Maxillary Deficiency: A Literature Review

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Abstract

Maxillary deficiency contributes to a high percentage of Class III malocclusion. Individual with Class III malocclusion can exist with any combination of skeletal and dental component. The underlying cause of discrepancy should be addressed accurately to be able to decide an appropriate treatment plan. Maxillary deficiency has been regarded as the primary etiologic factor of this type of malocclusion and also a decisive feature for a good prognosis. For those patients without growth potential, orthodontic treatment nowadays can provide a more possibility for orthodontic camouflage treatment in borderline skeletal class III. Surgical first approach becomes well-known and accepted, not only benefit in psychosocial well-being and appearance but also includes RAP effect that facilitated efficient tooth movement. The successful retention and stability seem to be similar with conventional orthognathic surgery. As the study on skeletal Class III treatment is increasing in great numbers, in the future it might be possible to prevent retardation of maxilla using molecular technology.

Keywords: Maxillary deficeincy, Class III malocclusion

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Introduction

Maxillary deficiency contributes to a high percentage of Class III malocclusion. According to Sanborn's retrognathic maxilla in combination with normal or prognathic mandible involved approximately 43% of his Class III study samples.[1] Most of class III in Asian were also noted as underdevelopment of the maxilla while normal maxilla were found in Caucasian. Simple maxillary retrusion was found varied percentage in many studies.[3] One third of Sanborn's[1], 37% of Dietrich's, and 25% of Jacobson and coworkers[4] sample exhibited pure maxillary skeletal retrusion. The objective of this literature review is to discuss the nature and possible treatment modalities of maxillary deficiency.

Characteristic

Individual with Class III malocclusion can exist with any combination of skeletal and dental component. The underlying cause of discrepancy should be addressed accurately to be able to decide an appropriate treatment plan. Maxillary deficiency has been regarded as the primary etiologic factor of this type of malocclusion and also a decisive feature for a good prognosis. Cephalometric analysis has been used widely to identify subjects with skeletal class III malocclusion in many studies. Class III subject usually has a shorter anterior cranial base, a more obtuse gonial angle, and more forward position of the glenoid fossa.[1, 5, 6] Common measurements used to evaluate the maxillary and mandibular position include, but are not limited to, SNA, SNB, ANB, Wits and linear measurements of Condylion to A point and Condylion to Gnathion. The analytic value that measure relative to anterior cranial base length may be changed due to abnormality. Proffit showed a significant increase of mandibular size whereas relative maxilla size was not significant[7]. Skeletal class III showed less ANB angle than normal and varied in each studies at least less than 1°. Jarvinen[8], however, demonstrated that the A-N-B criterion alone was not sufficient because it varied without any marked abnormalities in the sagittal jaw relationship. Wits appraisal, the measured distance between AO and BO point on the occlusal plane, may eliminate the inherent variation and problems associated with relying on ANB.[4] Even Wits appraisal has been extensively applied, it is largely dependent upon correct location or representation of the occlusal plane. Iwasaki et al. demonstrated that the ANB angle is a more critical cephalometric parameter than the Wits appraisal in Angle class III subjects with a counter-clockwise mandibular rotation and a flattened occlusal plane.[9] Neither ANB nor Wits appraisal exhibit the underlying abnormalities. To identify maxillary deficiency, SNA and Co-A measurement are often used and demonstrate in low value. However, A point is not true skeletal landmarks. It could be differed due to dentoalveolar change. Therefore, cephalometric analysis may not be the most reliable tool to differentiate whether the maxilla or mandible contributes to skeletal disharmony.

Profile disharmony can be used as a good clinical predictor in the skeletal discrepancy. Also, it is an important evaluative factor for diagnosis and treatment planning to optimize facial esthetics. Facial profile concavity is an indication of underlying Class III skeletal pattern for maxillary retrognathism or mandibular prognathism, or combination of both. Paranasal hollowing is a sign of midface deficiency, which shows flattening of upper lip and obtuse nasolabial angle[10]. Increased showing of sclera above lower eyelid which normally assessed in the frontal facial examination, is also a sign of midface deficiency.[11] The cause of this abnormality has been attributed to the soft tissue draping effect of a protruded mandible, in which the inferior origins of the orbicularis oris musculature are anteriorly located, giving a flat appearance to the face. The lower lip is often protruded relative to the upper lip. [12] Staudt and Killaridis[13] study showed strong correlation between soft-tissue facial profile and skeletal structure of Class III subject. However, the sample in this study were

included from their dental malocclusion and the result did not show the contribution of maxillary or mandibular position to sagittal relationship.

