The Influence of Vertical Growth on Class III Malocclusions

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Abstract

The aim of this paper is to approach the influence of vertical growth in the development of high and low angle,skeletal Class III malocclusions. Genetic, environmental and occlusal function are factors that contribute to the development of a Skeletal Class III malocclusion. Decreased cranial base angle can leave a forward position of the condyles and increase the vertical growth of the maxilla. The functional occlusal plane, and the spatial position of themaxilla,influence mandible growth which effects the lower face height. The control of dental vertical height is very important to achieve a stable occlusion, as it effects the occlusal plane and craniomandibular growth.

Introduction

Class III malocclusions are thought to be a polygenic disorder that results from an interaction between susceptibility genes, and environmental factors. However, research on family pedigrees has indicated that Class III malocclusions may also be a monogenic dominant phenotype. (1)

Studies indicate that 63-73% of Class III malocclusions are of skeletal type (2,3), resulting from a non harmonic growth between mandible and maxilla. A skeletal Class III malocclusion can display mandibular protrusion, maxillary retrusion or a combination of these factors(2,3,4,5).

The prevalence of Angle Class III malocclusion has been documented by multiple studies. However, there seems to be a wide range of prevalence rates reported, usually attributed to variation among samples.

Hardy D K et al.(6)published a meta-analysis about the prevalence of Angle Class III malocclusion, and conclude that in Eastern Asia, the Chinese (15,69%) and Malaysian (16,59%), populationshow a relatively higher prevalence of Angle Class III malocclusion whilethe Indian populations show a relatively lower prevalence.

The vertical growthof the viscerocranium in modern humans createssome difficulty in terms of proper fitting of theupper and lower dentition, because the descendingspatial position of the functional occlusal plane can easily createan anterior open bite. Thissituation is avoided by anterior mimic muscles. The vertical growth displaces the maxilla, and the continuous functional movement of the mandible allows an adaptation to the maxillary occlusal surfaces,in order to achieve a proper functional occlusion.Mandibular displacement is the primary process with condylargrowth being secondary and adaptive(7).

Growth and development of craniofacial complex and mandible.

The morphology of the cranial base has received some attention in respect to the morphogenesis and growth of the maxillo-mandibular complex.

The cranial base provides support for the brain and adapts during growth between neurocranium and viscerocranium. Due to this position between cranial, middle face, and glenoid fossa, the cranial base has the potential to influence cranium and facial growth.

The sutural dominance theory to explain the mechanism of craniofacial growth was presented by Sicher(8),stating the growth center as being located in the neurocranial base, nasal septum and mandibular condyle, strongly associatedto heredity, and less to environmental factors.

Scott(9) believed that sutural craniofacial growth wasn´t only due to heredity, but was greatly influenced by environmental factors.Nevertheless, Scott and Sicherbelieved that the craniofacial cartilage was the primary growth center, and the nasal septum cartilage has an important role in the anteroposterior growth of the maxilla(8,9).

The functional matrix theory, presented by Moss(10)explained that the expansion capacity of the brain results in the expansion of the whole cranium, and the growth of cranial suture isn´t only due to such external expansion. Environmental factors have an important role in thegrowth of the craniofacial skeleton, in the functioning space, and in the soft tissue components required for a specific function, such as breathing or mastication.The morphology andthe growth of thelower face are influenced and guided by dental function, and in a growing facial skeleton the adaptability is primarily located in the function of the dentition, while it`s secondarily located in the sutures and at condyles.

Petrovic(11)presented the cybernetic model of mandibular growth. The most relevant point in this concept is that the occlusal function is an important factor in the control of mandibular growth. Functional movement of the mandible is dependenton the action of the central nervous system andmasticatory muscles.The mandibular growth isn´t only controlled by the endocrine system and its growth potential, but also the position of the occlusal surface of maxillary teeth, and spatial position of maxilla, which constitutes the functional occlusal plane.

