PROXIMAL STRIPPING AND ENAMEL SURFACE ROUGHNESS

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INTRODUCTION

Proximal stripping, according to Peck and Peck (1972A), "is a clinical procedure involving the reduction, anatomic recontouring, and protection of the mesial and/or distal enamel surfaces of a permanent tooth". Interproximal, interdental, or proximal stripping, re-approximation, reproximation, recontouring, trimming, mesiodistal reduction and vertical grinding, are some of the various terms used to describe this procedure (Peck and Peck 1975B, Betteridge 1981).

The use of proximal stripping has over recent years increased in popularity with the desire of orthodontists to treat a greater variety of malocclusions, with perhaps less need to turn to extractions to provide the space to correct minor malocclusions. Orthodontists have also turned, increasingly, to proximal stripping to help them to stabilize the occlusions that have been produced by their therapy, and to help re-treat any relapse that may have occurred after this therapy. The various indications for the use of proximal stripping will be discussed and detailed.

With this increase in popularity of proximal stripping a number of different techniques of stripping have been developed and advocated by various authors. These various techniques will be stated, and some of the effects of these procedures on the enamel will later be related.

However proximal stripping is not without problems and dangers, and the various restrictions and limitations of proximal stripping will be discussed. One of these dangers is the possibility of decay occurring on the proximal surfaces of the teeth some time after proximal stripping. This possible consequence is due to the loss of
protective enamel, and the possibility that the rougher surface left after proximal stripping will collect more plaque and predispose the teeth to the decay processes. Various proximal stripping techniques, it is postulated, will produce varying roughnesses of the enamel surface; it is in this area that the original research in this thesis is focused.
CHAPTER 1

INDICATIONS FOR PROXIMAL STRIPPING

There are many reasons why a clinician may choose to carry out the procedure of proximal stripping, and these will be reviewed under five headings.

1.1 To correct tooth size discrepancies

Intra-arch size discrepancies

In his study of 500 cases Ballard (1944) found that 90% showed a left-right tooth size discrepancy in one or more pairs of teeth. Of these, 408 showed discrepancies greater than 0.5 millimetres, and another 40 had discrepancies of between 0.25 and 0.5 millimetres. Ballard believed these discrepancies, if not corrected, could be responsible for rotations and slipped contacts after cases are released from retention. He advocated the judicious stripping of proximal surfaces to correct this disharmony.

Sandilands (1965) also studied the variation in tooth size between left and right sides, and found there was a marked size difference occasionally in individual cases. He stressed that these discrepancies were individual and that there was no tendency for one side to dominate in size over the other.

Inter-arch size discrepancies

Kesling (1945) stresses the importance of a favourable inter-arch tooth-size relationship for the establishment of a stable occlusion. He used a "Kesling set-up" to study and determine the presence or extent of such discrepancies.
Steadman (1949) felt that the anterior tooth-size inter-arch relationship was of particular importance. To determine this relationship, he measured the distance from the distal of one lower cusp to the distal of the other lower cusp along the contact points of the lower incisors; to this distance he added half the labio-lingual thickness of the lower lateral incisors at the incisal third; similarly he measured the distance from the lingual eminence of one upper cusp to the lingual eminence of the other upper cusp, and, from this distance he subtracted one-half the labio-lingual thickness of the upper central at its incisal third. If these two measures were equal then the tooth-size inter-arch relationship was favourable; if not the same then the upper teeth would have been either too large or too small to ideally occlude with the lower teeth. If the upper teeth were slightly larger than the lower teeth and a good Class I canine relationship was to be maintained the clinician may either

1. Increase the overjet from the "ideal"
2. Increase the overbite from the "ideal"
3. Reverse torque the upper incisors from the "ideal" making them more upright decreasing the arch perimeter
4. Mesially tip the roots from the "ideal" to decrease the effective width of the crowns
5. Allow crowding of the upper anteriors or spacing of the lower anteriors
6. Proximal strip upper anteriors.

The orthodontic treatment of larger lower teeth (than upper teeth) can be performed with the above principles in reverse, to maintain a Class I canine relationship and favourable buccal interdigititation.
Rees (1953) also measured the relationship of the width of the maxillary teeth to the width of the mandibular teeth, and discussed the importance of discrepancies in the diagnosis of the malocclusion and its treatment.

Neff (1949) tackled the problem of the relationship between inter-arch tooth-size discrepancies and an acceptable anterior occlusion by developing his "anterior coefficient". He determined the anterior coefficient by dividing the total width of the upper six anterior teeth by the sum of the six lower anterior teeth. He determined that the "ideal anterior coefficient" would be 1.20 to 1.22 when there is a nicely balanced anterior occlusion with a 20 per cent overbite. He further points out that even when the anterior coefficient varies by 20 per cent a good occlusion is still obtainable.

Neff (1957) later converted this to what he termed the "Anterior Percentage Relation" (A.P.R.). This is the percentage larger the upper six anterior teeth are than their lower mates. He estimated that the normal range is between 18 and 36 per cent. He further demonstrated how this is related to overbite and how the thickness of the upper anterior teeth plays a part in the interincisal relationship; that is, he showed that when the upper anterior teeth are thicker labiolingually than normal at the interincisal point, the teeth are placed more forward bringing the canines mesially causing an imbalance in the anterior inter-arch relationship. Neff said that where the anterior percentage relation falls outside of his 22 to 36 per cent normal range, proximal stripping or extraction was indicated to correct the discrepancy. He said that relations (less than 22 per cent A.P.R.), that indicate reduction in tooth size of
the mandibular anterior teeth are necessary, occurred in approximately 10 per cent of malocclusions; it is very rare that reduction in the size of the maxillary anterior teeth is indicated (i.e. it is rarer that the A.P.R. is greater than 36 per cent).

Ballard (1956) found that denture manufacturers, when producing artificial teeth, made the combined mesiodistal widths of the lower six anterior teeth 75 per cent of the combined widths of the upper six anterior teeth, and so produced an "ideal anterior occlusion". He found that the formula coincides with Neff's findings. Ballard also studied some 400 orthodontic cases and found that more than 50 per cent of them, had a total mesiodistal width of the lower six anterior teeth 2 millimetres or more in excess of their ideal relationship with the total mesiodistal width of the upper six anterior teeth. He said that this means that if ideal contact point relationships are established in both arches and a highly satisfactory arch-to-arch relationship is achieved on one side, the other side may be thrown out by discrepancies in tooth size. He advocated the procedure of proximal stripping and/or extraction to rectify this discrepancy to attain an "ideal" relationship.

Lundstrom (1954, 1955) also studied the anterior relationship as well as looking at the posterior relation and the overall inter-arch tooth relationship. He produced three indices and values for these relationships, and Neff (1957) later found his Anterior Percentage Relation was almost identical to the value determined by Lundstrom for his anterior index. Lundstrom noted that when lower teeth are comparatively larger than the upper teeth, then there is a tendency to crowding in the lower arch; and in cases when comparatively smaller lower teeth are present, the upper teeth tend to be crowded. He said
that treatment planning must be modified to take this into account.

Bolton (1958, 1962) carried out his research along the same lines as Lundstrom. He studied 55 excellent occlusions (with good overbite and overjet relations) and found that when the twelve maxillary teeth were compared with the twelve mandibular teeth in a ratio:–

\[
\frac{\text{sum of widths of mandibular "12"}}{\text{sum of widths of maxillary "12"}} \times \frac{100}{1}
\]

it equalled an overall ratio of 91.3 ± 0.26. He found also that in comparing the six maxillary anterior teeth to the six mandibular anterior teeth in a ratio:–

\[
\frac{\text{sum of widths of mandibular "6"}}{\text{sum of widths of maxillary "6"}} \times \frac{100}{1}, \text{ an "anterior ratio" of 77.2 ± 0.22 was obtained. He suggested that where an interarch discrepancy was present or thought to be present, his formula could be used algebraically to determine the size and position of the discrepancy. For example the formula, \[
\frac{\text{mandibular "x"}}{\text{maxillary "6"}} \times \frac{100}{1} = 77.2
\]

could be used, and with simple mathematics a value for "x" is determined, and this is compared to the actual width of the mandibular "6" teeth. To simplify this procedure Bolton has produced his two well known tables which eliminate the need for computing the mathematical ratios. He said that once the size of the discrepancy is obtained, it can be corrected to produce a more desirable occlusion. He has suggested the use of mesiodistal stripping and/or extraction to rectify this imbalance.

Lundstrom (1981) has also re-emphasised the importance of tooth-size discrepancies, and has published a comprehensive table from which variations in upper tooth widths in relation to lower tooth widths can be established. (Table 1)
Table 1. Intermaxillary tooth-size relationships
(from: A. Lundstrom 1981)

Bolton also pointed out, in accordance with Steadman (1949) and Neff (1957), that the inclination of the teeth, and the thickness of the upper anterior teeth, can alter these ratios and relationships, and that corresponding adjustments must be made.

The accuracy of Bolton's ratios have been verified by many authors, including Neff (1957) and Stifter (1958), and have become well accepted diagnostic aids and indications for proximal stripping in indicating tooth size discrepancies when they exist.

White (1982) has however recently shed some doubt on the accuracy of Bolton's figures. From his study White felt that the acceptable range of the ratios of the mandibular "12" to maxillary "12" and mandibular "6" to maxillary "6" are much wider than that recorded by Bolton, though the mean of the ratios in both studies are very close.
White thereby feels that some occlusions, which have ratios about two millimetres greater or smaller than those regarded as favourable by Bolton's ratios, may still have quite favourable and acceptable occlusions without the need for adjustment.

White also shows with his study that there is a poor correlation between the "overall ratio" and the "anterior ratio" which Bolton believed had a moderate correlation. He further demonstrates some cases which he has treated where Bolton's ratios have been misleading and have not indicated correctly that an inter-arch tooth size discrepancy does or does not exist. However, without closer examination of these cases (not possible from the information presented), it is difficult to refute or corroborate these findings.

White recommends the use of occlusograms to establish accurately whether a tooth size discrepancy exists. An occlusogram is a one to one reproduction of the occlusal surfaces of plantar models on a sheet of acetate tracing paper. The tracings of the upper and lower casts are accurately superimposed, and the number and position of the teeth can be placed and re-arranged into an optimum occlusion, and from this, such factors as tooth size discrepancies can be gauged.

Marcotte (1976) and Burstone (1979) have also used occlusograms to study occlusion and have noted their usefulness in gauging tooth size discrepancies.

White also discusses the role of proximal stripping in reducing tooth size discrepancies, and recommends it as the "least offensive" approach to rectifying such discrepancies, though he points out that it may not always be the treatment of choice.

Another author, Boersma (1971), also showed that the combined
width of the maxillary teeth does not always correspond to those of the mandibular teeth. He found that a tooth size discrepancy occurs in 30 per cent of orthodontic problems, and that "perfect" occlusion can only be achieved in instances where there are no tooth size discrepancies. He advocates the use of proximal stripping, extraction or enlarging restorations to overcome these discrepancies.

