# A GENERAL REVIEW OF LITERATURE ON CHILD'S OCCLUSION

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## FIGURES

# Introduction

One of the major responsiblities of the dentists and orthodontists is to guide the dental growth and development of the child so that adverse conditions are reduced as much as possible.

One method to accomplish this goal is to control factors which interfere with the growth and development of the teeth and jaws. A second is to direct of occlusal development to effect a more desirable dentofacial growth.

One of the most useful aspects of mixed-dentition therapy is the practice of observation. By observation, we mean the collecting of information and data about growth of teeth and jaws in order to determine their ability to adjust and adapt into satisfactory occlusion. Too often dentists feel obliged to step in and try to expedite dental growth and development. In this way they upset developmental factors with gadgets and appliances and confuse their understanding of the true nature of the problem.

On the other hand, through observation of growth structures, they can gain information about the the direction of growth and the real need for treatment.

During this stage of development, there are a great many opportunities to guide and intercept malocclusion. Proffit (1986) stated that "Prevention of malocclusion is possible only in a few special circumstances."Interceptive" treatment can be very helpful in reducing the severity of problems, but rarely is so successful that later treatment becomes unnecessary".

In this thesis, I have attempted a general review of literature about guidance of development of the child's occlusion, which can serve as a basis for reaching decisions about orthodontic interception.

# CHAPTER ONE

## Development of Occlusion

The development of occlusion is a combination of processes, occurring from the primary dentition formation to the mixed dentition and finally, into the permanent dentition. Therefore, it takes place over a long period of time. Studies by Clinch (1946), Baume (1950), Friel (1954), Sillman (1964), Moorrees (1965 and 1969), Leighton (1969 and 1975) and Foster et al (1969 and 1972) have enabled us to predict the developmental processes with some degree of certainty.

### 1.1 The Primary Dentition

In the first year of life, human growth is more rapid than at any other time (Foster, 1972). The dentition is also developing at a rapid rate. The primary dentition is fully erupted and in occlusion by about 2.5 to 3 years of age, according to Foster (1972). From 3 to 6 years there is no further eruption or shedding of teeth. However, according to the studies of Clinch (1940), Baume (1950), Friel (1954), Leighton (1969), Moorrees (1969), and Foster (1972), the primary dentition undergoes noticeable changes concomitant with growth of the jaws. Thus, the following features of normal occlusion of the primary dentition (when fully erupted) can be seen:

1. Spacing of incisors

The spacing is an important characteristic in this dentition. In most normal cases, spacing occurs between all the teeth as they erupt (Fig1). White, Gardiner and Leighton (1976) noted that in most cases spacing occurs between all the teeth as they erupt, but occasionally spaces develop between the deciduous incisors subsequent to their eruption. Failure of incisor spacing to appear before the age of 5 occurs in about 20% of all cases and usually indicates crowding in the permanent dentition.

2. Anthropoid spaces, mesial to upper canine and distal to lower canine and into which the opposing canines interdigitate.

Somewhat wide spaces are present commonly mesial to the upper canine and distal to the lower canine. This space is referred to as the primate space by Baume (1950) (Fig 2).

In 60 children between the ages, Baume shows that primate spacing occurs between the of 4 and 6 years of age in the maxilla in 21 of 70% of the patients and 19 cases of 63% in the mandible. He also reported that a primary dentition without spacing is followed by crowding in the permanent dentition 40% of the time.

These findings show that the deciduous dentition exist in either of two forms, it is spaced or closed and does not develop from the other. Baume (1950) defined the spaced form as Type I and the closed form as Type II. However, all authors reported that Type II does not usually occur. Investigations by Foster (1969) found that only 1 % of his sample had no spacing. Goldberg (1929), Korkhaus (1941), and Newton (1944) believe that the presence or absence of spaces in the deciduous dentition maybe a hereditary characteristic.(Foster 1969)

After completion of the eruption of deciduous teeth, Baume (1950) believes that there is no physiological spacing and emphasized that there is no increase in interdental space in those arches with separated teeth; and no spacing develops in the arches in which teeth were in contact. The above findings demonstrate that no adequate extension or expansion of the deciduous arches took place between 3 and 5.5 years of age. This confirms Clinch's observation that she has never seen a case in which the spacing develop after full eruption of all deciduous teeth. Leighton's (1975) study of children between the ages of 3.5 to 5.5 years of age shows that the amount of spacing decreased.

3. Vertical position of incisors with the lower incisor touching cingulum of upper incisor.

The primary incisors generally erupt into a deep overbite. There is an average overbite of 4 mm with a normal range from 2 to 6 mm at 2 years of age. This overbite tends to reduce with eruption of the deciduous molars and by the more rapid attrition of the incisors, until at the age of 6 years, there may even be an edge-to-edge bite. However, Moorrees (1969) and Foster (1972) found that the changes in overbite are erratic. Foster (1972) found overall mean changes showed a decrease in incisal overbite in 27 out of the 53 children between the ages of 2.5 to 5.5 years of age. 24 of the children showed an increase in incisal overbite, and 2 subjects showed no change. Moorrees (1969) in his investigations concerning growth of the dentition described deep overbite in this period. He found a marked decrease of 3 to 4 mm or a moderate increase of 1.7 mm in the absolute overbite may occur with age.

Baume (1950) found that the anterior relationship remains practically unchanged with age. Leighton (1969) observed that "the overjet diminishes during the first 6 months of life, especially where occlusion is to develop normally. These changes are associated with rapid facial growth and increasing prominence of the chin. The process of steady reduction of incisal overjet might be impeded or even reversed by the presence of a sucking habit, whose effect is, however, nearly always transitory."

4. The distal surfaces of the upper and lower second primary molars are in the same vertical or "terminal" plane.

Usually, the molars erupt into a cusp-to-cusp intermaxillary relationship, as is also the case with the canines, but the canines may shift from a cusp-to-cusp relationship to a mesial relationship without any simultaneous change in the molar relationship before the teeth are fully erupted. Baume (1950) compared study models and found no physiologic mesial shift of the mandible or a forward adjustment of the mandibular teeth after the age of 4 years. The relationship of the primary molars could be divide d into 3 categories.(Fig 3).

i. Straight terminal plane

The distal surfaces of occluding second primary molars are in the same vertical plane.

This occurs in 76% of his sample which is by far the most frequently occurring relationship, and it is one which must be observed most critically. Depending on a number of factors, it can guide the permanent molars into a normal Class I or an abnormal Class II relationship. The transformation reduces the arch length in either the maxillary dentition or the mandibular depending on the situation. This is critical prior to treatment (Graber, 1985, pg 284).

It has been suggested from the results of these measurements that no essential changes in occlusion can take place during the period of the completed deciduous dentition (Baume, 1950).

ii. Mesial-step

This occurs in 14% of Baume's sample. The mesial step is an ideal relationship that routinely guides the permanent first molar into a favourable Class I intermaxillary relationship.

iii. Distal step

It was found to be present in 10% of the sample by Baume. The distal step as a rule guides the permanent first molars into an abnormal Class II malocclusion.

Another feature according to Baume (1950) is that arch dimension does not change during the primary dentition period. Arch length does not change in the maxilla in 89% of the cases and in the mandible in 83%; the arch width does not change in the maxilla in 82% of the cases and in the mandible in 83%.

Franke (1921) was the first to describe the reduction of the arch length with the natural loss of primary teeth. Since then, many investigators have confirmed these findings.

Review of the literature by Moorrees (1969), Foster (1972) demonstrate that between 4 to 6 years of age, a proportion of the subjects show arch length decrease slightly, owing to the closure of the interdental space between the deciduous molars. This occurs, as suggested by Baume (1950), because of mesial migration of the deciduous second molars just after their eruption or following the development of dental caries in proximal surface of molars.

## 1.2 The Mixed Dentition

The primary teeth are replaced by permanent teeth during 6 to 12 years of age. During this period, noticeable changes occur in the dentition.

### 1.2.1 Space Changes in the Mixed Dentition

#### 1.2.1.1. Anterior Spacing

In most children, there is excess space in the maxillary and mandibular arches before the permanent incisors erupt. It is recognized that a space change occurs during the period when the primary teeth are replaced by the permanent teeth. This is because the permanent incisors are considerably larger than the primary incisors that they replace. Black (1902) found that the four permanent maxillary incisors are on the average 7.6 mm larger in total mesio-distal widths than the primary incisors. The four mandibular permanent incisors are 6.0 mm larger. In addition, Moorrees (1965), observed that while central incisors erupt, they use up essentially all the excess space, and with the eruption of the lateral incisors the space situation becomes tight in both arches. According to Moorrees (1965), his research indicated that the maxillary arch, on the average, has just enough space to accommodate the incisors. In the mandibular arch, however, when the lateral incisors erupt, there is on the average 1.6 mm less space available for the four mandibular incisors than would be required to perfectly align them. Because of the above reasons, both maxillary and mandibular arches tend to crowd, but in fact most children during the mixed dentition only present with slight crowding that is concomitant with growth of jaws.

Moorrees (1965) reported 2 mm of crowding can be reduced to 0 mm by 8 years of age on the average. The extra space for alignment comes from the following sources:

i. A slight increase in the width of the dental arch across the canines. As growth continues the teeth erupt not only upward but also slightly outward. This increase is small about 2 mm on the average, but it does contribute to the resolution of early crowding of the incisors. More width is gained in the maxillary arch than in the mandibular and more is gained by boys than by girls.

ii. Labial positioning of the permanent incisors relative to the primary molars. Baume (1950) estimated that the permanent incisors after full eruption are 2.2 mm forward of the primary molars in the maxilla and 1.3 mm in the mandible. Thus this helps to resolve crowding.

iii. Repositioning of the canines in the mandibular arch. As the permanent incisors erupt, the canine teeth not only widen out slightly but move slightly back into the primate space. This contributes to the slight width increase already noted because the arch is wider posteriorly and also provides an extra millimetre of space.

In closed primary dentitions, as permanent mandibular lateral incisors emerge, the primary mandibular canines are moved laterally. A space is thus created for the proper alignment of the lateral incisors. This is referred to as secondary spacings described by Baume (1950). This spacing also occurs when the lower central incisors are erupting.

1.2.1.2. Leeway Space

A very important feature in the mixed dentition is the leeway space. The space occupied by deciduous canines and molars is greater than that required for the corresponding permanent succedaneous teeth. This space excess with eruption of the permanent canines and premolars is called the leeway space. It is first described by Nance (1936). The average leeway space according to Moyers is 2.6 mm (1.3 mm on each side) in the maxilla and 6.2 mm (3.1 mm on each side) in the mandible (Fig 4).
Moorrees (1969) stated that the leeway space is utilized by

i. permanent canine which is wider than the primary canine. It will tend to close part of the space. Liu (1949) mentioned in his study that space closure occurs with the emergence of incisors pushing other teeth distally.
Friel (1954) orientated cephalographs on the Bolton plane, concluded that teeth could only move forward. He explained that the distal migration seen in certain teeth is a function of an applied muscular force.

ii. the first molar moves forward following loss of the deciduous second molar. The mandibular molar normally moves mesially more than its maxillary counterpart. Liu (1949) also noted a mesial tipping of lower first molars, a movement accompanied by lingual rotation when it occurs in the maxilla. Moorrees (1969) measured tooth movement of the mandibular teeth and found 3 to 4 mm of mesial movement. This shift is a physiological phenomenon according to Moorrees.

In 1949, Seipel noted in his article on the prevention of malocclusion' that the age at which a premature loss occurred was important because earlier periods of development offered less anatomical resistance to migration. Unger (1938) had previously put forth the proposition that the earlier a tooth is lost, the greater the initial rate of total loss. Many other authors have supported these views (Seipel, 1949; Kronfeld, 1953, 1964; Lusterman, 1958; Linder-Aronson, 1960; Hinrichsen, 1962; Godt and

Grewe 1965; Seward, 1965, 1967; Krakowiak,1966; and Love and Adams, 1971).(Posen 1965)

Some researchers found a lack of predictability in the direction of space closure. Love and Adams (1971) found a small percentage of cases closing as a result of distal movement but a greater percentage closed by mesial migration. Salzmann (1957) reported that 13.6% of the cases he observed closed from the distal, 5.8% from the mesial and 67.6% showed movement in both directions.

Posen's (1965) article dealt with the effect of premature loss of second deciduous molar in the maxillary arch and showed that space was lost in both directions. In these individuals, the mean space loss attributed to mesial drift of the maxillary first permanent molar was 1.7 mm; while 1.6 mm was ascribed to distal movement of the first deciduous molar at the first bicuspid region in uncrowded arches. These values were 2.6 mm and 1.6 mm respectively in arches judged to have a negative leeway space.

Van der Linden (1974) found negligible changes in the patterns of rugae points, and used them as a reference, from where he measured tooth movement. The movement averaged 0.3 mm per year, relative to rugae points. This mesial shift, which is stronger in the mandible was attributed to forward growth.

Another consideration of the leeway space utilization is its dependence upon the sequence of shedding and eruption of the maxillary and mandibular posterior teeth and the molar occlusion (Moorrees 1969). When one tooth has erupted much farther than its neighbour, it can pass beyond that tooth and the two occupy the same saggital space as one. Another possibility observed by Van der Linden (1973, 1974) is the greater mesial movement of the first permanent molar in these cases where second molar emerges before the second premolar.

Fanning (1962) shows that early extractions may cause delay in the emergence and increase the period for the replacement of the absent teeth. This will afford more time for space closure. However, the boundary teeth can only move so far before they encounter the unemerged teeth.

Hutchinson (1884) said that the loss of space following premature extraction was dependent upon the eruptive state of the second molar. If this tooth had not emerged at that time, the space loss would be toward the mesial. If it had emerged the anterior teeth would close the gap by distal migration.(Posen 1965)

Lusterman (1958) also found great importance in the period of emergence of the second molar as he speculated that there was a growth centre distal to the first molar which could cause problems for a case with prematurely extracted deciduous molars.

### 1.2.2. Changes in Molar Relationship in the Mixed Dentition

Changes in the occlusal relationship in the mixed dentition occur during eruption of permanent teeth, especially of the molar.
Adams (1972) observed from the overall analysis of occlusion in children between the ages of 6 and 15 years that the occlusion changes in a forward relationship to the deciduous dentition. Other studies reported that changes in the molar occlusion depend on the deciduous dentition. Baume (1950) has observed in 60 cases, that before and after the eruption of permanent molars revealed three distinct kinds of normal molar relationship.(Fig 2)

1. In deciduous dentition which terminated with a marked mesial step the first permanent molars erupted immediately into normal cuspal interdigitation without altering the position of the neighbouring teeth.

2. In spaced primary teeth dentition (Type I) with a straight terminal plane relationship of the primary molars following the eruption of first permanent molars, at approximately 6 years of age, the straight terminal plane had developed into a mesial step, reducing arch length in the mandibular dentition. This allows the permanent maxillary molars to emerge into a Class I relationship. This is has been referred to as early mesial shift (Graber and Swain1985, pg 285-286).

3. In closed primary dentition (Type II) with a straight terminal plane, the permanent maxillary and mandibular first molars emerge into a cusp to cusp relationship simply because of the absence of the primate space (Graber and Swain1985, pg 286). This usually becomes converted into a normal molar relationship because on the average, cusp-to-cusp relation remains in this transitional phase until the mandibular deciduous second molar is lost and the permanent mandibular first molar migrates mesially into the excess leeway space provided by the differences in mesiodistal dimensions of the primary second molars and the succeeding second

premolar teeth. It has been referred to for a Class I relationship of the permanent first molars as the late mesial shift and is substantiated by the investigations of Moorrees(1969).
Mesial migration of the lower permanent first molars change their end-to-end relationship into a normal one. Baume(1950) stated that this is the last adjusting mechanism of the permanent molars occlusion.
The above adjustment is a physiological regulation of the development of occlusion.

### 1.2.3. Changes In Dental Arch Dimensions

Moorrees in 1965 expressed the view that the replacement of the deciduous molars and canine by the premolars and permanent canine respectively causes a small decrease in the length of each arch. The decrease in arch length is a function of differences in tooth size of posterior successional teeth and mesial migration of the permanent molars into leeway space.The arch length during the eruption of the incisors is primarily dependent on the inclination of these teeth in the jaws, rather than on tongue or lip forces. He also found replacement of anterior deciduous teeth by permanent teeth causes a small increase in the maxilla but is negligible in the mandibular arch (Moorrees 1969). This factor is primarily dependent on the inclination of these teeth in the jaws rather than on tongue or lip forces.
However, the arch length tends to decrease. Moorrees (1959) and Fisk (1966) noted that the mandibular perimeter decreases about 5.0 mm between 9 to 16 years of age and Knott(1961) also reported mandibular length shortening 3.0 mm between 9 to 15 years. Moorrees (1965) reported that the arch length decreases 2 to 3 mm and there is a reduction in arch circumference of approximately 3.5 mm in the mandible of boys and 4.5 mm in girls during mixed dentition period. Bjork (1963), Tweed (1966) and Enlow (1968) noted that as facial growth continues in an anterior direction into adulthood it throws the mandible into the facial musculature, which produces a posterior force vector on the crowns of the incisors. Thus arch length decrease from the anterior as well as the posterior. During this period, arch widths changes also occur but are very small.

Moorrees (1969) found that there is an increase of 1 to 2 mm which rarely exceeds 4 mm, between the ages of 6 to 9 years of age. This is completed in both arches by the age of 12.
White, Gardiner and Leighton (1976) have considered several reasons for the increase in arch width:

i. the labial and buccal inclination of the permanent teeth. This is greater than that of the deciduous teeth which are nearly vertical to the occlusal plane.

ii. the greater labial-lingual and buccal-lingual diameters of some of the permanent teeth.

iii. there is often some real increase of width of the arches due to the downward and outward growth of the alveolar border.

### 1.2.4 Overjet and Overbite

The overbite undergoes changes in the mixed dentition; from an increase to a decrease. In early mixed dentition, overbite relationship has developed because at that time, permanent lower central incisors have only erupted, while the upper central incisors are erupted and the overbite further increases.
According to Moyers (1969), overbite is correlated with a number of vertical facial dimensions; notably ramus height during this period of growth; and Foster (1972) suggested there maybe excessive vertical development of the anterior dento-alveolar segments which causes an excessive overbite with the teeth in occlusion between 6 to 8 years of age.
Bjork (1953) believes that the development of the bite is characterized by continued changes in structure and in the position of the teeth during the growth of the individual up to adulthood. He found this a necessary condition as the bite is known to change with size and direction of eruption of teeth at the various stages of development. Bjork (1953) associated overbite with age changes. He stated that generally the overbite decrease somewhat with advancing age. But overbite has been shown to vary from individual to individual. In some cases, the lower incisors are in contact with the cingulum of the maxillary incisors which is called deep anterior overbite, which is the characteristic of a reduced morphological height

from the nasion to the gnathion when the jaws are closed. In other individuals, the maxillary and the mandibular teeth are found to meet at their incisal edges or even not in contact, that is, open bite.

Bjork (1953) mentioned age changes of overbite. He found overbite decreases somewhat with advancing age. In some individuals, age changes are great. Deep overbite shows a greater tendency to open than normal overbite, whereas, openbite shows tendency to close. Individual differences, however, are pronounced.

Moorrees described the mean vertical overbite, which decrease slightly up to the age of 18 years. A continuous eruption is most likely to occur simultaneously with occlusal attrition of teeth.

Bjork (1953) and Moorrees (1959) concluded that the shift from the deciduous to the mixed dentition generally brings about an increase in overbite after which the overbite of the permanent incisors decreases slightly.

Overjet is usually a reflection of the anterior occlusion; and the posterior relationships of the maxillary and mandibular denture base (Moyers, 1980, pg 201).

In comparing the overbite and overjet changes, overjet is greater than overbite at the age of 12 years and the age changes are greater for overbite than for overjet at 20 years. The overjet generally changes with advancing age, so that the front teeth of the lower arch show a forward displacement in relation to the upper teeth. Bjork (1953) also reported that the range of variation for these age changes in the overjet (7.4 mm) is the best expression for the dynamics in the development of the bite.

## 1.3 The Permanent Dentition

Changes in the dental arches can still occur after an established occlusion has been achieved in the permanent teeth.

### 1.3.1 Possible Causes of Incisal Crowding

Moorrees (1959), Humerfelt (1972), and Foster (1972) reported that crowding of the lower incisors quite commonly develops in modern man by 14 years of age or later.

Causes of crowding are:

1. The dental arches become short especially in the mandibular incisal region. Foster (1972) found that it will be more crowded by 21 years of age due to a slight retroclination of the lower incisors which occurs during the late stages of facial maturation.

2. Crowding can be attributed to the force of eruption of the third molars pushing the teeth anterior to them. At present many authors find this point debatable. Vego (1962) found that arches with third molars had more crowding of incisors than those without, but they also found as did Garn (1962), that the rest of the teeth are smaller when the third molars are absent. Bergstom and Jensen (1960), studying incisal crowding by measurements on casts of subjects with unilateral absence of mandibular third molars noted more crowding on the side where the third molar was present.
On the other hand the crowding also develops in dentitions with teeth extracted in the buccal segments or before the roots of the third molars have developed appreciably and other explanations have been suggested.

3. The crowding is at least partly a result of mandibular growth which causes the lower incisors to be forced against the maxillary anterior teeth.
Bjork (1956) found incisor crowding correlated better with mandibular increments than with the eruption of third molars. More crowding is seen in males than in females. This observation is probably true because girls mandibular increments are greater at this time (Moyers, 1980). The space is generally sufficient for the maxillary incisors at this stage, whereas by 14 years of age or later some lack of space may develop for the mandibular incisors (Moorrees, 1959, Humerfetl, 1972).

Dental archlength and perimeter decrease a surprising amount during the late adolescent and young adult period. However, from 14 to 20 years of age, Moorrees (1959) found that the dental arches remain virtually the same although both widening and narrowing have been observed.
Greater forward growth of the mandible is also responsible for slight vertical overbite decrease up to age of 18 years (Moorrees 1959), and a continuous eruption most likely occurs simultaneously with the occlusal attrition of the teeth. Some authors (Bjork, 1953; Humerfelt and

Slagsvold, 1972) described both overbite and overjet decrease throughout the second decade of life. They suggested that it is probably due to the relatively greater forward growth of the mandible. Fisk (1966) noted that in the majority of his subjects the mandibular molar had a more forward occlusal relationship with age. Such posterior occlusal changes are due to the mesial drifting tendency, slight interproximal wear and, most importantly to the continuing growth of the mandible.

# CHAPTER TWO

## Factors Influencing Occlusion of Development

The factors influencing development of the occlusion have been studied for many years.The findings of clinical and basic research have identified factors which may be classified as dental, skeletal and functional.
The purpose of this chapter is to discuss:
1. Timing, sequence and path of eruption of the teeth
2. Tooth crowding
3. Timing of pubertal spurt and direction of growth
4. Functional aspects influencing development of occlusion.

## 2.1 Timing of Eruption of the Teeth

### 2.1.1 Assessment of Timing of Eruption of Permanent Teeth

Traditionally, consideration of timing of eruption of permanent teeth is based on the average chronological age at which the individual teeth erupt into the oral cavity, but this can only provide a rough guideline for the determination of the status of a child's dentition.
Criteria generally used to assess the timing of eruption of permanent teeth are:

1) Number of teeth present
The determination of the number teeth which should be present in the mouth is made according to the chronological age of the patient. The number of teeth present at any particular age may be different for different children (Fig 5)

2) Tooth maturation
Tooth maturation is determined by information about root development. Nanda (1960 ) believes the most reliable means of estimating the timing of eruption of the teeth for a given child depends upon the maturational status of the teeth prior to eruption.

As present, the most widely used method for making a meaningful estimation of eruption time is based upon the stages of tooth formation formulated by Nolla (1960). He classified the maturation of each tooth in terms of ten stages, ranging from crypt formation to root completion.

10. Apical end of root completed
9. Root almost completed, open apex
8. Two thirds of root completed
7. One third of root completed
6. Crown completed
5. Crown almost completed
4. Two thirds of crown completed
3. One third of crown completed
2. Initial calcification
1. Presence of crypt
0. Absence of crypt

As a general rule, the following three stages of maturation in Nolla's classification are usually used;
Stage 2; Initial calcification: calcification permits the usual determination of the presence of tooth by radiograph.
Stage 6; Completion of crown: as soon as the crown is completed, root formation begins and the tooth is in the process of eruption.
Stage 8; Two -thirds of root completed. At the completion of stage 8, most teeth emerge through the alveolar crest.
A maturation stage presents only a determined qualitative event such as the formation of a crown, or the beginning of root formation or the completion of root formation. But this is not a precise method since the maturational rates of different teeth are not the same, especially at the earlier age levels. However, between the age of 9-12 years, the estimation of the order of eruption is reasonably accurate, based upon the amount of root formation.
In observing root formation, Gron (1962) found that the majority of all teeth had attained approximately three quarters of their roots at the time of clincial emergence. Formation of less than one quarter root length or a closing apex was never observed for any emerging tooth. Gron also found that the differences in the amount of root formation for various tooth classes proved of interest. The mandibular first molar and central incisor had generally less root development at emergence than any of the other

teeth with about half of their root formed. On the other hand, the typical mandibular canine and second molar had just passed the three quarter root stage at emergence.
The association of root formation and skeletal development studied by Schour and Massler (1941), Boulanger (1958), Lamons and Gray (1958), and Weishaupt, Lamonos (1959) gave a slightly higher correlation between root formation and chronological age than between root formation and skeletal age (Gron 1962)

### 2.1.2 Factors Influencing the Time of Eruption

Factors influencing the time of eruption have been mentioned in many papers, but none has been confirmed until now.
Factors influencing may be considered following the list by Gordon and Kusin 's research in 1935.

1) Endocrine factor e.g the functional activity of the thyroid and of the growth of anterior lobe of pituitary.

2) Nonendocrine factors, such as familial tendencies, chronic disease, rickets and acute infections.

3) The mentality of the infant in the first six months of life.

4) Chronologic relationship between the time of inception of the influencing factor and the normal time of teething.

5) oral physiological condition ;
The density of the bone, the thickness and amount of keratinzation of the mucosa, the amount of calcification of the predecessors, the rate of resorption of the predecessors.

6) Oral pathological conditions.
dental caries, periodontal infections, ankylosis of teeth, abscesses.etc.

7) Hereditary factors.

Nanda (1982) and some other authors suggested that sex, race, growth in height and weight, and loss of a primary tooth, might have an influence on the time of eruption.

1) Sex differences

Eruption of the teeth tends to occur earlier girls than in boys. This should be due to growth and development. On the average girls are advanced over boys in a great many respects: they are earlier in appearance of ossification centres; they are ahead in epiphysial union and the appearance of secondary sexual characteristics.

Garn (1962 ) reported that the permanent teeth of boys were an average of five months later in erupting than those of girls.The difference was greater for the lower cuspid,whose median age of eruption was 10 years 7 months for boys and 9 years 10 months for girls.In this context, he (1958) studied 255 children age-means and average sex difference are given for the mandibular molar and premolar teeth; girls tend to be advanced over boys an average of 0.32 years,and by amounts up to 0.92 years.Comparing the eruption stage 2 ( alveolar eruption and attainment of the occlusion level) to the calcification stage (follicle and beginning root) the sex difference of 0.52 years for the former is greater than the average sex difference of 0.16 years for the latter.

2) Race Difference

Influence of racial type on eruption timing is not much noted, but a number of studies cite that teeth tend to erupt earlier in American Black and American Indian children than in American white of European ancestry (Nanda 1982).

3) Height and Weight

High correlation have been reported between height and weight and the timing of tooth emergence among children of the same chronological age. Taller and heavier children have a greater number of erupted teeth and their teeth erupt earlier in contrast to shorter and lighter children.

4) Malocclusion

Local factors play a significant role in the eruption of an individual tooth. The permanent teeth may be delayed in their eruption if space is not adequate for the proper alignment of the permanent teeth.

5) Loss of a Primary tooth

If the primary tooth is lost and the crown of its successor tooth is completed ( stage 6) and root formation has begun, then the permanent successor will be accelerated in its eruption. In contrast, if the crown of a successor tooth is not completed at the time of loss of the primary tooth, the eruption of the permanent tooth will be delayed beyond its normal eruption time.

## 2.2 Sequence of Eruption of the Permanent Dentition

### 2.2.1 Sequence of Eruption

Massler and Schour (1941) divided the eruption of the the permanent teeth into three groups:

1) Group one includes the permanent first molar and all of the permanent incisors.These teeth erupt within one year of each other.
2) Group two consists of the permanent cuspid, premolars and second molars.
3) Group three is limited to the third molars.

Lo and Moyers (1953) found that there is more variation in the eruption sequence in the teeth of the second group than in the other groups.
In 1953 Lo and Moyers observed 236 younger children. They found eighteen different sequences in the maxilla. The most frequently occurring sequence of eruption of teeth was 61 2 4 5 3 7, which appeared 48.72% of the time. The 6.1 2 4 3 5 7, sequence appeared 16.01% of the time; the 6 1 2 4 5 7 3, sequence was in 11.8% of cases; the 61 2 3 4 5 7, sequence was observed 5.93% of the time; and the 6 1 2 4 3 7 5, sequence just 5.51% of the time .
Seventeen different eruption sequences were noted in the mandible , 61 2 3 4 5 7, was found 45.77% of the time; 61 2 3 4 7 5, in 18.64% of cases; 6 1 2 4 3 5 7, in 8.47%; 61 2 3 7 4 5, in 5.93%; 6 1 2 4 5 3 7 in 5.93% .
In 1964 Gates selected 5660 children aged between 6 to 15 years in N.S.W. He found that the sex difference with females more advanced, in the sequences of eruption, particularly large sex difference in the median age of eruption of the caines and shorter age range of eruption of these teeth compared with bicuspids. He also found no great difference between the sequence of eruption compared with other studies.

### 2.2.2 Relation for Homologous Teeth on the Two Sides of Each Arch and Two Arches

A typical eruption sequence is merely symptomatic of more fundamental underlying factors ultimately responsible for malocclusion.
Sturdivant's (1962) work shows that the clustered or compact distributions are those for the permanent first molars and central incisors. Ages of eruption of corresponding teeth on the right and left differ by no more than six months for 100% of the mandibular first molars, 98% of the maxillary central incisors, 96% of the mandibular central incisors and 93% of the maxillary first molars. He also found at relative frequencies approximating 5%, eruption ages on the right and left for these teeth are found to differ by as much as eighteen months to thirty-five months.
In regard to eruption relations for complementary teeth in the two arches, he described three characteristics:

1) Eruption of the right mandibular tooth precedes eruption of the right maxillary tooth by six months or more for 85% of the central incisors, and 63% of the canines. In none of these three distributions does emergence of a maxillary tooth precede eruption of its antagonist by more than four months.

2) Approximately 60% of the right first premolars erupt within a period of six months in both arches. A similar finding holds for the second premolars.

3) The range or variation for the first molars extends from earlier emergence of the maxillary tooth by seven months to earlier emergence of the mandibular tooth by thirteen months.

In many instances, the anterior segment of the incisors did not correspond to the posterior section of bicuspids and molars. In the majority of readings, the lower teeth were in advance of the upper. The right side of the the arch was not always comparable with the left side.
Moyers (1953) observed that the order of eruption is bilaterally symmetrical except in cases of localized pathology. Where an intense area of pathology appears at the roots of a deciduous tooth, the loss of bone is

sometimes sufficient to cause the succeeding permanent tooth to erupt faster than adjacent teeth. Where this was observed, the sequence on the nonpathological side of the arch was used.

