J. Maxillofac. Oral Surg. (Oct–Dec 2021) 20(4):680–688
https://doi.org/10.1007/s12663-020-01404-0

ORIGINAL ARTICLE

Cephalometric Analysis of Hard and Soft Tissue Changes Following Anterior Maxillary Osteotomy Distraction in Cleft Maxillary Hypoplasia

Adarsh Lingeshbabu Pawar[1] · Jayanth Basavapattana Shivasubramanya[2] · Shanavas Kolothu Parambil[3] · Anand Shivamoga Raju[4] · Abhitosh Debata[5]

Received: 29 November 2019 / Accepted: 1 July 2020 / Published online: 1 September 2020

Abstract

Background Nonsyndromic unilateral CLAP patients despite the best surgical efforts present with variable degree of maxillary hypoplasia after cleft palate repair. AMOD is an extension of anterior maxillary osteotomy where the resulting segment anterior to the chosen site of vertical corticotomy cut is distracted with the help of hyrax screw through a tooth-borne appliance.

Aims and Objectives To analyze the hard and soft tissue profile changes following AMOD. To determine the ratio of soft tissue changes to the given extent of hard tissue movements.

Materials and Methods Study group consisted of 25 patients with cleft maxillary hypoplasia reporting to the Department of OMFS, Coorg Institute of Dental Science. The preoperative and postoperative radiographs were taken followed by prediction tracing. In comparison of pre-op and post-op ceph mean improvement in hard tissue profile was seen at N-A by 2.84 mm, N-A-Pg by 2.52, ANS-Gn by 2.28 mm, N-ANS by 0.68 mm, 1-Nf by 0.32 and at PNS-ANS was 4.2 mm signifying improvement in middle third of face. Mean improvement in soft tissue profile at G-Sn-Pg angle by 1.2, G-Sn was 3.92 mm, nasolabial angle by 10.92, incisor exposure (Stm-1) by 0.24 mm and interlabial gap by 0.56 mm. On ratio and correlation of soft tissue changes to given extent of hard tissue change, with movement of point A and U1 resulted significant changes in Sn and Ls. Movement of ANS resulted in significant changes in pronasale and columella.

Conclusions In our study significant improvement was seen in hard and soft tissue facial profile. In conclusion, AMOD is one of the emerging techniques to correct cleft maxillary hypoplasia which will have a defined definitive role to play in future.

Keywords AMOD · Cleft maxillary hypoplasia · Unilateral CLAP

✉ Adarsh Lingeshbabu Pawar
adarshlpawar@gmail.com

Jayanth Basavapattana Shivasubramanya
jayanth2g@gmail.com; jayanth.b.s@spaltkinder.org

Shanavas Kolothu Parambil
drshankp1@gmail.com

Anand Shivamoga Raju
dranandsrpcd@gmail.com

Abhitosh Debata
abhitosh.debata@gmail.com

[1] Department of Oral and Maxillofacial Surgery, Sri Hasanamba Dental College and Hospital, Vidyanagar, Hassan 573201, India

[2] ABMSS/DCKH Cleft Centre, Indi, India

[3] Kannur, India

[4] Department of Public Health Dentistry, Coorg Institute of Dental Science, Virajpet, Coorg, Karnataka 571218, India

[5] Hitech Dental College, Bhubaneshwar, Odissa 0674, India

Nonsyndromic orofacial clefts, which include cleft lip, cleft lip and palate, and palate alone, comprise a range of disorders affecting the lips and oral cavity. Clefts of lip and palate are among the most common congenital abnormalities with a reported incidence of b/w 3.7/1000 and 0.4/1000 live birth [1].

Cleft lip and palate pose significant lifelong communicative and aesthetic challenges along with difficulties in deglutition. The growth retardation is seen in all three dimensions, anterior–posterior, transverse and vertical directions. Although surgical protocols and results have

greatly improved in past decades, some patients with cleft lip and palate still present with severe maxillary hypoplasia.

Only 25% of unilateral CLAP adolescents had near-normal maxillary growth. The other 50% were in a borderline category with some degree of maxillary hypoplasia and 25% of adolescents with unilateral CLAP require orthognathic surgery to achieve even the limited objective of an acceptable occlusion [2].

Conventionally it was corrected by orthognathic surgery (advancement LeFort I osteotomy) The surgical difficulty in advancement Le Fort osteotomy includes intraoperative hemorrhage, palate exposure leading to sinusitis, scarring from cleft lip palate repair, the less predictable vascular supply, the extend of advancement, the fixation of transposed segments, negative effect on velopharyngeal closure, the requirement for a bone graft, high risk of bone necrosis and higher post-surgical relapse rates ranging up to 50%. Donor site morbidities, resorption, and infection can occur and potentiate a relapse [3–6]. Moreover, conventional surgery is not recommended in growing patients due to the tooth buds and the need for tremendous mobilization. Hence, in such situations anterior maxillary osteotomy distraction may be the procedure of choice [7].