Sanin and Savara (1971) use another method to compare tooth sizes. They use a table on which the width of each tooth is plotted, and a line graph is drawn. These are then compared to normal values, and to each other, to assess the magnitude and position of any discrepancies. They note that 22 billion possible combinations of crown-size discrepancies exist. However, they do add that many of these discrepancies exist in good normal occlusions, and that, unless the discrepancies are large, they seldom cause any occlusal irregularities.

This point, perhaps should be emphasised, that not all discrepancies need to be adjusted, or are indication for proximal stripping. Only when the discrepancies are large enough to cause unacceptable irregularities in the occlusion should such measures be considered for these reasons alone. In fact Moorrees and Reed (1954) believed that only 0.7 per cent of crowding and spacing problems were due to tooth-size discrepancies, while 99.3 per cent were due to discrepancies between the tooth sizes and their bases (though these figures are a matter of interpretation).

Also, many discrepancies, as Steadman (1949) Neff (1957) and Bolton (1962) have explained, can be accommodated in good occlusions with only slight acceptable adjustments of overbite,
overjet, inclination of teeth or slight crowding or spacing.

Reidel (1975) indicated that interproximal stripping is recommended when an anterior relationship shows a discrepancy of more than 2.5 mm.

Macrodontia size discrepancies

Various writers, Moorrees and Reed (1954), Fastlicht (1970), Norderval, Wisth and Boe (1975) and Lundstrom, according to Norderval, Wisth and Boe (1975), have shown (although others disagree, Mills, 1964) that crowding is more common in cases where the mesiodistal widths of teeth are larger than normal. Though this in itself is not an indication for proximal stripping, in cases where teeth are crowded and larger than normal, proximal stripping should be considered.

Doris, Bernard and Kuftinec (1981) in their study showed also that the total mesiodistal width of teeth was uniformly larger in a crowded arch than in a well-aligned arch. They went on to propose that the measurement of tooth mass could be employed as an aid in diagnosing "borderline extraction cases". They said that "when the sum of the twenty teeth (from second premolar to its antimere in both arches) is 140 millimetres or greater, the clinician can label the case as one having larger than normal tooth mass and thus consider the need for extraction therapy"; which of course must be considered in conjunction with the other diagnostic information such as the available arch length. It can then be speculated that if the tooth mass could be reduced by proximal stripping to below the 140 millimetre figure, a potential borderline extraction case could be transformed into a possible non-extraction case.
Tooth shape size discrepancies

Imbalance of tooth structure may occur not only when all the teeth are present and apparently normal, but often also when the teeth are malformed, congenitally absent or have been lost. Tuverson (1970, 1980A and B) and McNeill and Joondeph (1973) indicate that tooth-size discrepancies are a major problem in such cases and that amongst other procedures, proximal stripping is a very important tool in obtaining a good occlusion.

An important landmark in the assessment of tooth size discrepancies has been the work of Peck and Peck (1972A and B, 1975A and B). They indicate that a substantial relationship exists between mandibular incisor shape and the presence and absence of mandibular incisor crowding. Apparently well aligned mandibular central and lateral incisors have a remarkably distinctive crown shape, as expressed by the mesiodistal to faciolingual index - (MD/FL index); well aligned mandibular incisors have MD/FL indices significantly lower than those of crowded incisors. The index for each tooth is calculated by the following formula.

\[
\text{MD/FL index} = \frac{\text{mesiodistal crown diameter in millimetres}}{\text{faciolingual crown diameter in millimetres}} \times 100
\]

From their research of crowded and uncrowded teeth, Peck and Peck found that the maximum limit of desirable MD/FL index, is 88-92 for mandibular central incisors, and 90-95 for mandibular lateral incisors. That is, lower incisors within or below these ranges may be considered favourably shaped for good alignment. Any mandibular incisor with a MD/FL index above these ranges, however, possesses a crown shape deviation which may influence or contribute to crowding.
Peck and Peck stress that there are many factors indicated in the etiology of crowded teeth, and that teeth with favourable MD/FL indices may still become crowded, while teeth with high MD/FL indices may be well aligned naturally. However in cases where there is an unfavourable MD/FL index they do recommend the proximal stripping of the tooth to attain a favourable index and potentially a more stable crown shape and size. Where extensive mesiodistal re-shaping and stripping has taken place, they recommend that the maxillary incisors also be stripped to maintain an acceptable Bolton's index.

Their studies were done using females only as subjects, and they expect that the same relationships would apply for males. Bau (1973) using male subjects was in agreement with the findings of Peck and Peck for females. He however raised the point that it was not the faciolingual dimensions, but the mesiodistal dimensions which were critical in the index as it related to well aligned or crowded incisors. He found that there was no statistically significant differences in the faciolingual dimension between the two groups (aligned and crowded mandibular incisors).

This author further questions, that if an incisor with a favourable MD/FL index was reduced faciolingually to produce a tooth with an unfavourable or high MD/FL index, would the incisor become more unstable and likely to become crowded in its arch. Similarly, if an incisor with a highly unfavourable MD/FL index was "built out" faciolingually to give it a low and favourable MD/FL index, would it become more stable or less likely to be involved in crowding than it was previously.

This only goes to highlight the importance of the mesiodistal dimension, as opposed to the faciolingual dimension in crowding, and
is not meant to downgrade the usefulness of the Peck and Peck index. The faciolingual dimension still serves to function as a good reliable reference point to gauge mesiodistal dimension and whether proximal stripping would help to attain a better tooth size for a more stable occlusion.

Many authors (Ackerman and Proffit 1975, Swain 1975, Boese 1980A and B and Wallman 1980) have recommended the use of the Peck and Peck index, followed by proximal stripping where necessary to attain a more favourable tooth size relationship.

Keene and Engel (1979) report a method of forecasting the potential for mandibular incisor crowding and relapse by calculating a patient's 'optimal incisal size' using certain computer-generated cephalometric skeletal relationships. This method has a very similar application to that of the Peck and Peck index, using skeletal reference dimensions rather than the faciolingual dimension of the tooth, and Keene and Engel recommend proximal stripping to attain a favourable mesiodistal lower incisor tooth dimension where the analysis indicates a larger than optimal size.

Considerable doubt has been placed on the validity of the analysis of Keene and Engel by Peck and Peck (1980), who show up a number of inconsistencies in the Keene and Engel article. However Keene and Engel do cite a number of other authors who have studied this relationship between lower incisor and skeletal dimensions, and have found some correlations, though they only be of 'low order'. At this stage the analysis of Keene and Engel could not be used to indicate the need for proximal stripping as they suggest. However with more positive support for the validity of their analysis, it could become a useful diagnostic aid.
As can be seen, there is no lack of reference to proximal stripping being carried out to correct tooth size discrepancies to provide better tooth size relationships and occlusion; and there are many other authors (Lusterman 1954, Dipaolo and Boruchov 1971, Sain 1974, Reidel 1976, Begg and Kesling 1977b, 1979-81 and Zachrisson 1978) who have recommended proximal stripping to correct such discrepancies.

1.2 To create space to correct a malocclusion

There is no doubt that one of the main aims of orthodontic treatment is to alleviate crowding of the teeth, and as Moorrees, Thomsen, Jensen and Yen (1957) have said "Since the crowding of teeth depends in large measure on the relationship between the size of the bony dental arch and the size of the teeth, the importance of mesiodistal crown diameter as one of the two factors in the equation is clear". One of the major and most frequent problems faced by the orthodontic clinician is when he is confronted by an arch perimeter too small to accommodate all the teeth. There are a number of methods available to the clinician that will allow him to correct this tooth-size to arch length discrepancy. The arch perimeter may be increased by extra-oral traction to drive the molars distally or by arch expansion to gain space, or more commonly, the tooth structure may be decreased by extraction or proximal stripping to rectify the discrepancy.

When a large amount of tooth structure must be reduced to rectify this discrepancy, only extractions will provide this and the treatment decision in this respect is straightforward (Martinek 1956). However,
when the discrepancy is small or 'borderline', extractions may provide excessive space, making space closure difficult, and in Martinek's words, create "terrific space closing problems". Martinek also found that if on the other hand these cases were attempted by non-extraction therapy, residual crowding may remain - a less than ideal result. In such cases proximal stripping may be used to reduce the tooth structure necessary, and alleviate the need for a difficult and time consuming space closure problem, and spare the patient from a potentially distressing experience and create a more desirable treatment result.

Lusterman (1975) has found that in specific cases multiple extractions of teeth will produce premature aging of the face - the so-called 'dished-in' appearance - in young adults; and that it is often possible, without resorting to removal of teeth, to treat with proximal stripping and create a proper occlusal relationship and marked improvement of facial form in patients who have some minor imbrication and rotation of the incisors.

The problem of the tooth-size to arch length discrepancy has been explored by many authors. The great number of articles written about this discrepancy testifies to its perplexing importance; authors have tried to develop analyses which will allow clinicians to simply, accurately and systematically decide which cases need extraction or those that can be treated non-extraction.

Howes (1947), amongst other measurements and conclusions, related the width of the apical basal bone from canine fossa to canine fossa in the maxilla (C.F.), to the maxillary tooth material (M.T.M.) and concluded that:

1. If the ratio of canine fossa (C.F.) to the combined width
of the maxillary first molars, premolars, canines, and incisors (M.T.M.) is 44 per cent, it may be assumed that the apical bone is adequate.

2. If the ratio between canine fossa and maxillary tooth material is between 37 per cent and 44 per cent, the adequacy of basal bone is questionable. In such cases, Howes suggests that it may be wise not to treat at all or to accept residual irregularity of the lower anterior teeth following treatment. Although Howes did not recommend proximal stripping in these cases, this author believes that the use of proximal stripping may well be used to remove what Howes terms residual irregularities, to produce a well aligned stable arch.

3. Extractions in treatment are definitely indicated if canine fossa to maxillary tooth material is 37 per cent or less.

Nance (1947) and Carey (1949) are two other authors who have developed techniques to measure the arch length and mesiodistal tooth size, and stress the importance of positioning teeth over basal bone, and where discrepancies exist, the need to reduce tooth structure.

Strayer's (1952) method of analysis is a visual means of judging whether the apical bone is of sufficient dimension to accommodate all the teeth. He makes a drawing on plexiglass, producing the apical bone, and marks the widths of the teeth on it. This drawing is co-ordinated with the model, and the relationship of apical base and teeth is readily seen, and the quantity of tooth material alteration can be determined by exact measurement over the malocclusion.

Rees (1953) studied the proportional relation of 1. maxillary apical base to contact diameters of maxillary teeth, 2. mandibular apical base to contact diameters of mandibular teeth, 3. maxillary to mandibular apical base, and to contact diameters of maxillary to
mandibular teeth. He found that in normal cases these measurements showed that upper apical bone exceeds tooth mass by a mean of 3.2 millimetres, lower bone exceeds lower teeth by a mean of 4.47 millimetres, the upper bone exceeds the lower bone by a mean of 6.34 millimetres, and upper teeth exceed lower teeth by a mean of 7.57 millimetres.

Rees says that by using these figures, the analysis will determine accurately whether a malocclusion is an extraction, non-extraction, or borderline problem. This author would once again refer to these "borderline problems" as possible proximal stripping cases.

