conventional retainer just would not fit. My experience, and those of the orthodontists I spoke to, is that if the positioner is worn correctly, then virtually all the desired tooth movements, apart from vertical movements, occur in the first week. Therefore, at any time after one week the impressions for the conventional
retainer may be taken. The use of the “Prefinisher” is continued until the conventional retainer can be inserted. The preformed positioner is superior to the conventional retainers in controlling rotations, holding space closure, and guiding erupting and settling teeth, particularly molars.

When the desired movements have been achieved and stabilised sufficiently, the “Prefinisher” may be replaced by a conventional retainer. T.P. Laboratories Inc. suggest the “Prefinisher” be used for one to twelve weeks.

The patient may keep the “Prefinisher” for later use if desired. Alternatively it may be recycled by the orthodontist. Recycling a “Prefinisher” involves drying it out, followed by chemical sterilisation. Chemical sterilisation may not be considered suitable for all operators. Recycling was not routine with any of the orthodontists I questioned. I would expect reluctance from the patients to wear an appliance if they realised it had been worn by another patient. As co-operation is paramount with positioners, we must not make the positioner unpleasant for the patients.

**Clinical Experiences**

To evaluate the clinical use of preformed positioners, I made extensive enquiries to find orthodontists who use these appliances. Seven orthodontists replied to my questions. From the answers received I have arranged the following information for which I am grateful to R. Aston, J. Fricker, R. Fryer, M. McLachlan, M. Rapaport, D. Scott and D. Vickers.

All the orthodontists presently use the T.P. Laboratories produced “Prefinisher”. One had used a Rocky Mountain preformed positioner but considered these too hard. Another orthodontist used Orthotain preformed positioners but experienced problems with their availability and their poor size range. Orthotain Inc. do not have a supplier of their products in Australia. Consequently the positioners must be ordered from America. Four orthodontists have used the “Prefinishers” for about four years, one for eighteen months and two for four months. As the latter two are still familiarising themselves with the appliance, I mention their inexperience if I discuss observations that are theirs only, to differ from those of the long term users. The orthodontists are all very happy with the results obtained.

Five orthodontists regularly use the “Prefinisher” as the sole retainer after the removal of fixed appliances. One does so for the minority of his cases, four
do so for the majority. All closely monitor progress and will revert to a conventional retainer if the preformed positioner is unable to prevent undesirable changes.

All orthodontists do, on occasion, follow the "Prefinisher" with a conventional retainer. The conventional retainers used include Howley retainers, Begg retainers, Spring aligners and lower fixed lingual bars. The "Prefinisher" is usually worn for the initial five to six weeks. The impressions for the conventional retainer are taken one to six weeks after the insertion of the "Prefinisher". As insertion of the retainer, a week or more after the impression is taken, is no problem, this indicates that little tooth movement has occurred during the manufacturing period. This concurs with the orthodontists' general observations that most tooth movement occurs in the first week.

All of the orthodontists consider the "Prefinisher" to be a passive appliance only. This is a very important aspect and they consider that failures are the result of people expecting too much from the appliance. The two orthodontists who always follow the "Prefinisher" with a conventional retainer report that it cannot always be relied on to align over-corrections. However, most of the operators have found that, in some cases, it will align teeth and operates as an active appliance. Unfortunately, these successful cases cannot be predicted. I would expect the accuracy of the fit of the patient's teeth, compared to the tooth sockets in the "Prefinisher" to be an important factor.

Compatibility with Preformed Archwires

Today there is a mini revolution in orthodontics with preformed, premade appliances and accessories. These "plug in, pull out" appliances receive criticism as they are all of "average" fit, and so could not be as good as an appliance custom made for the individual. Examples of appliances in this category are preformed archwires, and preformed positioners.

As one manufacturer produces both preformed appliances, I would expect both to be of the same arch form, which they are. Therefore, if an orthodontist used preformed archwires for a Stage IV archwire, his arch form would automatically suit the preformed positioner. To see if this was true in practice I asked the orthodontists what their experience was. The replies surprised me. All but one gave a polite but very definite NO, they do not use preformed archwires. The other uses preformed archwires but modifies their shape routinely so he could not assist my enquiry.
From these replies I draw an inference that the orthodontists who use preformed positioners do not do so for convenience alone, otherwise they would also use preformed archwires. I believe that the results are very important to them and they use the preformed positioners because they obtain the quality of finish they desire with them.

**Advantages of Preformed Positioners**

The advantages of preformed positioners are considerable. They make the appliance unique. It is not a substitute for anything else, nor is it a compromise. To understand this, we must assess these advantages. They are:

1. **Convenience:** The preformed positioner is a very convenient appliance to use. Stocks can be kept in the surgery, and immediately the fixed appliances are removed the positioner may be inserted. The only other appliance that is regularly inserted on the same day is the tooth positioner. Same day insertion of a preformed positioner does not require the logistics that the tooth positioner does. Relapse occurs mainly in the first five hours after removal of fixed appliances (Reitan, 1969; Brain, 1969). Therefore, immediate insertion of a retention device is very desirable.

Convenience for branch practices is also very important. If a branch practice is only visited every two to six weeks, the insertion of the retainer may not be able to wait until the next visit. There is no need for this delay if preformed positioners are used.

2. **Efficiency:** A prefinisher is capable of producing very good results if worn correctly. The orthodontists I spoke to had considerable praise for the appliance and I was unable to find one with criticism of preformed positioners. It was stressed by different operators that preformed positioners were excellent for deep bite cases. They are also very useful for guiding the eruption of second permanent molars.

3. **Minor corrections may be achieved:** I was uncertain whether to include, or to leave out, this point. As stated earlier, minor corrections may be achieved in some patients. The variables affecting success would appear to be patient cooperation and closeness of fit of the preformed positioner. Therefore, as “eternal optimists”, orthodontists may try to achieve minor corrections with due regard to the variables and likelihood of success. Corrections achieved by the orthodontists I questioned include minor rotations of lower incisors, small midline discrepancies and alignment of over-corrections.
4. **Cost:** The preformed positioner is a low priced appliance. In May 1985 they were sold by A. J. Wilcock for $32 without seating springs and $37 with seating springs. These prices are considerably cheaper than any other form of retention for both arches. I do not believe orthodontists use preformed positioners to save money. Indeed, many use them as an extra appliance, followed later by the conventional retainer. The low cost allows the appliance to be used in such a way.

   If a tooth positioner was used, the extra cost would have to be passed on to the patient and this may not be justified.

5. **Co-operation can be assessed:** Co-operation is a problem throughout orthodontic treatment. Normally the level of co-operation is only assessed by questioning the patient and parents, and assessing the treatment results. "Prefinishers" have a significant improvement over these methods by having the appliance change colour depending on use. As co-operation is such an important facet of positioner use, this advantage is very significant.

6. **Gingival health:** As tooth positioners have been claimed to assist gingival health, I asked each orthodontist what his clinical impression was. It was interesting that only one attributed the "Prefinisher" with the ability to improve the recovery of the gingiva from the orthodontic treatment. The general feeling was that, with proper care, the gingiva recovers very rapidly. Patients selected for treatment with a positioner are those that would also have very good hygiene.

**Disadvantages of Preformed Positioners**

   Preformed positioners are not the answer to all our problems. They are appliances that will benefit our patients if used within their ("their" applying to both the patient's and the appliance's) limitations. These limitations should be given careful consideration as failures only really occur when they are exceeded.

1. **Patient co-operation is paramount.** A retainer that does not require patient co-operation is desirable. Unfortunately, preformed positioners are at the other end of this spectrum. More co-operation is required with positioners than with any other form of retention. For the first four to six weeks the patient should wear the appliance actively for four hours per day, plus during the night. After this the wearing time is reduced in stages until after three to six months it is worn only during the night.
Patient co-operation is easier to achieve where the positioner is only to be worn for four to six weeks. Some orthodontists tell their patients that once they reach a certain standard of wear, and consequently tooth positioning, then the positioner will be replaced with a simpler appliance. Of course, the patients are not told that if they fail this test dismally they may receive the conventional retainer even sooner.

However, it should not be construed that this is an uncomfortable appliance or that co-operation is always a problem. Some patients prefer the positioner as it is only worn in the evenings and at night. There are also a good number of patients who would prefer to have a positioner, to achieve a better result, than to have a conventional retainer. The orthodontists who use “Prefinishers” state that these patients invariably receive an excellent result.

Fortunately, co-operation can be assessed by observing the colour change with “Prefinishers”.

Patients who are likely to be poor co-operators should not be given a positioner. The orthodontists questioned all noted that lack of co-operation is becoming less of a problem due to their ability to assess patients better. Some also noted that with time they are becoming more confident with the results of the positioner and are better able to instruct and convince the patient to use the appliance, and this reduces the number of patients who fail due to lack of co-operation.

One orthodontist uses firm guidelines and only his top 40% of patients receive positioners. This would seem to be ideal to me, but unfortunately we are all optimists and it is the patients who need a positioner (due to failure to co-operate earlier perhaps) that produce our most spectacular successes, or failures, depending again on their co-operation at this late stage.

2. Poor fit of appliance: The preformed positioner, being made to average sizes, not fit all patients.

Orthodontists who routinely follow the “Prefinisher” wear with a conventional retainer report that between one and five per cent of patients do not fit a “Prefinisher”. The orthodontists who use the “Prefinisher” as the sole retainer, reported 15-25% of patients do not fit a “Prefinisher”. Perhaps the longer period of wear reveals minor incompatibilities in fit.
The reasons for the "Prefinishers" not fitting are:

(a) If there is a Bolton's or an inter-arch tooth size discrepancy. The standardised setups do not allow for this factor. The overbite and overjet of the standard setup are both about 0.5mm.

(b) Intra-arch tooth size discrepancies. The most common form of intra-arch tooth size discrepancy is a result of peg shaped lateral incisors. The premolars are also very variable in size, as may be the maxillary central incisors and canines.

(c) Tooth size asymmetry: Tooth size asymmetries, due to variations of the size of contralateral teeth, have been with orthodontists since the days of banding. Today, with the use of bonded brackets these asymmetries go largely unnoticed. However, a "Prefinisher" cannot be correctly fitted in these cases. If the teeth on one side of the mouth are significantly larger than those on the other side, then a "Prefinisher" that fits one side of the mouth will not fit the other. The ruler supplied by T.P. Laboratories (fig. 12), conveniently has the midline measurements marked and comparison of the two measurements will reveal any bilateral discrepancy.

