CHAPTER 6

DISCUSSION

CHAPTER 6

DISCUSSION

6.1 DESCRIPTION

6.1.1 Morphology and Classification

6.1.2 Aetiology

6.1.3 Significance of the Malocclusion

6.1.4 Cephalometric Analysis

6.2 TREATMENT PLANNING

6.2.1 Differential Diagnosis

6.2.2 Facial Growth Patterns and Treatment Planning

6.2.3 Growth and its Role in Treatment Planning

6.2.4 Growth Modification in the Pre and Early Adolescent Period

6.2.5 Treatment Planning when Growth is Substantially Finished or when Growth Modification is Unsuitable

6.2.6 Prediction of the Pubertal Growth Spurt and the Value of Current Methods of Growth Prediction

6.3 THE EDGEWISE APPLIANCE - ITS PRESENT EVOLUTIONARY STATE

6.3.1 Passive Elements

6.3.1.1 The straightwire bracket

6.3.1.2 Variation in the straightwire prescriptions

6.3.1.3 Changed dynamics and their clinical effects associated with straightwire brackets

-----o0o-----

CHAPTER 6

DISCUSSION

6.1 DESCRIPTION

6.1.1 Morphology and Classification

Class II, Division 1 malocclusion is not a single clinical entity, as suggested by Angle's classification, but has been found to consist of a diverse range of skeletal and dental relationships. For example, two recent cephalometric studies by Moyers et al, (1980) and McNamara (1981) have both shown that the most common morphological characteristic was a neutrally placed maxilla and a retruded or short mandible in relation to other craniofacial structures (approximately 66% of the sample), while approximately only 20% of the sample showed a prognathic maxilla. The two studies reported a wide variation in vertical development; Moyers et al described five different vertical facial patterns and McNamara reported that 50% of his sample exhibited excessive vertical development.

Attempts have been made to achieve a more useful and descriptive classification of the malocclusion, for example, Ballard (1957) divides the malocclusion into two types, dentoalveolar and skeletal, by analysis of the labial skeletal segments and the associated soft tissue function.

No classification effectively relates the jaws to the other craniofacial structures, nor do they adequately describe the wide ranging variation in vertical development. (Sassouni, 1970; Hitchcock, 1973).

The deep overbite is in itself a complex orthodontic problem that may involve a group of teeth or the whole dentition; alveolar bone; mandible and maxilla and the soft tissues of the face. Correction of deep overbite is highly desirable if it affects the facial aesthetics and impairs dental health. (Nanda, 1981). Overbite can be classified as:

(i) dentoalveolar, where normal skeletal development exists, or

(ii) skeletal (basal), here it is often manifested as a deep curve of Spee in the lower jaw and is generally associated with an excessively forward rotating mandibular growth pattern. (Bjork, 1963).

Overbite is described either as a linear measure of overlap of the lower incisor by the upper incisor or as a percentage of the lower incisor overlapped. (Prakash and Margolis, 1952).

6.1.2 Aetiology

The aetiology of this malocclusion has been the subject of considerable controversy. The literature is divided between those supporting the influence of environmental factors and those who support the role of heredity alone.

The importance of environmental factors on the aetiology has greatly diminished since the publication of studies by Weinstein et al (1963); Subtelny (1970); and Proffit (1978), who showed that orofacial soft tissue behaviour sometimes associated with Class II, Division 1 malocclusion, such as tongue thrusting and hypermentalis activity, to be an adaptation to, rather than a cause of the malocclusion. The literature does however indicate that thumb sucking into the early mixed dentition period may be an aetiological factor in creating dentoalveolar Class II, Division 1 malocclusion and may also enhance the onset and degree of the skeletal Class II, Division 1 malocclusion. (Graber, 1963; Graber, 1972: pp313-329; Proffit, 1986: p109). Skieller (1972), suggests that dentoalveolar Class II malocclusion is in fact a local anomaly and not genetic in origin, and can develop in all facial patterns - dolichofacial, brachyfacial and orthognathic - and is associated with extended thumb sucking and subsequent dysfunction of the tongue and lips. On the other hand skeletal Class II malocclusion is totally dependent on the genetically influenced facial growth pattern. The direction of growth at the condyles may vary from the extreme vertical to the more sagital direction, and it is these changes in condylar growth direction that give rise to individual differences in position of the lower jaw. (Björk, 1963).

The side of the proponents of genetics is perhaps best summarized by Hovell (1950) who suggests that all factors which shape and position the dental arches i.e. skeletal and soft tissue morphology, tooth size and orofacial behaviour, are genetically determined and habits such as finger sucking may only temporarily change the shape of the dental arch.

The recent literature indicates that the aetiology of Class II malocclusion is largely genetic in origin, but not simply one of independent inheritance of dental and facial characteristics. The actual role of inheritance has not yet been clarified, (Lundstrom, 1984). Long term habits can not be totally discounted, but it seems likely that they only accentuate the inherited skeletal dysplasia rather than cause it. (Subtelny, 1970; Graber, 1972: pp313-329; Proffit, 1978).

6.1.3 Significance of the Malocclusion

This malocclusion is estimated to occur in 15-20% of contemporary Caucasian population groups (Proffit, 1986: pp118-119). The presence of deep overbite and overjet has not been closely correlated statistically to severe periodontal disease or other oral pathology (Geiger, 1973). However, other studies have found increased periodontal destruction and gingival trauma (Poulton and Aaronson, 1961). No correlation between Class II, Division 1 malocclusion and TMJ dysfunction has been found in recent studies. (Logsdon & Chaconas, 1975; Pullinger et al, 1987).

Apart from these health considerations, several authors have linked some malocclusions to a reduction of the child's socio-cultural expectations and psychological disadvantage (Jenny, 1975; Shaw, 1981; Godfrey, 1984) and this alone may be adequate reason to treat this malocclusion.

6.1.4 Cephalometric Analysis: because of the variety of skeletal and dental configurations that may occur within the Class II, Division 1 classification, a lateral cephalometric analysis is of great value in describing the malocclusion in relation to the other craniofacial structures and subsequently for planning its treatment. The anteroposterior analysis should locate the maxilla in relation to other craniofacial structures and this is important to treatment planning decisions.

Maxillary skeletal position:

* SNA angle
* point A to nasion perpendicular
* "Wits" appraisal relates the upper jaw to the lower jaw effectively.

Several studies (Sassouni, 1958; Hitchcock, 1973; Jacobson, 1975; McNamara, 1981) suggest a lack of confidence in the angle SNA and ANB to indicate skeletal position of the maxilla and "Wits" appraisal and nasion perpendicular can be used as a back up.

The mandibular skeletal position

* angle SNB
* facial angle - this varies with age
* Y axis to NS angle can indicate likely movement of the chin point with growth.

McNamara (1981) writes that SNB is not totally reliable in Class II Division 1 cases because of the possible influence of circumoral muscle dysfunction on point B and he suggests the use of the facial angle to locate the mandible as well.

Skeletal Vertical Analysis: the following measurements relate the vertical position of the maxilla and mandible to the cranium:

* anterior facial height; the lower face, lips and chin should be 55% of the total nasion-pogonion distance.

* O.M. plane angle (occlusal plane to mandibular plane) and SN to mandibular plane (SN to MP) angle. These angles have been used to establish patterns of facial growth which react differently to orthodontic procedures. High angle (hyperdivergent) patterns are backward mandibular rotators while low angle (hypodivergent) are forward rotators. Schudy (1964) relates these patterns to treatment planning and this will be discussed later. McNamara (1981) also uses the mandibular plane angle to Frankfurt horizontal and a measurement of anterior nasal spine (ANS) to menton and he uses the Michigan growth study standards (60 mm at 9 years for his norms which change with age, (1 mm per year).

* facial/growth axis angle to describe vertical development has been recommended by both McNamara (1981) and Ricketts (1960 [b]) (See Figure 1.7).

* Y axis is useful in vertical analysis, norm is 62^{o} - 70^{o} if greater than 70^{o} little forward growth of the chin point can be expected while if an angle of 60^{o} is present the chin point can be expected to move forward (Godfrey, 1985).

The Sassouni analysis has been described along with more recent cephalometric analyses designed by Ricketts (1981) and McNamara (1983) both of whom rely on the use of data from various growth studies such as the Bolton and Michigan studies and from which templates representing average growth patterns for different age groups are now available and may be useful in growth prediction.

6.2 TREATMENT PLANNING

6.2.1 Differential Diagnosis

The literature clearly indicates that lateral cephalometric analysis can be used to help individualise treatment decisions for cases in the broad spectrum of Class II,Division 1 classifications. Differential diagnosis is important to enable selection of appropriate mechanotherapy that will assist correction and not lead to a worsening of the malocclusion or soft tissue/skeletal profile.

Both the studies by Moyers et al (1980) and McNamara (1981) have highlighted the need to assess the anteroposterior skeletal position of the maxilla relative to other craniofacial structures. Both their findings show the average position of the maxilla to be neutrally placed and that retrusion of the mandible is the most common factor contributing to Class II malocclusion.

McNamara (1981) also found that protrusion of the maxillary dentition occurs less frequently in Class II than previously thought. He states that the relationship of the upper incisor to A-P line measurement is frequently erroneously taken as protrusion of the upper incisors rather than a retrusion of the mandibular skeleton and he suggests the use of a method of cephalometric measurement of the actual horizontal distance of the incisor from point A which is therefore independent of mandibular position. (See Section 1.4.1.2)

The mandibular dental position showed that the lower incisor is on average well positioned relative to AP line (1.3 mm ahead), indicating support for the findings of Schulhof et al (1977) that the position of the mandibular central incisor is more related to maxillary skeletal structures than to the mandibular skeletal structures and may be an expression of labial and lingual postural muscle activity (McNamara, 1981).

