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Guiding Atypical Facial Growth Back to Normal Part 2: Causative Factors, Patient Assessment, and Treatment Planning

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Abstract: *It has been well-documented that the most common factors associated with atypical facial growth involve the airway, which when compromised, leads to mouth breathing and associated aberrant tongue function. The most common changes include downward and backward rotation of the mandible, deficient nasomaxillary complex, a vertical growth pattern, posterior displacement of the TMJ, narrow maxillary arch, dental malocclusions, and dental crowding. It is imperative that clinicians recognize, diagnose, and begin treatment as early as possible when facial growth deviates from normal. Several specific diagnostic tools, coupled with traditional diagnostic records, assist the clinician in determining the degree and direction of atypical growth. Such a clear-cut diagnostic process sets in motion the treatment plan requirements necessary to accomplish the goal of returning facial growth to normal. Diagnosis and treatment planning requires that each practitioner has a broad base of knowledge, a good power of observation, and insight into the complex subject of facial growth and development*

Key Words: *Facial growth, assessment of facial growth, mouth breathing, tongue function*

In the previous article, we discussed the relationship between the development of dentition and the growing face which in most cases will lead to a functional intercuspation of the posterior teeth even when an atypical growth pattern exists. These dilemmas representing such atypical growth are often the most difficult to diagnose. There are two major factors that generally influence the delicate balance of facial growth: the airway and the manner in which the tongue functions. Diagnosis and treatment planning requires that each practitioner has a broad base of knowledge, a good power of observation, and insight into the complex subject of facial growth and development. Many of the characteristics of atypical growth are often missed by practitioners, thus understanding the precisely controlled biological process of facial growth is essential. Normal facial growth involves ongoing bone remodeling and displacement while atypical growth begins when this biological balance is disturbed. The direct target for clinical intervention must be the control process which regulates the biology of facial growth, which is the influence of the soft tissue and neuromusculature. With this knowledge, clinicians can adequately assess each patient and determine the causes of atypical facial growth patterns. This article will examine the causes of these atypical patterns, describe the assessment of atypical facial growth, and define the optimal and most effective treatment plans to guide each individual patient's growth back towards normal.

The Effect of the Airway on Facial Growth

Human beings are obligate nasal breathers with the mouth functioning as a back-up breathing organ. The nose is the ideal organ for warming, filtration, and humidification of inhaled air. Breathing is a primal function necessary for survival and thus is a reflex function that prevails over all regulatory brain activity. The basis of human evolutionary design is made possible because of nasal breathing. Adaptation of humans to an erect posture required an equilibrium of structure and function which allowed the back and neck to balance the head in the upright posture.[1] When this equilibrium exists, predominate nasal breathing and normal tongue function, the result is normal growth as described in Part I of this series. It is when mouth breathing becomes the predominate mode of breathing that atypical growth patterns emerge.

Mouth breathers may have an obstructed naso-pharyngeal airway, or they may include individuals who have an innate capacity for nose breathing–but, for one reason or another, they breathe mainly through the mouth. The change in breathing method from nasal breathing to mouth breathing frequently leads to malocclusion and atypical facial growth.[2,3]

In such cases, one or more of the following three neuromuscular responses to the change in breathing method will be observed:[2,4,5]

1. Altered mandibular posture: The mandible rotates down and backwards in response to the change from nasal to mouth breathing.
2. Altered tongue posture: The tongue moves inferiorly and anteriorly in response to the change from nasal to mouth breathing.
3. Extended head posture: The mandible is held in position while the cranium and maxilla rotate upward to increase the size of the airway.

Figure 1 -

In a landmark study by Linder-Aronson,[6] 81 children who had severe nasal obstruction and open mouth breathing were compared to an equal number of nasal breathers. The two groups were matched for similar age and sex. The findings of this study demonstrated that children with obstructed nasal breathing were characterized by increased lower face height, increased total facial light, and more retrognathic mandibles compared to the control group. In addition, the sagittal depth of the bony nasopharynx was found to be small in the mouth breathers when compared with the controls. Linder-Aronson also reported that in most cases (88%), the tongue position was also altered forward, and the typical dentition of the mouth breathers demonstrated retroclined incisors in both arches, a narrow maxillary arch, a posterior crossbite, incisor crowding in both arches, and in some individuals, a tendency toward an anterior open bite.