2.2.3 The Sequence of Eruption in Relation to Occlusion

Sequence of eruption of permanent teeth in relation to occlusion was based on the mesiodistal relationship of the first molars and on the extent of crowding and spacing seen.Nanda (1960) suggested the best eruption sequence is that which ensures no loss of space during the exchange from the primary to the permanent dentition. In his investigation, only three types of eruption sequence were studied in detail, even though other orders of eruption were also observed. The reason for this limitation was that almost all the children had one of three types of sequence in either one or both jaws. This was also found to be necessary for comparison with the findings of Bengston (1935) and Lo and Moyers(1953). The three sequence of eruption considered were as follows.

1) Child Research Counil (Bengston 1935)
Maxillary M1 I1 I2 Pm1 C Pm2 M2
Mandible I1M1 I2 C Pm2 M2

2) Lo and Moyers (1953) Gates (1964)
Maxilla M1I1I2 Pm1 Pm2 C M2
Mandible M1 I1 I2 C Pm1 Pm2 M2

3) Second molars erupted earlier than the second premolars(Nanda)
Maxilla M1 I1 I2 Pm1 C M2 Pm2
Mandible I1 or M1 I2 C Pm M2 Pm2

Lo and Moyers noted that 61.3% of the case with this "normal " eruption sequence exhibiting Class I occlusion were female children.
The 6 1 2 4 5 3 7
6 1 2 4 5 3 7

sequence combination showed 90.67% Class I occlusion, whereas in the total study only 69.02% were Class I.

MacGregor (1945) and Seipel (1949) have each reported on the role of the erupting second molar in producing certain malocclusion. They observed that when this tooth erupted prior to the cuspids or premolars there was a tendency for a malrelationship of the first molars to occur as a result.
Lo and Moyers (1953) findings bear this out. In the maxilla the early eruption of the second molar reduced greatly the number of Class I molar relationships and increased the percentage of Class II molar relationships.In the mandible there is a similar reduction of Class I cases. However,there is an increase of Class III molar relationships. When the Class II molar relationship cases were considered separately, it was found that in 89.11% of the cases the maxillary second molar erupted prior to the mandibular second molar. Only 56.5% of the maxillary first molars arrived ahead of the mandibular first molar in Class II cases.

### 2.2.4 Variations in Eruption Sequence

Several reasonably normal variations in eruption sequence have clinical significance and should be recognized. Proffit (1986) put forward the important variation of;

1) eruption of second molars ahead of premolars in the mandibular arch. It can tend to decrease the space for the second premolar and may lead to its being partially blocked out of the arch. Some dental intervention may be needed to get the second premolar into the arch when the mandibular second molar erupts early.

2) eruption of canines ahead of premolars in the maxillary arch. It will probably be forced labially. Labial positioning of maxillary canines often occurs when there is an overall lack of space in the arch, because this tooth is usually the last to erupt. But displacement of the canine can also be an unfortunate consequence of an eruption sequence abnormality.

3) asymmetries in eruption between the right and left side.

## 2.3. Path of Eruption of the Teeth

A tooth erupting is pushed by a force which moves a tooth into occlusal position. Nanda's (1982) definition of path of eruption is: "the direction of movement of a developing tooth through the bone."

### 2.3.1 Normal Developmental Axis and Direction of Tooth Eruption

The inclination of the developmental axis can be determined from the primary direction of a tooth. Bjork (1972) stated that the mean direction of eruption of the permanent teeth is vertical and somewhat forward into the occlusal position.
Jaraback and Fizzell (1963) found that the change in axial inclination of teeth depends on the functional force and crowding presents as a compensating mechanism.

#### 2.3.1.1 Anterior Incisors

Mandibular incisors:
Normally the mandibular incisors develop lingually to the resorbing roots of the primary incisors forcing the latter labially to be exfoliated.(Nande 1982,Pg 81)
Furthermore their roots converge towards the midline to a greater degree than their predecessors.
Usually, the problems of eruption are more encountered with the permanent lateral incisors because the lateral incisors are positioned further lingually than mandibular central incisors, and tend to be proportionally larger. Thus, they are relatively more dependent upon the available space.
If there is no primate space, and little or no interincisor spacing is present in the dental arch, then the permanent lateral incisors may follow either of two possible paths:

1) the permanent lateral incisors erupt lingually out of alignment and the primary incisors may be retained.

2) the permanent lateral incisor may cause pressure on the root of the primary cuspid, inducing root resorption and causing its premature

exfoliation. Then the permanent lateral incisor may erupt in its correct position in the arch.

In addition, Paul Lee (1980 ) observed that if lower lateral incisors are erupting anatomically correctly, then there must be an inherent force for the lateral incisors to move labially.

Maxillary incisors:

The positioning of the maxillary permanent incisors is very similar to that of the mandibular permanent incisors. But their path of eruption is relatively more labial and oblique than that of the mandibular permanent incisors. As the two maxillary permanent central incisors erupt, their crowns are tilted somewhat distally, which causes a slight midline diastema With the eruption of the maxillary permanent lateral incisors, the crowns of the maxillary permanent central incisors normally converge to eliminate the midline space that existed earlier, and which resulted from their divergent course of eruption ( Nanda 1982).

2.3.1.2 Cuspid and bicupid eruption

Mandible

The crowns of the permanent cuspids are positioned labially relative to the permanent lateral incisors and are situated lingually and distally in relation to the primary cuspids.

During the process of eruption, the axes of the permanent cuspid are directed mesially and lingually.

The permanent cuspids erupted along the distal aspect of the roots of the permanent lateral incisors and their eruption is preceded by a marked increase in the primary intercuspid width.The final positioning, relative to their predecessors, is labial with a mesial inclination.(Nanda 1982)

The path of eruption of the first bicupsids is directly toward the occlusal plane, leading to their final positioning in the dental arch.

The eruption path of second bicupids varies from individual to individual. The tooth will take one of three possible paths of eruption.

1) Distal path of eruption

When it is referred to as "normal " it implies that there is a minimum loss of the space during the replacement of the primary second molar by the mandibular second bicuspid.

2) Occlusal path of eruption

Although this path of eruption is commonly observed, it should not be considered normal because there is a loss of space due to the mesial shifting of the first permanent molar at the time of exfoliation of the second primary molars.

3) Mesial path of eruption

Mesial path of eruption is due to too much time elapse between the exfoliation of the second primary molar and the eruption of the second bicupid. The first permanent molar will tip mesially, causing a loss of space with the resulting " blocking out "or impaction of the second bicuspid.

Maxilla :

Maxillary cuspids are usually the last teeth to erupt anterior to the first permanent molars. Thus, their position in the dental arch depends to a great degree upon the available space. If the space is not adequate, they most frequently occupy a high labial position in the arch or remain impacted.

The maxillary cuspids are positioned lingually and somewhat distally to their predecessors, and close to the mesial roots of the maxillary first primary molars.

The position of the developing maxillary cuspids are changing relative to the adjacent teeth during the course of their eruption. At the beginning of the late mixed dentition phase, the primary intercuspid width increases,the maxillary permanent cuspids spread out laterally and the earlier staggered arrangement disappears. The axial inclination of the maxillary cuspids is mesially directed and in close proximity to the distal aspect of the maxillary permanent lateral incisors. The cusp tips of the maxillary permanent cuspids are lingual to the apices of the maxillary primary cuspids, and the roots of the maxillary primary first molars are in close proximity to the distal aspects of the crowns of the maxillary permanent cuspids. Of all the teeth, the cuspids travel the greatest distance from their initial formation position to complete their eruption into the oral cavity.

As the maxillary cuspids start erupting towards the occlusal plane after the formation of the crown,they are directed towards the distal aspects of the maxillary permanent lateral incisor roots and erupt into the dental arch.

The position and path of eruption of the maxillary first bicuspids are very similar to the mandibular first bicuspids.
The position and path of eruption of second bicupid is identical to that of the first bicuspid. The final positioning in the dental arch is uneventful if the second primary molar is exfoliated at the proper time.(Nanda 1982)

2.3.1.3 Molar eruption

Mandible
Prior to molar eruption, the crown of mandibular first permanent molars are canted mesially and lingually and their bony crypts are positioned at the angle formed by the anterior border of the ramus. During its course of eruption, the molar undergos a rotation resulting in a reorientation of the crown in relation to the occlusal plane. Ultimately, the mandibular first permanent molar achieves a definitive orientation that is characterized by a slight mesial tilt and by a slight lingual inclination in the transverse axis.
The first permanent molars are guided into the dental arch by the distal surfaces of the second primary molars.
The position of the mandibular second permanent molar, during and upon its eruption,is mechanically regulated by the mandibular first permanent molar just as the position of the mandibular first permolar molar by the second primary molar.(Nanda 1982)

Maxillary
The maxillary first permanent molars rotate mesially and the crowns are uprighted so that the molars move vertically toward the occlusal plane at the time of their emergence. After completion of eruption, the maxillary first molars are inclined mesially on their long axes and buccally in the transverse axis.
The direction of eruption of second molar is similar to that of the maxillary first permanent molar. Consequent the crown of the maxillary second permanent molar is inclined mesiobuccally in the oral cavity.(Nanda 1982)

2.3.2 Disturbance Factors in Path of Eruption of the Teeth

Some of the disturbance factors as listed by Nanda (1982) are;

1) Over-retained primary teeth

It is usually due to improper resorping roots of the primary teeth.

This situation is more frequently with the primary lateral incisors because of the lingual position of the crypts relative to the central incisors. If there is over-retention of the primary cuspid or primary molar, the permanent teeth will be deflected from their normal position in either a labial or lingual direction.

2) Very early loss of primary teeth

The permanent lateral incisors may resorb the roots of the primary cuspids during their eruption due to lack of space. In this event, the primary cuspids are exfoliated prematurely. The early loss of the primary cuspids reflect insufficient arch length in the anterior segment.

Early loss of lower second primary molar, when a long interval elapses between the loss of the second primary molar and the eruption of the second bicuspid, the condition is referred to as "early tooth loss". The early loss breaks the continuity of the dental arches and permits the abnormal movement of the adjacent teeth. Following the early loss of the second primary molar, the first permanent molar will tip mesially and the first bicuspid crown will migrate distally, with a loss of the space required for the second bicuspid. If the crown of the second bicuspid is completely formed and the path of eruption is distal, then this tooth may be blocked under the bulge of the mesially tipped first permanent molar.

If the crown is completed and the path of eruption is occlusal, then the second bicuspid erupts lingually and it will be blocked out of normal alignment in the arch.

With loss of the upper second primary molar, the maxillary first permanent molar usually rotates on its lingual root and the mesiobuccal cusp encroaches upon the space required by the maxillary second bicuspid. In the mandible ,on the other hand, when the second primary molar is lost prematurely the first permanent molar simply tips mesially and no rotation is observed.

If a maxillary primary cuspid is extracted at any age before its normal exfoliation time, the extraction constitutes a premature loss of the tooth. This premature loss may permit the posterior teeth to shift mesially into the extraction space, while the incisor teeth shift distally, thereby resulting in insufficient space for the maxillary permanent cuspids.(Nanda 1982)

3) Lack of space in the arch

Crowding in the arch is caused by lack of space and the last tooth erupting may thus be retained .According to Haavikko(1980), the teeth which most frequently remain impacted, or may erupt late in an abnormal position, are the maxillary canines,
the mandibular second premolars, and the wisdom teeth.

Nanda (1982) found that if no spacing is present in the maxillary arch the erupting maxillary first permanent molars may cause resorption of the roots of the maxillary second primary molars. The resorption of the roots of the maxillary second primary molars may occur even if the spacing in the maxillary arch is adequate, should the path of eruption be abnormal. If the space required by the permanent cuspids is inadequate then the permanent cuspid will be diverted from its normal eruption path by interference from the mesial aspect of the first primary molar. If the permanent cuspids erupt after the mandibular first, bicuspids with insufficient space for the permanent cuspids, then the permanent cuspids will erupt in a labial position.

Due to lack of space, an ectopic path of eruption may result in the forward positioning of the maxillary second permanent molars and disrupt a desirable occlusal relationship.

4) Congenitally missing teeth

Graber (1956 ) and Muller (1970 ) reported that the tooth missing with the greatest frequency was the upper lateral incisor, and lower second premolar was second in frequency. The congenital absence of the permanent cuspid is encountered only in rare instances. No differences were encountered between the right and left side when both upper and lower jaws were considered. Bilateral symmetry was predominant among the different combinations of missing teeth.

Many studies on families and twins have indicated the importance of genetic factors in the occurrence of congenital absence of teeth .

Nanda (1982) reported that when any of the permanent incisors are absent, the corresponding primary teeth may be retained in the arch.

If a primary incisors is lost, and its replacement tooth is congenitally absent, however, the remaining incisors may change their axial inclinations and position, resulting in a displacement of the midline of the arch or create a prominent diastema. The permanent cuspids can be shifted mesially and occupy part or the permanent lateral incisor space.

When mandibular second bicuspids are missing, the degree of maloccusion produced depends upon the following events.

i) When the second bicuspid is missing, the normal impetus for the second primary molar root resorption is lost and the second primary molar is retained well beyond its usual time of exfoliation. Often such teeth become ankylosed, so that the ankylosed tooth remains at a submerged level,compared with adjacent teeth. This process results in the loss of proper contact points between the normally erupting first permanent molar and ankylosed second primary molar. Because of the differences in crown height between the primary and the permanent molars, the ankylosed second primary molars appears submerged and does not reach the occlusal plane of the permanent dentition. Then, the first permanent molar tips mesially over the second primary molar, resulting in an unfavorable axial inclination of the first permanent molar. This mesial shift of the mandibular first permanent molar will result in a change in the mesiodistal relationship to the maxillary first permanent molar. and will form a Class III molar relationship.

ii) If the second primary molar is exfoliated or lost, because of decay or for some other reason, both the first permanent molar and the first bicuspid will tip into the space that was intended for the second bicuspid. This will have a deleterious effect on the teeth of the maxillary aıch and may result in the supraeruption of the maxillary posterior teeth.(Nanda 1982)

5) Supernumerary teeth

The presence of supernumerary teeth is uncommon in the incisor segment of the arch.

According to Lundstrom (1960) this anomaly is 8 to 9 times more common in the maxillary than in the mandibular arch. Supernumerary laterals are typical in cleft palate patients, and a high incidence of supernumerary teeth has been recorded in cases of cleidocranial dysplasia.

A Supernumerary tooth, according to Haavikko (1980), may be typical or atypical in shape compared with other teeth of the region in which it occurs.An atypical supernumerary tooth is most frequently one cuspid found in the first place in the midline of the upper jaw, and sometimes in the midline of lower jaw.

Supernumerary teeth are found most frequently in the maxillary incisor region, the presence of a supernumerary maxillary incisor tooth may have one of the following three influences on the relationship of the permanent incisors (Nanda)

i) If the supernumerary tooth is not located in the eruption path of the permanent incisors, then the effect on this region is minimal .In this situation, the extra tooth stays unerupted or erupts labially or lingually.

ii) If the supernumerary tooth is located in the eruption path of any of the permanent incisors, the permanent incisor affected is deflected from its normal position or prevented from erupting. In the event that only one central incisor has erupted, yet the lateral incisors have erupted into the oral cavity, then this may indicate presence of a supernumerary tooth .

iii) If a supernumerary tooth occupies the position of a permanent incisors, the permanent incisors will usually erupt in a malposition in the dental arch.

The presence of supernumerary teeth is infrequent in the bicuspid area. If a surpernumerary tooth is identified, however, it is advisable to extract this tooth even though it is unerupted.(Nanda 1982 Pg152)

6) Ectopic eruption of teeth

Ectopic eruption observed more frequently in the maxillary arch is caused by the first permanent molar erupting mesially in relation to its normal path of eruption. The mesial surface of the first permanent molar then becomes trapped apically to the bulge on the distal contour of the second primary molar. This condition often causes resorption of the distal aspect of the second primary molar, which impedes further eruption.(Nanda 1982 Pg 156)

7) Transposition

When a maxillary cuspid exchanges position, with a maxillary first bicuspid, a malocclusion results.Clinical management of such problems must be considered on an individual basis.The mandibular canine may be similarly transfosed.

8) Muscles

In patients with hyperactive muscles, the chin usually presents a wrinkled, pursed appearance when the person swallows and the lips are compressed. The pressure exerted by the lips and the mentalis muscle causes the

anterior segment of the mandibular arch to become flattened.This condition is commonly observed in patients with severe Class II Division 1 malocclusions.
A pronounced diastema between the maxillary permanent centrals is frequently attributed to an abnormally sized, or improperly attached labial frenulum.(Nanda1982 Pg 107)
Because a short upper lip and a lack of support from the lower lip, spacing in the maxillary incisors is created. In individuals where there is a severe overjet, this problem is further exaggerated by the posture of the lower lip. This clinical entity is commonly observed in severe Class II Division 1 malocclusion.

9) Special position
The rotated position of the first molar causes this tooth to encroach upon the space required by the maxillary second bicuspid. Because of the rotation of the maxillary first permanent molar into this space, the second bicuspid follows the path of least resistance and erupts palatally.
If the maxillary permanent lateral incisors are in a lingual maxillary position or rotated, the erupting maxillary permanent cuspids will lose the proper guidance from the maxillary permanent lateral incisors and will be malpositioned labially. Upon eruption they even overlap the labial surface of the maxillary permanent lateral incisors.
If the permanent mandibular lateral incisors are lingually positioned or rotated, the erupting permanent cuspids will usually be displaced labially towards the midline.(Nanda 1982 Pg 111)

10) Oral habits
Habits that exert a prolonged local and direct pressure on the teeth (such as thumb sucking and tongue thrusting) will influence the position of the maxillary and mandibular incisors. Graber (1985) noted that finger - suckers displace the maxillary incisors labially and the mandibular incisors lingually. The first separate and the second tend to crowd .Thumb sucking, in its severest form , will cause an open bite with spacing in the maxillary anterior segment; it also flattens, the mandibular anterior segment. Abnormal tongue thrusting habits during swallowing will produce generalized spacing in the maxillary and mandibular anterior segments in addition to a circumscribed open bite .The open bite produced by

abnormal tongue thrusting is clinically similar to open bite resulting from sucking.

## 2.4.Tooth Size Consideration

### 2.4.1 Prediction of Tooth Crowding

From primary phases into permanent phases, the tooth size variation contributes to changes. The relationship between the mesiodistal crown diameters of the deciduous and permanent teeth likewise plays an important role in the development of occlusion of tooth permanent dentition.

At present,the prediction of the size of the permanent teeth from the size of the primary teeth is not sufficiently reliable for diagnostic purposes. Therefore, it is necessary to determine the tooth size for each patient by using dental casts and periapical radiographs of unerupted teeth.

Keene's (1979) formula for predicting incisor crowding was based on three cephalometric measures, but substantially more of the thirty-five treated cases were predicted to crowd than actually did. Studies that have incorporated a cephalometric analysis with incisor measurements have not substantially increased the predictability of incisor crowding. Norderval and associates (1975) found that uncrowded cases had a mean ANB angle that was about 1 less than crowded cases and a smaller mandibular plane to palatal plane angle, as well as narrower incisors.

Savin and Savara (1973) found that they could predict incisor crowding with the same accuracy by using a discriminate analysis, including six cephalometric measures, or by simply assuming that crowded mixed dentitions would lead to crowded permanent dentitions.

Generally speaking,the permanent incisors and canines are larger, but the premolars are smaller than their deciduous predecessors .

Moorrees and Chadha (1962) found that mesiodistal crown diameters of the permanent maxillary central and lateral incisors were 3.7 and 3.3 mm, greater on average than their deciduous predecessors in males and females, respectively. In the mandible, the two permanent incisors exceeded the deciduous ones by 2.6 mm in both sexes. However,the transition of the deciduous canine and the two deciduous molars contributed additional space because, in their study, the permanent teeth were smaller than the

deciduous teeth, with mean differences of 1.2 and 1.5 mm in the maxillary and of 2.2 and 2.6 mm, in the mandible of male and female, respectively.
Moorrees (1957) found the average value of the combined crown diameters of the maxillary permanent teeth is 5.22 mm, larger than that of their deciduous predecessors in males, and 3.59 mm larger in the females. In the mandible the permanent teeth of the male are only 0.77 mm larger than the deciduous teeth. In the females on the other hand, the difference between the means is even less, or only 0.17 mm.
Linen (1974) who studied the morphogenesis of teeth, the development of the dentition and the growth of the craniofacial complex, separated crowding into three classes, primary, secondary and tertiary crowding.(Fig 6)
Primary crowding refers to the discrepancy between jaw size and tooth dimensions that is mainly determined genetically. It may be assumed that many genes play a role in the morphogenesis of the craniofacial skeleton, the jaw sizes, and the tooth dimensions An inharmonious combination in genetic composition may lead to primary crowding.
Secondary crowding refers to the crowding that is caused mainly by environmental factors. The premature loss of deciduous teeth is the most essential contributing factor.
Tertiary crowding refers to the crowding that occurs during the adolescent and postadolescent period. Ideally arranged dental arches may start to show overlapping of anterior teeth, a phenomenon that is observed more in male than in female.This is related to the difference between the two sexes in late facial growth.

### 2.4.3 Clinical Considerations

1) Ratios

The tooth size is clinically important concerning the ratios of the mandibular teeth to the corresponding maxillary teeth, including the first molars. Bolton (1958) measured the permanent dentition. The mean ratio is 91.3, with the maxillary teeth exceeding the mandibulars teeth in size. If one is to obtain a proper interarch dental relationship (interdigitation, overbite and overjet ) then mandibular  maxillary tooth size ratios should not demonstrate any measurable discrepancy. If the interarch tooth size ratios deviate markedly, improper interdigitation, overjet, overbite, and

spacing between teeth may be encountered, even though there is no intraarch tooth size and arch length discrepancy.
For the individual teeth, Lundstrom (1960) showed genetic factors as a rule, 2-3 times as great an influence as the non-genetic factors on the variation of the single tooth diameters, while for the sum of the diameters of the I1-M1 the corresponding ratio is about 4-5 .
Using the Bolton analysis, the twelve maxillary teeth were compared with the twelve mandibular teeth in a ratio as:

$$\frac{\text{Sum mandibular 12}}{\text{Sum maxillary 12}} \times 100 = \text{"Overall ratio"}$$

Bolton (1958) stated that a statistically significant mean, standard deviation and coefficient of variation were found to exist. They were 91.3+0.26,1.91 and 2.09% respectively .
In comparing the six maxillary anterior teeth to the six mandibular anterior teeth in a similar ratio as

$$\frac{\text{Sum mandible 6}}{\text{Sum maxillary 6}} \times 100 = \text{"Anterior ratio"}$$

Equally significant findings were obtained.With a mean of 77.2+ 0.22 the standard deviation, and a coefficient of variation of 2.14%.

In 1987 Chan mesured thirty three excellent chinese occlusion cases. He found that anterior ratio range from 71.75%-78.88%, the mean was 75.95% and the standard deviation was 1.62. The overall ratio range from 86.86%-92.25%, the mean was 89.65% the standard deviation was 1.32. Chan stated that significant differences were found between his chinese group and Bolton's(1958) caucasian group.
In those studies in which statistically significant difference in incisor dimensions has been found between crowded and uncrowded cases, the actual mean difference has been in the range of 0.25 mm per incisor. Correlation coefficients between incisor dimension and crowding have been uniformly low.
Peck and Peck (1972) found statistically significant differences in both the mesiodistal and facio-lingual widths of mandibular incisors between perfectly aligned and control populations of untreated females. Combining

these measures into an index (MD/FLx100), they formulated ideal size range required for central and lateral incisors to be well aligned. They recommended mesiodistal reduction of incisors to keep them within this range and prevent future crowding, although no treated cases were narrowed and assessed later. Edwards (1970) and Boese (1980 ) have suggested the combination of reshaping of incisor contact plus incising of supracrestal gingival fibers to prevent post-treatment crowding.

### 2.4.4 The Factors Influencing Tooth Size

The major factors influencing the observed variation are genetic, including sex and race. Further, asymmetries in size between homologous teeth of the right and left side are observed in many individuals.

Linden (1974) observed that ideally arranged dental arches may start to show overlapping of anterior teeth,a phenomenon that is observed more in males than in females. This is related to the difference between the two sexes in late facial growth.

The tooth crowns of the male are seen to be invariable broader than those of females. This sex difference is larger for the permanent than for the deciduous teeth, as indicated by the critical ratios. Moorrees (1957) found these more pronounced for the canines than for any other teeth in both dentitions.

From the racial aspect, Moorrees (1957) investigating mesiodistal crown diameters observed that the deciduous teeth are smaller for the North American children than for the Swedish children measured by Seipel, except in the case of the deciduous maxillary second molars.

In general, judging from the mean mesiodistal crown diameters obtained, Moorrees also found that the permanent teeth of the North American children are smaller, although not always significantly smaller than the teeth in the two samples of Swedish children.

Regarding the variation in tooth size, one interesting problem is the frequency of the various degrees of asymmetry with respect to the mesiodistal widths of the teeth.

Ballard in 1956 studied asymmetry in tooth size. He measured the teeth on five hundred sets of casts and compared a tooth on one side with the corresponding tooth on the opposite side of the dental arch. Ninety per cent of the sample demonstrated a right- left discrepancy in mesiodistal width amounting to 0.25 millimeters or more. He advocated the judicious

stripping of proximal surface primarily in the anterior segments when a lack of balance existed.
Lundstrom (1960) suggested that there is no correlation between the asymmetry for different teeth. Hence, if in the case of a particular tooth, the right side, for instance, pre-dominates over the left, the adjacent tooth is as likely to show a similar as a contrary difference, or no difference at all.

## 2.5 Prediction of the Timing of the Pubertal Spurt

Nanda (1982) recommended that prediction of direction and timing of growth should consider three aspects;

1) Estimation of the reciprocal relationship of the mandibular and maxillary basal bone in the anteroposterior direction after the growing period. Moorrees and Reed in 1965 demonstrated that no significant increase in posteroanterior arch length takes place during the six to twelve years period. These observations indicate that the anterior parts of both the maxilla and mandible are not required to increase in anteroposterior size after completion of the primary dentition and Kurihara and colleagues (1980) findings provide supporting histological and morphogenetic evidence.
Difference of growth in the maxilla and mandible is associated with variation in cranial base flexure,thus influencing assessment of occlusal development. Nanda (1982 Pg54) stated that if the maxillary and mandibular denture bases grow more than anticipated and the teeth have been set back, the face will manifest a concave appearance.

2) Pubertal spurt of growth
For accuracy of predicting the timing of the adolescent growth spurt the key elements to be assessed are skeletal age and the physiological age related to the development of sexual maturation during adolescence in girls and boys. Of course, elements of heredity and environment also can influence timing of puberty.

i) Skeletal maturity is usually assessed from bone stages. There are a number of reports on the relationship between ossification events and other maturational characteristics. Garn and Ronmann (1962) demonstrated moderate correlations between the time of ossification of this bone and the times of menarche and of epiphyseal union. Hoston (1979) stated that the adductor sesamoid of the thumb always ossified before puberty. Bjork and Helm (1967) support him points, but Bowden (1971 ), Grave (1973) and Pileski (1973 ) found that ossification of the sesamoid can occur after puberty in some children. Helm et.al (1971) suggested the use of other ossification events to improve the prediction of puberty and investigated a number that occur close to puberty.

ii) Skeletal age: An assessment of skeletal age must be based on the maturational status of markers within the skeletal system .
Current clinical,hand-wrist X-ray standards are normally used to estimate for skeletal development because they may be helpful in predicting whether the age of the development is markedly advanced or retarded (Houston 1979 ). The configuration of articular margins of the bony epiphysis, and the reciprocal modelling of the articular surfaces of the carpal bone are markers.
Generally speaking, the maturation of the skeleton progresses at a faster pace in girls than in boys, the difference is relatively smaller at birth, increases during childhood and puberty, then decreases again during young adulthood.
The relations of facial growth and dimensions have been compared with the state of skeletal maturation as evidenced from skeletal age or menarche by Van Natta (1963), Moreschi (1964), Greene (1964) and Johnston (1965). Moreschi (1964), Johnston (1965), Hufham (1965), Hunter,Bambha (1966) and Fishman (1971) indicated generally that the best correlations of facial growth with skeletal age involved measurement of the mandibular body (Go-Gn and Art -Gn ). They also found that the length of the mandible was highly correlated with other body measurements and the most consistently inherited characteristic of several facial dimensions.

For early growth spurts, Krieg (1987) found early growth spurts of the face (S-Gn ,N-Gn) show higher incidence and greater magnitude than spurts in the cranial base dimension S-N. Incidence of early facial growth spurts was greater in the male sample, but there was little difference in the peak velocity of the spurts between males and females. A relatively short lower face height appears to be correlated with the absence of early growth

spurts in the dimensions S-Gn and N-Gn during the childhood and juvenile growth periods.A steeper Y-axis appears to be associated with the incidence of early growth spurts in S-N during the juvenile period only.
By comparing skeletal age with chronological age, it can be determined whether the child is growing rapidly or slowly. Proffit (1986) said that average children have a skeletal age less than 12 months ahead or behind their chronological age of 12, but when a child's skeletal age is advanced in comparison to his chronological age, less growth can be anticipated ; conversely, if the child's skeletal age is behind his (her) chronological age, then a greater growth potential may be assumed and this information incorporated into the treatment plan.
Skeletal age and the age at which menarche appears are closely related . Greulich and Pyle (1959 ) observed that the menarche typically occurs around the skeletal age of 13 years 6 months .Maresh (1961) found that the menarche occurs at a mean skeletal age 12.96 years. At this age, the Maresh sample of girls showed a mean chronological age 13.09 years.Menarche occurs early in girls who are advanced in skeletal age. Girls who are skeletal by retarded, on the other hand, begin their menstruation at a chronological age appreciably higher than the average.
Physical growth status also varies with chronologic age in many children but does correlate well with skeletal age, Nanda (1982 Pg 67) reported that children who are very tall at an early age and are well advanced skeletal are regarded as being constitutionally large and developmentally advanced. On the other hand children who are constitutionally small at an early age and retarded skeletally will continue to follow that pattern.
Prediction of facial growth or morphology, based either on other facial dimensions or body dimensions has exhibited only mild success, according to Bjork (1964), Johnston (1968) and Ricketts (1972). They indicate a " higher degree" of success in the prediction of facial growth from existing means of facial dimensions and their average growth increments.
Rose in 1960 studied 125 children from 9 to 18 years, comparing the growth and size of various facial areas with certain body measurements. He found, stature and body weight proved the best indicators of facial development. Both show distinct correspondence with facial growth during this period .
The body type also has an interesting effect on timing of puberty and thereby the eventual height. Caricatures of the body types were described

by Sheldon (1940) and Proffit (1986). As a general rule, ectomorphics tend to mature more slowly than mesomorphs and endomorphs.

On the average,after the age of 4 years sutural growth is responsible for about half of the growth in height of the upper facial skeleton and for most of the growth in depth.( Houston 1982). Thoms (1972) studied puberty and the adolescent growth spurt with girls and boys. She observed that girls on the average, completed growth nearly 2 years earlier than boys. Nanda (1982 Pg 67) believed that the adult statural growth will usually cease after 18 years in girls and 20 years in boys.

On the other hand, environment also can influence rate of physical growth; for instance, seasonal and cultural factors.Growth tends to be faster in spring and summer than in fall, winter. City children tend to mature faster than rural ones .