According to Stifter (1958) the analysis by Pont who developed a system whereby the mere measurement of the four maxillary incisors automatically established the widths of the arches in the premolar and molar regions, and Kesling's use of the diagnostic set-up and cephalogram to analyse tooth structure to basal bone relationships, have been and are useful to varying extents, to determine if the case is an 'extraction', 'non-extraction' or 'borderline' one.

Since these "early pioneers" many other authors have developed techniques for analysing tooth size to arch length relationships, including Beazley (1971), Lombardi (1972) and lately Burstone (1979) and BeGole, Cleall and Gorny (1981) who have used computer systems to this end.

How much space can be gained by proximal stripping to correct these mal-relationships depends very much on how much enamel the clinician feels he can remove from the teeth safely, without discomfort, or without endangering the teeth or supporting structures. This aspect of proximal stripping will be discussed more fully later.
According to Bau (1973), Berger felt that if the lack of space in the lower anterior region is less than 3 millimetres, then one can either accept the crowding or resort to stripping or buccal expansion. If the discrepancy is greater than 3 millimetres, then he recommends extraction of a mandibular lateral incisor.

Barrer (1974) said "that space requirements less than 2.5 millimetres will usually respond to interproximal stripping. However, a discrepancy of more than 2.5 millimetres generally requires the loss of a tooth".

Betteridge (1979) has shown that interdental stripping of enamel is indicated for alignment of the lower labial segment where less than 4 millimetres of space is required. In such cases extraction of an incisor would create too much space. If the space needed for alignment is greater than 4 millimetres, it would be gained more readily by extraction of a lower incisor. She says that the incisors should be measured carefully to determine whether treatment should involve enamel removal or the extraction of an incisor. Betteridge (1976) describes an index to measure the degree of crowding in the lower labial segment. The index (B.1) is a ratio of the sum of the mesiodistal widths of the lower six front teeth to the amount of space available.

Tuverson (1980A) says that in a slight arch length discrepancy of less than 4.0 millimetres, this amount of intercanine tooth material can be reduced, eliminating the need for extraction of permanent teeth or canine expansion.

Thornton-Taylor (1982) also feels that discrepancies of up to 4 to 5 millimetres can be treated by proximal stripping.

As well as these authors, many others have recommended the use of

Peck and Peck (1975A) feel that "precious arch space" may be derived by "reproximation". They also find reproximation helpful to gain space to allow the fitting of preformed bands on very 'tightly packed' incisors.

Swain (1975) has also recommended the use of proximal stripping to make room to fit orthodontic bands, especially in non-extraction cases where teeth are in good alignment with snug contacts. He feels that the use of separators in such cases, to make room for the fitting of bands, will cause buckling and slipped contacts, and this transient crowding may create a pattern for relapse after treatment.

As well as to initially create space, Paskow (1970), Weiss and Gurman (1971), Woodside according to Bau (1973) and Zachrisson (1978), have specifically recommended that proximal stripping be used to create space in treating relapse cases where small amounts of crowding have recurred some time after orthodontic therapy. Here, especially where extractions have previously been carried out for the orthodontic treatment, the clinician is loath to recommend tooth removal to retreat the case, and proximal stripping may be used to help provide a more simple solution.

1.3 To enhance retention and stability

Proximal stripping may enhance retention and stability in a number of ways. In cases where there are size discrepancies, whether tooth to
tooth or tooth to arch, as has been discussed, not only is it necessary to reduce these discrepancies so that the teeth can be aligned properly, but also so that the teeth will remain stable after orthodontic therapy and retention has been completed. Bau (1973), Begg and Kesling (1977B, p.79-81 and 656) and Tuviron (1980A) have all stressed the need to remove these discrepancies to allow the teeth to be placed in positions of stability.

Proximal stripping can also have the effect of flattening the contacts between the teeth. This broadened contact area, Tuviron (1980A) says, is much more resistant to slippage and subsequent rotations than the small rounded contact point normally found in unabraded anterior teeth. Fig.1.

Barrer (1975) agrees, stressing that the flat surface tends to resist the forces of rotation and shift, whereas rounded surfaces offer no resistance and quite possibly encourage further slipping by creating adverse plane angles.

Paskow (1970), Peck and Peck (1927A), Bau (1973), Boese (1980A and B), Kesling and Rocke (1980) and Williams and Von der Heydt (1982) have also expressed their belief that proximal stripping, by flattening the contact points, produces a more stable arch less likely to exhibit slipped contacts or rotations.

Barrer (1975) as well as flattening the contacts, also recommends that in certain instances the teeth be "keystone", so that the planes produced by stripping will be at an angle in opposition to the direction the teeth will move or rotate in their tendency to
Figure 1. Original small rounded contacts (A); following proximal stripping the contacts are broad and flattened (B).

relapse. Fig. 2. This has a locking action, and Barrer says, will provide a more stable alignment of teeth.

Kesling and Rocke (1980) also, in certain cases, will carry out the proximal stripping at slight inclinations to help prevent relapse.

Figure 2. Malposed anterior teeth (A); interproximal relations after keystoning (B).
However, this author feels that the long term stability of these teeth may be questionable, as the continuing pressure from the 'anterior vector of force' may eventually produce slippage of these contacts along the planes produced by this type of proximal stripping.

Boese (1980B) has also advocated stripping, after orthodontic therapy has been completed, to keep the occlusion stable when there is marked horizontal growth which can promote lower anterior crowding; the stripping will allow the teeth to settle distally, before they have a chance to crowd, and keep the teeth in a stable relationship.

Munday (1982) agrees, pointing out that certain growth patterns, as described by Bjork, are accompanied by lower incisor retroclination and subsequent possible crowding. He feels that the clinician is 'virtually committed' to proximal stripping in the post-treatment adolescent years if he is to retain the incisors in alignment.

But not all authors believe that proximal stripping will enhance retention and stability. Both Reidel (1976) and Zachrisson (1978) have expressed scepticism over these claims. Zachrisson believes that other factors such as amount and direction of growth, tooth eruption, musculature, possible influence from erupting third molars and other factors will influence the stability of the incisors despite the effects of proximal stripping.

1.4 To simulate stone-age man's proximal attrition

It is not the aim here to justify or refute the actual theory of 'normal physiologic attrition' in primitive man. However many authors have used the theory to show how proximal stripping may be beneficial to the health and development of the dentition and supporting structures.
Physiologic attrition is a gradual, regular loss of tooth material as a result of natural masticatory processes. Wolpoff (1971) has shown that interproximal wear occurs in nearly all human groups, though, at greatly different rates. Sorrin (1960) and Eissman, Radke and Noble (1971) have also made this observation.

Watson (1971) says that "the fundamental premise of attritional occlusion theory is that mesial migration and continual active eruption (vertical migration) are natural physiologic processes which persist throughout life in the human dentition. In common with many other animals, man in his natural primitive state experiences attritional wear, both occlusally and interproximally, through the whole life span of his dentition. Thus the occlusion is constantly changing and mesial and vertical migration compensate for the loss of tooth substance". He further says that "immediately prior to the eruption of the third molars, approximal wear accounts for a reduction of 14.7 millimetres in the mandibular arch length, according to Begg's estimates. This amounts to proximal wear of an average of a little over half a millimetre per surface by the age of fourteen. These descriptions apply to the dentitions of tribal Australian aborigines and apparently to other stone age contemporaneous and extinct ethnic groups".

No doubt the foremost supporter and developer of the attritional theory has been P.R. Begg, who has developed his 'technique' of treatment based on this philosophy. Begg and Kesling (1977A) believe that attritional occlusion is of great benefit to Man, and that proximal stripping simulates this if carried out regularly throughout life. Begg and Kesling claim that the roots of civilized man's teeth cannot
migrate closer together because their crowns do not become narrower mesiodistally. This prevents the fibres of the periodontal membranes from becoming shorter with increasing age, as occurs naturally in stone-age man. Therefore, the transseptal fibres of the periodontal membrane in civilized man are subjected to ever-increasing and presumably destructive stretching forces. Begg and Kesling say that Periodontists who complain that artificial reduction of the widths of teeth causes harmful compression of periodontal membranes and their fibres, need to study stone-age dentitions.

Further Begg and Kesling say that the pyramidal interproximal space continually enlarges in civilized man as the teeth erupt and the transseptal fibres move toward the necks of the teeth. The interdental papilla continues to proliferate; however, the space finally becomes so large that the papilla can no longer fill it. This unnatural interdental space in civilized man, continually increasing in size, is a stagnation region where plaque forms and is protected from dislodgment by sheltering of the walls of the teeth and the papilla. Fig.3

Glickman (1972) agrees that large interproximal spaces allow the lateral forces from the lips, cheeks and tongue to force food interproximally and that this stagnation often leads to periodontal and dental destruction.

Begg and Kesling argue that proximal stripping of all the teeth would be more physiologic than extractions, to provide space to correct a malocclusion, and points out that this would conform more to biologic requirements. That is, reduction of the mesiodistal widths of adult's teeth (and so reducing the size of the interproximal space)
can eliminate existing interproximal periodontitis. Simultaneously, small areas of recurrent dental caries at the gingival margins of proximal fillings are eliminated. As well, the forces of mesial migration will be alleviated and the contacts flattened, so retaining a more stable occlusion.

Bau (1973), however, quite rightly points out, that much of this is highly circumstantial evidence as many other factors, especially dietary habits, could also be responsible for the lack of periodontal disease and caries in stone-age man.

Figure 3. Diagrammatic comparison of the changes at different ages of the teeth and gingiva of primitive man and civilized man to show how primitive man remained free from periodontal disease. Friction from his crude food kept the gingival trough (A to B) too shallow to harbour bacteria. The interproximal space was kept small by interproximal attrition. The triangles represent the relative sizes, at different ages, of the interproximal space. A, Free gingival margin, B, level of soft-tissue attachment to tooth. C, interproximal gingival papilla. A to B, Height of gingival trough.

(From Begg and Kesling 1977A)
P.R. Begg is not alone, and has not been the first to put forward that stone-age man's occlusion is normal and beneficial, Box (1940) lists the findings of Gottlieb, Stein, Cameron, Campbell, Keith, Müller and Linghorn who support the belief that attrition is a normal biologic process, and that no deleterious effects are noted. In fact, it is pointed out that periodontal disease is far less commonly found in attritional occlusion than the so called 'civilized non-attritional occlusion'. Box (1940) goes on to conclude that "In view of the lack of abrasive action of our modern diet, the use of an adjunct to supply this need is plainly indicated". This adjunct could be regular proximal stripping.

At this point it may also be wise to remember that not all authors believe that attritional occlusion is desirable, many, such as Seward (1976), believe it is in fact pathological. Also, though the regular proximal stripping of teeth to simulate attritional occlusion may be defensible on physiologic grounds, it may well not be acceptable for aesthetic and social reasons.

1.5 To improve the aesthetics and shape of teeth

Often the interproximal area provided by nature can be improved upon by proximal stripping and recontouring; not only from the point of view of periodontal and dental health, but also for aesthetic reasons.