According to Enlow(12) the mandibular ramus normally becomes more verticalduring the development. The ramus is actively growing in a posterior direction with greater amounts of bone additions on the superior part of the posterior border, than on the inferior part. The vertical lengthening of the ramus continues to take place after horizontal ramus growth slows, or ceases.

To accommodate the vertical nasomaxillary growth, and prevent changes in the occlusal relationship between the maxillary and mandibular arches, the gonial angle must close. The vertical growth changes, of the mandibular dentoalveolar arch, the ramus, and the middle cranial fossa must match the vertical nasomaxillary growth changes, to achieve continuing facial balance. Any differential will lead to a displacement of mandibular rotation, either downward and backward, or forward and upward (12).

The Cohlmia'sstudy (13) indicate that patients with dental and skeletal Class III growth pattern show condyles positioned forward in the thomografic evaluation. In the same way using TAC, Seren(14) described a relative condylar protrusion associated to a mandibular forward displacement, in Class III malocclusions.

Chang(15)and McNamara (16) noted a decreasein the angulation between the anterior and posterior region ofthe cranial base, particularly associated with Ar point. Thus the anterior displacement of TMJ seems to be demonstrable in a child with Class III malocclusion.

Schudy(17)introduced the relationship of the vertical growth of craniofacial skeleton andmandiblerotation. The increase in the vertical dimension of the craniofacial skeleton, through the vertical growth of nasion, vertical

displacement of the maxilla, and the increase of dental verticaldimension(DVD), leads to an adaptation of the mandible. When the harmony of thisvertical growth, DVD,and the vertical increase of the mandibular condyle, is maintained, a mandible rotation will not occur.
The maxillomandibular growth is correlated with the increase of skeletal and DVD. Alterations in the vertical dimension, and in the occlusal plane, during growth, significantly affect the craniomandibular growth and the skeletal malocclusion development (18,19,20,21,22,23,24,25, 26).

According to Hooper(27)the movement of the bones, that constitute the face and neurocranium, depends on their mutual articulation. Excluding thetemporomandibular joint (TMJ) the most important articulation in the skull is the sphenobasilar articulation. This fuses at about 18-20 years old. As it has a dynamic movement, (which is located at the center of the skull),it also affects the other bones of the maxillofacial skeleton.

According to Sadao Sato(28)mastication is the most important biodynamical function transmitted to the entire craniofacial skeleton. This occurs as a masticatory force from the occlusal functionis transmitted to temporal bones through, the TMJ. This causes an effect on the dynamic movement of the CB. Functionally, the mandible adapts to maxila'santeroinferior displacement.

The maxillary growth is correlated with the type of growth, and the cranial motion. Itsuffers displacement caused by the cranial growthi-ndirectly induced by sphenoid`srotational motion, through the vomer bone.

The Displacement direction of the maxilla is influenced by the occipito-spheno-ethmoidal dynamic connection.There are three types of maxillary growth, secondary to the displacement of the maxillary complex. The maxilla can be translated with the frontal bone, in an anteroposterior direction, can suffer anterior rotation with CB extension, and can suffer vertical elongation with CB flexion, correlated to Class III development. Bone deposition at the maxillary tuberosity is important to create space in order to allow eruption of posterior teeth, resulting in a posterior lengthening of the bony maxillary arch. This occurs with translation and anterior rotation of the maxillary complex, but not with vertical elongation (7,10,18,29,30).

Class III High and Low angle malocclusion-The Dental Frame Analysis

The Dental Frame Analysis(DFA) was introduced by Sadao Sato. The Dental Frame(DF) is a triangle formed by the Palatal Plane (PP), the A-B Plane (AB), and the Mandibular Plane (MP). The Occlusal Plane (OP) and Frankfurt Horizontal (FH) are two other planes that constitute this analysis.

DFA analysis determines the positions of the DFin thecraniofacial skeleton, and their morphology; the functional adaptation capacity of the mandible to the functional occlusal plane, with forward or backward rotation; and the positional relationship of the DF to the OP(7).

