Treatment Classification of Class III Malocclusion

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Purpose: *The purpose of this study was to identify Class III malocclusions within a pediatric practice that lend themselves to a more favorable treatment outcome at an earlier age (before 10 years) rather than initiating treatment at later adolescent growth stages and also to identify the degree of difficulty of the treatment of the Class III malocclusion.*

Methods: *Review of the current dental literature pertaining to the different clinical types of Class III malocclusions and their respective treatment protocols was performed. Various classification systems were studied and compared. A new treatment classification system of Class III malocclusions utilizing three dentoalveolar and three skeletal components combined with cephalometric information derived from commonly used cephalometric analyses was developed.*

Results: *Class III treatment types were conclusively identified: 1.) Early orthodontics only, 2.) Early combined orthodontics and orthopedics, 3.) Combined orthodontics and orthognathic surgery.*

Conclusions: *The conclusion supports Edward H. Angle's finding: "In studying a case of malocclusion, give no thought to the methods of treatment or appliances until the case shall have been classified and all peculiarities and variations from the normal type, occlusion and facial lines have been thoroughly comprehended. Then the requirements and proper plan of treatment becomes apparent."*

Keywords: *early treatment of malocclusion, class III, orthodontics, orthopedics, orthognathic surgery, protocols.*

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INTRODUCTION

The frequency of Class III malocclusions varies in the general population from 4% among Caucasians to upwards of 14% among Asians.[23] Patients with Class III malocclusions may have various combinations of dental and skeletal discrepancies that lead to Class III malocclusions.

Since Angle's first description of a Class III molar relationship,[1] much has been written in the dental literature about the components of a Class III malocclusion.[9-16] Class III malocclusions are not limited to a mesial, horizontal position of the lower first molars as described by Angle, but rather a combination of dentoalveolar, skeletal and vertical growth changes.

A paradigm shift to early orthodontic treatment continues to be an important clinical parameter in today's dental practices. The early detection of the Class III malocclusion in the late primary or early mixed dentition is important because at these growth stages, combined orthopedic and/or orthodontic treatment may correct the underlying etiology of the Class III.[37] In fact, delaying treatment of the Class III malocclusions beyond these stages may necessitate orthognathic surgery or camouflage extraction orthodontics.

As younger children are being screened for orthodontic services, the general dentists/pediatric dentists/orthodontists need to be able to identify the Class III malocclusion in the late primary or early mixed dentition. In the last 50 years, the components of a Class III malocclusion have been characterized and successful treatment strategies for the Class III malocclusion have been elicited.[9-16,21,22,25-37] However, current classification systems of malocclusions do not reflect the current knowledge base of the Class III malocclusion and furthermore, are inadequate in quantifying the components of a Class III malocclusion. This article introduces a new Treatment Classification of Class III Malocclusion in the pediatric patient population with the intent of clearly defining the components of each clinical form of the Class III malocclusion and identifying those Class III malocclusions that lend themselves to beneficial early correction.

HISTORICAL PERSPECTIVE

Angle's classification system as class I, II and III is the "gold standard" of orthodontic practice and is the most communicative system.[1] A system of classifying the permanent six year molars based on the anteroposterior position of the upper and lower first permanent molars offered an orderly, yet simple method of describing dental malocclusions which

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appealed to the treating clinician. Malocclusions of the arches were described as either Class I if the mesiobuccal cusp tip of the upper first molar aligned with the buccal groove of the lower first molar with a few millimeters deviation in either a mesial or distal direction with some other malocclusion of the remaining teeth; Class II if the mesiobuccal cusp tip of the upper first molar aligned with the embrasure space between the lower first molar and second bicuspid(distal); Class III if the mesiobuccal cusp tip of the upper first molar aligned with the embrasure space between the lower first and second molars(mesial). However, there were obvious deficiencies of this classification system since it did not address any information about the transverse and vertical planes of occlusion and merely classified the anteroposterior relationship of the jaws. Remember, modern cephalometric science had not been utilized in Angle's days and more importantly, it did not offer a plan for correction.

Dewey[2] and later Anderson[3] introduced subdivisions to the Class I Angle malocclusion and referred to them as types 1 thru 5. Anderson also formulated three subdivisions of the Angle Class III malocclusion. Type 1 was characterized as an Angle class III molar relationship with good teeth alignment but with an edge-to-edge incisor relationship; Type 2 was characterized as an Angle class III molar relationship with good alignment of the maxillary teeth but with a negative horizontal overlap of the incisors(reverse) and crowded mandibular teeth; Type 3 was characterized as an Angle class III molar relationship with good alignment of the mandibular teeth but with reverse incisor relationship and crowded maxillary teeth. Although this attempt of subdividing Class III malocclusions was well intended, it never was universally adopted by the orthodontic community.

Simon in the 1930's introduced a system of describing tooth malpositions to the cranium in three planes, sagittal, Frankfort and orbital.[4] Although this system added more precision and a three dimensional aspect to describing dental malocclusions, the system was cumbersome and confusing and again was not widely adopted by the orthodontic community. Modern cephalometric techniques and landmarks were more widely accepted and adopted in clinical practice in the 1950's with this system falling out of favor.

The need to differentiate dentoalveolar and skeletal discrepancies and how they relate to the development of malocclusions did not go unnoticed as Simon,[4] Hellman,[6] Horowitz and Hixon.[7] Moyers[8] and Ackeman and Proffit[5] all expressed the need to include these parameters in diagnosis and classifying dental malocclusions. As modern cephalometric techniques were being adopted by the orthodontic profession, skeletal discrepancies were being added to the Angle classification.