McNamara (1981) states that in his view there is a spectrum of Class II malocclusions and the choice of treatment should be a function of the individual problem. For example, rather than routine application of headgear he advises the use of treatment approaches that might alter the amount and direction of mandibular growth. Proffit (1986: p205) has suggested the selective use of functional appliances for those cases with a normally positioned maxilla and retrognathic or short mandible and although he states that there is no evidence that they will increase mandibular growth, they are often seen to be effective in the preadolescent child. Headgear is selected for growth modification where the maxilla is forward.

As previously stated McNamara (1981) found a wide variation in vertical development with almost 50% of his Class II sample exhibiting excessive vertical development. He further states that there may be some association between altered respiratory function and some of these vertical Class II malocclusions and he cites the study by Linder-Aronson (1970), linking enlarged adenoids to vertical facial growth. Moyers et al (1980) found five patterns or "types" in the vertical analysis of their Class II samples, the two vertical extremes being:

(i) the high angle dolichofacial pattern with steep mandibular plane, steeper occlusal plane and the palatal plane tipped down; the anterior cranial base tipped upwards, with large anterior face height - when compared with the Michigan Growth Study norms.

(ii) the low angle, brachyfacial pattern with low angles for the mandibular plane, occlusal plane and the palatal plane; all of which are more parallel to each other; the gonial angle was more square and the cranial base more horizontal than the Michigan Growth Study norms.

Both these facial patterns had been identified earlier in the orthodontic literature and their significance to treatment planning in terms of their mandibular rotational behaviour under orthodontic treatment has been well documented by Schudy, (1964); Sassouni (1965) and Creekmore, (1967).

The other less common vertical facial patterns include downwardly tipped mandibular, palatal and occlusal planes, a high lip line, often on the maxillary alveolar process and there is often an associated maxillary prognathism. Another pattern displayed a bi-maxillary protrusion, with the palatal plane and anterior cranial base tipped upwards.

6.2.2 Facial Growth Patterns and Treatment Planning

Differential diagnosis using cephalometric analysis enables a facial pattern to be developed for the patient, which to some extent helps to predict its future growth and especially to determine its reaction to particular treatment mechanics (Schudy, 1964).

The brachyfacial - hypodivergent pattern: this pattern is associated with a total forward growth rotation, especially in the mandible; there will be a short anterior face height and deep overbite. The cephalometric description is similar to Moyers et al, Type 2 pattern, with nearly horizontal mandibular, occlusal and palatal planes. Because of the forward growth rotation, treatment is designed to rotate the mandibular plane open increasing anterior face height, this being accomplished with extrusion of the buccal teeth (provided there is adequate freeway space, Nanda [1981]).

Treatment planning:

(i) use Class II elastics to extrude buccal teeth, but they may stubbornly resist occlusal extrusion if strong facial musculature and lack of freeway space prevail.

(ii) bond/band mandibular second molars to assist in arch levelling (extrusion of first molars and premolars) with reverse curve of Spee bends to the archwires.

(iii) maxillary molars should be moved distally as much as possible with cervical or horizontal headgear.

(iv) avoid extractions if possible as this will aid forward mandibular rotation.

(v) retain corrected overbite until growth is complete (Schudy, 1964, 1973; Creekmore, 1967).

Dolychofacial - hyperdivergent pattern: here the anterior facial height is excessive in proportion to posterior facial height, with a prominent mid-face and retrognathic mandibular profile. The cephalometric indicators are a steep mandibular plane and the occlusal plane to mandibular plane is high. In this pattern the pogonion has been shown to move downwards and backwards with growth and especially with treatment that extrudes posterior teeth, often worsening the already retrognathic profile.

Treatment planning:

(i) molars must not be extruded or moved distally as this will rotate the chin point further back.

(ii) a highpull headgear to inhibit maxillary alveolar growth in the molar region is advised.

(iii) intrusion of incisors to correct deep overbite.

(iv) extraction of teeth in the maxillary arch may facilitate most aspects of Class II treatment planning, provided there is not excessive arch crowding (Schudy, 1965; Creekmore, 1967). Roth suggests extraction will assist treatment by creating a forward mandibular rotation. (Graber and Swain, 1985: p701).

(v) any improvement of ANB angle will not come from forward mandibular growth, but only from posterior movement of point A with treatment. (Schudy, 1964; Pearson, 1978).

A normal facial pattern: may be treated with the edgewise appliance using either extrusion of buccal teeth into freeway space or by intrusion of incisors or a combination of the two, depending on incisor soft tissue relationships. (Schudy, 1964; Burstone, 1966, 1967; Nanda, 1981).

6.2.3 Growth and its Role in Treatment Planning

Schudy (1964) has written, "A study of growth sites and growth sutures is of little value unless we know how, and to what extent the growth measurements affect occlusion". With this in mind I will attempt to discuss growth as it relates to the Class II skeletal malocclusion, placing emphasis on its application to the treatment planning.

The maxillary growth is described by Enlow (1982:p84) as a passive displacement in a downward and forward direction, created by growth at the cranial base and an active growth of the maxillary sutures and the nose. This is an important growth mechanism during the early primary dentition years, but becomes less important as growth at the synchondroses of the cranial base slows at approximately 7 years of age contributing only about one third of total maxillary forward and downward displacement, between 7 and 15 years of age. The remaining two thirds of this growth results from active growth of the maxillary sutures and bone apposition and remodelling to the surfaces, which is most likely in response to stimuli from the enveloping soft tissue as described in the functional matrix theory of Moss (1968) and Moss and Salentjin (1969).

The mandible grows in a pattern that has the chin moving downward and forward, if the cranium is used as a reference point. The principle sites of growth being the posterior surface of the ramus and the condylar and coronoid processes (both endochondral and periosteal growth activity contribute) with little change along the anterior part of the mandible. (Enlow, 1982: p43).

Two opposing theories are currently held as to the control of jaw growth and it remains the subject of considerable research (Proffit, 1986: p33). One theory holds that cartilage is the primary determinant of skeletal growth and bone responds secondarily and passively. The other theory is that the soft tissue matrix is the primary determinant of growth. This is the functional matrix theory of Moss (1968) and it assumes that genetic control is mediated largely outside the skeletal system. Volumetric growth of the oronasopharyngeal functioning spaces being the primary factor in facial and jaw growth, the objective being maintenance of an airway. It can be argued that the more indirectly growth is controlled the greater the opportunity for environmental influences to affect it. (Proffit, 1986: p33). With mandibular retrognathism being the most common characteristic of Class II malocclusion, the mechanotherapy for growth modification should be aimed at stimulating mandibular growth. McNamara and Carlson (1979) indicate that mandibular growth can be increased by changing the mandibular postural position. Other studies on animals suggest that growth of the condylar cartilage may be in part adaptive and that condylar response to changes in the environment may more closely resemble that of periosteum (rather than epiphyseal cartilages of long bones). (Petrovic, 1972; McNamara, 1981). However, this is by no means fully supported in the literature and other authors state that there is inadequate evidence of mandibular growth increase beyond its genetic potential.(Coben, 1966; Lindquist in Graber and Swain, 1985: p592; Proffit, 1986: pp204-206). However, it is conceded that acceleration of growth is possible when functional appliances are worn, much of their success being due to maxillary growth retardation (Graber and Swain, 1985: pp592-593).

If the maxilla is protrusive suitable headgear is selected for growth modification. Several authors suggest that during growth, distal traction can hold, retard or redirect forward eruption and migration of upper molars and growth at the maxillary sutures is a reactive process and not independently active (Coben, 1966; Enlow, 1982: pp86-162). Therefore extraoral force can be applied across the sutures to modify excessive maxillary growth in either the anteroposterior or vertical directions. Enlow (1982: p162) states that as well as affecting sutural growth (displacement) of the maxilla, the drift movements of teeth that occur with the growth of the alveolus can be directed to different eruption paths.

Rotation of the jaws during growth

Björk (1955) first introduced the term "growth rotation" when his metal implant studies revealed a mandibular rotation relative to the original shape. A more recent work by Björk and Skieller (1983) explains mandibular growth changes by dividing them into three components:

(i) total rotation of the mandibular corpus, measured as a change in inclination of an implant line relative to the anterior cranial base,

(ii) the matrix rotation of the outer surface with a centre of rotation at the condyles, and

(iii) the intramatrix rotation centred at a point within the body of the mandible.

The outer soft tissue covering (matrix) and the bony mandibular or maxillary bony corpus can be considered as independent tissue systems capable of separate rotation both forward and backward. In normal skeletal patterns Björk and Skieller have found a slight forward rotation of the mandible and maxilla. The brachyfacial patterns are characterised by an excessive forward growth rotation of the mandible resulting from both an increase in the normal internal rotation and a decreased matrix rotation. This produces a lack of compensation and the typical morphology of horizontal palatal and mandibular planes, a deep-bite and often overlap of the maxillary incisors.

In the dolichofacial patterns there is a lack of forward internal rotation or even a backward intramatrix rotation. The total rotation is a backward rotation effectively centred at the condyles and results in excessive anterior face height. The palatal plane rotates downwards posteriorly while the mandibular plane shows an opposite backward rotation. (Similar to Moyers et al, [1980] Type 1.)

This study helps to explain the treatment phenomenon reported by Schudy (1964) and Creekmore (1967). It has significance in planning both treatment and retention in Class II skeletal malocclusion and adds to this the concept of total rotation having two parts, intramatrix rotation (remodelling of the mandible) and matrix rotation. (Dibbets, 1985).

