
Class II Malocclusions: Diagnostic and Clinical Considerations With and Without Treatment

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Class II malocclusions are of interest to the practicing orthodontists since they constitute a significant percentage of the cases they treat. In individuals with normal occlusion and skeletal relationship, the amount of maxillary and mandibular growth is synchronized and the result is a well-balanced and esthetically pleasing profile. In individuals with Class II malocclusions, there is an anteroposterior discrepancy between the maxillary and mandibular dentitions, which may or may not be accompanied with a skeletal discrepancy. In growing individuals, the success of treatment is dependent, to a great extent, on the ability of the clinician to influence the relative growth changes in the maxilla and mandible. The purpose of this article is to provide a perspective on the characteristics, development, etiology, and broad treatment considerations in Class II malocclusions. (Semin Orthod 2006;12:11-24.) © 2006 Elsevier Inc. All rights reserved.

Part 1

Incidence of Class II Malocclusions

Ast and coworkers¹ examined 1413 high school students aged 15 to 18 years from upstate New York and found that 23.8% had Class II malocclusions, while 69.9% had Class I malocclusions. This relative frequency, which is approximately 1:3, was similar to that reported by Goldstein and Stanton² for white American children aged 2 through 12 years, and by Massler and Frankel³ for children aged 14 through 18 years. On the other hand, in a group of American blacks studied by Altemus⁴ the ratio of Class II to Class I was about 1 to 6, or half as much as whites.

Ast and coworkers¹ also found that the incidence of Class II Division 2 to be 3.4% and for Class II Division 2 subdivision to be 1.6%. When

compared with other malocclusions Class II Division 2 occurs less frequently than either Class I or Class II Division 1, but slightly more frequently than Class III.¹

For the interested reader, Staley⁵ presented a more comprehensive review of the overall incidence of malocclusions, whereas in another review, Spalding⁶ comprehensively discussed the incidence of Class II malocclusions in various populations.

Classification of Class II Malocclusions

Class II malocclusions are generally described as having either a dental, skeletal, and/or functional components or characteristics. Although these components will be discussed separately, it needs to be emphasized that they are often expressed at the same time and to various degrees.

I. Dental Arch Characteristics of Class II Malocclusions

Angle⁷ proposed a classification system based on the relationship of the mandibular first molars

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to the maxillary first molars. He characterized the Class II malocclusions as having a distal relationship of the mandibular teeth relative to the maxillary teeth of more than one-half the width of the cusp. The validity of using the relationship of the first molars as the main criterion for classifying malocclusions has been questioned, since each Class of malocclusion incorporates many variations that in turn significantly influence the treatment plan. Despite these obvious limitations, Angle's classification is still widely used because of its simplicity as a method of description and communication between dental professionals. Angle⁷ characterized two types of Class II malocclusions based on the inclination of the maxillary central incisors.

Class II Division 1 malocclusions are described as having labially inclined maxillary incisors, an increased overjet with or without a relatively narrow maxillary arch. The vertical incisor overlap may vary from a deep overbite to an openbite.

The Class II Division 2 malocclusions are described as having excessive lingual inclination of the maxillary central incisors overlapped on the labial by the maxillary lateral incisors. In some cases, both the central and the lateral incisors are lingually inclined and the canines overlap the lateral incisors on the labial.⁸ The Class II Division 2 malocclusion is often accompanied by a deep overbite and minimal overjet. In cases with extreme overbite, the incisal edges of the lower incisors may contact the soft tissues of the palate.^{9,10} In a few Class II Division 2 cases, the mandibular labial gingival tissues may be also traumatized by the lingually inclined maxillary incisors, particularly in the absence of an overjet. An inverted maxillary occlusal plane is often seen with two distinct occlusal levels, one in supra occlusion for the anterior teeth and one in a relative infra occlusion for the posterior segments.¹¹ An exaggerated curve of Spee may be present in the mandibular arch with extrusion of the mandibular incisors.¹²

With Class II Division 1 or 2 malocclusions, the molar relationship may be unilateral or bilateral. Unilateral cases are classified as a "subdivision" of the affected side. For the interested reader, Staley⁵ has a detailed review of the description and applications of Angle's classification.

Shape and relationships of the dental arches in Class II cases. Frölich¹³ evaluated the dental arch form during the transitional dentition of children with Class II malocclusions who did not undergo orthodontic treatment. The Class II sample was divided into four subgroups: Class II Division 2; Class II borderline between Division 1 and 2; Class II Division 1 with a "V" shaped maxillary arch; and Class II Division 1 with flaring and spacing of the maxillary incisors. No appreciable differences were present between normal and Class II individuals in absolute arch length and width. Anterior arch length was found to increase markedly during the transition period for all Class II types, except the Division 2 group. Overbite and overjet increased in the untreated Class II Division 1 cases and only excessive overbite increased in the Division 2 cases. Frölich¹³ found the shape of the mandibular dental arch to be very similar in all four categories of Class II malocclusion, but the maxillary dental arch was wider in the Division 2 cases.

It is of interest to note that the four Class II subgroups described by Frölich¹³ were found to develop from a very similar deciduous dental arch morphologic pattern. As a result, it is very difficult to distinguish and predict the ultimate shape of the dental arch before the eruption of the permanent incisors.