In the 1960's, Ackerman and Proffit introduced a system whereby five major characteristics of malocclusion were added to the Angle classification and could be represented by a Venn diagram.[5] The five characteristics were summarized by analyzing; 1) the alignment of the dental arches for crowding and arch-length discrepancy. 2) patient's facial profile, 3) lateral discrepancy of the arches like maxillary crossbites or mandibular constriction, 4) the anteroposterior discrepancy utilizing the Angle classification, and 5) the vertical dimension describing the arches either with open or closed bites. Photographs, dental casts and radiographs including a cephalogram were utilized in this assessment. Although the use of a Venn diagram in classifying dental malocclusion is not widely adopted, this multiple component approach to classifying dental malocclusions has become the modern standard of today.

Moyers believed that Angle's classification should be adopted for describing skeletal discrepancies. A Class 1 represented a normal anteroposterior skeletal relationship of the jaws (Wits appraisal 0) whereas Class 2 represented a more distal jaw relationship (Wits greater than 2.0) and a Class 3 represented a more mesial jaw relationship (Wits less than - 2.0).

Moyers introduced a system of Class I, II and III syndromes.[8] In addition to Angle classification, malocclusions are characterized by arch length discrepancy, skeletal/osseous problems, muscular malfunctions, dental problems and patient's profile. The Class III syndrome is usually of skeletal etiology, although functional Class III malocclusions could be seen (borderline class III). Moyers believed that most Class III malocclusions were skeletal in nature and in the young patient, treatment could redirect the growth pattern correcting the Class III syndrome. However, a more detail classification of the Class III syndrome was never elicited by Moyers.

REVIEW OF DENTAL LITERATURE

Class III Components

Numerous studies were retrieved from the dental literature describing the dental and skeletal features that are associated with a Class III malocclusion.[9-16] These studies confirm that a Class III malocclusion is not a single diagnostic entity but rather results from a combination of skeletal and dentoalveolar components.

Sanborn (1955)[9] divided the Class III malocclusion into four main skeletal categories: Group A consisted of prognathic mandible with normal maxillary position; Group B consisted of a retrognathic maxilla and normal position mandible; Group C consisted of neutral position of both maxilla and mandible, but with class III occlusal problems; Group D consisted of a combination skeletal problem with both retrognathic maxilla and prognathic mandible. Sanborn found higher mandibular plane angles among his Class III sample when compared to class I controls.

Pascoe (1960)[10] described five different types of mandibular prognathism. Type A consisted of both prognathic maxilla and mandible (bimaxillary protrusion), Type B consisted of normal position of the maxilla and prognathic mandible, Type C consisted of a retrognathic maxilla and normal position of the mandible, Type D consisted of normal position of both maxilla and mandible, but with mental prominence, and Type E consisted of normal position of

maxilla but mandibular prognathism due to increase lower facial height and anterior open bite.

Dietrich (1970)[11] identified three principle groups of Class III malocclusions with three other minor categories in his cohort of 172 cephalograms he analyzed. Group A consisted of orthognathic maxilla and mandible(neutral) with class III occlusal problems (28.5%); Group B consisted of a prognathic mandible and normal position maxilla (25%); Group C consisted of a retrognathic maxilla and normal position mandible(37%); The remaining three minor groups(9%) consisted of a combination of both retrognathic maxilla and mandible (D), both prognathic maxilla and mandible, bimaxillary protrusion (E) and retrognathic maxilla and prognathic mandible combination (F). Dietrich found very few combination (F) cases possibly due to the younger sample comprising deciduous or mixed dentitions (60%).

Jacobson (1974)[12] found chiefly three groups with the largest percentage (49%) having mandibular prognathism with a normal position maxilla, 26% had maxillary retrusion with a normal position mandible and 14% had normal position of both maxilla and mandible from a sample of 149 cephalograms. The sample consisted of adults (44%) and children age 6-16 years (56%). In the children group, the largest group (60%) consisted of normal position of both maxilla and mandible while the remaining 40% consisted of mandibular prognathism, maxillary retrognathism, and bimaxillary prognathism in descending frequency. The dominance of mandibular growth in the later adolescent and adult years was demonstrated by comparing the adult and child Class III cases. Class III malocclusions in the vertical plane are usually expressed as either a smaller mandibular plane angle (deficient lower facial height) or a greater one (excessive lower facial height). The female group tended to have greater mandibular plane angles than the male counterparts.

Ellis and McNamara (1984)[13] described 302 lateral cephalograms of Class III malocclusions within an adult population, 17 years or older. They found that a combination of retrognathic maxilla and prognathic mandible comprised 30% of the cases followed by retrognathic maxilla and normal position mandible at 19.5% and prognathic mandible with normal position maxilla at 19.2%. Bimaxillary protrusion of both maxilla and mandible comprised 15% of the cases, but when taken into account the short cranial bases of these cases, the relative measurements of the maxilla and mandible may be more within normal positions. Normal positioning of both the maxilla and mandible comprised 5% of the cases and the remaining 11% of the cases constituted some other combination of jaw disharmony. Like Jacobson, most of the cases expressed either an excessive lower facial height or deficient lower facial height. The mean mandibular plane angle (MH-FH) was 27.2 degrees in the study (normal 23.0degrees) However, 69% of the sample, exhibited values greater than 23 degrees and 20% exhibited values less than 21 degrees.