6.2.4 <u>Growth Modification in the Pre and Early Adolescent Period</u>

Growth modification therapy of the Class II skeletal relationship is successful provided a substantial amount of forward mandibular growth can be expected. It should be commenced 2 years prior to onset of puberty. Although jaw growth certainly continues long after puberty its magnitude is rarely sufficient to allow correction (Coben, 1966; Proffit, 1986: p201). As discussed earlier, in Section 6.2.3, if the maxilla is normal and the mandible is retrusive relative to other craniofacial structures, then functional appliances are selected to encourage mandibular growth. If on the other hand the maxilla is protrusive relative to the mandible and other craniofacial structures, then suitable headgear is selected to redirect maxillary growth and tooth eruption.

6.2.5 Treatment Planning when Growth is Substantially Finished or when Growth Modification is Unsuitable.

Ackerman and Proffit (1970), (and in Graber and Swain, 1985: p94) state that extraction of teeth may enable the correct molar and incisor relationship to be achieved, but the underlying Class II skeletal discrepancy remains resulting in a "camouflage treatment" (sic). While this is compatible in mild to moderate Class II cases, in the severe cases retraction of upper incisors will lead to increasing prominence of the nose and an unaesthetically obtuse nasiolabial angle that signal the effective limits of retraction. (Proffit, 1986: p214).

6.2.6 Prediction of the Pubertal Growth Spurt and the Value of Current Methods of Growth Prediction

The importance of growth to the treatment of the skeletal Class II malocclusion has been described, but to be effective this growth modification should commence 2 years prior to onset of puberty, 8 - 10 years of age in girls and 10-12 years of age in boys. Once the patient reaches puberty there may not be enough growth to effect a skeletal correction (Proffit, 1986: p204).

Indicators of the beginning of pubertal growth spurt

Pubertal growth spurt is directly related to sexual maturation.

* In **females**: menarche onset will only indicate that the greatest part of skeletal growth has already occurred. (Graber and Swain, 1985: p39).

* in **males**: voice change, markers of sexual maturation (pubic hair etc.).

These indicators tend to indicate the peak and not the onset of pubertal growth (Hagg and Taranger, 1982). On average the pubertal growth spurt began at 10 years in girls and finished at 14.8 years and 12 years in boys, finishing at 17.1 years. Skeletal age: a wrist film to examine the ossification of the carpal bone can be used.

Growth prediction: I have discussed several methods of jaw growth prediction, including the Johnston forecast grid and the Ricketts prediction. Both of these appear to rely on mean change along the existing cephalometric pattern and do not provide an individualized prediction. The use of templates that are superimposed on the original cephalogram are now available using norms from various growth studies (i.e. Michigan, Burlington, Bolton, etc.).

A study by Schulhof and Bagha (1975) has established up to 56% greater accuracy with the computer based prediction over the Johnston grid methods and the refinement of computer prediction may provide greater predictive accuracy. However, this is not promising when confronted by the statement from Björk and Skieller (1983), that facial growth increments are not uniform in either direction or rate and even the paths of eruption of teeth are variable. Growth prediction based on present cephalometric two dimensional criteria cannot therefore be totally relied upon. However, there is a considerable level of acceptance found in the literature and authors such as Ricketts et al (1979: p38) and Roth (in Graber and Swain, 1985: p671) support the use of growth prediction in treatment planning using VTOs.

Assessment of soft tissue, profile and proportions of the face. In diagnosis and treatment planning always check for disproportions, asymmetry of facial features and clinically examine and photograph the frontal view of the face. The profile should be described, remembering that the face of an adolescent becomes more orthognathic with growth. The lip/incisor relationship should be recorded, whether excess tooth or gum is displayed, any lip strain and the amount of freeway space. Evaluate T.M.J. and occlusal function; note any pain, noise or limitations of jaw opening.

6.3 THE EDGEWISE APPLIANCE - ITS PRESENT EVOLUTIONARY STATE

6.3.1 Passive Elements

The edgewise appliance has shown considerable adaptability to change since Angle first introduced the single winged bracket constructed of soft gold. The present evolutionary stage is the preadjusted bracket and molar tube which attempt to provide control in three planes. Commercial variations range from prescriptions that offer a total set of preadjustments for every tooth, to a wide range of preadjusted brackets that allow the practitioner to determine the preadjustments needed for a particular set of teeth. Incremental adjustments are not nearly as reliant on sequential archwire adjustments and are achieved by gradually increasing the archwire size. The final ideal tooth position in the preadjusted brackets is achieved with maximum slot expression obtained with placement of full-sized rectangular archwires (Meyer and Nelson, 1978).

6.3.1.1 The straight wire brackets

In the 1970s, following on from Andrews' work on occlusal analysis and studies of ideal tooth position, the first fully preadjusted brackets were manufactured to a "prescription" designed by Andrews (1976, 1976[b]). This prescription has all the brackets with some level of control and is able to produce, in conjunction with archwires, labial-lingual or bucco-lingual torque, mesiodistal tip and in/out control for both brackets anteriorly and buccally. The "tip" is designed to angulate the bracket so that it is parallel to the occlusal plane instead of perpendicular to the root, eliminating individualized bends in the final archwire.

In/out offsets account for the distance between the wire and the tooth surface and avoid rotational and translational effects that otherwise can only be eliminated with extensive final archwire bending seen in Angles' "ideal arch form" (Figure 3.6) with first, second and third order bands. (Meyer and Nelson, 1978).

The molar tube: The upper molar tube should have a 10^{o} offset in the prescription to place the molar buccal surface at an angle to the line of occlusion of the arch, i.e. the mesiobuccal cusp is more prominent than the distobuccal cusp; this applies to both first and second molar tubes. A smaller offset is required in the lower first molar tube (about 5^{o} - 7^{o}). Some prescriptions include a distal tip in the buccal brackets and provide a form of anchorage control to the molar and premolar which when tipped distally will resist mesial displacement; this is similar to the original Tweed technique for anchorage preparation. (Proffit, 1986: p304).

An auxiliary edgewise tube is needed if a Ricketts or Burstone utility arch is to be used for intrusion of incisors. It is a rectangular tube placed gingivally and is parallel to the archwire tube; headgear tubes (0.045" or 0.051") are routinely placed. The first molar brackets should be convertible to create an edgewise bracket if the second molars are to be banded in the treatment plan. (Proffit, 1986: p304).

6.3.1.2 <u>Variation in the straight wire prescriptions</u>

There are now many prescriptions for the straight wire brackets; Proffit (1986: p302) lists nine, the major difference between these prescriptions is the torque angulation of the upper centrals and laterals. For example "A" company has 7^{o} torque angulation on the centrals and 3^{o} on the laterals; "Roth modified" has 12^{o} and 8^{o}; Rocky Mountain (Triple Control) and Bioprogressive have 22^{o} and 14^{o}.

Both the low and high torque angulations are viable, the 7° Andrews bracket is bonded approximately in the centre of the clinical crown, while the 22° of Triple Control and Bioprogressive brackets can be placed more incisally if needed to assist in overbite correction, but when placed in this location, will only match the torque effect of the 7° placed at crown centre. Another advantage of the higher torque angulation is that it enables the use of an undersized rectangular arch; some practitioners preferring the lighter torque forces from less rigid wires, and this may be significant in high angle cases where beta titanium rectangular wire is sometimes selected for torque procedures (Lindquist, in Graber and Swain, 1985: p578; Roth, in Graber and Swain, 1985: p691). Because of variations in the shape and contour of individual teeth the torque for some teeth will be correct while for others third order (torque) bends will have to be added to the wire (Proffit, 1986: p304). Torque built into the bracket base has been highlighted in the Andrews prescription. However, Meyer and Nelson (1978) suggest that it effectively is no different to torque built into the slot.

6.3.1.3 <u>Changed dynamics and their clinical effects associated with straight wire brackets.</u>

Preadjusted edgewise brackets change the reaction to archwires from those seen with the standard bracket in the following ways:

* placement of the first rectangular archwire produces labial and buccal torque forces depending on the fit. Torque couples at the maxillary incisor brackets will cause a resultant mesial movement of

posterior anchorage and incisal flaring. The use of posterior anchorage control is needed earlier than with standard brackets.

* "tip" angulation will begin acting with the first archwire creating a mesial crown tip and anchorage enhancement may be needed earlier as well as cinch back bends distal to the molar tube.

* highpull headgear if applied to molar tubes with 5^{o} distal root tip may result in an excessive distal root position and excessive mesial tip of the crown and Meyer and Nelson (1978) suggest a reduction or no distal molar tip if highpull headgear is in the treatment plan. The outer bow should be placed to provide a translatory force rather than a rotational force.

6.3.2 Active Components of the Edgewise Appliance

The continuous arch extending from molar to molar remains the primary source of control and force distribution in edgewise therapy. The work of Storey and Smith (1952) and Begg (1956) led to the development of the differential light force concept that there is an optimum range of force values that will produce a maximum rate of tooth movement with a minimal loss of anchorage; this force being light while heavy forces produced the reverse effect with protraction of the anchorage units through the extraction space. The desire to apply this differential light force concept to the edgewise brackets was first developed by Jarabak and Burstone. Jarabak used light forces from multi-looped levelling archwires and also developed archwires of light gauge stainless steel with helical loops to intrude incisors correcting overbite or to retract groups of incisors.

Burstone (1966) introduced the segmented arch, also designed to deliver light constant forces to either intrude or to retract the incisor segments. The appliance uses a segmented arch approach where a heavy rigid arch segment is used to stabilize the buccal anchorage units, linked to a helical spring wire capable of light continuous forces in the anterior segment. A bypassing intrusion spring with a long lever arm (molar to incisors) and two labial springs provide a very light continuous force to intrude the incisors in overbite correction. There will be reciprocal extrusive forces to the anchorage units; if not desirable, vertical pull headgear or Goshgarian transpalatal bars will limit molar extrusion.

