A RETROSPECTIVE STUDY OF ANTERIOR OPEN BITE TREATMENT

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This paper submitted in partial fulfillment of the requirements for a Certificate in Orthodontics, Oregon Health Sciences University.

June, 1988

ACKNOWLEDGEMENTS

My sincere thanks go to Dr. Douglas Buck for the orthodontic education I have recieved at O.H.S.U. I recognize my good fortune in becoming a member of this specialty.

I am grateful to every member of the Faculty for their significant contributions to my training, Dr. Doyle in particular for his ever present, and always cheerful, readiness to help.

My good friends and classmates, Mike Kuhn, Joe Restic, and Carlos Saborio made the past two years much more pleasant than they otherwise would have been.

Every member of my family deserves part of the credit as well. My parents for their love and care. My father for imparting the love of working with my mind, my eyes, and my hands. My brother and father-in-law for their computer help. But most of all my thanks goes to my wife, Barb, for her love and support.

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INTRODUCTION

Anterior open bite malocclusions present a difficult diagnostic as well as clinical problem for the orthodontist. Specific etiology in each case as well as prognosis for closing an anterior open bite are not easy to determine or predict. After an anterior open bite is closed with an orthodontic appliance, certain factors predisposing to, or producing open bite may remain and re-exert their influence once active treatment is completed.

This investigation will focus on the degree of long-term success achieved in the orthodontic treatment of anterior open bite malocclusions. Subjects were selected from among patients having been treated in the graduate orthodontic clinic at the Oregon Health Sciences University. Selection criterion consisted of a lack of hard or soft tissue occlusal contact of the four lower incisors in pretreatment models in cases having been out of retention at least two years prior to this study.

On recall, lateral cephalometric skull films were obtained, along with dental models and intraoral and extraoral photographs. An examination of current conditions was made. From each patient's records relevant information, such as treatment modalities, history, and initial clinical observations, was noted. Cephalometrically, various methods were used in attempting to determine direction of mandibular growth rotation and other significant changes occurring during and after treatment.

Causes of anterior open bite are generally thought of as falling into two categories; those brought about by habit and those resulting from undesirable growth patterns. The question in treating open bite malocclusions is whether different manifestations of the problem require different approaches in treatment, and then what degree of success may be expected. The orthodontist would like to know what type of headgear is most helpful, and whether overtreatment in the correction of open bite is beneficial, for example. It would be good to know if the long or adenoid face syndrome actually exists as a true syndrome and whether a Class II molar relation is more common in open bite cases in light of the steep mandibular plane frequently present. This investigation was carried out with questions such as these in mind.

REVIEW OF THE LITERATURE

Milo Hellman[1], in a 1931 article on open bite malocclusions presented a discussion of his experience in treating them and some research he had conducted. His experience was that the frequency of correction without treatment was about the same as he achieved with treatment. This led him to an anthropologic investigation. In one sample of skulls, he found 41 normal and three open bite examples, all with a Class I molar relation. In another sample, there were 25 with normal occlusion, one with an open bite and one with a deep bite. The general finding was a decrease in ramus height and mandibular body length with an increased face height. The opposite was true in the deep bite case. Many of the facial widths were more narrow in the open bite skulls, and the gonial angle was more obtuse.

Hellman believed it was not a failure of development in the incisor region. He felt the relative shortness of the ramus and body of the mandible was due to an arresting of growth and that this was the actual cause of open bite. This growth pattern results in a "fulcrum" effect in the region of the posterior dentition. He states, "But growth is not constant and definate. It varies in intensity, it varies in time, it varies in direction, and it varies in different structures and in different parts of the same structure. An adequate knowledge of growth is therefore indispensable. But growth cannot be controlled. It is therefore also necessary to recognize our limitations." He believed that prognosis was not predictable because outcome depended on growth magnitude, direction, and pattern. He mentioned that habit control (finger sucking) might be important.

In hindsight, Hellman seems to have been very insightful, especially in light of the fact that he did not have the benefit of radiographic cephalometrics.

One of the most frequently cited early references dealing with the pattern of growth of the face is Brodie's[2] 1941 article "On the Growth Pattern of the Human Head." It was a descriptive radiographic longitudinal study of the growth of 21 males from three months through eight years of age. With reference to the work of Hunter and others he said, "Such investigations have tended to support the theory that function is one of the main factors, if not the main factor, in the determination of form." On the other hand he also hinted at the importance of genetic control.

In discussing growth of the various areas of the head and face, the consistent theme of his comments was the striking stability he saw in the pattern of development. He observed that the lower border of the mandible did not change in its angular relation to the cranial base and that the gonial angle did not change with time. The glenoid fossa was observed to move slightly downward and backward. The proportions of anterior facial height contributed by its component parts was established by one to one and one half years of age and maintained thereafter. The average nasal height was 43% of the total from two years of age on.

The upper dental area was found to be quite stable except for a slight lowering of the posterior end of the occlusal plane. One might conjecture that this gives a hint of rotational change.

In concluding he stated, "Thus the face as a whole travels straight forward and straight downward, with a downward and forward resultant at the chin point." With regard to variation he said, "...all types have been shown to possess the same basic pattern." And finally, "The most important single finding is that the morphogenetic pattern of the head is established by the third month of postnatal life, or perhaps earlier, and that once attained it does not change." Apparently he felt that the genetic makeup of an individual determined form at birth, allowing for variation, but that function normally dictated similar patterns of growth for all individuals from that time on. He stated that growth was a steady process with no "spurts" during this time period.

In Brodie's[3] 1953 article he continued his discussion of longitudinal growth changes focusing on the period from age eight to age seventeen. He emphasized that "...the head is a complex of different parts, each one of which serves different functions." He pointed out that the upper face and the mandible are associated with separate parts of the cranial base (anterior and posterior) which may show some independence in growth. In this study, he found a tendency for a small increase in the angle of the palatal plane relative to the sella-nasion line (SN) and a small decrease in occlusal plane (OP) and mandibular plane (MP) relative to SN. Significant variation was found in all of these. A tendency toward a decrease in prominence of the denture within the face was noted. Brodie continued to insist on the "stability of the individual pattern." He stated that the possibility that individuals could be found to exhibit a collection of extremes in one direction does not exist. He felt that "compensatory variation" precluded this possibility. This would seem to run counter to the idea that many have of extreme hyper- or hypodivergent cases, or the commonly reported "long face syndrome."

It is not surprising that an increasing understanding of the complexity of growth seemed to be the trend early on.

Swinehart[4] in 1942 wrote about his clinical experience with open bite cases. He presented a survey of the 115 open bite cases he had treated. (Not all were anterior open bite.) In terms of frequency of occurrence, there was a higher than expected number of Class II cases with open bite, and fewer Class I cases. Class III cases had an average share of open bites. In Class I cases the open bite tended to be confined to the anterior areas, whereas in Class II cases it was more extensive. In Class III cases it was irregular in pattern and location. The upper incisors were flared labially in about three forths of Class I open bite cases, half of the Class II cases and none of the Class III cases.

The tendency was for the maxillary occlusal plane to be deformed much more than that of the lower arch. He stated that "infraclusion" of the maxillary teeth in the open bite area was present in every case.

In his explanation of open bite, he ruled out obtuse gonial angle, downward bending of the body of the mandible and short ramus as contributing factors. These, he felt, would not account for the fact that the deformation was located in the maxilla. He ruled out supereruption of posterior teeth as a cause because he couldn't imagine the failure of the eruptive process in the anterior segment while a posterior fulcrum was established. He stated that the belief that dystrophic growth of the mandible could reopen space closed by orthodontics was "not tenable." He believed habits were to blame. He felt that thumb-sucking could precipitate the condition but that tongue habits were the most common cause of open bite and the only agent capable of maintaining the condition. He explained that in Class II cases, the tongue has the greatest need for "adjustment to permit efficient swallowing", hence the greater extent of these open bites. In Class I cases, the extent is reduced but there is less room for the tongue so flaring of incisors is more common. Class III individuals posture the tip of the tongue below the upper incisors so flaring is not present, but lateral thrusting is common, hence the posterior open bites.

Treatment of these cases should be done early and the correction of the vertical discrepancy should be accomplished primarily by forced eruption of the maxillary teeth, according to Swinehart. The arches should be expanded to sufficient size to accommodate the tongue.

Swinehart certainly understood the importance of habits in open bite but was also very narrowly focused in his viewpoint. One wonders about the stability of some of his expanded cases and whether his patients ever displayed excessively "gummy" smiles post-treatment. His assertion that the tongue could adapt to closure of an open bite was probably a significant contribution.

An early treatise on vertical development was written by

Wylie[5] in 1946. It was written in response to the idea that growth in the height of the ramus was the sole determinant of anterior facial height. This idea seemed to follow Brodie's widely accepted view that the pattern of an individual's craniofacial growth was constant. Wylie, in a cross sectional study found that individuals with a "slight" overbite had slightly shorter posterior face heights than those with "medium" overbites. He hinted at rotational growth, especially backward rotation, but only went so far as to say growth in this area is relatively complex in nature. It was indicated that lower face height was the more variable portion of total face height. Wylie remained convinced, however, that growth patterns remained fairly constant and also denied the existence of "growth spurts" in the craniofacial complex.

In a brief presentation of his research findings, White[6] discussed differences between skeletal and non-skeletal open bite cases. His approach involved comparing facial height between open bite and normal groups after removing the effect of the open bite or overbite, respectively, on the total facial height. He found very little difference between the corrected values, concluding that infraeruption of anterior teeth was not the primary cause of these open bites. He found instead significant differences in gonial and mandibular plane angles. The length of the ramus and body of the mandible were smaller in the open bite cases. The inclination of the posterior border of the ramus was found to be slightly greater in open bite cases. White concluded from this that the cause was not a supereruption of the molars propping the mandible open. He expressed the opinion that there are two types of open bite cases. Those due to habit will tend to remain stable after orthodontic or spontaneous closure, while skeletal open bites will tend to relapse after orthodontic treatment.

Meredith et al.[7] discussed the ratio of nasal height to subnasal height during growth. The trend in their sample was for an increase between the ages of 4 and 12. The individual variation did not support Brodie's concept of unchanging facial proportions. Variability increased with age. In a small, orthodontically treated group in which treatment seemed likely to cause an increase in subnasal height, an initial increase was usually followed by a decrease,leading them to suppose that long term clinical effects are either small or nonexistent.