Distraction osteogenesis (DO) is a technique of generating new bone by stretching the callus. This concept of bone lengthening was first described by Codivilla [8].

In distraction osteogenesis, the surrounding mucosal and muscular tissue may have a better chance to adapt to the skeletal changes through slow progressive movement rather than an immediate transposition of the cleft maxilla with advancement Le Fort osteotomy. Thus, DO has advanced the field of maxillofacial surgery because of its versatility, simplicity, and possibility of avoiding bone grafts, infections, blood transfusions, or intermaxillary fixation for long periods. A glance into literature reveals several cephalometric studies on postoperative soft tissue and hard tissue changes in CLAP cases treated by orthognathic surgery. But only a few reports regarding soft tissue and hard tissue changes in distraction osteogenesis of CLAP patients were published and none in the Indian population. Hence, this study was designed to compare cephalometric changes in hard and soft tissue in cleft lip and palate patients in the Indian population.

Aims and Objectives

Aim of the Study

To evaluate and determine the hard and soft tissue profile changes following Anterior Maxillary Osteotomy Distraction in unilateral cleft maxillary hypoplasia.

Objectives of the Study

- To analyze the hard and soft tissue profile changes following Anterior Maxillary Osteotomy Distraction in unilateral cleft maxillary hypoplasia.
- To determine the ratio of soft tissue changes to the given extent of hard tissue movements.

Materials and Method

1. Source of data

(a) Patient selection

Healthy adolescent and adult patients with growth completion between the age group of 16–35 years with moderate to severe maxillary hypoplasia will be taken up for the study.

(b) Inclusion criteria

- Healthy adolescent and adult patients between the age group of 16–35 years
- Subjects with unilateral cleft maxillary hypoplasia.
- Subjects consenting to cephalometric radiography and therefore to study.

(c) Exclusion criteria

- Pregnant individuals
- Individuals with cervical instability.
- Mentally challenged patients.
- Patients with lower limb deformities who cannot stand for lateral cephalogram.
- Growing adolescents.
- Patients having phobias viz. radiophobia, claustrophobia.

Cephalometric Criteria

Optimum quality cephalographs will be taken preoperatively (S1) and postoperatively (S2) using standard cephalometric settings with patients in natural head position in centric occlusion.

The preoperative radiographs (S1) will be taken within 1 week before surgery and postoperative radiographs (S2) will be taken not less than 3 months after surgery to allow for complete reduction in edema and establishment of soft tissue stability before the start of any orthodontic treatment.

A horizontal reference line (*X* horizontal reference line) is constructed at 70 from the SN plane and a vertical

reference line (*Y* vertical reference line) is drawn perpendicular to the horizontal line passing through the nasion.

All linear and angular measurements required for hard and soft tissue COGS analysis pertinent to this study (utilizing standard cephalometric landmarks) will be done by 2 Orthodontist and 2 surgeons and the inter-observer validity test will be done and the average value will be considered to avoid error in landmark identification. Finally, the values obtained will be evaluated with statistical analysis.

Results

A total of 25 healthy patients were enrolled in the study. The study group consisted of 25 patients (7 male and 18 female), age group of 12–26 years (mean age of 19 years) seeking treatment, and who were diagnosed with cleft maxillary hypoplasia.

All patients underwent a thorough workup medically. Impressions were taken; the appliance was fabricated on the obtained study model. All the patients underwent anterior maxillary osteotomy with Distraction carried out after 1 week.

The preoperative radiographs (S1) were taken within 1 week before surgery and postoperative radiographs (S2) were taken before the start of any orthodontic treatment.

The results of the parameters taken up during the study are as follows (Table 1).

In comparison of pre-op and post-op horizontal ceph values, the mean difference of N-A-Pg angle was − 2.52° and significant changes seen with nasion to point A with mean difference of − 2.84 mm signifying forward movement of point A and thereby improvement in facial convexity (Fig. 1, Table 2).

In comparison of pre-op and post-op vertical ceph values, mean difference of N-ANS was − 0.68 mm which signifies a decrease in distance from N-ANS and the mean difference of 1-Nf was + 0.32 which signifies a forward and upward movement of anterior maxilla and significant changes seen with ANS-Gn with mean difference of + 2.28 mm, which signifies improvement in middle third of the face (Fig. 2, Table 3).

In comparison of pre-op to post-op maxilla-mandible ceph values, highly significant changes seen in PNS-ANS with mean difference of 4.2 mm which signifies an increase in length of the maxilla (Fig. 3, Table 4).