Guyer *et al (*1986)[15] studied 144 cephalograms from children ages 5–15 years exhibiting a Class III malocclusion. Maxillary retrusion with a normal position mandible constituted 25% of the total sample whereas mandibular protrusion with a normal position maxilla constituted 18.7% of the total sample. Combination of retrognathic maxilla and prognathic mandible comprised 22.2 % of the total sample. The remaining 30% of the sample demonstrated no anteroposterior imbalance of the jaws. In the younger children, deciduous to late mixed dentition ages, simple maxillary retrusion with normal position mandible and mandibular protrusion with normal position maxilla were the more frequently occurring examples, whereas, in the age range of 11 to 15 years of age, the more common example of jaw disharmony was a combination of retrognathic maxilla and prognathic mandible. Dietrich (1970) found no combination cases in his primary tooth sample and only 3% in his mixed dentitions. Jacobson (1974) found none in his child sample. Guyer *et al* found the mandibular plane angles in their study to be greater than the Class I controls. Significantly, this study showed that the increased in vertical lower facial heights of the Class III group occur in later adolescent to adult growth stages and is not typically seen in early childhood (5-10 years of age).

Mouakeh (2001)[16] reported on 69 primary or mixed dentition patients with a Class III malocclusion of Syrian ancestry. Maxillary retrusion with a normal position mandible constituted 43.5% of the total sample. A combination of maxillary retrusion and mandibular protrusion occurred in 29% of the sample followed by a combination of both maxillary and mandibular retrusion at 23%. Only 3% of the sample exhibited no anteroposterior disharmony of the jaws. Deficient lower facial height occurred in 42% of the sample and only 19% of the sample demonstrated excessive lower facial heights.

Design of a Classification System

Classification involves the systematic categorization of malocclusions on the basis of designated characteristics for the purpose of predicting biologic behavior in order that appropriate therapeutic modalities may be used. Because different therapies may exist for different types of malocclusions, a classification system needs to be able to predict the biologic behavior of a particular malocclusion. But more significantly, the ability to specifically classify a malocclusion instills confidence in its predicted biologic behavior and renders the selection of treatment options more clearly for the clinician.

A classification system should categorize specific distinguishing clinical and cephalometric characteristics of each clinical form of Class III malocclusions such that they may be recognized as both different and unique. Furthermore, each form that is recognized should present to the treating clinician a predictable biologic behavior in order that treatment maybe directed against the etiologic cause.

The components that compose a Class III malocclusion are varied and for this reason, a more elaborate, but yet specific, detailed classification system would be a beneficial

aid to the treating clinician. Class III malocclusion is not a single diagnostic entity but rather represents many differing morphologic forms.

Class III malocclusions may be limited to dentoalveolar discrepancies but are more frequently skeletal in nature.[8] The etiology of the skeletal components of a Class III malocclusion may have its origins in either a retronagthic maxilla or a prognathic mandible or a combination of both.[9-16] Other factors determining a Class III malocclusion are vertical in nature and may have its origin in either deficient vertical skeletal growth(brachycephalic) or excessive vertical growth(doliocephalic). All of these factors may contribute to the overall prognosis of a particular Class III malocclusion making identification of such components of paramount importance within a classification system.

Class III malocclusion poses a more challenging dilemma for the clinician because of differing growth patterns when compared to Class I children. The Class III children frequently develop differing growth patterns in the maxilla and mandible whereby the mandible grows more rapidly than the maxilla exacerbating the Class III malocclusion as children go through adolescence.[37] The maxilla tends to grow less anteriorly in Class III subjects than Class I normal controls.[39] In addition, the vertical growth pattern of the craniofacial structures of Class III subjects differ when compared to Class I subjects. Excessive vertical growth occurs in late childhood and early adult stages in Class III subjects with greater frequency than Class I controls.[37,39]

Age also plays a significant role in classifying Class III malocclusions. Younger children appear to exhibit both lesser mandibular growth and lesser vertical facial growth when compared to adult cases with Class III malocclusion.[11,15] Patients with normal or deficient lower facial heights have a more favorable outcome from combined orthodontic and orthopedic treatment.[13,16,26] Age is also important in predicting therapy outcome because younger patients treated at a late deciduous to early mixed dentitions have a more favorable prognosis when treated with a rapid palatal expander followed with reverse pull face mask; control of excessive mandibular growth while advancing a retruded maxilla maybe accomplished in younger children.[22,25-37]

Dental components such as the molar relationship, incisor relationship and the existence of crossbites determine the extent of the dentoalveolar problems of the Class III malocclusion. Crossbites that are left untreated at an early age tend to limit the dentoalveolar development of children.

Combined, all of these factors need to be considered in the design of classifying Class III malocclusions. Combining three dentoalveolar elements (molar relationship, incisor relationship and crossbites) and three skeletal elements (Wits appraisal, mandibular plane angle and face) with the Angle classification, similar to systems proposed by Ackerman and Proffitt[5] and Moyers,[8] we will attempt to standardize the classification of Class III malocclusions.