In addition, Angle's class III molars and canines relationship, edge-to-edge incisor relationship or anterior cross bite seem to be the consistent dental characteristics in class III malocclusion. Proclined maxillary incisors and retroclined mandibular incisors are a result of dentoalveolar compensation. The upper arch is usually much narrower than the lower, and the overjet and overbite can range from reduced to reversed number.[3, 5, 12] Early detection of skeletal class III malocclusion is difficult due to differential growth between maxilla and mandible. Several investigations attempt to predict the progression of Class III malocclusions to determine if growth prediction can be used to differentiate children with Class III tendency from Class I sample. Dietrich reported that Class III skeletal discrepancies worsened with age. One attempt to identify morphologic characteristic of class III skeletal pattern, the numeric predictive system based on an average incremental growth and a single formula as suggested by William and Anderson. However, the exhibited skeletal Cass III malocclusion could not imply to maxillary deficiency, The appearance of parents or other family members might probably be used to forecast the tendency of skeletal discrepancy.

Etiology

Class III malocclusion is most prevalent in Oriental population especially with the maxillary retrusion type. Its etiology is generally believed to be genetic and familial occurrence as demonstrated in several studies.[14] The significant contribution of genetic component is gleaned from the subjects with maxillonasal dysostosis (Binder's syndrome) that exhibits maxillary and associated soft tissue hypoplasia. The variation in shape and size of the cranio-dento-facial structures depend on both genetic and environmental influences. Many

cephalometric studies show distinct skeleto-facial pattern in monozygotic twins having Class III malocclusions. From these studies it was concluded that genetic is not the sole etiological factor of the class III skeletal displasia.[15, 16] Environmental factors also play significant role in its severity. Such dentoalveolar compensation is considered as an important environmental factor in the variation of severity of class III incisor relationship among twins. Patients with Craniofacial abnormality, orofacial clef, achondroplasia, craniofacial synostosis syndrom, Apert's syndrome and Crouzon syndrome express midface deficiency that contribute to retrusive maxilla. According to Singh, maxillary hypoplasia and midfacial retrusion are complex phenomenon, they may affect only dento-alveolar regions or involve midface abnormality. Maxillary growth takes place through the apposition of bone at the sutures between the cranium and maxilla causing a downward and forward displacement. Deficient growth in either directions or a decrease in the anterior posterior dimension may lead to a Class III skeletal pattern.[17] It is conceivable that Class III malocclusions may result from the activity of the circumoral musculature as the inhibition of anteroposterior growth and significant maxillary retrusion are found in patients with cleft lip. An abnormal activity of soft tissue component may be a contributing factor in class III malocclusions with retrusive maxilla.

Treatment

Correcting skeletal Class III malocclusions with maxillary hypoplasia alone reveals better prognosis than the one involves prognathic mandible for early treatment. Both sagittal and vertical maxillary deficiency can contribute to Class III malocclusion, resulting in a prognathic appearance of the jaws, dentition and soft tissue profile. The direct effect can be seen when maxilla is positioned posteriorly and if the maxilla does not develop vertically, the mandible rotates upward and forward producing the appearance of a prognathic

mandible. Orthodontic treatment could be introduced with growth modification in early age or waited until growth has ceased thereby committing the patient to either dental camouflage treatment or orthognathic surgery. However, unfavorable growth of mandible can occur in mature stage, eventually orthognathic surgery still has to be done even maxillary growth modification is completed earlier.

Proper timing for orthodontic treatment especially for those children with developing Class III malocclusions has always been somewhat controversial. The definitive treatment tends to be delayed for severe Class III cases.[18] Turpin developed a list of positive and negative factors that helped decision making on developing Class III malocclusion. The positive factors included good facial esthetics, mild skeletal disharmony, no familial prognathism, presence of anteroposterior functional shift, convergent facial type, symmetric condylar growth and growing patients with expected good cooperation. The negative factors included poor facial esthetics, severe skeletal disharmony, familial pattern established, no anteroposterior shift, divergent facial type, asymmetric condylar growth, growth complete and poor cooperation. Turpin recommended that early treatment should be considered for a patient who presented with positive characteristics as mentioned.