Sliding mechanics with twin edgewise brackets and continuous arch, produce considerable friction, limiting the effectiveness of light forces, so Burstone substituted a retraction spring with four helical loops to retract the incisor segments, the lighter forces placing minimal strain on posterior anchorage units (Burstone, 1963, 1966, 1977).

This concept of segmented or sectional arch mechanics has been adopted by Ricketts et al (1979) in the development of "Bioprogressive Therapy", where the anchorage units are again enhanced with rectangular sectional buccal arches connected by a transpalatal arch of various designs. Continuous arches are avoided until the end of treatment when they are used for torque movements. The active sections of the archwire consist of the utility intrusion (bypassing) arch which fits into the molar tube auxiliary and is constructed of 0.016" x 0.016" chrome cobalt, designed to apply light continuous force to the incisors, it is activated by 30^{o} molar tip-back bends and 30^{o} buccal root torque. Retraction of the incisor segments is achieved with a double delta helical utility arch.

Ricketts et al (1980: p22) state that the principles of light differential force demonstrated by Storey and Smith, explain their mechanics and they suggest that no more than 100 gm/cm^2 of enface root surface need be used with their sectional arch system. This means that on average, cuspids can be retracted with forces of 75 - 100 grams and all four lower incisors can be intruded with a force of only 60 - 80 grams (20 grams/tooth); upper incisors require 160 - 200 grams for their intrusion, these forces being well within the range of optimal forces outlined by Storey and Smith (1952).

The continuous arch: The difficulty of obtaining light intrusive forces and flexibility (without distortion) in the initial bracket levelling stages has been largely overcome with the use of continuous Nickel titanium (NiTi) arches. The advantages of this alloy are its outstanding springiness and flexibility, which result in lighter forces and larger tooth displacements (Kusy, 1981); it has better properties than stainless steel multistrand wires and properties similar to steel archwire with multiple loops (Proffit, 1986: p255; Kusy and Stevens, 1987). The intermediate wires generally start with 0.016" and progress to 0.020" (in an 0.022" slot), the final wire being 0.002" within the bracket slot size

(Thurow, 1982: p294). Drake et al (1982) suggest that Beta titanium (B.Ti) wire can be substituted for stainless steel in the intermediate stages. B.Ti. has reasonably good formability and weldability and can be shaped for closing loops and is of value where slightly more flexibility is required. Kusy and Greenberg (1981) even suggest that B.Ti. is a superior intermediate wire to stainless steel which they relegate for use mainly as finishing wires where stability of form is required. Andreason (1978) has suggested that with pretorqued and angulated brackets, titanium alloys may be adequate for finishing in some cases, where little needs to be done to the arch, except that it may need closer monitoring because of the wires elasticity and more continuous force. This latter use of Beta titanium wire for finishing is advised by Roth in treatment of high angle cases where light forces are required and buccal extrusion is to be avoided. However the literature generally indicates that stainless steel or chrome cobalt are the choice of wires for finishing procedures (Kusy and Greenberg, 1981; Thurow, 1982: p294; Proffit, 1986: p255).

The current state of the edgewise appliance.

Before the advent of titanium alloy wires the Jarabak multi-looped archwire was frequently used to increase the range and decrease the stiffness, by effectively increasing the interlabial wire length. This arch poses problems of hygiene and tissue impingement as well as increased chair time (Kusy and Stevens, 1987) and has now been virtually displaced in the initial levelling stages by the continuous titanium alloys.

The role of the Jarabak and Burstone therapies has been to introduce the concept of differential light forces and of moving one segment of teeth relative to another, rather than along a continuous arch. These techniques however appear to have been displaced by the Ricketts Bioprogressive Therapy, which is identical in mechanical principle but simpler and less cumbersome in use and its preformed utility arch has become readily available in the orthodontic catalogues.

In summary the current edgewise appliance has evolved to a level where several different archwire auxiliaries are available for selection generally with a triple controlled straight wire bracket prescription. This choice helps to individualize the treatment mechanics so that they suit the facial skeletal pattern, tooth/lip relationships and soft tissue considerations.

The literature currently suggests three major choices of edgewise therapy: the first has continuous arches levelling overbite by extrusion; the second combines sectional archwires and continuous archwires and the third involves the use of sectional arches described by Burstone and Ricketts and used to both intrude and retract anterior segments.

(i) **Using continuous arches:** progress from light force nickel titanium levelling archwires to either stainless steel round wires or Beta titanium rectangular wires as intermediate wires for further levelling and space closure; finally finishing with stainless steel rectangular archwires to gain maximum expression of the pre-angulated brackets. Anchorage control will be needed in the intermediate and last stage.

(ii) **Combination of continuous and sectional intrusion arch:** if the treatment plan calls for intrusion of upper or lower incisor segments, then the Ricketts utility arch is used first, followed by continuous arches and sliding mechanics for retraction, in conjunction with suitable anchorage control.

(iii) Sectional arches - (Bioprogressive Therapy): used where light differential forces are called for, placing minimal stress on the posterior anchorage in both the vertical and horizontal planes. The posterior anchorage is provided with rigid posterior segmental archwires joined by a transpalatal arch and/or suitable headgear. (Ricketts et al, 1980; Roth, in Graber and Swain, 1985:p675; Proffit, 1986: pp413-418).

6.4 MECHANICS SELECTION

The preceding discussion of the evolution of the contemporary edgewise appliance indicates a wide ranging versatility which enables adaptations of the appliance to suit the requirements of the individual case within the Class II, Division 1 deep overbite group. Skeletal Class II relationships can be treated either by growth modification therapy or extraction therapy. Growth modification is commenced with suitable headgear or functional appliances depending on the differential diagnosis for the particular case. Both appliances are commenced in the mixed dentition periods, aimed at achieving correction of the Class II skeletal discrepancy. The occlusion may need to be treated later in the permanent dentition with full banding appliances to level the occlusal plane and retract upper incisors. Extraction and edgewise full banding therapy is usually indicated if adolescent growth is past its peak velocity or its direction is unsuitable, or patient co-operation with growth modification appliances is judged or found insufficient.

There are several factors revealed in the literature that play an important role in selecting appropriate mechanotherapy for a case in this malocclusion group:

* age and growth potential of the patient;
* the facial (skeletal) growth pattern;
* the soft tissue relationships, including lip/tooth relationships, the profile (nose, lips and chin relationships), and the facial musculature;
* patient co-operation.

6.4.1 Age/Growth Potential

In growth modification, treatment success is largely dependent on achieving the maximum differential growth to correct the Class II discrepancy. Treatment should be commenced well before the pubertal growth spurt begins. This means on average, commencing treatment 2 to 3 years before puberty, at 8 to 9 years of age in girls, and at 10 to 11 in boys and applies to both headgear and functional appliances. (Coben, 1966; Lindquist, in Graber and Swain, 1985: p607; Proffit, 1986: p419).

Once the patient has entered puberty there may be inadequate growth potential to correct the Class II relationship except in mild or partial skeletal cases. The pubertal growth spurt can be determined by indicators of sexual maturation, but Hagg and Taranger (1982) suggest these indicators mark only the peak and end of pubertal growth spurt and not the onset and therefore can only be used retrospectively.

6.4.2 Facial Pattern

The literature has shown that Class II, Division 1 malocclusion exists in a variety of facial patterns that will respond differently to any given set of treatment mechanics. (McNamara, 1981).

Roth (in Graber and Swain, 1985: p671) states that treatment mechanics for this malocclusion can be divided into two groups:

(i) those used in the normal to brachyfacial patterns, and

(ii) those used in the more dolichofacial, high angle patterns.

This division in treatment mechanics follows on from the earlier work of Schudy (1964, 1965) who divided cases into hypodivergent (with low mandibular plane angles); hyperdivergent (high angle cases) and normal (harmonious vertical development). Sassouni (1970) and Thurow (1982: p117), also differentiate between cases that have flat mandibular and occlusal planes and cases with steep mandibular planes and weak masticatory musculature in their selection of mechanotherapy.

In the brachyfacial (hypodivergent) pattern there is a forward total rotation of the mandibular growth (Björk and Skieller, 1983) and to a lesser extent a forward maxillary rotation which tends to result in a proportionately smaller anterior face height, deep anterior overbite with more parallel mandibular, occlusal and palatal planes. (Moyers et al, 1980).

Treatment with growth modification is possible with either cervical headgear or functional appliances. In the normal to brachyfacial cases with fixed banding it is safe to level the curve of Spee by extrusion of the buccal teeth and to use the continuous arch edgewise appliance with:

* reverse curve of Spee and exaggerated compensating curves;
* the banding of second molars will assist in extrusion of premolars and first molars, also assisting lower anchorage control;
* Class II elastics if acceptable to the treatment plan;
* cervical headgear will extrude upper molars;
* extractions are to be avoided where possible.

(Schudy, 1965; Creekmore, 1967; Roth,in Graber and Swain, 1985: p671).

The second category is the more **dolichofacial (hyperdivergent) pattern**: here the anterior facial height is proportionately long, the occlusal plane to mandibular plane angle is high with a steep mandibular plane. Often this provides a pattern of prominent mid-face and retrognathic mandible (Schudy, 1964, 1965; Roth, in Graber and Swain, 1985: p671). Björk and Skieller (1983) report a total backward rotation in these cases, essentially centred around the condyle. In the more extreme high angle cases a backward rotation of the chin point may very easily occur with even minor molar extrusion resulting in a further deterioration of the Class II profile.