The mandible presents a phenotypic diversity that may represent an additional factor in the orthodontic management of Class III malocclusion, and presumably arises due to heterochrony during development (31).

Skeletal High Angle Class III malocclusion is usually characterized as having an excessive vertical dimension(VD), flat OP, an obtuse gonial angle, an overdeveloped mandible,with anterior displacement, and an underdeveloped maxilla. There is also a small CB angle which may displace the glenoid cavity anteriorly, promoting mandible forward growth. This constitutes a skeletal reversed occlusion that can be associated with an open bite condition(Fig.1) (3,32,33).

The DVD and OP will influence development of the malocclusion during the growth process.An excessive increase of DVD, influenced by posterior discrepancy and "squeezing out" effect, with a less steep OP, are factors that promote a protrusive adjustment of the mandible and consequently a Class III development (7,16,21,24,28,34,35,36).

According to Sadao Sato(20) the OP is the most important factor affecting the lower face, vertically. The Influence of posterior discrepancy, in a skeletal high angle Class III development has been associated as the most important factor to the development of this kind of malocclusion. Posterior discrepancycan be defined as a discrepancy between molar tooth size, and denture base size, in the molar region (Fig.2). The relationship between the higher dimension of the molar teeth and/or a smaller dimension of jaw, may result in crowding at the posterior region of the jaw (29).

The sphenocipital flexion and the vertical elongation of maxilla leads to a maxillary posterior discrepancy which in turn will promote molar overeruption. The molar overeruption, due to the "squeezing out" effect (Fig.3) ofthe posterior discrepancy leads to a less steep maxillary OP with mesial dental inclination. Thispromotes the molarfulcrum, occlusal instability and anhorizontalized OP,associated with subluxation of the mandibular condyles and functional translation. There is also active proliferation of the condilar cartilage, followed by growth and abnormal condylar elongation and adaptation of the glenoid fossa, in growing patients.The mandible exhibits an anterior displacement to avoid the molar interference, and consequently the external rotation of temporal bone and the anterior displacement lead to a lack of load to the condyle that promotes secondary growth of the mandible by adaptation (7,18,20,29,37).

When molar overeruption occurs one of two possible events may happen: if the patient is at a growth stage, and has enough growth potential, mandibularforward displacement will occur, followed by mandibular condyle elongation. We see continuous mandibular forward rotation, resulting in a skeletal high angle Class III malocclusion. If the neuromuscular system does not respond to anterior displacement of the mandible,orwhen the effects of overeruption occur after puberty, themandible does not adapt to maxillary molar overeruption, and an anterior open bite,with tongue-thrust swallowing pattern,may develop by mandibularbackward rotation (18,20,28,37,38,39,40).

Studies developed by Suzuki and Sato(18), observed that in normocclusion patients, or in patients whose posterior discrepancy was eliminated by the extraction of third molars, the OP position keeps stable, during future facial growth and development.

Bacceti et al. (41,42) analyzed the growth tendency in Class III individuals and concluded that significant changes exist in mandibular length, until 18 years of age, with accentuated expression in Class III individuals rather than in normocclusion individuals. This becomes evident, in the later stages of development, corresponding to the complete eruption of second and third molars. This increases the tendency to Class III profiles, and increases ofthe facial vertical dimensions.

The development of Low angle Class III malocclusionis not completely understood and constitutes one of the important challenges in orthodontic therapy.

This skeletal pattern has an increased vertical growth of mandible, decrease AFH , mild posterior discrepancy, and significant Curve of Spee.We also see the steepening of the OP in the upper molar area, a deep anterior overbite, excessive anterior mandible rotation, and insufficient VD.Despite the insufficient vertical growth of the maxilla when compared with high angle Class III, there is a longer antero-posterior growth of the maxillary basal bone(Fig. 4)(32).