It has also been established that the antero-posterior relationship of the dental arches in untreated Class II cases, whether in the deciduous, mixed, or permanent dentitions, did not improve with age.^{13,14}

Transverse dental arch relationship in Class II Division 1 patients. Bishara and coworkers¹⁵ evaluated the changes in the dental arch width and length from the deciduous to the mixed and permanent dentitions. Their findings indicated that the growth trends were similar, that is, the changes in the normal and Class II Division 1 groups follow similar patterns in both male and female subjects. In addition, the differences between the measurements of maxillary and mandibular intermolar arch widths were greater in the normal subjects than in subjects with Class II Division 1 malocclusions. The presence of this relative constriction of the maxillary arch, when related to the mandibular arch in Class II malocclusions, is expressed from the earlier stages of dental arch development. These trends con-

tinue in the mixed and early permanent dentitions and do not self-correct without treatment. Therefore, if there is a discrepancy in the transverse relationship, it should be corrected together with the anteroposterior discrepancy.

II. Skeletal Characteristics of Class II Malocclusions

In general, Class II cases with anteroposterior skeletal discrepancies are characterized by a large ANB angle and Wits Appraisal, reflecting the malrelationship between the maxilla and mandible. The anteroposterior skeletal discrepancies may also be accompanied by a vertical discrepancy, for example, a relatively long or short anterior face.

Cephalometric characteristics of the Class II Division 1 malocclusion. The determination of the extent of a dysplasia is usually attempted by comparing the dentofacial characteristics of individuals with a certain Class of malocclusion to another group of individuals with "normal" occlusion and facial relationships. One could assume that individuals with the same type of malocclusion have common cephalometric characteristics and that these characteristics are significantly different from individuals with either normal occlusion or other types of malocclusions. These assumptions are questionable.

Using Angle's classification, several authors have tried to describe the cephalometric characteristics of Class II Division 1 malocclusions. Fisk¹⁶ described the following six possible morphological variations in their dentofacial complex: (1) The maxilla and teeth are anteriorly situated in relationship to the cranium; (2) the maxillary teeth are anteriorly placed in a normally positioned maxilla; (3) the mandible is of normal size, but posteriorly positioned; (4) the mandible is underdeveloped; (5) the mandibular teeth are posteriorly placed on a mandible that is in a normal position; and (6) various combinations of the above relationships.

A number of cephalometric studies¹⁷⁻²¹ that dealt with Class II Division 1 malocclusions indicated that the relationship of the maxilla to the cranial base showed no significant differences between these individuals and matched normal subjects. On the other hand, the mandible was significantly retrusive with the chin located farther posteriorly resulting in a larger angle of facial con-

vexity. Craig¹⁷ believes that Class II and normal individuals have essentially the same composite pattern except that the body of the mandible appears shorter and the lower first molars are more posterior in the Class II Division 1 cases.

On the other hand, Blair²¹ and Gilmore²² found minor differences in the mean skeletal patterns of Class I and Class II Division 1 malocclusions and concluded that a high degree of variability can be seen within each of these two malocclusions. Maj and coworkers²³ examined lateral head plates of 220 subjects and found that total mandibular length in Class II Division 1 subjects was similar to that of normal subjects of corresponding age. In 96% of the cases, the relative anteroposterior positions of the upper and lower incisor apices were very close to the limits found in normal subjects. They found a steeper mandibular plane angulation in more than one-third of the cases. They suggested that in some cases, the inclination of the anterior teeth either exaggerates or camouflages the differences between the bony bases. Maj and coworkers²³ concluded that the skeletal differences were not due to an abnormal development in the size of any specific part, but rather were the result of an abnormal relationship between the parts, that is, the result of variations in the position of the skeletal structures, in the direction of the discrepancy.

Cephalometric characteristics of the Class II Division 2 malocclusion. Wallis²⁴ compared Class II Division 2 and Class I and Class II Division 1 individuals and found that the posterior cranial base was larger in Division 2 cases. He also noted that the mandibular form in a "typical" Division 2 case has relatively more acute gonial and mandibular plane angles, shorter lower anterior face height, and excessive overbite.

Hedges²⁵ also noted a larger angle of convexity in Division 2 cases and speculated that the maxillary basal bone is either larger or in a more anterior position, but he also observed a similar range of variation in the skeletal pattern of Class II Division 2 and Class I patients. Hedges²⁵ concluded that the only consistent cephalometric finding was the lingual axial inclination of the maxillary central incisors.

In summary, describing the skeletal discrepancies accompanying Class II Division 1 or 2 malocclusions as being a "skeletal Class II malrelationship" is a diagnostic oversimplification

and of limited value in treatment planning. This is because the mandible can either be in a normal or retruded relationship to the maxilla, and in turn the maxilla may be either normal or in a protruded relationship to the mandible. As a result, the clinician should evaluate and diagnose, in each individual patient, the occlusal relationships, the anteroposterior and vertical skeletal discrepancies, the soft tissue facial relationships, as well as the presence of any abnormal function.

III. Perioral Functional Characteristics of Class II Malocclusions

Abnormal muscular patterns may be associated with either type of Class II malocclusions.^{26,27} For example, in Class II Division 1, the increased overjet may allow the lower lip to rest between the maxillary and mandibular incisors maintaining or accentuating the overjet. Furthermore, during swallowing, an abnormal mentalis muscle activity and aberrant buccinator activity, together with compensatory tongue function and position, could cause changes in the dentofacial structures such as constriction of the maxillary posterior segments, protrusion and spacing of the maxillary incisors, and abnormal inclination of the mandibular incisors.^{28,29}

In Class II Division 2 individuals, the orbicularis oris and mentalis muscles are often well developed and active.¹¹ The lingual inclination of the maxillary incisors may accentuate the appearance of the lower "lip curl" associated with the vertical overclosure.³⁰ In addition, the combined effects of the hyperactive mentalis muscle and the reduced vertical height accentuates the chin prominence.¹²

The position of the condyle in Class II malocclusions. Ricketts²⁰ demonstrated that before treatment the condyles in Class II Division I malocclusions were in a relatively forward position in the fossa. Following treatment the condyles moved back to a normal position. The initial forward condylar position was explained as an attempt to maintain an adequate airway in these patients. Using laminagraphy, Ricketts²⁰ found that both the condyles as well as the path of mandibular closure showed significantly more distal movement from the rest position to centric occlusion in Class II Division 1 cases than in Class II Division 2 cases. In another study,³¹

Ricketts also observed that Class II Division 2 cases had a larger freeway space.