In his 1963 article, Bjork[8] discussed mandibular growth in 45 boys as seen in yearly radiographs with the aid of metallic implants. The direction of condylar growth was not always found to be linear in direction and there was a great deal of variation in direction between individuals. The average direction of growth was 123° relative to the initial mandibular plane. As this was about 6° less than the beginning angle that the posterior border made with the inferior border, it meant that the mandible became more curved with growth. The gonial angle would then be decreased, although this was partially compensated for by resorption below the angle of the mandible and apposition below the symphysis. The symphysis also increased in thickness at its posterior border but its anterior surface did not change much.

In those mandibles growing in a more vertical direction, the gonial angle decreased, and there was more extensive resorption below the angle of the mandible. All the teeth tended to erupt in a forward direction. In those where condyles grew in a more posterior direction, the gonial angle increased, the resorption below the angle was not as extensive, if present at all, and the anterior teeth erupted in a posterior direction while the posterior teeth erupted more vertically.

During the juvenile period, condylar growth was about 3mm per year, slowing slightly to a minimum at about 11 years, 9 months. It then increased to a maximum of about 5mm per year at about 14 years, 6 months.

Bjork later[9] stated that the growth spurts in sutures of the face and in the condyles occurred at the time of the growth spurt in body height or soon afterward. The growth in facial sutures stopped about two years before the growth in stature did, while condylar growth continued a little longer than growth in height.

Bjork[10] wrote another article in 1969 with the intention of making the knowledge gained from his implant studies applicable to the normal (non-implant) clinical situation. He began by pointing out the difficulty in predicting rotational growth of the mandible; "Individual variations in the direction of growth at the condyles are large and, in the adolescent period, have been found to vary by almost 45 degrees." For this reason, prediction based on observation of change over a preliminary period are not valid. Bjork also found prediction based on cephalometric analysis lacking. He found a correlation of only

0.22 between the inclination of the mandible at 12 and its subsequent rotation.

The method he proposed involved identifying certain structural variations that would indicate a liklihood of extreme rotational growth. The first was the inclination of the condylar head. It curves forward in a forward rotator. The curvature of the mandibular canal was another. A straighter canal indicates backward rotation. The anterior part of the lower border of a forward rotating mandible is thickened and rounded. The chin is prominent in forward rotators, recessive in the other case. The teeth in backward rotators meet the opposing teeth at acute angles. Long lower face is indicative of backward rotation.

Bjork also pointed out that if the center of rotation is not at the incisors in forward rotation, it will be near the premolars and allow a deepening of the bite. In backward rotation the condyle grows more posteriorly, and the center of rotation is at the posterior end of the occlusal table. Eruption was found to be hindered at the point of rotation so it was concluded that overeruption of molars is not a factor. Unidentified muscular factors were believed responsible for direction of condylar growth, hence rotation of the mandible. Rotational growth in either direction may result in dental crowding in the mandible.

In their 1972 paper, Bjork and Skieller[11] discussed growth in a sample of 21 subjects. Metallic implants were used as landmarks. The subjects were not chosen at random, but to illustrate certain aspects of growth. The time period examined was six years around the time of puberty.

Rotational growth of the maxilla was noted. This tends to be disguised by a remodelling of the nasal floor that occurs in a compensatory direction. The inclination of the nasal floor was found to be quite stable. Rotational change might be influenced by extraoral or intermaxillary traction and should be taken into account, according to the authors.

The rotational growth of the mandible was more than twice as great, and three times more variable than that of the maxilla. Forward rotation of the face as a whole was most common. About one half the rotation of the mandible was masked by remodelling. The center of rotation varied. In some, it was in the incisal region, in others in the premolar area. In backward rotators it was in the area of the posterior teeth. Compensatory eruption of incisors was prevented by tongue posture in some of the backward rotators.

Bjork and Skieller[12] again discussed mandibular rotation in a 1983 paper. They examined three aspects of the rotation. Intramatrix rotation was the term they used to describe the rotation of the body of the mandible within the soft tissue matrix. It is also an expression of the degree of remodeling of the lower border over a period of time. It is measured as the change in relationship between the implant reference line and the "tangential mandibular line." This line indicates the plane marked by the lowest points of the lower border of the mandible, as opposed to the mandibular plane as used in cephalometrics.

Matrix rotation describes the rotation of the soft tissue matrix of the mandible relative to the anterior cranial base. It is measured as the rotational change of the tangential mandibular line. Total rotation is the rotation of the implants relative to the anterior cranial base. It is the rotation of the implants relative to the anterior cranial base and the additive total of the two components just mentioned. In forward rotators, matrix rotation is usually the smaller of the two and may even be in the opposite direction to total rotation. In the high angle or long face type of backward rotator, backward matrix rotation predominates, but in some growth disturbances of the condyles, intramatrix rotation is larger. Regarding the complexity of these high angle cases, the authors state that, "Backward growth rotation of the face has been generally considered to be simply a backward rotation of the mandible with the centre of rotation at the condyles. In fact, facial development in backward rotating cases is not a single growth pattern but consists of a combination of a wide variety of maxillary and mandibular rotation." They believe the "long face syndrome" type of case to be an extreme example of normal variation.

The remodelling of the lower border of the mandible is attributed to intramatrix rotation. If the anterior end of the mandible is rotating upward, pulling away from the matrix, the stretching of the periosteum results in apposition of bone. Resorption occurs near the angle in response to the pressure in that area. Intramatrix rotation is described as a compensatory function. It tends to maintain overall morphology in spite of rotational growth of the hard tissues.

Another topic covered in this paper concerned the condylar growth curves in nine cases of forward rotation. They stated that, "The generalizations made in the literature that condylar growth takes a circular course or has the shape of a logarithmic spiral were not confirmed by our material. Condylar growth curves were, on the contrary, characterized by marked individual variation which makes prediction of their course almost impossible."

Isaacson, Isaacson, Speidel, Worms and others from Minnesota have contributed over the years to the literature dealing with mandibular rotation. In a 1971 paper[13], a cross-sectional study of extreme mandibular plane angle cases was described. While acknowledging the remodeling which tends to mask rotational changes during growth, they felt that individuals demonstrating extremes in mandibular plane angle would show other morphologic deviations which make up the "syndromes" represented by these extreme cases.

They found that as the mandibular plane-sella-nasion angle (MP-SN) increased, overbite decreased to the point that open bite was the average in the high angle group, and palatal width decreased with increasing MP angle. Percentage of lower facial height increased with increasing MP angle. Of the factors they referred to as "morphologically causative" in the development of high or low angle cases, the posterior maxillary alveolar height was felt to be the most important while ramus height was less important and the height of the mandibular molars relative to MP was fairly unimportant.

They deduced that palatal or upper arch width would tend to be constricted with backward rotating mandibles due to the increased "passive stretch tension" of the facial muscles. If this reasoning is correct, one would assume bizygomatic width to be significantly decreased in these individuals. They describe a tendency toward buccal crossbite in backward rotators and increased buccal overjet in extreme forward rotators. They found the dentition tended to be more posteriorly located in high angle cases and more anteriorly in low angle cases.

In light of their findings they directed their conclusions at treatment and prognosis of these extreme cases. Referring to the degree of overbite in forward and backward rotating cases respectively, they state that "Such overbites or open bites are skeletal in nature and can be expected to get worse with continuance of the growth pattern already manifest." They further state that an open bite in a low angle case must be a result of a habit and would have a very good chance of being corrected once the habit is corrected.

Treatment modalities in high angle cases should include high pull headgear and extraction therapy if indicated to any degree. Intermaxillary elastics, leveling of the curve of Spee and banding of second molars all should be avoided. The opposite is recommended by these authors for forward rotating cases.

Worms, Meskin, and Isaacson[14] made a cross-sectional study of open bite in 1,408 Navajo children between 7 and 21 years of age. The classification of open bites was based on examination with occlusion in centric relation. They found that Class II individuals were affected more frequently and more extensively than Class I individuals. Between the age groups of 7-9 and 10-12 there was a large decrease in simple open bites (those involving the anterior 4 to 6 teeth with 1mm or more vertical incisal edge open bite). A slight increase occurred at later ages. More extensive, compound open bites (including premolars) increased in frequency with time. A decrease of up to 80 percent of simple open bites was seen between age groups. Reasons for this change were suggested. They might include changes in function during the transition to permanent dentition and a tendency for favorable growth rotation. One might wonder whether the increasing occurrance of compound open bites was due to backward rotational growth in those subjects.

Nemeth and Isaacson[15] selected thirteen anterior open bite relapse cases and thirteen anterior deep bite relapse cases simply on the basis of the relapse found after treatment and retention. The average age at the end of treatment was 13 years, 0 months and at post-retention it was 18 years, 2 months. Philosophically they subscribed to Bjork's concept of mandibular growth rotation. The balance between vertical growth at the condyle, and vertical growth of maxilla along with upper and lower dentoalveolar increase, is combined with the horizontal component of condylar growth to effect a rotation centered usually somewhere in the occlusion.

Through a complex cephalometric analysis, the authors found a variable change in incisor angulation after retention. Intrusion of incisors was not a common component of relapse of open bite correction, although present in one case. All open bite relapse cases exhibited backward rotational growth post-treatment while all deep bite relapse cases demonstrated forward rotation post-treatment.

Regarding retention of open bite cases, they advise that occipital or parietal-pull headgear to the upper molars could be worn until growth is complete (which they point out may run into the 20's) or, alternatively, a Milwaulkie brace type of appliance could be worn for the same period. No method of retaining lower molar height was known to the authors. Early treatment was encouraged to allow better control of vertical increase in molar areas.

Isaacson et al.[16] wrote in 1981 about mandibular growth rotation. They equated a backward rotating growth pattern with the long face syndrome. They believe the rotation of the mandible to result in increased dental height almost exclusively in the maxilla. The incisors must erupt further than the molars to compensate for the rotation. This compensation may or may not be complete. Their concept of orthodontic correction of skeletal open bite is that it is a process of building in more dental compensation. If compensation is complete, it is very likely to result in a "gummy" smile. The maxilla tends to be narrower than usual with a high palate and a tendency for molar crossbite. The arch width in forward rotators is wider so dental crowding is less common in this group, according to the authors. They believed backward rotators to generally be regarded as less esthetic in appearance.