The sizes of the "Prefinishers" are in length increments of one millimetre, and so a discrepancy, greater than one or two millimetres, between sides will preclude a "Prefinisher" from fitting.

(d) Unusual extraction cases: The "Prefinishers" are produced to fit arches that have four premolars, two maxillary premolars, or no teeth extracted. If the first permanent molars are extracted a non-extraction "Prefinisher" may still fit, though the extension for the second permanent molar should be removed. In these cases some molar control may be lost as the second molar is usually significantly smaller than the first molar.

Extraction regimes that are incompatible with "Prefinishers" are lateral incisor extraction cases, combination premolar and molar extraction cases, or asymmetrical extractions. Similarly, if there is a congenital absence of teeth, such as lateral incisors or canines, a "Prefinisher" cannot be used.

(e) Unusual arch forms: Preformed positioners are moulded to fit an ovoid arch form. If a patient had a square or very tapered arch form, the preformed positioners would not fit. Interestingly, not one of the orthodontists I questioned, nor did one article I have read, note that this problem had
occurred. However, in Japan, orthodontists use an oriental preformed positioner that has a square arch form. These same oriental preformed positioners should also be used for Japanese in Western countries.

(f) Cases with dental compensations: The preformed positioners are manufactured with the aim of stereotyping the angulation of the patient’s teeth. Unfortunately, individual variation is often required. A very good example of this is with a patient with a facial basal bone relationship that is skeletal Type II or III. We cannot correct the skeletal relationship during the orthodontic treatment, consequently we often mask the discrepancy with dental compensations. The usual dental compensations involve extreme proclination or retroclination of the maxillary and mandibular incisors. Preformed positioners cannot be used in these cases.

(g) Preformed positioners may not fit as they are manufactured on average measurements in relation to the condyle. This aspect is discussed further in Chapter 4.

(h) Other problems: Other problems of an apparent minor nature have occurred. An orthodontist with only four months experience with “Prefinishers” has found spaces opening between the maxillary incisors of some patients. The fit of the positioners was checked and the distances remeasured. The cause of this was unable to be determined. As this problem does not occur with the orthodontists more experienced with the use of “Prefinishers” it may be overcome with time. This orthodontist is now using ‘Prefinishers’ slightly smaller than indicated.

Another orthodontist considers “Prefinishers” are contra-indicated in patients who had open bites or Class III malocclusions. These two types would probably come under the heading “cases with dental compensations”.

Preformed Positioners & TMJ Dysfunction

Due to the nature of recent articles published (Williamson and Associates, 1984) attempting to relate preformed positioners with the likelihood of TMJ dysfunction, I carefully questioned the orthodontists regarding their experience with this problem.

Not one orthodontist has noticed any problems developing. Also none have received complaints from patients with signs or symptoms that could be related back to this problem. One orthodontist had a patient experiencing TMJ
problems during retention with a conventional retainer. He issued a "Prefinisher" which appears to have brought about an improvement. He does stress though that one patient hardly enables one to draw valid conclusions.

"Prefinishers" are manufactured so that the jaws are separated by the freeway space. The mandibular position, whilst the "Prefinisher" is being worn, is slightly posterior to a simple rotation open, from the intercuspal position, with the centre of rotation at the condyles. Therefore the positioning of the condyles, whilst the "Prefinisher" is being used, is virtually the same as the position of the condyles when the mandible is in intercuspal position. Therefore any deviation of condylar position whilst the "Prefinisher" is being worn, can be related back to a deviation of condylar position in centric occlusion. This is a fault of the basic treatment and so I must again emphasize that the preformed positioners must only be used after basic treatment has been satisfactorily completed. For more information on this aspect, see Appendix II.

The Oriental Pre-finisher

Acknowledgement

I am very grateful to Professor Akira Kameda, of the Nippon Dental College, Niigata City, for the English translation of previous papers. The information presented here is from the translation. This information is gathered from Kameda (1983a and b).

Introduction

In Japan tooth positioners were used for retention in the 1960's. However, their use gradually waned, due mainly to problems such as:

1. Time consuming for production.
2. Making of set-up models is cumbersome.
3. Developing of occlusal pattern depends on the quality of the setting up.
4. Availability problems of the materials.

In the 1970's more accurate retention appliances were earnestly hoped for and tooth positioners again came to the fore gradually. Their use as minute occlusal finishing appliances, far beyond mere retention appliances, was recognised.
The Japanese realised that preformed positioners made in America were unsuitable for the Japanese people. There were significant differences between the different populations. The differences they took into consideration when developing their preformed postioners were:

1. The Japanese people commonly have a thick border on the mesial and distal edges of the palatal surface of their incisors. These incisors are commonly termed "shovel shaped" in contrast to the American and European "chisel shaped" incisors.

2. Japanese are of brachyfacial type and also differ in the width and diameter of dental arches. Americans and Europeans are more commonly dolicho-mesofacial type. The dental arch of the Japanese are characteristically large in width in proportion to their length. The intercuspal width is also broader. These characteristics are in common with all the Oriental people.

**Development**

Therefore, a new series of preformed positioners had to be developed. T.P. Laboratories, Inc. approached the Orthodontic Department of the Nippon Dental College in Niigata City, Japan, in 1979. Lengthy discussions and testing followed resulting in the first Oriental "Prefinishers" being produced in 1982.

It is interesting to see the criteria for the 50 Japanese people who were used as the normal occlusions for the development of the oriental "Prefinishers". There criteria were:

1. Age from 20 to 25 years, with no facial asymmetry.
2. A favorable lateral profile.
3. An Angle's Class I molar and canine relationship, with coinciding midlines.
4. Overbite less than 3mm, overjet less than 2mm.
5. Less than 3mm space deficiency in either arch, that is, slight overlapping was allowed.
6. A favorable Bolton's ratio for the anterior teeth and for the whole arch.
7. The normals had to have all their own teeth with no prosthetic dental work.

From these cases arch form and tooth size and morphology was determined.

The inclination of the teeth was determined by using desired goals of treatment. The preferred inclination of the maxillary central incisor to the SN plane was 97° (but the range of 93–105° was considered normal, the preferred
inclination of the mandibular central incisor to the mandibular plane was 90° (range 85–93°), for the interincisal angle 135° (range 125–140°), and lastly, the mandibular plane should be less than 40°.

The Oriental “Prefinishers” were manufactured for cases that have had four premolars extracted. The combination of premolars may be four first premolars, four second premolars, or maxillary first premolars and mandibular second premolars.

The thickness of the “Prefinisher” separates the jaws by the average freeway space for Japanese, which is not specified.

The Oriental “Prefinisher” may be used for maxillary or mandibular protrusion cases.

Use of the Oriental “Prefinisher”

The Oriental “Prefinisher” is a precision finishing appliance. As a finisher, it will replace the use of a finishing archwire in the final stages of treatment. The patient must be instructed to wear the appliances four to six hours per day, exercising into it as much as possible, as well as wearing it at night. The “Prefinisher” is also a retaining appliance and may be used for about 12 months.

The following corrections may be achieved with the Oriental “Prefinisher”:

1. Correction of slight crowding and rotations of individual teeth, and arch form, if used concurrently with interproximal stripping.
2. Correction of slight discrepancy of canine relationships, providing there is not a Bolton’s tooth size discrepancy.
3. Correction of slight intercuspation discrepancies between the buccal segments.
4. Improvement of the labial inclination of canines and premolars.
5. Correction of rotations and labial inclination of molars.
6. Improvement of labio-lingual inclinations of upper and lower anterior teeth.
7. An improvement where clicking is developing by TMJ dysfunction.

Kameda adds a definite note that the Oriental “Prefinisher” will not reduce an open bite, nor improve the uprighting, in a mesiodistal direction, of the canines and premolars.

Failures with the use of the “Prefinisher” are largely due to patients “forgetting” to wear the appliance.
Review of the Literature

It is unusual to present the review of the literature at the end of the chapter. However, to correctly evaluate the literature we must be able to fully understand the abilities and limitations of the appliance, along with its current use.

Schuchard used his preformed positioners as the sole appliance (Lorentz, 1973). He treated patients with a range of preformed positioners, each with more correction, until their occlusion and dental arrangement was satisfactory. On average, two appliances were required. Schuchard termed these preformed positioners “Gebissformer”, this is a direct translation to German of the words “tooth positioner”.

The “Gebissformers” are made of soft vulcanised rubber, and there were 15 different sizes produced.

Lorentz (1973) assessed the results of 50 cases treated with the “Gebissformers” as sole appliances. Most had been out of retention for more than three years, some more than ten years postretention.

Lorentz considered the results of 47 patients to be stable and were satisfactory. The relapses were Angle’s Class II cases. The important feature of Lorentz’s paper is that preformed positioners may be used as an active appliance for patients in some cases.

Mischler & Delivanis (1984) compared preformed positioners (T.P. Laboratories “Prefinisher”) to custom-made tooth positioners from two laboratories (T.P. Laboratories and Professional Positioners).

Their study consisted of 12 patients, the “Prefinisher” of best fit was selected, and then its fit was evaluated to each patient.

They noted that the “Prefinisher” forms had the following attributes: no rotations, no spaces, ideal overbite, ideal overjet, a flat curve of spee, no teeth positioned out of arch symmetry, no midline discrepancy, and the mesiolingual cusp of the maxillary first molar articulated with the central fossa of the mandibular first molar in all cases. However, there was no articulation between the distal surface of the distobuccal cusp of the maxillary first molar and the mesial surface of the mesiobuccal cusp of the mandibular second molars in any of the “Prefinisher” setups.

The conclusions that Mischler & Delivanis came to were that:
1. “Prefinishers” were the most variable positioner studied in respect to fit.
2. "Prefinishers" should not be used indiscriminately but critical measurements such as arch length and intercanine width should be assessed.

3. If the fit of the "Prefinisher" is determined to be inadequate, the removal of fixed appliances should be delayed until a custom made tooth positioner can be fabricated.

   My conclusions from their results is that, on average, "Prefinishers" fit very well. The resiliency of the appliance would allow it to fit, in spite of a discrepancy of a millimetre or so, without the forces being strong enough to move teeth. The range of the fitting discrepancies is much more important and "Prefinishers" at the extremes, e.g. fitting discrepancies for the mandibular intercanine width being 5.15mm too small or 4.1mm too large, would not only make the appliance unsuitable, but the appliance may be so uncomfortable that the patient does not wear it and co-operation may be blamed for the lack of success.

   Kirshon (1984) assessed the efficacy of "Prefinishers" as a pre-retention appliance. In a study using 33 patients, he removed fixed appliances in patients "close" to finishing treatment. The term "close" is not defined. "Prefinishers" were then inserted and their subsequent tooth movement was assessed.