Early treatment: Maxillary protraction

Considering a skeletal Class III malocclusion, the better prognosis obtains when there is a greater the maxillary involvement at the expense of participation of the mandible. In this condition, the aim of performing orthopedic treatment is redirecting patient growth by applying forces on sutural surfaces, resulting in forward displacement of the maxilla and bone apposition.

For children who exhibiting early signs of a Class III malocclusion, the current treatment approach is to protract the maxilla. With the introduction of the facemask treatment by Delaire in 1976, it has become possible to move the maxilla forward with extraoral traction.

The principle of maxillary protraction technique is to apply an anteriorly directed force on the circummaxillary sutures, which are still patent at an early age and thereby the stimulation for bone apposition in the suture areas can be done. The facemask has an adjustable anterior wire that can accommodate a downward and forward pull on the maxilla with elastics. To minimize the tipping of the palatal plane, the protraction elastics are attached near maxillary canines with a downward and forward pull of 30° from the occlusal plane. Maxillary protraction usually requires 300 to 600 g of force per side, depending on the age of the patient. Patients are instructed to wear the appliance for 12 hours per day.

Many areas of the dentofacial complex response to face mask/ expansion therapy. Skeletal change is primarily a result of anterior and vertical movement of the maxilla. The maxilla can be advanced 0.8 to 5.5 mm over a 12 to 15-month period of headgear treatment.[12, 20, 25, 26] The Point-A advancement of the maxilla has been reported in many previous studies. Ishii[19], Takada[27] (10 to 12 age group), and Nartallo-Turley[23] observed significant rotation of the palatal plane. The rotation of the palatal plane described in this and other studies may be affected by many factors, including site of force application, direction of elastic traction, as well as the facial pattern of the patient. Tanne et al. and Hata et al. demonstrated that palatal plane rotation occurred where the PNS drops more than the ANS, despite a downward force vector, because the line of force was directed below the center of resistance of the maxillae creating a moment for rotation.[28, 29] The described movement of the maxilla and associated downward and backward rotation of the mandible is ideally suited for patients with excessive overbite and vertical maxillary deficiency. It should be noted that Class III malocclusion with an open bite tendency should be done with caution when considering face mask/ expansion therapy.

Table 1 : Skeletal changes in face mask/expansion therapy[12, 19-24]

	SNA angle change (°)	A-point change (mm)
Ishii et al.	2.218	2.104
Mermigos et al	1.76	4.75
Takada et al	2.04	NA
Baik	1.5	2.0
Ngan et al	1.3	2.3
Arman et al	1.83	2.11
Nartallo-Turley et al	2.35	3.34
Kapust et al	2.37	2.31

Significant changes in mandibular position also contribute to the Class III correction. Mandibular rotation may be due to a combination of vertical maxillary movement, eruption of the maxillary molar, and a distalizing or retraction force on the chin. Downward and backward movement of the chin is consistent with Ishii and Takada's findings with maxillary protraction and chincup treatment, and to Nartallo-Turley and Ngan involving palatal expansion with face mask.[12, 19, 23, 27] Conversely, Mermigos who used only maxillary protraction reported unchange in the mandibular plane.[20] Other vertical effects that can be found includ a significant change in the ANS-menton distance which cannot be seen clearly clinically. Mandibular rotation may occur due to a combination of vertical maxillary movement, eruption of the maxillary molar and/or distalizing or retraction force on the chin. A compensatory remodelling process from Bjork study[30], the lower border of the mandible presumably induced by mandibular relocation accounted for the minimal increase in mandibular plane angulation (Go-Gn-Sn +1S). Therefore, a redirection of future mandibular growth in a more downward and backward vector could be expected from the change in position and remodelling of the mandible.

