Interceptive orthopedics for the correction of maxillary transverse and sagittal deficiency in the early mixed dentition period

ASHOK KUMAR TALAPANENI, KARNATI PRAVEEN KUMAR, PRADEEP BABU KOMMI, SIVAKUMAR NUVVULA

Abstract

Dentofacial Orthopedics directed to a hypoplastic maxilla in the prepubertal period redirects growth of the maxilla in the vertical, transverse and sagittal planes of space. The orthopedic correction of maxillary hypoplasia in the early mixed dentition period thus intercepts the establishment of permanent structural asymmetry in the mandible and helps in the achievement of optimal dentofacial esthetics. This paper presents the growth redirection in a hypoplastic maxilla of an 8-year-old girl with simultaneous rapid maxillary expansion and protraction headgear therapy for a period of 11 months which corrected the posterior unilateral cross-bite, the positional asymmetry of the mandible and established an orthognathic profile in the individual.

Keywords: Face mask appliance, mandibular structural asymmetry, posterior unilateral cross-bite, rapid maxillary expansion

Introduction

Maxillary hypoplasia is a condition characterized by transverse, sagittal and vertical maxillary deficiency. Although most class III patients have excess mandibular development, nearly 30–40% have some degree of maxillary deficiency, which is enough to make it a significant etiological factor in skeletal class III malocclusion.[1-4] The main focus of concern in class III patients is the correction of concave facial profile, retrusive nasomaxillary area, a protrusive lower lip since this helps in achieving harmonious soft tissue profile, thus improving facial attractiveness. Therapeutic regimens designed to improve the facial morphology in class III skeletal malocclusion during the growth period include functional approaches,[5] chin-cup therapy[6] and reverse headgear or face mask therapy.[7] Palatal expansion along with face mask therapy has been advocated as the routine part of class III correction in patients with sagittal and transverse maxillary deficiency. The benefits of the palatal expansion include the expansion of the narrow maxilla, correction of the posterior cross-bite, increase in the arch length, loosening of the circum-maxillary suture and downward, forward movement of the maxillary complex.

Various authors like Bacetti et al. advocated the early treatment of developing class III malocclusion in children since the younger age group shows significant advancement of maxillary structure and upward, forward redirection of the condylar growth after the treatment.[8] Posterior unilateral cross-bite (PUXB) in class III skeletal malocclusion with transverse and sagittal maxillary hypoplasia is seen in the deciduous and mixed dentition period, with a prevalence between 7% and 23%, and is characterized by the buccal cups of the maxillary teeth occluding lingually to the buccal cusps of the corresponding mandibular teeth.[9] Lateral mandibular shift occurs toward the cross-bite side in patients with bilaterally constricted maxilla to facilitate better occlusal relationship, and thus results in the development of the PUXB. Lateral mandibular shift in children can cause a change in the pattern and intensity of the functional forces applied to the mandible and the temporomandibular joint (TMJ).[10,11] This positional asymmetry of the mandible associated with PUXB is expected to have immediate morphological consequences in the form of structural mandibular asymmetry. The structural mandibular asymmetry is characterized by a dominance of the non–cross-bite side and volumetric reduction of the cross-bite side of the mandible.[12] In children with PUXB, it was demonstrated that the condyles on the cross-bite side were positioned relatively more superiorly and posteriorly in the glenoid fossa than those on the non–cross-bite side.[13] Skeletal remodeling of the TMJ can occur over time so that the condyles are positioned more symmetrically in their fossae. Subsequent adaptation of the neuromusculature to the acquired mandibular position can cause asymmetric mandibular growth, facial disharmony and severe skeletal cross-bite in the permanent distortion.[14,15] Ingerval et al. reported asymmetric postural muscle activity in children
with PUXB, with the anterior temporalis muscle activity strongest on the normal occlusion side and the posterior temporal muscle activity strongest on the cross-bite side.\textsuperscript{[16]}

Early intervention of the transverse and sagittal maxillary hypoplasia with PUXB through maxillary expansion resolves the transverse and sagittal maxillary deficiency, allowing the mandible to regain the normal centric relation–intercuspal relationship, creating optimal condition for the normal growth of the craniofacial skeleton and function of the stomatognathic system.\textsuperscript{[17,18]}

### Case Report

An 8-year-old female child presented with class III malocclusion. The parents and the child were concerned that her lower jaw was shifting to the right side upon closure of the jaws. The patient was fit and well, with no relevant medical history. There was a family history of class III skeletal base relationship.