The aesthetics, for example, of an adult with bell-shaped crowns with very large interproximal spaces can be greatly improved by proximal stripping, allowing the proximal cervical area of adjacent teeth to be closer in proximity with one another (Tuverson 1980A).
Reducing the interproximal area allows the receded gingiva to fill in, reducing even more interproximal space and establishing a more normal-appearing interproximal gingival tissue and dentition.

McNeil and Joondeph (1973) have advocated the mesiodistal reshaping of canines, to improve their appearance, when they are used in place of missing lateral incisors.

Peck and Peck (1975A) also recommends the reshaping of incisors which have a greater crown perimeter at the incisal edge than towards the gingival margin. Not only for aesthetics, but also to allow bands to be fitted properly; he cites the not uncommon experience of a preformed band which fits very tightly at the contact level (near the incisal edge), but with slightly more seating pressure drops quickly to the gingival level resulting in a frustratingly poor fit.

Betteridge (1981) has found it possible to judiciously grind some of the irregular tooth surfaces to disguise the residual crowding and considerably improve the aesthetic result.
CHAPTER 2

PROXIMAL STRIPPING

2.1 When is proximal stripping carried out?

In making a decision on when to carry out proximal stripping, each case must be considered separately; timing of the proximal stripping procedure will vary with the reasons for stripping, the malocclusion present or treated, the appliance being used and the orthodontic philosophy of the clinician.

Boese (1980A) says that there are three basic phases of treatment during which proximal stripping is carried out. Firstly, directly before the commencement of treatment or in the early stages of treatment, secondly after band removal or during the early retention period, and thirdly after retention, related to any change or relapse in the arch form or occlusion.

When carrying out proximal stripping, most authors agree with Kelsten (1969), Swain (1975) and Boese (1980A) when they emphasise the importance of aligning the teeth first before stripping the teeth. If teeth are stripped in their crowded or rotated positions, the plane of stripping will probably produce angled contacts that are not stable, and will in fact promote relapse and the retention of the original malocclusion; furthermore, there is less chance of mutilating approximating teeth.

However it is not always possible to align the teeth first before proximal stripping procedures, as, the space provided by the proximal stripping is needed to align the teeth in the first place. This is the
case often when a sectional spring aligning appliance, as used by Barrer (1975) is used. In such cases the crowding is often only minor, and proximal stripping can be carried out to produce well shaped interproximal contacts; or, if crowding is a little more severe, initial stripping can later be re-contoured to produce a better shaped contact.

Usually, in those cases where there are definite tooth size discrepancies and tooth size to arch length discrepancies, the proximal stripping is carried out in the early phase of treatment to allow the teeth to be aligned and a good occlusion to be established (Lusterman 1954, Paskow 1970, Tuverson 1970, Reidel 1975, Swain 1975 and Boese 1980B).

In those cases where retention and stability are the main reasons for proximal stripping, the procedure is usually carried out in the second phase after band removal (Moss 1970, Paskow 1970 and Swain 1974). Peck and Peck (1975B) also may leave proximal stripping to be completed at this stage, even when definite tooth-size discrepancies exist, when the teeth are banded and not bonded; they say stripping at the earlier stage would require initial alignment, then debanding, selection of smaller bands after the proximal stripping, and then re-banding - a lengthy procedure. They feel no real problems arise by leaving the proximal stripping to be done at the later stage.

Begg and Kesling (1977B, p.656) will also often delay proximal stripping when the treatment is started when the pulps are still large. They prefer to wait till there is some deposition of secondary denture to reduce possible trauma to the pulp.

Betteridge (1979) feels that in treating late incisor crowding,
ideally proximal stripping should not be carried out until growth has been completed and any impacted third molars extracted, so that further deterioration in alignment is avoided.

2.2 Which teeth should be stripped?

Where there are specific tooth size discrepancies, obviously these teeth have to be trimmed. But in general all anterior teeth can be trimmed to rectify discrepancies and many authors (Weiss and Gurman 1971, Reidel 1975, Begg and Kesling 1977B p.80 and Thornton-Taylor 1982) say they also trim posterior teeth where necessary.

Dimpagolo and Boruchov (1971) recommend that teeth with thicker enamel be trimmed more than those with thinner enamel, and that teeth with hypoplasia and other enamel damage be avoided where possible.

2.3 How much enamel should be removed?

When proximal stripping is indicated, enough enamel should be removed to allow the discrepancy to be corrected or the orthodontic procedure to be completed successfully. For example, both Kelsten (1969) and Taylor (1982) believe the intercanine width is 'sacred', and where possible, they recommend the teeth should be stripped to maintain this. Taylor, using the Begg technique, uses his initial archwire as a measuring gauge to record the original intercanine width. He does this by placing the intermaxillary canine rings hard up against the canine brackets, and once the teeth are aligned, he strips the anterior teeth until the rings once again are hard up against the canine brackets - so maintaining the intercanine width.

There is however a maximum amount that can be removed from each tooth contact without causing problems, or predisposing the tooth to
future problems (as will be discussed later); and it is this amount that is the important factor to be considered here.

Hudson (1956) in his study, measured the thickness of enamel at the contact point of lower anterior teeth in adults. He further determined that the maximum amount that can be safely removed from each of these tooth contacts is approximately 0.20 millimetres for each central contact, 0.25 millimetres for each lateral contact, and 0.30 millimetres for each cuspid contact - a total of 3 millimetres.

Dip-polo and Boruchov (1971) recommend that no more than half the thickness of the interproximal enamel should be removed, and they feel that it is always necessary to take intraoral x-rays of the anterior teeth before stripping to determine the thickness of the enamel and the width of the roots in relation to the width of the crowns.

Peck and Peck (1975B), in their study, found that the coefficient of correlation between the mesiodistal crown diameters of lower incisors and the mesiodistal enamel thickness was moderately high. The values they developed were as follows:

<table>
<thead>
<tr>
<th>Mesiodistal diameter of lower incisors in millimetres</th>
<th>Total thickness of mesiodistal enamel</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3 - 4.7</td>
<td>0.8</td>
</tr>
<tr>
<td>4.8 - 5.1</td>
<td>1.0</td>
</tr>
<tr>
<td>5.2 - 5.5</td>
<td>1.2</td>
</tr>
<tr>
<td>5.6 - 5.9</td>
<td>1.4</td>
</tr>
<tr>
<td>6.0 - 6.3</td>
<td>1.6</td>
</tr>
<tr>
<td>6.4 - 6.7</td>
<td>1.8</td>
</tr>
<tr>
<td>6.8 - 7.3</td>
<td>2.0</td>
</tr>
</tbody>
</table>

From these values, without the use of x-rays, approximate enamel thickness for each tooth could be established. They recommended that
50 per cent (25 per cent from each contact) of mesiodistal enamel could be removed safely by proximal stripping.

Betteridge (1979) follows the recommendation of Peck and Peck and notes that since the width of lower incisors usually lies between 5.0 and 6.5 millimetres, slightly less than 4 millimetres of space can be made available for alignment by the proximal stripping of lower incisors. Further space can be obtained by removing enamel from the canines (and premolars) if necessary. She also notes that there are no published tables for upper incisor enamel thickness, but suggests that the Peck and Peck figures for lower incisors may be used, and by linear extrapolation provide an estimate for the upper labial segment.

Reidel (1975) says that generally 2 to 4 millimetres of enamel can be removed from the maxillary six or mandibular six anterior teeth. He feels that enamel thickness can be determined from x-rays, and that enamel should not be trimmed so far that dentine is exposed. It is also unwise, he says, to remove so much enamel from the contact area that this is narrower than the cervical region or narrower than the root or roots of the teeth themselves, for it will then be unlikely that the spaces between the teeth can be closed and maintained in a normal contact relationship. In a later interview, Reidel (1976) is more specific, and agrees with Bolton's figures that only as much as 3.5 millimetres of enamel can be removed from the maxillary anterior six teeth.

He says he believes that this is about the maximum that one could expect to remove without getting into the possible problems of exposing dentine and subsequent discolouration and possible sensitivity. He believes that about 3 millimetres is a maximum that can be removed from the mandibular anterior six teeth without similar problems.
Begg and Kesling (1977B p.80) say that it is not an unusual procedure to remove about 0.5 millimetres of enamel from each proximal surface of the six upper anterior teeth, and 0.4 millimetres of enamel from each proximal surface of the six lower anterior teeth. When this amount of stripping is done, the total reduction in width of the upper teeth is 6 millimetres, and of the lower teeth is about 5 millimetres. They go on to say, that in some patients, where necessary, they have removed twice this amount.

Tuverson (1980A) believes that 0.3 millimetres can be reduced from each of the eight surfaces of the four lower incisors and 0.4 millimetres from each of the surfaces of the canines, making a total of 4.0 millimetres, without unduly jeopardizing the health of these teeth.

2.4 Should local anaesthetics and separators be used?

Almost no mention has been made of the need for local anaesthesia to carry out proximal stripping, and, from this it can be concluded that local anaesthetics are not needed. Peck and Peck (1975B) and Tuverson (1980A) have said just this, finding that if proximal stripping is done carefully with the proper equipment, little discomfort is experienced.

However, one author, Zachrisson (1978), has anaesthetised the interdental papilla on occasions so that proper access to the subgingival area can be obtained to properly contour the proximal tooth structure. He says that in those cases where an anaesthetic is not used, the clinician finds it difficult to contour the tooth properly below the gingival margin, due to the discomfort of gingival irritation he causes, and interproximal steps are left in the tooth, and these can lead to problems of periodontal disease and caries.
Separators, on the other hand, have been recommended by many authors, to aid in proximal stripping procedures. Hudson (1956) and Barrer (1975) have both recommended separating teeth to give enough space to strip teeth accurately when tight contacts exist.

Tuverson (1970 and 1980A) has made similar recommendations, suggesting that an "Elliot" separator (S.S. White Ivory) is useful, and that it be tightened slowly allowing 30 to 45 seconds between tightening, so that the periodontal membrane fibres can yield to the pressure and provide sufficient space for the proximal stripping procedures.

Geiger and Hirschfeld (1974) have recommended mechanical separators, brass wire, grass line or elastic thread, and rubber for the same purpose. They especially recommend the rubber separators (dumbbell shape), which they say are relatively comfortable and can be placed by the patient a few hours before the visit.

Wallman (1980) separates the teeth with 0.016" soft brass wire prior to proximal stripping procedures. If this is not sufficient he uses an abrasive disc to increase the initial spacing prior to the actual stripping and contouring.

White (1982) uses a mechanical separator to gain access for stripping, especially where the anterior teeth are tightly aligned. He uses an ultrasonic unit to carry out the bulk of the tooth reduction, and often requires the use of abrasive strips, as well as the separator, to gain more room to apply the ultrasonic tips to the desired surfaces.

Thornton Taylor (1982) places elastomeric separating rings one to two weeks prior to carrying out the stripping procedures. If sufficient
space is not gained by these rings he uses a S.3 (Unitek) separator to gain further access.

It appears that both the ultra-sonic unit and diamond disc techniques, to be efficient and safe, require a certain amount of space between the proximal surfaces of the teeth prior to the commencement of the stripping procedure. If this space is not present, or cannot be provided by the band space at de-banding, separators appear to be especially useful in providing the space.