Proposed Classification of Class III Malocclusion

After review of the previous classification systems, dental literature and the current protocols used in private practices, the following classification system was devised (See Table 1). In summary, the system uses Angle's classification as the basis of describing the anteroposterior relationship of the dental arches (Class III) combined with three consistent dentoalveolar elements found in Class III malocclusions (see Table 5). Information from plaster dental casts or intraoral photos maybe obtained for this purpose. The skeletal components consist of three skeletal elements to describe the

Table 1. Treatment Classification of Class III Malocclusion

TREATMENT	CATEGORY
EARLY ORTHODONTIC ONLY	1. Class III Type 1 (Pseudo Class III ,or Dewey-Anderson Class I type 3. 2. Class III Type 2 (Dentoalveolar Class III or borderline Class III). 2a. Dental Closed Bite 2b. Dental Open Bite
EARLY ORTHOPEDICS/ ORTHODONTICS COMBINED	3. Class III Type 3 (Retrognathic Maxillary Class III). 3a. Skeletal Closed Bite 3b. Skeletal Open Bite 4. Class III Type 4 (Prognathic Mandibular Class III). 4a. Skeletal Closed Bite
ORTHOGNATHIC SURGERY/ MICROIMPLANT THERAPY/ CAMOUFLAGE EXTRACTIONS	4. Class III Type 4 (Prognathic Mandibular Class III). 4b. Skeletal Open Bite 5. Class III Type 5 (Combination Class III, Retrognathic Maxilla and Prognathic Mandible). 5a. Skeletal Closed Bite 5b. Skeletal Open Bite 6. Class III Type 6 (Bimaxillary). 6a. Protrusion 6b. Retrusion 7. Class III Type 7 (Craniofacial Malformations Class III, i.e. Crouzon's Syndrome, Beckwith-Weidemann Syndrome, Apert's Syndrome and Antley-Bixler Syndrome.

Table 2. Treatment Classification of Class III Malocclusion Categories Arranged to Treatment Protocols

EARLY ORTHODONTIC ONLY*	EARLY COMBINED ORTHODONTICS/ ORTHOPEDICS**	ORTHOGNATHIC SURGERY/ MICROIMPLANT THERAPY/ CAMOUFLAGE EXTRACTIONS***
Class III Type 1 Class III Type 2a Class III Type 2b	Class III Type 3a Class III Type 3b Class III Type 4a (Class III Type 4b and 5a if treatment initiated at late deciduous or early mixed dentitions	Class III Type 4b Class III Type 5a Class III Type 5b Class III Type 6a Class III Type 6b Class III Type 7

* Orthodontic consists of fixed appliances (UAWs, NPE and straight wire mechanics).
** Orthopedics consists of RPE followed by reverse pull face mask therapy.
*** Orthognathic surgery consists of Lefort I maxillary osteotomy, mandibular spilt osteotomy or both. Microimplant therapy with temporary anchorage devices (TADs) for absolute skeletal anchorage with mandibular distalizing mechanics. Extraction options include maxillary second bicuspid and mandibular first bicuspid or mandibular first permanent molar extractions.

extent of the skeletal discrepancies of the Class III (see Table 5). A good quality lateral cephalogram tracing using a combination of the Steiner, Jacobson (Wits appraisal) and McNamara analyses together is essential in determining the individual skeletal components of a Class III malocclusion.[17-20] Lastly, the maxillary length (A point to condylion) and mandibular length (gnathion to condylion) compared to standard normals must be evaluated in each case to determine the extent of jaw disharmony in each case (i.e. maxillary retrusion or mandibular protrusion or both).[23]

The different morphologic types of Class III malocclusion are ranked according to difficulty of treatment with the simpler cases placed first and more difficult cases ranked with higher numbers (see Table 2 and 3). The less complicated, treatable cases begin with type 1 and the more difficult cases have increasing greater numbers. Also, an attempt is made to separate the cases into early, treatable types and types that require later adult treatment with orthognathic surgery. The purpose is to provide the clinician a clear diagnostic picture of each type and a predictable treatment strategy.

Early Orthodontics Only

Class III Type 1 Pseudo Class III (Dewey-Anderson Class I, type 3)

Clinically the Class III Type 1 resembles a Class I malocclusion with an anterior crossbite (Pseudo Class III). However, the molar relationship is a Class I with a tendency toward Class III up to 1/4 cusp width (1-2 mm mesially). The skeletal components are characterized by normal length of

Table 3. Treatment Protocols Class III Malocclusion

Treatment Type	Class III Type	Age	Description of Treatment
Early Orthodontic Only	Type 1 (pseudo) Type 2a and 2b (dentoalveolar) in mixed dentition	Intiate treatment before age 10 yrs*	Correct crossbites with Nitanium Palatal Expander and Utility Arch Wires (UAWs). Serial guidance (extraction of primary teeth) than comprehensive orthodontics.
Early Combined Orthopedic And Orthodontic	Types 3a and 3b (retro max.), Types 4a (prog mand, deep bite) in early mixed dentition. *Types 4b (prog mand, open bite) and 5a (combined, deep bite)* in early childhood only. (mixed dentition)**	Intiate treatment before age 10 yrs*	Bonded RPE followed by reverse pull face mask 8-10 mos., chin cup use in type 4a. Anchorage with transpalatal bar or molar rotator or Frankel-III appliance after orthopedic phase. UAWs during mixed dentition and than comprehensive orthodontics
Orthognathic Surgery/ MicroImplant Therapy/ Camouflage Extractions	Types 4b (prog mand. open bite) at late childhood (permanent dentition); Types 5a and 5b (combined); Types 6a,6b (Bimax) and 7 (craniofacial)	Intiate treatment late adolescent or 14 years or older (permanent dentition)	Comprehensive orthodontics combined with orthognathic surgery (after 14 years of age) Alternatively, MicroImplant Therapy or Camouflage Extractions combined with comprehensive orthodontics

* Children need to be screened before the age of 10 years and preferable, at 5 or 6 years of age (late primary or early mixed dentition).
** Proper vertical growth control may only be achieved in the early mixed dentition with early orthopedic correction. Orthognathic surgery or microimplant therapy or camouflage extractions may also be required to complete case

both maxilla and mandible with lengths within the standard norms. The Wits appraisal may range from 2.0 to –2.0mm and the vertical lower facial heights are within normal range or deficient. The patient's face is usually mesocephalic to brachycephalic.