It has also been suggested that as the mandible is brought from the postural resting position to habitual occlusion in some Class II Division 2 cases, the path of closure is influenced by the lingually inclined maxillary incisors together with the infraocclusion of the posterior teeth.⁸ The combination of these two factors results in an abnormal path of mandibular closure as well as overclosure. More specifically, the mandible is forced into a retruded position by the anterior teeth and the condyles are displaced posteriorly and superiorly in the articular fossa.⁸ The presence of such a "posterior functional shift," in some cases, may favorably influence the prognosis for the correction of the Class II relationship. Swan¹¹ estimated that one-third of the cases exhibited a functional component that allowed for a partial correction of the malocclusion following the labial repositioning of the maxillary incisors. The creation of the overjet during treatment in such cases allowed the mandible to move forward to a normal centric relation position.

It is important to emphasize that clinicians should be aware of this possibility, but they should not assume that it is a consistent finding in Class II Division 2 cases.

Etiology

The etiology of Class II malocclusions is considered to be multifactorial.

Genetic, Racial, and Familial Characteristics

Genetic characteristics tend to recur; for example, a hereditary trait from either parent or a combination of traits from both parents may produce similar or modified characteristics in the offspring. In addition, the mixing of gene pools within a population may either create new traits or may change the frequency of expression of existing traits.^{29,32} Lundström³² reported that in monozygotic twins there was a 68% concordance of having a Class II malocclusion; on the other hand, dizygotic twins had a 24% concordance. These findings differed markedly from individuals with openbite, in whom concordance was 100% for monozygotic twins and 10% for dizygotic twins. Such findings indicate that

even in persons with an identical genotype, a Class II malocclusion does not always develop.

Studies on different ethnic groups, especially those with limited outside contact, are of interest. According to Graber,²⁹ the Aleuts showed no Class II malocclusions while the South African blacks had an incidence of only 2.7%.

Several investigators have suggested additional etiological factors that particularly pertain to the Class II Division 2 malocclusions including the following:

a. Genetic predisposition. Of some interest, Leech³⁴ published a case report on identical twins, one of whom had a Division 1 and the other a Division 2 malocclusion.

*b. Genetically determined abnormal axial inclination of the maxillary central incisors.*¹² A study by Milne and Cleall³⁵ indicated that the maxillary central incisors followed the same axis of eruption before and after their emergence into the oral cavity and did not change their angulation significantly. As a result, at least in theory, if the tooth bud develops with a more vertical axial inclination, the tooth would assume a more vertical position following its eruption.

c. Variations in morphology of the maxillary central incisors. Nicol³⁶ observed a difference in the crown-root angulation in some Class II Division 2 cases. In addition, Robertson and Hilton³⁷ suggested that the crowns of the upper incisors appeared thinner labiolingually when compared with incisors in other malocclusions.

d. Forward tipping of the maxillary posterior segments. Swann¹¹ described a definite pattern involving the timing of development of the maxillary tuberosity and maxillary tooth eruption resulting in mesial tipping of the maxillary posterior teeth.

Environmental Factors

Environment can play an important role in the development of certain types of malocclusion. As an example, the early loss of maxillary second deciduous molars in a patient with an otherwise Class I occlusion could result in the mesial migration, rotation and tipping of the maxillary first molars, and the creation of a Class II malocclusion.

In the mixed dentition, a flush terminal plane relationship of the first permanent molars is frequently present, and a persistent finger habit

displacing the maxillary dentition forward can tip the occlusal balance more toward the development of a Class II molar relationship. Furthermore, in patients with a persistent finger habit and excessive overjet, the lower lip may become trapped behind the maxillary incisors, causing abnormal contraction of the mentalis and other perioral muscles leading the maxillary incisors to further tip labially.³³ The malocclusion at this point expresses the cumulative effects of the compensatory malfunction of the perioral musculature superimposed on the original malocclusion.²⁹ Therefore, persistent finger, tongue, or lip habits can either result in a Class II malocclusion or accentuate an existing one.^{12,27}

In summary, for the majority of Class II Division I or II malocclusions, there are no specific preventive measures to be initiated except when it relates to environmental factors such as habits and early loss of deciduous teeth.

Part II

Growth and Treatment

Growth Patterns of the Maxilla and Mandible

General concepts. Growth of the skeletal craniofacial complex involves an increase in the absolute size of the various bones as well as changes in their position and form.