In a follow-up study, Linder-Aronson[7] reported that several children in the mouth breathing group underwent adenoidectomy and had subsequent improvement of the airway. This group of children had changed their mode of breathing from mouth to nose breathing. In a five year longitudinal study, these operated children showed more improvement in the lower anterior face height than the control group. A normalization of the lower face height occuring throughout the total observation period suggested that the neuromuscular changes which accompanied the abnormal mode of breathing were responsible for the large lower face height shown by the mouth open group.

The research of Behlfelt[8] demonstrated that children with enlarged tonsils presented with more retroclined mandibular incisors, shorter mandibular arch length, narrower maxillary arch, a high frequency of posterior crossbite, large overjet, tendency to anterior open bite, more retrognathic mandible, larger mandibular plane angle, and larger lower anterior face height.

In a correlation study by Solow & Siersbaek-Nielsen[9] 24 children age 7-9 years old were followed over 2-4 years before the age of peak velocity in pubertal skeletal growth. These findings demonstrated that large head extension was followed by vertical facial development and a backward displacement of the temporomandibular joint. These children were also noted to have reduced growth in maxillary length, reduced facial prognathism, and less than average true forward rotation of the mandible.

Salow &Tallgen's[10] study found that chronic mouth breathers unconsciously maintain an extended upward rotated head position which improves the oral pharyngeal airway, while at the same time creating an atypical change in facial growth as described above.

A steadily increasing body of evidence[6,11,12,13.14,15,16,17] associates malocclusions characterized by excessive lower anterior face height with chronic mouth breathing. A broken lip seal requires different neuromuscular actions for mandibular posturing, and an open jaw swallow similarly requires different neuromuscular combinations thus affecting the delicate but precise biological balance of facial growth. Habitual mouth breathing results in skeletal changes, postural changes, and alterations of normal function. A list of further scientific investigations can be found at the end of this article.

The Effect of Tongue Function on Facial Growth

The swallow is the most complex reflex activity the human nervous system performs, and it is done without conscious effort. The ideal scenario for head balance is nasal breathing, lips sealed, the teeth slightly apart at rest and the tongue positioned with a slight vacuum in the roof of the mouth. With each swallow, the teeth are brought into maximum occlusion (intercuspation) by the masticatory muscles, the lips continue to be sealed, and the tongue pushes the bolus of food posteriorly against the palate. At the end of the swallow, the tongue returns to its resting position with tongue again positioned with a slight vacuum in the roof of the mouth. A normal swallow provides maximum bracing for the head on the spinal column. Ideally, the tongue is in contact with the roof of the mouth at rest during subconscious swallowing and during nasal breathing. During the swallowing process, the tongue exerts an outward and forward force which is compensated for by the inward force of the cheeks and lips. When the tongue is positioned in the roof of the mouth, it functions ideally and produces healthy palatal and dental development.[18]

Unfortunately only 50% of children retain this normal swallowing pattern by age 6.[19] The remaining children develop a variation of an aberrant swallow pattern where there is no occlusal contact. Additionally, the tongue posture at rest is typically positioned lower and between the teeth, and this abnormal tongue position is repeatedly seen in mouth breathers and those whose neuromuscular patterns seem to be predisposed against keeping their tongues within the confines of the arches.