An elaborate explanation of their "center of rotation kinematic concept of facial growth" and how they determine the center of rotation is offered. This approach differs from that of Bjork. When Bjork speaks of the center of the rotation in mandibular growth, it is relative to the maxilla. These authors, though, speak of a center of rotation relative to cranial base landmarks. In an earlier article by Isaacson et al.[17], the same analysis was used. It was shown that Class II correction as it relates to growth does not directly relate to rotational growth changes in the mandible. Instead, the horizontal component of condylar growth and fossa positional change is the most significant factor. The more posteriorly directed condylar growth is, the higher the liklihood a Class II correction can be accomplished. Superimposed upon this, a backward rotational pattern will make the Class II correction more difficult to achieve. Their opinion was that the direction of growth of the condyle might be subject to alteration during treatment but that there is a tendency for this to rebound. They expressed doubt that growth patterns can permanently be altered.

In the 1981 article, the authors state that the backward rotational growth pattern has not been shown to be correlated with anteroposterior molar relations. They believe that the location of the center of rotation varies in an individual over time, but not to a large degree. This variability, though, contributes to difficulty in predicting growth in an individual.

Schudy[18] has written that the composite of anterior and posterior vertical growth, along with anteroposterior growth, is the determining factor in the type of occlusion an individual develops. He recognized late growth change with mandibular incisors uprighting and lower molars even drifting distally in some cases. In looking at 270 lateral cephalograms, he examined the relationships between SN-MP angles, occlusal plane-mandibular plane (OM) angles, anterior and posterior face height, and depth of face (facial plane to the posterior aspect of the condyle).

He proposed labelling cases with extremely high and extremely low SN-MP angles hyperdivergent and hypodivergent, respectively. He found little variation in upper anterior face height but a large difference in lower anterior face height between these groups. Lower face height was 56% of total height in the average type, 59.5% in hyperdivergent and 54.1% in hypodivergent types. The ratio of posterior to anterior dental height in the average type was 68%. It was 56.5% in hyperdivergent cases and 79.7% in hypodivergent cases. He believed the OM angle to be very important in classifying facial divergence and felt that a correlation coefficient of only 0.364 between OM angle and degree of overbite proved it so. He was disappointed that the SN-MP angle had a correlation coefficient of only 0.274 with degree of overbite. He used a correlation of 0.27 as the point above which significance was established. These low correlations, however, may be more indicative of large variation in degree of dental compensation in extreme cases.

Schudy felt that the ratio between raums height and anterior dental height was "the most sensitive indicator for overbite factors" and also that the higher the OM and SN-MP angles, the greater the deficiency of posterior facial height. He concluded by discussing principles of treatment. In the average case he felt ideal overbite should be easy to obtain, and maintain. In the hypodivergent type he recommended banding lower second molars to assist in a difficult overbite correction, upper molars should be distallized as much as possible because alveolar height is deficient, extractions should be avoided if possible, and retention of overbite correction should be prolonged. The hyperdivergent type was said to have facial height out of proportion with depth. A corrected open bite will be difficult to retain. The mandibular incisors should not be allowed to move lingually as this would necessitate use of Class II elastics which should be avoided along with any other mechanics which would tend to erupt molars. Upper molars should not be distallized very much. Extraction of two maxillary teeth would be advantageous, if indicated.

Subtelny and Sakuda[19] summarized the thinking regarding open bite in 1964 saying that it was thought to be caused by either a vertical growth defiency of some sort, or tongue or digit activity. Their clinical experience led them to believe the activity of the tongue was normally adaptive. They also noted a decrease in frequency of open bite with increasing age. It would be logical to use a tongue crib or to excise hypertrophic lymphatic tissue in order to change the environment of the tongue and allow it to adapt to this more desirable state. They espoused this philosophy. They did not believe tongue training exercises to be useful.

A group of 25 open bite subjects were compared with 30 people having normal occlusion. All were over 12 years of age. They found, in the open bite cases, a shortening of posterior cranial base, and a tendency toward a shorter ramus, but the length of the body of the mandible was not changed. The gonial angles and mandibular plane angles were much greater. The mandibular dental height was not different, but in the maxilla there was a significantly greater dental height in both molar and incisor areas. SNA and SNB were significantly reduced, while ANB was increased. (Controls had normal occlusions.) The lower face height was larger in the anterior but not the posterior part of the face. The maxillary arch tended to be constricted. This composite picture of differences they referred to as a skeletal open bite and felt it was responsible for "persistent" open bites as opposed to the simple open bite maintained by adaptive function of the tongue.

Regarding treatment of these cases, they cautioned against eruption therapy with elastics as they found no indication of inadequate eruption. Depression of upper molars seemed more appropriate, although relapse potential was felt to be high either way. A fairly bleak prognosis was offered in the treatment of skeletal type open bites.

Sassouni and Nanda[20] selected eight skeletal open bite, and eight skeletal deep bite cases from a Denver Child Research Council longitudinal study. They found that, in comparing open bite to deep bite types, the open bite cases on average had larger maxillary dental height in the area of incisors and molars and the dental height was larger in the mandible, although only slightly so in the molar region. Undereruption was not the problem in these skeletal open bites. Gonial angle was wider, but the total length of the mandible was unchanged. The distance from the condyles to the molars was unchanged, but the ramus was smaller in open bite cases (the condyle was "higher"). When comparing the skeletal pattern at age six in these sixteen cases with that at adulthood, it was noted that the pattern was present early, but not with the degree of severity gained by adulthood. Comparing a child with parents remains one of the best methods of predicting growth outcome.

Sassouni and Nanda theorized that the position of the posterior teeth relative to the "posterior vertical chain of muscles" is significantly different between the two extreme types. In deep bite cases, the muscles are oriented such that the molars remain depressed by the forces perpendicular to the plane of occlusion. In open bite cases, the muscle chain is more posteriorly and obliquely positioned so that a smaller depressing force and a mesially directed component are present.

For treatment of Class II skeletal open bite cases, they recommend avoidance of intermaxillary elastics and cervical traction to the upper molars. High pull headgear and extraction therapy (when indicated) are beneficial. In the most severe cases, first premolars, upper first molars, and lower second molars are all removed. The prognosis is considered good if these rules are followed. The Class III open bite case has a poor prognosis when treated only orthodontically. Rotating the mandible upward increases the Class III tendency while rotating it downward increases the open bite tendency. Their primary thesis was that many anteroposterior discrepancies are symptoms of vertical dysplasia.

Hapak[21] wrote in 1964 about a sample of 52 open bite cases. He found them to demonstrate a Class II tendency. Lower face height was increased with lower alveolar height increased in an apparent attempt to compensate for the growth pattern and resultant open bite. Tongue thrust was common and blamed for a tendency for proclination of incisors. He found large variation in skeletal pattern in this open bite sample.

Richardson[22], in comparing cephalograms of 110 open bite cases with a similar number of deep bite cases matched for sex and age, found that the angle sella-articulare-gonion as well as the gonial angle were significantly larger in the open bite sample. Differences in angular relations seemed to be more important than differences in relative size of parts.

Using the same sample, Richardson[23] studied differences in vertical height in the incisal region. He found that dentoalveolar heights were significantly smaller in the open bite group throughout all ages but that some of this difference was made up for by more of an increase in maxillary and mandibular basal height with age. Further accentuating the difference in overbite was the finding that the incisors were shorter and more proclined in the open bite group.

In a third report, Richardson[24] told of a study of 127 open bite cases that were followed over a period of three years. This group was divided into age groups of 7-10 years, 11-14 years, and 15-21 years with 44, 33, and 50 individuals, respectively. These groups were broken down into those having spontaneous closure of open bite during the three year period and those not closing. The amount of open bite was not reported. In the youngest group, closure occurred in those who had a relatively small amount of growth in lower facial height and a large amount of lower dentoalveolar height increase. The most significant of the two was the difference in lower facial height growth. In the second age group, there was no significant difference in face height growth but the upper and lower dentoalveolar heights increased significantly more in those with spontaneous closure. In the older group, the only significant difference was in lower face height growth.

Vertical growth of the upper face didn't seem to be a factor in spontaneous closure as no differences were noted. Richardson found no measurements that could serve as prognostic indicators of the liklihood of spontaneous closure of open bite.

Nahoum[25] investigated the role of the palatal plane angle in makeup of the face. He compared 52 open bite subjects with a normal, untreated Class I group. Forty of the open bite cases had Class II molar relation. The average open bite was 5mm. The upper face height to lower face height ratio (UFH/LFH) was 0.809 in normals and 0.699 in open bite cases. Upper face height was smaller in open bite cases, but lower face height was larger to the degree that total face height was slightly larger in this group. Nahoum felt that the relative development of the oral and nasal "functional matrices" may be important in the etiology of open bite through influence on the angulation of the palatal plane.

Nahoum[26], in a summary of his findings and opinions regarding anterior open bite cases, described them as a collection of "several skeletal variants". His approach is one of examining the components of a malocclusion and treating the symptoms. Dental open bites may be transitional, and close on their own, or are generally stable after orthodontic correction.

Skeletal open bite cases are described as usually having a shorter posterior face height than normal. The palatal plane may be tilted upward anteriorly resulting in a shorter upper face height and longer lower face height with total face height longer than average. A diagnostic criterion offered relates to the UFH/LFH ratio. He stated the normal to be 0.800, open bite cases to have a ratio of less than 0.700, and that for closed bite cases greater than 0.900. A steep, notched mandibular plane and an obtuse gonial angle are present. The dentoalveolar height is at least as large as normal except that for the lower molars which is significantly less. The distance from the sella-nasion line to the upper incisor is shorter than normal. Subtle neuromuscular deviations are found in the tongue and other muscles. He believed the angle between the palatal and mandibular planes to be the most commonly abnormal feature in skeletal open bites.

In treatment, it should be recognized that correction is often unsuccessful. He did not believe myofunctional therapy to be beneficial. Growth with hindsight is the best estimate of success. The determination of severity of overbite suggested by Kim was not found to be useful. Nahoum felt a surgical approach should be considered in many cases, although he questioned the stability of the result that could be expected.

Schendel et al.[27] believed the long face syndrome (LFS) to be a "clinically recognizable facial morphology". They stated that its primary manifestation is excessive lower vertical facial height but that it also variably demonstrates narrow nose, narrow alar base, high lip line, large interlabial distance, prominent nasal dorsum, retropositioned chin, high palatal vault, and a large maxillary dental height. They said the occlusion is often Class II. The purpose of the report was to investigate differences between those long face syndrome individuals with open bite and those without. Of 31 long face individuals in the study, 15 had open bite, and 16 did not. These were compared to a normal group.