The maxillary complex is usually displaced in a downward and forward direction.³⁸ Bone is deposited on the posterior surface of the maxillary tuberosity, adding to the length of the dental arch as well as the anteroposterior dimension of the maxilla to accommodate for the eruption of the posterior teeth. As the maxilla moves downward and forward in relation to the cranial base, bone is deposited at the circummaxillary system of sutures. The zygomatic processes are also growing in a posterior and lateral directions. As the maxilla is moving forward there is also resorption of bone on its anterior surface.³⁸ The superior surface of the maxillary shelves that form the nasal floor undergo resorption and the palatal surface undergoes apposition. Consequently the nasal floor and palatal vault move downward in a parallel fashion. Eruption of the dentition allows the alveolar processes to increase the vertical palatal height.³⁸

Scott^{39,40} suggested that the cartilages of the

nasal septum are an extension of the cartilaginous portion of the cranial base, and as the nasal septum grows it acts as a driving force that carries the maxilla downward and forward. Therefore, according to Scott, the nasal septum is a primary growth center, that is, one that has a tissue separating force, while the circummaxillary sutures are secondary growth sites, that is, passively adapting. Moss⁴¹ proposed the functional matrix theory whereby bones adapt to the functional demands of the various craniofacial components. Sutural and nasal septum growth are therefore passive processes, that is, secondary growth sites, that adapt to the functional demands of the various vital systems including respiration and mastication.^{41,42}

The same controversy regarding whether the nasal septum is a growth center or growth site involves the mandible. Moss⁴¹ and Koski⁴² promoted the secondary growth potential for the condyles whereas others feel it is a primary growth center.^{39,40} Again whether condylar growth is primary or secondary, the resultant growth translates the mandible in a downward and forward direction at pogonion. There is bone apposition on the posterior border of the ramus, on the lower border of the mandibular body, and on its lateral surfaces as well as at the alveolar processes as the teeth continue to erupt. There is also a concurrent bony resorption on the anterior surfaces of the coronoid processes, rami, and the anterior surface of the symphysis above the chin. The magnitude of the downward and forward growth of the mandible usually exceeds that of the maxilla and as a result the bony face becomes less convex with age.⁴³

It needs to be remembered that this description is of the average growth changes occurring in the maxilla and mandible. In reality, there is a significant amount of individual variation that also results in either a relatively more downward or a more forward maxillary or mandibular change. The broad range of growth variation has been illustrated comprehensively in Bjork's implant studies.⁴⁴

Using metallic implants, Bjork⁴⁴ described the mandible as being able to rotate either forward or backward with growth. Forward rotation can occur with its center at the condyles, at the lower incisors, or at the premolars. Such forward mandibular rotation would be favorable in the correction of Class II malocclusions. On the

other hand, backward rotation of the mandible can occur with its center at the condyles or at the last occluding molar and, in general, is not favorable in the treatment of Class II cases. Therefore, the direction and magnitude of growth in an individual, as well as the type of mandibular rotation whether favorable or unfavorable, in addition to the degree of patient cooperation as well as the skill of the clinician in using the optimal mechanics, will determine the prognosis for the successful correction of a Class II malocclusion with a retrognathic mandible.

Class II versus normal growth patterns. In general, the overall growth patterns of untreated Class II Division 1 individuals do not seem to differ from those observed in normal subjects. Lande⁴⁵ found that in both groups, the maxilla and mandible, on the average, grow in a downward and forward direction. Anteroposterior discrepancies between the maxilla and mandible in Class II malocclusions are often present early and are maintained unless corrected orthodontically. Moore⁴⁶ believes that a severely retrognathic face in childhood invariably develops into a retrognathic type of adult face. Furthermore, untreated Class II malocclusions with a retrognathic face will maintain the Class II dental relationship even when growth has improved the skeletal mandibular retrusion.¹⁴

Bishara and coworkers⁴⁷ compared the dentofacial growth trends in untreated Class II Division 1 subjects and normal subjects both cross-sectionally and longitudinally, from the deciduous to the mixed and permanent dentitions. Their results indicated that in the cross-sectional comparisons there were few consistent differences between the Class II Division 1 and normal subjects at the different ages evaluated. The differences in mandibular length and position were more evident in the early stages of development than at the later stages. This may point to the possibility of a "catch up" period in mandibular growth in Class II Division 1 subjects at the later stages of development.⁴⁷

The longitudinal comparisons have also indicated that the growth profiles or trends are essentially similar between Class II Division 1 and normal subjects in the various dentofacial parameters compared, except for upper lip protrusion. On the other hand, the growth magnitude (amount of growth) pointed to the presence of greater skeletal and soft tissue convexities in

Class II Division 1 subjects.⁴⁷ These results point to the importance of evaluating the changes in the facial parameters in their totality and over time rather than cross sectionally at any one point.

Changes in the profile without treatment. It has also been suggested by Moore that the facial profiles of untreated patients tend to maintain their original configuration whereas those of treated patients show a tendency for the profile to improve.⁴⁶

Changes in the molar relationship without treatment. During the development of the dentition, the terminal planes (distal surfaces) of the upper and lower second deciduous molars assume different relationships, namely, mesial step, flush, or distal step. In a longitudinal study on the changes in molar relationships from the deciduous to the permanent dentitions, Bishara and coworkers¹⁴ observed that all the cases that started with a distal step in the deciduous dentition proceeded to have a Class II molar relationship in the permanent dentition, that is, none of these cases self-corrected.¹⁴ Of those cases where the first permanent molars erupted in an end-to-end position, 45% remained end-to-end or assumed a full Class II occlusion. The remaining 55% assumed a Class I relationship. In addition, they observed that the greater the mesial step the less probability of a Class II relationship.¹⁴

Their findings also indicated that once the Class II molar relationship is established in either the deciduous, mixed, or permanent dentitions, it does not self-correct although mandibular growth may occur at a faster rate and for a longer time than that of the maxilla. Therefore, such growth differential by itself is not sufficient to correct the dental malocclusion.¹⁴

In summary, the individual growth trends in the untreated Class II patient may be favorable or unfavorable and are difficult to accurately predict. Yet clinicians need to realize that each individual has his/her unique growth pattern that in turn affects the treatment response; for example, in one patient correction of the Class II relationship can be accomplished by tooth movement alone, whereas another patient may benefit from a change in the skeletal relationships. In one patient favorable growth may assist in the anteroposterior correction, while in another, unfavorable growth may even increase the

difficulty of the Class II correction or make it impossible to accomplish without surgical intervention.