According to Bjork(40) forward mandibular rotation occurs when the posterior facial height(PFH) overdevelops relative to the anterior facial height(AFH). However, in many literature sources more attentionwas given to the AFH, and lower PFH has beenconfirmed as having a strong influence on the formationof vertical facial disproportions (43,44,45).

Wang et al. (46)concludedthat the PFH,rather than AFH is assumed to play a key role in the verticalfacial type, whereas AFH seems to undergo relativelyintrinsic growth.

Chen F. et al(47) studied vertical growth on untreated Class III patients, aged between 8 and 14 years old, via a cephalometric analysis, biannually. He noteda decreased PP-MP, and an increased PFH/AFH, in the low angle group , and inverse in the high angle group.

When there is a very active vertical growth of the mandibular condyle, due toinsufficient vertical growth of the maxilla, andinsufficient vertical dimension, the mandible exhibits excessive anterior rotation. We seeareversed occlusion which constitutes an anterior functional adaptation to the increased vertical growth of the condyle, associated with a decreased vertical dimension(33).

In fact, there is a disharmony in the relationship between the vertical dimension, and the vertical growth of the mandibule, with PFH increases. Despite the importance of VD in high angle Class III patterns, lowangle Class III is associated withan increase of PFH, a decrease of AFH, and a decrease of DVD.

Conclusion

Class III malocclusion has a low prevalence in the general population and has been associated to genetic factors. However, environmental factors, such as occlusal function, and breathing, will influence the genotype expression, and the severity of themalocclusion .

The CB influences the vertical growth of the face, the forward position of the TMJ and consequently thesagittal relationship between the maxilla and mandible. The mandible must adapt to the vertical growth, to create a balance for correct development of the face. The functional occlusal plane, and the spatial position of the maxilla, arestrongly influenced by the dynamic motion of thesphenooccipital articulation. This affects the mandible adaptation, and secondary growth.

The development of low or high angle Class III is strongly correlated with DVD, and the differences between these two types of Class III are extremely important to in our understanding of the origin and cause of this complex malocclusion.

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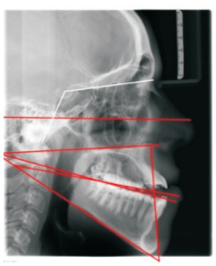
Fig 1.High angle Class III - Dental Frame Analysis.



FH-MP	25.9° +/- 4.3	33°
PP-MP	24.6 °+/- 3.9	36.5°
OP-MP	13.2° +/- 3.7	21°
OP-MP/PP-MP	0.54	0.58
AB-MP	71.3° +/- 4.4	52°

Fig.2 Posterior Discrepancy.

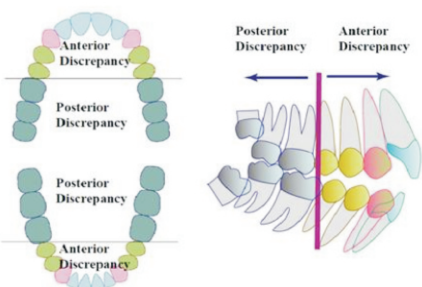


Fig.3 The "squeezing out"effect.

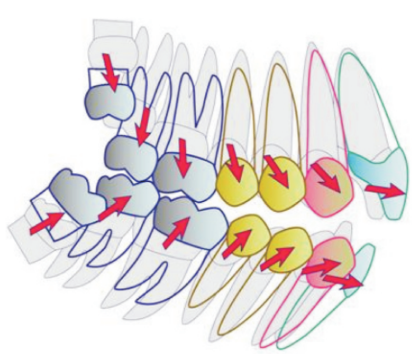


Fig 4.Low angle Class III - Dental Frame Analysis.

FH-MP	25.9° +/- 4.3	10°
PP-MP	24.6 °+/- 3.9	9°
OP-MP	13.2° +/- 3.7	6°
OP-MP/PP-MP	0.54	0.67
AB-MP	71.3° +/- 4.4	70°

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