Treatment is directed at the dentoalveolar problem and would consist of eliminating the anterior crossbite, arch development and establishing a Class I molar relationship. This may be accomplished by use of a Nitanium Palatal Expander (NPE, Ortho Organizers, Inc., Carlsbad, CA) combined with utility arch wires (UAWs)[41] in the mixed dentition and a pre-adjusted fixed appliance in the permanent dentition.[42] A stable, excellent prognosis would be predicted.

Class III Type 2) Dentoalveloar Class III (marginal or borderline Class III)

These cases, in contrast to the above, have a more definite Class III molar relationship with up to 1/2 cusp width (3-4 mm) mesially. An anterior crossbite is usually present and a posterior crossbite frequently. Theses types are usually found in later childhood in contrast to Class III Type 1 which is usually seen in younger childhood (Table 4). The skeletal components are characterized by normal length of both maxilla and mandible with lengths within the standard normals, The Wits appraisal may range from 2.0 to -2.0 mm. The vertical is usually within normal range with a lower mandibular plane angle of 30.0 degrees or less (MP-PH). There may be a dentoalveolar vertical deficiency manifested as a dental deep bite and less frequent, a dental open bite. The latter may be a result of either of a tongue thrusting habit or thumb/finger sucking habit.[23] The patient's face is usually mesocephalic or brachycephalic. Frequently, these cases present as a functional Class III whereby there is an anterior slide upon closure, especially if a dental deep bite is present.

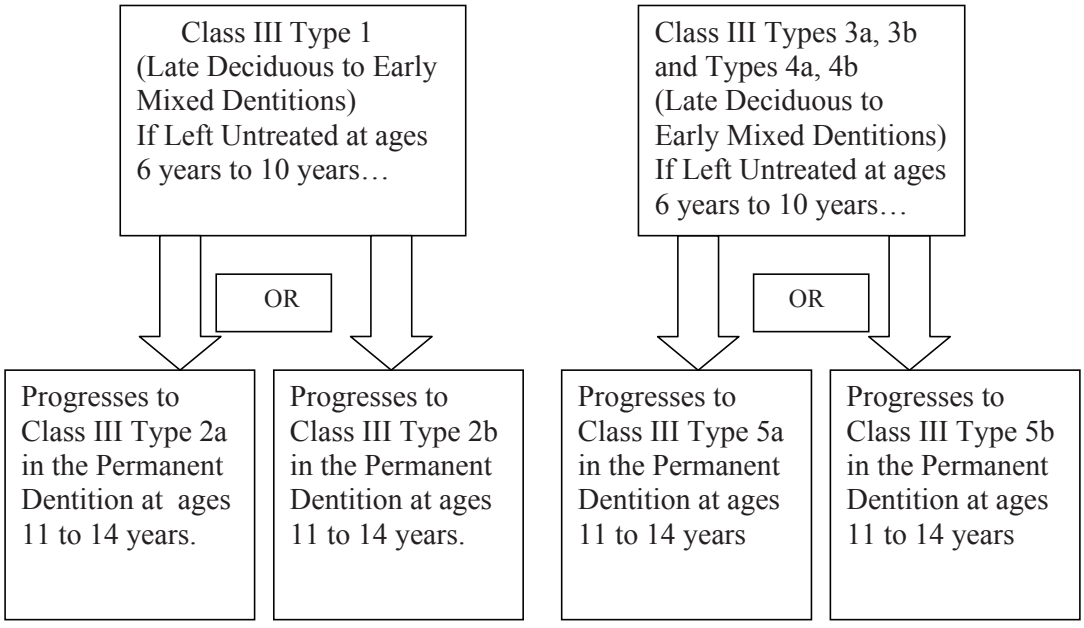
Treatment again is directed at the dentoalveolar problem and would consist of correcting any anterior or posterior crossbite, arch development and establishing a Class I molar relationship. UAWs, NPE, and straight wire mechanics with Class III elastics should complete most cases. Mandibular distalizers may also be employed if a Class I molar relationship is difficult to complete but clinicians should be cautioned to the use of these distalizers in dental open bite cases since they may increase the vertical dimension. Alternatively, a RPE without facemask therapy followed by fixed orthodontic appliance has been shown to complete treatment.[23] A stable, good prognosis would be predicted.

Early Combined Orthodontics and Orthopedics

Class III Type 3 (Retrognathic Maxillary Class III)

The most common Class III orthopedic disharmony in the young child is a retrognathic maxilla with normal mandibular length and these cases are more frequently seen in children ages 5 to 10 years than children ages 11 to 16 years.[11,15] The molars exhibit a Class III molar relationship between 1/2 to a full cusp mesially (4-6.0mm). Usually there is both posterior and anterior crossbites with a reverse incisor relationship. The incisors may exhibit either a deep bite or open bite depending on the lower mandibular plane angle. The Wits appraisal ranges from -2.0 to -7.0 mm. The lower

Table 4. Progression of the Class III Malocclusion In Young Children*



*Mandibular growth greater than maxillary growth from 7 to 12 years of age for which accounts for more Class III, type 5 (combined retro max/prog mand) observed in late adolescents and adults.[37]

mandibular plane angle may be either less than 20.0 degrees (skeletal closed bite, hypodivergent) or greater than 30.0 degrees (skeletal open bite, hyperdivergent). Often, there is midfacial deficiency. The faces of the patients are usually brachycephalic in closed bites cases and doliocephalic in open bites cases.