   Kirshon found the "Prefinisher" to be an appliance of merit in achieving some refinement of the occlusion in a well-controlled orthodontic case. He also found that they offer the possibility of reducing treatment time whilst at the same time improving patient cooperation at a stage where patient interest is waning.

   I interpret Kirshon's conclusions to mean that the "Prefinisher" is effective in some cases, but his use of the term "well controlled" suggests little active movement should be required.

**Conclusion**

Preformed tooth positioners are useful. They have not gained wider usage due to individual preferences, as well as the different treatment modes requiring different forms of retention.

In the hands of an operator skilled in their use, preformed positioners can be very effective.
EXPERIMENT

INTRODUCTION

This experiment was planned to test the advantage, after active fixed appliance treatment, of using a tooth positioner in contrast to the traditional Begg retainer. Two groups were used. One group of patients was issued with tooth positioners as retainers. This became the “experimental group”. The second group of patients were issued with conventional Begg retainers. They became the control group. The method of judging such advantages was to make counts of the occlusal contacts registered prior to and at the end of a period of use of the positioners. It was conjectured that if a significant increase in the number of contacts was registered, then this would be an indication of the efficacy of the positioner.

All patients were evaluated immediately at debanding, then again 6–10½ months later. Figs 15 & 16 are typical examples of patients at the start and end of this study.

Occlusal contacts were recorded in the clench position. Clench position was selected due to its ease of evaluation and accuracy. A preliminary assessment was carried out on a 30 year old male. The total number of occlusal contacts in clench position was found to be consistent at different assessments three months apart (i.e. 23 contacts and 25 contacts respectively).

For this experiment the occlusal contacts were recorded with GHM occlusal foil and were then carefully mapped onto an occlusal diagram. The contacts were then tallied according to the number of teeth with interocclusal contact, the number of cusps with interocclusal contact, and the total number of interocclusal contacts.

The results were then tabulated showing individual changes, as well as group changes.

The results were also graphed to assess any relationship between the initial number of interocclusal contacts, related to change, as well as the duration of the period between initial and final assessment, related to change.

These results were then examined to see if conclusions could be reached regarding the efficacy of the tooth positioner compared to the conventional Begg retainer, in increasing the number of occlusal contacts following orthodontic treatment.
Fig. 15: J.M. at debanding and tooth positioner insertion.
Fig. 15 (cont.): J.M. at debanding and tooth positioner insertion.
Fig. 15 (cont.): J.M. at debanding and tooth positioner insertion.
Fig. 16: J.M. after eight months of tooth positioner use.
Fig. 16 (cont.): J.M. after eight months of tooth positioner use.
Experimental Procedure

The experimental procedure was carefully planned to allow simple clinical procedures and clarity of results. I was careful that the accuracy of the experiment was not compromised except in possibly two respects, i.e:
1. Patients were not randomly selected for the control or experimental group, and
2. Although it was intended that patients would be reassessed after six months, the time lapse ranged from six to 10½ months.

Patient Selection

Twenty-seven patients were selected for inclusion into the study. The only criterion used for inclusion was patient willingness to participate and the belief that the patient would return for the reassessment six months later.

All patients were treated using the Begg lightwire technique. They were treated by either Dr P. Taylor, Dr K. Marshall, Dr K. Powell or Dr D. Basser. The treatment of all patients had progressed well and was completed to the operators' satisfaction.

It was originally planned to issue a tooth positioner or Begg retainer to the patients alternately as they entered the study. This was considered a simple method of random selection. Unfortunately, I was unable to do this as one orthodontist involved felt ethically bound to issue tooth positioners in many cases. The end result was that there was little random selection of patients. If the orthodontist did not specify a tooth positioner for a patient, it was very likely that the patient was issued a Begg retainer.

Of the original 27 patients, 14 were issued with tooth positioners, 13 with Begg retainers. Ten patients from each group returned for re-evaluation (table 2).

Control Group: It is questionable whether patients issued with Begg retainers were suitable for a control group. Perhaps a control group should have no form of retention whatsoever. The normal procedure following orthodontic treatment is to issue a retainer such as the Begg retainer. As I wanted to compare the tooth positioner to the norm I selected a control group who wore Begg retainers. In this way I may also gain meaningful results. A comparison of a tooth positioner to no form of retention would have little meaning, unless there was no difference. Associated also is the question of ethics. It would be difficult to justify not issuing retainers to patients for an experiment such as this. Therefore, the group of 13 patients wearing Begg retainers became my control group by which I could judge the performance of the tooth positioners.
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$x = 8.25$ months.

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<tr>
<td>GM</td>
<td>cl. I, deep bite</td>
<td>non exo</td>
<td>6.5</td>
</tr>
<tr>
<td>EP</td>
<td>cl. I, deep bite</td>
<td>4 x 4's</td>
<td>7</td>
</tr>
<tr>
<td>RS</td>
<td>cl. I</td>
<td>4 x 4's</td>
<td>6.5</td>
</tr>
<tr>
<td>AS</td>
<td>cl. II, div. II</td>
<td>4 x 5's</td>
<td>6.5</td>
</tr>
<tr>
<td>AV</td>
<td>cl. II, div. I</td>
<td>4 x 4's</td>
<td>10</td>
</tr>
</tbody>
</table>

$x = 7.5$ months.

Table 2: Details of patients in study.
Tooth Positioners

The manufacture of the tooth positioners was shared between two laboratories. The method of manufacture was the same for both laboratories and is explained fully in Chapter 4.

Prior to this study I familiarised myself with tooth positioners by manufacturing, issuing and supervising the use of 12 positioners.

The tooth positioners used in this study were of a clear PVC based material, commercially sold as “Stay guard”. They were made as two separate units and joined.

The tooth positioners were issued at the debanding appointment. The patients’ instructions were:

1. For the first three or four days the tooth positioner was to be worn as much as possible. If this included a weekend up to 18 hours a day was expected.
2. Up till the six week review appointment, the patients were to wear the tooth positioner to bed plus four hours in the afternoon/evening.
3. The patients must also clench their teeth into the tooth positioner regularly. This consists of 30 seconds clenching of the jaw muscles, followed by a two minute rest. The clenching is then repeated. The patient is instructed to do this intermittently during positioner wear so that a total of one to two hours is completed (i.e. only twelve to twenty four minutes with the teeth clenched).
4. At the six week review the patients were told they could cease the clenching, as the tooth positioner should now be a passive appliance only. They were instructed to wear the positioner for three hours in the evening, plus to bed.
5. Some patients were reviewed after three to four months. These patients were instructed to wear the positioner for two hours in the evening, as well as to bed.

The positioner wear for all patients was good and some were excellent. No patients who returned for reassessment were disqualified for failing to wear the positioner. I suspect though, that some of the patients who failed to return, did not wear their tooth positioner.

Begg Retainers

The Begg retainers were manufactured by 2 experienced dental technicians. They were all of good fit and made to standard specifications.

Impressions for the Begg retainers were taken after debanding and the retainer was issued one week later.
The patients were instructed to wear the Begg retainer at all times unless they were eating, cleaning their teeth, or playing active sport.

The patients were reviewed after six weeks and again after three or four months. The Begg retainers were adjusted as required.

Patient co-operation for these patients was pleasing.

Occlusal Records

The occlusal records were made using GHM occlusal foil (GHM Occlusion Pruf Folie, manufactured by Gebr. Hanel Medizinal, D-7440 Nurtigen, West Germany). GHM foil is 20mm thick and is a very accurate indicator of tooth contact (Kelleher & Satchell, 1984). The foil was held in Miller's forceps for the recordings.

Although only the clench position was evaluated for this thesis, occlusal contact in 3 different relationships was recorded. The maxillo-mandibular relationships recorded were centric relation, median occlusal position, and clench position. I chose these positions for the following reasons:

Centric Relation (CR): CR is given considerable emphasis by many gnathologists (Ramfjord & Ash, 1983). This level of importance may not be completely An alternate view is that many people rarely engage CR in normal function and for those that do, all that is desired is balanced contacts, that is, contacts evenly distributed on both sides of the mouth (Klineberg, 1985).

Problems existed with the recording of CR. Generally time was not available for "deprogramming" habitual paths of closure. Without doing this a true CR recording cannot be made (Williamson & Associates, 1980).

CR was recorded using the method recommended by Dawson (1974). This involves mandibular manipulation by the operator, which is a two handed procedure. In most cases a second person was not available for holding the articulating foil. This would considerably lower the accuracy of this technique. In spite of this it was decided that this was the most appropriate method of recording CR for this study.

Median Occlusal Position (MOP): MOP has limited value in gnathological studies and procedures. MOP is achieved by a snap closure of the mandible from a resting opening of about five millimetres. MOP is very similar to centric occlusion or intercuspal position. The advantage of MOP is that the snap closing is thought to
produce a more uniform path of closure as the muscles controlling the mandible are under reflex control and not slow directed control. An important variable that occurs when patients close into the position of maximum intercuspation is that the number of contacts vary according to the pressure exerted. MOP usually involves relatively light forces. If we were to compare the number of contacts in MOP recorded on two different occasions, we would be limited in any conclusions that could be drawn unless we assessed the force of contact on each occasion.

**Clench Position (Clench):** Clench is obtained by having the patient close into MOP or intercuspal position, and then clenching his or her jaws together very firmly. The recordings of Clench were chosen for comparison in this study because:

1. They represent a functional position. Clench is a position of maximum intercuspation. Maximum intercuspation is engaged repeatedly during normal function, although not necessarily with the same pressure as Clench.
2. Clench is a reproducible maxillo-mandibular relationship in both position of contacts and number of contacts. Biting pressure becomes a minor variable as the maximum force the patient can exert is unlikely to vary greatly over the period of the experiment. The high biting pressure produces minor tooth movement allowing more interocclusal contacts. It was not considered significant that the teeth were highly mobile at debanding, but this had reduced to normal mobility in all cases at the reassessment.

MOP recordings were taken to assist the Clench recordings. As the difference between Clench and MOP is the pressure exerted, patients could be instructed to close into MOP, and then clench their jaws together firmly. The earlier recordings of MOP could then be used to judge the accuracy of the Clench recordings. The MOP closing action is favorable as it reduced the likelihood of patients closing together with the mandible positioned forward of maximum intercuspation. When articulating paper is placed between the jaws, especially in the anterior region, patients show a tendency to bite together on their incisors instead of on their posterior teeth.

