Soft Tissue Changes in Cleft Lip and Palate Patients: Anterior Maxillary Distraction versus Conventional Le-Fort I Osteotomy

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Abstract The purpose of the study was to compare the soft tissue changes after maxillary advancement in patients with maxillary deficiency associated with cleft lip and palate (CLP) by two approaches—anterior maxillary distraction (AMD) and advancement LeFort I osteotomy (ALO). Twenty patients with maxillary hypoplasia associated with cleft lip and palate who had undergone either LeFort I osteotomy or distraction osteogenesis with maxillary advancement were included in this study. Lateral cephalogram taken at various intervals of time were used to evaluate soft tissue and hard tissue changes over time. In both groups, vertical as well as horizontal changes in pronasale was well observed. A substantial increase in nasal parameters was noted in case of AMD group in comparison to ALO. Though maxillary advancement was evident in both the groups, a significant and consistent change was observed in AMD. Significant vertical and horizontal changes were seen with respect to subnasale and labrale superius in AMD group. Soft tissue as well as hard tissue relapse was greater in ALO group than AMD group. Significant soft tissue and hard tissue changes were clearly observed in both the groups, but the treatment results were more consistent in cases treated with AMD. Hence AMD

could be considered as a better treatment of choice in cases of maxillary hypoplasia associated with cleft lip and palate.

Keywords Anterior maxillary distraction · Maxillary hypoplasia · Cleft lip and palate

Introduction

Maxillary hypoplasia is a common developmental sequelae in patients with cleft lip and palate. Conventionally it was corrected by orthognathic surgery (advancement LeFort I osteotomy) since 1970s [1]. Very often extreme maxillary deficiency is difficult to treat with ALO, as greater advancement was required in such cases [2–9]. The surgical difficulty in ALO includes intra operative 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, requirement for bone graft, negative effect on velopharyngeal closure, high risk of bone necrosis and higher post-surgical relapse rates ranging up to 50 % [6, 7, 9, 10]. 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 ALO. Hence AMD was preferred for severe deformity corrections [7]. Moreover alteration in speech and relapse tendency was greater in cases treated with ALO due to tension from palatal scar leading to compromised results [6, 7, 10–13]. Distraction osteogenesis has opened a new perspective in treatment of CLP since 1995 [14]. Distraction osteogenesis is defined as a process of generating new bone by gradual traction between two surgically separated segments using a distractor [13].

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Various studies have been carried out to evaluate the racial and genetic differences in the incidence of cleft lip with or without palate. Blacks have the lowest incidence rate of clefts [15]. The highest incidence rate was found in Native Americans with 3.74 per 1,000 live births followed by Japanese subjects with 3.36 per 1,000 live births [16]. Chung and Kau analysed the morphological and developmental basis for racial difference in cleft lip and palate which revealed that Japanese, Chinese, and Filipinos had smaller dimensions than Caucasians and Hawaiians in size of the cranial base, facial height, palatal length and mandibular length [8, 17]. Asians are at higher risk than whites or blacks [18, 19]. A glance into literature reveals several studies on post-operative soft tissue and hard tissue changes in CLP cases treated by orthognathic surgery. But only a few reports regarding soft tissue changes in distraction osteogenesis of CLP patients were published and none in Indian population. Hence this study was designed to compare soft tissue changes achieved by two modes of treatment in cleft lip and palate patients in Indian population. The results of the study would impart a better understanding on the facial soft tissue changes brought about by ALO and AMD. It is of great importance to every clinician while planning surgical maxillary movements in patients with CLP.

Material and Methods

Twenty patients with CLP (irrespective of location and extend of cleft) requiring maxillary advancement were included in the study (ten patients in each group). Subjects were above 18 years of age (both males and females) and the skeletal maturity was confirmed by hand wrist radiographs. The cleft alveolus was grafted at 9–11 years of age. Orthodontic treatment was started 8 months prior to surgery to achieve orthodontic alignment and dental decompensation. Preoperative evaluations such as model analysis, prediction tracing and surgical assessment were done in all patients. Patients with syndromes and those with systemic disease were excluded. The patients who satisfied the

inclusion criteria were randomly assigned to two surgical groups for treatment by distraction with internal maxillary distractors or by conventional orthognathic surgery with mini-plate fixation under general anaesthesia. Maxillary advancement ranged from 6 to 10 mm in ALO group and 8–12 mm in AMD group as determined by preoperative assessment.