In addition to skeletal changes in the maxilla and mandible, orthodontic effects such as forward and downward movement of the maxillary dentition and a decrease in the inclination of the lower incisors occur. Ngan and Baik[12, 21] reported that superimposition on the maxilla confirmed that the maxillary movement in forward direction and the incline plane was effected where the upper incisor moved forward and the lower incisor moved back. Nartallo-Turley using the same method observed slightly less maxillary molar movement but did not measure incisor change.[23]

Various soft tissue changes attempt to be made to improve the Class III profile. Forward movement of the upper lip, retraction of the lower lip, soft tissue pogonion backward movement and menton downward movement contribute to increase profile convexity. Karpust reported concordantly with Ngan that significant correlations were found between changes of the sagittal relationships of skeletal and soft tissue profiles in both the maxilla and mandible.[12, 22] Nartallo-Turley also reported these changes but also found significant forward repositioning of pronasale and

subnasale. The observed soft tissue effects appeared to result from the induced skeletal changes.[23]

Force application

However, maxillary protraction does not always result in forward movement of the maxilla. With the same line of force, different midfacial bones are displaced in different directions depending on the moments of force generated at the sutures. The center of resistance of the maxilla is found to be located at the distal contacts of the maxillary first molars one half the distances from the functional occlusal plane to the inferior border of the orbit. Protraction of the maxilla below the center of resistance produces counterclockwise rotation of the maxilla, which may not be favourable for patients with an open bite tendency. Hata suggested a force applied 5 mm above palatal plane to obtain forward displacement of maxilla, if a rotational of the maxilla is contraindicated.[28]

Duration of treatment

Clinically, anterior crossbite can be corrected with 3 to 4 months of maxillary expansion and protraction depending on the severity of the malocclusion. Improvement in overbite and molar relationship can be expected with an additional 4 to 6 months of treatment. Delaire suggested one year or more to carry out the treatment.[31]

Effect of age on maxillary protraction therapy.

Clinically, studies have shown that maxillary protraction was effective in the primary and mixed as well as early permanent dentitions. Several studies suggested that a greater degree of anterior maxillary displacement can be found when treatment was initiated in the primary or early mixed dentition.[21, 27, 32] The optimal time to intervene a Class III malocclusion is at the time of the initial eruption of the maxillary incisors. A positive overjet and overbite at the end of the facemask treatment appears to maintain the anterior occlusion.

Biologically, the circummaxillary sutures are smooth and broad before age 8 and become more heavily interdigitated around puberty. Takada concluded that a greater orthopedic effect was observed when therapy was initiated before or during the pubertal growth spurt (7 to 12 years).[27] On the other hand, Baik concluded from statistical comparisons that face mask expansion therapy in younger children was not significantly different from older children.[21]

Clinical studies have employed maxillary protraction in the late-mixed to early-permanent dentition stages of development in order to take maximum advantage of growth. Some studies have indicated that the orthopedic response may be greater if treatment is initiated at an even earlier age. Baccetti showed that the combination of a bonded maxillary expander and face-mask therapy is more effective in early mixed dentition than in late mixed dentition, especially with regard to the magnitude of the protraction effects on maxillary structures.[33] Merwin and Baik studies similarly showed no statistical difference between age.[21, 32] Results from meta-analysis demonstrated that treatment changes in the younger group were larger than those in the older group. However, the magnitude of the difference between the 2 groups was not substantial.[34] However, even results suggested that early treatment may be most effective, face mask therapy could provide a viable option for older children as well.

Rapid palatal expansion effect

Rapid palatal expansion (RPE) is typically used on young patients and has been shown to produce effects that favor Class III correction.[35-38] Face-mask therapy often is supplemented with maxillary expansion even in the absence of maxillary constriction.[25] RME expands a narrow maxilla, corrects a posterior crossbite, increases arch length and splints the maxillary dentition during protraction therapy. Maxillary expansion in conjunction

with maxillary protraction tends to counteract the side effect of anterior constriction.[39] Midfacial orthopedic expansion has been recommended for the use in conjunction with protraction forces on the maxilla because it disrupts the circummaxillary sutural system and presumably facilitates the forward movement of the maxilla via facemask therapy and leads to downward and forward movement of A-point by approximately 1 mm.[25, 40, 41] Kim suggested that the use of an expansion appliance enhanced the protraction effect in terms of time with less dental effect.[34] In fact, there are some evidences in the literature that maxillary expansion alone can be beneficial in the treatment of certain types of Class III malocclusion, particularly for borderline skeletal discrepancy.