Dentofacial Structures That Can Be Influenced by Orthodontic Treatment

As explained earlier, patients with Class II malocclusions might have a normal skeletal pattern, maxillary protrusion, or mandibular retrusion often superimposed on a vertical dental and/or skeletal discrepancy. As a result, treatment should be planned to correct the discrepancies diagnosed in each individual patient. The following discussion will provide some helpful guidelines when formulating an individualized treatment plan.

a. Factors that need to be considered in treating the maxilla. Moore⁴⁶ listed five possible scenarios that can influence the treatment of the maxilla in a Class II malocclusion: (1) inhibiting the normal forward and downward growth of the maxilla; (2) inhibiting the normal forward movement of the maxillary denture; (3) moving the maxillary denture distally; (4) influencing the eruption pattern of the maxillary teeth; and (5) creating spaces by selective extractions to allow for differential tooth movement. All five of these factors are designed to either control the forward and vertical growth of the maxilla or decrease the protrusion of the maxillary denture through the use of extra- and intraoral forces, implants functional appliances, or Class II elastics.

The effectiveness of attempting to inhibit the growth of the maxillary complex has been disputed for many years. Brodie⁴⁸ felt that the maxillary growth pattern is established early and that treatment can only influence the alveolar processes. Moore⁴⁶ also believed that orthodontic treatment with headgear to the molars did not significantly influence the forward growth of the maxilla but has more of an effect on the maxillary denture. Weislander,⁴⁹ on the other hand, found that with the use of the cervical headgear, the anterior nasal spine expressed a significantly less anterior movement than the control group. Maxillary length did not change, but the entire maxilla acquired a relatively greater downward positioning or downward and backward rotation. Klein,⁵⁰ Newcomb,⁵¹ and Watson⁵² found similar results as those of Weislander.

Moore,⁴⁶ Weislander,⁴⁹ and others⁵⁰⁻⁵² have demonstrated that treatment can inhibit the normal anterior movement of the maxillary denture and is usually accomplished by the use of either extra- or intraoral appliances. Maxillary superimpositions have indicated that during treatment, the maxillary molars can be distalized with a variety of appliances to appreciable distances. This distal movement of the first molars may relapse after the distal force is discontinued. Superimpositions of the posttreatment changes showed that the first molars often move mesially toward their pretreatment position within the maxilla. However, the critical factor to remember is that once a solid Class I occlusion is obtained during treatment, the mesial movement of the maxillary molars is usually synchronized with the mesial movement of the mandibular teeth, thus maintaining the correction of the molar relationship in most cases.

Modifications in the eruption pattern of the maxillary teeth have been observed during the orthodontic treatment of Class II malocclusions. Moore⁴⁶ found that in untreated individuals the maxillary posterior teeth erupted forward and downward, whereas in the treated group they erupted in a downward or downward and backward direction. Coben⁵³ also demonstrated a more distal and vertical eruption of the molars when treated with a headgear instead of the usual downward and forward eruption. Similar dental changes were accomplished when these malocclusions were corrected by using functional appliances.⁵⁴

b. Factors that need to be considered in treating the mandible. Moore⁴⁶ pointed to the following five possible changes in the mandible that can enhance the correction of a Class II malocclusion: (1) stimulating the horizontal growth of the mandible; (2) anterior repositioning of the mandibular body; (3) influencing the eruption pattern of the mandibular teeth; (4) moving the mandibular denture forward on its skeletal base; and (5) creating space by selective extractions to allow for the desired tooth movements.

Stimulating horizontal growth of the mandible has been attempted, but there is little evidence that in humans a clinically significant long-term increase in mandibular length can be generated beyond the existing potential of the patient.⁵⁴

Repositioning the mandible anteriorly can be accomplished with a functional appliance. The

repositioning is only successful if it is accompanied by favorable condylar growth⁵⁴; otherwise the patient will end up with either a dual bite between centric relation and centric occlusion or a total relapse to the Class II malocclusion.

Altering the eruption pattern of the mandibular teeth in a more mesial direction by moving the whole mandibular denture forward along its skeletal base can be accomplished with functional appliance therapy or with the use of Class II elastics. The proclination of the mandibular incisors, extrusions of the molars, and the long-term stability of treatment with the use of elastics as a method of correcting skeletal discrepancies is questionable, particularly in the absence of favorable mandibular growth since molar extrusion will cause backward mandibular rotation.⁵⁵

Schudy⁵⁶ has described the following four areas of vertical growth in the dentofacial complex: (1) vertical descent of the body of the maxilla; (2) vertical growth of the maxillary alveolar process; (3) vertical growth of the mandibular alveolar process; and (4) vertical condylar growth. The balance between the vertical vectors of growth and the horizontal vectors determines the position of the chin point. For example, if condylar growth expresses a significant forward vector but is accompanied with a greater vertical alveolar growth in the maxillary and mandibular molar regions, the net effect will be a backward rotation of the chin point. The vertical growth of the maxillary and mandibular alveolar processes will, in a sense, negate the effects of the horizontal growth at the condyle; on the other hand, if the vertical alveolar growth increments are relatively smaller, the chin point will be positioned more anteriorly. The latter scenario is considered a favorable growth pattern when treating Class II malocclusions.