In ALO group, vestibular incision was made from molar to molar and a standard LeFort I osteotomy was performed. Maxilla was downfractured and was positioned into occlusion according to the surgical treatment plan as performed in the model surgery. After IMF, the mobilized maxilla was fixed with 2 mm titanium miniplate on each side at buttress and pyriform region. In AMD group, space (3–4 mm) was created bilaterally between premolars and molars orthodontically prior to surgery. Vestibular incision was done up to the maxillary first molars on both sides. Vertical and horizontal bony cuts were performed as for anterior maxillary osteotomy and anterior maxilla was fully mobilized. The expander used for distraction was fabricated on dental model by the orthodontist. Hyrax expander was positioned parallel to the palatal plane so as to correct the antero-posterior skeletal discrepancy. The distractor was activated few millimeters to check the accuracy of maxillary movement. The wound was closed by continuous interlocking suturing. After a latency of 3 days, distraction was initiated at the rate of 1 mm/day in two rhythms until the predetermined maxillary advancement was achieved. The appliance was kept in situ for the period of 12–14 weeks for consolidation following which orthodontic treatment and prosthetic rehabilitation was done.

The present report focused on the changes in the soft tissues over 2 years. The changes in the soft tissue were assessed by comparing serial lateral cephalographs taken preoperatively (S), 6 months post-operatively (S₁) and 2 years after surgery (S₂). A series of soft tissue landmarks were derived for soft tissue analysis. The definition of the soft tissue landmarks are listed in Table 1. The parameters considered to evaluate the hard and soft tissues are well explained in Table 2. For soft tissue analysis, a horizontal line (X-horizontal reference line) was constructed at

Table 1 Definition of the soft tissue landmarks

Sl no.	Landmark	Definition
1.	Point A	Deepest point in the midline between anterior nasal spine and alveolar crest between two central incisors
2.	Palatal plane	Line connecting anterior nasal spine of maxilla and posterior nasal spine of palatine bone
3.	Subnasale	The intersection of the lower border of nose and outer contour of the upper lip
4.	Pronasale	Most prominent point of the nose
5.	Labrale superius	Median point in the upper margin of the upper membranous lip
6.	Esthetic-Plane	Line between the most anterior point of soft tissue nose and soft tissue chin

Table 2 Parameters considered for hard and soft tissue evaluation

Sl no.	Parameters considered	
Nasal parameter		
I.	Vertical change in pronasale	X reference line-Pn
II.	Horizontal change in pronasale	Y reference line-Pn
III.	Nasolabial angle	Cm-Sn-Ls
Hard tissue parameter		
I.	Vertical change in PtA	X reference PtA
II.	Horizontal change in PtA	Y reference PtA
III.	Vertical change in upper incisor tip	X reference line-UI
IV	Horizontal change in upper incisor tip	Y reference line-UI
V	Vertical change in palatal plane	Y reference line-Palatal plane
Vertical labial parameter		
I.	Vertical change in subnasale	X reference line-Sn
II.	Vertical change in labrale superius	X reference line-Ls
Horizontal labial parameter		
I.	Horizontal change in subnasale	Y reference linc-Sn
II.	Horizontal change in labrale superius	Y reference line-Ls
III.	Esthetic line to labrale superius	E reference line-Ls

7° from SN line. The vertical reference line (Y-vertical reference line) was drawn perpendicular to the horizontal line (X reference line) passing through the sella. S_1 and S parameters were compared in the study so as to quantify the 6 months post-surgical skeletal as well as soft tissue changes achieved in AMD and ALO groups. Similarly S_2 and S_1 values were correlated to assess the amount of skeletal and soft tissue relapse in each treatment modality. In all patients lateral cephalogram was obtained using the same machine in natural head position and centric occlusion. In order to avoid individualistic error in landmark identification in lateral cephalograms, all the lateral cephalograms were digitally traced using Nemoceph imaging software by three orthodontists and the average value was considered.