3) Direction of Growth

Maxilla

Growth of the maxilla is produced by a) passive displacement created by growth in the cranial base that pushes the maxilla forward,and b) active growth of the maxillary structures and the nose .

Within the maxilla, Moorrees (1959) observes there are primary areas of growth. These are located at the superior margin of the frontonasal process the maxillary tuberosity, and the alveolar process. Growth at the tip of the frontonasal process increases the height of the maxilla and thus adds to the vertical development of the face. The same is true for growth of the alveolar process brought about by eruption of the maxillary teeth. Deposition of bone at the maxillary tuberosity adds to the depth of the face and positions the anterior portion of the maxilla forward in relation to cranial landmarks.

According to Proffit (1986) during the entire period between ages 7 to 15 years about one-third of the total forward movement of the maxilla can be accounted for on the basis of passive displacement.

Enlow (1982) found that anterior surfaces of the bone are resorbing at the same time as maxillary growth in the tuberosity area posteriorly and the posterior and superior sutures. The body of the maxilla and the maxillary teeth are carried downward. Forward growth is greater by about 25% more than the forward movement of the anterior surface of the maxilla. This tendency for surface remodeling to conceal the extent of relocation of the jaws is even more pronounced when rotation of the maxilla during growth is considered.

Bjork and Skieller (1972) found that transverse displacement growth exceeds the change in the width of the dental arch but is fairly well correlated with these changes. It is thus clear that adaptative increase in the width of the dental arch must compensate for the greater growth in width seen in its base. The separation of the two bodies has also been shown to be greater posteriorly than anteriorly, suggesting that lateral displacement includes a rotational movement of the two in relation one to another.

Growth of the nose occurs at a more rapid rate than growth of the rest of the face, however, particularly during the adolescent growth spurt .Nasal growth is produced in part by an increase in size of the cartilaginous nasal septum. In addition, proliferation of the lateral cartilages alters the shape of the nose and contributes to an increase in overall size.

Mandible

The mandible increases in size primary through growth at three different areas- the alveolar process,the condyle and the posterior border of ramus.

i) Ramus;

Kurihara in 1980 stated that most of the vertical growth movement for the mandibular arch is provided by the enlarging ramus.On the average, Proffit found that ramus height increases 1mm to 2mm per year and body length increases 2 to 3 mm per year.

ii) Condyle

The mandibular condyle adds to both the height and the length of the facial complex because of its orientation to the mandibular body.

The direction of growth of the condyle shows great individual variabilty. Bjork (1972) from a study of 12 boys and 9 girls showed that the rate of growth seems to be greatest in individuals with predominantly anterior condyle growth .Relative to the mandibular base, condyle growth amounts on average to about 3mm during childhood and up to about 5mm during the pubertal growth spurt (Bjork1972)

Tomer(1982) demonstrated appreciable variation direction of the growth of the condyle among individuals and formulated the concepts of anterior and posterior rotation of the mandible. She also found that there was no

correlation between the direction of mandibular growth occurring in the age periods of 6 to 9 and 9 to 12 years .
On the other hand, anterior ( forward ) rotation will take place in subjects with an upward and forward direction of condyle of growth, while in subjects with a predominantly backward direction of condyle growth the mandible will rotate in a posterior (backward) direction.
Mandibular rotation depends on the level at which the chin is maintained and the associated remodelling of the ramus. The factors that control mandibular rotation are those that influence the postural position along different pathways ( Tomer 1982 ).
On the average, there is about 15 degrees of internal forward rotation and 11 to 12 degrees of external backward rotation producing the 3 to 4 degrees decrease in mandibular plane angle observed in the average individual during childhood and adolescence (Proffit 1986)

iii) Alveolus
Deposition of bone on the alveolar process through the eruption of the mandibular teeth also adds to the anterior and posterior vertical height of the face. Thilander (1982) stated that growth in height enables the alveolar process to adjust to the downward displacement of the mandibular body, depending on the direction and rate of growth of the condyle.

## 2.6 Functional Aspects of Influencing Occlusal Development

The growth changes in the face have been regarded as resulting from functions within and around its bony structures. This observation of occlusal development is related to respiration, oral function of muscles and posture of the head.

### 2.6.1 Respiration

It is an important factor in facial development of the oronasal structures, which was already considered by Angle (1907). It has been recognized that enlarged adenoids leads to mouth breathing, primarily in children with a small nasopharynx.
Mandelman (1976) described that adenoids usually peak in their growth prior to the adolescent spurt of the skeleton. If they increase in mass faster than the nasopharynx increases in size, proper nasorespiratory function is

impeded and mouth breathing may develop. Subtelny and Baker (1956) emphasized that growth of the adenoids and contiguous nasopharynx are in a delicate balance if the airway is to be maintained. In mouthbreathing due to nasal obstruction, the tongue is held lower than in nasal breathing. This reduces pressure from the tongue on the buccal teeth, and if the pressure from the cheek muscles remains unchanged the upper molar will tend to shift in a palatal direction. The altered inclination of the lower incisors and a widening of the upper dental arch in relation to the mandibular line after adenoidectomy is interpreted as a consequence of the change from mouth to nose breathing.

Linder- Aronson (1970) found that restoration of nasal breathing leads to:

1. a change in the inclination of the upper and lower incisors
2. a change in the width of the upper arch
3. an effect on the saggital depth of the bony nasopharynx

The finding about the relationship of the upper and lower incisors was interpreted as a consequence of an influence from the lip muscles when the mouth is held open because nasal breathing is obstructed by adenoids.

The finding that angles of the upper and lower incisors to the nasion-sella line and the mandibular plane respectively increase after adenoidectomy provides further verification of the previous study that the upper and lower incisors are more retroclined in mouthbreathers than nasal breathers.

Adenoidectomy is similarly followed by a widening of the upper dental arch.

2.6.2 Muscles

Oral function is achieved by an equilibrium between gravity and activity of different muscles.

The muscles influence the position of dentition in the following ways:

1. while the teeth erupt into an environment resembling a rubber mould composed of the tongue, lips and cheeks
2. the mode of breathing is a mechanism which is envisaged as an activity of the lip and cheek muscles
3. The muscles of the oral region exert a tension upon the dental arches which varies with function but is present even at rest. Each tooth in the dentition is in equilibrium with its surrounding structures.

### 2.6.3 Posture of the Head

Ronning (1975) studied physiological rest postion of mandible .He found when at rest, the mandible is held by the soft tissues in such a position that there is a little space between the upper and lower teeth. The distance is called the freeway space. When teeth are brought from the physiological rest position into contact with each other, the inclined planes formed by the cusps guide the separated teeth into'line. Small malocclusions of the teeth may be spontaneously corrected. An imbalance in the process of dental arch widening caused by some oral habits may nevertheless lead to a cusp-to-cusp occlusion of the canines and molars.

The relationship between head posture and craniofacial morphology has been thought to be mediated by functional factors such as respiration, swallowing and speech (Solow 1980).

The mandibular ramus is positioned rather vertically in relation to the nasal floor, evidently to compensate for the encroachment of the adenoid tissue into the pharyngeal space ( Koski 1975). The larger adenoids usually present with change in facial height, that is, a large angle between the mandibular plane and the occlusal, nasal floor and nasion-sella lines. The position of the tongue is lower and the incisors are retroclined in relation to their base-lines. Adenoidectomy as already noted is also followed by some changes mainly within the dentition.

# CHAPTER THREE

## Definitions, Features of Normal Occlusion and Classification of Malcclusion

### 3.1 Definitions

An ideal occlusion, as defined by Salzmann (1957) is "a hypothetical formula where teeth are in perfect alignment; that is, all teeth are in anatomically correct contact and in physiologically optimal occlusion with their corresponding teeth in the opposite dental arch." Most authors, for example, Salzmann (1957) and Lundstrom (1985) believe that ideal occlusion does not and cannot exist in man and is frequently referred to in the literature as normal occlusion.

Salzmann's (1957) definition of normal occlusion is: "the usual or accepted relationship for the species of the teeth in the same jaw to each other and to those in the opposing jaw when the teeth are approximated and the mandibular condyles are in rest or centric position in the glenoid fossae".

In normal occlusion, according to Enlow (1972), the underlying skeletal and dental factors combine to place the upper and lower teeth in the following way:

i. there is no undue amount of overjet

ii. all teeth interdigitate perfectly

iii. there is no undue amount of overbite, the maxillary front teeth should not overlap and cover the mandibular anterior teeth by more than about one-third of the crown height of the lower incisors

iv. the maxillary canine is about one-half tooth width behind (distal to) the mandibular canine

v. the maxillary first molar is about one-half cusp behind the mandibular first molar

Andrews (1972) gave a well-delineated prescription for ideal intercuspation of the teeth. These prescriptions define only a static relationship and tend to ignore eccentric functional positions. His 6 keys to normal occlusion can be summarized as (Fig 7)

1. Key 1- Class I molar relationship
The distal surface of the disto buccal cusp of the upper first permanent molar occludes with the mesial surface of the mesiobuccal cusp of the lower second molar

2. Key 2- Correct crown angulation (mesio-distal tip)
The long axis of all crowns are more distal than the incisal portion. Normal occlusion depends on proper distal crown tip, especially of the upper anterior teeth since they have longer crowns. Thus, the degree of tip of the incisors, for example, determines the amount of the mesio-distal space they consume and, therefore, has a considerable effect on posterior occlusion as well as anterior aesthetics.

3. Key 3- Correct crown inclination (labio-lingual torque)
Crown inclination, representing the angle formed by a line which bears 90° to the occlusal plane and a line that is tangential to the cervical third of the crown. The upper and lower anterior crown inclination should be sufficient to resist overeruption of anterior teeth and sufficient also to allow proper distal positioning of the contact points of the upper teeth in their relationship to the lower teeth, permitting proper occlusion.
For the upper posterior teeth, a lingual crown inclination exists. This inclination is constant and similar from canine through the second premolars and slightly more pronounced in the molars.
For the lower posterior teeth, the lingual crown inclination in the lower posterior teeth progressively increase from the canines through the second molars.

4. Key 4- Correct tooth rotations
The teeth should be free of any undesirable rotation.

5. Key 5- Tight teeth contact
The contact points should be tight (no spaces).

6. Key 6- Minimal curve of Spee
The plane of occlusion varied from generally flat to a slight curve of Spee.

## 3.2 Features of Normal Occlusion

There are 3 features inherent in a normal occlusion according to Nanda (1982). These are:

3.2.1. Cuspal interdigitation

i. Anteroposteriorly, each tooth in the mandibular arch is in a more mesial position relative to its counterpart in the maxillary arch, with the exception of the mandibular central incisors.

ii. Each tooth in each arch is in occlusal contact with part of two teeth in the opposing dental arch, with the exception of the mandibular central incisors and maxillary third molars,which have contact with only one opposing tooth.

iii. All of the teeth in the maxillary arch overlap the mandibular teeth. Thus, the maxillary posterior teeth project buccally while the maxillary incisors overlap their counterparts labially. The buccal cusps of the mandibular molars and bicuspids occlude between the buccal and lingual cusps of the maxillary bicuspids and molars. Correspondingly, the lingual cusps of the maxillary molars and bicuspids occlude between the buccal and lingual cusps of the mandibular teeth.

3.2.2. Overbite

The vertical labial overlap of the maxillary incisors over the mandibular incisors with the teeth in centric relation is termed overbite. It can be expressed as vertical occlusion. Normal overbites cover a range of 3 to 4 mm and are equivalent to approximately one-third of the height of the crowns of the mandibular incisors. Ideally, the maxillary and mandibular incisors should have contact, thus preventing supereruption of the mandibular incisors.

3.2.3. Overjet

Overjet is used to express the horizontal distance between the most labial surface of the mandibular incisors and the labial surface of the maxillary central incisor edge when the jaws are in centric relation. Based on this relationship, the overjet is approximately equal to the labiolingual thickness of the maxillary incisors. (Nanda 1982). Houston (1982) pointed out that overjet is determined partly by the skeletal pattern and partly by the inclination of the incisors. Bjork (1953) found that overjet as well as the molar position may serve as a measure of the variation in the saggital occlusion. To this also should be added the fact that it is easier to determine more exactly the position of the front teeth metrically. With advancing age, he found overjet generally reduces because muscular action is normal and the teeth are not interfered with by the lips or tongue, while the jaws grow normally forward and the teeth show independent occlusal arrangement. As growth continues, compensatory changes occur between the occlusion of the teeth and the jaw growth which tend to maintain the occlusion and to reduce overjet (Salzmann 1957).

## 3.3. Classification of Malocclusion

At present, the most popular and widely used classification is Angle's classification, which is universally recognized.

### 3.3.1. Angle's (1907) Classification

This is based on the maxillary first permanent molar as the key to the classification of the malocclusion. All malocclusions are categorized into three broad classes:

i. Class I Malocclusion

In this category, the maxillary and mandibular molar relationship in the anteroposterior dimension is normal. The mesiobuccal cusp of the maxillary first permanent molar occludes in the buccal groove of the mandibular first permanent molar. Angle noted that the first permanent molar may be malposed buccolingually (crossbite) and still exhibit a normal anteroposterior relationship. Thus the molar meet the primary criterion of the Class I relationship in terms of their mesiodistal positions. In spite of their incorrect buccolingual relationship, they constitute a Class I malocclusion. Generally, the anterior limits of the maxillary and mandibular denture bases are in harmony and there is no evidence of skeletal imbalance. Soft tissue facial profile is pleasing and straight. The problems encountered in the Class I malocclusion are most frequently crowding and/or improper spacing of teeth. Other problems include rotation, supernumerary teeth, congenital absence of teeth, crossbite, or drifting of teeth resulting from premature loss of primary teeth. Foster and Day (1974) observed that between the age of 11 to 12 years of age, 44% of children show a Class I malocclusion.

ii. Class II Malocclusion

In general, Class II malocclusion is characterized by posterior (backward) relationship of the lower arch. The mandibular first molar is in distal relationship to the maxillary first molar. The mesiobuccal cusp of the maxillary first molar occludes in the embrasure formed by the lower second bicuspid and the lower first molar, instead of the mesiobuccal groove of the mandibular first molar. Bjork (1947), Magnusson (1979), Helm (1970), Myllarniemi (1970), Siepel (1946), Telle (1951), Thilander and Myberg (1973) reported 14 to 26% of children with Class II malocclusion at the stage of dental development where the deciduous teeth are replaced by the permanent teeth. The Class II malocclusion is further divided into two divisions based upon the axial inclination of the maxillary incisors. It must be emphasized that the mandibular molar relationship is distal in both divisions.

a. Class II div 1 Malocclusion

The dental irregularities frequently encountered in the division 1 are:

1. the maxillary incisors are protrusive
2. the range of overjet extends from moderate to extreme
3. the lower incisors may be supraerupted resulting in a mild to excessive amount of overbite, usually in association with an accentuated curve of Spee
4. the maxillary arch form is narrow and constricted in the cuspid region

Class II div 1 is usually associated with skeletal imbalance. The possible skeletal disharmonies observed in Class II div 1 are:

1. underdeveloped mandible and a retruded chin
2. a large maxilla with a normal mandible
3. a larger maxilla with a deficient mandible

The combination of any of these deviations resulting from a failure differential growth will produce a receding chin, (retrognathic) and a convex profile. The upper lip may be short and the lip seal is lacking. Lundstrom (1984) reported that Class II div 1 is about 4 times as common as Class II div 2; excessive overjet over 6 mm was found in 8 to 15% and 4% had overjet exceeding 9 mm.

b. Class II div 2 Malocclusion

The key feature is the fact that the maxillary central incisors are retruded (lingually inclined) and crowded. As a result, the mandible is forced into a retruded position due to the tooth guidance of the maxillary central incisors. In this category of malocclusion, there is no obvious disharmony between the maxillary and mandibular denture bases. The facial profile is straight with very little suggestion of convexity. Primarily the division category does not demonstrate a skeletal disharmony comparable to that observed in division 1.

The characteristic dental irregularities are:

1. excessive lingual inclination of the maxillary central incisors
2. the maxillary lateral incisors project labially and overlap the central incisors
3. an excessive curve of Spee that maybe associated with a traumatic overbite
4. a maxillary arch form that is nearly normal, in contrast to the form of the arch in division 1

iii. Class III Malocclusion

In this category the mandibular molar is found to be positioned too far anteriorly in relation to the maxillary molar. The mesiobuccal cusp of the maxillary first molar occludes with the distobuccal cusp of the mandibular first molar and the mesiobuccal cusp of the mandibular second molar. Incisor inclinations are important symptoms as forced bites often have retroclined upper incisors and more or less normally inclined lower incisors, whereas, protruded or normal inclination of the upper incisors and retroclination of the lower ones are probably due to lip pressure moulding against the lower front teeth. The negative overjet thereby becomes less than the basal discrepancy (Lundstrom 1984).

The possible skeletal disharmonies observed in Class III malocclusions are

1. a normally sized and positioned maxillary width and overdeveloped mandible and protruded chin
2. a small retrusive maxilla with a mandible of normal size
3. a small maxilla with a large mandible

The dental irregularities frequently observed in the Class III malocclusion are as follows;

1. The maxillary incisors are lingual to the mandibular incisors ( anterior crossbite ) resulting in a negative overjet ( the opposite of Class II div.1)
2. The lower incisors are inclined lingually due to the pressure of the lower lip.
3. The maxillary arch is constricted, with a maxillary lingual posterior crossbite.
4. The maxillary arch length tends to be deficient particularly in the anterior segment, causing malpositioning of the lateral incisor.

Two main types of class III relationship are seen.
a. In the first, pseudo-class III, the maxillary incisors are in crossbite while the molars are in a Class I relationship and the facial profile is straight.
b. In the second, skeletal Class II malocclusion the mandibular molars are mesial and the chin is prominent (prognathic). These features are present in addition to an anterior crossbite .

iv. Subdivisions of Class II and Class III Malocclusions
The term subdivision is used to describe a bilateral asymmetrical condition in which a Class II or Class III molar relationship exists on one side of the dental arch and a Class I on the opposite side.

There are two categories of the molar relationship that are not accounted for in the Angle classification.
1. a Class II molar relationship on one side and a Class III on the other side
2. an end-to-end molar relationship of the maxillary and mandibular dental arches

3.3.3.1. Limitations of Angle's Classification

i. Angle's classification is limited to antero-posterior deviations and does not take into account lateral and vertical relationship, crowding and local malposition of the teeth (Foster 1982).

ii. One of Angle's strongest critics is Calvin Case (1921), who pointed out that Angle's method disregarded (in treatment planning as well as classification) the relationship of the teeth to the face, that is, the profile.

iii. Another criticism by Case and others was that although malocclusion was a three-dimensional problem, in the Angle's system only anteroposterior deviations (saggital plane) were taken into consideration. To quote Case (1921), "For the very advantage of perfect harmony and unanimity in our literature and teaching, the author would gladly have adopted the Angle classification, were it not for the fact that as it now stands, it cannot be made to express a large number of very important characteristics of malocclusion which should be fully recognized and systematically included...... ."(Proffit 1969).

iv. Furthermore, the Angle classification does not recognize those wide difference in the character of certain malocclusions which have the same mesiodistal occlusion of the buccal teeth (Proffit 1969).

v. Another early criticism of Angle's system was that it merely described the relationship of the teeth and did not include a diagnosis. Simon (1926), Lundstrom (1923), Hellman (1944) and more recently, Horowitz and Hixon (1966) recognized the need to differentiate dentoalveolar and skeletal discrepancies and to evaluate their relative contributions toward the creation of a malocclusion. These authors suggested that classification should include this type of diagnosis and point logically to a treatment plan.

vi. From a clinical point of view, there are two clinical entities that are not included in Angle's Classification; biprotrusion and biretrusion. These terms are based on the positions (axial inclination) of the upper and lower incisors relative to their respective basal bones and to each other. Both have essentially normal molar relationship (Nanda 1982).

a. In biprotrusion, the incisors are in a forward position relative to the basal bone (the interincisal angle between the axes of the upper and lower incisors is small). Biprotrusion is a characteristic of the Black race and is usually associated with lower facial prognathism.

b. Biretrusion is the extreme opposite of the biprotrusive condition. The incisors are positioned vertically and insert lingually relative to the basal bone. The interincisal angle of the axes of the incisors is very large and the teeth are nearly oriented in the vertical plane. The profile may exhibit a "dished-in" appearance of the middle face with a concavity below the lower lips. (Nanda 1985)

In order to comprehend Angle's classification, more classifications are presented.

### 3.3.2. Incisor Classification

Many clinicians found it useful to classify the incisor relationship separately from buccal segment relationship. It must be emphasized that this is not Angle's classification. (Houston 1982)
They are also categorized into 3 broad classes.

i. Class I- the lower incisal edges occlude with the middle part of the palatal surface of the upper incisors or lie directly below them if the overbite is incomplete.
ii. Class II- the lower incisal edge lies posterior to the middle part of the palatal surface of the upper incisors
a. Class II incisal relationship is divided into Division 1 where the upper central incisors are proclined
b. Division 2 is where the upper central incisors are retroclined
iii. Class III- the lower incisal edges lie anterior to the middle part of the palatal surface of the upper incisors.

### 3.3.3. Group Classification

Proffit and Ackerman (1969) proposed the use of Venn diagrams to classify the various malocclusions. It is a scheme for malocclusion in which five characteristics and their relationships are assessed.This method of classification is based on five descriptive characteristics and defined nine groups of malocclusions. It overcomes the major weaknesses of the Angle system. Specifically, arch-length problems with or without an influence on the profile are recognized; the influence of the dentition on the profile is taken into account. All three planes of space, not just the saggital plane are also taken into consideration; the differentiation between dental and skeletal problems is made at the appropriate level as diagnosis is inherent in the classification .

### 3.3.4. Carabelli's System of Classification

Carabelli in the mid-nineteen century was probably the first to describe in any systematic way abnormal relationship of the upper and lower dental

arches. The terms edge-to-edge bite and overbite are actually derived from Carabelli's system of classification.(Proffit,1986, Pg443)
Norman Kingsley in the early twentieth century, described irregularities and abnormal relationship of the teeth and jaws but did not find any acceptable method of classification.(Proffit,1986, Pg 443)
In 1912, Norman Bennett suggested that malocclusion be classified with regard to deviations in the transverse dimension, the saggital dimension and the vertical dimension. This recommendation rejected at that time was later realized in the work of Simon (1926) and the development of his system of gnathostatics. Simon related the teeth to the rest of the face and cranium in all three planes of space. His approach, although somewhat complex, clearly has advantages.(Proffit, 1986,Pg 444)

3.3.5. Lundstrom's (1985) Classification

In an effort to overcome the limitation of the Angle's Classification, Lundstrom pointed out the importance of the following observations:
1. malposition (or malocclusion) within the dental arches
2. single teeth rotation
3. space discrepancy e.g., spacings and crowding
4. malrelationship between dental arches including anteroposterior malocclusion, distal occlusion (with or without a large overjet), mesial occlusion (usually with a negative overjet), vertical malocclusion (deep overbite or openbite), transverse malocclusion (lateral crossbite and scissor bite).

3.3.6. Mao's (1959) Classification(Fig 8)

This classification is commonly used in China. His classification is divided into 6 classes.(Fig 4) They are:

Class 1: Where an imbalance of the number of teeth to the jaw size exists.
Class I div 1- With the occurrence of crowding
Class I div 2- With spacing between teeth

Class II: Where an imbalance of archlength and skeletal pattern

Class II div 1- Is similar to Angle Class III molar relationship, with an anterior crossbite, and chin prominence
Class II div 2- A Class II molar relationship is present with an increased overjet or a deep overbite. There is a recessive chin.
Class II div 3- The molars are in Class I relationship, with anterior crossbite
Class II div 4- Molars are in Class I relationship with an increased overjet
Class II div 5- Bimaxillary dental protrusion

Class III: Where a deviation of the dental and skeletal archform is present.
Class III div 1- Where the upper dental arch is wider than the lower dental arch. There is a buccal crossbite posteriorly
Class III div 2- Where the upper dental arch is narrower than the lower dental arch. A lingual crossbite of the upper posterior teeth exists.
Class III div 3- Both dental arches are constricted.

Class IV: There is a vertical discrepancy
Class IV div 1- There is a deep overbite. The lower anterior facial height is reduced.
Class IV div 2- An anterior open bite and an increased lower facial height is present.

Class V: Malpositioning of single tooth. This malpositioned tooth could be in labio-or buccoversion; disto-or mesioversion; infra-or supraversion; torsiversion or transversion; or axiversion.

Class VI: Any malocclusion not included in the above 5 classes of malocclusion will belong to this category.

### 3.4. Criteria for Prediction of a Normal Occlusion in the Mixed Dentition

In the mixed dentition, especially in the later stage which extends from the age of 9 to 12 years, the dentition acquires the characteristics of the young adult occlusion. The nature of this relationship of the maxillary and mandibular first permanent molars during the early mixed dentition phase

is the criterion for the determination of normality. An end-to-end relationship signifies normality during this period; the mesial contours of the maxillary and mandibular first molars are in the same vertical plane,called the "flush terminal plane".(Fig 9) At this time the overbite and overjet cannot be determined as the incisors may not be fully erupted.
The proper differential growth of the maxilla and mandible will correct the end-to-end molar relationship. If this relationship exists in a retrognathic face (due to skeletal dysplasia) during the mixed dentition phase, the growth of the mandible will not evoke a Class I molar configuration. One must take into consideration all of the variables that determine the development of the occlusion. The occlusal development of a child exhibits a flush, distal or mesial step terminal relationship at approximately 6 years of age. For each subject, the terminal relationship pertains to the primary second molar. Some of the subjects follow a consistent pattern while others change from one pattern of occlusal development to another. It is frequently assumed that the status of the adult occlusal relationship is accurately predictable from the terminal relationship of the second primary molar. In a small minority of the children, however, it is to be observed that individual occlusions are altered by the time young adulthood is attained. The factors determining the specific pattern of occlusal development include the magnitude of the leeway space and the ratios of growth between the maxilla and the mandible in the horizontal and the vertical directions as well as the initial relationship of the primary molar. (Nanda, 1982)
The distribution of the terminal plane relationship in the deciduous dentition has been described by several investigators. Different opinions concerning the influence of the terminal plane relationship on the initial occlusion of the first permanent molars have been expressed. Baume (1950) has concluded that the first permanent molars are guided into position by distal surface of the second deciduous molars. The initial occlusion of the first permanent molars is not entirely influenced by the terminal plane relationship of the deciduous dentition. Carlson and Meredith (1960) found direct relationship of only moderate magnitude between the anteroposterior relationship of the second deciduous molar and the first permanent molar and conclude that the initial occlusion of the first permanent molar is not determined solely by the anteroposterior relationship of the posterior terminal plane of the deciduous dentition. (Bhupendra 1973).

It is generally thought that once the first permanent molar relationship is established in either normal or full-cusp distal occlusion, it does not change spontaneously.

Lewis and Lehman (1932) thought that measurement of the deciduous teeth offered no solution in diagnosing the malocclusion of the permanent dentition and that predicting the outcome of the permanent dentition from the deciduous is hazardous.

Bhupendra's (1973) study showed that at the initial occlusion stage, 50% of the buucal segments in his sample have cusp-to-cusp occlusion while the remainder are almost equally distributed between distal and normal occlusion. His study also indicated that a pattern of changes from the initial occlusion to the occlusion in the permanent dentition exists. Most often, the first permanent molars erupted into distal or normal occlusion and did not change their anteroposterior relationship. Almost all cases which showed changes in the occlusion were the ones in which the first permanent molar erupted in the cusp-to-cusp initial occlusion. Of these, approximately 70% changed to Class I and the remainder to Class II occlusion in the complete permanent dentition. Almost all cases which changed classification from cusp-to-cusp initial occlusion to Class II permanent occlusion were, in fact, not full cusp distal occlusion, but were still cusp-to-cusp.

# CHAPTER FOUR

## Guidance of Development of the Mixed Dentition

Generally, "Guidance" means to help reach certain objectives, but in the orthodontic point of view, it may be limited to help development continue in the right or correct direction, or to help development towards an improved or corrected condition.

Godfrey (1987) described the guidance of development as a planned human-directed process and should be regarded as artificial and not simply left to nature. This also implies that guidance is a mixture of artificial and natural processes to help development in the desired direction.

This chapter is limited to the discussion of:

1. preventive and interceptive orthodontics
2. general principles in the guidance of the mixed dentition.

## 4.1. Preventive and Interceptive Orthodontics

### 4.1.1 Definition

Graber (1972) believed that the dentist who renders preventive orthodontic service should strive to maintain a normal occlusion for that particular age. Interceptive orthodontics, in his view actually "intercepts" a malocclusion that has already developed or is developing and the goal is to restore a normal occlusion."

Popovich and Thompson's (1975) definitions are similar to Graber's but grouped somewhat differently. For example, preventive orthodontics is any action taken to preserve the integrity of a normal occlusion (all aspects of preventive dentistry). Interceptive orthodontic treatment comprises procedures that eliminate or reduce the severity of a developing malocclusion.

Ackerman and Proffit (1980) defined the concept of preventive orthodontics as prevention of potential interferences with occlusal development; while interceptive orthodontics is the elimination of existing interferences with key factors involved in the development of the dentition.

### 4.1.2 Difference Between Preventive and Interceptive Orthodontics

To differentiate between preventive and interceptive orthodontics, Graber (1972), stated that in preventive orthodontics, the occlusion is within normal limits at that time and these procedures are intended to keep it that way. In contrast, in interceptive orthodontics, the occlusion is developing or has already developed a malocclusion.

Another difference lies in the timing of services rendered. Ricketts (1979) pointed out that prevention should be carried out first, being the first approach to early treatment in the deciduous or primary dentition or even earlier. Interceptive orthodontics is the second stage of treatment which occurs in the mixed dentition.

Proffit and his colleague (1980) have not found a clear demarcation between potential interference and an existing interference. It is only academic interest to distinguish operationally between preventive and interceptive orthodontics, thus they have considered the two together.

### 4.1.3 Clinical Application of Preventive and Interceptive Orthodontics

Graber (1972), Popovich and Thompson (1975), Freeman (1977), and Proffit (1980) have described the clinical application of preventive and interceptive orthodontics.

Treatment-wise, preventive orthodontics is any set of treatment procedures concerned with keeping potential developmental problems from arising. Fluoridation, good restorative dentistry, genetic counseling and most space maintenance, therefore, would fall under this heading. Preventive treatment is mainly concerned with space control, space maintenance and space regaining, maintenance of a quadrant tooth-shedding time-table, functional analysis and elimination of adverse oral habits, muscle exercises, caries control and prevention of malocclusion caused by wear of the Milwaukee brace.

Any treatment procedure aimed at eliminating existing interferences with normal development fall under the heading of interceptive orthodontics. Interceptive treatment includes habit consultation, removal of supernumerary teeth, occlusal equilibration, slicing of mesial surfaces of

deciduous cuspids, insertion of fixed and removable space maintainers, space regainers and labial shields, frenectomies, swallowing exercises, extraction of deciduous and permanent teeth as part of serial extraction procedure, removal of over-retained teeth and pathology cross-bite.
Freeman (1977) suggested the following criteria for the selection of patients for preventive and interceptive procedures:

1. the patient should be in the primary or transitional dentition
2. the patient should be growing
3. there should not be a basal bone dysplasia
4. there should only be one occlusal characteristic present, as shown by the orthogonal analysis
5. there should be minimal appliance therapy. If fixed appliances are used, no more than 6 bands in either arch are required
6. a short treatment time should be anticipated
7. at the end of treatment the occlusion should be acceptable
8. no further treatment would be necessary to obtain an acceptable occlusion
9. the malocclusion should be potentially self-correcting.