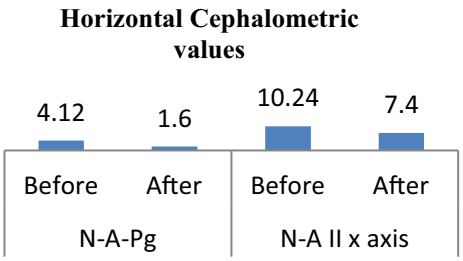


Fig. 1 This graph shows decrease in the N-A-Pg angle from S1 to S2 which signifies an improvement in the facial angle. It show decrease in distance of N-A II *x* axis which signifies a forward movement of point A improving the facial angle

Comparison of pre- and post-treatment facial form values mean difference of G-Sn-Pg′ angle was − 1.2° and significant changes seen with glabella to subnasale with mean difference of − 3.92 mm which signifies an improvement in soft tissue profile (Fig. 4, Table 5).

On soft tissue ceph changes, highly significant changes seen in nasolabial angle (Cm-Sn-Ls) with mean deference of + 10.92°. Improvement was seen in upper lip protrusion (Ls-(Sn-Pg) with a mean difference of 0.44 mm. Improvement was seen in incisor exposure (Stm-1) with a mean difference of − 0.24 and improvement in interlabial gap (Stm-Stmi) with a mean difference of − 0.56 mm (Figs. 5, 6).

Ratio and Correlation of Soft Tissue Changes to the Given Extent of Hard Tissue Movements

To compare the ratio of soft tissue changes to given extent of hard tissue, the hard tissue changes of the landmarks between S1 and S2 were prefixed with a "d," such as dA (change in A point), dU1 (change in upper incisor tip), and the soft tissue changes included dPn (change in pronasale), dSn (change in subnasale), dLs (change in labrale superius) and dStms (change in stomion superius) (Table 6).

On ratio and correlation of soft tissue to hard tissue changes, with movement of point A significant changes were seen in soft tissue point Sn. Changes in upper incisor (U1), significant changes seen in upper lip (Ls).change in point ANS resulted in significant changes in pronasale and columella. With the changes of hard tissue facial convexity angle, significant soft tissue angle changed. Change in N-A resulted in significant change in G-Sn.

Table 1 Comparison of before and after treatment horizontal cephalometric values among study subjects

Horizontal cephalometric values	Before	After	*P*
N-A-Pg	4.12 ± 12.46	1.60 ± 10.50	0.098
N-A II *x* axis	10.24 ± 3.40	7.40 ± 3.51	0.001*

*$P < 0.05$ is Significant

Table 2 Comparison of before and after treatment vertical (skeletal and dental) cephalometric values among study subjects

Vertical cephalometric values	Before	After	*P*
N-ANS (II *y* axis)	47.24 ± 3.68	46.56 ± 4.13	0.147
ANS-Gn (II *y* axis)	59.92 + 5.29	62.20 + 5.81	0.001
1-NF (angle)	106.24 + 12.26	106.56 + 16.39	0.848

NS non-significant, *S* significant

$P < 0.05$

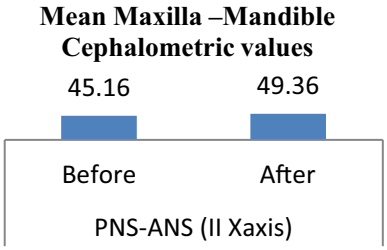


Fig. 2 The graph interprets decrease in N-ANS, an increase in ANS-Gn and increase in 1-NF which signifies improvement in middle third of the face

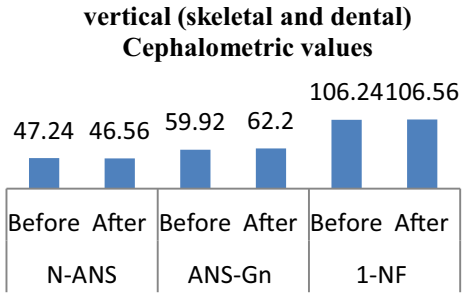


Fig. 3 Graph shows S1 and S2 changes of PNS-ANS which shows an increase in length of the maxilla

Discussion

Distraction osteogenesis (DO) has emerged as an important modality in maxillofacial surgery for the correction of maxillo-mandibular deformities. Polley and co-authors were the first to clinically apply the midface distraction when they used an externally fixed cranial halo to distract the midface [9].

The first reported anterior segmental maxillary osteotomy was performed in 1921 by Cohn-stock.

AMOD is an extension of anterior maxillary osteotomy where the resulting segment anterior to the chosen site of vertical corticotomy cut is distracted with the help of hyrax screw through a tooth-borne appliance (Figs. 7, 8).