The occlusal recordings were made on the mandibular teeth only. The mandibular teeth were chosen for better vision which was necessary if the smallest contacts were to be detected.

The instruction leaflet accompanying GHM foil states the foil is accurate if the teeth are wet. Once the study was well underway I was informed that this was not necessarily so and that the foil should be used with dry teeth (Klineberg, 1985).
Throughout the study the teeth were dried and kept as dry as possible. However, I do feel that moisture contamination did occur on occasions.

If the occlusal contacts were recorded on the maxillary teeth, moisture contamination may have been reduced, at the expense of loss of direct vision of the occlusal markings.

**Clinical Procedure**

During clinical sessions a routine was followed to ensure reproducibility.

A printed worksheet was used so that all relevant information was gathered.

The routine followed was:

1. Patient was debanded.
2. Impressions were taken for record models and for a Begg retainer if one was to be inserted.
3. Occlusal records were taken and transferred to an occlusal diagram (fig. 14). The patient was kept in a horizontal position. The CR recording was taken using black GHM articulating foil. The markings on the teeth were then copied accurately onto an occlusal diagram. The action of drying the teeth for the next set of occlusal recordings was found to remove many of the marks.

The MOP recordings were made next. The patient was seated upright and instructed how to close into MOP, i.e. the mandible is to be held relaxed, open a little bit. It is then snapped shut so that an audible click is heard. I would demonstrate this to the patients and then have them practise it. The teeth were then dried and the MOP recordings made with red GHM articulating foil. The patients were instructed to snap close three times. These recordings were then transferred to an occlusal diagram.

The teeth were again dried, but the red marks were not necessarily removed.

The patient was then instructed to close into the clench position. The instructions were to close into MOP, as previously, and then to clench the jaws together very firmly. I stressed to the patients that a lot of force was required. These recordings were made with green GHM foil and were again transferred to an occlusal diagram.

All occlusal records were made on one side of the mouth, then repeated for the other side, then repeated for the anterior segment.

4. Photographs. The next stage of the debanding was the taking of clinical photographs. These were not considered satisfactory as a means of recording the occlusal contacts.
Patients name

Date

Number of registrations of
CR (black)
Clench (green)
MOP (red)

Significant notes

Fig. 14: Occlusal diagram used for recording occlusal contacts.
5. Radiographs. For many patients lateral cephalometric radiographs and orthopantomograms were taken. These were taken as part of treatment and were not assessed for this thesis.

   This concluded the gathering of records. If the patient was for a Begg retainer he or she was dismissed to return in seven days for the insertion of the retainer. If a tooth positioner was to be inserted its use was explained fully to the patient and it was inserted at this appointment.

   Impressions for tooth positioners had been taken two to three weeks prior to debanding.

**Reassessment**

   All patients were recalled after six months for a repetition of the occlusal records taken at the debanding appointment. Due to lack of enthusiasm with some patients up to ten months and two weeks elapsed before I was able to reassess them. The mean time interval for the experimental group was 8.25 months, whereas for the Begg retainer group it was 7.45 months. The significance of this will be discussed later.

**Analysis**

   The results are presented in a range of forms. Each form has limitations and extensive conclusions can be drawn from none. However, presented together they allow a clearer picture to be formed as to the overall changes.

   The number of occlusal contacts recorded at each assessment, for each patient, is presented in Table 1. The occlusal contacts have been counted in three different manners, that is;

1. The number of dental interocclusal contacts, i.e. the number of mandibular teeth contacting the maxillary teeth. Each tooth registered as one contact if it was in contact with an opposing tooth. There was no differentiation according to the number of contacts a tooth made.

2. The number of cuspal contacts, i.e. the number of cusps of the mandibular teeth in contact with the maxillary teeth. With this method premolars were able to register two contacts if they had one or more on each cusp. Molars were able to register four or five contacts, depending on their number of cusps. Prior to the study I had to consider whether marginal ridges should be considered separate to cusps. However, assessment of cuspid contacts of a
### Experimental Group

<table>
<thead>
<tr>
<th>Patients Initials</th>
<th>Contacts at Debanding</th>
<th>Contacts at Review Decl.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Teeth</td>
<td>Cusps</td>
</tr>
<tr>
<td>LD</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>SF</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>PG</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>JH</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>TH</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>KH</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>KJ</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>PK</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>JM</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>MS</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td><strong>Sum =</strong></td>
<td>53</td>
<td>88</td>
</tr>
</tbody>
</table>

### Control Group

| AA | 9   | 14  | 15  | 8   | -1  | 10  | -4  | 10  | -5  |
| AB | 10  | 17  | 19  | 10  | -   | 23  | 6   | 23  | 4   |
| MC | 8   | 14  | 16  | 11  | 3   | 21  | 7   | 23  | 7   |
| CL | 9   | 14  | 14  | 7   | -2  | 16  | 2   | 18  | 4   |
| CM | 8   | 10  | 11  | 7   | -1  | 16  | 6   | 19  | 8   |
| GM | 7   | 8   | 8   | 7   | -   | 10  | 2   | 14  | 6   |
| EP | 6   | 10  | 11  | 11  | 5   | 18  | 8   | 23  | 12  |
| RS | 9   | 16  | 18  | 8   | -1  | 16  | -   | 16  | -2  |
| AS | 7   | 8   | 10  | 13  | 6   | 17  | 9   | 22  | 12  |
| AV | 6   | 9   | 9   | 7   | 1   | 15  | 6   | 19  | 10  |
| **Sum =**       | 79   | 120 | 131 | 89  | 10  | 162 | 42  | 187 | 56  |

Table 3: Intercuscular Contacts in Clench Position.

*Occlusal column refers to the total number of intercuscular contacts (see page 158).
small group of patients showed that cuspal contacts often extended along marginal ridges. Therefore ridges were considered to be part of the cusps and any contact on a marginal ridge was deemed as belonging to the nearest cusp. If the contact extended over the midline between two cusps it was considered to be two contacts.

3. The total number of interocclusal contacts, i.e. the total number of contacts the mandibular teeth have with the maxillary teeth. It is possible, and in fact frequently occurred, that a cusp would have two, or even three, contacts with opposing teeth. With this method of counting all individual contacts were counted. The potential exists for many more occlusal contacts to be present, this was more noticeable where one tooth may have five or six separate contacts on only 3 cusps.

No method of evaluation initially appeared to be any better than the others. The most appropriate method of measurement will be assessed at the completion of the study.

Each case is listed in Table 2. From this table may be read:
1. The initial number of contacts for each individual, listed for each category.
2. The final number of contacts for each individual, listed for each category.
3. The time lapse between initial and final recordings for each patient.
4. The original malocclusion for each patient.
5. The total number of contacts for each category for each group.

From the results shown in Table 2, I have produced histograms to illustrate the variations present.

The first graphs are to assess the effect of time on the change recorded during the study. Figs 17-19 represent the three categories. The X-axis represents the length of the interval between initial and final recordings, expressed in months and recorded to the nearest 0.5 month. The Y-axis represents the change recorded during the study. For each interval of time there are three possible columns, i.e. the experimental group, the control group, and the combination of the two groups, i.e. the average for all patients involved in the study.

There is not an even distribution of patients along the X-axis. However, this does not appear to affect our general conclusions.

The second set of graphs (figs 20-22) assess the effect of the initial number of contacts, on the change recorded during the study. The X-axis represents the
Fig. 17: Relationship between the change in tooth contacts and time

Red — Experimental Group
Black — All patients in study, i.e. combination of Experimental and Control Groups.
Green — Control Group.
Fig. 18: Relationship between the change in cuspal contacts and time

Red — Experimental Group.
Black — All patients in study, i.e. combination of Experimental and Control Groups.
Green — Control Group.
Fig. 19: Relationship between the total number of interocclusal contacts and time

Red — Experimental Group
Black — All patients in study, i.e. combination of Experimental and Control Groups.
Green — Control Group.
Fig. 20: Relationship between the change in tooth contacts and the number of initial contacts

Red — Experimental Group
Black — All patients in study, i.e. combination of Experimental and Control Groups.
Green — Control Group.
Fig. 21: Relationship between the change in cuspal contacts and the number of initial contacts

Red — Experimental Group
Black — All patients in study, i.e. combination of Experimental and Control Groups.
Green — Control Group.
Fig. 22: Relationship between the change in the total number of interocclusal contacts and the number of initial contacts

Red — Experimental Group
Black — All patients in study, i.e. combination of Experimental and Control Groups.
Green — Control Group.
initial number of contacts, the Y-axis represents the change recorded during the study. Again there are three possible columns at each stage and they are shown as previously.

From the preceding assessments the effects of the variables can be assessed. "Student's" t testing is used to determine the significance of the differences between groups. In each case the null hypothesis is tested. The null hypothesis is that there is no difference in the number of occlusal contacts in the groups assessed. If the null hypothesis is rejected, an alternative hypothesis must be proposed. In this case the alternative hypothesis is that there is a significant difference between the two groups being compared.

Initially the pre-treatment occlusal contact counts of the experimental group is compared to that of the control group. The object of this is to determine if they both belong to the same population. If they do belong to the same population "student's" t testing will show there is no significant difference between the two groups.

The results of t tests shows that the null hypothesis is rejected at the 0.05 probability level (Appendix 1). Therefore the alternate hypothesis is proposed, i.e. that there is a significant difference between the two groups. This hypothesis is supported. This has shown that the control group and the experimental group are not drawn from the same population. I attribute this to the method of placing the patients in either the experimental or control group, i.e. it is due to the failure to use random selection of the groups. Therefore they cannot be compared to one another directly.

The next step is to assess the changes that occurred in each group. Again "Student's" t testing is the first step. The t testing is used to show if the groups had a significant change in the number of contacts over the period of the study. For each group, i.e. the control and experimental group, three t tests were carried out. These were to assess the significance of the changes in cuspal contacts, dental contacts, or the total number of occlusal contacts.

The results of the "Student's" t tests shows that all groups had a significant change in the number of contacts, at the 0.05 probability level, except for the dental contacts of the control group. For the number of dental contacts in the control group there was no significant change over the period of the study.
Discussion

The discussion should now fall into two sections to allow us to evaluate our findings. These sections are:

1. The determination of the best method of measuring occlusal contacts.
2. To see if either form of retention was significantly better than the other.

**Measuring occlusal contacts:** Earlier, uncertainty was expressed as to whether the number of dental contacts, cuspal contacts, or the total number of contacts, was the most suitable to evaluate.

During this study problems were experienced with assessment of all categories. Of the problems, I considered those affecting the categories of "dental contacts" and "total number of contacts" significant. Therefore I favor the measuring and assessing of the number of cuspal contacts.