Therefore, in Class II cases it is advantageous to use orthodontic appliances that control the vertical growth vectors to minimize mandibular backward rotation, for example, by using high pull extraoral forces. Such an approach will enhance the correction of Class II malocclusions,⁵⁶ since the control of the maxillary vertical growth vectors will allow the mandible to express its growth in a relatively more forward direction.

Growth in Class II Patients with Treatment

Over the years, various treatment philosophies and biomechanical approaches have been advo-

cated by orthodontists. Coben⁵³ emphasized the individual variability found in growth patterns and the importance of having an individualized treatment plan designed to capitalize on the patient's growth potential. Since individual variation is the rule rather than the exception, a routine or standardized approach to every case cannot be proposed; that is, before using a specific appliance, the orthodontist must carefully evaluate the patient dentofacial characteristics and commitment before treatment and then constantly monitor the patient response to therapy as it progresses.

Some of the treatment approaches suggested include repositioning the mandible in a forward direction with guide planes or functional appliances, in an attempt to "stimulate" condylar growth.^{2,9,33} Others consider that the mandible cannot be stimulated beyond its genetic potential and emphasize the need to redirect the growth of the maxillary complex or drive the maxillary teeth distally with extraoral anchorage traction while the mandible continues its forward growth.^{53,57}

West⁵⁸ evaluated Class II Division 1 individuals treated in mixed dentition using maxillary extraoral traction supplemented with light intermaxillary elastics. A satisfactory correction of the occlusion, along with significant improvement in facial esthetics, was achieved in 8 to 13 months. Most corrections resulted from a combination of favorable mandibular growth accompanied by changes in the maxillary dentition from the headgear forces. According to West,⁵⁸ a few patients demonstrated significant forward mandibular growth relative to maxillary growth with little actual tooth movement. Other patients expressed little mandibular growth and the correction was obtained entirely by distal movement of the maxillary dentition. West⁵⁸ observed that although individual patient responses cannot be anticipated, early headgear correction of the molar relationship seems to be effective in the majority of cases.

Moore⁴⁶ evaluated the changes in 46 treated Class II patients; all were initially retrognathic and he found that the chin point became more prognathic in 50% of the cases, there was no change in 25% of the cases, and the chin point became even more retrognathic in 25% of the cases.

In conclusion, orthodontic forces can greatly influence the dentition. On the other hand, the success of the skeletal correction depends on the growth potential of the patient in addition to appropriate treatment and appliance planning as well as patient cooperation in wearing the appliances. Therefore, the lack of sufficient favorable growth and patient cooperation during treatment may not allow for the optimal correction of the skeletal relationship or significantly improve the facial profile.

The Effects of the Extraction of Premolars on the Dentofacial Structures in Class II Division 1 Patients

Bishara and coworkers⁵⁹ compared the changes in subjects with Class II Division 1 malocclusions treated with and without the extraction of four first premolars. Lateral cephalograms on 91 patients (44 extractions and 47 nonextractions) were evaluated at three stages: pretreatment, posttreatment, and at least 2 years after treatment. Their findings indicated that before treatment, the upper and lower lips were more protrusive relative to the esthetic plane among the subjects treated with four first premolar extractions. Excessive lip protrusion was an important pretreatment profile characteristic that influenced the extraction decision in addition to the presence of a tooth size-arch length discrepancy.

Following treatment the upper and lower lips were more retrusive in the extraction group and more protrusive in the nonextraction group. The extraction group tended to have straighter faces and slightly more upright maxillary and mandibular incisors, whereas the nonextraction group had the opposite tendencies.⁵⁹ They also observed that the average soft tissue and skeletal measurements for both groups were close to the corresponding averages derived from the Iowa normative standards. These findings indicated that both the extraction and nonextraction decisions, if based on sound diagnostic criteria, seem to have no deleterious effects on the facial profile.⁵⁹

Timing of Treatment

In general, correction of the skeletal discrepancy can best be accomplished during periods of active growth. Advocates of the early treatment concept suggest that the correction of skeletal

discrepancies is as effective in the preadolescent years as during adolescence. Other orthodontists believe that treatment should be postponed to coincide with the adolescent “growth spurt.” Regardless of the approach, it needs to be remembered that clinically significant mandibular growth spurts do not occur in most individuals.⁶⁰ In those cases where it does occur, prediction of its timing, duration, and magnitude are not sufficiently accurate for such predictions to be clinically useful. Furthermore, the acceleration in mandibular length is not usually reflected as a corresponding favorable change in mandibular relationships. Therefore, for the clinician to wait for these unpredictable events to happen (or not to happen) at a future point in time, while ignoring the significant growth that is continuously occurring in the preadolescent as well as early adolescent years, is not prudent.⁶⁰ Another variable should also be considered in this context; in adolescence, the enthusiasm for wearing extraoral or functional appliances is often less than in earlier years.

As a result of all of these factors, Mathews⁶¹ recommends a two-stage treatment approach. The objectives of the first stage are the early correction of the incisor flaring, the molar relationship, and crossbite (if present) followed by a period of retention. Treatment is completed in the second stage after the eruption of the permanent dentition. The early molar and crossbite correction considerably simplifies treatment in the second stage while the maxillary incisor retraction minimizes the danger of a traumatic injury and improves abnormal lip position.⁶¹ On the other hand, advocates of a one-stage treatment contend that the increased length and cost of treatment do not support the need for two stages in most cases.