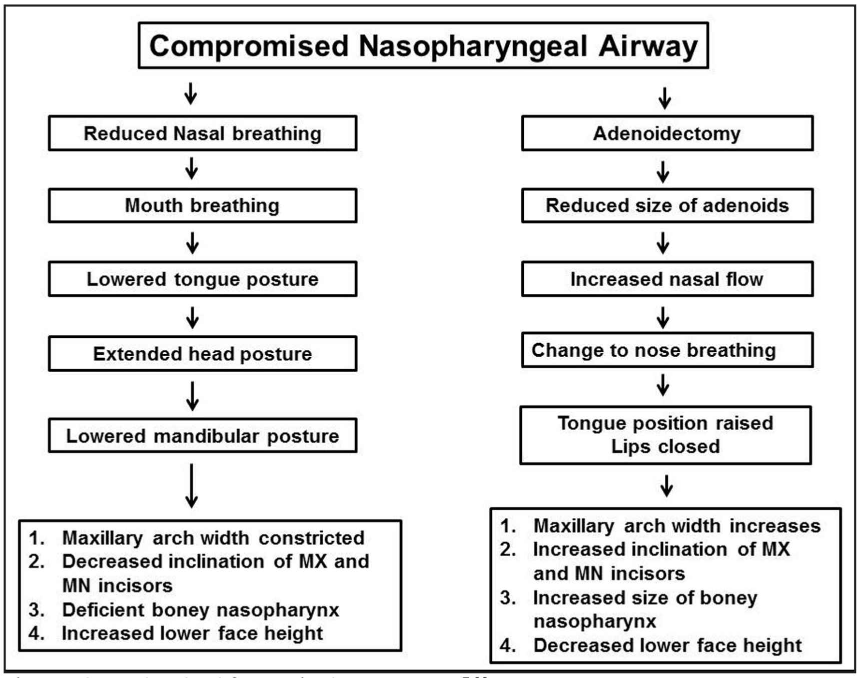

Figure 2 - Adapted from Linder-Aronson[7,33]

It is well known that constriction of the oral pharyngeal space may be caused by grossly enlarged tonsils or adenoids which may lead to a forward placement of the tongue and an inferior displacement of the hyoid bone. Even though these changes may be reversed after a tonsillectomy or adenoidectomy, re-initiation of a normal swallow may not necessarily follow. In such cases, the child's swallow pattern must be re-trained to produce a normal swallow. Lowe[20] found a high correlation between the activity of the genioglossal muscle and development of an overbite suggesting that the postural activity of the tongue exerts a definite influence on incisor position. Takahashi et al[21] found that the hyoid bone position produced by changing the mode of breathing and body position appears to play a critical role in determining tongue pressure which affects growth patterns.

Summary of Facial Growth Changes Affected by the Airway and Tongue Function

Current research[2,3,5,6,8,14,17,22,23,25,26,27,28] indicates that the change of mode of breathing from nasal to mouth breathing is the main causative factor of aberrant growth and aberrant tongue function. Each may be identified separately; however, it is the combination of the two that most significantly causes atypical facial growth patterns in children. It is the soft tissue response, i.e., the neuromusculature changes initiated when function deviates from normal that alters facial growth.[28] The most common changes are:[1,2,4,5,6,7.8,11,14,22,30,25,32]

1. Mid-face deficiency (vertical naso-maxillary growth)
2. Vertical growth pattern of the mandible
3. Narrowing of the maxillary arch
4. Posterior displacement of the TMJ
5. Forward or rotated head posture
6. Dental malocclusions
7. Dental crowding

The Importance of Normal Facial Growth and Long-Term Facial Esthetics

Traditional orthodontics suggests that the clinician wait until growth is complete or nearly complete to initiate treatment. In contrast, growth guidance orthodontics utilizes active growth to re-establish normal facial growth, and statistically by:

1. Age four: 60% of facial growth is complete.
2. Age six: 80% of facial growth is complete.
3. Age 11 (or when the second molars have erupted): 90% of facial growth is completed.[18]

Orthodontic treatment between the ages of 6 and 11 often results in re-establishment of normal facial growth by age of 12. Growth guidance orthodontics elevates "straight teeth orthodontics" to a new level by focusing on breathing, swallowing, and posture problems, as well as producing esthetic faces, beautiful smiles, healthy temporomandibular joints, and long-term stability. Growth guidance orthodontics takes advantage of growth to simplify treatment while achieving physiological and psychological gains for each child as early as possible. It is well known that attractive children and adults tend to have more self-confidence and are initially viewed more favorably by their peers. Good looks and good health are viewed positively in society.