#### Extraoral assessment

The patient had a class III sagittal skeletal relationship with a mild degree of mid-face retrusion. The patient’s vertical skeletal proportions were normal and there was a marked facial asymmetry in the lower face with a dominance of the symphysis to the right side. Her lips were competent at rest and her incisal show was reduced at maximum smile. The naso-labial angle was obtuse [Figure 1a, b]. Clinical assessment of the TMJs was unremarkable.

#### Intraoral assessment

The patient demonstrated good oral hygiene. She had a class III molar relationship on the left side and end-on molar relationship on the right side. The canines were in class I relationship on the right side and had a tendency to class III relationship on the left side. The incisors were in an edge-to-edge relationship. The patient had unilateral cross-bite affecting all the erupted teeth on the right quadrant of the maxillary arch. She presented with latero-occlusion, with the skeletal midlines of the mandibular and maxillary apical bases coincident with each other and with the facial midline in the open mouth posture. Upon the closure of the jaws into maximum intercuspation, there was an initial contact between upper and lower left central and lateral incisors from which the patient displaced the lower jaw forward and laterally into maximum intercuspation [Figure 2a–c].

The lower arch form was normal and the maxillary arch form was asymmetrical, with rotations seen with respect to the right maxillary central and lateral incisors [Figure 3].

#### Radiographic assessment

Pre-treatment panoramic radiograph shows the cuspal tip of right permanent canine located in Lindauers\textsuperscript{[19]} sector IV, predicting the possibility of its imminent impaction [Figure 4].

Pre-treatment lateral cephalogram and postero-anterior (PA) cephalogram were used to analyze the sagittal and transverse relationship between the jaws and of the jaws to the cranial base.

Thirteen cephalometric variables [Table 1] were used to assess the antero-posterior skeletal discrepancy in the craniofacial skeleton. The Eastman\textsuperscript{[20]} (ANB = 0°), Wits appraisal\textsuperscript{[21]} (−2 mm) and beta angle\textsuperscript{[22]} (37°) suggested a
mild class III sagittal relationship. The position of Nasion-perpendicular to point A (−2 mm) and Nasion-perpendicular to point B (−4 mm), reduced effective maxillary length (83 mm), and normal effective mandibular length (110 mm) implicated a mild deficiency of the maxilla in the etiology as well as the diagnosis of a class III skeletal base. The upper lip was retrusive (−2 mm) to the S-Line and the nasio-labial angle was obtuse (110°)[23] [Figure 5].

The Grummon’s[24] mandibular morphology analysis on PA cephalogram showed an increase in the surface area of the left-side triangle as compared to the right-side triangle, indicating a dominance in size on the left-side corpus than on the right-side corpus of the mandible. Svanholt and Solow[25] analysis indicated the mandibular skeletal midline deviated 4 mm to the right side to the mid-sagittal plane as well as to the maxillary skeletal midline [Figure 6].

Aims of the treatment
1. To encourage the transverse and sagittal maxillary development thorough growth modification.
2. Establishment of positive overjet and overbite.
3. Correction of mandibular lateral functional shift and PUXB.
4. Interception of the establishment of permanent mandibular structural asymmetry.

Treatment plan and rationale
The patient presented with the mild sagittal and transverse maxillary hypoplasia, with normal vertical skeletal dimensions. Protraction headgear along with the rapid maxillary expansion (RME) appliance was utilized to encourage the sagittal and transverse development of the mid-face. A bonded RME appliance was designed which incorporated two hooks buccal to the premolars to facilitate protraction face mask

| Variable | Mean ± SD | Pre-treatment | Post-treatment | Change |
|----------|-----------|---------------|----------------|--------|
| ANB      | 0°–2°     | 0°            | 3°             | 3°     |
| Wits appraisal | 0–2 mm | −2 mm | +2 mm | 4 mm |
| Beta angle | 27°–35° | 37° | 32° | 9° |
| SNA      | 82° ± 2°  | 79°           | 82°            | 3°     |
| N-perpendicular to point A | 0–2 mm | −2 mm | +2 mm | 4 mm |
| Effective maxillary length | 85 ± 3 mm | 83 mm | 85 mm | 2 mm |
| SNB      | 80° ± 2°  | 79°           | 79°            | 0°     |
| N-perpendicular to point B | 0 to −4 mm | −4 mm | −5 mm | −1 mm |
| Effective mandibular length | 106 ± 3.5 mm | 110 mm | 110 mm | 0 mm |
| Sn-Go-Gn | 32°       | 30°           | 33°            | 3°     |
| FMA      | 25°       | 21°           | 25°            | 4°     |
| ANS-Gn   | 60 ± 3 mm | 60 mm         | 64 mm          | 4 mm   |
| Upper lip prominence to S-line | 0 | -2 mm | +2 mm | 4 mm |
Figure 6: Pre-treatment postero-anterior cephalometric tracing