Upper face height was about the same in all three groups. Lower face height was increased in LFS groups; more so in the open bite group. Posterior face height was much larger in the non-open bite LFS group than in the open bite group. The ramus height was about normal in the open bite group, but longer in the non-open bite LFS group. Both maxillary and mandibular anterior dental heights were increased similarly in both LFS groups. Mandibular length was about the same in all groups. SNA was about the same in all groups while SNB was decreased in both LFS groups. ANB was highest in the open bite group. The MP-SN angles for normal, non-open bite, and open bite groups were 31.75°, 39.78°, and 48.61° respectively, while the OP-SN angles were 15.70°, 14.39°, and 20.6°. The average lip length was the same in all groups but maxillary tooth exposure was increased in LFS subjects.

The authors concluded that the central skeletal dysmorphology in LFS is vertical maxillary excess and the primary difference between those having open bite and those without is posterior facial height. They described the groups as demonstrating two variants of the long face syndrome, increased ramus height in the closed bite group making the distinction.

Trouten et al.[28] discussed the morphology involved in open bite and deep bite cases using the "counterpart analysis." They found a tendency toward mandibular protrusion in their sample of open bite cases, as well as in their normal sample. They stated that, "...the combination of a large gonial angle in conjunction with a posteriorly inclined ramus, lack of compensating curve of Spee, certain rotations of the maxilla and basicranium, large vertical maxillary height and long horizontal mandibular dimension, underlie the aggregate composite morphological basis for an open bite."

In two back-to-back articles in the JDR in 1983, Proffit and others[29,30] wrote about investigations into occlusal forces in normal and long faced subjects. They found that forces generated during swallowing, simulated chewing, and maximum force were respectively similar in long faced and normal children, and in long faced adults, but only about half the value generated by normal adults. Conjecture was made as to why this might be. They considered it unlikely, but possible, that since long faced individuals tend to be tall and slender, their musculature is not as capable of generating force. The geometric differences may produce a mechanical advantage when an upright ramus and an acute gonial angle are present. If this accounts for differences in the adult, the normal child must not yet have developed the increased muscular strength to take advantage of it. The long face and hypereruption of posterior teeth may be a result of muscular forces operating on the occlusion. However, the fact that the long face pattern is evident prior to the presence of a difference in muscular forces, it would appear more likely that the decreased forces are an effect of the long face pattern rather than a cause of it. If this last conclusion is true, one might think that in the forward rotator, the pattern allows an increase in muscular force over what it normally might have been. Other comments of interest in these papers were made regarding growth of the mandible and stability of pattern. "The mandible appears to respond as if growth of the muscles and surrounding soft tissues translated it downward and forward, allowing upward and backward proliferation at the condyle. Whether growth of the muscle is a primary factor in producing downward and forward translation of the mandible, or whether growth changes in both muscle and bone reflect some deeper underlying cause, is simply not known." Also, it was stated that while the long face pattern is not always evident before puberty, once established it almost always persists throughout growth.

Cangialosi[31] reported a cross-sectional cephalometric study of sixty open bite cases, comparing them to sixty normal Class I cases. Among the significant differences were a larger mandibular plane angle (SN-GoGn, 38.3° vs. 29.8°), larger gonial angle (132.5° vs. 123.9°), and smaller posterior face height to anterior face (PFH/AFH) and upper face height to lower face height (UFH/LFH) ratios in open bite cases. Palatal plane angle was not significantly different. When comparing open bite individuals in permanent dentition to those still in mixed dentition, the only significant difference was a smaller UFH/LFH ratio in the older group. He felt this to be an indication that there was a change in size but not in shape or proportion as the open bite case grew. (It seems, however, that a significant change in UFH/LFH with age is inconsistent with a concept of unchanging proportion in growth.) An attempt was made to distinguish skeletal and dentoalveolar open bites but it seemed to be an arbitrary division between the more and less severe examples of open bite cases. The author concluded that the phenomenon of open bite is multifactorial in nature and subject to extreme variation in expression.

Fields et al.[32] discussed differences in facial pattern in a cross-sectional study involving normal and long faced children and adults. Among children, long faced individuals had significantly steeper mandibular plane angles and longer lower face height, but similar upper face height and posterior face height as was seen in normals. The size of the ramus and the body of the mandible were also the same as normal but the gonial angle was significantly larger in the long faced children. They were found to have significantly greater dental height in the upper and lower posterior areas and lower anterior area but not in the upper anterior area.

The long faced adults also showed an increase in mandibular plane angle and anterior lower face height over normal. The total posterior face height was not different, but there was a trend toward shorter ramus length. The gonial angle again was greater. There was a tendency toward excess eruption of all teeth but no statistically significant differences.

Both children and adults with long faces tended to be retrognathic and both had a normal cranial base orientation with a natural head posture. The authors felt that the difference between long faced and normal individuals was all below the palatal plane, primarily in the morphology of the mandible. But they pointed out that "...a simple explanation of complex biologic phenomena is inadequate."

Nanda's[33] review of the literature in his 1988 paper led him to say, "The conclusions based upon these studies are ambiguous, have led to confusion, and no composite picture of pattern of development associated with vertical dysplasias has emerged, preventing appropriate comparison of data from different studies."

Nanda selected subjects for his study on the basis of lower face height as a percentage of total face height values. Eight males and eight females from both extremes were selected from a pool of 250. They were untreated and followed between the ages of 3 and 18 years. The five dimensions he examined were total anterior and posterior face heights (N-Me and S-Go), upper and lower anterior face heights (N-ANS and ANS-Me), and ramal height (Ar-Go).

He found that the patterns of vertical growth were established very early, even before age six, but that these patterns differed between the open and deep bite types in terms of timing and morphology. There did not seem to be significant differences in either the total posterior face height or the ramus height. Sexual dimorphism was usually overshadowed by that of type. Males reached their period of maximal growth later than females while open bite cases tended to precede deep bite cases. On the basis of these findings, Nanda recommended that earlier treatment might be beneficial in long lower face individuals and that overtreatment and long retention periods are appropriate for the later maturing deep bite individuals.

Lopez-Gavito et al.[34] in 1985 published a postretention study of treated anterior open bite cases. There were 41 cases having at least 3mm of open bite, as projected along the long axis of the lower incisors, pretreatment. As compared to a group with normal occlusion, the open bite group, before treatment, was retrognathic (it contained many Class II individuals), had larger SN-MP, PP-MP (palatal plane-mandibular plane), and NS-Gn (nasion-sella-gnathion) angles, smaller SN-PP (SN-palatal plane) angle, similar anterior face height, smaller upper and larger lower anterior face height, and similar posterior face height. The maxillary dental height was increased in anterior and posterior areas but the mandibular dental height was no different.

Stable and relapse (more than 3mm open bite postretention) groups were compared. A little over a third fit into the relapse category. Both groups had similar magnitudes of open bite pretreatment, and of reduction of open bite, during treatment. The amount of eruption of lower incisors was also similar between groups but the mean lower incisor height relative to the mandibular plane was less at all points in time in the relapse group. Also, in this group, the lower anterior facial height increased more than in the stable group during the postretention period. The upper posterior face height was less posttreatment and postretention in the relapse group, indicating that depression or inhibition of eruption of upper molars with headgear may not guarantee stable closure of open bite. The authors found no satisfactory pretreatment predictors, or set of predictors, of stability of correction.

Rowley, Hill, and Winter[35] wrote about an association between skeletal open bite and the hypoplastic and hypocalcification types of amelogenesis imperfecta. They believed the association to be genetic in origin. Local factors, such as abnormal tongue activity in response to sensitivity or roughness of teeth, or crowning of posterior teeth, did not seem to explain the association adequately. They concluded that there may be a pleiotropic effect of the amelogenesis imperfecta gene defect causing a vertical growth dysplasia. If true, this would support the concept of the existence of a long face syndrome.

Koski and Lahdemaki[36] examined a small sample of individuals having large adenoids or having a history of adenoidectomy. The most significant difference between these and a control sample group was the orientation of the posterior border of the ramus relative to other landmark borders. This border was found to be distally rotated relative to the cranial base. In other words, the lower end of the ramus was more posterior relative to the upper end than normal. This in spite of the fact that the orientation of the lower border of the body of the mandible and of the posterior border of the condyle were not significantly different than normal. Another, less significant difference was in the orientation of the line referred to as "clivus" which represents the angle of the posterior cranial base.

It was felt that an antegonial notch was not necessarily present in the adenoid juvenile face but a bend between the posterior borders of the ramus and condyle is. It was concluded that maintenance of the pharyngeal airway required the tongue, soft palate, mandible, and associated tissues to be carried in a lower position which causes a dorsal rotation of the mandible, or at least of the ramus. The authors therefore refer to the ramus as an "adaptive link" joining the condyle and the corpus while conforming to the needs of the other tissues in its area. It was speculated that the ventral rotation of clivus was caused by a habitual dorsiflexion of the head to assist in maintaining the airway.

Subtelny[37] in 1954 published a relatively qualitative assessment of the importance of adenoid tissue relative to craniofacial growth. A description, based on longitudinal radiographs, was given. The tissue could not be detected radiographically until six months to one year of age. It then grows rapidly so that by 2-3 years the tissue may occupy about one half the volume of the nasopharynx. Growth continued from this time at a slightly slower rate until a point anywhere from 10 to 15 years of age after which it began to atrophy. This diminution in size is complete by adulthood. He cites Brodie as showing that by the age of two the distance between the posterior nasal spine and the anterior arch of the atlas is established and will remain throughout growth. He concludes that it is growth in the vertical dimension that is important in maintaining the airway. Excessive growth, allergic reaction, or infection may cause an obstruction, causing the individual to adapt by lowering the tongue and mandible and mouth-breathing. He theorized that the lower position of the tongue results in a narrowing of the upper arch. Also the relaxation of the lip musculature results in a proclination of the upper anterior teeth followed by anterior migration of the entire arch resulting in a Class II division 1 malocclusion. He concluded that in cases of nasopharyngeal obstruction, adenoidectomy should be considered before the permanent dentition erupts. Otherwise, retention of orthodontic treatment may be necessary until atrophy of the adenoid tissue is complete.

Regarding an investigation into the effects that adenoids have on the dentition, Linder-Aronson[38] discussed the retroclined incisors and narrow upper arch that he found common in children with large adenoids. The retroinclination of the upper and lower incisors was felt to be caused by lip posture in the mouth breathing brought on by the presence of the adenoids. In a group of children that underwent adenoidectomy, he found that the majority became nose breathers. The incisors tended to become more proclined than those in a control group, and the transverse width of upper first molars increased more in the experimental group as well; especially in those who switched from mouth to nose breathing.