In addition, other factors have to be considered in the selection of patients. Oral hygiene has to be reasonably good and any hard or soft tissue pathology had to be under control. Also, the expressed interest and co-operation shown by the patient are important considerations.
Preventive and interceptive orthodontics have been regarded as to totally eliminate the need for further treatment. For this reason, Graber (1972) and Popovich and Thompson (1975) have not included extraction, Class II or Class III modalities in preventive and interceptive orthodontics as these malocclusions would invariably require a second phase of treatment. Therefore, ".. it becomes necessary to modify and redistribute the 'interceptive only' category in order to achieve our own objectives."
A general rule as observed by Godfrey (1987) is that "prevention and interception of simpler problems of malocclusion and guidance of development of the occlusion should be simple and not require complex treatment plans and complex orthodontic appliances.", but for certain patients more complex treatment which include the use of bite planes, expansion plates, monoblocs, labial and lingual archwires, cervical headgear partial bands, and full upper and/or lower bands may be needed.

## 4.2. General Principles in the Guidance of the Mixed Dentition

The following principles have to be observed in the guidance of the mixed dentition (Godfrey 1987):

1. that growth and the long term changes to the mixed dentition should be predicted with reasonable certainty
2. that this treatment should help or produce changes in tooth positions and occlusion which would lessen or remove the identified problems of malocclusion and malposition of teeth
3. that it should be able to provide total clinical guidance until full maturity of the dental occlusion or
4. that the operator is able to collaborate with another clinician who is experienced and will share the responsibility of continuing the guidance of the dentition

### 4.2.1. Indications for Mixed Dentition Treatment

Traditionally, the indications for mixed dentition treatment have been crossbite, malocclusion associated with habits, deepening of the vertical bite, loss of space created by premature loss of adjacent teeth, ectopic eruption and supernumerary teeth (Wagers 1976).

All Class I and some Class II and Class III cases are candidates for preorthodontic guidance. The more severe Class II or Class III cases are candidates for corrective mixed dentition treatment.

Severe protrusion, both in dental discrepancy and non discrepancy cases should receive early treatment. Discrepancy cases in neutral or Class I malocclusion should undergo serial extraction and early extraction of unerupted first premolars. In severe discrepancy cases requiring the eventual removal of first premolars and first molars (called 8 tooth-extraction case), the first molars should be extracted shortly after eruption in many instances (Wagers, 1976).

### 4.2.2. Contraindications for Mixed Dentition Treatment

Barich (1952) noted that the only type of case regardless of the classification that do not respect early interference in all of its aspects are those in which arch length is inadequate or definitely shortened and in extreme conditions where we are all aware because these patients would require extractions. He preferred to leave treatment till a later date. This is in contradiction to the opinion mentioned by the earlier authors.

Wagers (1976) believed that if there is no severe malalignment of the dental arches or facial bone dysplasia, it is better to wait until the permanent dentition erupts in order to regulate all teeth that are able to be accommodated in the dental arches.

### 4.2.3. Objectives of Mixed Dentition Treatment

The general opinion of most authors (Krieg, 1963, 1969; Foster, 1972; and Freeman, 1977), is that mixed dentition treatment is dependent upon the growth factors which influence the amount and direction of growth of the facial complex. This would help in the

i. arrangement and configuration of the teeth, and dental arches are in a highly delicate state of equilibrium, which could easily be disturbed by interfering with forces which maintain this equilibrium

ii. guidance and the supervision of growth and development of the dentition and

iii. early correction of certain types of malocclusion which would enable normal development of the dentition and often eliminate the need for future treatment, (Freeman, 1977)

Cherney (1963) feels that controlling the factors which interfere with dentofacial growth and development will help direct the occlusion into a morphologically and functionally harmonious system. He stated, "There are many therapeutic techniques to achieve this goal, but it must not be forgotten that an important factor during the mixed dentition is observation, and the collection of information concerning the growing structures; their direction, degree and speed, in order to obtain a sure basis for planning treatment in the light of considerable variation in individual development."

### 4.2.4. Advantages of Mixed Dentition Treatment

Some of the advantages as listed by Wagers (1976) are:

1. Early treatment eliminates the development of psychological disturbances due to severe facial disharmony especially in the Class II div 1 malocclusion

2. Teeth are protected from accidental harm, especially in severe maxillary protrusion where teeth originally extend beyond the lips and after treatment are cushioned by the soft tissue in case of accidents

3. Perverted muscular habits change and seldom persist after treatment; a small percentage (less than 10%) of these habits will persist but the rest phase between the treatment periods alerts the orthodontist to the future course he must take in guiding the patient to correct them.

Cherney (1963) found that controlling factors which interfere with dentofacial growth in the mixed dentition centres around the management of abnormal lip and tongue activity.

Dewel (1964) stated that if normal function is restored at an early age, both the teeth and the surrounding musculature will have a greater opportunity to follow an ideal developmental pattern than if all treatment is postponed to a later date.

4. Facial complex growth especially in the realm of musculature will develop better in its proper correlation to adjacent structures after early treatment.

Thilander (1975) observed that early correction of functional disturbances allows the masticatory system to develop with its entire capacity towards normality during the pubertal growth spurt at the same time as functional displacements are prevented from becoming permanent dento-alveolar or skeletal deviations.

Khloen (1953) said, "We must work with nature and give the denture and alveolar bone every possible opportunity for their optimal growth and development. If this is done early, while there is still considerable growth to follow, corresponding changes and adjustments will occur in the soft tissue and musculature of the face."

This is true and very noticeable clinically when the patients are treated early. The face develops better and esthetically looks better after early corrective orthodontic treatment.

5. In discrepancy cases, early treatment affords a better eruptive path for teeth which otherwise would have been deviated to an abnormal position

Tweed (1966) advised in these cases to "observe the eruptive path of the permanent cuspids as they migrate distally toward the space previously occupied by the first premolars."
Thilander (1975) noted that early correction of malposition of individual teeth creates means for spontaneous correction during the continued development of the dentition.

6. Post-treatment stability is enhanced by early treatment. This is a clinical observation but it has been emphatically stated by Reitan (1971), "The simplest way to avoid relapse after treatment is to perform special types of tooth movement as early as possible." Reitan referred especially to severely malposed and rotated teeth as well as to closure of extraction spaces. He further stated, "Early rotation of malposed lower anterior teeth may ensure a stable tooth position as the patient becomes older, for there will be formation of new and stronger fibres which will be attached in the apical third of the root, thus gradually stabilizing the tooth position."

7. Early treatment allows orthodontic appliances to be removed earlier in the permanent dentition and that total treatment time in the second phase of treatment is reduced

8. Patients at a younger age in the mixed dentition are more easily manageable than those of an older age in the permanent dentition period. Thilander (1975) also found that early treatment reduces the need for treatment at a psychologically sensitive age.

9. Early correction of Class II and Class III malocclusions try to establish a normal occlusion (Thilander,1975)

Jenkins (1953) categorizes advantages in the following way:
1. Psychological. Bernhardt stressed that, "The best guarantee the individual can have of satisfactory adjustment in any stage of development is that individual has been able to adjust satisfactorily in all previous stages of development. This is a rather important principle. Obviously the shorter the period of a deformity the less its possible psychologic effect."
2. Physiologic. Abnormal developmental pattern may be redirected into normal channels with least deformity at an early age. Optimum

development can best occur with a minimum period of disturbance. The mechanical force applied to the teeth will not influence growth pattern of the facial bones but can change the position and relation of the teeth, thereby guiding alveolar bone growth. This will influence growth and development of facial musculature and produce a better functioning denture and better facial esthetic results.

Albert (1971) mentioned that a child 8 or 9 years of age has a mandible composed of soft trabeculated bone. Although this bone is compact, it does not reach maturity until the child is 16 years old. Therefore, it should be feasible by the application of a light force to move the mandibular permanent first molar in a distal direction 1 mm and at the most 2 mm, to gain enough space to correct most mild discrepancies.

Dewel (1964) emphasized the importance of early treatment. He said, "If the growth and development of the dentition and its surrounding structures are to be influenced to any degree, it must be done while the mysterious forces of growth are still at the peak of activity in the developing child. Obviously, extensive new bones, no matter what their origin, have ceased to function in the adult dentition."

3. Pathologic. Steadman (1950) found that breakdown of dental and supporting tissues probably commences in the early mixed dentition. Early treatment achieves minimal accumulation of dental and periodontal damage and disease.

4.2.5. Disadvantages of Mixed Dentition Treatment

Wagers (1976) listed the following disadvantages:

1. The patient is worn out by the long treatment which is often necessary when treatment is started at an early age

2. Early treatment involves two phases of treatment and this is not efficient or desirable in most clinics.

Thompson (1975) stated that the completion of the treatment too soon by starting too early may produce a dentition that is harmonious with the jaws and muscles only temporarily and future disproportionate growth may introduce disharmonious relation such as incisal interference, posterior mandibular displacement or premature contact of teeth. All may appear well at 12 years of age but following the pubertal growth spurt disharmonious function may exist, thus necessitating additional orthodontic treatment, occlusal equilibration and/or restorative dentistry in various combination.

3. There appears to be a financial loss in mixed dentition treatment

4. Rate of root resorption especially of incisors will increase with early treatment although this does not occur often

5. Better treatment results are obtained by waiting for the permanent dentition before undertaking corrective orthodontic treatment. Indeed, in certain types of malocclusion one should wait for the permanent dentition to erupt before commencing corrective treatment. According to Begg (1954), mixed dentition treatment takes ingenuity in these severe cases, but it can be accomplished with care.

6. Molar anchorage will be lost if an attempt is made in correcting the mixed dentition and this will make permanent dentition treatment more difficult or impossible.

7. The inconvenience of performing certain operations e.g., extraction, mentioned by Jenkins (1953).

8. Finally, the orthodontist's lack of flexibility in appliance technique (Jenkins, 1953).

## 4.3. Timing of Treatment in the Mixed Dentition

Generally, the age of 7 to 11 years includes most children in the mixed dentition and most of those receiving mixed dentition treatment belong to this age group. Reitman (1971) recommended that treatment should begin when the patient is 8 to 9 years of age to take maximum advantage of the growth potential of the soft tissue and bone.

Thompson (1975) advised that a functional malocclusion should be treated as early as possible because early treatment is usually of a simple nature requiring little time. Also, a functional malocclusion becomes progressively more severe and in the developmental period of the dentition and becomes almost impossible to correct. He recommended the ideal treatment time to be 12 years of age. Structural treatment on the other hand requires more time since it is relative to the nature of the skeletal pattern and the time of the facial growth. Thus, structural malocclusion is free of functional problems and may be best treated at the time of the pubertal growth spurt.

However, many different ages have been reported as the ideal age for treatment. Eby (1937), reports 3 to 6 years of age; Rogers (1943) found success in treatment from 4 years of age; and Higley (1943) proposed treatment at the age of 6 or 7 years.

### 4.3.1. Principles of Treatment Timing

Some principles of timing treatment of the various Angle malocclusions are listed below:

#### 4.3.1.1. Timing of Class I Treatment

This Class of malocclusion includes functional anomalies as in some crossbite and pseudo-Class II and Class III malocclusions. Immediate treatment within the limits of patient co-operation and deciduous root resorption appear indicated. Any deformation of the dental arches should desirably be treated early.

When a malrelationship between tooth-size and dental arch is present, then it is preferable to leave it untreated until eruption of premolars.

Foster (1951), observed that severe cases of anterior crowding requiring deciduous cuspid extractions are handled at about 8.5 years of age for most spontaneous improvement.

#### 4.3.1.2. Timing of Class II Treatment

Class II malocclusion is the result of functional and structural elements. Ricketts (1950) demonstrated that the majority of patients exhibit a functional mandibular retraction and overclosure of varying degrees.

##### a. Treatment Timing of Class II div 1 Cases

Moyers (1949) observed that hypertonicity of the temporalis muscle may occur in the Class II div 1 patient and if treated early will liberate the mandible from growth-restraining influences.

Lo (1951) demonstrated the significant association of Class II molar relation with an abnormal sequence of eruption of the permanent teeth.

Early disturbance of the normal sequence maybe observed at the 6 year level.

The chronological time for treatment of Class II div 1 cases will vary with the individual treatment philosophy. On a physiological basis, if the mandibular dental arch is located within the normal limits on the body of the mandible, the physiological rest position of the mandible is the anteroposterior limiting factor in treatment.

Copeland and Moyers (1952) report a relative inability to alter this physiologic rest position of the mandible through orthodontic treatment. Therefore, any relative maxillary dental protraction must be reduced to this physiologic rest position. On the basis of this treatment rationale, unless extraction is indicated, the timing of treatment of Class II div 1 cases appears to be most advantageous in the mixed dentition.

Primary correction of protrusive incisors or harmful overbite may be undertaken early in extraction cases as a protective measure irrespective of the main treatment plan.

Where extraction is not indicated, the reduction of maxillary protrusion in the mixed dentition era has been demonstrated clinically by Goldstein and Myer (1940), Oppenheim (1944), Khloen (1947) and Carey (1952). Jenkins (1953) reported that the age of 8 to 10 years is a practical treatment time.

Dewel (1964) explained that delayed treatment of Class II div 1 malocclusion may result in overdevelopment of certain maxillary structures. He also mentioned that if the Class II irregularities are left untreated, all the remaining unerupted teeth will assume the same Class II position as the malposed upper first molars. Similarly, structural imbalance will increase as will muscular imbalance, and each will add to the severity of the other if these misdirected forces are permitted to continue without interruption. For example, slight prominence of the upper lip will lead to a tendency toward increased reliance on the mentalis muscle in attaining lip closure. This will become more severe with age.

b. Treatment Timing of Class II div 2 Malocclusion

Since this condition has been shown by Ricketts (1950) and Swann (1952) to consist of maxillary dental protraction, combined with a mandibular functional retraction, treatment timing in the mixed dentition stage around 8 to 10 years of age is considered desirable and practical. Swann (1952) has obtained good result in this age group.

4.3.1.3. Treatment timing of Class III Malocclusion

This condition is a true dysgnathic deformation of characteristic pattern. Because of the nature of the anomaly, treatment commencing at an early age has been shown to be desirable as reported by Strang (1950), Goldstein and Myer (1940).

4.3.1.4. Mixed Dentition Treatment of the Borderline Case

Harris (1972) noted the borderline case for early treatment. He listed them as follows:

1. Severe Class I bimaxilllary protrusion cases, in which normal relaxed lip closure is not possible would require extraction of premolars in order to achieve a satisfactory esthetic result even though the functional aspects of the occlusion are good. For these patients it is usually best to defer treatment until the full dentition erupts. Similarly, early treatment that leads to the creation of a bimaxillary protrusion in which the muscular envelope is strained in lip closure will be of no benefit to the patient since full treatment with extraction of teeth will eventually be necessary. A small percent age of borderline cases treated in the early mixed dentition will end up in this category, but Harris (1972) feels that it is a small price to pay when measured against the much greater number of patients who benefit from early treatment. Proper selection of patients through accurate diagnosis and treatment planning can virtually eliminate this situation. Mild Class II bimaxillary protrusion cases should be treated to a normal mesiodistal molar relation before a decision is made on the need for extractions and full banding later. Often, a patient with what appears to be a Class II four premolar-extraction case will take on a satisfactory facial appearance when the Class I molar relation has been achieved.
2. Severe arch length deficiency in both arches with normal relation and good facial esthetics illustrates the textbook serial extraction case that will usually benefit greatly if are carefully timed extraction procedure is undertaken early enough. Dewel (1969) has shown that these criteria are present in only a very small percentage of cases and it would be prudent to err on the side of conservation rather than extraction if doubt persists in the orthodontist's mind about the benefits of serial extraction in a particular case. This conservative course of action will allow for alternative treatment, including extraction at a later time if necessary.

The reverse of this situation in which serial extraction is tried first leaves little room for changing treatment procedures at a later date.

3. Arch length deficiencies may be associated with anterior open-bite. Dental open-bite associated with skeletal open-bite pattern do not usually benefit tongue or finger habits will have no discernible effect on the malocclusion. Most other types of borderline extraction cases seem to benefit from early intervention as described later.

## 4.4. Sequence of Correction in the Mixed Dentition

Harris (1972) states a definite sequence to be followed in the correction of developing malocclusions, provided that it maybe helpful to use this order of priorities as a guide in developing one's own treatment rationale.

i. Elimination or control of perverse muscular or local habits

Normalization of the muscular envelope surrounding the developing dentition is one of the key benefits to be derived from early orthodontic intervention and a careful examination will reveal that virtually all malocclusions are associated with some degree of perversion of facial muscles as reported by Harvold (1969). In the most obvious cases, this will take the form of a tongue or lip habit. In other more insidious instances breathing problems may force an alteration in the integrity of the labial musculature as in mouth breathing associated with obstructive adenoidal or tonsillar tissue (Ricketts, 1968). Quite obviously, an attempt to create a normal anatomic configuration of the dentition is doomed to fail if all aspects of the system affecting the teeth are not considered. Since the orofacial complex is in effect a closed system the alteration of one factor in the system will require compensatory changes in other parts of the system in order for an equilibrium to be achieved. Failure of this compensation to take place leads to relapse of the new anatomic configuration achieved through orthodontic treatment (Harris 1972).

Control of the factors involved in the alteration of the muscle and soft tissue envelope may consist of surgical intervention and wear of habit-breaking appliances. Removal of these causative factors will directly affect the degree to which the remaining treatment to the normal will eliminate perverse habits. It is far more logical to control these factors first or at least simultaneously with tooth movement

ii. Achievement of Class I molar relations:
The localization of one relationship in the dentition such as the upper to lower permanent first molars (both to each other and to their respective skeletal bases) aids markedly in helping us to determine the location of the remaining teeth as they erupt. (Atkinson 1968). Indeed, the correct position of these teeth seems to be a significant factor in causing other teeth to erupt into a normal position. Based on this one factor, all other static and functional tooth relationship become easier to achieve.

iii. Achievement of the normal incisor positioning
Once molars have been positioned correctly, incisors should be moved to their correct position, both with respect to each other and with respect to the investing tissues. This means developing sufficient overbite either by opening or closing anterior teeth, to disocclude posterior teeth without 'locking in' of the occlusion. Care must also be taken to ensure that an unstrained labial and buccal musculature is developed by not forcing anterior teeth forward against the lips. For this reason, lower incisors are rarely banded during this early stage of treatment and are allowed to position themselves labiolingually.

iv. Determination of the need for extraction and further treatment based on the amount of arch length available, the size of the erupting teeth and the position of these teeth.
At this point the first phase of treatment is over. It may represent the only treatment needed, but in the majority of the cases, additional second-phase therapy will be needed. If insufficient arch length is available to accommodate all teeth, this is the time to determine it.

# CHAPER FIVE

## General Guidance Methods During Mixed Dentition Development

In clinical practice, most malpositions and malocclusions in mixed dentition are frequently treated by natural forces or simple methods which can result in normal position and occlusion.

### 5.1 Common Malposition and Malocclusion

Most maloccusion and malposition becomes obvious and is recognized by patients and parents as well as dentists during mixed dentition development. The common indicators are: ( Godfrey, 1987 )

-incisor crowding

-protrusion of maxillary incisors (and,or retrusion of mandibular incisors)

-deep incisor overbite.

-prominent mandibular incisor(and,or,retrusion of mandibular incisors)

-one or two incisors in crossbite .

-posterior crossbite of one or more occluding pairs of teeth

-rotated incisors.

-incisor open bite .

-functional shifts of the mandible corresponding to full anterior crossbites ( anterior shift ) and unilateral crossbite ( lateral shifts ).

### 5.2 Natural Guidance of Developing Occlusion

Natural guidance of the mixed dentition is accomplished without appliances (Godfrey 1987). Its working principle is based on the degree of eruption of teeth. Therefore, it is only used in narrow categories.The following general rules as observed by Godfrey (1987) are:

1. Teeth which are still erupting have greater potential for some, if not total, bodily migration; that is, an erupting tooth will not always tip into

adjacent free space-the crown and root apex will tend to move together in the same direction.

2. Teeth which are already erupted are only likely to tip towards any adjacent space which may be produced by an exfoliation, or an extraction, or proximal caries, or proximal tooth contact grinding (stripping"). If such an erupted tooth is already upright it will become more inclined to the occlusal plane. Such natural tipping may be partly or totally prevented if there is sufficient occlusal ( locking ) contact.

3. Natural tipping away from vertical (upright) inclination is more likely to happen when there is already existing malocclusion.

## 5.3 Guidance with Simple Appliance

Many children require using a simple appliance to help the occlusion into correct position in order to assist better development of occlusion, but a point to emphasise here is that simple appliances are used at this stage only for moderate problems. For severe problems, especially the patient with skeletal discrepancy, the treatment is often made in the early permanent dentition again.

5.3.1 Treatment for Potential alignment Problems

1) Space Maintenance

A space maintainer is to prevent further drift and space loss until the succedaneous teeth have erupted.If primary canines,first molars or second molars are lost, and then there are more than a 6 months delay before the permanent premolar erupts, mesial drifting of the permanent molars and distal migration of the anterior teeth can commonly occur, space maintenance is then needed. In addition, its is used when there is early loss of a single primary canine to eliminate midline changes and prevent lingual movement of the incisors.

Use of a space maintainer,of course,is not indicated for all patients with premature loss of deciduous molars or canines, that depending on the specific situation. ( Proffit, 1986 ), such as if the predicted space is deficient or if succedaneous teeth are missing, when space maintenance alone is also inadequate.

Several treatment techniques for space maintenance have been recommended by Proffit (1986):(Fig 10)

i) Band and loop space maintainers are used most frequently to maintain the space of primary first molars before eruption of the permanent first molars, but can also be used to maintain the space of either a primary first or second molar after the permanent first molar has erupted. It is ideal for isolated unilateral space maintenance.
The band portion of a band and loop can be placed on either a primary or a permanent molar.But many clinicians prefer to band the primary teeth in this situation because of risk of decalcification around the band. A more important consideration is the eruption sequence of the succedaneous teeth.The primary first molars should not be banded if the first premolar is developing more rapidly than the second premolar,because loss of the banded abutment tooth would require replacement of the appliance.The loop portion should be wide enough faciolingually to allow eruption of the permanent premolar without removing the appliance.

ii) Partial denture space maintainers are most useful for bilateral posterior space maintenance when more than one tooth has been lost per segment and the permanent incisors have not yet erupted. It also has the advantage of restoring occlusal function.Another indication for this appliance is posterior space maintenance in conjunction with replacement of anterior teeth for esthetics, but anterior space maintenance is unnecessary because arch circumference is not lost even if the teeth drift and redistribute the space. Proffit found that the problems often occurred with partial dentures in a young child with failure to wear the appliance, and failure to remove it for cleaning,which can cause soft tissue irritation.

iii) A distal shoe space maintainer is chosen when a primary second molar is lost before eruption of the permanent first molar. Unfortunately, this appliance has low strength and provides no functional replacement for the missing tooth. It is contraindicated in patients who are at risk for subacute bacterial endocarditis since complete epithelialization around the intraalveolar portion has been demonstrated.

iiii) A Lingual arch is indicated as a space maintainer when more than one primary posterior tooth is missing and the permanent incisors have erupted. A conventional lingual arch attached to bands on the primary second or permanent first molars and contacting the cingula of the maxillary or mandibular incisors, prevents anterior movement of the posterior teeth and posterior movement of the anterior teeth. It is contraindicated only in patient whose bite depth allows the lower incisors to contact the arch wire on the lingual of the maxillary incisors.When deep bite does not allow use of a conventional design, either the Nance lingual arch or a transpalatal arch can be used.

The Nance arch is simply a maxillary lingual arch that dose not contact the anterior teeth,but approximates the anterior palate .The palatal portion incorporates an acrylic button that contacts the palatal tissue,which in theory provides resistance to anterior movement of the posterior teeth.The appliance is an effective space maintainer but soft tissue irritation and oral hygiene can be problems.

The transpalatal arch supposedly eliminates anterior molar movement by prevent this rotation. The best indication for a transpalatal arch is when one side of the arch is intact,and several primary teeth are missing on the other side. Its common problems are failure of appliance to remain passive.

2) Space Regaining

Localized space ( of 3 mm or less ) can be regained by repositioning the teeth.Space regaining procedures should be limited to reestablishing 3 mm or less of space lost in a localized area. Proffit (1986) stated that if space loss is bilateral,the limit of space regaining is about 4 mm for the total arch,or 2mm per quadrant.If the primary second molar has been lost prematurely in a single quadrant, up to 3 mm of space may be regained by tipping the first molar back distally.

Space regaining is needed when primary maxillary or mandibular second molars have been lost prematurely because of decay or, rarely, because of ectopic eruption of the permanent first molar. The permanent first molar usually migrates mesially quite rapidly when the primary second molar has been lost, and in the extreme case will totally close the primary second molar extraction site.

Generally, space is easier to regain in the maxillary arch than in the mandibular arch, because of the increased anchorage for removable appliance afforded by the palatal vault and the possibility for use of

extraoral force. Space lost from tipping can be regained when the crown of the tooth is tipped back to its original position but space lost by bodily movement requires that the tooth be bodily repositioned. This repositioning, in turn, requires more force and control for reliable movement of the crown and root.
The techniques for space regaining appliances are usually divided into maxillary space regaining and mandibular space regaining.

i) The maxillary space regainers are fixed and removable appliances.Tipping of permanent maxillary first molar to distal can be done using removable appliance or fixed appliance but bodily movement requires a fixed appliance.
A removable appliance retained with Adams clasps and incorporating a helical finger spring adjacent to the tooth to be moved is very effective.This appliance is the ideal design for tipping one molar.One posterior tooth can be moved up to 3 mm distally during 3 to 4 months of full-time appliance wear.
When space regaining by tipping is needed bilaterally or when bodily movement is required,extraoral force via a face bow to the molar is the most effective method,because the force is directed specifically to the teeth that need to be moved and reciprocal forces are not distributed on the other teeth that are in the correct positions.

ii) Mandibular space regaining -Removable appliance can be used but may be difficult to retain, the mandibular appliance also, is prone to breakage.
If space has been lost on one side of the mandibular arch,the appliance of choice is a removable lingual arch,incorporating a loop that can be opened to provide the necessary distal force. It is important that the lingual arch be activated so that the molar is tipped up and back, and the reaction force is expressed largely downward on the cingulum area of the lower incisor.
There is inevitable tendency to tip the incisors forward also.If space has been lost bilaterally, a lingual arch can also be used, but pitting posterior movement of both molars against the anchorage affered by the incisors means that significant forward displacement of the incisors must be expected.(Proffit1986)

ii) Another fixed appliance for mandibular space regaining is the lip bumper.The ideal is that the appliance presses against the lip,which creates a distal force to tip the molars posteriorly. The result is that forward movement of lower incisors occurs with the lip bumper to about the same extent as with a lingual arch but when the mandibular incisors protrude, the lip bumper is contraindicated.

3) Space Management

During the mixed dentition much attention must be given to the problems of space management.A child with a generalized arch length discrepancy up to 4 mm and no prematurely missing primary teeth can be expected to have moderately crowded incisors. The problems can be treated in two different ways ( Linden, 1978):

i) To increase arch perimeter.This is usually accomplished by sagittal or transverse expansion,or both, with gentle expansion of the arch,tipping the molars slightly distally and the incisors slightly forward while widening the arch in the premolar region.

ii) Decreased arch length can be treated by extraction or by stripping of the teeth.If extraction of primary canine to allow the permanent incisors to align themselves, it is important to control incisors drifting lingually or labially. In stripping, the mesiodistal width of permanent teeth are reduced by taking off material at the approximal surfaces.

5.3.2 Midline Diastema

Midline diastema in maxillary between the central incisors is greater than 2 mm.( Proffit1986) may be treated.

It is debatable whether the frenum is an important causative factor, or consequence of persistent diastemas (Jensen 1973 and Thompson 1977) In any case, the occurrence of a hypertrophic frenum is not in itself a hindrance to spontanenous diastema closure,but it has been shown that the closure is achieved earlier when the frenum is excised than when it is not,especially in the "divergent" type.

Another possible cause of a diastema is a tooth size discrepancy resulting from small upper and larger lower anterior teeth. Treatment usually requires both a change in tooth size ( bulding up small maxillary lateral with composite resin, for instance) and permanent retention. Attempts to simply close the space will result in relapse because the occlusion will force the space to reopen. In this situation also, treatment should be deferred until all permanent teeth have erupted

The major indications for closure of midline diastema are:

i) a diastema that remains open after the permanent canines have erupted,because the unerupted canines often rest superior and distal to the lateral incisor roots, and force the lateral and central incisor roots toward the midline while their crowns diverge distally.This situation creates space between the incisors and is called the "ugly duckling" stage (Fig 11) These spaces tend to close .

However,spontaneous closure is unlikely (Case1964). Persistent spacing between the incisors is correlated with a cleft in the alveolar process between the central incisors into which fibres from the maxillary labial frenum insert.

Midline diastema is present in many children but is not necessarily an indication for orthodontic treatment.

ii) before canine eruption, a diastema of 3 mm or more.

When the canines have erupted and the diastema is less than 2 mm, the central incisors can usually by tipped together.A maxillary removable appliance with clasps, fingersprings and possibly an anterior bow will sucessfully complete this type of treatment. Use of this appliance does not require root repositioning, because the incisor teeth are being tipped to an upright position.

In a few case more than 3 mm space can be corrected but most large diastemas will require bodily repositioning of the incisors. When the situation demands only mesiodistal movement and no retraction of the incisors, the teeth can be moved along a segmental rectangular arch wire that is placed in bonded brackets on the incisors. The force to move the incisors together is provided by an elastomeric chain or less conveniently a contraction coil spring.

When a wide diastema is complicated by space and protrusive incisors that require bodily movement,an arch wire should be used with bands on posterior teeth and bonded brackets on anterior teeth.This appliance must provide a retracting and space-closing force, which can be obtained from closing loops incorporated into the arch wire, or from a section of elastomeric chain and using a multi band/bond fixed appliance. A head-

gear chosen with consideration for vertical facial and dental characteristics, may be necessary for supplemental anchorage support.
In diastema cases with parallel central incisors or a generalized spreading tendency, however, a spontaneous closure should not be expected. Such cases need appliance therapy.

iii) Surgical elimination of the frenum with the orthodontic closure of the diastema is recommended in such cases.
For large diastemas, it may be necessary to surgically remove the frenal attachment to obtain a stable closure of the midline diastema.The frenotomy should be performed just before the eruption of the lateral incisors in order to further the progressive reduction of the diastema that takes place at this stage.
Proffit (1986) suggested that the best approach, however, is to do nothing until the permanent canines erupt .If the space does not close spontaneously at that time,an appliance can be used to move the teeth together.
Investigations by Berstrom and Jensen (1962 ) and Jakobsson (1965) showed that frenular surgery appreciably accelerates spontaneous correction of the diastema .According to Thilander, the most favourable time for operation would seem to be in conjunction with, or just before the eruption of the lateral incisors so that they can develop their greatest mesial force on the central incisors.

iiii) Any types of treatment will require retention,.because, after closing midline diastemas, there is frequent instability of the approximated incisors.
Edwards (1977) feels that many factors can contribute to the reopening, such as improper axial inclination of the incisor roots, tooth size discrepancies ( narrow maxillary lateral incisors), habits ( sucking, biting, tongue thrust ) and the labial frenum. Diastema cases in which there are "abnormal" frena demonstrate a strong potential for relapse after orthodontic closure.
Edwards (1977) observed that a retention problem may be the presence of a large or inferiorly attached labial frenum. Therefore, a frenectomy before treatment is contraindicated, and a posttreatment frenectomy should be done only if a continued tendency of the diastema to reopen and unresolved bunching of tissue between the teeth shows that it is necessary.