In growth modification treatment highpull headgear may be used but functional appliances are precluded

Mechanics selection:

* mechanics that do not extrude buccal teeth must be selected;

* heavy gauge wires should be avoided to reduce extrusive forces. Roth (op cit: p671) suggests only low force wire should be used even for torque control (i.e. nickel titanium round wires and Beta-titanium rectangular wires in large sizes [0.021" x 0.025"]).

* Schudy (1964) states that in high angle cases it is best to treat as if the patient is an adult, since growth is of little advantage, possibly a disadvantage, and he suggests the extraction of the upper first premolars to correct the overjet but not the Class II molar relationship. Roth (in Graber and Swain, 1985: p701) suggests that extraction of teeth can be employed to slip posterior teeth forward, allowing the mandible to hinge in the direction of bite closure.

* anterior overbite if present is generally an over eruption of incisors and is treated by incisor intrusion. A Ricketts utility arch or Burstone intrusion spring is used in conjunction with heavy gauge sectional archwires and transpalatal (Goshgarian or lingual) arch to the buccal segment. Highpull headgear is sometimes needed for anchorage control and to inhibit vertical growth and may need to be continued throughout the post-treatment growth period.

6.4.3 Soft Tissue Considerations

6.4.3.1 Lip/tooth relationship

(i) **Interlabial gap**: in a relaxed mandibular position an interlabial gap between upper and lower lips of 2-4 mm is the norm.

If the case displays a larger gap then buccal tooth extrusion to correct overbite will only worsen aesthetics, by increasing anterior lower face height and increasing lip strain. Thus intrusion mechanics is selected. If, on the other hand, there is no gap and a redundancy of lip, then posterior extrusion mechanics should be selected (Kuhn, 1968; Nanda, 1981).

(ii) **Upper incisal edge - stomion distance:** is on average 2-4 mm. If normal (average), then intrusion is contraindicated. If a large amount of upper incisor shows, with a high smile line, then intrusion mechanics are selected (Burstone, 1977; Nanda, 1981).

(iii) **Lip/tooth imbalance in the high angle cases:** If the height of the buccal teeth cannot be changed and the incisors need intrusion to correct lip/tooth disharmony, then the upper incisors may be intruded, creating a "step" in the occlusal plane (Nanda, 1981).

(iv) **Freeway space** (norm is 2-4 mm): if minimal then buccal extrusion is contraindicated and correction of overbite by intrusion is the mechanics of choice, and may be more stable because of strong masticatory muscle forces usually associated with a smaller than average freeway space. (Creekmore, 1967; Berg, 1980; Nanda, 1981).

6.4.3.2 Soft tissue profile

Assessment of the profile using the E plane,Holdaway line, etc., indicates the degree of anteroposterior retraction needed. Ideally in Europeans the lower lip is 2 mm posterior to the E plane. Ricketts (1957) adds that in adolescents of 7 - 12 years of age, the lower lip should be on the E plane to result in a pleasing adult lip profile. Graber and Swain (1985: pp68-69) also suggest that in assessing facial profile, it should be remembered that the face tends to become orthognathic with maturation.

Ricketts (1960[b]), and Williams (1969, 1985) suggest that the lower incisor be placed on, or just in front of the AP plane, to achieve a balanced lip and facial profile. This will require mechanics selection that will stabilize the lower incisor when the patients desired profile is reached. This is achieved with the use of a lower utility arch if bioprogressive auxiliaries are available, or the use of lower rectangular torqued archwires, with rounded buccal sections, or uprighting springs on the canines or first premolars to limit lower incisor retraction. (Ricketts et al, 1980: p144; Bennett, 1985).

6.4.4 Patient Co-operation

Patient co-operation is an important factor in treatment planning, especially if growth modification therapy is selected, because it relies upon removable appliances. Full banding requires patient co-operation in the use of elastics, headgear, oral hygiene and attendance.

Evaluation of co-operation: explore the patient's motivation for treatment and what they expect from treatment. This motivation can be described as external or internal. External motivation is that provided by pressure from another individual, e.g. parent or peer group. Internal motivation may be rare in a young child. Co-operation will be good if the child genuinely wants treatment and attitudes need to be developed in the child so that it will see the treatment as a benefit as opposed to something else he or she must undergo (sic). Parental co-operation is valuable while a resentful child and/or ineffective or disinterested parents may provide more than a challenge in growth modification. (Proffit, 1986: p127). Ackerman and Proffit (1970) have suggested that perhaps the best solution, if the patient and parents are in agreement is "therapeutic diagnosis", a concept which is applied over a trial period to test not only the usefulness of the growth pattern, but also to assess the patient's co-operation.

6.4.5 Headgear Selection

Headgear traction plays an important role in the treatment of Class II; Division 1 malocclusion. It may apply force across the maxillary sutures in growth modification and secondly as an integral part of the force system of the edgewise appliance, controlling anchorage, moving buccal teeth, or groups of incisors (with J hooks).

The facial pattern is vital to suitable headgear selection. In the **brachyfacial** cases, extrusion of posterior molars will be an advantage to bite opening and cervical or horizontal lines of traction are selected. The outer bow if placed below CR will provide distal tipping of the molar (Kuhn, 1968) and this is an alternative to bodily movement (Godfrey, 1986: personal communication).

If the archwire is ligated (rigidly) the CR changes to the level of the premolar apices and bodily movement is achieved by placing the outer bow at this position. If rotation of the maxilla, say upward anteriorly is required, then the outer hook should be elevated above the premolar apices (CR) when cervical traction is used (Kuhn, 1968; Godfrey, 1985).

In the normal to high angle, dolichofacial pattern, occipital headgear is selected to provide an intrusive force, and if it can be tolerated, a distalizing force for anchorage control to the molars or maxilla.

If an archwire is ligated then the outer bow hook if placed so that the line of action passes through the CR at the premolar apices, then there should be bodily movement which tends to reduce both the overjet and overbite. (Nikolae, 1985: p353). In the extreme high angle case, no molar distalization can be tolerated and high occipital headgear is selected and requires a transpalatal bar to prevent buccal roll (Kuhn, 1968; Burstone, 1977). This type of headgear therapy acts to limit vertical growth and to prevent any extrusion of the molar anchorage when sectional intrusion mechanics are used. (Burstone, 1977).

6.5 STABILITY GOALS, POST - TREATMENT RELAPSE STUDIES AND METHODS OF RETENTION

6.5.1 Stability Goals

The stability of treated cases is dependent on corrected occlusion which should be within the bounds of normal muscle balance that is in turn dependent on the relationship of the apical bases to one another. (Riedel, 1960). The literature also reveals the concept of an ideal occlusion that is stable in both the static (centric/occlusal) relationship and in functional relationship.

(Andrews, 1972; Ricketts et al, 1980; Roth, 1981; Williams, 1985). The static goals of occlusion have been effectively described by Andrews (1972) who enumerated six keys consistently present in ideal naturally excellent occlusions, including molar relationship, crown angulation (mesiodistal tip), crown inclination (labio-lingual), correction of all rotations, and with tight contact and level curve of Spee. Roth concurs with Andrews "keys" and declares them to be consistent with desirable functional occlusal goals provided the occlusion occurs with the mandible in centric relation i.e. maximum intercuspation with the condyles seated in centric relation (Graber and Swain, 1985: p666). Ricketts et al (1980) write that Class II cases are best positioned so eruption will combine with growth and physiology to settle the occlusion into the best position for each individual.

Functional occlusal goals:

* ideal functional occlusion requires that the lower jaw may be closed from its physiologic rest position to maximum occlusion without deviation of the condyle from its socket on either the right or left side and without occlusal interference in the movement. (Roth, 1981).

* a mutually protected occlusion in which there should be minimal or no slide from centric relation to centric occlusion; even contact on both sides with no lateral slide or forced mandibular movement; canine protected occlusion on the working side; no balancing interference upon lateral movement and disclusion of the posterior teeth in protrusion (Tuverson, 1980).

Static goals of occlusion:

* Anteroposterior Overcorrection

1-2 mm overcorrection is advised in Class II treatment. Once the headgear and/or Class II elastics have been discontinued teeth may rebound by 1 - 2 mm. (Riedel, 1960; Graber, 1966; Ricketts et al, 1980: p703; Proffit, 1986: p458).

* Vertical overcorrection

An edge to edge incisal relationship should be aimed at in deep overbite correction, by flattening the occlusal plane within the constraints of the case. This overcorrection is perhaps particularly important in the low angle cases (Creekmore, 1967; Simons and Joondeph, 1973).

* Low interincisal angle: of about 125° - 130° should be aimed at, this allows for some post-retention uprighting, still providing adequate contact for axial stress distribution rather than deflection (Backlund, 1958; Simons and Joondeph, 1973; Ricketts et al, 1980: p213).

* The occlusal plane: tipping the occlusal plane is to be avoided; it results in relapse and probably cannot be permanently altered. (Riedel, 1960; Lindquist, in Graber and Swain, 1985: p609).

Stability of deep overbite correction

Berg (1983) found that relapse of the corrected overbite was greatest in the extreme brachyfacial cases. The Class II,Division 2 cases only showed 3.2% greater relapse than the Class II,Division 1 relapse and other studies also confirm a significant probability of relapse in the extreme low angle cases. (Creekmore, 1967; Simons and

Joondeph, 1973).

Engel et al (1980) report that while low angle cases show the greatest relapse tendency (up to 100% in some cases) the more dolichofacial high angle cases correlate with stable overbite correction related to their vertical growth pattern.