In our study we used the Cupar technique. It is, in essence, a minor version of the total maxillary osteotomy down fracture technique (Fig. 9).

Activation of the distraction appliances started on the 5th postoperative day at a rate of 1 mm/day. The duration of the activation period was determined clinically by the severity of the maxillary hypoplasia and anterior reverse dental cross-bite. This was followed by a consolidation period of 12–16 weeks. All the patients tolerated the distraction procedure well. There was no surgical morbidity in any of the patients. After 3–4 months of consolidation the appliance was removed (Fig. 10).

Table 4 Comparison of before and after treatment facial form values among study subjects

Facial form vales	Before	After	*P*
G-Sn-Pg	3.04 + 13.28	1.84 + 12.17	0.475
G-Sn (II *X* axis)	7.60 + 5.01	3.68 + 3.89	< 0.001

NS non-significant, *HS* highly significant

$P < 0.05$

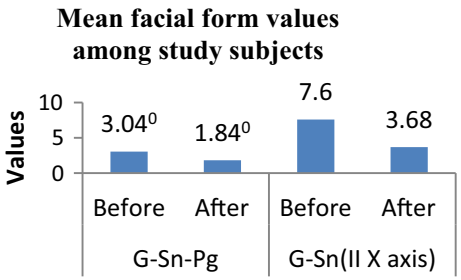


Fig. 4 The graph shows decrease in the G-Sn-Pg′ angle from S1 to S2, which signifies improvement in facial angle. It show a decrease in distance of G-Sn II *x* axis which signifies forward movement of point Sn which signifies improvement in soft tissue profile

Table 3 Comparison of before and after treatment maxilla-mandible cephalometric values among study subjects

Maxilla-mandible Ceph values	Before	After	*P*
PNS-ANS (II *X* axis)	45.16 + 4.96	49.36 + 5.08	< 0.001

Table 5 Comparison of before and after treatment lip position and form values among study subjects

Nasolabial angle	Before	After	*P*
Cm-Sn-Ls	68.56 + 24.98	79.48 + 21.19	< 0.001*
Lip position and form values	Before	After	*P*
Ls-(Sn-Pg)	3.76 + 3.50	4.20 + 2.62	0.566
Stm-1	3.00 + 2.29	2.76 + 2.47	0.559
Stm-Stmi	2.16 + 1.74	1.600 + 1.25	0.134

NS non-significant, *HS* highly significant

*$P < 0.05$

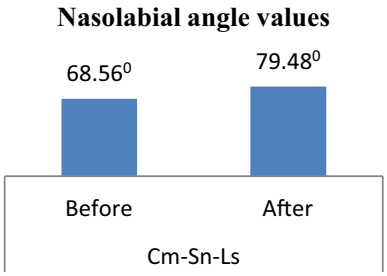


Fig. 5 The graph shows significant change in nasolabial angle between S1 and S2

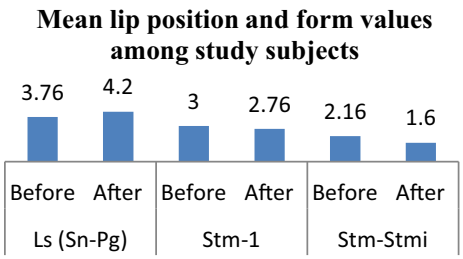


Fig. 6 The graph shows increase in Ls-(Sn-Pg) which shows improvement in upper lip protrusion Increase in Stm-1 which shows improvement in incisal exposure and decrease in Stm-Stmi showing improvement in interlabial gap

In our study, 25 patients were included according to our inclusion and exclusion criteria. All the patients underwent the procedure well and an average of 4–6 mm distraction was achieved. All the patients reported after 3–4 months for follow-up lateral ceph as shown in Figs. 11 and 12. None of the patients presented with surgical or technical complications (Figs. 11, 12).

Radiographs were taken preoperatively and post-distraction after 3–4 months before orthodontic treatment cephalometric tracings were done preoperatively and postoperatively. Both hard and soft tissue profile changes were measured. Both linear and angular measurements were recorded using Burstone analysis of COGS.