Tooth borne VS Bone Borne

For tooth-borne device, the point of force application locates at maxillary teeth and the forehead and the chin are used as anchorage sources for protraction in facemask therapy. Indirect application of force limits the potential for orthopedic change and causes undesirable tooth movements unavoidably such as mesial movement and extrusion of the maxillary molars and labial tipping of the maxillary incisors. Hence, the force that directly transferred to the circummaxillary sutures can increase the skeletal effects of the maxilla and eliminate the dental movements by using skeletal anchorage. In recent years, a few researchers have shown that the maxilla can be effectively protracted via ankylosed deciduous teeth, osseointegrated implants, titanium screws, onplants, and titanium miniplates.[42-46] The undesirable effects of conventional facemask therapy such as anterior rotation of the maxilla, posterior rotation of the mandible and increase in facial height were reduced; so protrusion of the maxillary incisors, mesialization and extrusion of the maxillary molars were eliminated by the skeletal anchorage. In addition, the treatment duration was reduced significantly.[46] The treatment effects for maxillary advancement induced by bone-anchored maxillary protraction showed significant increase in the amount of maxillary advancement than using face mask with rapid maxillary expansion.[47] Eventhough there are many advantages of maxillary protraction with skeletal anchorage, the surgical operations when placing and removing miniplates are the major disadvantages of this application.

Retention and stability

Petit and McNamara and Brudon recommended the use of Fränkel-III (FR-3) for retention after protraction headgear therapy.[48] Study reported that relapse tendency in early treatment subjects primarily affected in the maxillary region, whereas late treatment subjects exhibited a significant rebound in mandibular sagittal position. Williams and colleagues concluded that the effects of maxillary protraction appeared to be stable. The return to a Class III skeletal pattern was primarily because of mandibular growth rather than the relapse of treatment in the maxilla.[38] Other studies included a cephalometric observation 3 years from the end of active orthopedic treatment reported a lack of significant differences between treated and control groups, suggesting that the favorable treatment effects on the maxillomandibular relationship were maintained. It appears that the favorable skeletal change observed over the long term is almost entirely due to the orthopedic correction achieved during the rapid palatal expansion with a facemask protocol.[49] However, Many investigators have stated the need for retention and overcorrection after maxillary protractors to balance greater pubertal mandibular growth.[50]

Early treatment with orthopedic forces for maxillary advancement is able to reduce the need for surgical intervention in later age. If surgery still need to be perform, it might be reduced to 1-jaw surgery, thereby minimizing complications and increasing the stability.[51] In addition, the growth treatment response vector (GTRV) analysis can be used as a tool to predict patients with excessive mandibular growth that may not be able to be camouflaged with orthodontic treatment.

Ngan suggested that Class III patients with maxillary deficiency and a GTRV ratio that falls between 0.33 and 0.88 can be successfully camouflaged with orthodontic treatment.[52]

Camouflage treatment

Regarding the orthodontic treatment for patients who are at the completion of growth, even though small amount of facial growth continues but not sufficient to correct skeletal problem. The possible treatment is either displacement of teeth relative to their supporting bone to compensate for the underlying jaw discrepancy or surgical repositioning of the jaw. Camouflage is a therapeutic process which is done through extraction and orthodontic treatment to mask the skeletal discrepancies instead of correcting them. Therefore, a dentoalveolar compensation is made without correcting an underlying jaw discrepancy. Camouflage treatment is recommended for patient who willing to accept a less than ideal result. By the way, the amount and direction of tooth movement to create acceptable occlusion have to be possible to do by comprehensive orthodontic treatment. Studies had shown an increase in the ANB angle, little or no change in the vertical dimension and a decreased in concavity of the facial profile with Class III camouflage treatment.[53-56] A remarkable soft tissue change was noted after the treatment, the concave facial profile changed to a straight profile in Lin study.[53] Many case reports in camouflage treatment also showed improved facial profile.

Common predictors for successful class III camouflage for the evaluation of the maxillary and mandibular position include
1. ANB (less-2 to -3)
2. Wits appraisal (-2 to -6 for nonsurgical treatment, -6 to -9 for a compromised orthodontic result)
3. Linear measurement of Co-A and Co-Gn
4. Percentage of Co-A/Co-Gn ratio
5. The net sum difference between maxillary and mandibular length, the mandibular ramus height/mandibular length ration, and gonial angle

Clinical assessment may be the most important evaluation to optimize facial esthetic. Stellzig-Eisenhower et al[16] reported that the Wits appraisal was the most discriminative in determining whether the developing Class III malocclusion should be treated by camouflage treatment or surgery. Class III patient with mild to moderate class III skeletal patterns with a growth treatment response vector (GTRV) ratio between 0.33 and 0.88 can be successfully camouflaged with orthodontic treatment, and a GTRV ratio below 0.38 should be warned.[52] However, GTRV ratio need a serial lateral cephalogram to be obtained, so this tool may not be suitable for decision making in new coming patients.