Stability of cases treated with posterior extrusion and an opening rotation of the mandibular plane is only permanent if vertical growth occurs which may provide an increase in posterior face height. Riedel, (1960), Schudy (1964) and Creekmore (1967) agree with this but advocate extended use of an upper bite platform in the retainer throughout the growth period of the mandible. This lack of stability reported by Riedel et al is probably due to a return to the extreme forward intramatrix rotation of the mandible reported by Björk and Skieller (1983) in brachyfacial cases.

Stability of intruded incisors: Engel et al (1980) report that studies of incisor intrusion using utility sectional arches showed an average intrusion of 3 mm and this was followed by a relapse of 1 mm, i.e. two thirds of the intrusion held. There appeared to be no difference in the ability to intrude either in the upper or lower arch in both adults and children (perhaps demonstrating a real intrusion as opposed to preventing incisor eruption?).

Occlusion: overbite stability has also been correlated with good continuity of both dental arches and good intercuspal relationships of all posterior segments (Ludwig, 1967). The importance of incisal contact on the cingulum plateau area and a low interincisal angle has been reported by Backlund (1958).

6.5.2 Retention and the Prevention of Relapse

Post-treatment growth changes: long term relapse of Class II, Division 1 treatment will occur in cases that are partially or fully skeletal in origin (Proffit, 1986: p456). Condylar growth may continue after body growth is virtually complete; in girls until 15-16 years of age and in boys until 18-20 years of age. (Graber and Swain, 1985: pp38-39).

Björk and Skieller (1983) state that bite opening by orthodontic treatment influences remodelling of the mandible as does headgear on the maxilla by inducing intramatrix rotation which may show a tendency to relapse, requiring suitable retention. Proffit (1986: p86) states that a post-treatment return to forward growth rotation of the mandible and deepened overbite occurs in skeletal cases.

Retention in brachyfacial cases will require a continuation of headgear and a bite platform in the retainer, or alternatively, a functional appliance (a simple activator), until growth is complete; wearing the appliance night and day for 6 months and then at night only until growth is complete (Graber and Swain, 1985: p536; Proffit, 1986: p463).

In the dolichofacial cases there is a resumption of backward growth rotation of the mandible often worsening the convexity of the profile, with the chin point becoming more retrognathic. Retention suggested includes continued use of highpull headgear, to help limit further vertical growth. Corrected overbite is stable in this skeletal pattern and will not need a bite platform in the retainer

(Björk and Skieller, 1972; Engel, 1980; Proffit, 1986: p86).

Björk and Skieller (1972, 1983) report a late adolescent decrease in arch length that will occur as part of normal growth between 10-21 years of age and resulting from an internal jaw rotation which uprights the incisors while the molars migrate further mesially (see Figure 5.5). In the lower jaw the greater forward rotation will often tip the incisors lingually or cause crowding. The literature has suggested continued use of a fixed lower lingual retainer throughout the growth period especially in forward mandibular rotators. (Schudy, 1973).

The AP plane and lower incisor stability

The use of the AP plane in positioning lower incisors in a stable position relative to the maxilla and in relation to the musculature and soft tissue drape, is supported by several investigations. (Downs, 1956; Ricketts 1960[b]; Williams, 1969; Linder and Aronson, 1976).

The proclination of lower incisors may be necessary in some Class II, Division 1 cases, notably where lingual retroclination has occurred, often associated with circumoral dysfunction and habits. Zachrisson (1984, 1987) suggests that in these cases proclination to suitable cephalometric reference line will remain stable.

The literature suggests that intercanine width expansion must be avoided as it relapses towards the original pretreatment width resulting in incisal crowding (Riedel, 1960; Gardiner and Chaconas, 1976).

Several studies have linked lower incisor crowding to large mesiodistal widths, possibly showing some degree of Bolton discrepancy. For stability interproximal reduction has been recommended (Nordeurval et al, 1975; Williams, 1985).

------o0o------

SUMMARY

The purpose of the treatise was to describe Class II, Division 1, deep overbite malocclusion and discuss its treatment in the adolescent, using the edgewise appliance. The following list, drawn from the treatise, is wide ranging and indicates the nature and diversity of the malocclusion and its treatment.

(i) A variety of skeletal and dental relationships exist:

* on average the maxilla is neutrally placed with a retruded mandible (60% of cases); vertical development also varies and up to 50% of cases may show excessive vertical development.
* protrusion of maxillary dentition is less commonly seen than previously thought and should be related to the maxilla (point A) rather than the mandible.

(ii) The aetiology is regarded as largely genetic in origin; orofacial dysfunction, if present, has been found to be an adaptation to rather than a causal factor of the malocclusion, but may, along with habits, accentuate the severity of the skeletal cases and play a role in the aetiology of dentoalveolar cases.

(iii) Differential diagnosis using cephalometric analysis is useful in treatment planning:

* to locate the maxilla/mandible in relation to other craniofacial structures.
* to determine facial growth patterns from vertical analysis i.e., more brachyfacial or more dolichofacial cases.
* to determine dental relationships to both skeletal and soft

tissue structure.

(iv) Treatment planning should assess the possibility of commencing growth modification to assist in correction of the skeletal Class II relationship. If it is to be successful, forward mandibular growth and co-operation must be adequate; alternately extraction and edgewise mechanotherapy is selected for the mild to moderate cases.

(v) The current edgewise appliance provides a range of archwires from continuous to sectionals and their selection depends on the individual needs of the case. Preangulated brackets and tubes are used to reduce archwire bending.

The following factors play a role in the selection of mechanotherapy: facial growth pattern, lip/incisor relationships, lip strain/lip redundancy, freeway space/facial musculature forces.

(vi) Stability in the anteroposterior and vertical planes will require attention to the following treatment goals:

* overtreatment of both the anteroposterior and vertical planes.
* an interincisal angulation of $125^{\circ} - 130^{\circ}$.
* positioning the lower incisors relative to the AP plane, up to 2-3 mm forward of AP may remain stable and considerable proclination may be needed in cases with a history of finger sucking habits and circumoral dysfunction.
* attention to static and functional goals of occlusion has also been stressed.

(vii) In skeletal cases extended retention is needed throughout the growth period and it should be selected to suit the facial pattern and the degree of patient co-operation.

CONCLUSION

Class II, Division 1, deep overbite malocclusion is not a single clinical entity, but consists of a diverse range of skeletal, dental and soft tissue relationships. There may or may not be associated orofacial dysfunction; if present it is generally regarded as an adaptation to, rather than a cause of, the malocclusion. The aetiology is presently believed to be largely genetic in origin.

Careful differential diagnosis to locate the jaws, the dentition and soft tissue, in relationship to each other and the other craniofacial structures is considered essential. This diagnosis together with the facial/skeletal growth pattern, enables appropriate selection of mechanotherapy for the individual case.

The current "evolutionary" state of the edgewise appliance provides a range of archwire designs, from various segmented archwires, bypass "utility" archwires to continuous archwires. This enables correction of the deep overbite by a choice of incisor intrusion, buccal extrusion or a combination of the two. The treatise has emphasized the value of the following factors in the selection of suitable edgewise mechanotherapy: facial growth pattern (the more brachyfacial or more dolichofacial); incisor/lip relationship; lip strain or lip redundancy; freeway space and facial musculature.

Goals of stability of the treated malocclusion have been described and compared to recent findings reported in the literature. Retention of the skeletal Class II relationship and the deep overbite (especially in brachyfacial cases) will need to be extended throughout the post-treatment growth period and the retainers must be selected to suit the growth pattern diagnosed for the case.

------o0o------

BIBLIOGRAPHY

Ackerman, J.L. and Proffit, W.R.	1969	The characteristics of malocclusion. Am J Orthod 50: 443 - 454
Ackerman J.L. and Proffit W.R.	1970	Treatment response as an aid in diagnosis and treatment planning. Am J Orthod 57: 490 - 496
Altemus L.A.	1955	Horizontal and vertical dento-facial relationships in normal Class II, Division 1 malocclusion in girls 11-15 years Angle Orthod 25: 120 - 137
Andreasen G.F. and Morrow R.E.	1978	Laboratory and clinical analyses of nitinol wire Am J Orthod 73: 142 - 151
Andrews L.F.	1976[B]	The Diagnostic System: Occlusal Analysis Symposium on Orthodontic Systems 671 - 690
Andrews L.F.	1976[A]	The straightwire appliance, arch form, wire bending J Clin Orthod 10: 581 - 588
Angle, E.H.	1928	The latest and best in orthodontic mechanism Dental Cosmos 70: 1153 - 1154
Angle E.H.	1929	The latest and best in orthodontic mechanism Dental Cosmos 71: 170 Quoted in Thurow R.C., 1972: p151 The C.V. Mosby Co., St Louis
Backlund E.	1958	Overbite and the incisor angle Trans Eur Orthod Soc 277 - 286

Baldridge D.W.	1962	Levelling the curve of Spee: its effect on mandibular arch length Am J Orthod 48: 554-560
Ballard C.P.	1957	A symposium on Class II, Division 1 malocclusion The Dental Practitioner Vol. VII, 269 - 286
Barrer H.G.	1975	Protecting the integrity of mandibular incisor position through keystoning procedure and spring retainer appliance J Clin Orthod 9: 486-495
Baume L.J.	1950	Physiological tooth migration and its significance for development of occlusion in the biogenesis of overbite J Dent Res 29: 440 - 447
Begg P.R.	1956	Differential force in orthodontic treatment Am J Orthod 42: 481 - 510
Bench B.W., Gugino C.F. and Hilgers J.J.	1978	Bioprogressive therapy Part 5 J Clin Orthod XII: 48 - 69
Bench B.W., Gugino C.F. and Hilgers J.J.	1978	Bioprogressive therapy Part 9 Mechanics sequence for extraction cases J Clin Orthod XII: 334 - 357
Bennett J.C.	1985	Straightwire Course Johnson & Johnson Australia "A" Company Unpublished notes
Berg R.	1983	Stability of deep overbite correction Europ J Orthod 5: 75 - 83