Treatment is principally directed at the retruded maxilla and crossbites. Treatment must be initiated before the age of 10 years according to most studies published.[22,25-37] An upper banded rapid palatal expander (RPE) maybe employed in the deep bite type 3a cases while a bonded, occlusal coverage RPE should be utilized in the open bite 3b cases. This is followed by 8-9 months of a reverse pull face mask as described previously.[22,23,25-37] A regulator of Frankel-III may be used as a removable retention appliance until comprehensive orthodontics is completed.[29] Alternatively, a palatal bar or molar rotator (Ortho Organizers) maybe placed on the upper first molars after face mask therapy for anchorage followed by UAWs and then comprehensive orthodontics with a preadjusted fixed appliance. Care should be directed against any open bite tendency in the Type 3b cases.[30] A stable, fair to good prognosis would be predicted. However, cases should be monitored until age 18 years old.

Class III Type 4(Prognathic Mandibular Class III)

The second most common Class III orthopedic disharmony in the young child (ages 5-10 years) is a prognathic mandible with normal maxillary length. The most important feature, in addition to the prognathic mandible, is the presence of either deficient (Type 4a) or excessive (Type 4b) vertical growth. These cases, like the aforementioned, are required to be separated into two categories based on the vertical growth dimension because of their differing biologic behavior and treatment protocols. Type 4b cases are more likely to require some orthognathic surgery whereas the Type 4a cases may exhibit favorable outcomes with reverse pull face mask and chin cup therapy. The remaining clinical features are identical to what was described for the Types 3a and 3b cases (see Table 5).

Type 4a cases maybe treated with RPE, banded or bonded, followed with reverse pull face mask for 8-10 months. Continue care with either intermittent face mask therapy or chin cup therapy maybe indicated depending on the severity of the prognathic mandible. Treatment must be initiated before the age of 10 years. Treatment maybe completed as mentioned for the Type 3a cases. A fair to good prognosis would be predicted.

Type 4b cases are difficult to treat in the young child with mixed results predicted non-surgically. Control of the vertical dimension is critical and the earlier treatment is initiated, the better the prognosis because of potentially greater control of the vertical dimension in open bite cases.[30,37] A bonded, occlusal coverage RPE followed by 8-10 months of reverse face mask therapy is recommended.[30] Fixed orthodontic appliances are placed after facemask therapy with anchorage of the upper molars with a palatal bar or molar rotator (Ortho Organizers). Intermittent high pull chin cup therapy may be used to control mandibular growth and vertical dimension. Cases should be monitored closely. However, parents should be informed of potential orthognathic surgery at a later date if treatment objectives are not met during the early non-surgical phase. A poor to fair prognosis would be predicted. The later the stage of child growth, with concomitant excessive vertical growth, a poorer prognosis would be predicted without surgical intervention. If treatment is delayed beyond 10 years of age, combined orthodontics and orthognathic surgery is the best option because of limited control of both horizontal and vertical mandibular growth at these later stages of child development.

Combined Orthodontics and Orthognathic Surgery

Class III Type 5 (Combination Class III with Retrognathic Maxilla/Prognathic Mandible)

Unlike Type 3 and Type 4 cases, these combination cases are more common in the later adolescent stages of growth. The Class III Type 5 combination cases result from delayed treatment in the mixed dentition or parental indecision when presented with early treatment options (iatrogenic). The mandible grows more rapidly through adolescence than the maxilla in the Class III malocclusions when compared to Class I normals.[37] Thus, if left untreated in a young child, these cases progress to a more severe orthopedic Class III malocclusion limiting treatment options after the age of 10 years (see Table 4). It is of paramount importance that young children between the ages of 5 to 10 years of age be identified as having a Class III malocclusion in order that appropriate treatment strategies maybe initiated at the earliest time possible.

The molar relationship is Class III, usually a full cusp width mesially (6-7.0mm). There is usually both anterior and posterior crossbites. The maxilla is retrognathic and the mandible is prognathic when analyzed. The Wits appraisal may range from -2.0 to -10.0mm with ranges typically between -6.0 to -10.0mm. The vertical dimension may either be deficient or excessive. When identified in a young child, treatment consisting of RPE followed by reverse pull face mask and a removable retention appliance (Frankel-III)[29] should be initiated as soon as possible to at least potentially minimize orthognathic surgery to none or one jaw (mandibular spilt osteotomy). In an older child, combined orthognathic surgery of both jaws with comprehensive orthodontics is the only treatment choice other than camouflage orthodontics with extraction of some permanent teeth.

Class III Type 6 (Other Combination Class III, either Bimaxillary Protrusion or Bimaxillary Retrusion).