Class III camouflage logically base on retracting the lower incisors, advancing the upper incisors, rotating the mandible downward and backward when chin is prominent. Class III cases with mild mandibular prognathism and crowding can be treated by various extraction schemes including 4 premolars (maxillary second premolars and mandibular first molars), 2 premolars (mandibular second or first premolar) or a mandibular incisor. Extraction of a mandibular incisor is occasionally indicated for patients with an anterior crossbite or an edge-to-edge incisor relationship. The decision is determined by factors such as the severity of anterior crowding in the mandibular arch, the Bolton discrepancy and the degrees of negative overjet and overbite. However, if irreversible camouflage treatment is plan, verification before extraction must be confirmed to ensure that the goals of treatment with nonsurgical treatment approach can be achieved. There is little to no evidence compares the benefit of outcome between extraction and non-extraction in camouflage treatment. Upper premolars extraction are not always advisable because extraction make it difficult to create proclination of the incisors in Class III camouflage. In case that lower incisors are already decompensated, lower

premolar extraction would be done with caution. Lower premolar extraction can cause even more retroclination of lower incisor. If surgical treatment is needed in the future, final esthetic often has to be compromised. Moreover, over retraction of lower incisors creates the risk of developing dehiscence and lack of bone support.

A common strategy of orthodontic camouflage treatment is the use of intermaxillary Class III elastics to correct the sagittal discrepancy. Patient cooperation is required for wearing elastics. The effect of Class III elastics result in mesial movement of the upper dentition and distal movement of the lower dentition with proclination of upper and retroclination of the lower dentition. They also induce extrusion of the upper molars and lower incisors, resulting in counterclockwise rotation of the occlusal plane and increase in the facial height. However, these change can lead to instability during retention. Proclination of upper incisors and flat smile arcs are unfavorable esthetic outcomes. The position and inclination of the upper incisors and the sagittal cant of the occlusal plane are important components of facial and smile esthetics. To prevent these undesirable changes, several studies have reported mini-implant assisted distalization of the lower dentition.[57]

Kim developed and studied the use of multiloop edgewise archwire therapy (MEAW) in order to correct malocclusion. Although, most of Kim's study had focused on correcting anterior open bites, he states that "The MEAW can be applied as a multipurpose mechanism in different types of malocclusions: openbites, deep bites, and Class I, II, or III patterns." Kim's technique is essentially a way of camouflaging skeletal problems through orthodontic tooth movement. In 1994, Sato proposed the Multi loop edgewise arch wire in order to reconstruct the occlusal plane[58]. A multiloop edgewise archwire (MEAW) can produce distal en-masse movement of the mandibular dentition. Multiple L-loops and tip-back bends with intermaxillary elastics would

efficiently upright and distalize the mandibular posterior teeth and change the inclination of the occlusal planes, making it possible to correct the occlusal sagittal relationship and obtain the correct intercuspation in a significantly shorter time. In more severe cases certain extraction are necessary for camouflage method.

The use of temporary anchorage device makes treatment more possible in severe class III problem. Microimplants can be placed more anteriorly in the maxillary arch and use for en-masse protraction when anterior movement of the maxillary dentition is allowed. Corticotomy which can create regional acceleratory phenomenon, have been proposed to move teeth beyond the enveloped of tooth movements.[49] However, more evidence is needed to prove its efficiency and the biologic limitation should be concerned. When treating a Class III patient, the clinician should monitor the patient constantly so that the treatemt does not exceed the range of successful camouflage treatment. In addition, patients should be followed up for periodontal health after camouflage treatment. Increasing morbidity in the long-term must be evaluated as gingival recession has been found in Class III patients who is camouflaged by greater dental compensation. If a satisfactory result cannot be predicted in advance, the orthodontic treatment should not be offered. Several followed up case reports show success in stability after treat,emt even without good retention. But Battagel considered that Class III malocclusions posed special clinical problems because of the tendency of relapse.[59] Unfavorable growth pattern might alter the occlusion and stability in most class III with relapse.