Patient Assessment

In recent years, there has been a major paradigm shift in not only how we plan our treatment but how we see the patient clinically. With the introduction of 3-D radiographic imaging technology, the doctor has effectively been released from two dimensional thinking thus effectively opening up a whole new world for patient assessment and diagnostics. With the advent of a three dimensional analysis, orthodontists have also been afforded the opportunity to better organize treatment algorithms and manage those patients with craniofacial abnormalities.

Understanding Facial Architecture: The Art of Visualization and Seeing the Face in Three Dimensions

It is imperative that clinicians see each patient more as a three dimensional subject instead of numbers, lines, and angles. Identifying each face in terms of geometric and physiological balance--*balanced facial architecture*--and the ability to visualize the progression of normal facial growth assist the clinician in better determining the causative influences of atypical growth. Volumetric imaging allows the clinician the opportunity to clearly see and understand the dynamics of regional and relational change. Whether utilizing 2D or 3D diagnostic imaging, there are some fresh tools and templates that help provide a common sense approach to diagnosing atypical facial growth. Clinicians interested in providing early correction of atypical growth and reducing the effects on subsequent malocclusions benefit greatly by adding a growth evaluation module to their current diagnostic regimen. The growth evaluation requires some additional skills and measurements not usually associated with orthodontic work-ups. The customary growth evaluation module use by the authors is presented as follows:

Facial Growth Evaluation

1. Subjective Tests

Mode of Breathing: The mode of breathing is particularly important since it is the major causative factor in atypical growth. Observing the patient's mode of breathing may seem simple by determining whether or not there is lip seal or open mouth breathing. However, the clinician should also note the function of the nares during lip seal breathing. By asking the patient to perform nasal (with lips sealed) breathing, the nares will react in one of two ways on inspiration. If the patient is a nasal breather with a patent nasal airway, then the nares will flare on inspiration; however, if the patient is a nasally obstructed mouth breather, the nares will constrict. Since many patients are mouth breathers without being nasally obstructed, there is another subjective test which assists the clinician in determining whether or not the propensity for mouth breathing exists. Under direct supervision, a strip of two inch wide hypoallergenic surgical paper tape is placed over the patient's closed lips. While quietly talking while the patient listens for approximately five minutes, the patient is observed to determine if there is difficulty breathing with this oral obstruction. If this is the case, it is most likely that the patient is predominately a mouth breather. If careful examination of the mouth demonstrates generalized chapping of the lips with gingivitis, again it is probable that the patient again favors mouth breathing.

Swallow Patterns: Examining the patient's swallow pattern may also reveal a tendency towards atypical facial growth. Clinical observations should include asking the patient to swallow and watch for para-functional activity, i.e., excessive constriction of the mentalis, obicularis oris, and buccinators muscles. By asking the patient to count aloud up to six, the clinician may also assess tongue activity and establish the resting lip posture. In normal swallow patterns, the lips touch briefly as each number is pronounced. With abnormal swallow patterns, the lips do not touch between the pronunciations, and the tongue is often positioned between the teeth when making the "s" sound. Gently placing two fingers on the submandibular muscles under the chin and asking the patient to swallow is also an excellent indicator of an improper swallow. If the fingers are pushed downward during the swallow, then the swallow is aberrant; if the fingers are not dislodged, then a normal swallow has ensued. Subsequent oral examination may also reveal a dental open bite and/or scalloping of the tongue both indicative of a dysfunctional swallow.
Mouth breathing and an aberrant swallow pattern are often part of the wider concept called the adenoid face,

Figure 3

the characteristics of which are a long narrow face, a large anterior lower face height, a steeply sloping lower border of the mandible, inactive lips lacking tonicity, a short upper lip, an open mouth, maxillary incisors continually visible, and a low degree of facial animation.