Statistical Analysis

The mean and standard deviation of the cephalometric values were calculated as given in Tables 3 and 4. The differences in the skeletal and soft tissue movements at two time intervals are given in Tables 5 and 6. The difference between S_1 and S parameters was calculated to estimate the amount of skeletal and soft tissue changes in AMD and ALO groups 6 months after surgery. The differences in the skeletal and soft tissue movements at two time intervals were tabulated. S_2 values were compared to S_1 using 2-sample *t* test in both AMD and ALO to quantify relapse (Table 6).

Results

The statistical evaluations of the results given in Tables 3 and 4 were analyzed on the following lines.

- (1) The difference between S_1 and S revealed the amount of soft tissue changes in AMD and ALO groups 6 months after surgery (Table 5).
- (2) The differences between S_2 and S_1 in both groups revealed the amount of skeletal and soft tissue relapse in each treatment modality and the $P < 0.05$ denotes the statistical significance (Table 6).

Nasal Parameter

In both the groups, vertical as well as horizontal change in pronasale was well observed. A substantial significant ($P = 0.002$) increase in Y-Pn (9.3 mm) was observed in case of AMD group in comparison to ALO (5.6 mm). Minimal change in the X-Pn was noted in AMD group (−5.93 mm) in contrast to ALO (−8.1 mm). No remarkable change in nasolabial angle was observed.

Hard Tissue Parameter

A minimal decrease in X-PtA was observed in both groups, with −2.92 mm upward shift of PtA in ALO. Though Y-PtA increased in both the groups, a remarkable, significant ($P = 0.012$) and consistent change was observed in AMD group (10.8 mm). Minimal change in palatal plane was

Table 3 The mean and standard deviation of pre-operative, 6 months and 2 years post-operative cephalometric values in AMD group

Sl no.	Landmarks	AMD		
		Pre Rx (S)	6 months (S ₁)	2 years (S ₂)
<i>Nasal parameter</i>				
1.	Y-Pn	88 mm (1.43)	97.3 mm (1.21)	95.8 mm (1.05)
2.	X-Pn	36.02 mm (1.64)	30.09 mm (1.58)	31.7 mm (1.49)
3.	NLA	90° (4.2)	106° (3.7)	104° (3.59)
<i>Hard tissue parameter</i>				
4.	Y-PtA	59.5 mm (5.76)	70.3 mm (4.97)	69.8 mm (4.78)
5.	X-PtA	45.4 mm (2.59)	44.6 mm (2.34)	45 mm (1.99)
6.	U1-Y	51.5 mm (5.37)	67.01 mm (4.45)	65.5 mm (4.35)
7.	U1-X	65 mm (2.60)	63.5 mm (2.49)	64 mm (2.16)
8.	PP-Y	86.5° (5.53)	84.3° (3.37)	84° (3.34)
<i>Vertical labial parameter</i>				
9.	X-Sn	51.8 mm (1.94)	48.02 mm (1.79)	49 mm (1.65)
10.	X-Ls	52 mm (3.54)	49.08 mm (3.13)	48.7 mm (2.9)
<i>Horizontal labial parameter</i>				
11.	Y-Sn	66.01 mm (2.39)	80.2 mm (1.85)	79.01 mm (1.6)
12.	Y-Ls	54 mm (4.46)	66.5 mm (3.87)	65.5 mm (3.78)
13.	E-Ls	18.4 mm (1.15)	9.8 mm (0.95)	10.03 mm (0.87)

Table 4 The mean and standard deviation of pre-operative, 6 months and 2 years post-operative cephalometric values in ALO group