Orthodontic combined with orthognathic surgery

Orthognathic surgical treatment is required for adults because growth modification could not be an option. Not all of these patients are candidates for surgical correction, patient assessment and selection are essential in diagnosis and treatment

planning. Kerr et al reported that patients with ANB angles of less than –4° and mandibular incisor inclinations of less than 83° were more likely to have surgical-orthodontic treatment than conventional orthodontic treatment.[60] Stellzig-Eisenhauer suggested that Wits appraisal was the most decisive parameter and concluded that surgical patients could be distinguished from nonsurgical ones on the basis of Wits measurement, maxillary/mandibular length ratio, gonial angle and sella-nasion distance.[61] However, this study still cannot definitively distinguish between the patient who can be properly treated by orthodontic mechanotherapy alone to those who requires orthognathic surgery. Musich also agreed with the use of Wits appraisal to evaluate patient treatment planning. His study revealed that the Wits measurement of -9 to -12 would require surgical treatment and a measurement of -12 and above would require a double jaw surgery.[56]

Surgical-orthodontic treatment requires preoperative orthodontic treatment to decompensate the malocclusion, followed by surgical detailing and finishing of the occlusion. Typical dental decompensation in class III malocclusion is to retract the proclined maxillary incisors and procline the retroclined mandibular incisors to obtain normal axial inclination. The severity of the Class III dental malocclusion is increased and often worsen patient's facial profile prior the surgery. The preoperative dental decompensation dictates the magnitude and type of surgical procedure, also it is a major factor in prediction of success in the treatment. Lack of optimal dental decompensation compromises the quality and quantity for the orthognathic correction.[62] The main objectives of surgical-orthodontic treatment are obtaining facial esthetic, good occlusion and function. Various choice of surgical procedures are based on clinical examination and cephalometric evaluation. In skeletal class III with retrusive maxilla, maxillary advancement is an optimal choice to support facial profile whether mandibular setback is needed or not.

The use of a LeFort I osteotomy to correct maxillary deformity was first described by Obwegeser in 1969. During the 1970s, the procedure became increasingly popular because it can be used to manage discrepancies in all 3 planes of space. Its versatility with minimal effects has made the LeFort I osteotomy becomes the procedure of preference in the treatment of many skeletal class III patient. For patient with clinically marginal maxillary retrusion and proclined maxillary incisors, the most appropriate treatment may be extraction of the maxillary first premolars and retraction of the incisors. Maxillary advancement surgery then can be performed as a part of the overall treatment plan not only to improve the occlusal and skeletal problems, but also to improve the clinical appearance of the patient.

Alternatively, extractions with segmental alignment of the maxillary dentition can shorten the period of presurgical orthodontics. Segmental osteotomy also allows the maxilla to be widened or narrowed, but widening seem to be unstable because of the pull of the stretched palatal tissues.[49] Total maxillary segmental surgery can then be performed to advance the maxilla and consolidate the arch. In cases in which maxillary advancement surgery is necessary, it is important to retract maxillary incisors so that optimal advancement of the maxilla can occur. An acute nasolabial angle may occur after maxillary advancement surgery if the maxillary incisors have not been adequately retracted. In severe midface deficiency patient, LeFort II advancement may be performed instead. The maxilla is moved downward as well as forward in maxillary advancement procedure, there is a strong tendency for relapse by upward movement of maxilla.[63] As a result, the chin becomes more prominent in 1 year follow up. However, the Le Fort I maxillary advancement surgery shows almost no relapse in antero-posterior direction.[63, 64] For the treatment of Class III patients, the maxilla has almost no tendency for major relapse. The horizontal relapse occurs during the first 6 months

postoperatively.[65] For 2 jaws surgery which maxilla is moved downward and forward while the mandible is set back, moderate vertical relapse of the maxilla and anteroposterior relapse of the mandible are observed. Stability of the downward movement of the maxilla is on average better than that resulting from maxillary surgery alone.[66] There is a lack of stability for mandibular setback due to counterclockwise rotation of the mandible between post-operative periods, so good intercuspation after surgery and muscle adaptation should be obtained.