Ricketts[39] wrote in 1968 on what he called "respiratory obstruction syndrome". He recognized a wide variety of both genetic and environmental factors which he believed would lead to mouth breathing and dentofacial deformity. The interdependency of hard and soft tissue morphology, airway size, head posture, and soft palate and tongue posture was discussed. He spoke of three cases of bilateral posterior crossbite that self-corrected after tonsil and/or adenoid removal. He believed that after removal of the obstruction, the head was postured downward, bringing the upper dentition down over the tongue which, in turn, caused an increase in width of the upper arch. Allergic conditions consequent to early exposure to foods other than breast milk were also indicted. Many interesting thoughts were presented, but, for the most part, they were in the form of opinion and conjecture.

Woodside and Linder-Aronson[40] investigated relationships between anterior face height components, respiratory pattern, and hypertrophic adenoid presence. Out of 120 males, ages 6 to 20, from the Burlington sample, 22 children were selected who had anterior face height greater than the 90th percentile or increasing much faster than average. The variance in lower face height is two to three times that of the upper face height in the group of 120.

In the subgroup of 22, the lateral skull film was used to assess nasal airway obstruction. (They acknowledged the possibility of error in this assessment.) They interpreted their data as tending to suggest an association between nasal obstruction and more rapid increases in lower anterior face height.

In another sample of 32 Swedish children, 16 had large adenoids and subsequent adenoidectomy, and 16 were normal. The adenoid group was found to habitually posture their heads in a more upright or extended manner before surgery. Upper face height was normal but lower face height was significantly larger in the adenoid group. One month after adenoidectomy, a significant difference in posture between the groups could not be detected.

Growth of the upper face height in the group of 120 was correlated with growth of other parts of the cranium, but growth of lower face height was highly independent of these. The assumption was expressed that growth of lower face height is influenced by "growth direction of the mandible and those neuromuscular factors influencing mandibular posture, such as mouth breathing and head posture." Position of glenoid fossa may be a factor.

In 1986, Woodside and Linder-Aronson[41] followed up the article of 1979 on the channelization of face height in males with a report relating to growth of lower face height in females. The results were similar to the previous study, but the more rapid increase in lower face height, in those exhibiting it, occurred at an earlier age.

Appliances to aid in the correction of skeletal open bite were also discussed. They are used in those patients who have a skeletal open bite as a result of an environmental factor such as hypertrophic adenoids. The appliance therapy begins after the etiologic factor has been removed. Their purpose is to prevent further eruption, and possibly intrude the buccal segments. This is intended to permit autorotation of the mandible so that additional growth will be in a more horizontal direction. The maxilla must sometimes be held back to prevent a tendency to become more prognathic with use of these appliances. One design consists of upper and lower acrylic portions separated by a spring. A hinge action is produced with the hinge toward the anterior. Use of magnets in bite blocks is also described.

Woodside and Linder-Aronson also discussed a case of severe anterior open bite in a patient with amelogenesis imperfecta. Nasal obstruction, large adenoids, and long lower face height were also present. Treatment consisted of adenoidectomy, desensitization of teeth, and a spring-loaded posterior bite block followed by "repelling magnet vertical correctors." Upper second molars were removed during treatment.

Vig et al.[42] made a quantitative study of nasal airflow in 28 adults. Nine had lip incompetence with normal vertical development, nine had a long lower face height, and ten were normal with respect to these traits. They found no significant differences in respiratory pattern or nasal airflow between the groups. The long face group did have the highest nasal airway resistance and the lowest amount of nasal airflow as a group, but individual variation was too large for significant differences to be noted. Conditions present during growth, but undetectable later, may have contributed to adult morphology.

Straub[43] summarized his observations regarding the abnormal swallowers in his practice. He concluded that abnormal swallowing is associated with open bite and with a history of bottle-feeding in infancy. While it was a subjectively written paper, it seems to have had a significant influence on many people.

Andersen[44] examined 127 students averaging 6 years, 4 months of age, 123 at 11 years, 6 months, and 155 at 17 years, 8 months average age. He found anterior open bites in decreasing percentages of 21.3, 14.6, and 9.0, respectively. Although he was taking anterior open bite as representative of a tongue thrusting habit, this illustrates a tendency for self correction of open bite with time, and probably reflects a decrease in tongue thrusting as well. He also conducted a survey regarding bottle and breast feeding, digit sucking, cold and sore throat frequency, and removal of tonsils. Method of feeding in infancy did not seem to be important. History of digit sucking was about twice as common in open bite cases. Neither history of tonsillectomy or frequent colds and sore throats seemed to differ between open bite and normal individuals.

A study of the level of the hyoid bone in adults was also done. Comparing 34 anterior open bite cases with 40 normals, no difference in the level of the hyoid was noted. It was concluded that tongue posture at rest was not related to open bite, although tongue size could be.

Subtelny and Subtelny[45] in 1973 summarized some current and some previous research regarding oral habits. In reviewing the literature they found many reports that teeth do not always occlude during swallowing in subjects with normal occlusion and that "abnormal swallow" in general is not always associated with a malocclusion. They pointed out that the later growth of the jaws typically accomodates the initially relatively large tongue, often leading to spontaneous closure of an open bite. Partial glossectomy may be advantageous in extreme cases. Thumb sucking was felt to be a fairly common cause of anterior open bite with an adaptive tongue thrust following. Their experience was that tongue thrust generally ceased after digit sucking was discontinued. Removal of hypertrophic tonsil and adenoid tissue was found to result in closure of open bites at times. The posture of the tongue was felt to cause open bite when normal atrophy of lymphoid tissues occurred too late in the development of the occlusion. Another problem can be a lack of neuromuscular control of the tongue. Cerebral palsy serves as an extreme example of this. These defects may be very subtle, however, and seem to be unresolvable for the most part.

In examining deglutition with cineradiography, the authors concluded that the reflex was very uniform in a variety of malocclusion types, except for the adaptation of the tongue to its particular environment. In two other cineradiographic studies they failed to see improvement in tongue protrusion after tongue crib therapy and after myofunctional therapy. After orthodontic correction in five of the patients from the myofunctional therapy study, the aberrant function was reduced or eliminated. Their recommendation was that myofunctional therapy be instituted after orthodontic treatment when adverse patterns persist. They classified open bite malocclusions into two types; those due to habit which are subject to stable orthodontic correction, and the skeletal variety, which must be treated with surgery, if at all.

Melsen et al.[46] examined 824 children, aged 13 to 14 years, in Italy. About 8% fell into the category of tongue thrust swallow and about 12% had what they called a teeth apart swallow. Open bite was found in 1% of those with a normal swallow, 12% in tongue thrust swallowers, and 4% of teeth apart swallowers. Posterior crossbite was found in 11%, 22%, and 34% in these groups, respectively. Open bite was found in 2% of nasal breathers and 10% of mouth breathers while posterior crossbite was found in 14% of nasal breathers and 33% of mouth breathers. The authors felt that the most statistically significant finding was that relating posterior crossbite to mode of respiration.

Bernard and his coworker[47] reported that a medial glossectomy on a young Rhesus monkey resulted in closure of an anterior open bite. This open bite had developed in response to what they termed a relative macroglossia. They could not ascertain whether the tongue was actually oversized or forced into a forward posture.

Meyers and Hertzberg[48], in a study based on questionnaires regarding 454 children aged 10 to 12 years, found that only parental orthodontic history was significantly related to the child's need for orthodontics. There was, however, a trend toward need for treatment with increasing exposure to bottle-feeding, but this was of marginal significance. Other factors such as finger sucking and pacifier use did not seem of significance.

Fletcher, Casteel, and Bradley[49] investigated the associations between tongue thrust, sibilant distortion, and age in 1615 students between the ages of 6 and 18. The proportion with tongue thrust decreased gradually from a little over 50% to about 20% by age 18. The largest decrease appeared to occur between the ages of 7 and 9 indicating that reestablishment of potential hard tissue enclosure of the oral cavity is a significant factor. A slight decrease in sibilant distortion with age was not statistically significant, but this did decrease significantly with age in those children without tongue thrust. Sibilant distortion was found to be highly associated with tongue thrust and did not decrease with age in this group.

Gershater[50], in an investigation of mentally retarded and emotionally disturbed children, many having open bite, found no greater incidence of defective speech among individuals with open bite as compared with the other children.

Proffit and Mason[51] discussed myofunctional therapy in a 1975 paper. They pointed out that the pattern of growth of the mandible tends to follow that of stature, and the adenoids and tonsils follow the lymphoid growth pattern. The tongue follows a neural type pattern, attaining full size at about eight years of age. They recommend that speech therapy be instituted at the time a speech problem is detected. They recommend myofunctional therapy only in older children who do not show progress toward adult swallowing pattern, and then only concurrently with orthodontics.

In another article, Proffit[52] indicated that myofunctional therapy had not been shown to be effective in closing open bites in and of itself.

Mehnert[53] found that speech is affected by the presence of anterior open bite. He compared a group of 21 subjects with normal occlusion with a group of 16 having anterior open bite (average ages 25.0 and 27.3 years, respectively) and with two other groups having less than ideal occlusion. It was found that, "The anterior open bite occupies first place with regard to its susceptibility to disturbances of the S-sound." The investigation was based on "electro-acoustic sound analysis." There was only one person in the open bite group able to pronounce "S" sounds correctly.

Creekmore[54], in a 1967 article, discussed vertical control of cases, pointing out the interdependence of vertical and anteroposterior change. Relatively well matched treated and untreated groups were studied radiographically over time to determine the effect of orthodontic treatment on normal growth. Another study of treated high and low angle cases was compared to Creekmore's average facial type treated group. One assumption he made was that "from present knowledge it seems doubtful that any treatment method could materially affect growth in length of the mandible."

In the untreated group the ANB angle decreased with time due to a stable SNA angle and an increasing SNB angle. The relation of maxillary to mandibular teeth was found to be quite stable due to migration of the teeth relative to their bony bases. They move more or less as one group except during late mixed dentition when the posterior teeth move forward while the incisors drift lingually. Rotational change in the mandible was said to result from a difference in vertical growth at the condyle and total vertical growth in the molar region. Therefore, in "normal" growth, with vertical growth at the condyles greater than that of the molars, the forward growth of the mandible is greater than its horizontal growth. It was found that the upper molars grew down more than the upper incisors while the opposite was true of the lower teeth resulting in the "normal" decrease in OP angle, as was noted by Brodie.