Sl no.	Landmarks	ALO		
		Pre Rx (S)	6 months (S ₁)	2 years (S ₂)
<i>Nasal parameter</i>				
1.	Y-Pn	79.3 mm (3.75)	84.9 mm (3.39)	82.2 mm (3.05)
2.	X-Pn	38.7 mm (2.18)	30.6 mm (2.03)	32.2 mm (2.1)
3.	NLA	88° (3.7)	100° (2.5)	96° (2.18)
<i>Hard tissue parameter</i>				
4.	Y-PtA	55.8 mm (6.19)	61.9 mm (6.08)	59.8 mm (5.8)
5.	X-PtA	40.02 mm (4.13)	37.1 mm (3.89)	37.6 mm (3.77)
6.	U1-Y	47.5 mm (7.14)	56.5 mm (6.1)	53 mm (5.58)
7.	U1-X	55 mm (3.8)	50.5 mm (3.23)	52 mm (2.9)
8.	PP-Y	82° (6.8)	78.5° (5.53)	78° (4.92)
<i>Vertical labial parameter</i>				
9.	X-Sn	46.3 mm (2.24)	42.8 mm (2.08)	44.9 mm (1.87)
10.	X-Ls	46.02 mm (3.84)	43.4 mm (3.39)	42.8 mm (3.15)
<i>Horizontal labial parameter</i>				
11.	Y-Sn	59.1 mm (3.18)	64.2 mm (2.82)	61.9 mm (2.69)
12.	Y-Ls	52 mm (5.09)	60.5 mm (4.45)	58.9 mm (4.15)
13.	E-Ls	15.2 mm (1.89)	8.9 mm (1.75)	9.05 mm (1.25)

observed in both the groups. Y-U1 was significantly ($P = 0.001$) increased with 15.51 mm advancement of central incisor in AMD.

Labial Parameter

Significant vertical and horizontal changes were observed with respect to subnasale and labrale superius. X-Sn was more

reduced in ALO group (−3.5 mm) and substantial increase ($P = 0.025$) in Y-Sn was noted in AMD group (14.01 mm). E line-Ls was better improved in cases treated by AMD.

Relapse

A significantly greater relapse in Y-PtA ($P = 0.032$) was observed in ALO (2.1 mm) over a period of 2 years, which

Table 5 Difference in S_1-S in AMD and ALO

Sl no.	Landmarks	S_1-S AMD	S_1-S ALO	P value
<i>Nasal parameter</i>				
1.	Y-Pn	9.3 mm	5.6 mm	0.002*
2.	X-Pn	−5.93 mm	−8.1 mm	0.061
3.	NLA	16°	12°	0.07
<i>Hard tissue parameter</i>				
4.	Y-PtA	10.8 mm	6.1 mm	0.012*
5.	X-PtA	−0.8 mm	−2.92 mm	0.12
6.	U1-Y	15.51 mm	9 mm	0.001*
7.	U1-X	−1.5 mm	−5 mm	0.052
8.	PP-Y	2.2°	3.5°	0.068
<i>Vertical labial parameter</i>				
9.	X-Sn	−3.78 mm	−3.5 mm	0.075
10.	X-Ls	−2.92 mm	−2.62 mm	0.069
<i>Horizontal labial parameter</i>				
11.	Y-Sn	14.01 mm	5.1 mm	0.025*
12.	Y-Ls	12.5 mm	8.5 mm	0.053
13.	E-Ls	8.6 mm	8.3 mm	0.084

* Indicates significant P values**Table 6** Difference in S_2-S_1 in AMD and ALO with their corresponding P values