2.5 How are the teeth reduced?

Hudson (1956) used "lightning" steel strips to reduce the bulk of the enamel to be stripped. He found that the amount of enamel removed, corresponded to the thickness of the strip itself, about 0.10 to 0.12 millimetres. He then smoothed the surface with fine finishing abrasive strips to remove the roughness; he found that this removed approximately another 0.12 millimetres. He took care to maintain a normal rounded contour of the proximal tooth surface, and was careful not to injure the lips, tongue and gingiva, placing rubber dam over the teeth to protect the soft tissues.

Paskow (1970) begins stripping with wide metal abrasive polishing strips, presumably to gain access to the interproximal surfaces, then follows with a coarse abrasive metal disc and then a single-sided diamond disc. He takes care to preserve the crown shape and uses a small diamond stone to round off all sharp edges. He then finally uses a rubber abrasive disc to polish all surfaces.

Peck and Peck (1975B) recommend the use of abrasive steel strips for gross reduction when less than 0.2 millimetres of enamel has to be
reduced from each surface. They prefer to use double-sided strips, though they also use single-sided strips; and often use several thicknesses of abrasive strips combined for faster results as the interproximal space widens. Beyond 0.2 millimetres reduction per surface, the abrasive strips, used manually or motorized, become rather ineffective because of the increased contact surface area they must now cover. Instead, safe-sided steel abrasive discs on a slow speed straight handpiece are used. They say the use of a special disc-guard makes the procedure very safe. They also emphasise the need to cut the teeth carefully in the desired plane, and to contour the teeth correctly; they use either fine stones at slow speeds or hand-pulled abrasive strips to round out all sharp enamel corners and to recontour the surfaces. The final step, they say, is to finish anatomically recontouring with cuttlefish strips to polish the surfaces lightly.

Reidel (1975) uses lightning strips to break open contact points, and reduces the greater bulk of the enamel with diamond discs. He completes the trimming with lightning strips, and coarse and fine sandpaper strips, so that the original contour of the tooth crown can be maintained and the tooth enamel kept smooth.

Zachrisson (1978), for stripping purposes, uses a thin, flexible diamond disc for gross reduction, steel strips for contouring, and finishing and polishing strips for surface smoothing.

Tuverson (1970 and 1980A) says that a number of methods of proximal stripping are available. Gross reduction can be done with garnet abrasive discs, ultrasonic unit using an aluminium hydroxide paste and special reducing tips, lightning and abrasive linen strips, and motorized lightning strips. He recommends that the tooth surface be
then polished, and for this cuttle or sandpaper discs can be used.

Tuverson says that mesiodistal enamel reduction should be an accurate procedure, and that the amount of enamel reduction should be predeteremined for the particular method of removal, by using accurately measured extracted teeth. For example, he has found that if a 5/8 inch medium garnet disc is used against each tooth surface until all the abrasive material is worn down and a medium-cuttle disc is followed by a fine-cuttle disc for final polishing, 0.3 millimetres of enamel will be reduced from each of the adjacent tooth surfaces.

Geiger and Hirschfeld (1974) have also recommended abrasive strips and discs, and very thin tapering burs or stones to reduce and recontour proximal surfaces. They also refer to Gorelick and Tascher, who use specially designed ultrasonic tips with aluminium oxide to remove interproximal enamel.

Other authors who have recommended the use of ultrasonic units for this purpose are Kelston (1969), Weiss and Gurman (1971) and White (1982).

Another commonly used method, as has again already been mentioned, is the motorized stripping machine, for example, the Dome Stripper, which can be used with single or double-sided abrasive strips. Woodside (according to Bau [1973]), Sain (1974), Barrer (1975), Betteridge (1979) and Wallman (1980) have all used this type of instrument and method with apparent success. Both Woodside and Wallman use it to increase initial interproximal spacing, and if further enamel reduction is necessary, use abrasive discs (e.g. Wallman uses a 3/4" Horico disc) to complete the bulk of the reduction. Both authors then use fine cuttlefish discs to polish and contour the enamel surface.
Thornton Taylor (1982) uses a 19 millimetre Horico Diaflex diamond disc or a thinner and more flexible 22 millimetre Horico Super-Diaflex disc to reduce the bulk of the proximal enamel to be trimmed. He then uses a fine pointed high speed diamond bur to round off the embrasures, and various grades of polishing discs to provide a smoothly finished surface.

Betteridge when using the Dome Stripper, which moves the abrasive strip labio-lingually, will move it in an inciso-gingival direction to avoid the creation of a shoulder at the neck of the tooth. She says that the final contour is achieved with hand-held polishing strips (which may have also been used to initially clear the contact points) since these can be curved around the tooth on its labial and lingual sides to remove any sharp corners that develop. She says that small trimming stones can also be used for the contouring purpose.

It can so be seen, that a number of different methods of proximal stripping and polishing have been advocated by various authors and clinicians, and these are summarised in Table 2, with many of the authors using a number of different tools at various times to carry out the procedure, depending on the particular situation.

2.6 Should fluoride be applied after proximal stripping?

There seems to be little argument or dissension amongst authors as to the importance of applying fluoride to the enamel after proximal stripping; nearly all have made special mention of this, though they may have used different techniques and solutions of fluoride in their treatments. The need for fluoride applications, and the susceptibility of the enamel to decalcification after proximal stripping is highlighted by the fact that it is the surface layer of the enamel that is rich in
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<th>Name</th>
<th>Ultrasonic stripping</th>
<th>Diamond disc</th>
<th>Hand-held metal polishing strip</th>
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Table 2. Instruments used by authors at various times and stages to carry out proximal stripping and polishing procedures.
fluoride, and is the most caries resistant portion of the enamel (Isaac et al 1958, von der Fehr 1965 and 1966, Hallsworth and Weatherell 1969, Petersson 1976 and Weatherall, Nayler and Hallsworth 1977). Therefore, the protective fluoride removed with the surface layer of enamel by proximal stripping should be replaced immediately.

2.7 Use of spring retainer appliance?

One appliance which is commonly used in conjunction with proximal stripping is the spring retainer or aligner appliance. If there is slight crowding, for example in the lower anterior region, it can be used, after proximal stripping has provided space, to correct the alignment of the teeth. Weiss and Gurman (1971), Barrer (1975) and Betteridge (1979) prefer the appliance to consist of two pads of acrylic, one covering the lingual of the incisors and the other covering the labial of the incisors, joined by wires crossing over the occlusal between the canine and premolar teeth. Fig. 4. The wire functions as a spring, when activated, drawing the pads of acrylic together. This force is transmitted to the teeth, to both act as retention for the appliance and to correct the mal-alignment of the teeth.

The appliance is made up on a duplicate model in which the teeth have been placed into ideal alignment. The pads of acrylic will have the effect of squeezing the teeth into this ideal alignment. The design of the appliance can be altered, and springs, elastics and buttons of acrylic can be added or acrylic removed, to move teeth as desired.
Figure 4  A. Spring aligner.  B. inserted in the mouth to align the lower incisor teeth.
The proximal stripping is usually carried out before the impression is taken for the construction of the appliance; however further stripping may be needed during the course of the spring aligner treatment, not only to provide more space to align the teeth, but also to perhaps "keystone" the teeth (Barrer 1975).

Betteridge says that the appliance is well tolerated in the upper jaw as well, and may in conjunction, use an anterior bite plane where there is a deep bite to make it more comfortable. Betteridge (1981) has shown that the spring aligner is successful in treating mild or slight anterior crowding, but has expressed some disappointment in the stability of the results, especially in correcting rotations, after one year out of retention - though the patients treated were happy with the results, and the relapse was only slight.
CHAPTER 3
LIMITATIONS OF PROXIMAL STRIPPING

3.1 Interproximal contact and embrasure shape

There is little disagreement among authors about the ideal or normal shape that interproximal embrasures and contacts should take. Begg (1945), Sorin (1960), Kraus, Jordan and Abrams (1969), Burch (1971 and 1975), Grant Stern and Everett (1972), Farer and Isaacson (1974), Wheeler (1974), Baer and Morris (1977), Goldman and Cohen (1980), Takei (1980) and Becker and Kaldahl (1981), all agree on the general form the interproximal area should take.

The interproximal spaces between the teeth are triangularly shaped spaces normally filled by gingival tissue, the gingival papilla. The base of the triangle is the open area of the alveolar ridge, while the sides of the triangle are the proximal surfaces of the contacting teeth, and the apex of the triangle is in the area of the contact. There is also a smaller incisal embrasure which helps to establish the morphological character of the teeth.

The contact areas on natural teeth generally occur at the incisal one third of teeth (especially in the anterior teeth). They generally begin as small contact points, but with age, wear to become broader contact areas. The contact area is also generally more buccal to the buccolingual centres of the teeth, therefore creating an embrasure that is longer and broader linguually than buccally. The axial line angle which forms the transition between the flat or concave proximal surface and the convex facial or lingual surfaces, is termed the transitional line angle. The angle generally exhibits the same contour as the
proximal surface and forms the opening for the residence of the interdental tissue.

A detailed description of the contact area shape and position, and the embrasures, can be found in the text "Dental Anatomy, Physiology and Occlusion" by R.C. Wheeler (1974).

Under normal circumstances the interdental papilla will completely fill the interproximal embrasure. It consists of two pyramid-shaped papilla, one on the facial aspect and the other on the lingual joined by a saddle-like depression, the col. The shape of the col depends upon the nature and size of the contact area of the proximal tooth surface. In the incisor region it is minimal or it may not even be present. On the other hand, the col tends to be prominent in the molar areas where proximal contact areas are broad (Fig. 5).

Figure 5. The periodontium and tooth contact as viewed in a plane through the proximal contacts of a molar (A) and incisor (B).
Three distinct types of interdental papilla can be recognised according to Baer and Morris (1977); when the adjourning proximal contacting surfaces of the teeth are minimal, the papilla consists of both free and attached gingiva. When the proximal tooth contacts are flat and broad, or if there is crowding of the teeth, the interdental papilla may consist entirely of free gingiva. When the teeth are separated from one another by diastemas, there is no papilla.

The gingival col area, according to Burch (1975), has a very thin protective epithelial covering, and even in good health, when housed in a well shaped interproximal area, the col is vulnerable to physical or bacterial attack.

A correctly shaped interproximal area has a number of important functions in maintaining the health of the tooth and periodontium, according to Sorrin (1960), Linkow (1962), Kraus, Jordan and Abrams (1969), Eissman, Radke and Noble (1971), Wheeler (1974), Farrer and Isaacson (1974) and Takei (1980). Firstly it helps to establish the visual character of the tooth. Teeth whose interproximal areas have been completely flattened by proximal stripping and have not been recontoured, can have a distinctly unpleasant 'tombstone' appearance. Conversely, those which are left with very large embrasures, or have long wide interproximal spaces unfilled by the gingival papilla, will detract from a pleasant smile. It is interesting to note that Eissmann, Radke and Noble (1971) have found also that air escaping through large interproximal spaces, can on occasions cause phonetic impairment.