Table 6 Ratio and correlation of soft tissue changes to the given extent of hard tissue movements

Hard tissue movements versus soft tissue changes				
DA	D-Sn	DA/D-sn	*R* value	*P*
4.82	4.52	1.085	0.914	< 0.001
DUI	DLS	DUI/DLs	r value	*P*
5.52	4.60	1.306	0.610	0.001
D-ANS	D-Pn	D-Ans/D-Pn	*r* value	*P*
4.24	3.52	1.612	0.848	< 0.001
D-ANS	D-Cm	D-Ans/D-Cm	*r* value	*P*
4.24	3.96	1.311	0.753	< 0.001
N-A-Pg	G-Sn-Pg	N-A-Pg/G-Sn-Pg	*r* value	*P*
− 2.52	− 1.24	0.888	0.771	< 0.001
N-A II *x* axis	G-Sn (II *X* axis)	N-A II *x* axis/G-Sn	*r* value	*P*
− 2.84	− 4.36	0.583	0.732	< 0.001

Fig. 7 Hyrax appliance

In a comparison of pre-op and post-op horizontal ceph values, significant changes are seen with nasion to point A with a mean difference of 2.84 mm; changes seen with N-A-Pg angle with a mean difference of 2.52° was noted which signifies an improvement in facial convexity due to sagittal movement of the maxilla brought about by distraction.

In a comparison of pre-op and post-op vertical ceph values, significant changes seen with ANS-Gn with a mean difference of 2.28 mm. The mean difference of N-ANS was − 0.68 mm and the mean difference of 1-Nf was 0.32 which signifies improvement in the middle third of the face. This confirms the fact that anterior maxilla goes up

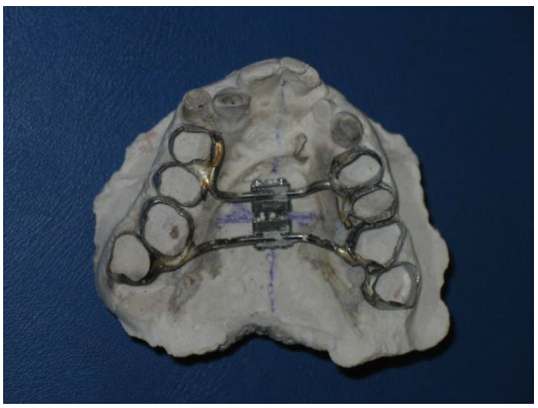


Fig. 8 Distractor fabricated and ready to be luted into the patients maxilla

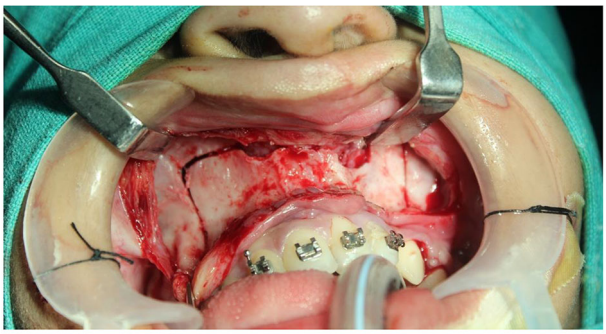


Fig. 9 Inta operative pictures

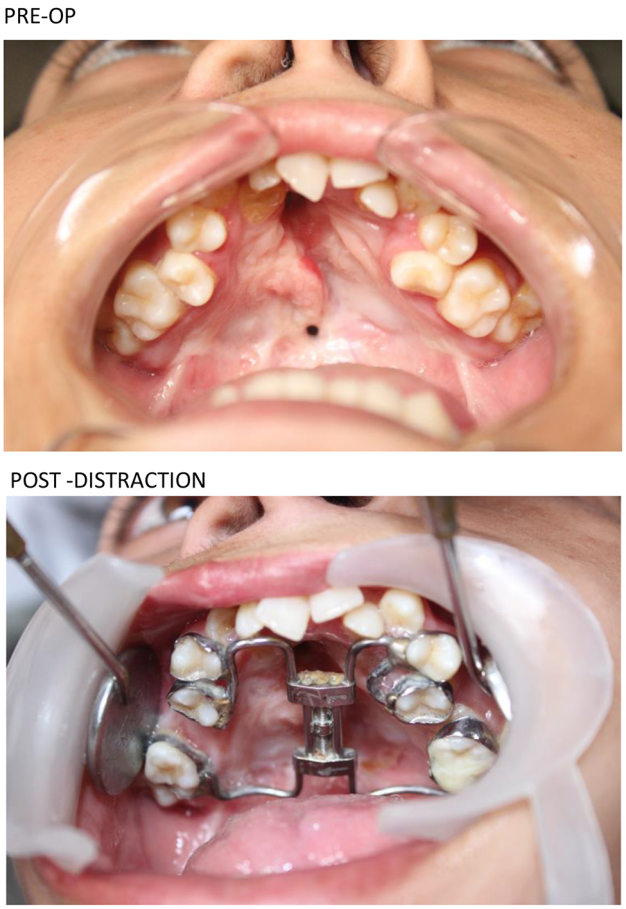


Fig. 10 Distraction phase

during distraction creating mild anterior open bite and a compensatory dental supra eruption.