The problems I found with the unfavoured categories are:

**Dental contacts:** When counting dental contacts there is no consideration of the contribution of each occluding pair of teeth to the whole contacting occlusion. Each molar is worth one contact irrespective of whether it is perfectly placed, lingually rolled or distally tipped. Yet the molars are functionally of such importance that I consider that the method of evaluation must attempt to evaluate both the quantity and quality of their positioning.

In this study there was a very good example of this point. If the dental contacts are considered, the control group had no significant increase in the number of contacts, while the experimental group experienced a significant increase in the number of dental contacts. From this data alone the conclusion may be drawn that the tooth positioners were better retainers. However, in the other categories, viz., the cuspal contacts and the total number of contacts, the control groups had significant increases in the number of contacts. Therefore, for the control group, there was no significant increase in the number of teeth in contact, but the quality of the contact of these teeth improved so that there was a significant increase in the number of cusps in contact, as well as the total number of contacts.

As a result of this I do not favor consideration of the number of teeth in contact for assessing the improvement of the occlusal contacts.

**The Total Number of Contacts:** There were two aspects of the total number of contacts that I was troubled about.

The first was the frequency with which two contacts would merge into one. In the twenty cases studied for this thesis, there were seven occasions when
two contacts merged into one. Although this does not appear to have affected the results, I do not favor the situation where the number of contacts decreases despite possible improvement in the occlusion.

The second situation relates to my dislike of evaluation of dental contacts. There was one case where a mandibular molar had rolled lingually. Yet as the buccal cusps were in occlusal contact with the maxillary teeth, the mandibular molar had five occlusal contacts. I feel the five contacts recorded for this tooth were not a valid assessment of its contribution to the overall contacting occlusion.

As a result of these factors, I do not favor consideration of the total number of occlusal contacts for assessing the improvement in the occlusal contacts.

Therefore I consider that the number of cusps in occlusal contact is the most appropriate measure of the improvement in occlusal contact. However, even the cusps are not without problems. The problems to be considered are:

1. Is a marginal ridge sufficiently important to be considered a cusp, or should the contacts belong to the nearest cusp. If so the line of division should be determined. For this study I considered the marginal ridges as belonging to the nearest cusp and the line of division was midway between the two cusp tips.

2. If we count the contacts on the maxillary teeth, how may we differentiate between a maxillary central incisor contacting one lower incisor from one contacting two lower incisors. I overcame this problem by counting mandibular contacts. I suggest that the central incisor be considered just one cusp and that the situation mentioned need not be differentiated. Incisor contacts are not important and some authorities prefer that in intercuspal position that the incisors are just out of contact.

**Discussion of results of cuspal contacts**

Once it is decided that the cuspal contacts are to be considered, the changes noted can be assessed.

Firstly, the “Student’s” t test determined the control group and the experimental group to be different, i.e. they were not drawn from the same population (Appendix 1). Therefore these two groups cannot be compared directly to each other.
A "Student's" t test was then used to assess the changes each group showed (Appendix 2). This showed that each of these groups had a significant change in the number of cusps in contact.

From these results no further information can be gathered. Therefore this study did not find any difference between the effectiveness of a tooth positioner as a retainer, when compared to a Begg retainer.

Conclusion

From an assessment of the changes in occlusal contacts in intercuspal clench position over a six to 10½ month period, this study found that:

1. The best method of measuring occlusal contacts was by counting the number of cusps in contact.

2. There was no difference evident in the occlusions of the patients who wore tooth positioners when compared to the patients who wore Begg retainers.
Bibliography


KAMADA, K and NISHIYAMA, M (1982): Construction of Tooth Positioners with LTV Vinyl Silicone Rubber and Some Case Reports.


Appendix 1

T testing between 2 groups (experimental and control).

Tooth Contacts

<table>
<thead>
<tr>
<th>GROUP</th>
<th>No. OF POINTS</th>
<th>n - 1</th>
<th>MEAN TOOTH CONTACTS</th>
<th>$\sum (x - \mu)^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>10</td>
<td>9</td>
<td>5.3</td>
<td>34.4</td>
</tr>
<tr>
<td>Control</td>
<td>10</td>
<td>9</td>
<td>7.9</td>
<td>68</td>
</tr>
</tbody>
</table>

Sum = 18  Diff = $\bar{x}_1 - \bar{x}_2$  Sum = 102.4

\[ \frac{\sum x^2}{2(n-1)} = \frac{102.4}{18} = 5.7 \]

\[ \sqrt{\frac{2 \times 5.7}{10}} = \sqrt{\frac{11.4}{10}} = \frac{3.4}{10} = 0.3 \]

\[ t = \frac{\bar{x}_1 - \bar{x}_2}{S_{\bar{x}_1 - \bar{x}_2}} = \frac{2.6}{0.3} = 8.7 \]

Significant
### Cusp Contacts

<table>
<thead>
<tr>
<th>GROUP</th>
<th>No. OF PATIENTS</th>
<th>DEGREES OF FREEDOM</th>
<th>MEAN NUMBER OF CUSP CONTACTS</th>
<th>$\sum(x-x)^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>10</td>
<td>9</td>
<td>8.8</td>
<td>41.6</td>
</tr>
<tr>
<td>Control</td>
<td>10</td>
<td>9</td>
<td>12</td>
<td>149.6</td>
</tr>
</tbody>
</table>

Sum = 18  
Diff = $\bar{x}_1 - \bar{x}_2$  
Sum = 191.2  
\[= 3.2\]

Pooled square mean = $S^2 = \frac{\sum x^2}{2(n-1)} = \frac{191.2}{18} = 10.6$

\[
S\bar{x}_1 - \bar{x}_2 = \sqrt{2s^2}
\]

\[= \sqrt{2 \times 10.6} = \frac{\sqrt{21.2}}{10} = 4.6 \frac{10}{10} = 0.5\]

\[t = \frac{\bar{x}_1 - \bar{x}_2}{S\bar{x}_1 - \bar{x}_2} = \frac{3.2}{0.5} = 6.4\]

Significant
Appendix 1

Total Number of Occlusal Contacts.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>No. OF POINTS</th>
<th>n-1</th>
<th>( \bar{x} )</th>
<th>( \Sigma (\bar{x} - x)^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>10</td>
<td>9</td>
<td>9.6</td>
<td>48.4</td>
</tr>
<tr>
<td>Control</td>
<td>10</td>
<td>9</td>
<td>13.1</td>
<td>284.4</td>
</tr>
</tbody>
</table>

\( \Sigma (n-1) = 18 \)  \( \text{Diff} = \bar{x}_1 - \bar{x}_2 \)  \( \text{Sum} = 332.8 \)

\( = 3.5 \)

Pooled square mean = \( S^2 = \frac{\Sigma x^2}{2(n-1)} = \frac{332.8}{18} \)

\( = 18.5 \)

\( S \bar{x}_1 - \bar{x}_2 = \frac{\sqrt{2s^2}}{n} \)

\( = \frac{\sqrt{2 \times 18.5}}{10} = \frac{\sqrt{37}}{10} = \frac{6}{10} \)

\( = 0.6 \)

\( t = \frac{\bar{x}_1 - \bar{x}_2}{S \bar{x}_1 - \bar{x}_2} \)

\( = \frac{3.5}{0.6} \)

\( = 5.8 \)

Significant.
Appendix 2

"Student's" t tests, Intra-group.

Tooth Contacts

Control group

\[
t = \frac{\bar{x} - \mu}{\frac{SD}{\sqrt{n}}}
\]

where \(SD = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}\)

<table>
<thead>
<tr>
<th>(x)</th>
<th>(\bar{x} - x)</th>
<th>((\bar{x} - x)^2)</th>
</tr>
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<tr>
<td>-1</td>
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<td>4</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
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<tr>
<td>3</td>
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<td>10</td>
<td></td>
<td>(\sum(\bar{x} - x)^2 = 68)</td>
</tr>
</tbody>
</table>

\[\bar{x} = 1\]

\[
SD = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}
\]

\[= \sqrt{\frac{68}{9}}\]

\[= \sqrt{7.6}\]

\[= 2.7\]

\[
t = \frac{\bar{x} - \mu}{\frac{SD}{\sqrt{n}}}
\]

\[= \frac{1 - 0}{\frac{2.7}{10}}\]

\[= \frac{1}{\frac{2.7}{10}}\]

\[= \frac{1}{0.27} = 3.7\]

Not significant
Appendix 2

Tooth Contacts

Experimental group

<table>
<thead>
<tr>
<th>x</th>
<th>$\bar{x} - x$</th>
<th>$(\bar{x} - x)^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.6</td>
<td>6.76</td>
</tr>
<tr>
<td>2</td>
<td>0.6</td>
<td>0.36</td>
</tr>
<tr>
<td>4</td>
<td>-1.4</td>
<td>1.96</td>
</tr>
<tr>
<td>1</td>
<td>1.6</td>
<td>2.56</td>
</tr>
<tr>
<td>4</td>
<td>-1.4</td>
<td>1.96</td>
</tr>
<tr>
<td>6</td>
<td>-3.4</td>
<td>11.56</td>
</tr>
<tr>
<td>2</td>
<td>0.6</td>
<td>0.36</td>
</tr>
<tr>
<td>3</td>
<td>-0.4</td>
<td>1.16</td>
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<tr>
<td>0</td>
<td>2.6</td>
<td>6.76</td>
</tr>
<tr>
<td>4</td>
<td>-1.4</td>
<td>1.96</td>
</tr>
</tbody>
</table>

$\bar{x} = 2.6$

$$SD = \sqrt{\frac{\sum (\bar{x} - x)^2}{n - 1}}$$

$$= \sqrt{\frac{34.4}{9}}$$

$$= \sqrt{3.82}$$

$$t = \frac{\bar{x} - \mu}{\frac{SD}{\sqrt{n}}}$$

$$= \frac{2.6 - 0}{\frac{1.9}{\sqrt{10}}}$$

$$= \frac{2.6}{1.9}$$

$$= \frac{2.6}{0.6} = 4.3$$

Significant. $P < 0.01$
Appendix 2

Cuspal Contacts

Experimental group

<table>
<thead>
<tr>
<th>x</th>
<th>(x - \bar{x})</th>
<th>((x - \bar{x})^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.8</td>
<td>7.84</td>
</tr>
<tr>
<td>7</td>
<td>-3.2</td>
<td>10.24</td>
</tr>
<tr>
<td>5</td>
<td>-1.2</td>
<td>1.44</td>
</tr>
<tr>
<td>2</td>
<td>1.8</td>
<td>3.24</td>
</tr>
<tr>
<td>6</td>
<td>-2.2</td>
<td>4.84</td>
</tr>
<tr>
<td>5</td>
<td>-1.2</td>
<td>1.44</td>
</tr>
<tr>
<td>2</td>
<td>-1.8</td>
<td>3.24</td>
</tr>
<tr>
<td>5</td>
<td>-1.2</td>
<td>1.44</td>
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<tr>
<td>1</td>
<td>2.8</td>
<td>7.84</td>
</tr>
<tr>
<td>4</td>
<td>-0.2</td>
<td>0.04</td>
</tr>
<tr>
<td>38</td>
<td></td>
<td>(\sum (x - \bar{x})^2 = 41.6)</td>
</tr>
</tbody>
</table>