Björk A.	1953	Variability and age changes in overjet and overbite Am J Orthod 39: 779 - 801
Björk A.	1955	Facial growth in man, studied with the aid of metallic implants Acta Odontol Scand 13: 9 - 34
Björk A.	1963	Variations in growth patterns of the human mandible J Dent Res 42: 400 - 411
Björk A.	1969	Prediction of mandibular growth rotation Am J Orthod 55: 585 - 599
Björk A. and Palling M.	1974	A study quoted by Zachrisson, 1984: p81
Björk A. and Skieller V.	1972	Facial development and tooth eruption Am J Orthod 62: 339 - 383
Björk A. and Skieller V.	1976	Postnatal growth and development of the maxillary complex. In McNamara J.A., editor Factors affecting growth of the midface, Ann Arbor, University of Michigan, Centre of Human Growth and Development. Quoted in Proffit, 1986: p86
Björk A. and Skieller V.	1983	Normal and abnormal growth of the mandible: a synthesis of longitudinal cephalometric implant studies over a period of 25 years Europ J Orthod 5: 1 - 46
Block L.S.	1947	Diagnosis and treatment of disturbances of the temporomandibular joint especially in relation to vertical dimension J Am Dent Assoc 34: 253 - 260

Bolton W.A.	1962	The clinical application of a tooth size analysis Am J Orthod 48: 502-529
Broadbent B.H.	1937	The face of the normal child Angle Orthod 7: 183 - 208
Broussard G.	1979	Technique of Broussard Rocky Mountain Orthodontics
Burstone C.J.	1966	The mechanics of the segmented arch technique Angle Orthod 36: 99 - 120
Burstone C.J.	1962	Rationale of the segmented arch Am J Orthod 48: 805-822
Burstone C.J.	1977	Deep overbite correction by intrusion Am J Orthod 72: 1 - 22
Chaconas S.	1986	Unpublished findings University of California, Course No. 428, Biochemical Principles Post Graduate Committee in Dental Science, University of Sydney
Coben S.E.	1966	Growth and Class II treatment Am J Orthod 52: 5 - 26
Corrucini R.S. and Potter R.H.	1980	Genetic analysis of occlusal variation in twins Am J Orthod 78: 140 - 154
Craig C.E.	1951	Skeletal patterns characteristic of Class I and Class II, Division 1 malocclusions in norma lateralis Can J Orthod 21: 44 - 56
Creekmore T.D.	1967	Inhibition or stimulation of vertical growth of the facial complex Angle Orthod 37: 285 - 297

Dibbets J.M.H.	1985	The puzzle of growth rotation Am J Orthod 87: 473 - 478
Downs W.B.	1956	Analysis of the dentofacial profile Angle Orthod 26: 191 - 212
Drake S.R.	1982	Mechanical proportions of orthodontic wires in tension, bending and torsion Am J Orthod 89: 206 - 210
Edwards J.G.	1970	A surgical procedure to eliminate rotational relapse Am J Orthod 57: 35 - 46
Engel G., Cornforth G. Damerell J.M. et al	1980	Treatment of deepbite cases Am J Orthod 77: 1 - 13
Enlow D.H.	1982	Handbook of Facial Growth, Second Edition, W.B. Saunders Co., Philadelphia
Fields H.W. Jr	1981	Orthodontic restorative treatment for relative mandibular anterior excess in tooth size problems Am J Orthod 85: 217 - 229
Fisher E.A.	1942	Migraine and the closed bite J Am Dent Assoc 29: 844 - 845
Geiger A.W.	1962	Occlusal studies in 188 consecutive cases of periodontal disease Am J Orthod 48: 330 - 336
Geiger A.W. Wasserman B.H. and Turgeon L.	1973	Relationship of occlusion and periodontal disease Part VI Relation of anterior overjet and overbite to periodontal destruction and gingival inflammation J Periodontol 44: 150 - 157

Godfrey K.	1984	Assessment of orthodontic views Unpublished paper, Dept. of Preventive Dentistry, University of Sydney
Godfrey K.	1985	Extraoral anchorage using a face-bow Printed notes, Dept. of Preventive Dentistry, University of Sydney
Godfrey K.	1986	Stability Lecture, Dept. of Preventive Dentistry, University of Sydney
Godfrey K.	1986	Radiographic cephalometry Unpublished notes Dept. of Preventive Dentistry University of Sydney
Graber T.M.	1966	Post-mortem in post-treatment adjustment Am J Orthod 52: 331 - 352
Graber T.M.	1972	Orthodontics, Principles and Practice Third Edition W.B. Saunders Co., Philadelphia
Graber T.M. and Neumann B.	1977	Removable Orthodontic Appliances W.B. Saunders Co., Philadelphia
Graber T.M. and Swain B.F.	1985	Orthodontics, Current Principles and Techniques The C.V. Mosby Co. St. Louis
Green C.S.	1973	A survey of current professional concepts and opinions about the myofascial pain dysfunction syndrome J Am Dent Assoc 86: 128 - 135
Greenburg L.Z. and Johnston L.E.	1975	Computerised prediction Am J Orthod 67: 243 - 252
Hagg U. and Taranger J.	1982	Maturation indicators and the pubertal growth spurt Am J Orthod 82: 299 - 309

Harvold E.P.	1968	The role of function in the aetiology and treatment of malocclusion Am J Orthod 54: 883 - 898
Harvold E.P. et al	1981	Primate experiments on oral respiration Am J Orthod 79: 359 - 372
Henry R.G.	1957	A classification of Class II, Division 1 malocclusion Angle Orthod 27: 83 - 92
Hershey H.G.	1972	Incisor tooth retraction and subsequent profile change in post adolescent female patients Am J Orthod 61: 45 - 54
Hitchcock H.P.	1973	A cephalometric description of Class II, Division 1 malocclusion Am J Orthod 63: 414 - 425
Hixon E.H.	1972	Cephalometrics: a perspective Angle Orthod 42: 200 - 211
Hocevar R.A.	1981	Understanding, planning and managing tooth movement: orthodontic force system theory Am J Orthod 80: 457 - 477
Hovell J.	1950	The genetically imposed limitations of orthodontic treatment Trans Europ Orthod Soc 68 - 75
Humerfelt A. and Slagsvold O.	1972	Changes in occlusion and craniofacial pattern between 11 and 25 years of age Trans Europ Orthod Soc pp.113 - 122
Ireland V.E.	1953	The problem of "the clicking jaw" J Prosthet Dent 3: 200 - 212

Jacobson A.	1975	The "Wits" appraisal of jaw disharmony Am J Orthod 67: 125 - 138
Jacobson A.	1979	A key to the understanding of extraoral forces Am J Orthod 75: 361 - 386
Janzen E.K.	1977	A balanced smile - a most important treatment objective Am J Orthod 72: 359 - 372
Jarabak J.R. and Fizzell J.A.	1963	The technique and treatment with the light-wire appliances The C.V. Mosby Co, St. Louis
Jenny J.A.	1975	A social perspective on need and demand for orthodontic treatment Int Dent J 25: 249 - 256
Johnston L.E.	1975	A simplified approach to prediction Am J Orthod 65: 253 - 257
Kaplan R.G.	1974	Mandibular third molars and post retention crowding Am J Orthod 66: 411 - 430
Kuhn R.J.	1968	Control of anterior vertical dimension and proper selection of extraoral anchorage Angle Orthod 38: 340 - 349
Kusy R.P.	1981	Comparison of nickel-titanium and beta-titanium wire sizes to conventional orthodontic archwire material Am J Orthod 79: 625 - 629
Kusy R.P. and Greenburg A.R.	1981	Effects of composition and cross section on the elastic properties of orthodontic wires Am J Orthod 51: 325 - 341

Kusy R.P. and Stevens L.E.	1987	Triple-stranded stainless steel wires - evaluation of mechanical properties and comparison with titanium alloy alternatives Angle Orthod 57: 18 - 32
Linder-Aronson S.	1970	Adenoids: Their effect on mode of breathing and nasal air flow and their relationship to characteristics of the facial skeleton and dentition Acta Oto-laryng Suppl. 265: 132 (Quoted by McNamara, 1981)
Linder Aronson S. and Corelius M.	1976	The relationship between lower incisor, inclination and various reference lines Angle Orthod 46: 111 - 117
Lindquist B. and Thilander B.	1982	Extraction of third molars in cases of anticipated crowding in the lower jaw Am J Orthod 81: 130 - 139
Little R.M., Wallen T.R. and Riedel R.A.	1981	Stability and relapse of mandibular anterior alignment - first premolar extraction cases treated by traditional edgewise orthodontics Am J Orthod 80: 349 - 365
Logsdon L.C. and Chaconas S.J.	1975	Laminographic evaluation of the temporomandibular joint J Dent Res 54 (Supplem. A): 184
Ludwig M.	1967	A cephalometric analysis of the relationship between facial pattern, inter-incisal angulation and anterior overbite changes Angle Orthod 37: 194 - 203
Lundström A.	1984	Nature vs nurture in dentofacial variation Europ J Orthod 6: 77 - 91