Distraction osteogenesis

Distraction osteogenesis is frequently performed in growing Class III patients with maxillary dysplasia. This technique is based on manipulation of a healing bone to generate the formation of additional bone and soft tissue adaptation. Overcorrection is suggested to prevent relapse.[49] Different types of external and internal distractors are available. Extraoral distractors have the capacity for multidirectional maxillary advancement and the vectors can be changed during the process. However, patient acceptance is low and accidental trauma is frequently found. The rigid external distraction device is fixed to the cranium. The protection of the maxillary teeth is superior than other types of extraoral devices which are anchored to the maxilla. The relapse of maxillary advancement with the rigid external distraction device is reported to be 22% after 3 years.[67] Recently, Iida et al developed an intraoral distractor to selectively move a segment of the maxilla forward.[68]

Surgery first

Surgical first approach is also proposed for class III patients for psychosocial benefits in a recent year. Cases with minimal presurgical orthodontic alignment and decompensation are indicated. Orthodontics is an adjunctive treatment postoperatively for the surgery-first approach to make the transitional occlusion into the solid final occlusion. This alternative treatment procedure also has obvious advantages in shortening treatment time and creating of favorable function for orthodontic tooth movement.[69, 70] The phenomenon of post-operatively accelerated orthodontic tooth movement or RAP reduces the difficulty and treatment time of orthodontic management in the surgery-first approach.[71] Liou et al suggested that RAP in humans began within a few days of surgery, typically peaked in the first and second month and might take from 6 months to more than 24 months to subside.[72] Nagasaka et al. showed a case of over corrected skeletal Class III and immediate improvement of soft tissue profile after surgery. [73] The patients had good occlusion, balanced profile and stable results in the following three years. The treatment outcomes and stability seem to be similar to conventional orthorgnathic surgery.[69, 70, 74] However, without proper orthodontic decompensation, it's difficult to estimate the final occlusion, so accuracy for wafer fabrication is more important. This technique may be suitable for patient who requires mild to moderate decompensation. Experience of surgeon and orthodontist are also important factors in applying the appropriate treatment method to achieve patient need and goal.[70]

Conclusion

Maxillary deficiency has better prognosis than mandibular prognathism in treating a skeletal class III malocclusion. Early treatment with maxillary protraction provides good outcome if unfavorable growth pattern of mandible does not appear in later year. Initial accurate evaluation leads to proper treatment plan. For those patients without growth potential, orthodontic treatment nowadays can provide a more possibility for orthodontic camouflage treatment in borderline skeletal class III. Surgical first approach becomes well-known and accepted, not only benefit in psychosocial well-being and appearance but also includes RAP effect that facilitated efficient tooth movement. The successful retention and stability seem to be similar with conventional orthognathic surgery. However, surgeon's expertise and experience are important to determine the difficulty in

orthodontic management and obtain optimum treatment outcome. As the study on skeletal Class III treatment is increasing in great numbers, in the future it might be possible to prevent retardation of maxilla using molecular technology.

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การเจริญของขากรรไกรบนบกพร่อง: บทความปริทัศน์

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บทคัดย่อ

ผู้ป่วยที่พบความผิดปกติของการเจริญของขากรรไกรบนบกพร่องมักสัมพันธ์กับความผิดปกติของโครงสร้างขากรรไกรแบบที่ 3 วิธีการแก้ไขผู้ป่วยที่พบความผิดปกติของการเจริญของขากรรไกรบนบกพร่องจำเป็นต้องอาศัยการวินิจฉัยที่ถูกต้องเพื่อให้ผลการรักษาเป็นไปตามที่วางแผน สำหรับวิธีการรักษาอาจจะใช้วิธีการจัดฟันโดยอำพรางความผิดปกติของขากรรไกรและใบหน้าในกรณีที่ผู้ป่วยมีความผิดปกติเล็กน้อย แต่ถ้าหากผู้ป่วยมีความผิดปกติมากจำเป็นต้องใช้การรักษาด้วยวิธีการผ่าตัดร่วมด้วย ซึ่งการผ่าตัดร่วมกับการจัดฟันจะช่วยให้ผลการรักษาประสบความสำเร็จและเห็นผลรวดเร็วขึ้น ทั้งนี้ปัจจัยที่สำคัญในการเลือกตัดสินใจวางแผนนั้นขึ้นกับประสบการณ์ของผู้ให้การรักษาและความคาดหวังของผู้ป่วยเป็นสำคัญ

คำสำคัญ: ความผิดปกติของการเจริญของขากรรไกรบน, ความผิดปกติของโครงสร้างขากรรไกรแบบที่ 3

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