\(\bar{x} = 3.8\)

\[SD = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}\]
\[= \sqrt{\frac{41.6}{9}}\]
\[= \sqrt{4.6}\]
\[= 2.1\]

\[t = \frac{\bar{x} - \mu}{\frac{SD}{\sqrt{n}}}\]
\[= \frac{3.8 - 0}{\frac{2.1}{\sqrt{10}}}\]
\[= \frac{3.8}{2.1}\]
\[= 1.8\]

Significant \(P < 0.01\)
## Appendix 2

### Cuspal Contacts

<table>
<thead>
<tr>
<th>Control group</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( x )</td>
<td>( \bar{x} - x )</td>
<td>( (\bar{x} - x)^2 )</td>
</tr>
<tr>
<td>(-4)</td>
<td>8.2</td>
<td>67.24</td>
<td></td>
</tr>
<tr>
<td>(6)</td>
<td>-1.8</td>
<td>3.24</td>
<td></td>
</tr>
<tr>
<td>(7)</td>
<td>-2.8</td>
<td>7.84</td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td>2.2</td>
<td>4.84</td>
<td></td>
</tr>
<tr>
<td>(6)</td>
<td>-1.8</td>
<td>3.24</td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td>2.2</td>
<td>4.84</td>
<td></td>
</tr>
<tr>
<td>(8)</td>
<td>3.8</td>
<td>14.84</td>
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<td>17.64</td>
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<tr>
<td>(9)</td>
<td>-4.8</td>
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<tr>
<td>(6)</td>
<td>-1.8</td>
<td>3.24</td>
<td></td>
</tr>
<tr>
<td>(42)</td>
<td>( \sum (\bar{x} - x)^2 = 149.6 )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \bar{x} = 4.2 \]

\[ SD = \sqrt{\frac{\sum (\bar{x} - x)^2}{n-1}} \]

\[ = \sqrt{\frac{149.6}{9}} \]

\[ = \sqrt{16.6} \]

\[ = 4 \]

\[ t = \frac{\bar{x} - \mu}{\frac{SD}{\sqrt{n}}} \]

\[ = \frac{4.2 - 0}{\frac{4}{\sqrt{10}}} \]

\[ = \frac{4.2}{1.25} \]

\[ = 3.36 \]

Significant \( p < 0.01 \)
Appendix 2

Total Number of Contacts

Control group

<table>
<thead>
<tr>
<th>x</th>
<th>$\bar{x} - x$</th>
<th>$(\bar{x} - x)^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5</td>
<td>10.6</td>
<td>112.36</td>
</tr>
<tr>
<td>4</td>
<td>1.6</td>
<td>2.56</td>
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<tr>
<td>7</td>
<td>-1.4</td>
<td>1.96</td>
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<tr>
<td>4</td>
<td>1.6</td>
<td>2.56</td>
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<tr>
<td>8</td>
<td>-2.4</td>
<td>5.76</td>
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<td>6</td>
<td>-0.4</td>
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<tr>
<td>12</td>
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<td>40.96</td>
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<tr>
<td>10</td>
<td>-4.4</td>
<td>19.36</td>
</tr>
<tr>
<td>56</td>
<td></td>
<td>$\sum (\bar{x} - x)^2 = 284.4$</td>
</tr>
</tbody>
</table>

$\bar{x} = 5.6$

$$SD = \sqrt{\frac{\sum (\bar{x} - x)^2}{n - 1}}$$

$$= \sqrt{\frac{284.4}{9}}$$

$$= \sqrt{31.6}$$

$$= 5.6$$

$$t = \frac{\bar{x} - \mu}{\frac{SD}{\sqrt{n}}}$$

$$= \frac{5.6 - 0}{\frac{5.6}{\sqrt{10}}}$$

$$= \frac{5.6}{1.75}$$

$$= 3.2$$

Significant $\quad \rho < 0.01$
Appendix 2

Total Number of Contacts

Experimental group

<table>
<thead>
<tr>
<th>x</th>
<th>(x - \bar{x})</th>
<th>((x - \bar{x})^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.6</td>
<td>21.6</td>
</tr>
<tr>
<td>1</td>
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<td>5.76</td>
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<tr>
<td>3</td>
<td>1.6</td>
<td>2.56</td>
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<tr>
<td>6</td>
<td>-1.4</td>
<td>1.96</td>
</tr>
<tr>
<td>4</td>
<td>-0.6</td>
<td>0.36</td>
</tr>
<tr>
<td>2</td>
<td>-2.6</td>
<td>6.76</td>
</tr>
<tr>
<td>6</td>
<td>-1.4</td>
<td>1.96</td>
</tr>
<tr>
<td>6</td>
<td>-1.4</td>
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<td>5</td>
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<td>0.16</td>
</tr>
<tr>
<td>46</td>
<td>(\sum (x - \bar{x})^2 = 48.4)</td>
<td></td>
</tr>
</tbody>
</table>

\(\bar{x} = 4.6\)

\[SD = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}\]

\[= \sqrt{\frac{48.4}{9}}\]

\[= \sqrt{7}\]

\[= 2.6\]

\[t = \frac{\bar{x} - \mu}{\frac{SD}{\sqrt{n}}}\]

\[= \frac{4.6 - 0}{\frac{2.6}{\sqrt{10}}}\]

\[= \frac{4.6}{0.8}\]

\[= 5.76\]

Significant \(p < 0.01\).
APPENDIX 3

Discussion on the paper
"THE INFLUENCE OF THREE TYPES OF POSITIONERS
ON MANDIBULAR CONDYLE RELATIONSHIPS"

This paper is a sign of the feelings towards preformed positioners, and other aspects of tooth positioners. I consider this paper to be a poor piece of scientific reporting and that it achieved acceptance in orthodontic circles as it "confirmed" the thoughts that many people had.

I object to this paper on the following grounds:

1. Very important variables are hidden in the information presented. These variables greatly affect the results and yet are not discussed, and
2. I suspect the experimental groups were not randomly gathered but may have been the result of careful selection so that a preconceived result may be obtained.

My evidence of these points is:

1. Hidden variable

Of special concern to me is the position used for the maxillo-mandibular recording. The authors do not specify what form of interocclusal recording they use for each group. However, for the Hinge axis group (HA) of patients, they use the leaf gauge technique. This means that a centric relation (CR) record was taken, although they do not specify it. I know this because Williamson & Associates (1980) found the leaf gauge method to be the most accurate method of establishing the centric relation position. For the 1980 study, the definition of centric relation was the most superior POSTERIOR position for the condyle in the glenoid fossa. In a later paper, Williamson (1981) changed his view of centric relation and he, in line with most grathologists, considered CR to be the most superior ANTERIOR position of the condyle in the glenoid fossa. However, Williamson did not change his technique of recording CR, despite his changed objective. Klineberg (1985) considers the leaf gauge method, as outlined by Williamson & Associates (1980), to be an unsatisfactory way of recording CR as it may distalise the condyles too far.

For the “bench made” positioners (BM) used in this study, Williamson & Associates used a maximal intercuspation interocclusal record.
Preformed positioners (PF), also used for comparison, are manufactured from models opened from a maximal intercuspation recording.

Therefore, although this point is not made apparent, different maxillo-mandibular relationships, and therefore condylar positions, were used.

The most important point here is how apparent is this fact. As this was a factor in which I was interested, I realised it. However, I asked eight other orthodontic students and orthodontists, some of these having postgraduate training in occlusion, to list all the variables that may affect the results. Not one of them noted the different interocclusal recording methods.

Therefore, I conclude that this is a "hidden" variable. It is one that should have been discussed. The effect of this variable will be discussed shortly.

2. Random or Careful Selection?

Again this may be considered a "hidden" factor. Nowhere do the authors state that a random selection was used. Therefore careful selection is a possibility. The facts should be examined closely.

If we examine the Fig. 2 from the study (fig. 3). The easiest group to discuss is the Preformed positioners (Ortho-tain brand). These preformed positioners are manufuctured with the incisor midlines coincident. If the patient has his dental midlines coincident and he bites into an Ortho-tain preformed positioner the mandible must come forward, from centric relation, into near maximal intercuspal position, for the bite. If maximal intercuspation coincides with centric relation there is no condylar translation. If maximal intercuspation is "x"mm forward, the mandible and the condyles must come forward "x"mm. Very importantly, the condyles must come forward an equal amount to keep the midlines level (figs. 25 and 26).

If the dental midlines did not coincide in central relation, when the patient bites into the Ortho-tain preformed positioner there would have to be a lateral movement of the mandible so that the dental midlines would coincide to enable the patient to close into the preformed positioner. This lateral movement of the mandible would require one condyle to come forward more than the other (figs. 27 and 28). The converse is also true, i.e., if one condyle comes forward more than the other, the relationship of the dental midlines must change.
Now, if we examine Williamson & Associates (1984) figure 2 (our Fig. 23), if we look at the columns detailing condylar movements for the preformed positioners, we can see that there are a maximum of only seven cases, out of the total of 19, where both condyles may have moved evenly. As all of these cases had their midlines coincident with the tooth positioner in place, in at least 12 the midlines were not coincident in centric relation.

An important question is whether this amount of midline discrepancy would occur in a randomly selected group. The answer to this is only conjecture. However, I believe that in the Begg lightwire technique, this degree of discrepancy would not occur, especially in a teaching school. In the patients examined in this study of Williamson & Associates, the condyle on one side moved forward up to 3mm more than the other condyle. This is a considerable difference.

Other Doubtful Considerations

There are other questions about examiner bias. Although of less importance, when weighed with the above evidence it looks unfavorable. Some of these points are:

1. In their fig. 2, it can be noted that at times the maximum intercuspation positions actually placed the condyles posterior to the centric relation condylar position. This is a very unusual relationship that is difficult to understand. I am very surprised with the frequency that this occurs in this experiment.