In the comparison of pre-op to post-op maxilla-mandible ceph values, highly significant changes seen in PNS-ANS with a mean difference of 4.2 mm which signifies an increase in the length of the maxilla.

On comparison of pre-op and post-op soft tissue facial form values, the mean difference of G-Sn-Pg′ angle was 1.2° and significant changes are seen with G-Sn with a mean difference of 3.92 mm which signifies an improvement in soft tissue profile which correlates with the hard tissue movement in an upper and forward direction.

On soft tissue cephalometric changes, the highly significant improvement seen in nasolabial angle (Cm-Sn-Ls) with a mean difference of + 10.92° was noted as a result of the advancement of the maxilla improving the support to the lips and nasal base. Improvement was also seen in incisor exposure (Stm-1) with a mean difference of 0.24 and improvement in interlabial gap (Stm-Stmi) with a mean difference of 0.56 mm resulting from the open bite.

On deriving the ratio and correlation of soft tissue changes to the given extent of hard tissue movement, highly significant changes were seen in Sn with the movement of point A at a ratio of 1:0.9. Significant changes were seen in the upper lip (Ls) with the movement of the upper incisor (U1) at a ratio of 1:0.83. With the movement of ANS, highly significant changes seen in the columella (Cm) at a ratio of 1:0.93 and pronasale (Pn) at a ratio of 1:0.83. With the change in hard tissue facial angle (N-A-Pg) resulted in a highly significant change in soft tissue profile (G-Sn-Pg) at a ratio of 1:0.5 and with improvement in hard tissue middle third (N-A II *x*-axis) resulted in highly significant changes in G-Sn (II *x* axis) at a ratio of 1:1.5.

There have not been many reports describing the hard and soft tissue profile changes after anterior maxillary distraction.

Comparing the treatment of horizontal ceph pre-op and post-op shows the difference of N-A-Pg which is seen to be 0.098 which is non-significant. While in a study by Rao et al. [10] the difference was 0.006 which seems to be significant. Comparing the treatment of horizontal ceph pre-op and post-op shows the difference of N-A II *x* axis which is seen to be 0.001 which is significant. While in a study by Rao et al. [10] the difference was 0.008 which seems to be significant. Comparing the treatment of