Clinical Assessment of Facial Growth: Although measurements of the bony structures of the face may be very precise, especially with CBCT technology, it is rather difficult to precisely measure the soft tissue of the face. Fortunately the human eye has the ability to discern changes in facial soft tissue to within 1-2 mm.[39] By utilizing the following clinical assessments, the clinician can make an initial determination of the degree of atypical facial growth which can be verified later with traditional orthodontic records. When atypical growth of the naso-maxillary complex occurs in a downward direction (mid-face deficiency), several clinical signs are observed. The first step is to exam the position and shape of the eyes. The lateral canthes of the eyes tend to droop inferiorly indicating lack of development of the lateral orbit, and the sclera under the pupil shows more than that above the pupil. The eyes themselves may also be protrusive (see Figure 3).

The cheek line[39] is another key indicator. This line extends from the center of the lower eye lid sagittally down the cheek at a tangent to the soft tissue. Ideally it should be parallel to the bridge of the nose; but if mid-face deficiency is present, the angle between them may be as high as thirty degrees.

The Mew indicator line[40] is often used to determine the severity of the mid-face deficiency and vertical growth. The Mew indicator line represents the distance between the tip of the nose and the upper (left) central incisor. The tip of the nose is assessed as the furthest point from the tragus of the ear. This gives an indication of the position of the maxilla and warns if there is excessive vertical growth.

The Mew indicator line[41] will estimate the direction of growth and the approximate amount of mid-face deficiency. The line is measured from the point previously indicated at the tip of the nose to the incisal edge of the maxillary left central incisor. Ideally it should be 28 mm at the age of five and increase 1 mm each year until puberty when it should be 38 mm for an average sized boy and 36 for an average sized girl (as a quick guide add 23 to their age for a boy and 21 for a girl). Since the nose drops less than the maxilla, the value of the Mew indicator line represents about half of the total increase in vertical growth.[41] That is to say, if the ideal value for the indicator

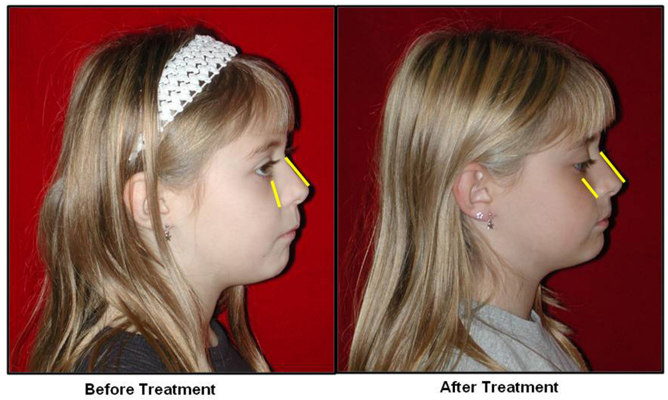

Figure 4

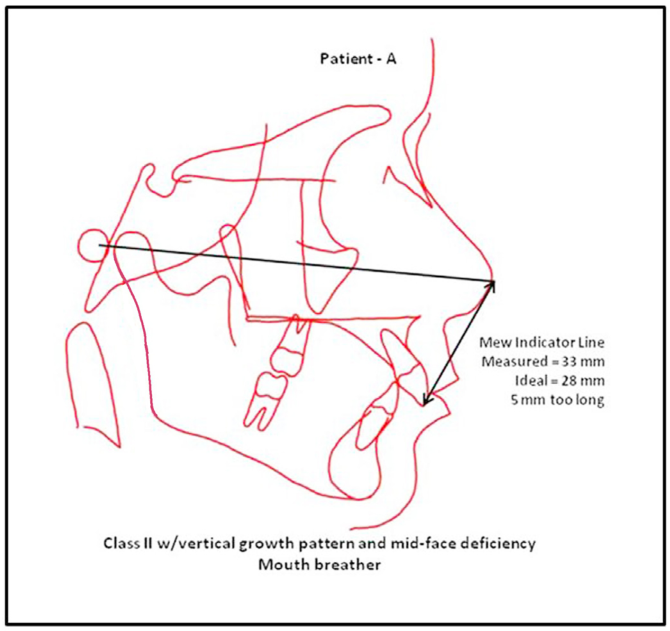

Figure 5

Mew Indicator Line Clinical Measurement Recording Sheet

Patient Age	Ideal Measurement	Actual Measurement	Difference	Correction Needed Sagittal	Correction Needed Vertical
5	28				
6	29				
7	30				
8	31				
9	32				
10	33				
11	34				
12	35				
13	36				
14	37				
15	38				

All measurements recorded in mm.