Sl no.	Landmarks	ALO S_2-S_1	P value	AMD S_2-S_1	P value
<i>Nasal parameter</i>					
1.	Y-Pn	2.7 mm	0.003*	1.5 mm	0.057
2.	X-Pn	−1.6 mm	0.056	−1.61 mm	0.059
3.	NLA	4°	0.14	2°	0.04
<i>Hard tissue parameter</i>					
4.	Y-PtA	2.1 mm	0.032	0.5 mm	0.065
5.	X-PtA	−1.2 mm	0.08	−0.4 mm	0.23
6.	U1-Y	3.5 mm	0.005	1.5 mm	0.055
7.	U1-X	−2 mm	0.65	−0.5 mm	0.85
8.	PP-Y	0.5°	0.1	0.3°	0.13
<i>Vertical labial parameter</i>					
9.	X-Sn	−2.1 mm	0.18	−0.98 mm	0.12
10.	X-Ls	−0.6 mm	0.04	−0.38 mm	0.06
<i>Horizontal labial parameter</i>					
11.	Y-Sn	2.3 mm	0.006	1.01 mm	0.051
12.	Y-Ls	1.6 mm	0.008	1 mm	0.07
13.	E-Ls	2.1 mm	0.01	0.23 mm	0.05

* Indicates significant P values

in turn is reflected in all nasal and labial parameters. Y-Pn dropped by 1.5 mm in AMD compared to 2.7 mm in ALO cases ($P = 0.003$). A similar change was observed in subnasale indicating more relapse tendency with ALO. Nasolabial and PP-Y angle did not show much variation in both groups. U1-Y showed remarkable relapse in ALO (3.5 mm). Labrale superius dropped back by 1.6 mm

2 years after surgery in ALO. Y-U1 demonstrated a definite relapse in ALO group in contrast to AMD.

Discussion

Treating maxillary hypoplasia associated with CLP is a challenging task which requires a multi-disciplinary approach. Correction of maxillary hypoplasia is usually performed after the cessation of growth when mandibular growth has ceased. Wolford's study showed that correction of maxillary hypoplasia during growth can result into the class III skeletal relationship as the mandible continues to grow normally [20]. If surgical correction is performed before growth ceases, further surgical intervention may be required later in life [7, 10]. Hence all the subjects considered in the present study were 18 years and above.

The cleft alveolus should be grafted before distraction to transform maxilla to a single unit so that maxillary distraction is more effective; otherwise the distractors would push the non-grafted alveolar segments together closing the alveolar cleft space [7]. Literature reveals extensive use of tooth-borne devices in anterior maxillary segmental distraction, resulting in reliable advancement of anterior maxillary segment [21–27]. Chua et al. [10] reported that extra oral distractors produces higher relapse rates compared to intra oral ones. On removal of extra oral distractors, the tension accumulated from the pulling force tends to rebound, resulting in higher relapse rate. In the present study tooth borne HYRAX expander was used to advance the anterior maxilla.

Considerable body of literature exists on the treatment of CLP patients by both conventional osteotomy and anterior maxillary distraction; which makes it difficult to decide which technique offers better results. Though Cheung et al. [6, 7, 10, 11, 13] reported no major differences in clinical morbidities between distraction osteogenesis and conventional osteotomy, skeletal and soft tissue stability was better with distraction. The present study goes hand in hand with the results published by Cheung et al. For larger movements AMD appears to offer greater stability than that seen with conventional osteotomies. In the present study, the soft tissue and hard tissue response to advancement by distraction was more reliable than LeFort I osteotomies. The change in soft tissue was significantly greater in AMD groups. In traditional methods, a relapse of 20–60 % has been reported in literature [28]. In the present study AMD shows lesser relapse rate; offering better and consistent post-operative results. The previous studies reported that different soft tissue response can be expected from different types of cleft lip [29]. Tindlund and Rygh [30] reported that bilateral CLP showed larger upper lip advancement and more prominent nasal projection, while lower lip goes backwards in distraction.

But he concluded that overall change in soft tissue profile was similar in both unilateral and bilateral CLP. The sample size in the present study was small to compare soft tissue response relating to specific type of cleft. Chua and Cheung [13] reported significant improvement in pronasale, subnasale and labrale superius in distraction group. Though soft tissue changes were observed in both groups after maxillary advancement, pronasale, subnasale and labrale superius showed significant remarkable change in AMD group. A significant horizontal and vertical change in pronasale was observed in AMD group than in ALO group. This is in correlation with previous studies reported in the literature [6, 13]. Nasal flaring and alar base widening is more observed in cases treated with conventional LeFort I maxillary advancement even though alar cinch suturing and V–Y closure have been done [31]. This could very well explain why AMD has greater change in pronasale. Even though studies conducted by Baek et al. [11] and Chua and Cheung [13] reported that nasolabial angle increased more in distraction group than in conventional orthognathic surgery, no significant variation was observed in the present study. Nasolabial angle was better improved in AMD group when compared to ALO group.