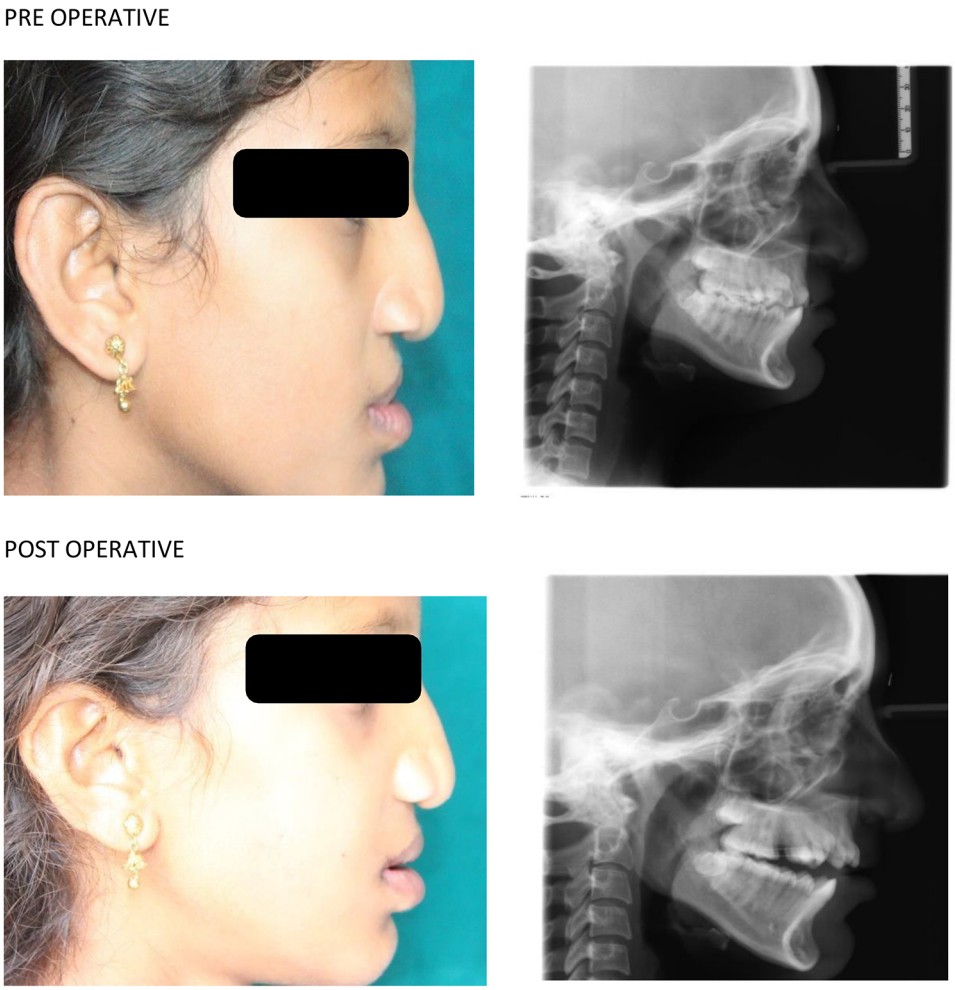
Fig. 11 Case 1

vertical ceph pre-op and post-op shows the difference of N-ANS II *y* axis which is seen to be 0.147 which is non-significant, while in a study by Rao et al. [10] the difference was 0.806 which seem to be non-significant. Comparing the treatment of pre-op and post-op maxilla-mandible ceph values, shows a difference of PNS-ANS II *x* axis which seems to be < 0.001 which is highly significant showing increase in the length of the maxilla, while in a preliminary report by Bengi et al. [11] difference was 0.017 which was significant. On comparison of before and after treatment facial form values, shows a difference of upper lip length, upper lip protrusion, and interlabial gap which is seen to be non-significant while in a study by Rao et al. [10] the difference was similar which is seen to be non-significant.

There are very few studies comparing hard and soft tissue changes in cleft maxillary hypoplasia treated by AMOD and hence comparing it to LeFort I osteotomy with advancement was naturally difficult.

In a study by Dr. Malik et al. [12], the facial convexity angle (N-A-Pg) with Le Fort 1 osteotomy was decreased from 5.14° to 4.17°. But in our study it was 4.12° to 1.60° which indicates, better improvement in facial angle by AMOD. The degree of horizontal dysplasia of maxilla (NA II HP) with Le Fort 1 osteotomy was changed from 0.71 to 1.2 mm. But in our study it was 10.24 mm to 7.40 mm which indicates better advancement of point A to nasion with AMOD. Height of the Middle 3rd of the Face (N-ANS perpendicular to HP) with Le Fort 1 osteotomy decreased from 57.62 to 52.4 mm but with our study it was 47.24 to 46.56 mm indicating less reduction in height in middle a third of the face with AMOD. Height of the Lower 3rd of the Face (ANS-Gn perpendicular to HP) with Le Fort 1 osteotomy decreased from 75.8 to 69.3 mm but in our study it was 59.92 mm to 62.20 mm indicating less reduction in the height of lower third of the face with AMOD. Cm-Sn-Ls (nasolabial Angle) with Le Fort 1 osteotomy has decreased from 102.4° to 99° but in our

Fig. 12 Case 2



study it was 68.56° to 79.48° indicating the better result of nasolabial angle making it more obtuse with AMOD.

Change in Upper lip length (Ls-(Sn-Pg) with Le Fort 1 osteotomy was increased from 21.68 to 22.28 mm but in our study it was 3.76 mm to 4.2 mm which shows similar improvement in upper lip length with AMOD.

In a study by Chua [6] the ratio of soft tissue movement to the hard tissue movement with 1 osteotomy dA/dPn was 1:0.062 but in our study it was 1:0.73. dA/Sn was 1:0.069 while in our study it was 1:0.93.dA/dLs was 1:0.19 while in our study it was 1:0.9. dU1/dLs was 1:0.5 while in our study it was 0.83. This signifies better hard tissue to soft tissue ratio was obtained with AMOD compared to Le Fort 1 osteotomy.

The current studies objectives were to analyze hard and soft tissue cephalometric changes in cleft maxillary hypoplasia by AMOD, on hard tissue examination results were highly significant with an increase in the length of the maxilla (ANS-PNS), significant changes seen in horizontal movement of the maxilla (N-A ll *X* axis) and significant improvement in vertical maxillary height (ANS-GN). The facial soft tissue contour showed an average decrease in the concavity of 2.84°, thereby establishing a straight to convex profile from the preexisting concave profile. On soft tissue examination, highly significant changes were seen in nasolabial angle, upper lip protrusion, upper incisor exposure were noted, though the rest of the values were not significant, clinically, the facial balance was restored and the previously retruded upper lips attained normal protrusion. Improvement in facial balance, with positive soft tissue changes produced by increasing the nasal projection, normalizing the nasolabial angle, and making the upper lip more prominent, and the anterior movement ratio for soft to hard tissue is relatively high than the le Fort 1 osteotomy. Therefore, AMOD is an effective method for improving the hard and soft tissue profile in cleft lip and palate patients with marked retrusion of the midface.