Secondly, one of the functions of the contact area is to maintain a stable dental arch. The buttressing of one tooth against another on a stable contact area contributes to a stable arch.
Thirdly, the prevention of food impaction in the interdental area is, according to Linkow (1962) and Glickman (1972), provided by, a). continuity of the teeth in the dental arch with no loose contacts; b). proper location, shape and size of contact areas; and c). the presence of marginal ridges and grooves.

Fourthly, according to Sorrin (1960), a function of the interproximal area is to create a spillway for the escape of food during mastication, thus reducing the forces upon the teeth during the reduction of any food that offers resistance.

Fifthly, to make the teeth more self-cleansing by the establishment of a series of contours that will either prevent debris retention or allow the normal process of detergent mastication and lip, cheek and tongue action to render the area clean. The gingiva, aided by the saliva, fluid intake and the friction of food during mastication, also helps to prevent the stasis of food about and between the teeth by its elasticity, smoothness and pyramidal shape.

Sixthly, and very importantly, a correctly shaped contact embrasure area will provide sufficient room to house the gingival tissue and allow for minimum col formation as required, and protect the gingival tissue from excessive trauma, but allow the proper degree of frictional massage of the tissue during mastication.

If proximal stripping and recontouring is done carefully to produce or restore the desirable tooth contours, potential problems will be minimised and the interproximal area will be able to carry out its function normally.

One common problem that can arise with proximal stripping is the reduction of the interproximal space for the gingival papilla. If this
occurs, according to Linkow (1962), Baer and Benjamin (1974), Burch (1975), Goldman and Cohen (1980 p.1010-1014), Takei (1980) and Becker and Kaldahl (1981), it results in the overcontouring of the crowns evicting the gingival tissue (Fig. 6).

This results in a mushrooming of both labial and lingual peaks, each hyperemic and flaccid, strangulated by the absence of embrasure space. The col area is lengthened facio-lingually and degenerates, and a crater remains as the proliferating tissue collects more bacterial plaque and makes it very difficult to remove this plaque from the interdental region; this plaque retention progressively leads to further periodontal disease and pocket formation, as well as, possible interproximal caries.

According to Goldman and Cohen (1980, p.1010-1014) this periodontal defect cannot be removed by periodontal surgery alone, unless the interproximal space for the gingiva is increased, as the gingiva is reduced in height coincidentally with greater spacing between the teeth as they taper apically; or unless the teeth themselves are recontoured to produce a desirable interproximal space.

The reverse situation may also occur, according to Linkow (1962) and Takei (1980), where a contact area is placed too high incisally, and a space is left between the tip of the gingiva and contact area (Fig. 6). This space can become a food retention area, not only a nuisance to the patient, but an area where the plaque retention can lead to periodontal disease and dental caries.

Not only is the height at which the contact is placed important, but also, so is the width of the contact and the contour of the embrasures. According to Linkow (1962), if the contact is too narrow, and the embrasure too wide, the gingival tissue and periodontal
attachment is exposed to injury, and also can lead to accumulation of food in the area (Fig. 6).

If however, the contact is too wide facio-lingually and the embrasures are closed, a similar situation may arise to that which was produced by the reduction of the interproximal space for the gingival papilla by the lowering of the contact area. That is, there is strangulation and impingement of the gingiva, with lengthening (facio-lingually) of the col, and subsequent plaque accumulation with periodontal and dental disease (Fig. 6).

Figure 6.  A. Favourably shaped teeth with healthy gingiva.  
B. A contact area placed too low, toward the interdental gingiva, along with convex contours of the transitional lines of the crowns, reducing the space available to the papilla. The lack of interdental embrasure space resulted in a hyperplastic and swollen interdental papilla.  
C. A contact area placed too incisally, leaving space between the tip of the papilla and the contact area, which is prone to food impaction.  
D. Overconvexity of the surfaces with a small contact area allows the gingiva to be exposed to injury.  
E. Flattened interproximal surfaces facio-lingually cause impingement of the gingival tissue and hyperplastic and swollen tissue results.
Linkow also points out that the plane at which the contact area is placed is important. He says that a plane angled incorrectly may not buttress and stabilise the dentition, but allow the teeth to be displaced from the arch easily. (Fig. 7).

Another problem that may arise, according to Valinoti (1974), Reidel (1975), Wilson and Maynard (1979) and Goldman and Cohen (1980 p.1010-1014), is when the teeth do not, to any great extent, taper apically. In these situations proximal stripping will not only probably reduce the size of the interproximal space available to the gingival papilla (and produce the problems already mentioned), but also, as the roots of the teeth come closer together, will cause compressive and destructive forces to be placed on the already thin and vulnerable interseptal bone. This destruction, with the periodontal breakdown that can progress very quickly in this situation, can greatly reduce the prognosis for the teeth. Reidel also points out that if too much enamel is removed by proximal stripping in these cases, the spaces between the teeth will never close due to the root approximation.

The shape of the teeth, when contemplating carrying out proximal stripping, is very important, not only from the point of root approximation, but because certain shaped teeth will allow more mesiodistal width reduction than others, without compromising the health of the teeth and their supporting tissues. Geiger and Hirschfeld (1974), Zachrisson (1978) and Goldman and Cohen (1980 p.604), all agree that large tapering, bell-shaped or wedge-shaped teeth, lend themselves much better to proximal stripping than teeth which are rectangular in shape, and have long contact points from the incisal edge toward the gingival margin. (Fig. 8). These tapering teeth
Figure 7. Improperly directed contact areas allow displacement, in the direction of the light arrows, of the teeth, when the teeth are subjected to normal, or abnormal, intra-arch forces, represented by the heavy arrows.

Figure 8. The tapering or wedge-shaped tooth (A) can be reduced more mesiodistally than the more rectangular shaped tooth. (B) without predisposing the tooth to periodontal or dental disease.
can be reduced mesiodistally considerably more, while still maintaining a favourable and desirable interproximal contour; they can also be progressively trimmed, over the years, as the gingiva recedes and the teeth continue to erupt, according to Begg (1945), to maintain an aesthetic and functional occlusion.

In essence, it should be re-stated, that if any one of the six functions of the interproximal area is not maintained after proximal stripping, the procedure runs the risk of being aesthetically unacceptable or predisposing the teeth to periodontal or dental disease. The teeth, so, must be able to be recontoured after proximal stripping to establish, or re-establish, the optimal contours; otherwise proximal stripping should not be attempted, or limited at least, to only the amount of enamel that can be reduced, and still allow the optimal contours to be established. In this way the shape of the teeth and the shape and size of the interproximal areas can limit the amount of proximal stripping that can be carried out safely.

3.2 Enamel thickness and its properties

One of the major limiting factors regarding how much proximal stripping can be done is the thickness of the enamel. Reidel (1975, 1976) says the enamel should not be trimmed so far that dentine is exposed, as this may lead to discolouration and sensitivity, and greatly predispose the enamel to decay. In fact, most authors, including Reidel, believe that arbitrarily, only about half the enamel thickness can be removed safely (Hudson 1956, Dimaolo and Boruchov 1971, Peck and Peck 1975B, Zachrisson 1978, Betteridge 1979 and Tuverson 1980A).

The thickness of enamel present varies between individuals and between various teeth in the one individual, and Dimaolo and Boruchov
(1971) and Goldman and Cohen (1980 p.575) recommend that x-rays be taken in every case of proximal stripping to gauge the thickness of the enamel present in each individual tooth. However, though neither of these authors describes their x-ray technique of establishing the enamel thickness, it seems a daunting task to routinely assess the enamel thickness accurately in this way.

Hudson (1956), by sectioning thirty mandibular cuspids, thirty mandibular lateral incisors, and thirty mandibular central incisors, measured the thickness of the enamel, and from this made his recommendations on how much enamel is generally present in lower anterior teeth, and how much can be safely removed by proximal stripping from these teeth.

Peck and Peck (1975B) used the mesiodistal width of the tooth to calculate how much enamel is present in the tooth. As has been explained, he produced a table from which approximate enamel thickness can be readily estimated for a given mesiodistal dimension.

Gillings and Buonocore (1961) have also made measurements of enamel thickness, and though they do not specifically give the average enamel thickness at the contact point, their findings indicate that the average enamel thickness of incisors is just over 0.6 millimetres per contact. They point out that the enamel on the mesial surface is slightly thinner than on the distal surface of teeth; and that enamel thickness decreases markedly in an inciso-gingival direction, so that there is only a very thin layer of enamel nearing the cemento-enamel junction, whereas the thickest layer is towards the incisal edge. These observations on enamel thickness will also be limiting factors when carrying out proximal stripping on particular teeth.
No matter which way the clinician gauges the amount of enamel present and that which can be trimmed, it is important that the amount of enamel removed by proximal stripping does not exceed the amount that can be prudently removed.

Though it appears that half the enamel can generally be removed with safety, there are occasions when even this amount may be deleterious to the health of the tooth. Such factors as sensitivity, discolouration, hypoplastic or damaged enamel and caries susceptibility, may alter greatly the amount of enamel that can be removed safely by proximal stripping.

Sensitivity to hot, cold, sweet and other sensations has not been found to be a problem generally (Paskow 1970, Tuverson 1970, Dapaolo and Boruchov 1971, Zachrisson and Mjor 1975 and Boese 1980A), although in some cases, according to Paskow (1970), it may arise and care should be taken to carry out proximal stripping slowly, and perhaps over several visits (Dapaolo and Boruchov 1971), to reduce this phenomenon. If the patient has a history of sensitivity, or begins to develop sensitivity during the stripping procedure, the amount of enamel stripping to be done may have to be curtailed. However, it should be emphasised that this is quite rare and Zachrisson and Mjor (1975), in their study, found that even in cases of much more severe remodelling of teeth by grinding, increased sensitivity was rare, and if it occurred, usually only lasted for one to three days after the procedure. They also found that there was usually no, or only minor, pulp and dentine reactions noted histologically after extensive grinding, let alone the minor grinding of proximal stripping.

Dapaolo and Boruchov (1971) also emphasise that teeth with hypoplasia, hypocalcification and other enamel damage, should be avoided
when carrying out proximal stripping, or at least the stripping should be minimised, as these areas tend to be more susceptible to sensitivity, carious activity, discolouration and natural attrition. Discolouration, however, according to Zachrisson and Mjör (1975), is not a problem with normal sound enamel and only occurs when dentine is exposed or the enamel surface is left rough and collects stain and debris.

A very important factor which must be considered when assessing a patient and specific teeth for proximal stripping, is caries susceptibility. Most authors (Hudson 1956, Paskow 1970, Begg and Kesling 1975, Zachrisson and Mjör 1975 and Boese 1980B) believe that caries after proximal stripping is not a problem, and Paskow has found that three years after stripping was carried out, not one case he examined showed signs of caries. He does however stress, along with Tuverson (1980A), that only those patients and teeth with low caries susceptibility are selected for proximal stripping. Boese (1980B) also found that over varying periods of four to nine years post stripping, no caries was detected in his cases.

Zachrisson and Mjör (1975), in their study, also found that caries did not commonly occur after proximal stripping, though their period of examination after the grinding procedure was relatively short and so not conclusive. However they did note that two of their cases did develop caries, though these they found were associated with steps which had been left in the enamel and had collected plaque; in those cases which had been contoured properly, they found no signs of incipient caries.