Thilander (1985) found a bonded lingual retainer ideal for such a purpose in the waiting period between two phases of treatment .

5.3.3 Correction of Crossbite

1) Anterior Cross Bite

Anterior cross bite refers to an abnormal labiolingual relationship between one or more maxillary and mandibular anterior incisor teeth. It is expressed as a "Reverse overjet"(Lee1978).

Proffit(1986) stated that anterior cross bite of all the incisorsis rarely found in children who do not have a skeletal Class III jaw relationship. Clifford(1970), McDonald (1969) stated the following factors should be considered before treatment begins;

1) adequate mesiodistal space to move the inlocked tooth into better alignment.

2) sufficient overbite to hold the tooth in position following correction .

3) an apical position of the tooth in crossbite that is the same as it would be if the tooth was in normal occlusion.

4) A Class I occlusion, and

5) the extent of root formation.This factor often dictates the form of treatment, since light forces are recommended for teeth with incomplete root formation to prevent dilaceration.

According to Sharma (1968) correction of a pseudo Class III anterior crossbite may require only the removal of premature tooth contacts by incisal grinding of the maxillary and mandibular incisors. However, generally some type of appliance therapy for simple guidance can be required to correct crossbite;

i) Simple one tooth anterior dental crossbite may be corrected by using a tongue blade (Sim 1972).Mcdonald (1969) Hitchcock (1968) Wood (1962) which is held at 45 degrees behind the inlocked tooth and using the lower incisors as a fulcrum, to exert slight pressure on the tooth in a labial direction.This should be done for an hour or two a day for 10 to 14 days.This method works best with teeth in the early stages of eruption. But Clifford in 1971 found the method does not give precise control of the amount and direction of force being applied. Because of this, some authors feel this method may lead to dilaceration of roots with incomplete development if heavy force is applied to a tooth.

Graber (1972 ) in his text book recommended that the best suited for single tooth crossbite is a stainless steel crown and banded metal incline when the lower mandibular incisor has been previously displaced labially. Generally correction occurs in one to two weeks.

ii) Anterior crossbite involving one or two teeth may be corrected by using a cemented lower acrylic inclined plane.The acrylic resin should cover the six lower anterior teeth and plane should be contoured and polished at a 45 degree angle to the long axis of the lower incisor teeth prior to cementation.The principle of the plane is accomplished by force being exerted on the tooth during closure of the dentition. Godfrey (1987) stated that this appliance is only useful in the case of at least 3 mm of vertical incisor overbite,because eruption of posterior teeth occurs during its use, leading to reduction of incisor overbite at appliance removal.

Lee (1978) found the appliance is easy to fabricate but the exact amount of labial movement of the crossbite incisor toward its proper alignment is unpredictable and uncontrollable and also keeps posterior teeth separated and so, in as little as two to three weeks the molars teeth can erupt to produce an increased vertical interarch dimension of 2 to 3 mm.

Removable Hawley appliance with an S-shaped spring or a double helical spring which can involve more than one tooth in crossbite.Valentine (1970) and Howitt (1970) suggest the use of a Erd Micro Screw, instead of the more conventional type spring,because the screw device provides more accurate control of the amount and direction of force applied to the tooth .Sim (1972 ) says the patient wears the appliance 24 hours a day and moves the screw 1.5 mm to 2 mm every one or two weeks.Crossbite correction can be anticipated in two to three weeks. After correction, the appliance should be worn in passive retention for an additional month.

The above methods,according to Godfrey (1987), produce tipping movement of incisors. The crown of the malplaced incisor moves labially but the root moves lingually and such correction may produce an unstable tooth position.

Fixed appliance is the most effective for moving one or more of the maxillary permanent incisors over the mandibular teeth.The appliance mainly extrudes the maxillary incisors to improve the vertical overbite,thus providing greater stabilty .

2) Posterior Crossbite

The treatment of posterior crossbite during the mixed dentition depends on the cause of the crossbite situation. Dental crossbite caused by a displacement of teeth within the dental arches often appear to be unilateral but are usually found on closer examination to result from a bilateral constriction of the maxillary arch and a shift of the mandible to one side on closure .More severe constriction may result in a bilateral crossbite without mandibular shift and occasionally,a true unilateral posterior crossbite from an intraarch asymmetry will be noted.

Skeletal crossbites due to narrow maxilla are often treated by fixed appliance such as, Minnesota expander, fixed split palatal acrylic appliance,Quad-helix or Hyrax Jackscrew appliance. These appliances can offer precise control of applied force and expansion.

Most dental unilateral or bilateral crossbite involving one or more teeth can be treated by three basic approaches in children;equilibration to eliminate mandibular shift,expansion of a constricted maxillary arch,and repositioning of individual teeth to deal with intraarch asymmetries.(Proffit and Lee). There are following types;

i) W-arch Porter appliances which will move both primary and permanent teeth and may accelerate the rate of normal expansion of the midplatal suture particularly in a young child. Therefore correction may result from a combination of skeletal and dental change even if only dental age is required. The W-arch is activated simply by opening the apices of the W, and is easily adjusted to provide more anterior than posterior expansion if this is desired .Expansion should continue at the rate of 2 mm/month (1 mm tooth movement on each side ) until the crossbite is slightly overcorrected (Proffit 1986 ). Too much force may open the midpalatal suture or create unnecessary pain in the child .The W-arch appliance can be modified and used simultaneously as a dental crib to break a thumb or finger habit and to correct a bilateral dental crossbite. Because of the reciprocal action of this appliance, it should not be used in cases of correction of a dental unilateral crossbite, but should be limited to only bilateral dental crossbite conditions ( Lee 1978) unless the crossbite is a result of lateral mandibular shift.

ii) The quad helix is also used for correction of posterior crossbite,it is a more flexible version of the W-arch ( Chaconas 1977). The helices in the anterior palate are bulky,which can effectively serve as a reminder to aid in stopping a finger habit .The combination of a posterior crossbite and a finger sucking habit is the best indication for this appliance .Appropriate force is produced when the appliance is widened by 3 to 8 mm .The appliance is being used to correct a bilateral maxillary constriction in the primary dentition.

iii) Cross elastic therapy All of the previously described appliances are aimed at correction of teeth in the maxillary arch, which is usually where the problem is located .If teeth in both arches contribute to the problem, cross elastics between banded or bonded attachments in both arches can help to reposition both upper and lower teeth. If only the upper tooth needs to be moved lingually or buccally then the lower tooth should be stabilized with a lower lingual arch wire appliance.
Crossbite elastics should be used with caution in children with increased lower face height or limited overbite because of the reuk of molar . Crossbite treated with elastics should be overcorrected and the bands left in place immediately after active treatment.

iiii) Removable Hawley appliance to treat posterior crossbite is the a split -plate type of removable appliance incorporating a wire spring or jackscrew for force generation . The appliance offers good control of the amount and direction of force being applied to the teeth .The appliance also can be modified to permit correction of a bilateral dental lingual crossbite .Movement of the teeth is accomplished by turning the jackscrew one-quarter turn every five to seven days. Each quarter turn produce 0.2 to 0.25 mm of expansion.

From mechanical analysis, these above types of appliance basically use tooth-tipping type of action. They should not be considered in the correction of posterior crossbite of skeletal origin.
The time correction take varies from four weeks to four months, depending on the extent of tooth movement required. Complete lingual or

buccal dental crossbites usually take longer to correct than a single cusp lingual dental crossbite.
When the crossbite is corrected,according to Lee (1978), the appliance should be worn in passive retention for an additional three to six months. This approach is less successful than the expansion lingual arches. This appliance should not be used in the correction of a skeletal bilateral posterior crossbite condition.

### 5.3.4. Persisting Thumb or Finger Sucking

Most sucking habits have stopped by 8-9 years of age. Discussion of the effects and demonstrating the problem in a face mirror to the patient often is enough to encourage a proportion of the patients to stop the habit.
Larsson (1972) and Wisth, Thunold and Boe (1974) found that incisor retroclination and the anterior open bite tend to close if the patients stopped their habit.
Leivesley(1984) stated that the spontaneous overjet and overbite reduction may not occur where there is a skeletal II pattern and the habit has proclined the upper incisors outside the lower lip control or there is an adaptive forward tongue position into the open bite during rest or swallowing.
Appliances are required in these cases to reduce overjet .The tongue habit usually disappears and stability is possible after correction and retention.Similarly ,where thumb sucking continues an appliance may be fitted to break the habit .Full orthodontic treatment is not desirable until the habit is controlled.

### 5.3.5 Ankylosis and Submerging Deciduous Molar

Brealey and Mckibben (1973) found 1.5 per cent of primary molar teeth ankylosed with mandibular molar teeth much more commonly ankylosed than maxillary.
Usually, it is diagnosed by infraocclusion and immobility to rocking.
The treatment depends on the degrees of infraocclusion of the molar, the pattern and extent of resorption of the affected tooth, and the presence or absence of a permanent successor. Moyers (1974) recommended extracting it and placing a space management appliance if needed.

Henderson(1979) observed that less severely infraoccluded second primary molars can be monitored and it is not unusual to find a previously ankylosed tooth breaking loose following resorption of an ankylose area. Messer also found in many case ankylosed teeth will resorb and exfoliate at the normal time. Sequelae such as retained primary root fragments, rotated permanent teeth and vertical bone loss can occur if exfoliation is delayed.

# CHAPTER SIX

## Funtional Appliance for Guidance of Development of the Occlusion

In last 20 years, functional appliance therapy has becomes more generally accepted to treat severe and moderate discrepancices of saggittal jaw relationships in children.Its forms include "Activator","Bionator,"Frankel regulator "," Teuscher " and "Oral Screen," "Herbst".(Fig 12)

### 6.1 General Considerations

Carels (1987) stated that general consideration about functional appliances should include a "new pattern of function"and "new morphologic pattern". The new pattern of function can refer to different functional components of the orofacial system, for example, the tongue, the lips, the facial and masticate muscles, the ligments, and the periosteum. Depending on the type of appliance, its proponents puts more emphasis on one of these different functional components.

The new morphologic pattern includes a different arrangement of the teeth within the jaws, an improvement of the occlusion, and an altered relation of the jaws. It also includes changes in the amount and direction of growth of the jaws, and differences in the facial size and proportions.

Where fixed orthodontic mechanotherapy predominantly relies on the delivery of forces, a major part of functional appliance therapy makes use of force-removal systems also.

### 6.2 Cases Selection

A functional appliance has varying limitations for each patient.Based on their experience, Schulhofand and Engel (1982) point out that all cases are selected with the following stipulations:

1. All patients must be growing children.

2. Complete records must be available at each time point.

3. No other appliances are used during the time period in question.

Functional appliances therapy is completed during the time interval under study.

Apart from above the points, Godfrey (1987) suggested some other conditions might be considered when making case selection.

1. A well-formed mandibular dental arch ,with no crowding and upright or slightly lingually inclined incisor teeth.

2. Proclined and spaced maxillary incisors teeth.

3. With or without distocclusion. No more than a dental Class II malocclusion,without skeletal abnormality.

### 6.3 Treatment Timing

Bjork (1951) is of the opinion that the functional treatment is most effective during the stage of the deciduous dentition (ages 4-7 years), and little less effective in the mixed dentition (age 8-12 years). In permanent dentitions, he finds that the effect of the functional appliance treatment is very limited. He advocates the nocturnal used of the activator plus one warking hour at any convenient time during the day.

Godfrey (1987) prefer that treatment should be from the start of the adolescent growth spurt, when it is expected to use only the functional appliance for the complete correction of the malocclusion.

With some appliances, treatment may be started earlier, for example, FR3 functional appliance can be readily used in the complete deciduous dentition if necessary. Robertson (1985) found that the indicated adaptations in both hard and soft tissues during treatment so that the ultimate balance between function and form should favour long term stability of the result of early treatment..

Regarding the timing of using Herbst appliance, Panchez (1985) feels that treatment during the pubertal growth period is favoured, but Weislander (1984) has demonstrated that the mandibular response in the early mixed dentition is, if anything, slightly superior.

## 6.4 Clinical studies

Most authors agree that dentoalveolar adaptations contribute to the correction of Class II malocclusion with function appliances. These dentoalveolar changes include an inhibition of mesial migration of maxillary teeth,an inhibition of maxillary alveolar height increase, a change in antero-posterior positions of the upper and lower incisors, an intrusion of maxillary and mandibular incisors, and a mesial movement of mandibular teeth. Bjork (1951), Andresen (1952) and Wiesland and Lagerstrom (1979) found that functional treatment effects are limited to the dentoalveolar area.

Meach(1967), McNamara (1985) and Panchez (1985) indicate that the increase in mandibular growth is the distinguishing aspect of functional treatment compared with other treatment procedures, Harvold (1971), Vargervik (1985), Wiesland and Lagerstrom (1979) and Bjork (1951) maintain that increased mandibular length does not result from functional appliance treatment .Wieslander (1984), Harvold (1971), Vargervik (1985) and Panchez (1985) have shown that functional treatment has an effect on the location of the glenoid fosse, giving rise to relocation of the mandible in an anterior direction.

Wieslander and Lagerstrom (1979) investigated the effect of activator treatment on Class II malocclusion in the mixed dentition period. A group of treated patients was compared with a similar group of untreated Class II maloccusion patients. Lateral cephalometric films before treatment, after treatment ,and after the retention period were compared.They found that the effect of treatment was usually of dentoalveolar origin with a major favourable change in position of the upper incisors. The lower incisors were slightly intruded with significant protrusion.The improvement of the relationship between the upper and lower molars was caused mostly by tooth movement within the dentoalveolar area. The average orthopedic effect of treatment was limited ,in spite of individual cases with excellent response. A significant improvement of the anteroposterior relationship between the maxilla and the mandible was registered ,as well as an increase in the lower face height and a slightly steeper mandibular plane angle. There were differences in the amount of mandibular growth recorded. Lastly, several years after the treatment period the dentoalvolar treatment effect upon the maxilla was quite evident, with no sign of relapse.

Trayfoot and Richardson (1968) showed that the Andresen appliances reduce the large overjet of Class II divsion 1 malocclusion by restricting growth of the maxilla while allowing slight forward positioning or growth of the mandible. These two effects result in a marked improvement in the SNA-SNB difference which is greater than that which might have occurred spontaneously during growth and development. There are also pronounced changes in the dentition taking the form of retroclination of upper incisors and slight proclination of lower incisors.
Andresen (1957) observed that using an activator can stimuate the protractor muscles of the mandible. Ahlgren (1978 and1982) claimed that only day-time use of the activator stimulates the protractor muscles and that during the night its stimulation effect disappears. The appliance would thus become effective during day time with the contraction of the protracting masticatory muscles. The force produced by these muscle contractions would be transmitted to selected teeth and their periodontium, to the jaws, and to the temporomandibular joints.
According to Harvold (1974), the activator does not elicit responses in the mechanisms controlling the growth of the jaw bones, but merely induces changes in the musculature supporting the mandibile relative to the maxilla and finally a rearrangement of the muscle attachments.
Harvold and Vargervik (1974) found in their study with a type of activator, that treatment effects a significant increase in mandibular alveolar height in the molar region and a reduced forward growth of the entire maxilla. This resulted in a transformation of the Class II molar relationship into a Class I molar relationship. The overjet was decreased by the reduced forward growth of the maxilla in combination with lingual tipping of the maxillary incisors.The growth in length of the mandible did not appear to be significantly influenced by the treatment.
Bass (1982) reported that use of on activator-like appliance and headgear implies both a "functional component and a mechanical force appliance. The treatment philosophy of the functional part of the combination appliance is that temporary additional condylar growth should likely be induced, that the mandible must be unlocked from its habitual position, that occlusal transfer of distally oriented headgear forces from the maxilla to the mandible must be avoided (Van Beek 1978) and that specific muscles should be trained.
Jakobsson(1967) did a study on patients with Class II division 1 treated with either activator or headgear and studied the differences between the

two methods. He reported that in both forms of treatment,the entire maxilla is held back and rotated downward anteriorly; Also that extra-oral treatment seems to be more efficient in restablishing the posterior movement of the dentoalveolar parts of the maxilla, while activator treatment also affects the dentoalveolar parts of the mandible.His findings did not support the hypothesis that activator treatment can bring the mandible to a more forward position or affect the condylar growth.

Luderz (1981) appears to have been the first to report a sex difference in the response to activator treatment. This may explain the variable results from mixed studies. Boys showed increased condylar growth expressed in a modified direction, without a posterior component. Girls experienced a change in the direction of condylar growth with no change in the amount of growth.

Meach (1966) did a comparative study of the bony profile changes in patients treated with functional appliances and head-gear .He concluded that, in comparison to extraoral force, functional jaw orthopedics has a more favourable influence on the position of pogonion in the bony profile, as evidenced by a closing of the Frankfurt-mandibular plane angle, a statistically significant increase in the facial angle, and a high percentage of forward positioning of chin point. It appears that such improvements are brought about by a normalizing of the growth process of the class II divsion 1 patient through alteration of the horizontal and vertical components of growth of the dentofacial complex , especially the mandibular condyle.

Frankel (1981 ) and Frankel (1983 ) claimed that with Frankel functional regulator system of labial, lingual, and buccal pads and shields directly affects the level of postural activity in the facial and masticatory muscles by means of a training effect. The buccal and labial shields placed high in the vestibule would also indirectly put traction onto the periosteum. This traction would stimulate bone growth in the apical subperiosteal areas and provide a guidance of eruption for the teeth.

Frankel (1975) and Graber (1977) found that Frankel -2 helps mandibular advancement in small increments and then further stimulates the condylar proliferative process and achieves the desired physiological response. In contrast, McNamara (1981 and 1982) has shown that mandibular advancements of 4-6mm are well tolerated, for most Class II problems. This commonly places the incisors in an edge-to-edge position.

Panchez (1985) claimed that treatment with Herbst appliance favourable affects the function of the masticatory musculature.

## 6.5 The appliance Selection

The appliance selection for the treatment can be adapted to the type of anomaly and to the growth pattern. The growth direction, the growth amount, and the timing are relevant to the ultimate success of the treatment.
Various types of functional appliance have been used for different purposes:

1. to effect neuromuscelar and functional changes,
2. to impede or enhance growth or to change growth direction of certain structures, and
3. to achieve tooth movements .

6.5.1 Activator
Activator indications are summarized by Godfrey (1987):

1. Class II Division 1 and Class II Division 2 malocclusions.
2. Pre-adolescent patient with late mixed dentition or permanent dentition.
3. Absence of dental arch crowding, except labio-lingual displacement of incisors ,such as incisors of Class II Division 2 malocclusion.
4. Absence of rotation of teeth especially associated with overlap.(crowding)
5. In case of class II Division 1 malocclusion, proclination and some spacing of maxillary incisors ,and upright or retroinclined mandibular incisors.
6. In case of Class II Division 2 moalocclusion, retroclined maxillary and mandibular incisors with estimated dental arch space deficiency of 2 millimetres or less.
7. Absence of significant maxillo-mandibular skeletal discrepancy.

6.5.2.Bionator
Mosby (1985) noted that Bionator like most activators are at their prime for Class II Division 1 cases.

Indications:

1. The dental arches are well aligned
2. The mandible is in a retruded position (functional)
3. The skeletal discrepancy is not severe
4. There is a labial tipping of the upper incisors

He also emphasized that one of the best indications for the use of a Bionator is for some patients with T.M.J. dysfunction.

6.5.3 Frankel Functional Regulator

An ideal patient for treatment with FR2 (and FR1) appliance would have the following features (Roberts 1985).

1. Normal maxillary position in the sagittal and vertical dimensions.
2. Retrognathic mandible,
3. Normal or reduced lower face height;
4. Normal relationship of the maxillary denture to the maxillary in the sagittal and vertical dimensions;
5. Mild crowding in the mandibular arch or in both arches is acceptable, but axial rotations and bodily displacement of individual teeth require a separate phase of fixed appliance treatment.

FR3 is indicated in Class III malocclusion associated with reduced lower face height.

6.5.4 The Herbst Appliance

An ideal patient for treatment with the Herbst appliance would have the following features (Roberts 1985):

1. Normal or slightly prognathic maxilla.
2. Retronathic mandible.
3. Anterior growth direction of the mandible (facial axis more than, or equal to,90 degrees)
4. Normal or reduced lower face height.
5. Minor crowding in maxillary incisor segment is acceptable.Class II dental arch relationship with increased overjet and normal or increased overbite.
6. A Class II division 2 configuration of the maxillary incisors is not a contraindication, provided that orthodontic alignment is carried out prior to the orthopaedic phase with the Herbst appliance.

## 6.6 Patient Cooperation

Both patients and parents must understand what you are trying to achieve with a functional appliance.It is important to show them in mirror how the soft tissues and profile look better with the appliance in place. Talk with the patient while he or she is wearing the appliance so the patient the patient gains confidence in speaking. Day time use of functional appliance probably increases the effectiveness of removable functional appliances.

# CHAPTER SEVEN

## "Serial Extraction" for Guidance of Development of Occlusion

"Serial extraction" as a method of guidance of development of the occlusion has been known for many years. In this regard,Dewel (1954 and1959), Fanning (1962), Moorrees (1965), Mayne (1968and1969), Hotz (1970) and Jacobs (1965 and1987) have contributed greatly. It is the aim of this chapter, 1) to present a review of the concepts; 2) to indicate principles of serial extraction, and 3) to outline of timing, sequence and problems of extractions.

### 7.1 Concepts

Serial extraction has been defined by Dewel (1969) as"an orthodontic treatment procedure that involves the orderly removal of selected deciduous and permanent teeth in a predetermined sequence.It is indicated only in arches that are structurally deficient with little or no hope of ever attaining a normal size and proportion."
Hotz (1970) refers to this interceptive guidance effort as"active supervision of the eruption of the teeth." Dale (1976) prefer Hotz's term.
In 1987, Jacobs stated that serial extraction can be defined as the correctly timed planned removal of certain deciduous and permanent teeth in mixed dentition cases with dento-alveolar disproprtion, i.e. teeth to supporting bone size imbalance, in order to 1) alleviate crowding of incisor teeth 2) allow unerupted teeth to guide themselves into improved positions (canines in particular), and 3) lessen (or eliminate) the period of active appliance therapy.

### 7.2 Working Principles

The working principles of serial extraction for guidance of development of the occlusion lie in the control of the sequence of primary tooth exfoliations and then eruption of their permanent successors (Godfrey,1987).

In this regard, Mayne (1968) stated that the purpose is to reconcile a persisting discrepancy between the amount of tooth material present and increasing the available jaw space in order to permit the remaining erupting, permanent teeth to assume more normal arch position as well as occlusal and spatial relationships.The muscular environment and normal growth activities are the guiding forces that accomplish this improved eruptive direction, as well as the favorable repositioning of those permanent teeth already fully erupted but in unphysiologic and compromised positions.

Dewel (1959 ) observed that it is designed to anticipate and prevent the development of a fully matured deformity in the permanent dentition.

Jacobs (1965) from Dewel (1954): "Serial extraction is based on the following premises;

1) In certain types of cases the orthodontist is confronted with a continuing discrepancy between total tooth material and supporting bone.
2) After eruption of the permanent first molar there is no further increase in arch length anterior to the first permanent molar.
3) The premature removal of teeth will permit physiologic movement of permanent teeth."

Apart from the above points, Grew (1982) provides us with a more coherent path of thought than most other authors.

1) The reduction of tooth material in an arch length deficiency case.
2) Allow physiological tooth movement .
3) Allow for normal dental and skeletal profile development.

## 7.3 Case Selection

Suitable cases for serial extraction depend on an exhaustive study of all available diagnostic criteria and a thorough understanding of orthodontic principles and mechano-therapy.In addition, knowlege and experience also help to clinicianls predictions.

The ideal conditions for serial extraction are described by Dale (1976). These are ;

1) Relatively severe hereditary tooth-size, jaw-size discrepancy.
2) A mesial step mixed dentition malocclusion developing into a class I permanent molar relationship.

3) Minimal overjet and overbite relationship of the incisor teeth.

4) Orthognathic facial pattern or a slight maxillary-mandibular alveolar dental protrusion.

5) Class I malocclusions are more suitable for serial extraction because the dentition is basically in a favorable relationship and successful treatment is possible with minimal mechanotherapy.

Clinical symptoms of an authentic serial extraction malocclusion include marked irregular anterior teeth, premature loss of one or more of the deciduous canines, various median line deviations, impacted or displaced lateral incisors, a gross reduction in arch length and frequently, gingival recession and alveolar destruction along the labial surfaces of one or both of the lower central incisors (Dewel 1969, Graber 1971 and Grewe 1982).

What is the amount of discrepancy which guides decision about extraction? Dale(1976) prefers a total arch discrepancy of 4 mm for patient before he will initiate a serial extraction program. Approximately 6 mm per quadrant and symmetrical arch length tooth-size discrepancy in the early stage of the mixed dentition is considered for extraction by Grewe (1982). Seipel (1946) found a mean space deficiency of 1.9 mm on the side of the extracted tooth or teeth and Breakspear (1961) recorded a deficiency of a little more than 3 mm. Proffit (1986 Pg 187) initiated extraction when the patient has large arch perimeter deficiency of 10 mm or more.

Dewel(1969) observes its most effective application in severe Class I arch reduction irregularities. But in rare instances, a child with good skeletal proportions will have a class II molar relationship and severe maxillary but not mandibular incisor crowding. This condition arises, of course, when upper posterior teeth have slipped mesially. Proffit (1986 Pg 187) stated that in this circumstance, a modification of the serial extraction procedure to encompass only the maxillary arch can be helpful. Serial extraction should be avoided in any child who has a skeletal Class II jaw discrepancy.

Godfrey (1987) indicated rules about avoiding extraction of teeth applied to serial extraction in the mixed dentition, such as

-Deep incisor overbite

-Large positive incisor protrusion

-Incisor crossbite

-Lack of availabe orthodontic follow-up which is often required

-The possiblity, in cases of minor crowding (Less than the "leeway space"), of natural correction.

In regard to the low gonial angle Class III case, Heath (1961) stated that it cannot be helped by serial extraction. Quite frequently the maxillary lateral incisors erupt in a plane behind the central incisors."Unless there is to be mechanical tooth movement it may be a fundamental error to extract these teeth (c's). In particular, the maxillary first and second premolar must not be extracted in these cases to make room for the outstanding canines." He does, however, concede that in the high gonial angle class III case with a narrow and short (A-P) maxilla the case may be easier to treat mechanically(post serial extraction) if it not severe.

Dale (1976) emphatically states that"Class III malocclusions are not suitable for serial extraction procedures".

Class II cases usually are skeletal problems that require concurrent orthodontic treatment. Serial extraction alone will not bring about an improvement in the supporting structures or in the first molar occlusal relations. Serial extraction can be an accessory to mechanical correction, but the major emphasis is mechanical treatment of Class II discrepancies.

Mayne(1969) said that serial extraction should be limited to cases that have good faces- those that present with harmony and balance of the two tissue systems, bone and muscle, and varying degrees of disharmony in the third, tooth size.The incisors are upright in their bases and well over the ridge and so related to facial anatomy as to produce the most complimentary facial esthetics. It is indicated only in arches which are structurally deficient with little or no hope of ever attaining a normal size and proportion. It demands good clinical diagnostic skill, as irreparable damage can occur when improperly applied. Therefore, it is important to differentiate between cases which can be treated with a full complement of teeth and cases which require extraction of permanent teeth.

## 7.4 Timing of Extraction

Based on studies of Moorrees (1963),Gron (1962), Fanning (1962) and Dale (1976) three factors to be considered on the optimum time for serial extraction are the effect of extraction on its permanent successor, the amount of root formation at the time, and attainment of various stages of root development.

For optimum results in serial extraction, Fanning(1962) showed that a deciduous tooth should be removed at time when the permanent successor will erupt without delay.It has been shown that extraction of a deciduous molar at any age causes a brief spurt in premolar eruption,but the timing of clinical emergence is not usual until at least one to three-fourths of root formation has occurred.

Especially, deciduous molars should not be extracted before at least one quarter of the premolar root length has been attained if close to alveolar emergence and otherwise one half root development. Deciduous canines, depending on the position of their permanent successors in the mandible and also on their inclination, should not be removed before the permanent canine has attained one-half of its root length unless the first premolar is about to emerge. The time needed for the formation of roots of the canines and premolars is also relevant for determining the timing and sequence of serial extraction in clinical practice. The mean time interval between attainment of 1/4 to 1/2 root length is 2.3 and 1.8 years respectively for the permanent canines in males and females, and 1.7 years for the premolar in both sexes.The average time for the formation of the next quarter root (1/2 to 3/4) is less, ranging from 1.6 to 1.1 years.(Moorrees 1963)

Moorrees (1963) believes that the optimal time for serial extraction therapy can be estimated also by directly predicting the time needed for reaching the 1/2 or 3/4 root length level, when emergence generally occurs,from the rating of root development at the time of extraction and the mean time interval between stages.

It has been shown by Gron (1962) that premolars emerge when one half to three fourths of their roots are formed but canines have slightly more root formation at emergence. Therefore, a deciduous tooth should not be removed until its permanent successor has an appropriate amount of root formation or at least one-fourth to one half of the root length.

Normally, radiographs are obtained routinely,as suggested, root length and the velocity of its development for the indivdual can be determined more precisely, resulting in better definition of the timing of serial extraction procedures.

It is also necessary to consider the ages at which the root stages mentioned are reached,as well as the duration, or interval, between these stages. Fanning (1962) emphasized that time needed for root formation prior to emergence is longer than generally expected. However, the interval between the stages root three -fourths formed to root with open apex,associated with emergence of the teeth, is shorter, ranging from 0.51 years to 0.86 years.

Another aspect affecting serial extraction and demonstrated by Fanning (1962) relates to early maturation and eruption of the permanent mandibular canine in girls.The timing of extraction of the first deciduous molar is especially critical in cases of crowding when the treatment plan calls for the subsequent extraction of the first premolar. If the deciduous tooth is removed too soon,the early erupting permanent canine may cause impaction of the first premolar, thereby defeating the objective, this problem will occur

less frequently in boys where the permanent canine is slower to mature and erupt.

Clinch (1959) reports that extraction performed before eruption of the first permanent molars invariably resulted in a loss of space, whereas Seipel (1946) found no crowding in 26% of his subjects.That the effect of space loss might be dependent on the time the extraction was performed was found also by Lundstrom(1948) who reported a highter incidence of crowding when extraction were performed at 7-8 years than at 9-10 years, although the differences were not statistically significant.

The studies of Moorrees (1963), Fanning (1962) and Gron (1962) show that the permanent premolar is literally standing still until one-half of its root is formed, and that if the overlying primary molar is extracted before the permanent premolar has reached one half root length, the emergence of the premolar will be delayed; that if the primary molar is extracted after one half of the premolar root is formed, emgergence will be accelerated. If serial extraction starts with the extraction of the primary cuspids, the length of the root of the premolars is not an important consideration regarding the initiation of the serial extraction.