In the treatment of cleft maxillary hypoplasia with conventional Le Fort I osteotomy, the major advancement, and the extreme discrepancies made stabilization difficult, and the added effect of palatal scarring can result in significant postsurgical relapse and also any existing VPI can get exaggerated. In full arch maxillary distraction osteogenesis, the procedure has the accompanying disadvantage

of the need to have an extraoral device in situ for 4 months with all associated comorbidities due to lack of suitable intraoral distractor and can also contribute to VPI as the soft palate moves away from posterior pharyngeal wall.

Conclusion

Anterior maxillary osteotomy with distraction is a relatively new technique for correcting cleft maxillary hypoplasia. In our study on 25 healthy patients, on hard tissue examination significant improvement was seen in the horizontal movement of the maxilla (N-A). An improvement in the midfacial height (ANS-GN) was seen. An increase in the length of the maxilla (ANS-PNS) was noted. On soft tissue examination significant results were obtained wrt soft tissue profile (G-Sn), and significant improvement in nasolabial angle. Though results of the interlabial gap, upper incisor exposure, and upper lip protrusion were not significant, clinically improvement was seen. On the ratio of soft tissue movement to the given extent of hard tissue movement, highly significant results were noted.

Based on the results achieved in our study, we conclude that AMOD is a procedure that is here to stay and will be used more often in the future by cleft surgeon world over.

Summary

Results showed significance for all parameters like hard tissue facial profile, length of the maxilla, vertical changes in the midface, and on soft tissue examination, significant changes were obtained in soft tissue profile, nasolabial angle. Though upper lip length, inter labial gap and upper incisor exposure were not significant, clinically they were appreciated. On the ratio of soft tissue changes to the given extent of hard tissue movements, highly significant results were obtained.

Based on the results achieved in our study, we conclude that AMOD is a good treatment of choice for correcting cleft maxillary hypoplasia in terms of predictable soft tissue changes for a given magnitude of hard tissue advancement and the overall improvement in the facial silhouette.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from the individual participant included in the case for the treatment as well consent was obtained for the photographs.

References

1. Mansour S, Burstone C, Legan H (1983) An evaluation of soft-tissue changes resulting from Le Fort I maxillary surgery. Am J Orthod 84(1):37–47
2. Ross RB (1987) Treatment variables affecting facial growth in complete unilateral cleft lip and palate. Part 1: treatment affecting growth. Cleft Palate J 24(1):5–23
3. Cheung LK, Chua HD (2006) A meta-analysis of cleft maxillary osteotomy and distraction osteogenesis. Int J Oral Maxillofac Surg 35(1):14–24
4. Cheung LK, Chua HD, Hägg MB (2006) Cleft maxillary distraction versus orthognathic surgery: clinical morbidities and surgical relapse. Plast Reconstr Surg 118(4):996–1008
5. Wang XX, Wang X, Li ZL, Yi B, Liang C, Jia YL, Zou BS (2009) Anterior maxillary segmental distraction for correction of maxillary hypoplasia and dental crowding in cleft palate patients: a preliminary report. Int J Oral Maxillofac Surg 38(12):1237–1243
6. Chua HD, Hägg MB, Cheung LK (2010) Cleft maxillary distraction versus orthognathic surgery–which one is more stable in 5 years? Oral Surg Oral Med Oral Pathol Oral Radiol Endod 109:803–814
7. Markose E, Paulose J, Paul ET (2013) Soft tissue changes in cleft lip and palate patients: anterior maxillary distraction versus conventional Le-Fort I osteotomy. J Maxillofac Oral Surg 12(4):429–435
8. Codivilla A (1905) On the means of lengthening, in the lower limbs, the muscles, and tissues are shortened through deformity. JBJS 2(4):353–369
9. Polley JW, Figueroa AA (1997) Management of severe maxillary deficiency in childhood and adolescence through distraction osteogenesis with an external, adjustable, rigid distraction device. J Craniofac Surg 8(3):181–185
10. Rao S, Kotrashetti SM, Lingaraj JB, Pinto PX, Keluskar KM, Jain S, Sone P, Rao S (2013) Anterior segmental distraction osteogenesis in the hypoplastic cleft maxilla: report of five cases. Sultan Qaboos Univ Med J 13(3):454
11. Bengi O, Karaçay Ş, Akin E, Okçu KM, Ölmez H, Mermut S (2007) Cephalometric evaluation of patients treated by maxillary anterior segmental distraction: a preliminary report. J Cranio-Maxillofac Surg 35(6):302–310
12. Malik S, Singh V, Singh G, Anand SC. Role of Le fort I osteotomy in orthosurgical management of maxillary deformities in the north Indian population