Craig (Bau 1973) believed, in theory, that proximal stripping should increase the caries susceptibility of the enamel, due to the
rough surface it leaves which would tend to collect more plaque; but also maintained that the mandibular anterior teeth are the safest to strip, as they are usually the least affected by decay.

Less limitations are placed on the stripping of teeth when the teeth have developed in an area where the fluoride content of the water supply is high (or where fluoride supplements were given to the developing child); studies by Ludwig (1971), Jackson, Murray and Fairpo (1973) and Backer Dirks (1974) have shown that caries susceptibility is greatly reduced, especially on flat tooth surfaces, in these fluoride rich teeth, so the likelihood of caries developing after proximal stripping is greatly reduced.

Weatherell, Hallsworth and Robinson (1973) further confirm this decreased likelihood of caries developing after proximal stripping in high fluoride level areas, by showing in their study that teeth which have developed in these areas, will not only have a high fluoride level in the surface enamel, but also in the deeper layers of the enamel. Therefore, this enamel exposed by proximal stripping is more caries resistant than the deeper layers (exposed by proximal stripping) of the teeth that developed in low fluoride areas and contain little caries resistant fluoride in them. The teeth which are very resistant to the carious processes, could often if necessary, be subjected to more stripping than that is normally recommended, without placing them in danger of possible decalcification and rapid decay extending into the dentine through the thin enamel surface layer.

Schmidt (1961), Sperber and Buonocore (1963), von der Fehr (1965 and 1967B) and von der Fehr and Steinnes (1966) have all found that abraded enamel is more susceptible to acid attack than unabraded enamel. Wickwire (1964) has shown in her study that proximal stripping
does render the enamel more susceptible to decalcification. However, to what extent this does occur, and to what extent this is clinically significant, or to what extent it is reversible by fluoride application and remineralisation is not clear. However, in highly caries susceptible teeth, this reduction in caries resistance may be critical, and should carefully be considered by the clinician, before proximal stripping is undertaken.

Certainly the application of fluoride to abraded or stripped enamel does increase the resistance of the enamel to decalcification (von der Fehr 1967B, Lehman and Davidson 1981), though the level of resistance to decalcification is probably not as high as it was in the unabraded enamel (Weatherell, Hallsworth and Robinson 1973, Leehman, Davidson and Duysters 1981).

In their studies, von der Fehr (1965) and von der Fehr and Steinnes (1966), have shown that after one to two months of exposure to the oral environment, the abraded surfaces regain their original resistance to decalcification. Four possible reasons for this increased resistance of the abraded surfaces were given. 1. Formation of organic films. 2. Deposition of minerals (remineralisation) 3. Chemical alteration with regard to minor constituents and trace elements. 4. Recrystallisation or loss of damaged crystals in the surface layer. von der Fehr (1967A) in a later experiment felt that the deposition of minerals (remineralisation) may play a major role in this occurrence.

Rogers and Wagner (1969), in their study of enamel after proximal stripping also showed that fluoride application after proximal stripping does protect the enamel surface, especially in the short period directly after the stripping procedure. They also maintained that regular
application of fluoride was necessary to maintain this protection, otherwise the tooth will not maintain its increased caries resistance, as compared to a tooth which did not have fluoride applied to it. Unfortunately it is those patients who have poor oral hygiene who benefit least from a single application of fluoride and require regular applications to replenish the fluoride levels in the enamel; so also it is these same patients, because of their poor oral hygiene, who also are usually more caries susceptible, and unless the clinician can be sure that regular fluoride applications will be applied to these teeth for some time after proximal stripping, (or oral hygiene improves), the teeth may be at considerable risk from the bacterial action of the plaque. In such cases the amount of enamel that can be removed safely by proximal stripping, may be very limited.

The question of whether the caries resistance of enamel can be returned to its original level, or increased satisfactorily after being abraded or stripped is not clear. Until this can be clearly shown to be the case, restraint must be shown in carrying out proximal stripping, especially on caries susceptible teeth.
CHAPTER 4

ENAMEL SURFACE ROUGHNESS

The caries susceptibility of the enamel and its decalcification, and the periodontal inflammation after proximal stripping may not only be related to such factors as contact shape and form, oral hygiene and fluoride content of the enamel, but may also be related to the texture of the surface left after the proximal stripping procedures.

In her study that showed that proximal stripping did increase the caries susceptibility of the enamel, Wickwire (1964) suggested that this was due to one or a combination of a number of factors. These factors were the removal of the protective enamel cuticle, denuding of the outer enamel surface, and the roughening of the enamel surface.

In their study on proximal stripping, Zachrisson and Mjor (1975) found that the only cases which later developed decalcification were those in which steps (major roughnesses) were left in the enamel, and so implicating enamel roughness as a factor to be considered in completing proximal stripping procedures.

Many other authors (Hudson 1956, Geiger and Hirschfeld 1974, Barrer 1975, Lusterman 1975, Peck and Peck 1975B, Zachrisson 1978 and Tuverson 1980A) have stressed the need to restore the enamel surface to as smooth a surface as possible to produce a favourable result.
4.1 Surface roughness and plaque

Zachrisson and Mjor (1975) implicated plaque retention in 'steps' in their two cases of proximal stripping where decalcification developed, as the cause of the decalcification. The relationship between bacterial plaque and caries and periodontal disease has been well established in the past (Bjorn and Carlsson 1964, Zoë, Thielade and Jensen 1965, Greene and Vermillion 1971 and Lindhe, Hemp and Loe 1975).

Waerhaug (1956), in his study on monkeys, roughened with a diamond bur a number of subgingival enamel surfaces. He found that the roughened surfaces, as compared to the smoother control surfaces, collected more plaque, and he concluded that the rough tooth surface facilitates plaque retention. In the same study it is interesting to note, that when regular tooth brushing was carried out on the teeth no apparent difference was noted in the gingival conditions of both groups, confirming that the roughness itself does not cause irritation and inflammation, but it is the increased plaque accumulation which causes the problems.

Swartz and Phillips (1957) carried out an in vitro study where they placed sterilized smooth and rough enamel sections in bacterial cultures, these they incubated and then calculated the amount of bacterial accumulation on the surfaces. They found that the rougher surfaces did accumulate more bacteria than the polished ones. They also, in a second experiment, found that after thorough tooth brushing, the rougher surfaces also maintained more bacterial accumulation than the smoother ones.

Turesky, Renstrup and Glickman (1961) used 244 cellulose acetate
strips, some roughened, in vivo, to compare plaque accumulation on smooth and roughened surfaces. They found quite clearly that plaque accumulated earlier, and in greater amounts on the roughened strips.

Kaqueler and Weiss (1970) studied in vivo plaque accumulation on the surface of restorations and found that plaque accumulated in greater quantities on the rougher surfaces.

Gildenhuys and Stallard (1975) polished gold crowns with various abrasives and polishing agents, and also found that greater quantities of plaque accumulated on the rougher surfaces, in their in vivo study.

Keenan et al (1980) in their study placed mandibular acrylic retainers which they polished with various abrasives. They found that after 24, 48 and 72 hours the rougher finished retainers accumulated more plaque than the smoother ones.


However, not all authors have come to this conclusion, showing in their studies that roughness may not necessarily increase plaque accumulation.

Clayton and Green (1970) measured, with the use of a profilometer, the surface roughness of cast gold, acrylic resin and glazed porcelain pontics, polished by standard techniques. Statistically significant
differences were found in the surface roughnesses of these materials. However, no definite biologic differences in plaque formation and retention could be demonstrated. Clayton and Green themselves shed doubt on the significance of such findings, saying that there is a necessity for a clear understanding of the difference between significance on a statistical basis, and significance on a biologic basis. That is, although the difference in roughness between the materials was statistically significant, it was not 'practically' significant to the degree that it would affect plaque accumulation, though greater differences in roughness may show differences in plaque accumulation.

Selvig (1970) noted that plaque did tend to accumulate more easily in cracks and grooves, but that even those surfaces which appeared to be naturally smooth, were in fact microscopically irregular, and provided areas for easy plaque accumulation. He cast doubt on whether macroscopic roughness would greatly increase the ease of plaque accumulation.

Jones, Lozdan and Boyde (1972) in their scanning electron microscope studies of 54 teeth which had been subjected to various mechanical abrasives, came to similar conclusions as to that of Selvig. They did however add that they felt grooves in the enamel surface may act as microstagnation areas, which would provide an environment that encourages microbial colonisation of the surface.

Knowles and Snyder (1970) using gold crowns, some with roughened surfaces, found that the smoother surfaces did collect less plaque, but not to a statistically significant level.

Rosenberg and Ash Jr. (1974) studied roughness, with the use of a profilometer, produced by periodontal scaling instruments. They
found there were statistically significant differences between the surfaces produced by the instrumentation and the smoother control surfaces. When assessing the plaque accumulation between the different surfaces, they found no significant differences, nor did they find differences in the degree of gingival inflammation between all the groups. These authors felt that the wide disagreement of results of studies carried out were due often to the fact that those studies which showed significant plaque accumulation on rough surfaces used surfaces much rougher than would be clinically found, while some other studies used surfaces unrealistically smooth. They also felt, agreeing with Clayton and Green (1970), that in their study, although the difference in roughness between the surfaces was significant, they were not large enough to be biologically and practically significant. Rosenberg and Ash Jr. also felt that the poor oral hygiene of their own patients may have been a significant factor in the results they received, which limits the significance of the results as they apply to patients with good oral hygiene.

Myers et al (1980) used 42 crowns of varying degrees of smoothness in their in vitro study to assess the amount of plaque accumulated over a one week period. They found no significant differences of plaque accumulation amongst their test subjects. However, many of the criticisms and limitations that were levelled by Rosenberg and Ash Jr. over their and other studies could be applicable here.

Carranza (1979 p.1011) supported the contention that oral hygiene standards affect the significance of plaque accumulation on varying surfaces. He felt that the amount of plaque accumulation in patients with relatively poor oral hygiene is not affected to a significant degree by minor changes in surface configurations; whereas for those
patients with good oral hygiene small changes in surface roughness could significantly affect plaque accumulation.

Though it is not conclusive, and some studies have shed doubt on the significance of surface roughness, it does appear that surfaces with increased roughness do collect greater quantities of plaque and in shorter periods of time, and plaque is more difficult to remove from these rougher surfaces.

4.2 Surface roughness and decalcification

Crouse, Swartz and Phillips (1954) used extracted teeth to measure the solubility of enamel. The enamel surfaces were carefully prepared, some being roughened by abrasives, the others being left smooth as controls, before being exposed to a decalcifying solution. The amount of calcium and phosphorus dissolved was then measured to assess the degree of decalcification that had taken place. They were unable to observe a statistically significant difference between surfaces roughened by emery paper and those of polished enamel, even though the averages indicated that slightly more calcium and phosphorus was removed from the roughened surfaces.