Creekmore's treated group showed a decrease in ANB due primarily to a decrease in the SNA angle. He stated that this was not a distalization of the maxilla but a failure to grow forward as much as the rest of the face. (All in this group were treated with the use of cervical headgear to the upper arch.) Lower molars were found to be significantly elevated, and lower incisors significantly intruded, as compared to those in the untreated group. The use of elastics was felt to be very significant in the vertical change in position of the teeth. The increase in anterior facial height was significantly higher in the treated group. MP angle increased in the treated group while it decreased in the untreated group.

In comparing the high and low angle treated groups with the other two groups, it was found that the MP angle decreased the most in the untreated group, to a lesser degree in the low angle group, increased slightly in the average group and even more in the high angle group. The increase in prominence of menton was least in the high angle group and highest in the low angle group. He concluded that "high angle faces are more susceptible to vertical development than average faces, whereas low angle faces are less susceptible."

In terms of treatment recommendations, he felt that most treatment approaches should result in a good outcome due to a favorable growth pattern. In low angle cases, growth favors correction of Class II relation, but not of deep overbite. He felt that vertical development of the posterior teeth is resisted in this type. Nonextraction treatment, elastics, and cervical headgear use are more favorable in these patients. With high angle cases, growth is generally unfavorable for Class II correction so these people should be treated as nongrowing individuals. Upper first premolar extraction is usually indicated for Class II cases. High pull headgear to the upper molars is helpful. Use of elastics should be avoided.

Pearson[55], in a 1973 article, discussed the importance of vertical control of the lower molars in extraction cases having steep mandibular plane angles. He demonstrated extrusion in treated cases and showed how it could be reduced by using cervical headgear to the lower molars. He states that, "The hypothesis that extraction therapy is especially desirable in steep cases is valid only if the case can be treated without appreciable extrusion in either arch." Extrusion of posterior teeth results in a vertical change at gnathion about three times as large, according to Pearson.

Pearson[56], in a later article, discusses treatment of backward rotators in general. He subscribes to Bjork's predictive morphologic signs. His treatment of these cases often involves extraction of first premolars just as they erupt, followed by vertical pull chin cup wear twelve hours a day until the remaining teeth erupt. The chin cup therapy is continued through treatment and, sometimes, until growth is complete. This is not successful in nongrowing patients. Extrusive forces, such as intermaxillary elastics, are avoided.

Other procedures which may be helpful include intrusive occipital headgear (used with an upper lingual arch to prevent rolling out of the molars), mandibular headgear, and mandibular bite blocks. Removal of remaining primary teeth after intrusion of permanent molars can be helpful in allowing the mandible to hinge further closed. Avoiding banding of the lower arch is helpful, although a lower fixed retainer is needed to prevent crowding. Overbite correction, when needed, is done with incisor intrusion mechanics rather than continuous arch mechanics because the author feels it leads to the least amount of posterior extrusion.

An article typical of those based on experience, opinion, and reason on the part of the writer is exemplified by that of Haas[57] in 1980. In it he described his treatment philosophy regarding vertical dysplasia. The problem in skeletal open bite, as he sees it, is deficient ramus length. He believes this is due to the muscular sling in these cases "being long and spindly and coursing obliquely downward and backward. Overeruption of anterior teeth leads to relapse.

In treating skeletal open bite cases, he finds Kloehn headgear appropriate for anteroposterior correction in all but severe MP angle cases. He doesn't believe a correctly applied headgear of this type is capable of permanently supererupting upper molars. In the severe high angle case, this headgear can cause the maxilla to shift downward and backward along the posterior cranial base to the detriment of vertical dimensions. The high pull type is of little value because it is pulling perpendicularly toward the posterior cranial base. Haas uses a vertical pull chin cup in these cases, with a Kloehn headgear if AP change is needed. He believes this can alter mandibular morphology. In dental open bite cases, treatment is directed toward a removal of etiology. Myofunctional therapy is of absolutely no value in his experience.

Kim[58] in 1987 discussed his approach in treating skeletal open bite cases. His concept is one of uprighting posterior teeth to correct the inclination, relative to the occlusal plane, of all the teeth in these cases. He believed that treatment techniques involving extrusion of incisors with vertical elastics, high pull headgear, chin cup therapy, and surgery (except in extreme cases) was not adequate. His technique involved tip back bends on multilooped edgewise archwires with anterior vertical elastics, sometimes with the extraction of molars.

In another article, Kim[59] proposed his "overbite depth indicator." It is a summation of certain angles he found to be correlated (0.394-0.588 in different samples) with degree of overbite.

Harvold[60,61] was able to make Rhesus monkeys into mouth breathers by blocking nasal airways. The face height increased more in experimental animals than in controls. This occurred through additional extrusion of the teeth when mandibles were held in a lower position. When acrylic blocks were used to fill the palatal vault in other monkeys, the jaw was held lower for a period of time but the tongue seemed to adapt a great deal. Anterior open bites developed in some of these animals. Harvold felt that any factors causing change in mandibular posture should be considered in determining etiology of malocclusions.

McNamara[62] described a radiographic survey of 277 children averaging nine years of age with Class II malocclusions. The average mandibular plane angle was about 27° with limits of the range of 13° and 49°. The lower face height was longer than average for that age, almost half the sample having what he considered excessive vertical development. He concluded from the study that Class II malocclusions may result from many combinations of factors. Since excessive vertical development is common, altered respiratory function may be numbered among those factors. He felt that, because of evidence from studies in monkeys indicating that growth of the condyles may be adaptive in the face of changes in mandibular posture, treatment of some Class II cases should be designed to alter and direct mandibular growth rather than focusing on restraining maxillary development.

Frankel and Frankel[63] described the use of their appliance in the correction of skeletal open bite in an article in 1983. A study was done involving 41 severe skeletal open bite cases, 11 of which were untreated, while 31 were treated with the Frankel appliance and lip seal excercises. They were all followed from about 7 to 16 years of age. Individual findings were not provided but, in the treated group, average SN-MP, PP-MP, and gonial angles decreased. These angles increased in the untreated group. UFH/LFH and AFH/PFH ratios improved to "average norms" in the treated group but worsened in the untreated group. No other treatment was provided in either group, but extraction of molars is advocated in more extreme cases while treating with a Frankel appliance.

The authors believe the appliance is useful in strengthening weak muscles and correcting muscle imbalances which factor into the etiology of the hyperdivergent pattern. They reported regularly finding an increase in ramus length larger than the increase in anterior lower face height after treatment with their appliance and successful establishment of the lip seal. Relapse occurred whenever a competent seal was not achieved. Whether this was the fault of the patient, the musculature, or the response to the appliance was not mentioned.

Mizrahi[64] described an appliance he designed to control the problem of excessive vertical growth of the mandible, which he equated with the long face syndrome. It is composed of maxillary and mandibular portions which rest on the buccal occlusion of both arches. There is a replaceable steel spring between the upper and lower parts on either side which must be compressed to close the jaws. It is worn at all times other than while eating. It is intended for use in long faced children beginning two or three years prior to their pubertal growth spurt. Mizrahi believes the muscles of mastication will become stronger, depressing the buccal teeth and redirecting mandibular growth toward a more horizontal pattern.

Blechman[65] reported successful results in fixed application of magnetic forces. Advantages cited were elimination of the cooperation variable, better control of force vectors, and force control in three dimensions. Theoretically, a system could be developed that would be directed at accomplishing posterior intrusion or extrusion with crossbite correction at the same time. He says that, "In open-bite cases, magnets in repulsion can be used to intrude posterior segments and result in bite closing as well as in moving teeth mesiodistally."

Double molar tubes are used with segmental archwires to which the magnets are attached. Two cases were discussed, one of which showed closure of an anterior open bite in a 13 year old boy.

Dellinger[66] described his "Active Vertical Corrector" as an "energized" bite block appliance. One or two pairs of magnets are placed on each side directly over the teeth. Each pair delivers about 700 grams of force when there is no air gap. The suggestion is made that the presence of the magnetic field may create a "positive cellular effect" in surrounding tissues. The appliance is said to give rapid closure of open bite by autorotation of the mandible. He found other methods of intrusion of posterior teeth to be far too slow. Full orthodontic treatment is almost always necessary after use of the appliance. A headcap and chin strap are to be worn as much as possible in addition to the appliance, which itself must be worn at least 12 hours per day. It is claimed that this appliance may be used in adults, although correction is not as fast as in growing individuals.

Woods and Nanda[67] discussed an experiment wherein two young baboons were used as control animals, two were fitted with acrylic posterior bite blocks, and two were fitted with bite blocks of similar size containing magnets. Metallic markers were placed in each animal. The growth of all animals was followed radiographically for six months before placement of the appliances. The force generated by the magnets was large when approximated (about 1400 grams per quadrant) but the force tapers off in an inverse square manner as magnets are separated.

Both appliance types caused inhibition and change in direction of the normal eruptive process in upper and lower posterior teeth. Anterior teeth erupted in a compensatory fashion, as the acrylic blocks were large. The maxilla grew in a more forward direction in the experimental animals. The intrusive effects were similar whether magnets were in place or not, although increased gonial remodeling was noted in the animals with the magnets in place.

Bell[68] in 1971 discussed the surgical aspect of the correction of skeletal open bites. He described these cases as demonstrating a steep mandibular plane angle due to a backward rotating growth pattern, long lower face height, short rami, antegonial notching, deep, narrow palate, and excessive curve of Spee of the upper arch due to downward tipping of the posterior maxillary alveolar segment. Tongue thrust and a chronic anterior posture of the tongue is present.

Surgical techniques will vary depending on the needs of the patient as demonstrated cephalometrically. Anterior osteotomy or ostectomy, sagittal split ramus osteotomy, or posterior maxillary osteotomy, often combined with genioplasty, may be appropriate.

He believes tongue thrust to be adaptive in these cases so that the habit will be altered upon closure of the open bite unless splaying of lower incisors, oversized tongue or chronic posturing of the tongue over the teeth is present. If so, reduction glossoplasty may be necessary to avoid relapse. Long term relapse potential was not discussed.

Thomas and Proffit[69] wrote a short history of surgical correction of skeletal open bite, followed by a good overview of currently popular methods; usually a LeFort procedure and, if needed, a mandibular advancement or setback. Recommendations were made regarding the orthodontic portion of the treatment of these cases. It was advised that as much of the orthodontics as is possible be completed before surgery. The exrusive component of tooth movement will then have been expressed. Transverse correction of the maxilla should be done surgically. Closure of extraction space in the upper arch can be done surgically, also. An excessive curve of Spee in the upper arch can be corrected surgically following segmental arch mechanics. It was felt that this would minimize relapse of levelling. Surgical planning and techniques are discussed, as are fixation methods. Increased width of the alar base of the nose and shortening of the upper lip often accompany maxillary impaction. Mechanisms of neuromuscular adaptation after maxillary impaction is not well understood, but it is quite complete. Greater mechanical advantage seems to allow an increase in biting force. Stability of the maxillary position seems to be quite good, with settling toward a more cephalad position occurring occasionally. The authors report that about one third of these patients present with increased nasal airway resistance. This resistance was found to decrease after maxillary impaction, presumably because of the increased width of the nostrils after the surgery.