Figure 7: (a, b) Rapid maxillary expansion and face mask appliance

Figure 8: (a–c) Intraoral post-treatment anterior, right lateral and left lateral

Figure 9: Post-treatment maxillary occlusal view

Figure 10: (a-b) Extraoral post-treatment frontal and profile photographs

Figure 11: Superimposition of pre- and post-treatment lateral cephalometric tracings

Figure 12: Post-treatment postero-anterior cephalometric tracing

Figure 13: Post-treatment pan-oral radiograph
appliance [Figure 7a, b]. The RME appliance was cemented and the patient instructed to turn the midline screw twice daily (0.5 mm). This activation of the screw was done for a period of 25 days to achieve an expansion of 12.5 mm. Over-correction of the transverse dimension was planned in order to accommodate and limit post-treatment relapse. Protraction headgear was fitted a week later after the cementation of RME and the patient was advised to wear the appliance for 12–14 hours each day. The applied force measured was 350 g on each side. A positive overjet and overbite were established after a period of 6 months. A sectional pre-adjusted edgewise appliance was bonded to the maxillary central and lateral incisors to correct the rotations and resolve the crowding in the maxillary labial segment, utilizing the space gained after the expansion of the maxillary skeletal base. The protraction headgear was continued for a period of 8 months after which the RME appliance was removed and a Hawley’s appliance was placed to hold on and retain the achieved expansion.

Results

Intraoral examination in the post-treatment aspect showed an expansion of the maxillary palatal vault, correction of the PUXB, establishment of the positive overjet and overbite and decrowding of the upper anterior teeth [Figures 8a–c and 9]. Profile of the patient showed a good improvement with a forward movement of the upper lip and a decrease in the naso-labial angle. However, the patient retained a mild degree of facial asymmetry [Figure 10a, b]. The post-treatment analysis of the lateral cephalogram and the PA cephalogram revealed favorable skeletal changes in the transverse and sagittal dimensions.

The sagittal inter-maxillary relationship improved as indicated by an ANB angle (3°), Wits appraisal (+2 mm), and beta angle (32°).

The maxillary skeletal base was advanced by 1.5 mm and the mandibular apical base retained its pre-treatment position as well as effective length. The mid-facial soft tissue prominence increased, with the upper lip positioned by 2 mm anterior to the S-line [Figure 11].

Svanholt and Solow analysis on the PA cephalogram shows the coincidence of the mandibular skeletal midline to the mid-sagittal plane of the face, reflecting the correction of positional asymmetry of the mandible. The symmetry of right- and left-sided triangles on the mandibular body, as evaluated by Grummon’s mandibular morphology analysis, elucidates the reduction of structural asymmetry of the mandible immediately following the resolution of mandibular functional shift [Figure 12].

Discussion

The positive change in the sagittal skeletal as well as soft tissue relationship can be attributed to the increased vertical skeletal dimensions as reflected by SN-Go-Gn (+3°), FMA (+4°), and lower facial height [ANS-Gn (+4 mm)]. Maxillary expansion and protraction causes downward and forward movement of the maxilla. This vector of movement in the maxilla along with the buccally moving palatal cusp tips of the maxillary buccal teeth cause clockwise rotation of the mandible, increase in the lower anterior facial height and reduction of the symphyseal prominence in the sagittal plane of space.

Schmidt et al. indicated the correction of maxillary deficiency in the transverse dimension eliminates mandibular functional shift and positions the mandible with a coincidence of centric relation and centric occlusion. Subsequent adaptation of the neuromusculature to the new and corrected mandibular position promotes an optimal growth of the underlying skeletal units, and thus leads to correction of structural asymmetry of the mandible.

The existence of pre-treatment molar, canine relationship and mild-facial asymmetry even after the elimination of lateral functional shift could be attributed to the structural adaptation of mandibular alveolus and its overlying dentition. Schmidt et al., in their previous study, stated that a combination of displacement asymmetry and structural asymmetry is the most frequent presentation in growing patients with PUXB. Patient requires an early extraction of right deciduous canine as a preventive measure with the hope that the permanent canine resolves its unfavorable position [Figure 13]. If the canine impaction is imminent, a 2 x 4 orthodontic appliance could be used for the correction of impacted canine, leveling and alignment of upper anteriors and establishment of ideal archform.

Conclusion

Transverse and sagittal mid-facial deficiency is a significant etiological factor behind the development of class III concave profiles and structural mandibular asymmetries. Early orthopedic interception of a deficient maxilla re-establishes an optimal growth in the sagittal and transverse dimensions, thus facilitating the correction of class III mid-facial deficiency and the elimination of permanent mandibular structural asymmetry.

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