Kapur, Fischer and Manly (1961) altered the surface enamel of extracted teeth by scratching, polishing and grinding in order to evaluate the influence of surface integrity on subsurface penetration by a lactate buffer. They reported that roughening of the enamel surface increased the rate of penetration of the buffer by up to 27 per cent, while polishing of the roughened surface with sandpaper reduced the penetration rate to within 10 per cent of the original. Two inferences can be drawn from this study; first, roughening of the enamel surface produces a considerable increase in the rate of
penetration of acidic buffer; second, polishing of a roughened surface of enamel increases its resistance to decalcification.

4.3 Surface roughness and enamel appearance

Swartz and Phillips (1957) believe that a highly polished surface is desirable from an aesthetic point of view. They say a highly polished tooth reflects more light and appears brighter, and has a more pleasant appearance.

Zachrisson and Mjor (1975) found in their study that only those surfaces in which retention grooves had inadvertently been left after grinding procedures, had there been any discolouration. They felt that routine polishing would produce a smooth surface which could not collect stains.

Gwinnett and Gorelick (1977) and Zachrisson and Arthus (1979) also believed that the scratches and grooves of rough surfaces could potentially contribute to stain and odour accumulation, and recommended the smoothest possible surface be aimed for, when finishing the enamel surface.

4.4 Surface roughness and age

With age there is a slow wearing away of the surface enamel due to natural attrition (Scott, Kaplan and Wyckoff 1949). The degree of attrition, and the pattern of roughness of the abrasion left varies with the coarseness and abrassiveness of the diet, and as could be expected, more primitive dentitions, whose diet is more abrasive, show more extensive scratching and grooving of the enamel surface than civilised man (Newman 1974). Primitive dentitions do not, however, commonly suffer from decay due to the self cleansing action of the
abrasive diet. Civilised man, however, whose diet is soft and processed, does more commonly suffer from decay due to the decreased self-cleansing action of the diet, and normally does not exhibit marked scratches or grooves on the enamel surface, especially in the interproximal area where very little natural attrition occurs (Scott 1952). For civilised man a smoother interproximal enamel surface is generally more natural and desirable.

Gorelick and Tascher (1966), in their study on proximal stripping, found that either stripping by abrasive strips or by ultrasonic units, whether followed by a fine cuttlefish strip or not, differs markedly from the natural tooth surface, even as it wears and ages.

Zachrisson and Arthun (1979) also found that the natural scratching that occurs on enamel is very fine, whereas, many of the finishing and polishing instruments used left scratches which are deeper and leave a rougher surface.

It appears then, that although natural scratching of the enamel surface does occur, the scratching produced by many abrasive instruments is more severe and needs to be polished further to return the enamel to a smooth finish which approaches the original enamel surface.

4.5 Surface roughness and remineralisation

According to Mannerberg (1960), Wolf and Neuwist in 1941 reported that they had found that chemical and mechanical lesions of the tooth surface could be repaired, and that scratches tend to fill in and disappear in time. Mannerberg himself carried out studies which also showed that some sort of substance is deposited into scratches which thereby become less pronounced or disappear. Mannerberg
felt that it is probable that the precipitation was an inorganic substance from the saliva, probably calcium phosphate.

Schlatter, Marthaler and Muhlemann (1961), who reported that other authors had made similar observations to that of Mannerberg, also had found in their study that some scratches in the enamel surface did decrease in depth over a six week period. They however could not speculate on the nature of this deposition or change.

In a later study Lenz and Muhlemann (1963) showed that the deposition in the scratches was not inorganic, as had been suggested by Mannerberg and others, and in fact that the scratches did not actually decrease or disappear as such. The deposition is organic and is a calculus like or plaque like deposit which is strongly adhering to the bottom of the scratches. The scratch did not repair with an inorganic deposit.

Though there is conclusive evidence that remineralisation of early carious lesions and etched enamel may occur, defects in the enamel surface will not be refilled, though demineralised walls of such defects may remineralise (Gron 1973).

The importance of leaving the enamel surface as smooth as is practically possible after proximal stripping cannot be over emphasised. If not polished, a rough enamel surface will increase the amount and rate of plaque accumulation, make it more difficult to remove the plaque, decrease the resistance of the surface to decalcification, be more likely to collect stain and discolouration and be less natural in appearance.
CHAPTER 5

ENAMEL SURFACE ROUGHNESS STUDIES

There has not been extensive research published on the effects of various instruments on the enamel surface, especially those instruments which are commonly employed in proximal stripping procedures.

Hudson (1956), although he did not study the difference in the enamel surface after various stripping procedures, did show photographically that enamel stripped with steel lightning strips appeared to be quite rough, and that once these surfaces were polished with cloth polishing strips they appeared to be considerably smoother.

Gorelick and Tascher (1966) studied and compared the surfaces of teeth where the enamel had been stripped by three different methods. The first method consisted in the use of a metallic lightning strip of medium grit; the second in the use of an ultrasonic powered handpiece and an abrasive paste of 280 grit; the third in the use of a fine cuttlefish polishing strip following either the lightning strip or the ultrasonic-abrasive method. Replicas were made at various stages during the stripping procedures, and these were examined under a microscope and photographed at a magnification of 150X.

The macroscopic appearance of the tooth, after one minute of abrasion with a medium grit lightning strip, showed abrasion and a dull surface. Microscopically it appeared to have a series of furrows frequently parallel and often intersecting.

When the fine cuttlefish strip was used after the lightning strip
the macroscopic appearance was shiny and closer to that of the natural teeth. Microscopically the appearance was of finer furrows both parallel and intersecting.

The macroscopic appearance of the tooth surface after the use of the ultrasonic and abrasive was dull. The microscopic appearance was that of an evenly flattened area with prism ends visible.

The macroscopic appearance when the fine cuttlefish strip followed the ultrasonic and abrasive was a shiny surface. The microscopic appearance showed a fine furrowed line pattern similar to that found when the cuttlefish strip followed the lightning strip. The furrows however seemed somewhat closer and finer.

They concluded that between the surfaces created by lightning strip alone compared to the ultrasonic and abrasive alone, the latter appears more even. When both are polished with fine cuttlefish strips, there is a great similarity between the two, though they do not approach the smoothness of unabraded enamel.

Zachrisson (1978) stated that in scanning electron microscopy studies (unpublished) he has shown the value of smoothing the enamel surface with polishing strips, after carrying out proximal stripping procedures with flexible diamond discs and steel abrasive strips.

A number of studies have been carried out on the enamel surface after various orthodontic debonding procedures, and some of these studies shed light on the effect of various abrasive instruments on the surface roughness of enamel which would be applicable in proximal stripping.

Gwinnett and Gorelick (1977) and Rentief and Denys (1979) used the scanning electron microscope to study the effect of various abrasive
instruments used in debonding and subsequent polishing procedures. Amongst the various instruments, they studied the effects of finishing and polishing discs, and they came to similar conclusions; that the coarser and medium discs produced some faceting and irregularities, but these were usually reduced considerably by the subsequent use of fine discs. Both studies also indicated that subsequent pumicing improved this surface even more to produce a very satisfactory surface.

In a similar scanning electron microscope study of debonding procedures, Burapavong et al (1978) showed that green stones leave considerable gouges and striations on the enamel surface, and these can be reduced, but not completely removed, by pumicing.

Zachrisson and Arthun (1979) examined with the use of a stereomicroscope and scanning electron microscope the enamel surface after various debonding and polishing procedures. They devised a scoring method by which they evaluated the finish of the enamel surface. This evaluation system they called the enamel surface index (ESI). The criteria of the ESI system are basically as follows:

- score 0 = perfect surface, no scratches
- score 1 = satisfactory surface, fine scratches
- score 2 = acceptable surface, several marked and some deeper scratches
- score 3 = imperfect surface, several distinct deep and coarse scratches
- score 4 = unacceptable surface, coarse scratches and deeply marred appearance.

Without exception, they found that the coarse and medium sandpaper discs produced surfaces which scored no.3; while all these surfaces which were then polished with fine sandpaper discs then scored no.2; pumicing after the sandpaper discs in all cases left the surface still
with a no.2 score, though it did reduce the surface roughness.

Various other studies have also been carried out which add extra information in comparing the effects of abrasive instruments on the enamel surface.

Street (1953), by using a paste of lamp black and alcohol rubbed into scratches and grooves made by various instruments on the enamel surface, showed that: the carborundum disc (Joe Dandy) produced numerous furrows of varying width, not always uniformly spaced. The fine sandpaper disc left the enamel almost free of any scratches, while the coarse sandpaper disc produced furrows of varying width and depth similar to, but not as pronounced as, those made with the carborundum disc. The furrows of the tooth sections cut with the diamond-impregnated disc were similar to, but definitely wider than those made by the carborundum disc.

Peyton and Mortell Jr. (1956) also found that the surfaces resulting from the action of a diamond disc have scratches that are a little coarser and deeper than those from corresponding carborundum discs.

Lammie (1957), with the use of a profilometer, measured the surface roughness produced by a number of instruments. He also found that the diamond discs produced a rougher surface than the carborundum discs.

Heath and Wilson (1976) also used a profilometer type machine, a Talysurf 4, to investigate the effects of finishing agents on the enamel and particularly on the surface of restorations. They stated the centre line average (C.L.A.) values for enamel under various conditions were: unerupted premolar - 1.4 μm, incisor from an elderly person - 0.4 μm, enamel subjected to the equivalent of 2 years of tooth
brushing - 0.1 um, subjected to 600 grade wet/dry paper - 0.08 um, subjected to sand/cuttle disc - 0.7 um, subjected to zirconium silicate disc - 0.8 um, subjected to prophylaxis paste - 0.8 um. These figures are a little confusing in light of other studies, and the discrepancies of these results were not explained by the authors, as their main interest was the effect of the abrasion on restorative materials and not on the enamel. Without further clarification of the results, the results of this study are unenlightening.

Various other studies have examined the effect of abrasive instruments on restorative materials. However, the results of these studies are often unreliable for the purpose here. This is because the interaction of various abrasives with enamel is different from the interaction of the same abrasives with the restorative materials. Scratching is produced when a harder material (as measured by its scratch hardness on the Mohs scale) is drawn over a softer material. The degree of scratching depends, apart from other factors such as particle size (grit), on the difference in hardness between the materials. As enamel and various restorative materials possess different hardnesses (values on the Mohs scale), comparisons of effects on these surfaces can be misleading.
CHAPTER 6

AIM OF STUDY

The use of proximal stripping has increased greatly in recent years and there are a number of reasons why the clinician may choose to carry out this procedure (Chapter 1). There are also a wide variety of techniques and procedures advocated by various authors and clinicians to carry out this proximal stripping (Chapter 2). However, proximal stripping is not without danger or risks and there are various limitations to the amount and technique of proximal stripping that can be prudently carried out (Chapter 3). One of these dangers is the possibility of leaving a roughened surface which is more likely to collect stains and especially dental plaque, which may predispose the tooth to the decay processes (Chapter 4). There have been relatively few studies which have looked at this roughness of the enamel surface after it has been subjected to various proximal stripping and polishing procedures (Chapter 5).

It is the aim of this study to compare the enamel surfaces, in terms of roughness, produced by varying proximal stripping and polishing procedures.