Merville and Diner[70] offered an intriguing discussion of diagnosis, including taxonomy and treatment of long faced individuals in a 1987 paper. They believed the long face to be multifactorial in etiology and to be varied with respect to its components. Their focus, therefore, was to develop methods of determining the best surgical approach to treating a specific case. They also proposed specific terminology to enhance description of these cases. Hypsoprosopia would signify long or high face. Three levels may contribute. Hyposmaxillia refers to increased maxillary height and results in excessive exposure of incisors and alveolus on smiling and should be distinguished from the short lip syndrome. The second level is open bite or hypsostomia. The last is hypsogenia or an increase in height of the chin. Open bite may be caused by one or more of three entities. It could be a vertical posterior maxillary dentoalveolar excess, a vertical anterior mandibular dentoalveolar deficiency or an excessively large gonial angle (referred to as amblygonia). All these may be found singly or in various combinations.

Treatment for hypsomaxillia would involve LeFort I osteotomy. Hypsogenia would be corrected by horizontal anterior basal reduction osteotomy. The vertical maxillary dentoalveolar excess should be treated by a posterior osteotomy such as that recommended by Schuchardt. The vertical anterior mandibular dentoalveolar deficiency would be treated with an anterior alveolar elevation osteotomy. Amblygonia should be corrected with a sagittal split ramus osteotomy or an angle osteotomy with bone graft. Choice of treatment should be based on specific anomalies present. The authors felt that a proper occlusion would contribute to stability of result.

Lansley et al.[71] discussed four cases out of a series of forty treated by LeFort I osteotomy which relapsed. After reviewing the literature, they concluded that the cause of anterior open bite is multifactorial. Historically, they said surgical treatment of this problem was confined to procedures involving the mandible only. Anterior mandibular segmental surgery provided good long term stability whereas ramus surgery did not. Treatment of choice at the time of writing was felt to be LeFort I osteotomy with posterior impaction to allow autorotation of the mandible. Sagittal split osteotomy of the mandible might be necessary to correct anteroposterior discrepancies. Genioplasty is frequently necessary.

Only one of the four cases involved orthodontic treatment in conjunction with the surgical treatment. The four were all between 17 and 19 years of age, had wire fixation of the maxilla and intermaxillary fixation for at least six weeks. Relapse was first noted at 6, 15, 22 and 24 months in the four cases. Reason for relapse in these cases was unclear. Inadequate positioning of the condyles may have been involved. "Latent long acting aetiological factors" were suggested. Presurgical extrusive orthodontic forces in one case were felt to lead to later relapse. The authors suggested that orthodontists "avoid the unstable extrusion of anterior teeth and intrusion of posterior teeth." They also recommended better fixation of the maxilla (involving bone plates or grafts), correct placement of condyles (push hard but not too hard), and following patients until at least five years after surgery.

MATERIALS AND METHODS

The eleven individuals examined in this study were those who had been treated for open bite malocclusions at OHSU and were willing to return for a postretention exam. This sample size does not warrant statistical analysis. Instead, the individuals are described in various ways. Many more who might have been called back were not, due to incomplete records. Of the eleven, all are Caucasian except patient A.W. who is of Chinese descent. All but J.D. and R.S. had one tooth in each quadrant either missing or extracted. Patient E.P. had a LeFort I osteotomy and mandibular advancement as a part of her treatment. All but three began treatment during or before adolescence, and all had been out of retention at least two years.

Models obtained as a part of beginning, final, and postretention records were compared. Overjet was measured as the difference between labial surfaces of upper and lower incisors. Initial open bite was measured roughly along a tangent to the labial surface of the lower incisors. A negative value is assigned to open bite values. Overbite was also measured by sighting along the occlusal plane, marking the vertical level of upper incisal edges on the lower incisors with tape and measuring the difference between this mark and the incisal edge of the mandibular teeth. These measurements were all done to the nearest millimeter and should be taken as estimates. The irregularities in these malocclusions make measurements such as these rather subjective.

Cephalometric radiographs from these same time periods were used. The cephalometric equipment used in obtaining these films was of at least two types and techniques were not as consistent over the years as one might like. Angular and linear measurements were taken from tracings and read to the nearest degree or millimeter. A postretention film was not obtained on patient L.O. because she was pregnant.

The point gonion used was one constructed by the intersection of the line passing through articulare and tangent to the posterior border of the ramus, and the line of the mandibular plane, which ran tangent to both the lower border of the posterior portion of the body of the mandible and the lower border of the symphysis.

The posterior face height (PFH) was taken as the distance between sella and the constructed gonion as projected onto a perpendicular to the Frankfort horizontal line.

The ramus height (RH) was the distance between articulare and the constructed gonion projected onto the perpendicular to the Frankfort horizontal.

Anterior face height (AFH) was the distance from nasion to menton as projected onto a perpendicular to the Frankfort horizontal. The components of AFH were upper and lower face height (UFH and LFH), the projection of ANS dividing the two portions.

The distance MD was the difference between sella and pogonion as projected onto the Frankfort line. The pogonion point used was transferred from beginning to final and postretention period tracings with mandibles superimposed over anatomic landmarks. This distance (MD) was used as a potential indicator of backward rotational growth. The assumption is that if this decreases, the mandible is most likely rotating backward. Of course, the truth is much more complicated than this as there may be some change in position of the articular fossa, and it is certainly possible to have backward rotation along with a significant amount of horizontal growth. Also, this measurement appears to be subject to a great deal of error as exemplified by comparing final and postretention record tracings on A.W. There was approximately a six millimeter difference between machine porion points when superimposing on sella and anterior cranial base structures. The Frankfort horizontal used in measuring the distance MD was constructed using machine porion.

Another angle which might indicate rotational growth or treatment change is that herein referred to as SUPER. The point articulare and a point in the inner cortical structure of the symphysis on the original film is transferred to the final and postretention tracings by superimposition of the inner cortical structure of the symphysis, the mandibular canal, and other structures when possible. The angle SUPER is the angle a line through these two points makes with SN.

Periapical radiographs of upper incisors were obtained for use in studying root resorption but this was beyond the scope of the present study.

The patient's identification numbers and ages at the three time intervals are listed on the following page.

Patient	ID#	Age beginning	Age final	Age postretention
JD	1769	10-9	14-5	24-11
CH	1735	11-1	15-4	25-4
RS	2550	11-9	13-5	20-0
MS	2247	11-11	19-5	22-5
LK	2391	12-1	14-8	21-5
AL	1696	12-4	15-6	26-9
JH	1902	13-9	17-1	26-3
AW	1732	15-6	18-1	29-9
LO	1623	16-11	19-2	32-3
ET	2464	21-1	23-11	30-4
EP	2461	40-3	43-5	49-7

FINDINGS

The observations based on dental models are described in Table 1. When two symbols appear in the table together under molar relation it is indicating an asymmetry. In each of the tables, the three rows list values from beginning, final, and postretention records for each patient. The notation of incisal contact is made with reference to centric occlusion. Open bite is given a negative value in the chart even when referred to as open bite, rather than degree of overbite.

In Table 2 a summary of observations drawn from patient records which are relevant to the subject is presented. With many observers, record keeping is variable in completeness and probably in accuracy as well. Under most headings, a positive response indicates that the item was noted at some point in time. A positive note under mouth breathing indicates that some degree of mouth breathing had been noted.

Table 3 lists a large collection of values derived from the lateral skull films. The last two columns are averages, the first taking all values into account, the second being the average of all but those for L.O. and E.P. because of the lack of a postretention film on one and the surgical correction in the other. The two values do not differ much.

The angle SNA (sella-nasion-point A) is near what most consider normal but seems to decrease during treatment on the average, probably as a result of the extraction therapy in most subjects. SNB (sella-nasion-point B) is smaller than one sees in the general population. This is probably a result of the selection process for acceptance for orthodontic treatment, as well as selection as open bite cases for this survey. It appears that open bite may be more common in a skeletal Class II malocclusion. ANB (point A-nasion-point B) is quite large to begin with and generally decreases somewhat but the group as a whole appears to consist more of downward growers rather than the downward and forward growers orthodontists enjoy.

The angle between the mandibular plane and the sella-nasion line (SN) is quite steep and doesn't seem to change much with growth or treatment, not even changing in the surgical patient.

The angle the palatal plane makes with SN seems as if it may increase slightly with growth and/or treatment but is relatively stable with time. The use of headgear may have some effect on the inclination of the palatal plane.

The five height dimensions all seem to increase with time as would be expected.

The MD dimension is relatively stable, not decreasing greatly in any case, therefore not seeming to indicate any severe backward rotation. The fact that it doesn't increase greatly, though, might also indicate that these individuals generally did not demonstrate much horizontal mandibular growth.

The ratios of anterior to posterior heights did seem to decrease somewhat with time on the average. If present, this trend would tend to be indicative of forward rotation. With some though, these ratios were quite stable and with L.K. they seemed to show consistent increase.

The upper and lower components of anterior face height did not seem to change in proportion during growth.

The angle SUPER was generally quite stable with time. M.S. demonstrated the largest change, with a decrease that would tend to indicate forward rotation.

If values for MD, AFH/PFH, LFH/RH, and SUPER are all examined for changes, M.S. appears in each to be a forward rotator and L.K. appears as if she may have been undergoing some backward rotation. The magnitude of the changes was not large and, in a sample of this size, significance is questionable.