Figure 6

line for a seven year- old was 30 mm, and the actual measurement was 36 mm, the difference would be 6 mm. The interpretation would be that the patient exhibits a vertical growth pattern of 12 mm above normal and a mid-face deficiency of 6 mm. The table in Figure 6 is a practical way to record clinical measurements.

Relating the maxilla to the cranial base is one of the most difficult values to determine accurately. The authors have found that the Mew indicator line is perhaps the most reliable method of determining if the maxilla is in a retruded, normal, or protrusive position and to what degree vertical growth has been affected. Many clinicians use Bimler Factor 1 or the Sassouni maxillary and vertical arcs to approximate the sagittal and vertical position of the maxilla; however, the authors have clinically found a substantial variance in accuracy.

The ratio of upper face height to lower face height is also an indicator of atypical growth. The ideal ratio

Before Treatment After Treatment

Figure 7

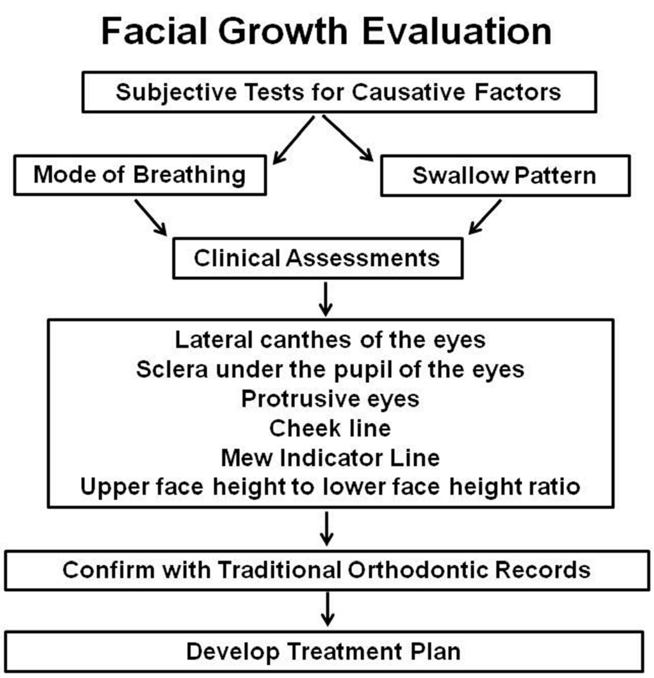

Figure 8

for children and adults should be 1:1. When the lower face height increases past this esthetic value, a vertical growth tendency exists, and the clinician should check for causative factors.

Early assessment as described allows the clinician to ascertain atypical facial growth patterns and determine the causative factors. Airway problems in children are directly linked to a wide range of health problems including ADHD (attention deficit disorder), asthma, OSA (obstructive sleep apnea), bedwetting, recurrent middle ear infections, and other substantial issues. It is prudent for the clinician to formulate well-defined treatment plans which will guide the atypical facial growth patterns back to normal, eliminate the causative factors, and ensure a stable balance of the stomatognathic system. Using this approach, predominate malocclusions encountered are reduced to minimal correction (if any corrections are needed at all).

When formulating treatment plans addressing atypical facial growth, several solutions should be considered. In order to guide facial growth back to normal, one must ask the following questions:

1. Can the causative factors (airway, swallow patterns, and neuromusculature imbalance) be resolved? As described previously, converting the mode of breathing from oral to nasal may involve eliminating obstructions in the nasal pharyngeal airway and/or retraining and reinstating nasal breathing. Swallow patterns would have to be retrained and a well-defined lip seal created.

2. What correction is necessary based on the diagnostic results? The most common anomalies include: vertical growth pattern, mid-face deficiency, retruded mandible, narrow maxilla, dental crowding, and posteriorly positioned TMJ. The diagnostic values apprise the clinician of the amount and direction of growth change that is necessary. An example would be a patient with the Mew indicator line that measured 4 mm too long. This would suggest a maxillary vertical excess of 4 mm and a maxillary sagittal deficiency of 8 mm.