The existence of bimaxillary protrusion with a Class III molar relationship may occur in some instances.[9-11,13] Screening these cases at an early age has less clinical significance than other forms of Class III malocclusions. Patients of Asian and African-American ancestry have a higher incidence of this profile. Short cranial bases have been frequently reported in Class III malocclusions.[11,13] Both

Table 5. Treatment Classification of Class III Malocclusion

Clinical and Cephalometric Morphologic Features COMPONENTS							
		Dentoalveolar Components			Skeletal Components		
Category	Age	Molar	Incisor	Crossbites	Wits	Mand PL<	Face
1. Class III Type 1 (pseudo Class III or Dewey-Anderson Class I Type 3)	6 yrs to Adult	Class I < 1/4 cusp mesial	Reverse	Anterior sometimes posterior	1.0 To -1.0	<30°	Mesocephalic (Meso)
2. Class III Type 2 (Dentoalveolar Class III) 2a. Dental closed bite	6 yrs to 14 yrs	Class III 1/4 to 1/2 cusp mesial	Reverse dental deep bite	Anterior Sometimes posterior	2.0 to -2.0	<30°	Meso to Brachcephalic (Brachy)
2b. Dental open bite	6 yrs to 14 yrs	Class III 1/4 to 1/2 cusp mesial	Edge to edge or dental open bite	Anterior sometimes posterior	2.0 to -2.0	<30° Open bite due to over Erupting molars	Meso
3. Class III Type 3 (Retrognathic Maxillary Class III) 3a. Skeletal Closed bite	6 yrs to adult	Class III 1/2 to full cusp mesial	Reverse dental deep bite	Anterior frequently posterior	-2.0 to -7.0*	< 20°	Brachy to Meso
3b. Skeletal open bite	6 yrs to adult	Class III 1/2 to Full cusp mesial	Edge to edge or dental open bite	Anterior frequently posterior	-2.0 to -7.0*	>30°	Doliocephalic (Dolio)
4. Class III Type 4 (Prognathic Mandibular Class III) 4a. Skeletal closed bite	6 yrs to adult	Class III 1/2 to full cusp mesial	Reverse Dental deep bite	Anterior frequently posterior	-2.0 to -7.0*	<20°	Brachy to Meso
4b. Skeletal open bite	6 yrs to adult	Class III 1/2 to full cusp mesial	Edge to edge or dental open bite	Anterior frequently posterior	-2.0 to -7.0*	>30°	Dolio
5. Class III Type 5 (Comination retro Maxillary/prog Mandibular) 5a. Skeletal closed bite	10 yrs to adult	Class III full cusp mesial	Reverse dental deep bite	Anterior frequently posterior	-4.0 to -10.0*	<20°	Brachy to Meso
5b. Skeletal open bite	10 yrs to adult	Class III full cusp mesial	Reverse dental open bite or edge to edge	Anterior frequently posterior	-4.0 to -10.0*	>30°	Meso to Dolio
6. Class III Type 6 (Bimaxillary) 6a. Protrusion	6 yrs to adult	Class III full cusp mesial	Reverse dental deep bite or open bite	Anterior frequently posterior	-2.0 to -7.0*	20° to >30° dependent on vertical dimension	Brachy to Dolio face dependent on skeletal vertical dimension
6b. Retrusion	6 yrs to adult	Class III full cusp mesial	Reverse dental deep bite or open bite	Anterior frequently posterior	-2.0 to -7.0*	20° to >30° dependent on vertical dimension	Brachy to Dolio face dependent on skeletal vertical dimension
7. Class III Type 7 (Craniofacial Syndrome i.e. Crouzon's)	Infant to adult	Class III full cusp mesial	Reverse usually dental open bite	Anterior and/or posterior	-4.0 to -10.0*	>30°	Dolio

*McNamara analysis required to determine both maxillary and mandibular lengths from point A to condylion and gnathion to condylion, respectively, and than compared to composite normal standards.[23] This analysis is the basis for determining maxillary retrognathism or mandibular prognathism.
Mandibular plane angle (Mand PL <) measured relative to the MP-FH line. If the MP-SN angle is used, add approximately 7 degrees to the above measures.[23]
Reverse incisor relationship represents a negative horizontal overlap of the incisors

Table 6. Craniofacial Malformations with Class III Malocclusions

SYNDROME	TRANS-MISSION	MUTATION	CST	RETROG MAX	PROG MAND
CROUZON'S	A.D.	FGFR2	YES	YES	NO
APERT'S	A.D.	FGFR2	YES	YES	NO
PFEIFFER'S	A.D.	FGFR2	YES	YES	NO
CARPENTER'S	A.R.	TWIST GENE CHR 7p21.1	YES	YES	NO
SAETHRE-CHOTZEN	A.D.	TWIST GENE CHR7p15 OR CHR 7p21.1	YES	YES	NO
ANTLEY-BIXLER	A.R.	FGFR2 OR P450 (POR)	YES	YES	NO
BECKWITH-WIEDEMANN	SPO-RADIC or A.D.	CHR 11p15.5	NO	NO	YES
PAPILLON-LEFEVRE	A.R.	CHR11q14-q21	NO	YES	NO

CST= CRANIOSYNOSTOSIS
A.D= AUTOSOMAL DOMINANT
A.R= AUTOSOMAL RECESSIVE
FGFR2= FIBROBLAST GROWTH FACTOR RECEPTOR 2
CHR= CHROMOSOME
POR= P450 OXIDOREDUCTASE
RETRO=RETROGNATHIC
PROG= PROGNATHIC
MAX=MAXILLA
MAND=MANDIBLE

Ellis *et al* (1984) and Dietrich (1970) described these cases and when analyses of the jaws were corrected for the short cranial bases sometimes observed in Class III malocclusions, the jaws had a more normal position anteroposteriorly. Orthodontic treatment would be directed more toward the facial appearance of the patients. Sometimes, extraction of four bicuspids and comprehensive orthodontics with straight wire techniques give excellent results. Orthognathic surgery with combined maxillary and mandibular osteotomy may also be employed.