Table 1 DENTAL MODEL DATA

	JD	CH	RS	MS	LK	AL	JH	AW	LO	ET	EP
Molar relation	II	II	I	II	II/I	E/I	E	E/I	II	I	II+
	I	E	I	E		I	I	I	I	I	I
	I	I	I	I	I	I	E/I	I	I	E	E/I
Incisal contact	-	-	-	-	-	-	-	-	-	-	-
	-	+	+	-		+	+	+	+	-	+
	-	+	+	+	-	+	+	+	+	+	+
Overjet mm	11	7	7	7	8	8	9	7	5	9	10
	3	3	2	4		2	4	2	1	3	3
	4	3	2	2	3	2	5	4	2	4	3
Initial open bite mm	-3	-6	-4	-3	-5	-3	-3	-4	-2	-4	-3
Overbite mm	1	-1	0	2	-1	0	2	-1	2	-1	2
	2	3	3	1		2	3	1	2	1	3
	2	4	3	1	0	2	2	2	3	2	3

E=end to end molar relation
LK final models unusable,RS final models taken well into retention period

Table 2 PATIENT HISTORY AND OBSERVATIONS

	JD	CH	RS	MS	LK	AL	JH	AW	LO	ET	EP
Tongue thrust initial	?	+	+	-	+	+	+	+	-	?	+
Tongue thrust postretention	+	+	-	+	+	+	+	+	-	-	-
Speech deviation	-	+	-	+	-	-	-	-	-	-	+
Mouth breathing	-	+	+	+	-	-	+	+	-	-	+
Thumb sucking hx	?	+	+	+	+	?	+	+	-	?	+
Adenoids visible on ceph	-	+	+	+	-	+	+	-	-	-	-
Hx of T&A if known		-		-	+	-	+	-			+
Headgear	K,HP	K	K	K	HP	-	K	K	K	HP	-
Class II elastics	+	-	-	+	+	+	+	-	+	+	-
Ant vert elastics	+	+	-	+	+	+	-	+	+	+	+

K=Kloehn HP=High pull

Table 3 CEPHALOMETRIC VALUES

	JD	CH	RS	MS	LK	AL	JH	AW	LO	ET	EP	AVE (all)	AVE (9)
Age	10-9	11-1	11-9	11-11	12-1	12-4	13-9	15-5	16-11	21-1	40-3		
SNA	82	82	82	71	85	77	80	79	81	78	80	80	80
degrees	77	75	84	67	82	72	78	79	77	77	80	77	77
	79	77	84	68	82	75	77	79		78	80	78	78
SNB	73	74	77	66	77	72	73	74	76	70	69	73	73
degrees	72	72	79	66	75	71	73	74	74	69	74	73	72
	72	74	79	68	75	72	73	73		69	73	73	73
ANB	9	8	5	5	8	5	7	5	5	8	11	7	7
degrees	5	3	5	1	7	1	5	5	3	8	6	4	4
	7	3	5	0	7	3	4	6		9	7	5	5
MP-SN	34	37	32	38	29	42	42	37	45	49	45	39	38
degrees	38	39	30	38	30	42	41	37	44	51	45	40	38
	37	38	29	35	32	40	40	37		51	45	38	38
PP-SN	5	8	8	13	5	7	8	9	6	10	8	8	8
degrees	6	13	5	17	8	8	11	8	9	11	9	10	10
	7	11	5	16	7	9	12	7		10	15	10	9
PFH	75	68	69	68	78	72	73	91	70	62	74	73	73
mm	81	73	72	79	80	77	78	92	71	63	72	76	77
	83	75	73	82	80	80	83	93		64	73	79	79
RH	43	39	41	41	50	40	38	56	42	33	45	43	42
mm	47	43	44	51	49	46	42	59	44	34	43	46	46
	48	46	44	53	49	48	46	58		34	45	47	47
AFH	118	109	107	112	114	125	126	138	120	118	122	119	119
mm	130	117	109	128	118	135	131	139	122	120	120	124	125
	130	117	110	129	120	133	137	139		120	119	125	126
UFH	55	50	51	54	49	56	54	59	53	55	53	54	54
mm	59	56	50	61	52	60	58	59	56	55	54	56	57
	60	55	50	60	52	60	62	57		55	53	56	57
LFH	63	59	56	58	65	69	72	79	67	63	69	65	65
mm	71	61	59	67	66	75	73	80	66	65	66	68	69
	70	62	60	69	68	73	75	82		65	66	69	69
MD	51	57	62	55	63	61	61	46	59	46	32	54	56
mm	51	49	64	60	55	59	59	47	59	46	49	54	54
	50	55	66	66	59	63	58	56		48	46	57	58
AFH/PFH	1.57	1.60	1.55	1.65	1.46	1.74	1.73	1.52	1.71	1.90	1.65	1.64	1.64
	1.60	1.60	1.51	1.62	1.48	1.75	1.68	1.51	1.72	1.90	1.67	1.64	1.63
	1.57	1.56	1.51	1.57	1.50	1.66	1.65	1.49		1.88	1.63	1.60	1.60
LFH/RH	1.47	1.51	1.37	1.41	1.30	1.72	1.89	1.41	1.60	1.91	1.53	1.56	1.55
	1.51	1.42	1.34	1.31	1.35	1.63	1.74	1.36	1.50	1.91	1.53	1.51	1.51
	1.46	1.35	1.36	1.30	1.39	1.52	1.63	1.41		1.91	1.47	1.48	1.48
UFH/AFH	.47	.46	.48	.48	.43	.45	.43	.43	.44	.47	.43	.45	.46
	.45	.48	.46	.48	.44	.44	.44	.43	.46	.46	.45	.45	.45
	.46	.47	.45	.47	.43	.45	.45	.41		.46	.45	.45	.45
SUPER	56	54	52	56	52	56	56	61	58	63	65	57	56
degrees	59	55	50	51	53	59	55	62	58	65	63	57	56
	58	56	50	50	54	56	54	62		65	63	57	56

DISCUSSION

Among the eleven subjects of this investigation, all had sufficient lack of lower incisal contact that one would at least take note of it during diagnosis of each case. Some had an appearance suggesting habit as a major component. Patients R.S. and C.H. were still sucking their thumbs at age eleven when beginning records were taken. L.K. reported sucking her thumb until age nine and when records were taken at age twelve her open bite had the classic look of one caused by sucking the right thumb. Most agree that open bites caused and/or maintained by habit are easier to correct than those with backward rotational growth as the primary component. These habits in L.K. had previously been addressed with myofunctional therapy elsewhere, presumably with the goal of stopping the tongue thrust which seemed to be maintaining the open bite caused by her thumb sucking. It is not known whether the myofunctional therapy caused any improvement, or whether the patient worked at it, but she had a 5mm open bite when she started orthodontics. She and J.D. were the only ones that did not have incisal contact in centric occlusion after orthodontic treatment. Both of these patients had a tongue thrust at the postretention exam, but five out of the other nine had evidence of tongue thrust postretention and had incisal contact in centric occlusion. It would seem that the tongue thrust habit may play a role in maintaining an open bite and may even make orthodontic correction of the open bite difficult, but it can be compatible with positive overbite. The tongue seems to be primarily adaptive in nature.

It does not appear that any of the growing patients included in this study were examples of extreme rotational growth in either direction. The apparent lack of the horizontal component of mandibular growth may have been a factor in allowing habits to more easily maintain the open bite malocclusions. The inability to accurately predict this lack of horizontal mandibular growth may be one reason for caution in diagnosis and in the making of a prognosis for open bite correction.

This survey, in combination with a review of the literature, would seem to indicate that open bite is frequently found in association with a Class II malocclusion. The reason is probably multifaceted. It is reasonable that in a backward rotator, with the increasing anterior vertical height and the tongue thrust that is common early in growth, that open bite is common and that a Class II molar relation would also be common as the mandible rotates down and back, even though it is not a rotation centered at the condyle. It is also clear that treatment mechanics that would tend to hinge the mandible open should be avoided. It is unclear whether high pull headgear is much better than Kloehn headgear in these cases, although it is certainly not worse.

The consensus seems to be that extraction therapy, when indicated, is a positive factor in treating backward rotators. It is also generally believed that the use of Class II and vertical elastics as a primary means of correction will lead to less stable results than other methods, such as those that take advantage of growth. The dilemma though, is that they are often unavoidable because of the amount of correction needed, timing, and level of cooperation with headgear.

Many orthodontists advocate the use of such things as bite blocks, magnets, functional appliances, and so on to take advantage of growth and even to redirect growth. On the other hand, many believe it is not possible to significantly alter the genetically programmed growth of the mandible. The curious side of this disagreement is that, as a group, the proponents of these attempts to alter growth patterns are much more optimistic and positive than the other camp. Regardless of one's bias and experience, it seems prudent to exercise caution in promising perfect results in correction of open bite malocclusions.

Some cases are certainly in need of surgical correction for best results. While excellent techniques have been developed, relapse remains a possibility to some degree.

In examining the relevant literature, one of the difficulties in drawing absolute conclusions is that methods of analysis of the results of investigations are far from uniform, so comparison is difficult. Comparisons are made to widely differing samples; sometimes to deep bite cases, sometimes to Class I "normals" only. Many contradictions are to be found. For example it is very unclear which portions of the alveolar ridges are smaller, the same as, or larger than normal in open bite cases because investigations have led to a wide variety of conclusions.

Another question that is difficult to answer is whether there is a long face syndrome of genetic cause having open bite as a frequent component. It would seem that there probably is not one specific genetic factor leading to the condition (as is the case with true syndromes) but rather a collection of environmental and genetic factors that may be found in various combinations leading to a range with a somewhat typical extreme type. It is understandable that the label of adenoid type face might be applied to some of these people because hypertrophic adenoids are frequently seen and probably are one of the factors that figures into the overall picture. There certainly is another end of the range where open bites are clearly a result of habit rather than genetics.

SUMMARY AND CONCLUSIONS

Open bite malocclusions are a result of environmental as well as genetic factors. The factors are many and, as a result, there is a wide range of manifestation due to the variable presence of these factors. On one end of the spectrum, the problem may be corrected simply by discontinuance of a habit. It has been observed that many open bites close spontaneously. At the other end are the extreme backward rotators with a skeletal Class II malocclusion, hypertrophic adenoids, long lower face, mouth breathing, allergies and so forth. Some factors are related to varying degrees.

In the small sample surveyed here, there do not appear to be any very extreme examples, although the surgical case was extreme enough to merit the surgical approach and may have undergone significant backward rotation during growth. Treatment was relatively successful in all cases although the open bite wasn't entirely corrected in two cases. Tongue thrust appears to be compatible with positive overbite in many cases. Myofunctional therapy does not seem capable of correcting open bite malocclusions but may be helpful in dealing with habits that persist during and after orthodontic treatment.

Some orthodontists believe they are able to redirect growth sufficiently to correct most open bite malocclusions. They tend to be more optimistic than others who do not feel that growth can be redirected significantly.

Careful diagnosis and treatment are called for in dealing with open bite malocclusions. Patients should be adequately educated regarding prognosis and level of cooperation necessary in treating these cases.

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