3. Will the treatment initiate the growth changes necessary in a relatively short period of time? Patient compliance decreases with time and the patient's age; therefore, the clinician should focus on the best formula for success, which would involve determining the appliance that best addresses necessary growth changes while controlling the time in treatment.

4. Will the child be compliant during treatment? Patient compliance is essential in obtaining a favorable outcome. In cases where the compliance factor is marginal, the clinician may want to choose a fixed appliance which limits the need for patient compliance.

5. Will the treatment be stable and how much relapse will occur? When guiding growth back to normal,

stability depends on the elimination of the causative factors, re-training problematic habits, and a method of securing the results until growth is complete.

6. What growth changes have occurred in the mandible, nasomaxillary complex, facial proportions, and maxillary and mandibular arches? From the diagnostic records, the clinician can readily determine the amount of change that has occurred. Each treatment plan involves addressing these anomalies in such a way that collectively they will be affected by treatment modalities which will result in normal growth patterns.

With an understanding of facial growth and the anomalies encountered as a result of atypical growth, the appliances necessary must incorporate several functions to be effective. The appliances should accomplish several objectives including:

1. Sagittal, transverse, and vertical correction of the nasomaxillary complex by stimulating the remodeling process. Such stimulation creates a 3-dimensional change in the size of the maxilla and creates a positive effect on the displacement process of the nasomaxillary complex to a more normal position.

2. Reducing excessive vertical growth or lower face height is ideally accomplished through the process of remodeling of the ramus. With proper neuromuscular function is achieved, the soft tissue signals create an environment where the ramus uprights through remodeling. This process described in Part 1 of this series increases the mandibular arch length, closes the gonial angle, and reduces the lower face height. Coupled with nasal breathing, a competent lip seal, and improved swallow pattern, this reversal of vertical growth shortens the face and advances the mandible from its retruded position.

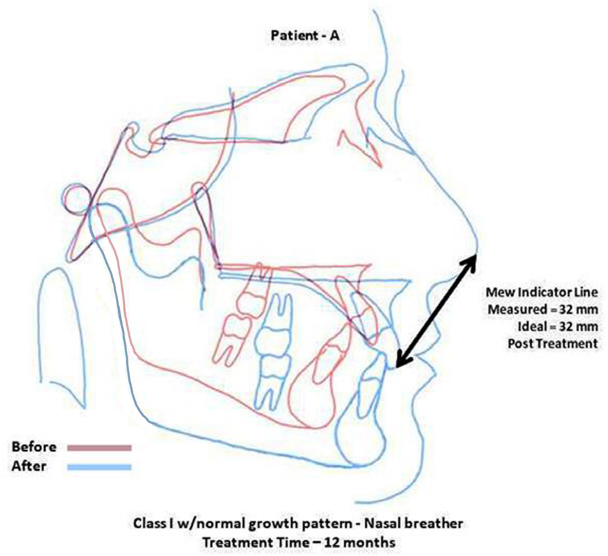

Figure 9

3. Posteriorly displaced TMJs in conjunction with ramus uprighting when unlocked further advance the mandible and establish an ideal functional relationship in the mandibular fossa.

4. With the return to nasal breathing, the facial bones are stimulated to return to normal by the muscles of mastication, thus setting off a plethora of facial growth changes.

5. Retraining swallow patterns to normal function moves the tongue to a more ideal position which again stimulates growth changes in the nasomaxillary complex and the mandible.

6. Increases in arch length and width create more room for the dentition to uncrowd allowing the normal function of the stomatognathic system to align the teeth naturally.