Lundström A. and Woodside D.G.	1983	Longitudinal changes in facial type in cases with vertical and horizontal mandibular growth change Europ J Orthod 5: 259 - 268
Magill J.M.	1960	Changes in the anterior overbite relationship, following orthodontic treatment in extraction cases Am J Orthod 46: 755 - 788
Mewing M.	1980	Electromyographic activity of mentalis muscle in Class II, Division 1 malocclusion submitted as M.D.Sc. Thesis, University of Sydney
Meyer M and Nelson G.	1978	Preadjusted edgewise appliances - theory and practice Am J Orthod 73: 485 - 498
Moore A.W.	1959	Orthodontic treatment factors in Class II malocclusion Am J Orthod 45: 323 - 352
Moore G.J. McNeill R.W. and D'Anna J.A.	1972	The effects of digit sucking on facial growth J Am Dent Assoc 84: 592 - 599
Moss M.L.	1968	The primacy of functional matrices in orofacial growth Dent Pract 19: 65 - 73
Moss M.L. and Salentjin L.	1969	The capsular matrix Am J Orthod 56: 474 - 490
Moyers R.E.	1973	Handbook of Orthodontics 3rd Edition, Year Book Publishers Inc, Chicago
Moyers R.E., Riolo M.L., Guire K.E. et al	1980	Differential diagnosis of Class II malocclusions Am J Orthod 78: 477 - 494

Mulligan T.F.	1979	Commonsense mechanics Part 1 J Clin Orthod 13: 588 - 594
Mulligan T.F.	1979	Commonsense mechanics Part 2 J Clin Orthod 13: 676 - 681
McNamara J.A.	1981	Components of Class II malocclusion in children 8 - 10 years of age Angle Orthod 51: 176 - 201
McNamara J.A.	1983	A method of cephalometric analysis in clinical alteration of the growing face. Monograph 12, Craniofacial growth series Ann Arbor, Univ of Michigan (Quoted in Proffit, 1986: p.167)
Nanda R.	1981	The differential diagnosis and treatment of excessive overbite Dent Clin North Am 25: 69 - 84
Nemeth R.B. and Isaacson R.J.	1974	Vertical anterior relapse Am J Orthod 65: 565 - 585
Nikolai R.J.	1985	Bioengineering analysis of orthodontic mechanics Lea and Febiger, Philadelphia
Nordeurval K. Wisth P.J. and Boe O.E.	1975	Mandibular anterior crowding in relation to tooth size and cranio- facial morphology Scand J Dent Res 83: 267 - 273
Pearson L.E.	1978	Vertical control in treatment of patients having backward - rotational growth tendencies Angle Orthod 48: 132 - 140
Petrovic A.	1972	Mechanisms and regulation of mandibular condylar growth Acta Morphol Scand 10: 25 - 34 (Cited in McNamara, 1981)

Posselt V	1968	The Physiology of Occlusion and Rehabilitation Second edition F.A. Davis Co., Philadelphia
Posen A.L.	1976	The application of quantitative perioral assessment to orthodontic case analysis and treatment planning Angle Orthod 46: 118 - 143
Poulton D.R. and Aaronson S.A.	1961	The relationship between occlusion and periodontal status Am J Orthod 47: 690 - 699
Prakash P. and Margolis H.I.	1952	Dento-craniofacial relations in varying degrees of overbite Am J Orthod 38: 657 - 673
Proffit W.R.	1978	Equilibrium theory revisited: factors influencing position of the teeth Angle Orthod 46: 175 - 186
Proffit W.R.	1986	Contemporary orthodontics The C.V. Mosby Co, St. Louis
Proffit W.R. and Vig K.W.L.	1981	Primary failure of eruption: a possible cause of posterior openbite Am J Orthod 80: 173 - 182
Pullinger A.G. Solberg W.K. Hollender L. et al	1987	Relationship of mandibular condylar position to dental occlusion factors in an asymptomatic population Am J Orthod 91: 200 - 206
Reitan K.	1969	Principles of retention and avoidance of post-treatment relapse Am J Orthod 55: 776 - 790

Richardson M.E.	1986	Late lower arch crowding: the role of facial morphology Angle Orthod 56: 244 - 254
Ricketts R.M.	1955	Abnormal function of the temporomandibular joint Am J Orthod 41: 435 - 441
Ricketts R.M.	1960	The influence of orthodontic treatment on facial growth and development Angle Orthod 30: 103 - 133
Ricketts R.M.	1960(b)	A cephalometric synthesis Am J Orthod 46: 647 - 673
Ricketts R.M.	1981	Perspectives in the clinical application of cephalometrics Angle Orthod 51: 115 - 150
Ricketts R.M., Bench, R.W., Hilgers J.J. et al	1972	An overview of computerised cephalometrics Am J Orthod 61: 1 - 28
Ricketts R.M., Bench R.W. Gugino C.F. et al	1979, 1980	Bioprogressive Therapy Rocky Mountain/Orthodontics J.P.O. Inc
Riedel R.A.	1950	Esthetics and its relation to orthodontic therapy Angle Orthod 20: 168 - 198
Riedel R.A.	1960	A review of the retention problem Angle Orthod 30: 179 - 199
Riolo M.L., Moyers J.A. McNamara J.A. et al	1974	An atlas of craniofacial growth Ann Arbor, Monograph 2 Centre for Human Growth and Development. University of Michigan (Quoted in Graber and Swain, 1985: p.81)

Roth R.H.	1981	Functional occlusion for the orthodontist J Clin Orthod, Part 1 XV: 32 - 51
Rothstein T.L.	1971	Facial morphology and growth from 10 to 14 years of age in children presenting Class II, Division 1 malocclusions Am J Orthod 60: 619 - 620
Rubin R.M.	1969	Treatment planning in Class II malocclusions Angle Orthod 39: 152 - 161
Sarnat B.G.	1976	The post-natal maxillary nasal-orbital complex: experimental surgery in factors affecting the growth of the midface. Univ of Michigan Centre for Human Growth and Development Ann Arbor (Quoted in Proffit, 1986: p35)
Sassouni V.	1958	Diagnosis and treatment planning via Roentgenographic cephalometry Am J Orthod 44: 433 - 463
Sassouni V.	1970	The Class II syndrome: differential diagnosis and treatment Angle Orthod 40: 334 - 341
Sassouni V. and Nanda S.	1964	Analysis of dentofacial vertical proportions Am J Orthod 50: 801 - 823
Schudy F.F.	1964	Vertical growth versus antero-posterior growth as related to function and treatment Angle Orthod 34: 75 - 93

Schudy F.F.	1965	The rotation of the mandible resulting from growth: its implications in orthodontic treatment Angle Orthod 35: 36 - 50
Schudy F.F.	1973	Sound biologic concepts in orthodontics Am J Orthod 63: 376 - 397
Schulhof R.J. and Bagha L.	1975	A statistical evaluation of the Ricketts and Johnston growth-forecasting methods Am J Orthod 67: 268 - 280
Schulhof R.J., Allen R.W. Walters R.D. et al	1977	The mandibular dental arch: Part 1, lower incisor position Am J Orthod 47: 280 - 287
Shaw W.C.	1981	Factors influencing the desire for orthodontic treatment Europ J Orthod 3: 151 - 162
Simons M.E. and Joondeph D.R.	1973	Change in overbite: a ten year post retention study Am J Orthod 64: 349 - 367
Simpson Mary McF.	1977	An electromyographic investigation of the perioral musculature in Class II, Division 1 malocclusion Br J Orthod 4: 17 - 22
Skieller V.	1967	Cephalometric growth analysis in treatment of overbite Trans Europ Orthod Soc Report pp 147 - 157
Stack B.C.	1977	Temporomandibular joint dysfunction in children J Periodontol 1: 240 - 247

Steadman S.R.	1940	Six different kinds of overbite J Am Dent Assoc 27: 1066 - 1071
Steiner C.C.	1953	Cephalometrics for you and me Am J Orthod 39: 729 - 755
Steiner C.C.	1960	The use of cephalometrics as an aid to planning and assessing orthodontic treatment Am J Orthod 46: 721 - 735
Stockard and Johnson	1941	Genetic and endocrinic basis for differences in form Wistar Institute, Philadelphia (Quoted in Proffit, 1986: p116)
Storey E. and Smith R.	1952	Force in orthodontics and its relation to tooth movement Aust Dent J 56: 11 - 19
Strang R.H.W.	1934	An analysis of the overbite problem in malocclusion Angle Orthod 4: 65 - 85
Subtelny J.D.	1970	Malocclusions, orthodontic corrections and orofacial muscle adaption Angle Orthod 40: 170 - 201
Swain B.F.	1952	Case analysis and treatment planning in Class II, Division 1 cases Angle Orthod 22: 187 - 204
Ten Hoeve A., Mulie R.M. and Brandt S.	1977	Technique modifications to achieve intrusion of the maxillary anterior segment J Clin Orthod 11: 174 - 193
Thurow R.C.	1982	Edgewise Orthodontics The C.V. Mosby Co, St. Louis

Tuverson D.L.	1980	Anterior interocclusal relations Parts I and II Am J Orthod 78: 361 - 393
Tweed C.H.	1941	The application of the principles of the edgewise arch in the treatment of malocclusion Angle Orthod 11: 12 - 67
Weinstein S., Haack D.C., Lightle Y.M. et al	1963	On an equilibrium theory of tooth position Angle Orthod 33: 1 - 26
Williams R.	1969	The diagnostic line Am J. Orthod 55: 458 - 476
Williams R.	1985	Eliminating lower retention J Clin Orthod 19: 342 - 349
Wylie W.L.	1946	The relationship between ramus height, dental height and overbite Am J Orthod and Oral Surg 32: 57 - 67
Wylie W.L. and Johnson E.L.	1952	Rapid evaluation of facial dysplasia in the vertical plane Angle Orthod 22: 165 - 182
Zachrisson B.V.	1984	In search of excellence in orthodontics Printed notes, Oslo, Norway Presented at Aust Orthod Soc Post Congress, Sydney, 1987.

-----o0o-----

UNIVERSITY
OF SYDNEY
DENTAL LIBRARY