2. From their Fig. 2, it may also be noted that one patient, from centric relation, had to move his right condyle forward 7.5mm, and left condyle 8mm, to get into a position of maximum intercuspation. I am assuming these measurements are from the one patient, if they are not there are two patients with problems. 7.5 and 8mm is the size of a premolar. Therefore, this patient has a dual bite and his or her true occlusal relationship is an Angle’s class II division 1 malocclusion. This situation is duplicated in my figures 25 and 26. Again this would have mislead any reader who assumed the subjects had class I occlusions.

   This argument can be extended to other patients who have 5 and 6mm discrepancies between centric relation and maximum intercuspation.

3. The use of the term “Bench-made” positioners is unusual. I have not read the term elsewhere, nor had any of the people I enquired to in Australia or
Fig. 2 Effect of different tooth positioners on mandibular condyle placement with respect to the anteroposterior plane. (CR = centric relation; HAR = hinge-axis positioner, right condyle; HAL = hinge-axis positioner, left condyle; BMR = bench-made positioner, right condyle; BML = bench-made positioner, left condyle; OR = Ortho-tain preformed positioner, right condyle; OL = Ortho-tain preformed positioner, left condyle)

Fig. 23: From Williamson and Associates, p. 338.

Fig. 24: Normal dental arch relationship. Midlines coincide. Condyle to fossa relationships normal.
Fig. 25: A Class II Division I case with 8mm overjet, in Centric Relation.

Fig. 26: The same case wearing a positioner with normal overjet. Note the 8mm displacement of both condyles from the fossa.
Fig. 27: A case where, in central relation, the midlines do not coincide.

Fig. 28: The same case, but wearing a positioner that makes the midlines level. Note the condyles move forward unevenly.
overseas. I consider this to be a derogatory term. The problem with “bench-made” positioners in Williamson & Associates (1984 p.335) is that “the teeth are unlikely to intercuspate maximally in the centric relation position”. No tooth positioner can make the teeth intercuspate maximally in centric relation. This must be achieved with fixed mechanics and intermaxillary or extra-oral traction. The authors infer their “hinge-axis” positioners can make centric relation and maximum intercuspation coincide where they did not previously. I do not believe this and have not found or read any evidence to suggest this is a constant occurrence.

Conclusion

This is sufficient discussion to show the misleading nature of this paper. There are no false claims. However, the numerous misleading statements are equally as damaging. It is a poor reflection on the journal which published the paper. I attribute the acceptance of this paper to be based on the reputation of the authors, as well as the general belief that their claims were true. I suspect the points they set out to prove are true. However, the discrepancies would be nowhere as great as they have shown.

A similar study has been undertaken by Grosse & Hofman (1985). Although published in German, I was able to obtain an English translation from Dr. Grosse. In this study a centric relation interocclusal record is used for the “hinge-axis” positioner. There is no specific statement describing the other occlusal relationships used. However, as no interocclusal records were taken, maximum intercuspation must have been the one. Therefore, I again credit the differences the authors found to be a result of the interocclusal record and not of the facebow use.

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APPENDIX 4

Booklet Produced by Professional Positioners.
For Issue to Patients with the Tooth Positioner.

CHECK POINTS

- Keep it clean
- Make sure your PROsitioner is fitting properly
- Keep it clean
- Wear your PROsitioner as many hours as directed
- Keep it clean
- Exercise with your PROsitioner by biting into it several times each minute

LET'S FINISH WHAT WE STARTED

This booklet is all about your PROsitioner — the next and very important phase of your treatment. Read this material carefully and feel free to discuss any additional questions or problems you may encounter — we want you to fully understand why you are wearing this appliance and what it is designed to accomplish.

Fixed appliances have done their part — now with the PROsitioner YOU must finish what we started! Several months of concentrated effort in wearing this finishing appliance will give you the smile we’ve worked for and also insure a more stable result.

Here’s what we’ve done

Your PROsitioner perfectly fits the corrected set-up model.

The most recent plaster models made of your teeth were used to construct your PROsitioner. Small but important changes were made on those models by actually cutting off the teeth and repositioning them with wax to their most ideal appearance and fit. Your rubber PROsitioner was then molded to match this corrected “set-up” model. When you bite into your custom-made PROsitioner, the elastic properties of the rubber will exert pressure to move your teeth into their new corrected positions. When the PROsitioner is worn as directed, these minor corrections become quickly evident; however, it is important to continue wearing this appliance as directed so that your teeth and the tissues and bone around them can properly stabilize to avoid relapse.
here's what you must do

When your teeth are fitting correctly into your PROsitioner, you are ready to exercise with it. This is done by biting vigorously for 10-15 seconds at a time and releasing, then repeat continuously — this biting action should be straight up and down, while your teeth are still fully engaged in the PROsitioner sockets.

Bite HARD straight Up and Down!

By repeating this biting and releasing cycle several times each minute, your cheek muscles are providing added force to achieve the desired tooth movement. Don't be discouraged if your teeth feel sore the first few days — this means your PROsitioner is working! Stick with it and in about a week the soreness should disappear as your teeth are guided into their proper positions.

to achieve that . . . beautiful smile

How many hours a day should you wear your PROsitioner? Many orthodontists require their patients to wear them 20-24 hours for the first 2-3 days, ideally over a weekend. This concentrated initial use normally produces very noticeable results. Thereafter, the PROsitioner should be worn 4 hours per day and at night if at all possible. This schedule must be maintained despite any soreness, social activities, or other excuses you might use to not exercise with your appliance. Diligent use of your PROsitioner will soon be rewarded by a reduction in daily wearing time.

Wear your PROsitioner whenever it is convenient — reading, watching TV, working around the house, etc. Each exercise period should be at least 20 minutes at one time — lesser amounts are not too beneficial. Remember — force your teeth into the sockets. You'll feel your cheek muscles tighten — then relax. Strive to repeat the process several times each minute. It is this type of exercise that will guide your teeth into their proper positions and speed the day when wearing time can be reduced.

Wear your PROsitioner whenever possible . . .

AT PLAY . . . OR AT WORK
keep it clean

Scrub your PROSitioner vigorously

Keep your PROSitioner clean by scrubbing it daily with a stiff toothbrush and your favorite toothpaste or powder — this also provides a pleasant taste. Get in the habit of also brushing your teeth before inserting your PROSitioner — this will prevent pushing any food residue under your gums. Your "PRO" will quickly become discolored and unattractive if you do not scrub and rinse it regularly. A PROSitioner is made from tough rubber; therefore, you can bend it to scrub it vigorously, or soak it in water and baking soda or denture cleaner to keep it fresh. If your PROSitioner has breathing holes, it is helpful to keep these holes clean by running a wire pipe cleaner through them each week.

keep it clean

A special Carrying Case has been provided with your PROSitioner — it can be a convenient container for carrying your "PRO" in either your purse or pocket. Again we repeat — wash or rinse your PROSitioner after wearing it; otherwise the inside of this plastic case can also become badly soiled! Keep the lid open for better air circulation if you are temporarily storing your PROSitioner in this container.

Your PROSitioner will be expensive to replace if lost or damaged — take good care of it. A special word of warning — keep it away from the family dog as they seem to like PROSitioners!

Beware! . . . Dogs love 'em!

wear chart

Accumulate total wearing time on your TIMEOMETER and record the number of hours your PROSitioner is worn at the end of the day. Place first entry in column corresponding to month and day your appliance is received. Maintain an accurate record and wear your PROSitioner the number of hours prescribed by your orthodontist.

A "Timeometer" has been included in the plastic case to aid in keeping track of your daily wearing time. Move the red arrow one notch for each 20-minute period of exercise wearing time. It's important that you achieve or exceed the prescribed number of wearing hours — the Timeometer makes it easier to record the total time throughout the day.

The chart on the opposite page should also be used to record wearing time — if you omit exercising one day, you will have to double up your wearing time the next day.
CONGRATULATIONS—
YOU HAVE SELECTED

PRE-FINISHER®

THE WORLD'S FINEST
PREFORMED FINISHING APPLIANCE

NOTE: The Pre-Finisher is not a tooth
positioner. By definition, a tooth
positioner is a custom-made
appliance constructed over the
models of a patient, on which one
or more teeth have been
rearranged. Obviously then, even
though a Pre-Finisher may
resemble and initially act and hold
like a tooth positioner, it cannot
be expected to maintain detailed
tooth positioning over an extended
period of time. A Pre-Finisher is
usually followed by a rigid,
custom-made retainer or a tooth
positioner.

Pre-Finishers are covered by
U.S. Patent Nos. 3,837,091 and 4,109,046

The PRE-FINISHER®—A Brief Introduction

Pre-Finishers are the finest
preformed orthodontic finishing
appliances. They are precision
molded from crystal-clear plastic,
with the upper and lower dental
arches related in rest position.
Tooth-to-socket relationships are
clearly visible to facilitate
proper size selection.
Available with or without Precision
Seating Springs, Pre-Finishers
meet the demands of each patient
and the preferences of all
orthodontists. Unique anterior
airways increase patient
acceptance, cooperation and
results.

Available in three series, they
accommodate the following
closures: Four Bicuspid
Extraction, Non-Extraction, and

Two Upper Bicuspid Extraction,
Sized in one millimeter increments
(range 40 to 60 millimeters), each
series of Pre-Finishers contains
more sizes than any other
preformed finishing appliance.
Size, in millimeters, is molded into
each part for easy identification.

Pre-Finishers are normally worn
for a short period of time between
the removal of fixed orthodontic
appliances and the placement of a
custom appliance, such as a
tooth positioner or a retainer.

For ease of ordering, and to help
create a balanced inventory,
Pre-Finishers are available in three
sizes of kits: Convincer, 10
appliances; Standard, 15 appliances;
Thrift, 20 appliances. (See pages
17-18-19 for complete information.)
PRE-FINISHER—Exclusive Features

Not Available in Any Other Preformed Finishing Appliance:

- Adequate coverage of second molars, when required.
- Available with or without seating springs.
- Smooth, rounded borders—no sharp edges.
- Relief for incisive papilla.
- Formed from crystal-clear, yet soft, resilient plastic.
- Accurate freeway space—insures maximum comfort and proper anteroposterior arch relationships.
- Unique, molded airways increase patient acceptance and cooperation.
- Last two digits of part number molded into airways of each appliance indicate size in millimeters.