7. A stable occlusion should be created to maintain the equilibrium established as facial growth returns to normal.

Treatment Planning

Treatment planning for growth guidance orthodontics should take into account the clinician's comprehensive diagnostics plus the facial growth assessment discussed previously.[3,5,28,33] Developing a sound strategy for treatment should begin by assessing the severity of the skeletal discrepancy and relate it with the age of the patient and the amount of growth potential remaining. The more vertical the growth, the younger treatment should begin; however, mild cases can be treated in older children. Many times these less severe cases provide excellent facial improvements and stability.[42,43,44] The ideal treatment timing should include patients in the age range of 5-10 years of age. The treatment design should begin by sagittally enlarging the maxillary arch to reduce the maxillary indicator line as close to ideal as possible, thus creating an ideal environment for the tongue to function normally.[44,45] At the same time (assuming the nasal airway is patent), the patient begins retraining the mode of breathing back to nasal breathing with a competent lip seal, and swallow patterns are retrained to a normal function with the tongue resting on the palate. When estimating the amount of arch development, a good rule of thumb is to create more space than necessary. With this in mind, the normalized function of the stomatognathic system will readily align the teeth. Keep in mind that the ever-changing dynamics of facial growth will balance any discrepancies created by appliance therapy as long as the causative factors of aberrant growth are normalized.[33,45,46,47]

Summary

It has been well-documented that the most common factors associated with atypical facial growth involve

Figure 10

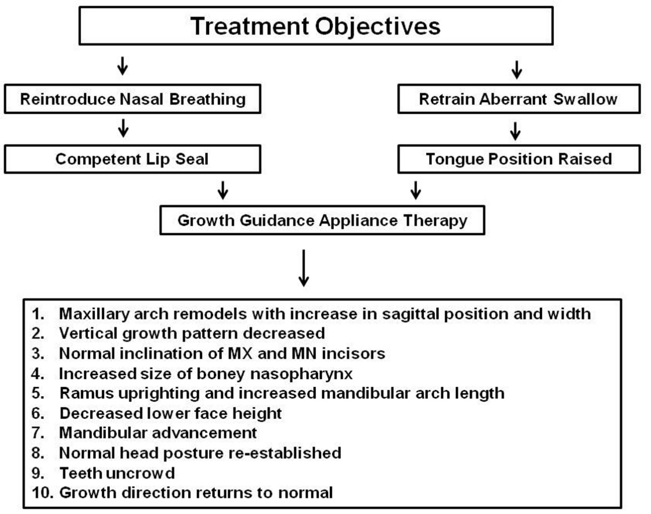

Figure 11

the airway, which when compromised, leads to mouth breathing and associated aberrant tongue function. The most common changes include downward and backward rotation of the mandible, deficient nasomaxillary complex, a vertical growth pattern, posterior displacement of the TMJ, narrow maxillary arch, dental malocclusions, and dental crowding. By the time the second molars erupt, approximately 90% of facial growth is complete. It is imperative that clinicians recognize, diagnose, and begin treatment as early as possible when facial growth deviates from normal. Several specific diagnostic tools, coupled with traditional diagnostic records, assist the clinician in determining the degree and direction of atypical growth. Such a clear-cut diagnostic process sets in motion the treatment plan requirements necessary to accomplish the goal of returning facial growth to normal.

Once the requirements are defined, the clinician must determine the best growth guidance appliance. The authors have designed several appliances to accomplish these optimal results. Each appliance accomplishes specific changes to the signals that guide facial growth for each patient. Treatment with these appliances is readily accomplished in 6-12 months. These growth guidance appliances target those specific areas of atypical growth and function and induce the growth process to be modified and returned to a normal growth sequence. These appliances and their uses will be discussed in Part 3 of this series.

Scientific Investigations

The following list of selected investigations has confirmed associations with malocclusions characterized by increased lower anterior face height:

Genetic predispositions[34]
Enlarged tonsils[8] and/or adenoids[6,32]
Allergic rhinitis[22]
Sleep apnea[27,30,35]
Deviated nasal septum[3,31]
Choanal atresia[36]
Altered mandibular posture[5,14,32]
Altered tongue posture[14]
Extended head posture[23.,26]
Incorrect orthodontic treatment, i.e., duel bite[37]
Amelogenesis imperfecta[38]
Weakness of the muscles of mastication[2,24,26]
Thumb-sucking[25]
Lip pressure with different modes of breathing[26]

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