In contrast, Dale (1976) suggested that if contemplating the start of serial extraction by the removal of the primary first molars rather than the primary cuspids, then the length of the roots of the premolars is an important consideration and guide for the commencement of the procedure.

As regards, the time for removal of the deciduous lateral incisors and canine, Hotz (1970) emphasized, it has to be chosen carefully to guide the eruption of the permanent canines mesially. It may be necessary to hold the central incisors to keep them from drifting distally.

## 7.5 Conventional and Alternative Serial Extraction sequence

### 7.5.1. Conventional sequence

As present,there is no ideal extraction sequence and serial extraction treatment is not an uncomplicated procedure the selection of the sequence must be made for each individual patient.

In addition, Fanning (1962) in considering of extraction sequence noted that it is important to prevent a spurt in the eruption of the permanent canine that may lead to impaction of the first premolars, especially in the mandible of females.

With extraction sequence Dewel (1959) reported that several conditions must exist in any given arch.Both deciduous cuspids must be present, arch length measurments should be unfavorable, and none of the incisors should be completely impacted. The second deciduous molars must be sturdy enough to remain in position for several years, and there should be no gingival recession or alveolar destruction along the labial surfaces of the lower incisors.

Dewel (1969) also asserted that Prelimary interception and correction by serial extraction are accomplished in three sepsarate stages for three separate purposes1) premature extraction of the deciduous canines provides the space for the incisors to assume normal positions in an even alignment directly over supporting bone 2) Subsequent extraction of the first deciduous molars permits the desirable early eruption of the first premolars and 3) the final extraction of the first premolars makes it possible for the canine to erupt in a favorable direction into the spaces formerly occupied by the first premolars. The interval between extractions varies from 6 to 15 months. The objective is to permit a measure of self-correction by reconciling differences between total tooth material and potential supporting bone.

The extraction sequence that Tweed (1963) recommended was;

1) At approximately eight years of age extract all deciduous first molars.Unless there is unhealthy soft tissue involvement around the lower incisors or blocked-out maxillary incisors, it is preferable to

maintain the deciduous tooth to retard eruption of the permanent canine.

2) Some four to ten months following extraction of all the deciduous first molars the first premolar will have erupted to gum level. They should not be removed until their crowns are through alveolar bone.At this time, all first premolars are removed, along with all deciduous canines. If this is done at least four to six months prior to the eruption of the canines when they erupt they usually migrate into good position.

Mayne(1968) also gives basic guidelines regarding extraction sequences;(Fig13)

1) Removal of the deciduous cuspids

Most often these objectives are better served at relieving the crowding of permanent incisors by the earlier extraction of the deciduous cuspids, because the purpose lies in producing the most rapid and maximum amounts of self improvement in the four lateral and central incisors crowding adjustments with greatest opportunity for interception of lingual crossbite of lateral incisors.

Graber (1970) wrote that the purpose of removal of deciduous canines is to permit the eruption and optimal alignment of the lateral incisors. Improvement in the position of the central incisors may reasonbly be expected. Prevention of the eruption of the maxillary lateral incisors in lingual cross-bite or the mandibular incisors in lingual malposition is a primary consideration, but this improvement is gained at the expense of space for the permanent canines. Important is the fact that correct lateral incisor position prevents the mesial migration of the canines into severe malposition that will require concerted mechanotherapy later. He also found that it is important to expedite the normal eruption of the maxillary lateral incisors.Belateed eruption and lingual malposition of these teeth permit the maxillary canines to migrate mesially and labially into the space that Nature has reserved for the lateral incisors.

According to Dale's experience (1976), if the periapical radiograms show the permanent mandibular first premolar crown ahead of the permanent cuspid crown,the premolar with less than one half of its root formed, and the mandibular incisors crowded, he will extract the primary cuspid to relieve the crowding and leave the primary first molar.

Generally speaking, if nature has not already spontaneously exfoliated the deciduous canines or has exfoliated only one or two of them. these teeth are removed between the ages of 8 and 9 years in patients with an average developmental pattern.

2) Removal of the first deciduous molars as the initial step produces the most favorable eruptive response of the underlying first bicuspid, Mayne (1968) found that this not only produces earliest eruption of first premolars, but so greatly reduces the speed and amount of improvement in anterior teeth crowding and position due to retention of deciduous canines, that it has limited application.
Graber (1971) stated that in the mandibular arch where the normal sequence so often is for the canine to erupt ahead of the first premolar removal of the first deciduous molars in the lower arch tips the eruption scales in the direction of the first premolar.
If the crown of the permanent mandibular first premolar is level with the permanent cuspid crown,the root of the premolar developed beyond one-half of its root length, and the cuspid developed even further beyond one-half of its root length. Dale (1976) will extract the primary first molar in an effort to accelerate the emergence of the first premolar,he thought that the cuspid emerges at a faster rate and the permanent mandibular cuspid emerges into the oral cavity ahead of the first premolar far more often than the reverse.
Generally speaking, the first deciduous molars are removed approximately 12 months after the deciduous canines.Thus, first deciduous molars would be removed between the age of 9 and 10 years in the average developmental pattern.It would vary from child to child and might sometimes be done earlier in the mandible than in the maxilla to enhance early eruption of the first premolars.Timing is really not so critical for removal of the first deciduous molars, and there are those who might prefer to remove the remaining deciduous canines and first deciduous molars at the same time, somewhere between the age of 8.5 and 10 years.(Graber1971 )

3) Removal of both the first deciduous molars and the deciduous cuspids simultaneously may appear to be the logical compromise of 1 and 2, but this does not generally prove to be the case in actual practice, as the resultant deep overbite often demonstrates.(Mayne 1968 )

Extracting deciduous first molars is a compromise between rapid improvement in anterior incisors and desired early eruption of premolars.

7.5.2 Alternative sequences

Many extraction sequences have been suggested such as

a) C,D,4

b) C+D,4

c) D,C +4

d) C, D + enucleation of 4

e) C, D, E,4,

f) C, D, no permanent tooth extraction

g) occasionally some or all second premolars are substituted for first premolars.

However, any sequential program of serial extraction aims at relieving the crowding of the permanent incisors by removing deciduous canines.Accelèration of the premolar eruption is obtained by extraction of its deciduous predecessor and extraction of the first premolars immediately following their emergence, then permitting self-alignment of the permanent canines.

Graber (1971) questioned removal of four first premolars,only to find that the third molars are congenitially missing and there would have been enough space without premolar removal. If the diagnostic study confirms the inherent arch length deficiency,the purpose of this step is to permit the canine to drop distally into the space created by the extraction. But Mayne (1969) points out that extraction of first premolar buds(enucleation) permits maximum distal translation of canines. This amount may be undesirable in many instances, producing excessive incisor and mid-face retrusion and reducing the resistance value of the anterior teeth for final space closure. This approach requires exacting surgical procedures to minimize alveolar trauma and possible injury to adjacent tooth buds. Enucleation in the upper arch is only rarely indicated. It is usually of genuine interest only in the lower arch .

Dale (1976) found that if the permanent mandibular cuspid crown is ahead of the first premolar crown in the periapical radiograms, he will not enucleate the premolar. Approximately six months later he usually observes the first premolar attempting to erupt,but being obstructed by the mesial contour of the primary second molar.He then extracts the primary second molar and extracts the permanent first premolar later when it emerges.By this time, the permanent cuspid is erupting into a relatively forward position and he is left with an excess of space to close.With the multibanded appliance,it is not difficult to close this excess space and it does not prolong treatment significantly.

If the timing has been right, it is a most rewarding experience, after removal of the first premolars, to see the bulging canine eminences move distally on their own into the premolar extraction sites. Clinical experience indicated that this happens more frequently in the maxillary than in the mandibular arch. It is here that the timely removal of the unerupted mandibular first premolar may prevent the abnormal mesial eruption of the mandibular canine, which would increase the appliance challenge later.

Hotz(1970) suggested two possible sequences of eruption. If the second premolar erupts before the canine,the first premolar serves as space maintainer and should not be extracted before eruption of the second premolar. If the canine erupts before the second premolar, the first premolar must be extracted early,often before eruption.

Dale(1969) suggested that the chief alternative in serial extraction is in reversing the removal of the two deciduous teeth. In certain borderline cases the first deciduous molars are extracted before the deciduous canines. As in the conventional sequence, the first premolars are the last to be extracted. It has its specific indications, and it serves a different purpose than the more conventional extraction order involving the initial extraction of the deciduous canines. Moorrees (1963) felt that depending on the inclination and position of the unerupted permanent teeth relative to each other and to the alveolar margin, extraction of the deciduous first molars should be performed first.The first premolars are extracted after emergence together with the deciduous canines when still present.

On the other hand,some authors advise removing the deciduous cuspid and first deciduous molar simultaneously. (Mayen,1968) so as to relieve the crowding of the permanent incisors.

### 7.5.3 Extraction of the Deciduous Second Molars

Where the canines have erupted prior to the first premolars in the mandibular arch,the convex mesial coronal portion of the second deciduous molar may interfere with first premolar eruption.In such cases, it is necessary to remove the second deciduous molars. Graber (1970) stated that this is a more conservative step, and it is usually preferable to enucleation,but it increases the likelihood that a holding arch may be needed to prevent undue loss of space and excessive mesial drift of the first permanent molar.

Removal of the second deciduous molar introduces additional consideration regarding anticipated arch length loss through mesial drift of the unstabilized first permanent molar.

When the primary second molar is lost prematurely,the permanent second premolar is quite often deep in the alveolar bone. Dale (1976) points out that this would encourage the permanent first molar to tip forward. However, when the primary first molar is lost prematurely, the permanent first premolar, which is scheduled to emerge before the second premolar,is not so deeply embedded in bone. Therefore, the tendency for tipping of the primary second molar is not as great, with the first premolar supporting the primary second molar.

## 7.6 Diagnostic Prerequisites for Serial extraction

### 7.6.1 Clinical Considerations

1) Cephalometric and skeletal aspects.

No serial extraction diagnosis is complete without a thorough cephalometric analysis and it is essential that this analysis be repeated prior to each succeeding stage in the serial extraction program. The purpose is to determine the nature and extent of skeletal growth during the prolonged period of supervision with serial extraction.

Standard cephalometric measurements are used in the thorough serial extraction analysis. According to Dewel (1969) the most important are SNA, SNB, the ANB difference, the Frankfort-mandibular plane angle, and the position and inclinations of the incisors relative to SN, to the mandibular plane, and to the NP facial plane.

The typical Class I serial extraction case presents a facial pattern that can best be described as flat or straight. Dewel (1969) found that it is frequently referred to as bimaxillary protrusion.In these protrusive cases,the incisors show a distinct anterior displacement when related by a line drawn from nasion to pogonion.The incisors not only are labially displaced but they also have an increased labial inclination. In patients with bimaxillary protrusion,the entire mass of teeth seems to occupy a wide area in the lower half of the face.

Dewel (1969) shows that in the classic serial extraction case, the dental area is limited in extent and the incisors are more vertical and in a more acceptable relation to the nasion-pogonion facial plane. Usually there is a marked reduction in arch perimeter length between the first molars and the lateral incisors, with total space loss that is approximately the width of a premolar in each of the four posterior segments of the dental arches. There is distal reduction in arch length as well as mesial to the first molars. He also stated that lower incisors position constitutes one of the most critical in cephalometric discrepancy analysis. Posterior arch length discrepancies are determined by second molar position and the combined mesiodistal widths of the cuspids and premolars. Anterior discrepancies are determined by cephalometric analysis of the positions and inclination of the lower incisors. If the lower incisors have an excessive lingual inclination,correction by labial repositioning will increase the space for the cuspid and premolars. Conversely, if the incisors must be repositioned in a lingual direction, this will decrease the space for the cuspid. Then the posterior arch length deficiency must be of severe order to justify a serial extraction program.

2) Dental consideration

Hotz (1970) recommended dental considerations: the mesiodistal relationship of the upper and lower first permanent molars and the width of the upper central and lateral incisors, as compared with the lower incisors, and the relation of the unerupted second permanent molar to the first molars .He summarized his morphologic evaluation as follows;

(1) State of tooth eruption and root formation.

(2) Size ratio of the deciduous and permanent teeth in the labial and buccal segments.

(3) Size of the apical base

(4) The relation of tooth size,arch width,and supporting bone

(5) Probable sequence of eruption

(6) Congenitally missing teeth

(7) Positions of unerupted canines,premolars and second molars

(8) Intercuspation of the first molars.

Jacobs (1987) stated that for first premolar extractions consider the following aspects:

i) Maxillary canines are larger than first premolars and therefore maxillary space maintenance is usually required.

ii) Maxillary first premolars are larger than second premolars which are often rotated and take up more space than estimated.

iii) Mandibular second premolars are larger than first premolars so sufficient space must be available for them .In addition, if the second premolars are rotated they require even more room.
In addition, Dewel (1969) pointed out that the second molar area should not be ignored in any extraction decision, serial or otherwises If radiographic examination reveals an unerupted second molar in close contact below the distogingival curvature of the first molar,then extraction can still be considered, provided that sufficient space can be demonstrated elsewhere in the dentition. If a space of 1 or 2mm is present between the first and second molars, then this should be considered in arch length evaluation, for it usually means that the lower first molars can be moved distally with reasonable assurance that they will retain their new position. For these reasons, every arch length evaluation must include a consideration of the positions of the second molars and of the four incisors. This is especially important in borderline mixed dentition irregularities,for these are the cases in which treatment should often be conducted with a full complement of teeth and not by serial extraction.

3) Facial Esthetics consideration
Esthetics usually is not a problem in the early stages.Lip fullness,therefore, is not a reliable criterion for extraction in the early mixed dentition. The straight profile must be viewed with greater concern, for the early removal of premolars is then more likely to cause a concave, recessive area in the lower half of the face in the permanent dentition.(Dewel,1967) ) On the other hand, nasal development represents another unpredictable hazard in every esthetic analysis. The nose can possibly grow long, after other facial parts have reached maturity. Moreover, there is no way of predicting how much remodeling will occur at the point of the chin as the face matures. If growth in the nose and at the chin exceeds the normal range of variation, a concave profile is assured midway between. Recognition of these unfavorable profile changes should act as a deterrent in all decisions for extraction in the early mixed dentition.

7.6.2 Prerequisites

Arch length analysis is an essential part of every serial extraction diagnosis. The purpose is to determine the extent of space loss mesial to the first permanent molars , and this is accomplished by comparing the combined mesiodistal widths of unerupted premolars and canines with the spaces present between the lateral incisors and the first molars.This analysis serves as a guide in determining the relation between available and required space,and it is based on the premise that there will be no change in the original positions of the incisors and the first molars.

At present there are two methods used for space analsis

i) Conventional method:

The space required the four mandibular incisors is measured at their greatest mesiodistal crown diameters by means of a sliding. Boley gauge with pointed beaks. All measurements are made with the gauge parallel to the incisal edge of the teeth, and all readings are to the nearest 0.1 mm

The widths of the four mandibular incisors are used to predict the size of the cuspid and the first and second bicuspids in the mandibular arch by referring to Moyer's probability chart. The value obtained,however, may not be sufficiently precise to permit application to an individual patient.In this system, the sum of the predicted mandibular cuspid and first and second bicuspid diameter is added to the sum of the mandibular incisors diameters. The total represents the required arch length necessary to accommodate the teeth. The actual arch length is then subtracted from the estimated required space.In this system it is also necessary to allow space for molar adjustment into Class I relationship.

For unerupted cuspid and first and second bicupids, sizes may be estimated on the periapical radiograph as Huckaba (1963) recommended. The method is a measurement of the maximum mesiodistal diameters of the unerupted cupids and bicuspid from periapical radiographs. .

ii) Tweed method

An assessment of the relationships between the axial inclination of the mandibular incisors and the base bone is made on a tracing of the lateral cephalograph.The amount of alveolodental protrusion or retrusion is assessed and incorporated into the mixed dentition analysis .

Tweed Foundation research has established the following relationship:
When the FMA is between 21 and 29 the FMIA should be 68
When the FMA is 30 or greater, the FMIA should be 65
When the FMA is 20 or less, the IMPA should not exceed 92

Arch length calculations,moreover,are more conclusive in the lower arch than in the upper arch for the simple reason that it is more difficult to recover lost space in the lower arch than it is in the upper arch.This means that if the irregularity can be corrected without extraction in the lower arch,then it ordinarily can be corrected without extraction in the upper arch.
On the other hand, Dewel (1976) stated that in the diagnostic decision, it must be remembered that at an early age the presence of teeth contributes to arch development and the absence of teeth detracts from arch development. This is due in great part to normal contacting relations, in which each tooth contributes its part in maintaining arch length.
The position of the lower incisors comprises the second neglected area in determining whether arch length can be increased. These incisors may spaced, or they may present an excessive lingual inclination beyond the range of normal variation. The usual cause is premature loss of the deciduous canines either by natural means or by ill-conceived serial extraction. Arch length often can be increased by closing the incisor spaces and by uprighting these four lower anterior teeth.

## 7.7 Variable Effects and Problems in Serial extraction Procedure

### 7.7.1 Variable effect

There is often an increased inclination of teeth on either side of the first premolar extraction site.As Dempster, Adams and Duddles (1963) showed in their study of axial inclination,the long axes of the teeth converge in the maxillary arch. The compensating curve and the occlusal surfaces of the mandibular arch form a concave arc, so that the long axes in the mandibular buccal segments diverge. Thus, there is automatic paralleling of the roots with removal of the first premolar in the maxillary arch.On the contrary, removal of the mandibular first premolar permits tipping the

together of the crowns, accentuating the "V" or "ditch", as it is called by some orthodontists.
The "bite" tends to close at least temporarily during the extraction supervsion period in most instances,particularly in patients with a Class II tendancy. Martin Schwarz (1961) showed that there are three periods of physiologic raising of the bite, with eruption of each successive permanent molar.This does not happen all the time but ample evidence exists to show that even in serial extraction cases there is an autonomous reduction of the overbite with the eruption of the second and third molars.
Sometimes there is further reduction in arch length during the period of guidance. The lower incisors, which align themselves, may also become more upright (lingually inclined ) which increases the overbite tendency.
More frequently, the serial extraction patient will come in with better adjustment in the maxillary arch than in the mandibular arch. Almost always there is the "ditch" between the permanent canine and the second premolar in the mandibular arch, whereas the roots of the maxillary second premolar will paralled themselves fairly well with autonomous adjustment. This is almost never true in the mandibular arch, as noted above.

### 7.7.2 Problems

Problems have been observed by Jacobs(1987):

1) Serial extraction may cause an increase of the overbite.
The procedure is best avoided in Class II Division 2 malocclusions.

2) It is unpleasant for a child to have four teeth extracted each time on three or four occasions i.e.up to sixteen teeth.This is an important consideration.

3) If extractions are carried out too early the results may be
i) space loss and, or,
ii) delayed eruption of permanent successors and, or,
iii) elimination of the opportunity to extract other teeth which may become carious without adequate care particularly permanent first molars.

iv) once permanent teeth are removed the patient is often committed to immediate appliance therapy otherwise space loss would occur.Use of orthodontic appliances (even space maintainers) is frequently required, which then greatly extends the period during which the patient must wear appliances.
Removal of premolars in the mandibular arch may enchance the overbite tendency. The mandibular incisors align themselves but also tend to move lingually, increasing the overbite. This may signal the need for holding arch or a bite plate.

v) In some cases, lingual collapse of lower incisors can occur producing collapse of lip profile, as noted earlier.

## 7.8 Summary and Conclusions

Serial extraction does have an effective place as a guide to occlusal development. It employs removal of deciduous teeth ahead of the time which provides room for certain teeth decreasing crowding in permanent dentition and causing autonmous adjustment to help establishing proper relationship of the maxilla and mandible.
To complete the procedure requires good diagnostic skills and continued management. In certain cases, it is possible to use this technique without orthodontic mechano-therapy but in others it is required. In all cases progress must be monitored. The serial extraction procedure is often of significantly shorter duration with less damage, and the results are more stable.

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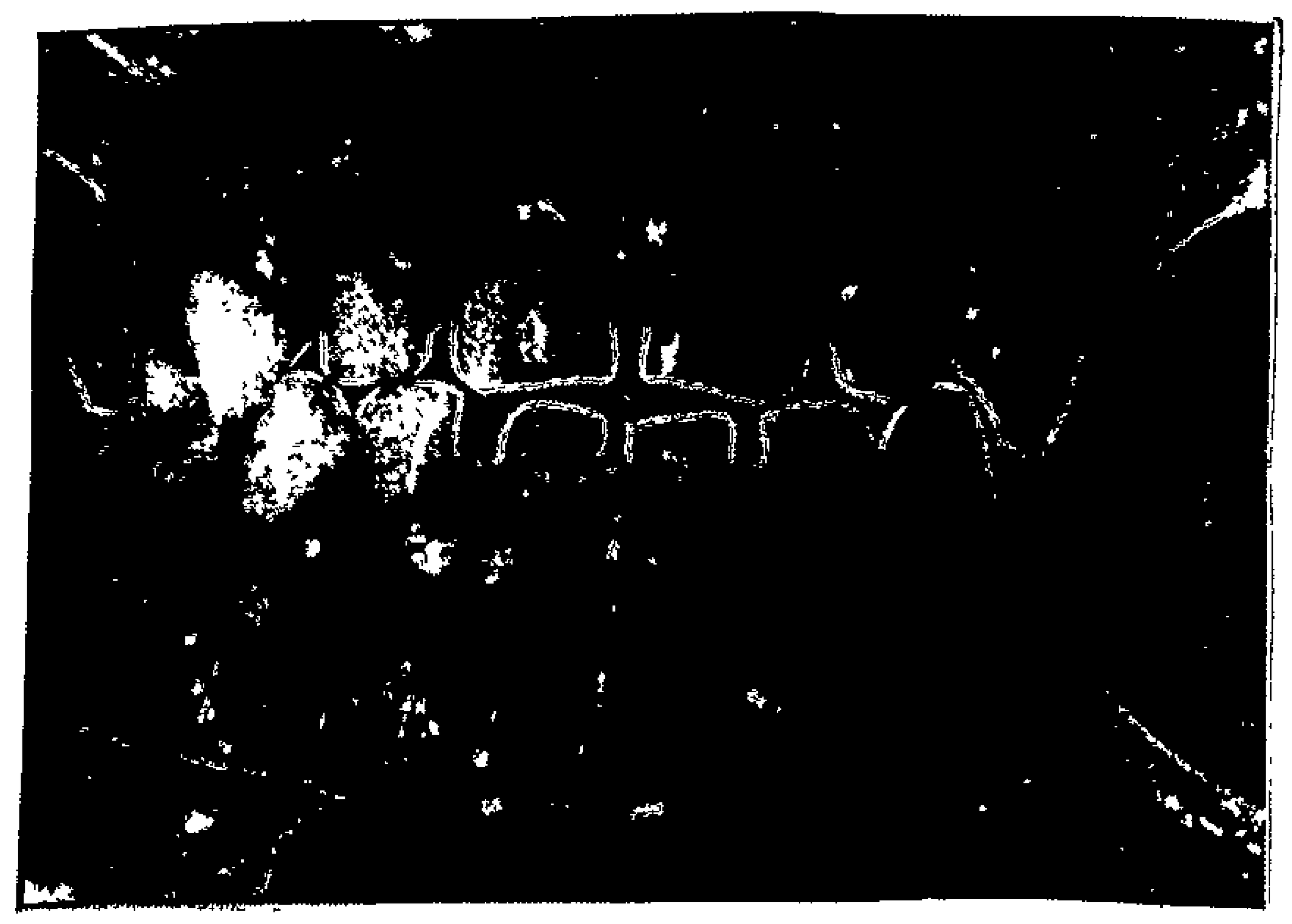


Fig 1. Space between the primary incisors are
hormal within the primary dentition. (Proffit 1986)

Fig 2. Primate space in the maxillary arch
between second incisor and canine,and in the
mandibular arch between canine and first
Deciduous molar of a deciduous dentition.(Baume 1950)

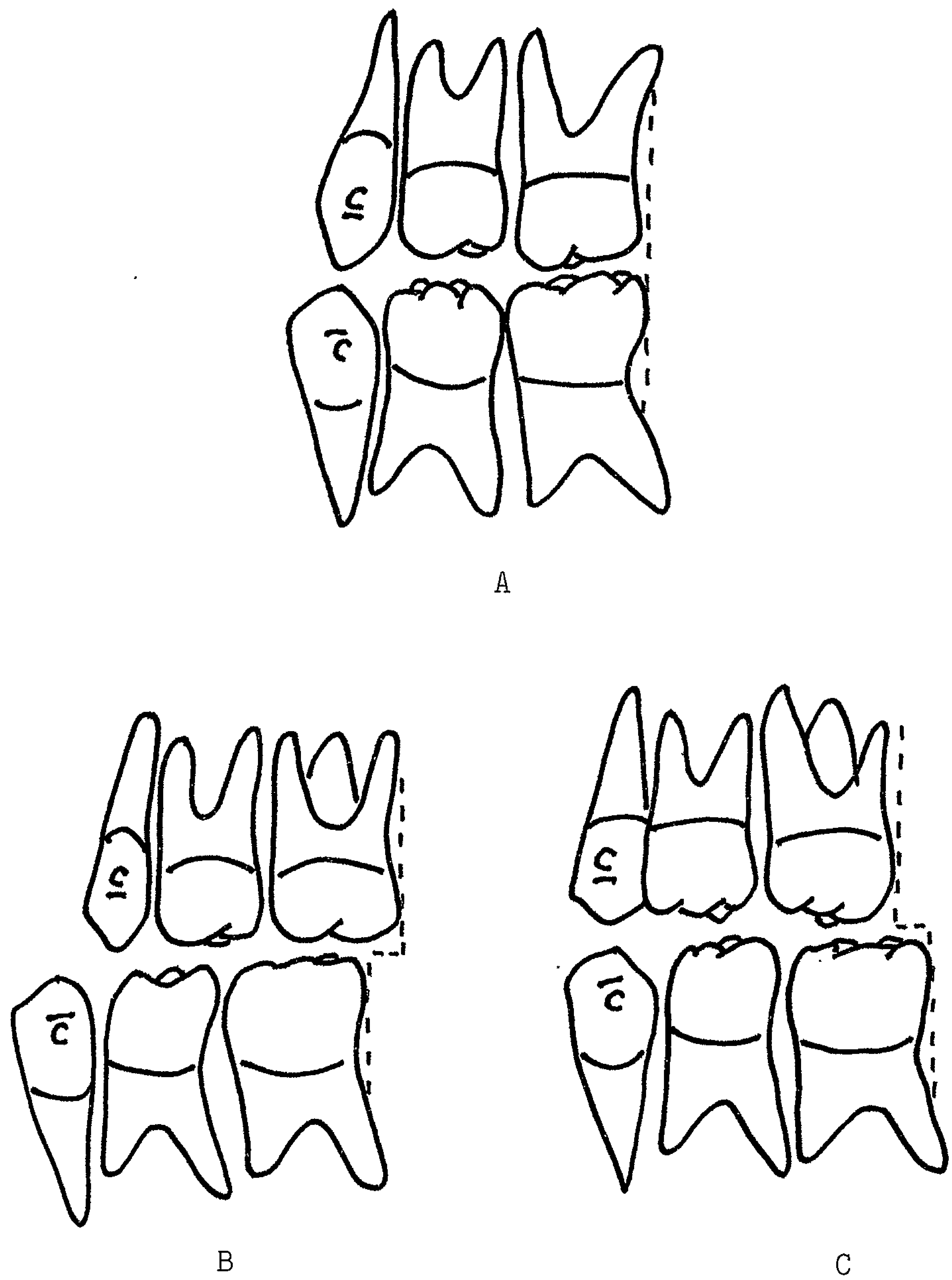



Fig 3. A, Straight terminal plane.
B, Mesial step.
C, distal step.
(Moyers 1968)

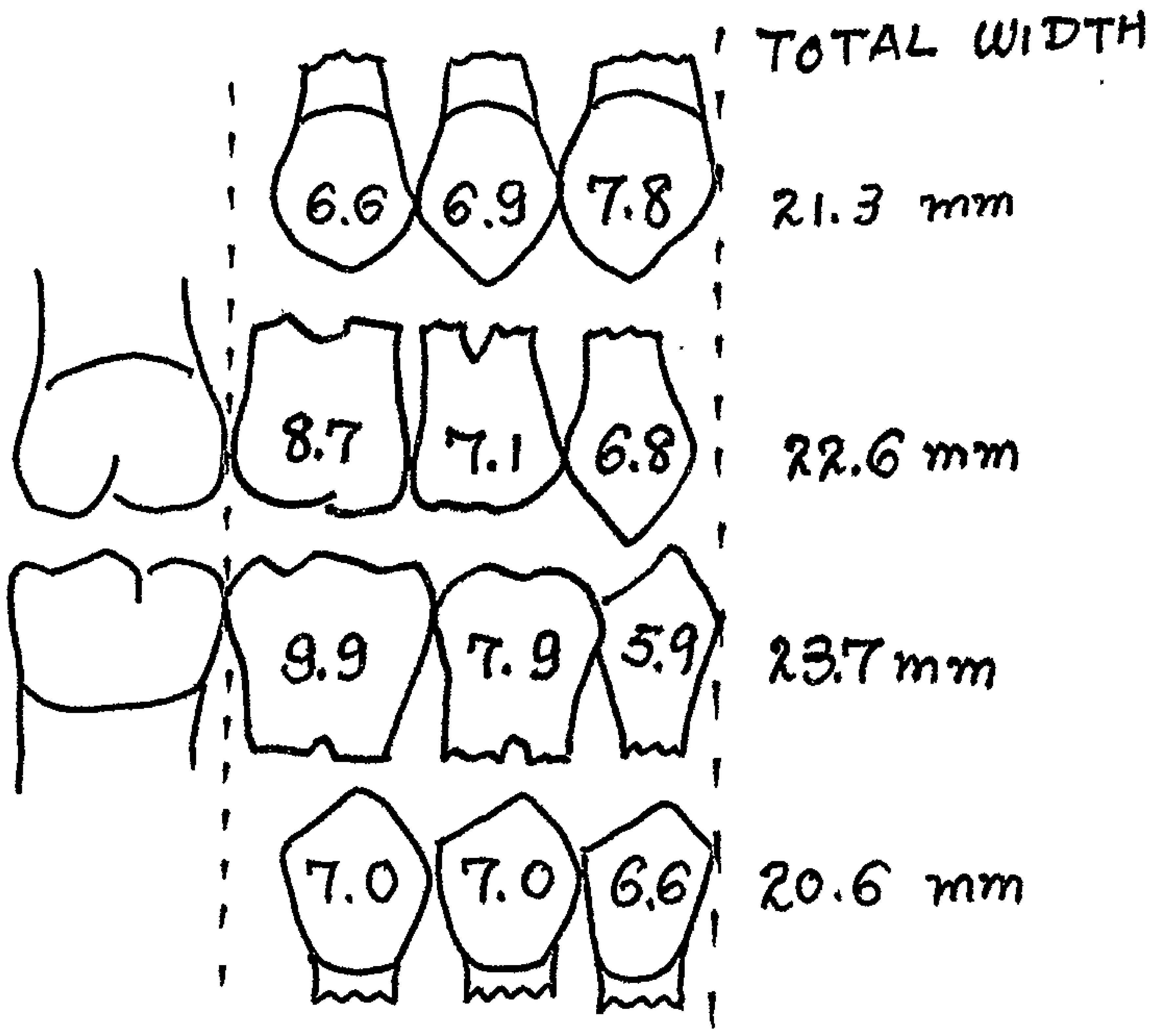



Fig 4. Leeway space has a mean value of 1.3 mm, and in the mandibular arch of 1.3 mm. (Moyers 1969)