Class III Type 7 (Craniofacial Malformations, Syndromes, i.e. Crouzon's Syndrome Beckwith-Wiedemann Syndrome and Antley-Bixler Syndrome))

Craniofacial malformations are rare and are not typically seen in most private practices. Most cases are seen at tertiary medical centers.

Crouzon's syndrome (craniofacial dysostosis) is characterized by variable cranial deformity, maxillary hypoplasia and shallow orbits with exopthalmos (bulging eyeballs) and hypertelosism.[24] There is mid-facial hypoplasia with relative mandibular prognathism. Bilateral posterior crossbites and anterior crossbites are common with anterior open bites. Signs occur early in life and become more severe during child growth. Early identification of these cases may aid in some growth modification, however most treatment strategies are aimed at early adulthood with both orthodontic and orthopedic surgery. Other types of craniosynostosis include Apert's, Pfeiffer's, Saethre-Chotzen, Antley-Bixler and Carpenter's syndromes (see Table 6).[44-46]

Beckwith-Wiedemann syndrome[43] was first described in 1963. A strong characteristic of this syndrome is macroglossia. Other related dentoskeletal abnormalities include proportional mandibular prognathism, bimaxillary protrusion, anteriorly inclined mandibular incisors and apertognathia. These findings appear to be a direct response to an enlarged tongue.

Antley-Bixler syndrome[44] is an autosomal recessive trait characterized by craniosynostosis, midface hypoplasia, choana stenosis or atresia and radiohumeral synostosis. There is usually maxillary retrognathism with severe skeletal open bite and dental Class III malocclusion. Orthognathic surgery, sometimes at a very young age, is necessary to correct some of the boney malformations.

These cases should be managed surgically by craniofacial centers experienced in managing these complex cases. Combined orthodontics and orthognathic surgery is the preferred treatment choice.

DISCUSSION

Classification of the Class III malocclusion is challenging. A Class III malocclusion is not a single diagnostic entity but rather a spectrum of protean clinical manifestations with varying clinical and cephalometric features that predict differing biologic potential. More importantly, identification of a specific Class III malocclusion in the young child leads to both early treatment of the malocclusion and correction of the underlying etiology in many of the subtypes of Class III malocclusion.

An attempt has been made to classify Class III malocclusions with a standardized method to both identify the characteristic features of each Class III form and predict its corresponding biologic potential. Class III malocclusions are classified based on identifiable morphologic features that predict biologic potential in order that appropriate treatment strategies maybe employed for individual patients.

The characteristic features of a Class III malocclusion are present at an early age (age 3–5 years).[11,12,15] The skeletal and dental features in Class III malocclusion are established early in childhood and are not self-correcting during child development.[40] Treatment strategies directed at the causative etiology of the Class III malocclusion may consist of corrective orthodontics, dentofacial orthopedics and orthognathic surgery or a combination of each depending on the classified type of Class III and age of the patient.

Orthodontic screening of young patients to identify potential Class III malocclusion is clinically significant because treatment timing of Class III malocclusion is critical for optimal treatment outcome.[37] Delaying appropriate treatment beyond the late mixed dentition (10 years of age) may limit the orthopedic correction required to treat most of the Class III malocclusions. More importantly, treating a Class III malocclusion in the late deciduous and early mixed dentitions has been shown to be more beneficial to the child because of improved maxillary orthopedic correction combined with controlled mandibular growth than compared to treatment in the later childhood growth stages.[37]

A dental deep bite or dental open bite is a frequent morphologic change present in Class III malocclusions.[15,16] In the Class III Types 1 and 2, the closed bite or open bite has its origin in a dentoalveolar cause, not skeletal. The faces of these patients as a result are more mesocephalic to brachycephalic and exhibit a lower mandibular plane angle between 20 and 30 degrees. In contrast, the remaining Class III malocclusions have their anterior dental bites as a reflection of the underlying skeletal cause resulting in either a skeletal closed bite or skeletal open bite. The vertical dimension as expressed in the mandibular plane angle may predict the corresponding anterior bite. An excessive mandibular plane angle greater than 30 degrees (MP-FH) would result in a skeletal open bite whereby a deficient lower mandibular plane angle less than 20 degrees would result in a skeletal closed bite.

Treatment strategies of the Class III malocclusion are directed at the underlying etiology. Class III malocclusions limited to dentoalveolar changes would be limited to orthodontic fixed mechanics (Types 1 and 2).[41,42] Skeletal changes such as a retrognathic maxilla, Type 3, and prognathic mandible, Type 4, maybe treated at a very early age, before 10 years, with combined dentofacial orthopedics(RPE followed with reversed pull face mask) and orthodontics(fixed appliances) with predictable results.[21,22,25-38] Lastly, Class III malocclusions that have progressed into later childhood (>10years of age) such as Types 5 and 6 or Types 3 and 4 are limited to orthonagthic surgery or camouflage extraction orthodontics. Type 7 cases should be managed at craniofacial centers experienced with these cases.

No attempt was made to correlate soft tissue changes such as tonsils, adenoids and tongue habits into the classification system. These topics are still controversial issues in the orthodontic community. However, patients should be screened for enlarged adenoids and tonsils because patients with Class III malocclusions frequently experience these problems. Any tongue or finger sucking habit should be addressed as well.

The concern of this article was to identify the degree of difficulty of the Class III malocclusions while at the same time develop a classification system. The purpose of this classification system is to bring some clarity to the treating dentists in order to be able to identify those Class III malocclusions that lend themselves to early orthodontic and/or orthopedic correction in contrast to those (Class III) that require orthognathic surgery at a later stage of development.

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