The following are indicators for starting of treatment in Class II malocclusions: With mild to moderate dental or skeletal discrepancies, treatment could be postponed until the late mixed or early permanent dentition stages. With more severe discrepancies treatment can be started as early as the patient is able to cooperate or tolerate wearing the appliance. In these severe cases, the clinician would like to maximize the potential for improving the skeletal discrepancy and at the same time minimize the potential for traumatizing the protruding maxillary incisors. If treatment is initiated in the early mixed dentition, the clinician should

be aware that when using extraoral appliances attached to the first permanent molars, it is important to evaluate the position of the still unerupted maxillary second molars in relation to the roots of the first molars to avoid their impaction. An optimal relationship is when the crowns of the second permanent molars have erupted past the apical third of the roots of the first molars, as determined from periapical or panoramic radiographs.

Treatment Approaches in Growing Patients

Various appliances have been successfully used for the correction of the developing Class II malocclusions including the following:

1. Orthopedic Hawley: This appliance is used in the mixed dentition for the correction of Class II Division I malocclusions utilizing extraoral traction and a removable maxillary Hawley appliance with a labial bow on the anterior teeth. Circumferential clasps are placed around the banded first molars to minimize the distal movement of the first molars with the extraoral force. If necessary, an anterior bite plate can be incorporated in the Hawley retainer to improve the deep overbite and also disocclude the teeth to help with the anteroposterior correction.⁶² Finger springs could also be incorporated to correct localized dental discrepancies such as a single tooth crossbite, or an expansion screw can be added to correct segmental posterior crossbites.
 2. Extraoral traction together with a transpalatal arch between the first molars can be used to minimize the distal movement of these teeth in an attempt to maximize the orthopedic effect on the maxilla. The advantage of this approach is that patient cooperation is limited to the wear of the headgear and the disadvantage is that fewer maxillary teeth are incorporated in the appliance, which decreases the potential for an orthopedic effect.
- Haas²⁶ promoted the use of a “maxillary orthopedic crib.” Following maxillary expansion, the appliance is used to stabilize the upper arch and a high-pull headgear is used to redirect maxillary growth.
3. With the use of extraoral appliances and transpalatal arches, the maxillary incisors can also be bonded to align, retract, or labially incline the teeth as indicated. These appli-

ances are often referred to as a 2×4 or a 4×4 appliance (if the second primary molars are included).

4. Regardless of the treatment approach, Lager⁶² recommends the use of a bite plate to eliminate the intercusp locking to facilitate the correction of the Class II relationship.
5. Functional appliances including activators, bionators, twin block, and Fränkel appliances are effective when indicated.
6. A successful outcome with the use of all the appliances described earlier is totally dependent on patient cooperation. If such cooperation cannot be attained, other appliances that are not patient dependent should be considered including the use of Herbst-like fixed appliances, pendulum appliances, and palatal and zygomatic implants, microimplants and onplants.

Extractions and Class II treatment. Extraction of premolars is another method of treating dental discrepancies as well as mild skeletal discrepancies in a Class II malocclusion. In adults, the facial skeletal relationship cannot be significantly altered by orthodontic treatment; as a result, the extraction of maxillary first premolars will allow for the correction of the overjet while maintaining the Class II molar relationship. An underlying assumption with such a treatment plan is that the lower arch can be aligned and leveled without the need to extract teeth. Essentially, dental compensations are introduced to camouflage the mild skeletal discrepancy.⁶³

In general, extracting premolars in the mandibular arch to align a severely crowded dentition and retract protrusive incisors will not help in the Class II correction unless part of the extraction space is used to protract the mandibular molars. If the mandibular dentition is mildly crowded, extraction of the second premolars and protraction of the first molars will help the correction of the molar relationship. On the other hand, in Class II Division 1 cases with severe skeletal discrepancies, extractions in the mandibular arch are often contraindicated since any uprighting of the lower incisors will increase the distance that the upper anterior teeth will need to be retracted to correct the overjet.

In adults, skeletal correction can only be accomplished through a combined surgical-orthodontic approach.

Treatment Considerations in Class II Division 2 Malocclusions

In general, Class II Division 2 malocclusions are easier to correct during the growth period than in adulthood, especially when favorable growth occurs during treatment.⁵⁵ A number of factors need to be considered when planning treatment for these patients.

1. Correction of the axial inclination of the maxillary incisors. The abnormal axial inclination of the maxillary central incisors present the clinician with two difficulties:

- a. The incisors will require more root torquing than in most other malocclusions. This movement can be efficiently provided with fixed orthodontic appliances. Schudy⁵⁵ stressed the establishment of proper interincisal angle (approximately 135°) to prevent the return of the deep overbite. Using high torque brackets to the maxillary central and lateral incisors (22° and 17° , respectively) will help achieve proper axial inclination when using an edge-wise appliance.
- b. As discussed earlier, the excessive lingual inclination of the maxillary incisors might have resulted in a functional mandibular retrusion. This could be determined by “freeing” the mandible either by tipping the maxillary central incisors labially or by placing a bite plate to disarticulate the anterior teeth allowing the mandible to assume a position dictated by the musculature. Swann¹¹ estimated that about one-third of the Class II Division 2 cases may have a functional posterior displacement of the mandible. When a shift is present, the anterior movement of the mandible will be advantageous in the treatment of the malocclusion. Furthermore, the labial movement of the maxillary incisors will facilitate the uncrowding of the mandibular incisors by allowing the tongue and lip musculature to establish the position of the lower incisors without the confining influence of the lingually tipped maxillary incisors.

2. Correction of the deep bite and the exaggerated curve of Spee. To be able to completely retract the maxillary incisors and correct the overjet, their incisal edges have to clear the brackets placed on the lower incisors. Therefore, leveling

the dental arches during orthodontic treatment is a biomechanical necessity.