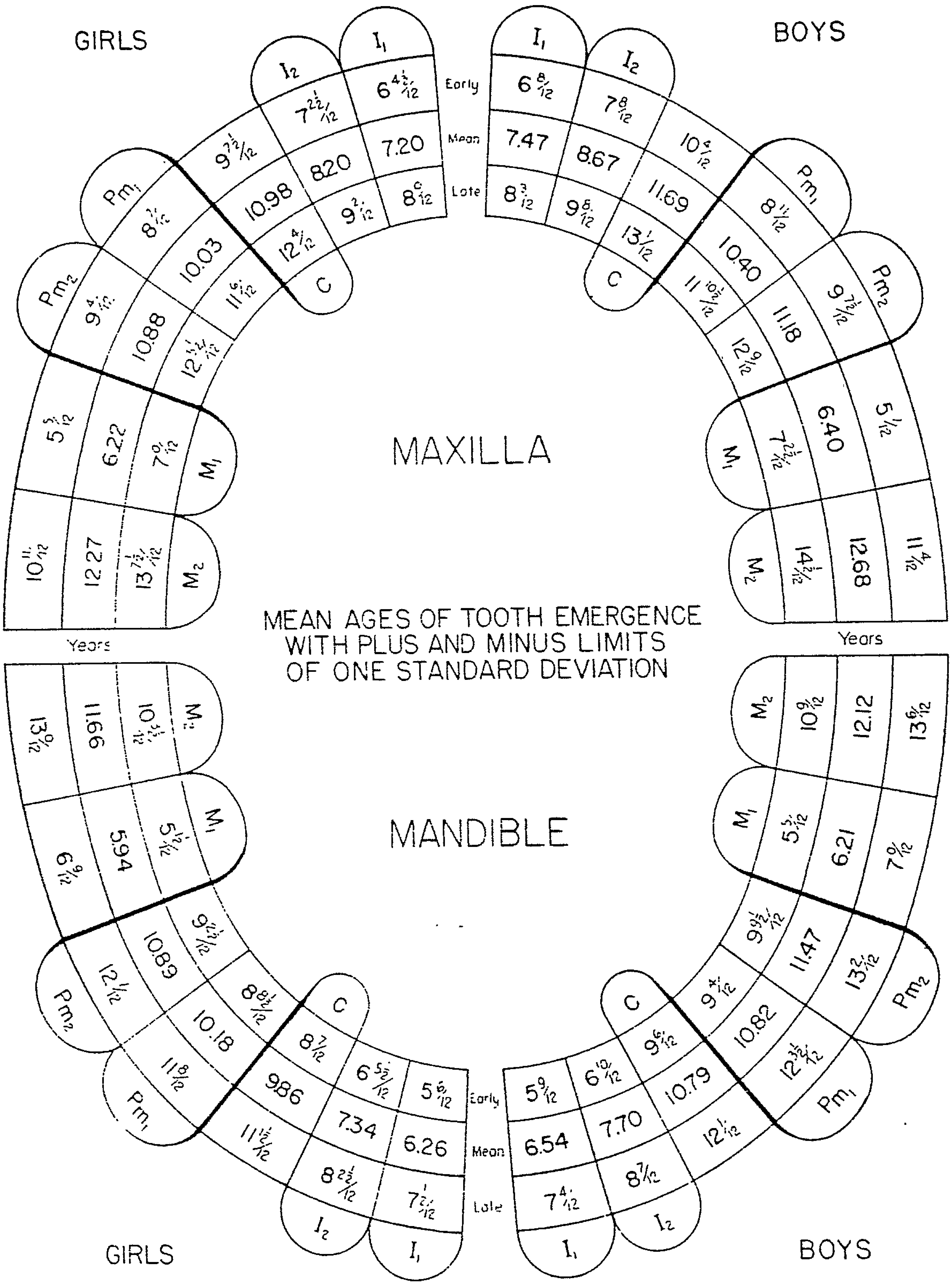
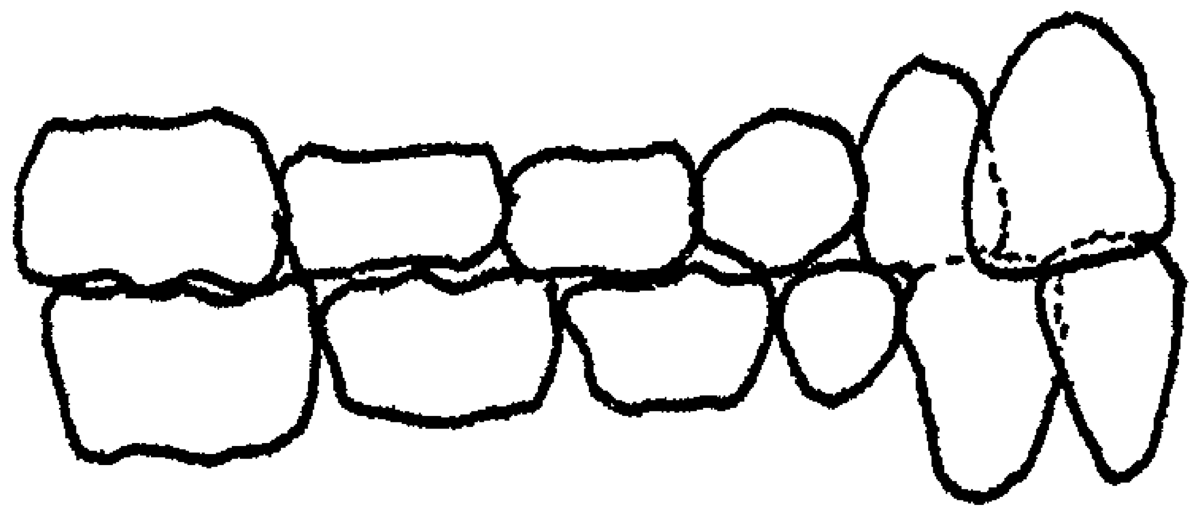
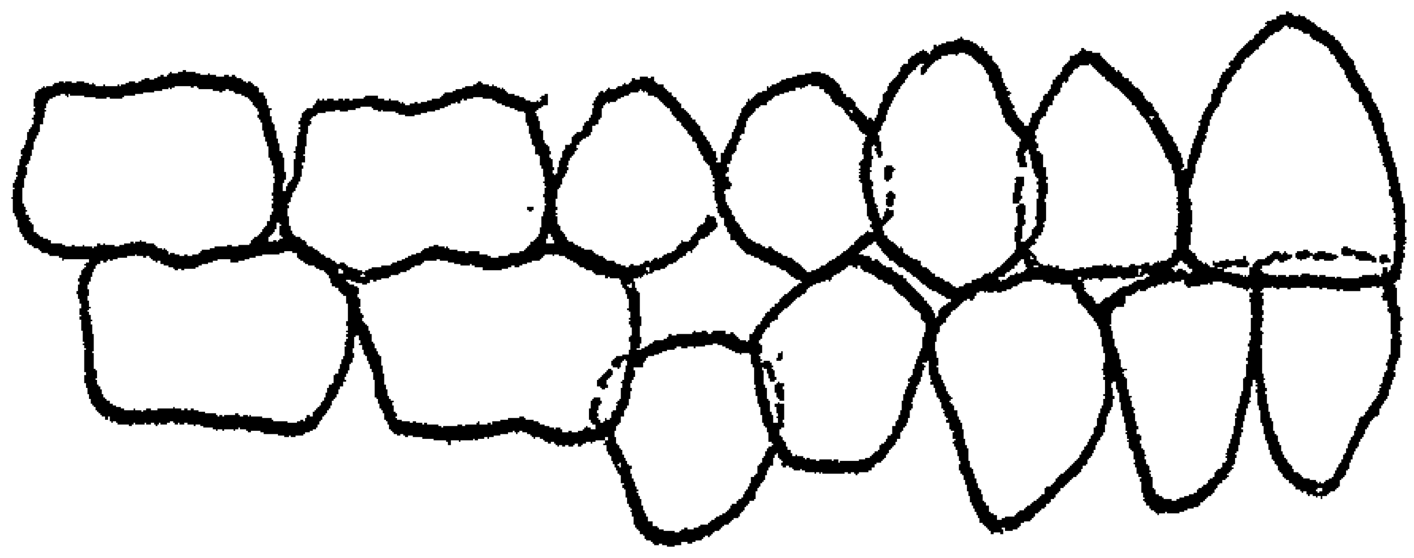


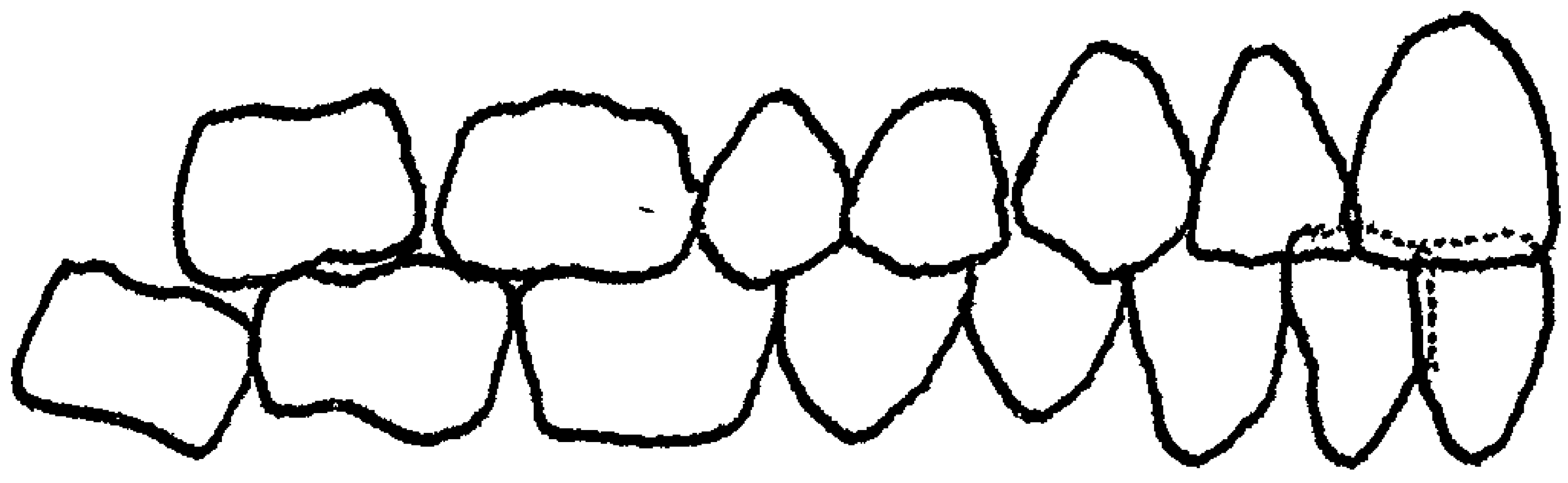

FIG. 5. From Hurme, V. O., and Forsyth Dental Infirmary.( Nanda 1982)



a. Primary crowding



b. Second crowding



c. Teriary crowding

Fig 6. Different of crowding(Linen 1974)

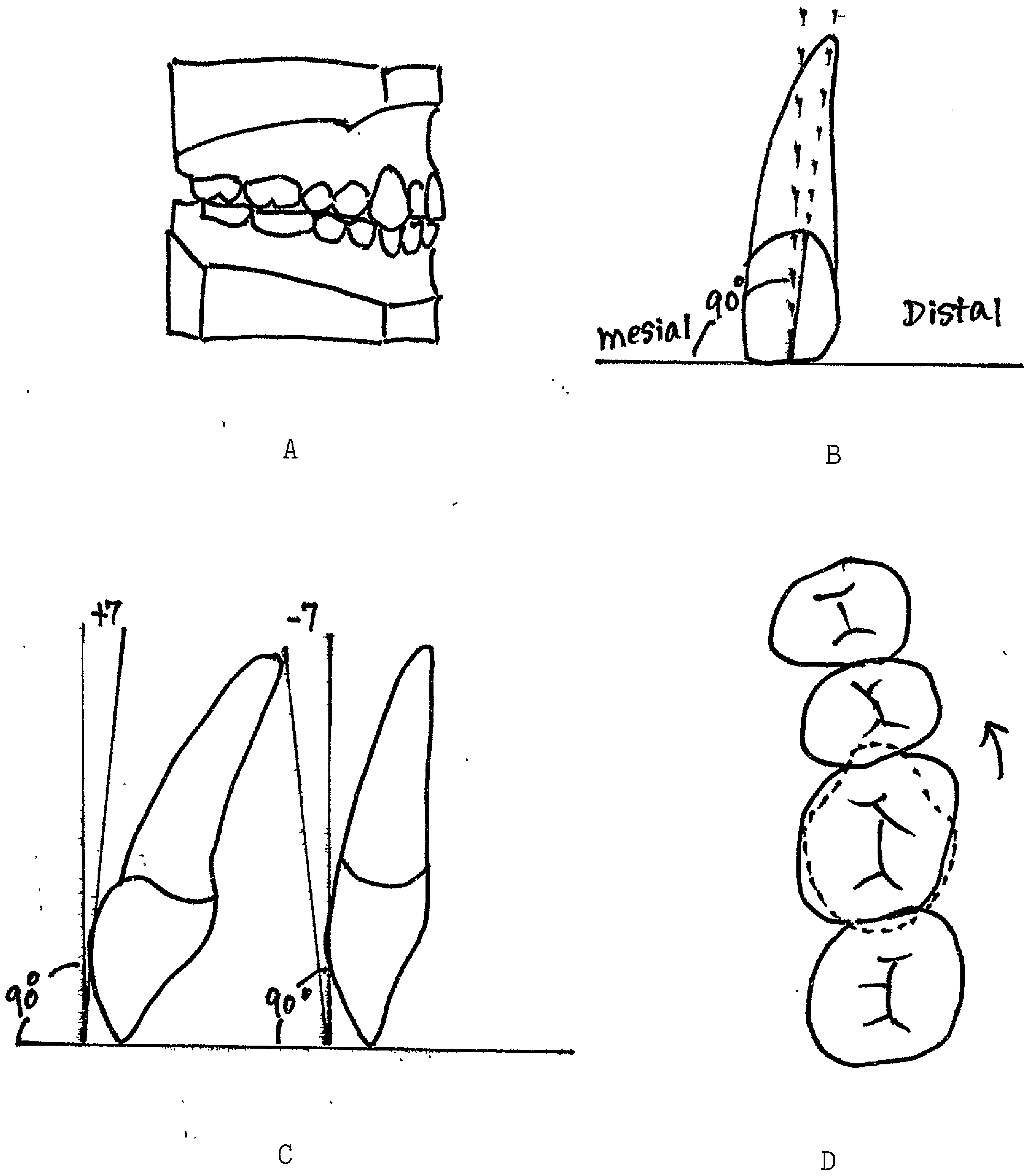



Fig 7. Andrews six keys.

A, Molar relationship (key I)

A flat curve of spee (key VI)

B, Crown angulation (key II)

C, Crown inclination (key II)

D, A rotated molar occupies more mesiodistal space.(key IV)

(Andrews 1976)

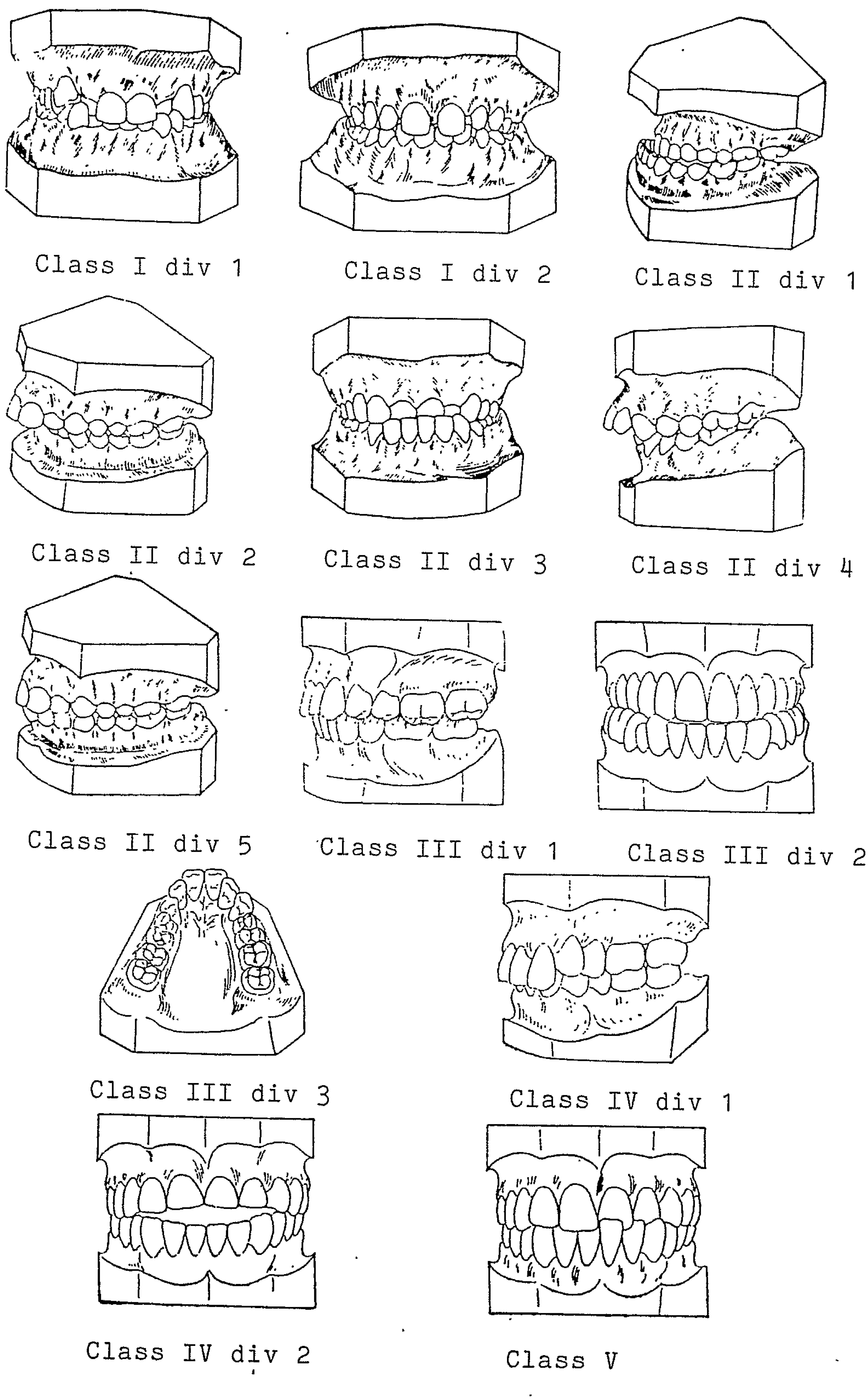



Fig 8.Mao's (1959) Classification.

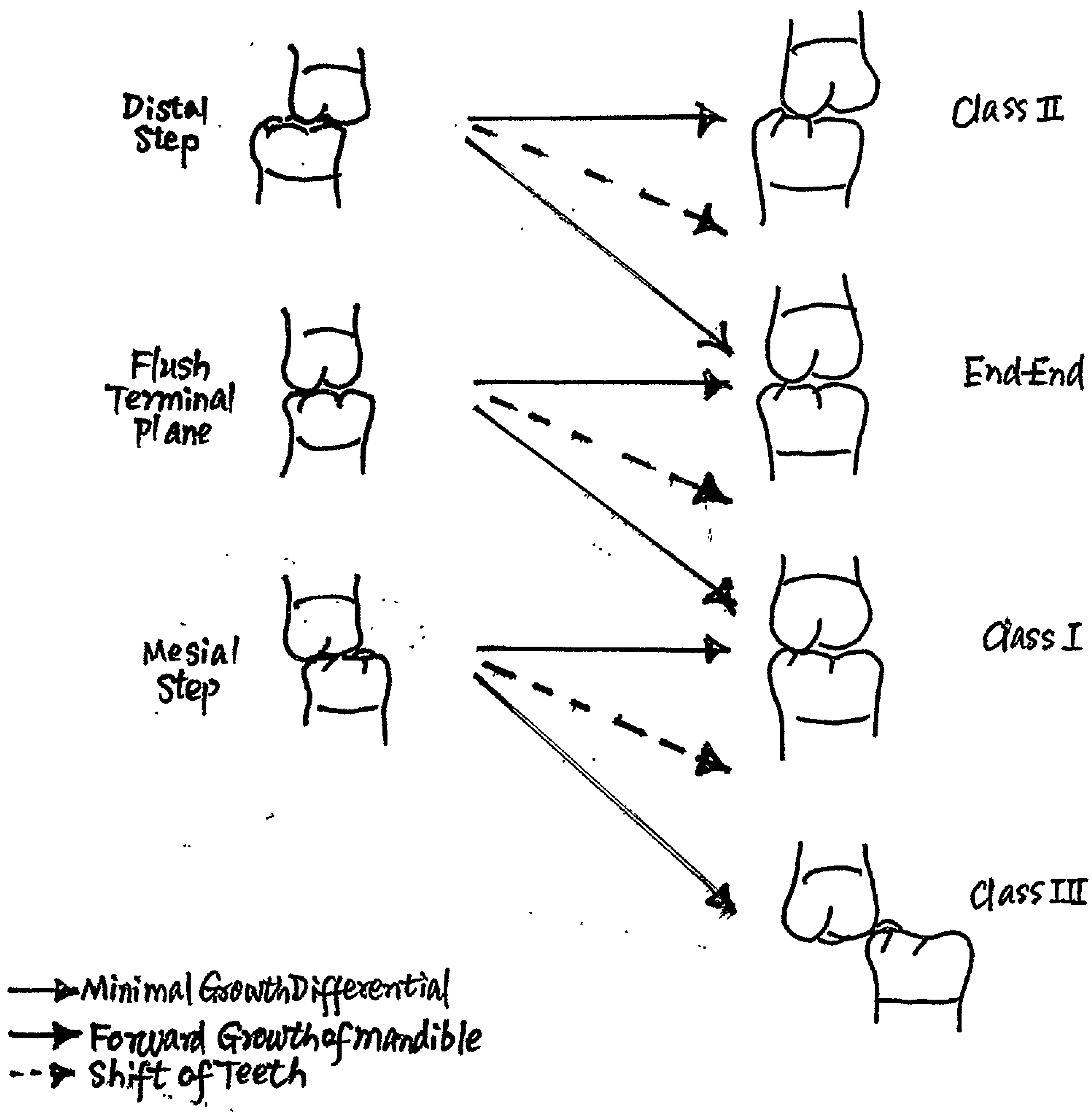
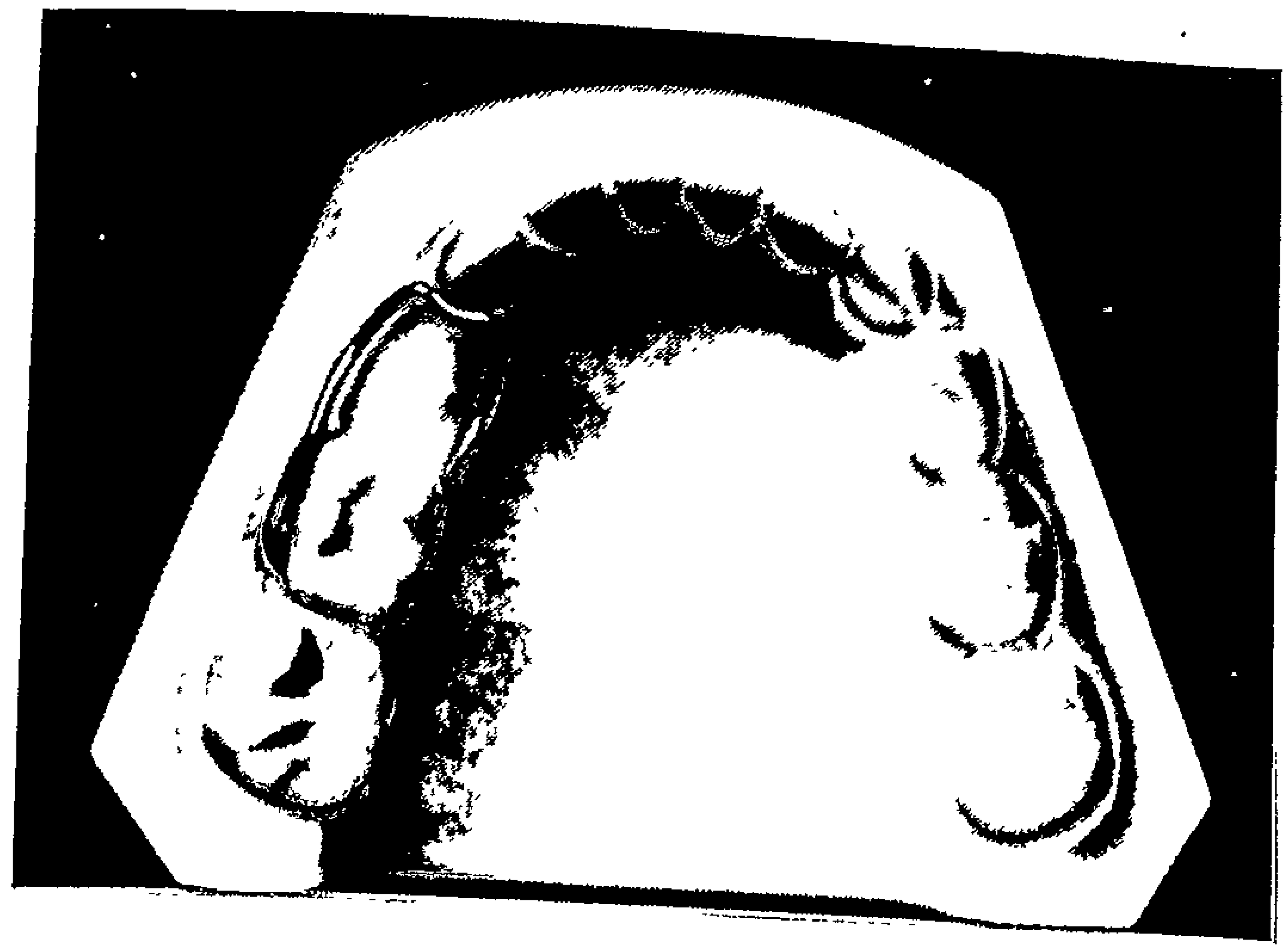
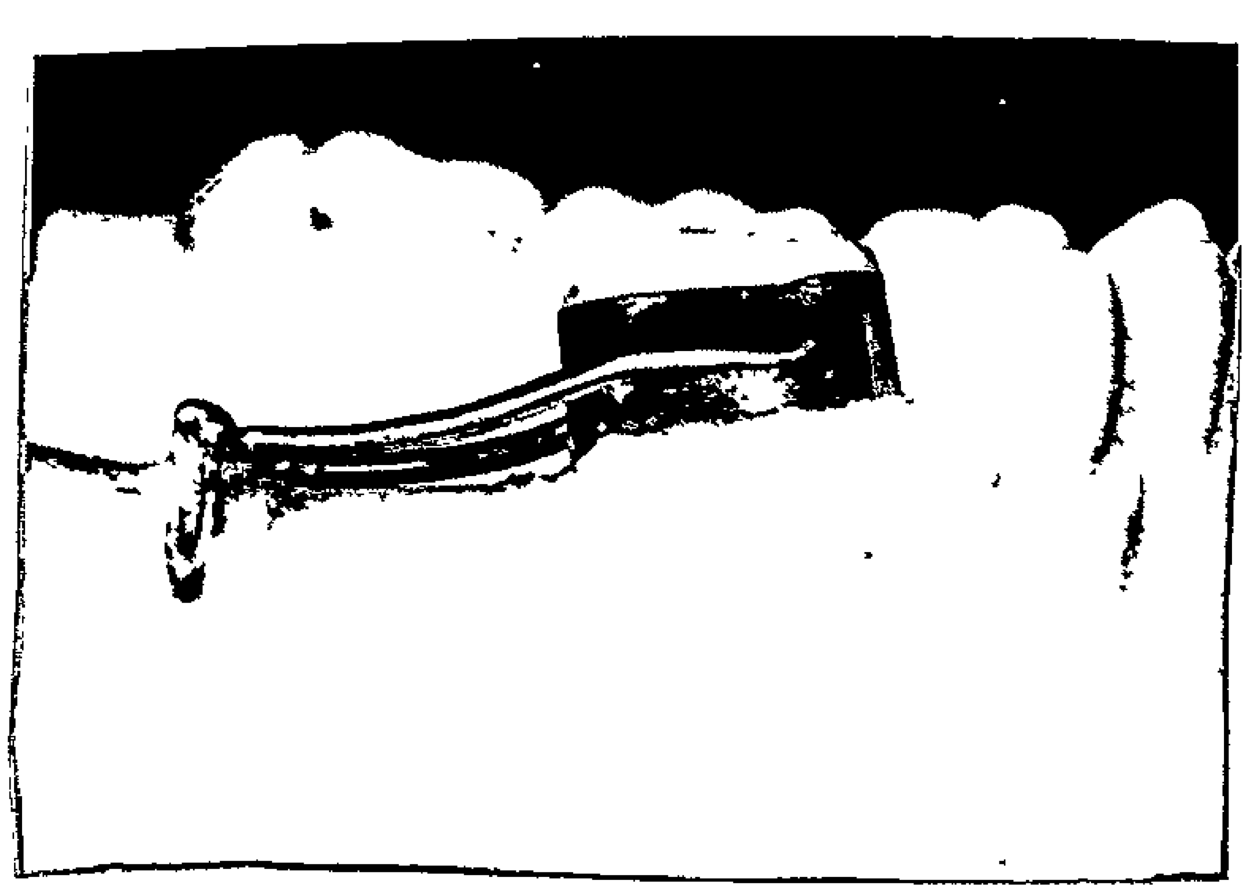