PRE-FINISHER—Suggested Applications:

1. As an immediate finishing appliance to bridge the gap between fixed appliance removal and the placement of a custom appliance such as a tooth positioner, or a rigid retainer. Normally when used for this purpose, the Pre-Finisher is worn from one to twelve weeks.
2. As an adjunct to fixed appliance therapy. By grinding away selected portions, the Pre-Finisher can be worn over fixed orthodontic appliances to help discourage clenching habits. It can also act as an anterior bite-plane, to encourage or permit bite-opening. When worn over existing appliances, a modified Pre-Finisher can also provide anteroposterior corrections to augment intermaxillary Class II or Class III elastic forces.
3. To supplement fixed retention. The lower anterior sockets can be eliminated, and the Pre-Finisher worn over a cuspid-to-cuspid retainer. This will permit simultaneous corrections in the upper arch and improvements in the anteroposterior interarch relationships, to help correct a relapse toward a Class II or Class III malocclusion.
4. To apply topical medication in the office or at home, following the dentist's instructions. Clear material permits visual examination of areas covered by medication, to insure maximum benefits. Airways permit continued breathing and peace of mind.
5. When properly fitted, the Pre-Finisher can be the finest preformed athletic mouthguard. Soft, tough material provides comfort and protection desired. Anterior airways and optional seating springs further encourage wearing by facilitating breathing and retention on the upper arch. (Note—Safety straps of some type should be attached to Pre-Finishers when they are to be worn during contact sports.)
**PRE-FINISHER—Expectations**

When worn as recommended, a properly fitted Pre-Finisher can be expected to accomplish one or all of the following corrections:

1. Close all interproximal spaces (if total spaces are more than one millimeter in either arch, a Pre-Finisher with seating springs is recommended).
2. Align anterior teeth, space permitting.
3. Correct both anterior and posterior cross-bites.
4. Rotate central and lateral incisors, provided space is available.
5. Maintain or correct anteroposterior interarch relationships.

6. Level the Curve of Spee, to help open deep anterior overbites.
7. Help close anterior, or lateral open bites by preventing tongue thrusts.
8. Improve and coordinate dental arch form.
9. Discourage the following habits:
   A. Mouth breathing (in patients who have no actual nasal airway obstructions)—Airways help patient accept appliance initially, can be gradually reduced in size with hot salvudal as patient progresses.
   B. Bruxism.
   C. Thumb-sucking.
   D. Finger-nail, or lip biting.

**PRE-FINISHER—Selection and Fitting**

Using the special millimeter rule provided with each Pre-Finisher Kit, measure along the incisal edges of the six upper anterior teeth to determine their total width.

The ruler is designed so it can be read on either the patient's right (as illustrated below), or left side—according to the preference of the operator.

Select an appliance in the proper series (Non-Extraction, Four Bicuspid Extraction, or Two Upper Bicuspid Extraction), having a part number ending in two digits the same as the millimeter measurement. If there are band spaces to close, select a Pre-Finisher one size (one millimeter) smaller.

For the patient pictured in Figure 1, with no band spaces (as would usually be the case with direct bonding), an appliance of the proper series with a part number ending in "51" would be selected. If this patient had four pre-molars extracted, and no seating springs were needed, a Pre-Finisher identified with the number "451" would be selected. The "4" indicates the Four Bicuspid Extraction Series with no springs. If seating springs were indicated, a "51" appliance would be chosen. The "5" identifies the Four Bicuspid Extraction Series with seating springs mesial to the upper molars. Refer to the chart on page(s) 17-18-19 for complete listing of all series, with and without seating springs, and their appropriate numbers.

Fit the Pre-Finisher selected onto the upper teeth and have patient close firmly into the appliance. The cuspids should be tightly in contact with the distal surfaces of their respective sockets in the appliance. This can easily be determined by visual examination.

**PRE-FINISHER—And Seating Springs**

If spaces in the upper arch total one millimeter or more, or increased retention of the appliance is desired, a Pre-Finisher with seating springs should be utilized.

Initial size selection procedure is the same as that used for Pre-Finishers without seating springs. Next, care is taken to seat one seating spring completely (usually the left), and while holding the appliance firmly to place on that quadrant, stretch it around and seat the spring on the opposite side.

If no distal pressure is needed to seat the second spring (i.e., if the springs do not press against the distal surfaces of the buccalides), then the springs may need to be modified. Bend the arms of the springs ¼ millimeter, as shown in Figure 3. This will effectively shorten the inter-spring arch length by one millimeter, and should result in the desired space-closing forces when the appliance is seated.

Figure 2. Desired cusp-socket relationships when fitting Pre-Finisher—pressure from appliance will urge teeth toward midline, through the appliance, (Figure 2). Of course, if spaces are to be closed between the anterior teeth, it may be necessary to slightly stretch the appliance to achieve the desired cusp-socket relationships.

Figure 3. Arms of seating springs can be bent mesially to increase space-closing forces.
If bending the springs does not give the desired results, select a smaller size Pre-Finisher and repeat the steps above, as required. Conversely, if it is not possible to seat both the right and left springs at the same time because the inter-spring arch length is too small, the arms of the springs are bent distally approximately 1/8 millimeter. After the patient has worn the Pre-Finisher and the spaces have begun to close, the springs can be returned to their original inclinations to "reactivate" the appliance.

NOTE: If one has not had experience with seating springs, the first thought may be that the arms of the seating springs are too long. Do not arbitrarily shorten these arms—they are designed properly, to provide maximum retention and delivery of forces. The opposing arms of each spring are directed toward one another, to place their retentive ball-ends in the gingival embrasure areas. If the end of a spring is causing discomfort, chances are it is not placed properly, or needs to be directed into the embrasure area. Check placement, and bend the arm of the spring before cutting the arm shorter.

**PRE-FINISHER—Comfort and Fit**

The Pre-Finisher can be made more resilient, and initial patient comfort aided, by immersing it in lukewarm water 15 to 30 seconds before placing. If this does not permit proper seating, choose the next appropriate size.

The depth of sockets in all Pre-Finishers is directly related to tooth width. This feature reduces the chances for impingement on the patient's soft tissues. However, it is recommended that all flanges be examined to determine any pressure points. These will be evident by blanching of the tissue when the patient clenches into the appliance. Small pressure areas can be relieved with an acrylic Burr, larger ones reduced with a carborundum wheel on a dental lathe.

The flanges may stand slightly away from the gingival tissue, especially in the upper anterior area. This is merely an indication of flared or excessively procumbent upper anterior teeth. As spaces close and/or teeth upright, the flanges will move closer to the gingiva. The Pre-Finisher is designed in this manner, to reduce the possibility of tissue impingement as the teeth move.

Pre-Finishers eliminated during fitting can be cold-sterilized (do not boil or autoclave), and placed back into inventory. Rinse thoroughly to clear all sterilizing solution from the anterior alveolus.

**PRE-FINISHER—And The Patient**

The manner in which the Pre-Finisher is presented and explained to the patient can often mean the difference between success or failure. Its design and function should be carefully explained—include a parent if the child is young, or seems uninterested. A Pre-Finisher booklet is provided to help explain wearing and care of the appliance, as well as a means of recording wearing time.

Satisfactory results can be achieved with a schedule of 4 hours of exercise wearing (firmly closing the teeth into the Pre-Finisher until muscle fatigue occurs, then relaxing, but keeping the teeth seated in the appliance) and night-time wearing. The daytime (exercise) wearing schedule need only be 3 hours if seating springs are employed.

The patient should be examined 2 to 3 weeks after the appliance is placed. If results are satisfactory, the exercise wearing time can be reduced—usually in one hour increments, and intervals between appointments lengthened by one week. After 2 to 3 months, the successful patient will have achieved all desired corrections, and will be wearing the appliance one hour during the day and while sleeping.

Pre-Finishers will fit most occlusions at the time fixed appliances are removed, or nearly normal occlusions that have had no orthodontic treatment. One exception would be those few cases with tooth mass discrepancies—i.e., patients who have one or more teeth that are relatively large or small. Another exceptional type case which would not lend itself to a Pre-Finisher would be one which exhibits unbalanced extractions—i.e., only one tooth removed in one or both arches.

However, it should be appreciated that the Non-Extraction Series of Pre-Finishers can be used on patients who have had the four first molars extracted. Also, the Four Bicuspid Extraction Series can be used when any combination of bicuspids has been removed—as long as one has been removed in each quadrant. For example, Pre-Finishers will fit cases with upper first and lower second bicuspids removed.

Even eight-tooth extraction cases (four molars and four bicuspids removed) can be finished using the Four Bicuspid Series of Pre-Finishers. It may be necessary to trim off the distal ends. Unless, of course, the third molars have erupted, which then would fit into the sockets normally occupied by the second molars.
Another suggested wearing schedule calls for the patient to wear the Pre-Finisher continually for the first two days—nearly 48 consecutive hours, with as much exercise wear as possible, if it is taken out for eating only. When this approach is used, the appliance is usually placed on a Friday so that the wearing schedule will not interfere with school activities. After two days the patient is instructed to reduce wearing to 3 or 4 hours a day, plus all night. The patient is seen in 2 to 3 weeks, and if the results are satisfactory, exercise wearing is reduced one hour each appointment, as mentioned above.

Of course, if after the initial wearing period no changes have occurred, the appliance has either not been worn enough, or improperly. Have the patient place the Pre-Finisher, and demonstrate exercise wearing. Check for fit—also for development of maserter muscles.

If the appliance fits well and the patient has exercised into it properly, he or she must not have worn it for a prescribed number of hours. Go over the wearing schedule. When lack of cooperation is suspected, and the patient is a child, discuss the problem with a parent. Often this will help emphasize the need for proper wearing, and result in progress at the next visit.

**PRE-Finisher—Available in Three Series**

Plain and With Seating Springs

**NON-EXTRACTION SERIES**

Can also be used on first molar extraction cases. Nineteen sizes (40 mm to 55 mm).

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<tr>
<th>Size Range</th>
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**PRE-Finisher—Kits Available**

To provide an immediate balanced supply of Pre-Finishers, according to the wishes of each orthodontist, the following kits are available:

**CONVENTIONAL KIT**

10 Assorted Sizes

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<tr>
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**STANDARD KIT**

15 Assorted Sizes

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**THRIFT KIT**

20 Assorted Sizes

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To facilitate replenishing kits and ensuring an adequate selection of sizes, it is suggested that each orthodontist designate a specific address for mailing and return to when restocking—also supply with the labels on an order card, or your letterhead stationary, and mail to TP. We will see to it that the proper sizes are on their way to your office, to enable you to have a complete selection when required.