To level the dental arches orthodontically, one must either extrude the molars and premolars or intrude the anterior teeth, but there is no consensus as to which of the two types of movements is more stable. Strang¹² believes that with good vertical growth during treatment, the overbite can be successfully corrected by intruding the anterior teeth. He suggested that in these very deep overbite cases, the extrusion of the posterior teeth in the absence of vertical growth will result in a muscular imbalance that will cause a relapse of the corrected overbite. Schudy,⁵⁵ on the other hand, advocates extrusion of the posterior teeth particularly in patients with a decreased lower face height, a flat mandibular plane angle, and a prominent chin. Strang¹² recognized this problem and treated it by placing high crowns on the molars to open the bite, then the premolars were extruded with vertical elastics, the molar crowns were then removed, and the elastics were applied to the molars to extrude them in turn. These same objectives can be achieved by placing a maxillary anterior bite plate and vertical elastics to the posterior segments. The archwire on the lower posterior teeth can be segmented to maximize their extrusion.

Other methods for correcting the overbite include placing reverse curves or steps in the archwires, bonding and incorporating second molars in the archwires, extruding the upper molars with the use of a cervical pull headgear, and extruding the lower molars by using Class II elastics.⁵⁵

It should be emphasized that a certain degree of backward mandibular rotation frequently occurs during the process of orthodontic leveling of the curve of Spee caused by the extrusion of the posterior teeth. Therefore, in patients with steep mandibular planes and openbite tendencies, backward mandibular rotation could be minimized by placing a high pull facebow during treatment.

In summary, during treatment planning, it is important to carefully evaluate the study models to identify which segments need to be leveled and in which arch. In some cases both the maxillary and the mandibular teeth are equally involved, whereas in other cases greater attention may have to be directed at the correction of one

arch. Lack of attention to some of these details may result in less than optimal results.

3. Extraction versus nonextraction. Most clinicians agree that when possible, the treatment of Class II Division 2 malocclusions with a low mandibular plane angle and deep overbite are best managed with a nonextraction approach to avoid retraction of the incisors and protraction of the molars; both of these movements tend to further deepen the overbite. On the other hand, with a nonextraction approach, the labial movement of the lower incisors during leveling as well as the distal movement and extrusion of the maxillary molars with various mechanics would help in the correction of the deep overbite.

Another critical parameter to consider in the extraction decision is the patient's profile. Many individuals with Class II Division 2 malocclusions have relatively retrusive lips as well as prominent chins and noses. Extraction of premolars followed by incisor and lip retraction will further retrude the lips. Such an outcome would worsen the profile and will result in an unacceptable "edentulous look."

In summary, the decision of whether to extract or not can only be determined through the proper diagnosis of each case. Before considering the extraction of premolars, the clinician needs to evaluate several factors including the prominence of the nose and chin, the presence of a functional mandibular retrusion, the patient growth potential and headgear cooperation, the extent of the tooth size-arch length discrepancy, and the periodontal condition of the lower anterior teeth. As a rule, in borderline crowded Class II Division 2 cases, it would be prudent to start the treatment with a nonextraction approach.

4. Timing of treatment. Although there is some controversy between those who advocate early versus late treatment, the author feels that treatment of Class II Division 2 malocclusion should be initiated in the late mixed dentition, when orthodontic therapy could be used to influence vertical alveolar growth and when most patients are more compliant with the wearing of extraoral appliances.

Retention Considerations

In general, retention plans are best determined by evaluating the characteristics and the severity

of the initial malocclusion. In addition, Class II cases might require additional retention considerations.

Moore⁴⁶ recommends that cases with severe skeletal Class II discrepancies should be retained with continued use of extraoral forces during the remaining growth period. The purpose is to maintain the maxillary dental and skeletal correction by minimizing the forward rebound that may occur when the headgear is discontinued.

Graber⁴³ considers that in Class II Division 2 cases, following the removal of the retention appliances, the deep overbite, mandibular incisor crowding, and lingual inclination of the maxillary incisors tend to return. To minimize these changes, Graber suggested that the retention appliances should be left for a longer period, compared with the average case, to allow for the musculature to better adapt. A Hawley retainer that incorporates an anterior bite plate should be considered, especially in patients who initially had excessive overbite.

Conclusions

Angle classification is a useful means of identifying Class II malocclusions, but it oversimplifies the description of a complex pattern of skeletal, dental, and profile relationships that are present.

A Class II malocclusion may be accompanied by an anteroposterior skeletal discrepancy between the maxilla and mandible, often with mandibular retrusion, however the maxilla may also be protrusive. These relationships are superimposed on an equally broad variation in the vertical facial pattern that ranges between increased, normal or decreased total, and lower anterior facial heights.

The incremental growth patterns in Class II individuals do not differ in magnitude from the normal growth patterns. Normal faces with normal dental occlusion appear to have a combination of skeletal units that are well related to each other. On the other hand, a skeletal discrepancy may be the result of having similar skeletal units that are less favorably related to each other.

The possible etiology, severity, growth potential, individual variability, biomechanics used, patient cooperation, and the retention plan are some of the variables that could influence the treatment results in patients with Class II maloc-

clusions. However, it is generally agreed that the orthodontist should attempt to recognize, diagnose, and treat these cases during the growth period to obtain optimal results.

Correction of the anteroposterior and vertical dental and skeletal discrepancies is advocated for most patients in the late mixed dentition or early adolescence. This could simplify the overall treatment by taking advantage of the patient's growth potential and cooperation in wearing extraoral appliances. Treatment is designed to redirect the growth of the maxilla and to allow the mandible to express its maximum potential.

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