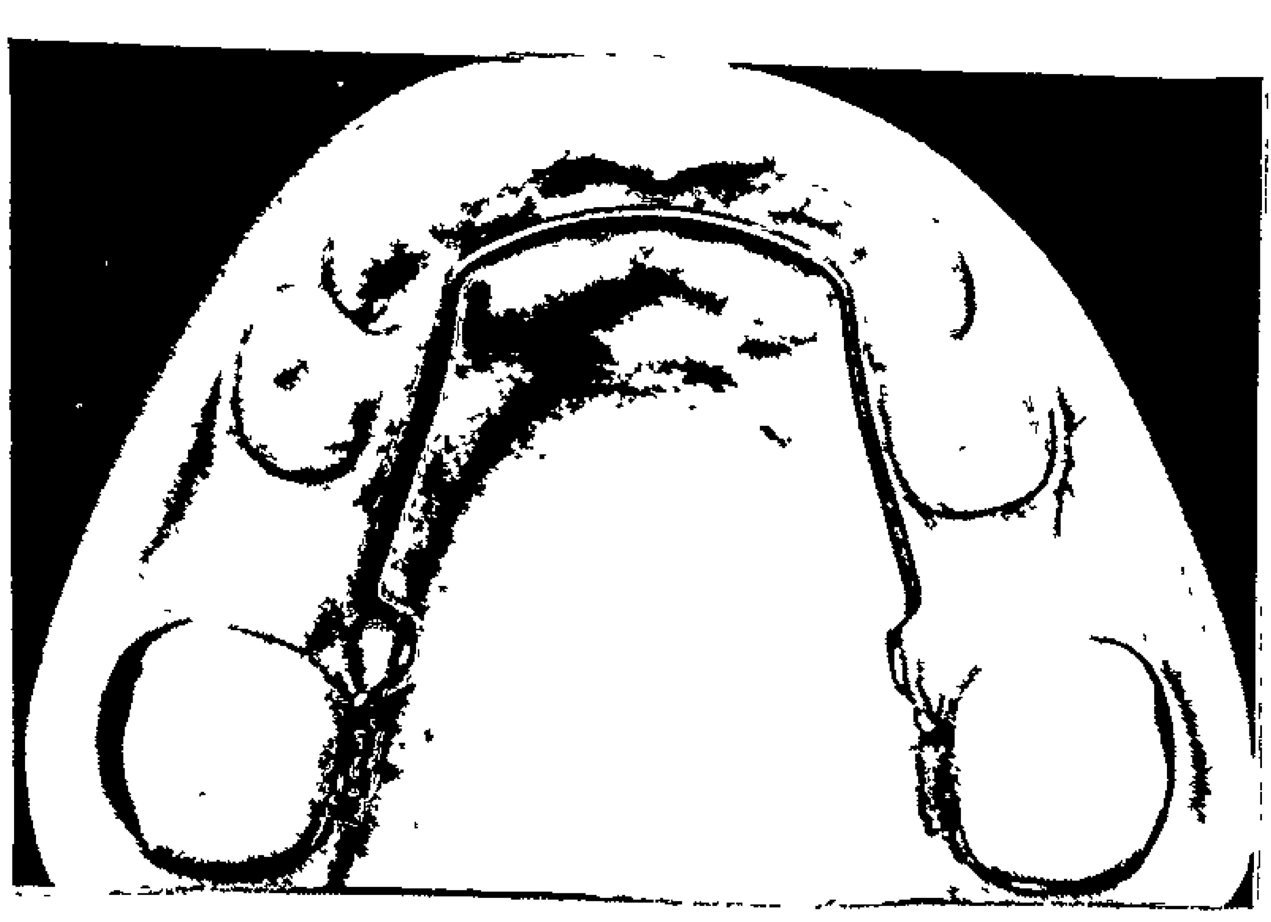

Fig 9. Occlusal relationship of the primary
and permanent molars. (Moyers 1980)



A

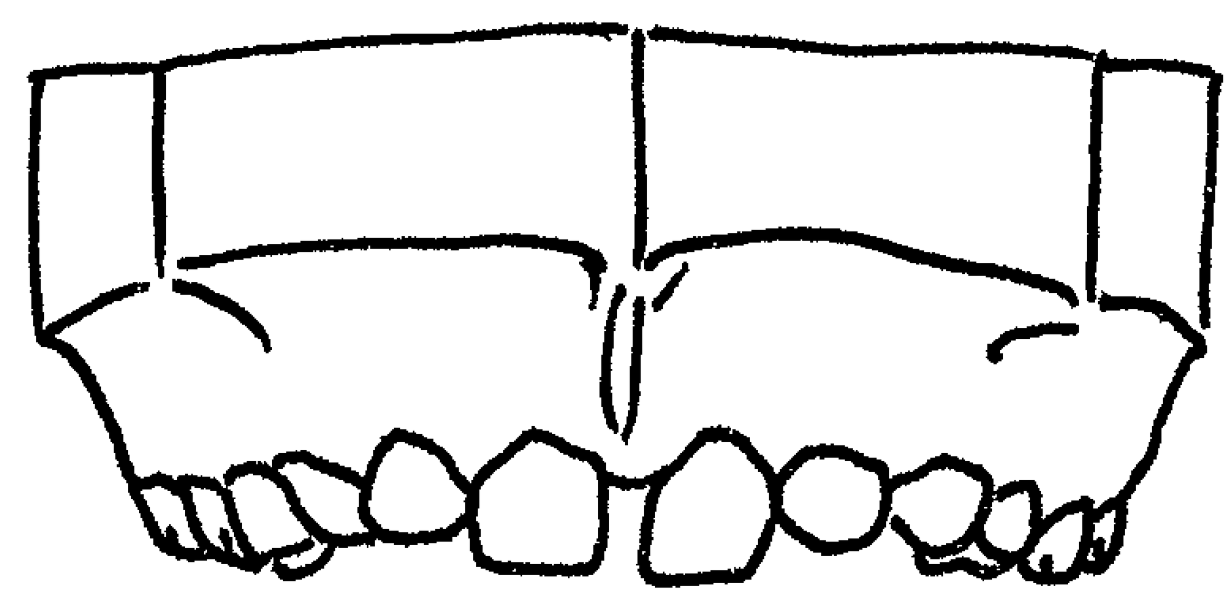


B

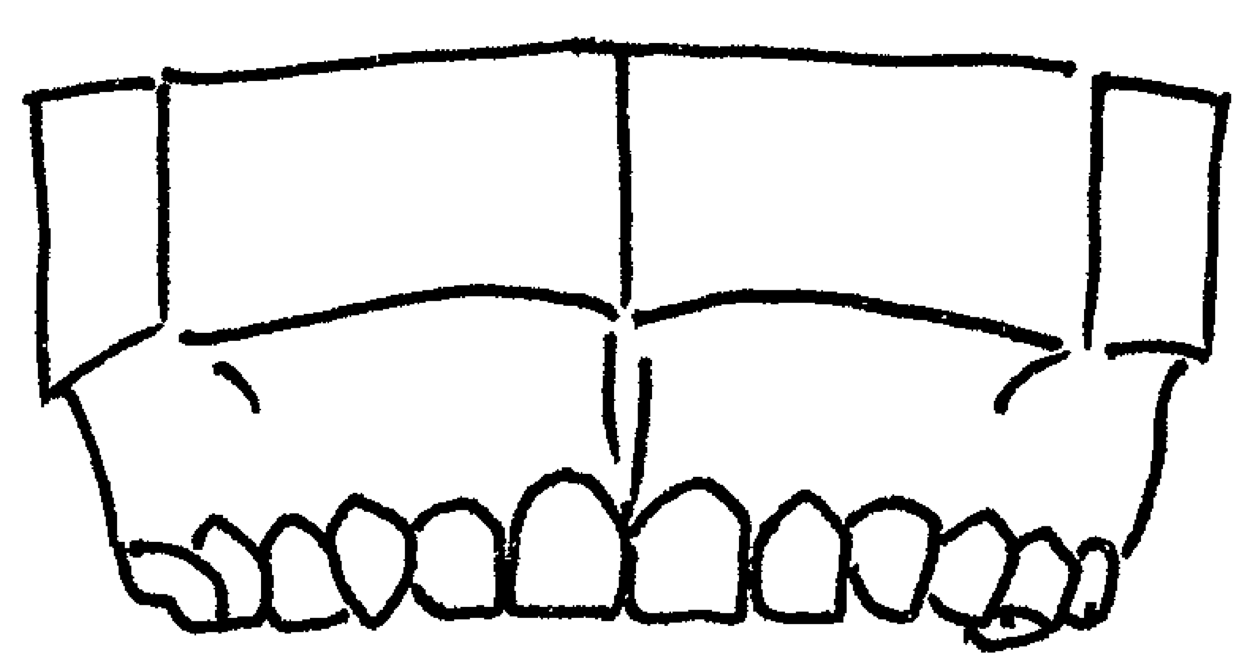


C

Fig 10. A, A band and loop space maintainer.
B, The distal shoe maintainer.
C, The lingual holding arch.
(Proffit 1986)



A

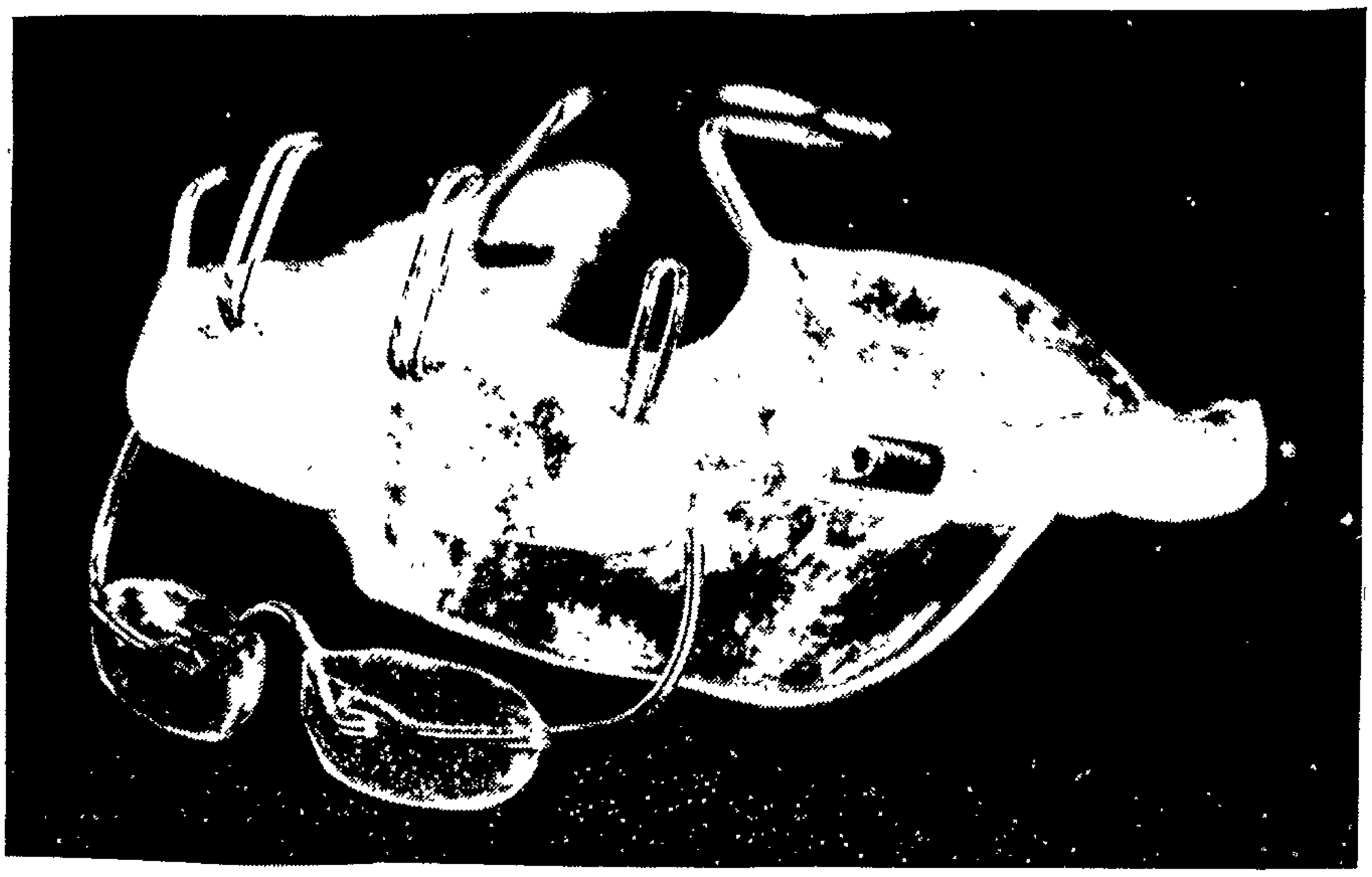


B

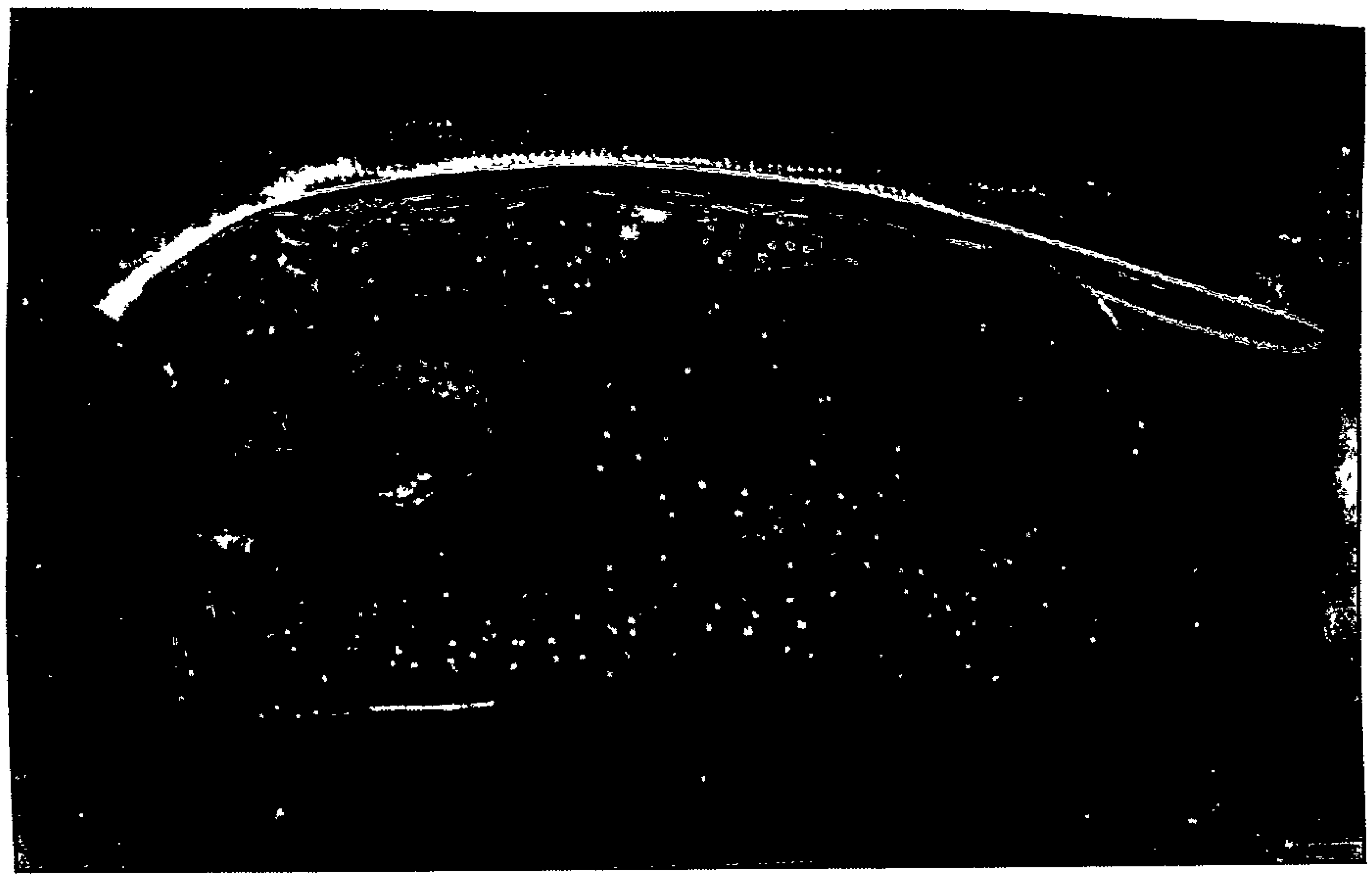
Fig 11. A, Broa bent's "Ugly Duckling" stage in the mixed dentition with spacing of central incisors and slight labioversion of lateral incisors.

B, The resulting normal development of the ull permanent dental arch.(Godfrey)

D, FR 3

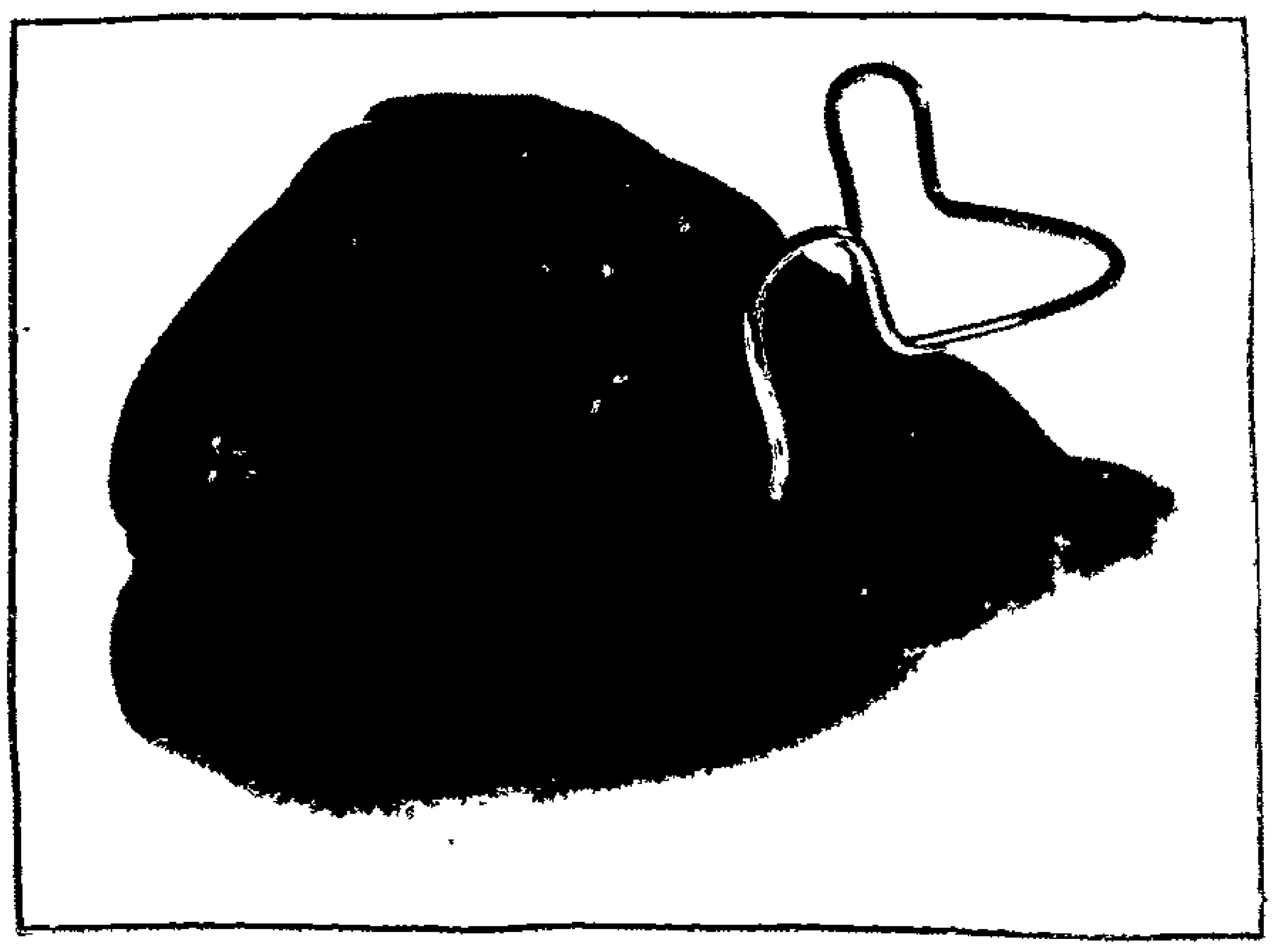


E, The Teuscher appliance (Roberts 1985)

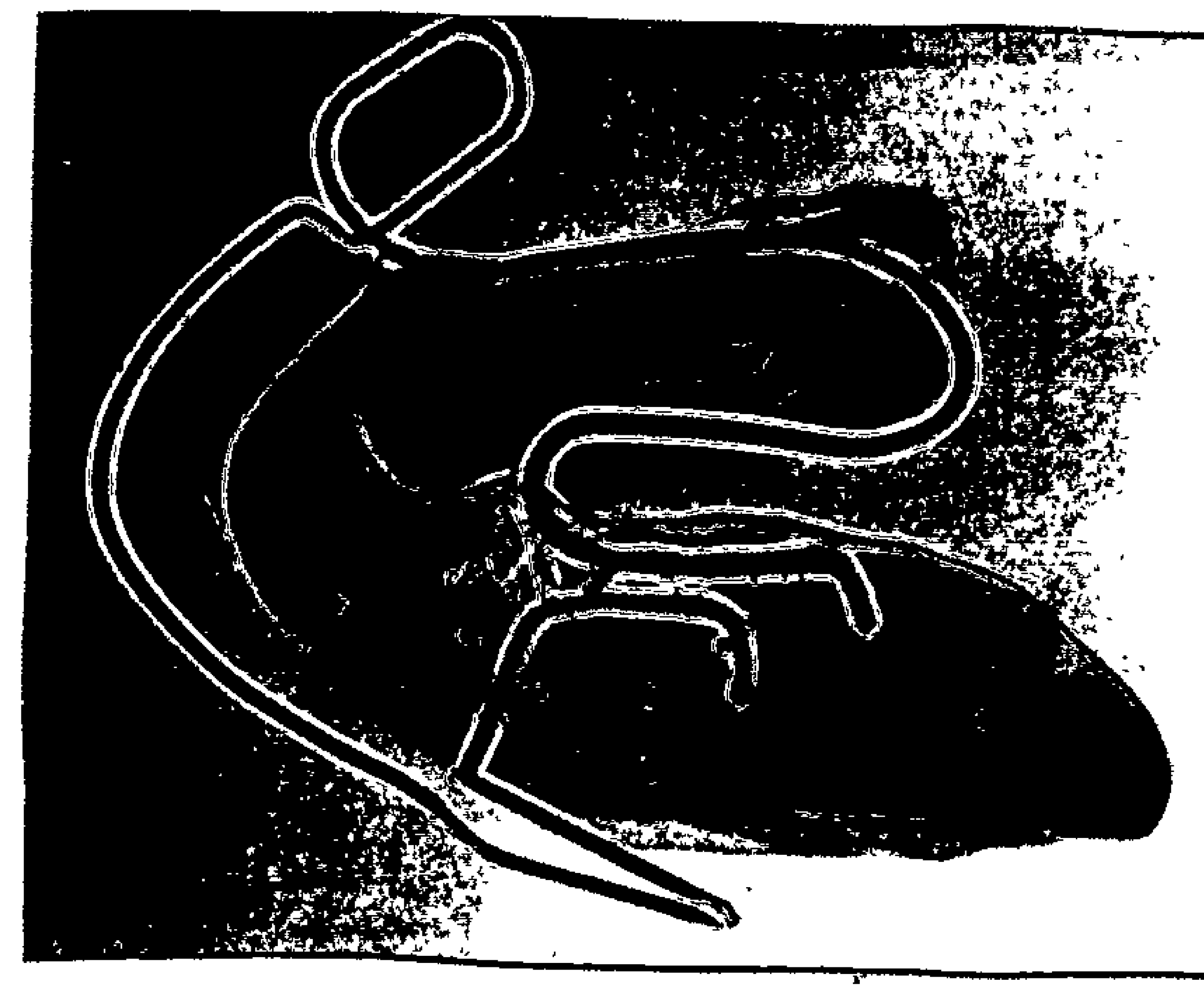


F, The Oral Screen.

Fig 12. The functional appliance.



A, The Andesen-type
activator. Proffit)



B, The Balters-type
bionator. (Proffit)

(b) Herbst appliance assembled on articulator

(c) Herbst appliance in place in the mouth

C, The Herbst appliance. (Roberts 1985)

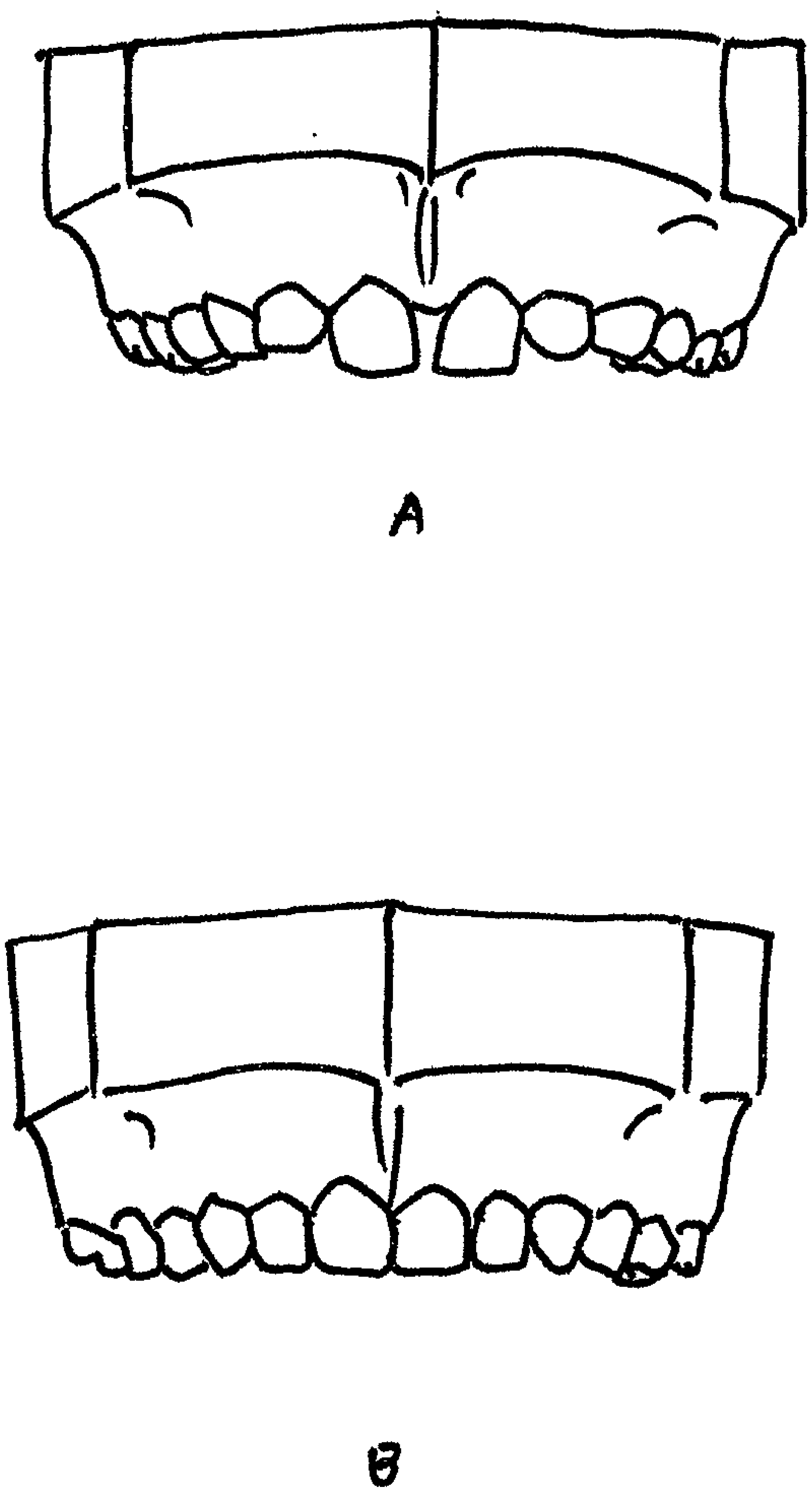



Fig 11. A, Broadbent's "Ugly Duckling" stage in the mixed dentition With spacing of central incisors and slight labioversion of lateral incisors.

B, The resulting normal development of the full permanent dental arch. (Godfrey)

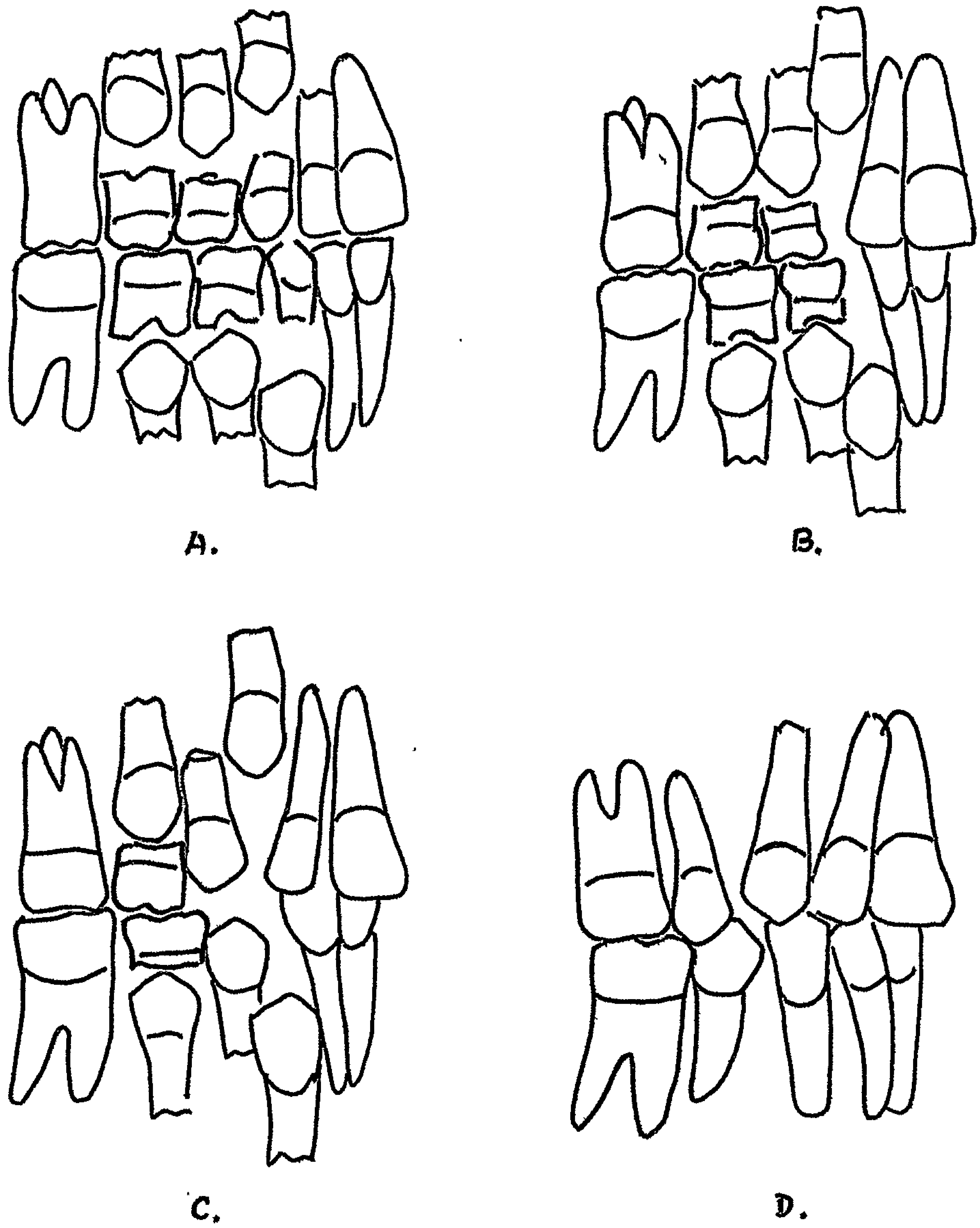



Fig 13. Sequences in serial extraction.

A, Extraction of primary canines as premanent laterals erupt.

B, Extraction of primary first molars 6 to 12 months before normal exfoliation.

C, Extraction of first premolar as they are just emerging before the canines erupt.

D, Spontaneous space closure as the canines erupt distall and molars/premolars drift mesially. (Proffit 1986)