Distraction osteogenesis is by gradual traction between two surgically separated segments which allow new bone formation along with soft tissue adaptation. Hence large surgical movement of cleft maxilla is possible with AMD, since soft tissue pull would be minimal. This very well explains the greater horizontal hard tissue change in AMD group. Controlled antero-posterior movement of cleft maxilla with minimal vertical change in PtA was achieved with AMD. Occlusal discrepancy was greater observed in cases treated with ALO. The post-treatment open bite in AMD cases was reported in the literature owing to the difficulty in deciding the optimal distraction direction [32]. This can be well eliminated by positioning the distractor with the force vector parallel to the palatal plane.

In conventional osteotomies the soft palate is pulled forward increasing the distance from posterior pharyngeal wall leading to stretch on palatal musculature which could result in velopharyngeal incompetence, increase in hypernasality, nasal emission and worsening of speech [7]. The application of maxillary distraction has lessened these drawbacks to a great extent. The demerits of AMD procedure includes the need for daily activation, compromised speech, eating and appearance, change of distraction vector (8 %) leading to anterior open bite/deep bite, fracture of distraction device (2 %), incomplete distraction (2 %), transient paresthesia (2 %) and requirement of prosthetic rehabilitation. In addition overcorrection may give rise to surrounding tissue tears or ischemia [7]. Cooperation of patients and their families is mandatory, since frequent post-operative monitoring of the patient is desirable.

Distraction osteogenesis is relatively a newer tool for surgeons to address mid-face deficiency in CLP. It allows advancement of hard tissue in par with soft tissue perfection. A definitive advantage of distraction over conventional osteotomy is that there is no need for bone graft to bridge the osteotomy gap because distraction regenerates new bone along its path. Hence it reduces donor site morbidity, surgery time and cost [7]. Moreover AMD allows greater advancement, more stable and long term results, lessens the effect on velopharyngeal incompetence and has become a newer treatment regime to correct maxillary hypoplasia in CLP [9, 33, 34].

Conclusion

Significant soft tissue and hard tissue changes were clearly observed in both the groups, but the treatment results were more consistent in cases treated with AMD. AMD improved the soft tissue profile by increasing nasal projection, normalizing the nasolabial angle, and making the upper lip more prominent. An acceptable incisor show was achieved in normal rest position without much change in upper lip length. The concave facial profile was greatly improved, with improved facial balance and aesthetics. Relapse in AMD was minimal in contrast with conventional osteotomies. Hence AMD could be considered as a better choice of treatment in cases of maxillary hypoplasia associated with cleft lip and palate.

References

1. Hirano A, Suzuki H (2001) Factors related to relapse after LeFort I maxillary advancement osteotomy in patients with cleft lip and palate. *Cleft Palate Craniofac J* 38:1–10
2. Bralley RC, Schoeny ZG (1977) Effects of maxillary advancement on the speech of a sub-mucosal cleft palate patient. *Cleft Palate J* 14:98–101
3. Fitzpatrick B (1977) Mid-face osteotomy in the adolescent cleft palate patient. *Aust Dent J* 22:338–350
4. Freihofer HP Jr (1977) Changes in nasal profile after maxillary advancement in cleft and non-cleft patients. *J Maxillofac Surg* 5:20–27
5. Lurie R (1974) Case report: maxillary osteotomy in a repaired cleft-palate patient. *J Dent Assoc S Afr* 29:571–574
6. Cheung LK, Chua HD, Hägg MB (2006) Cleft maxillary distraction versus orthognathic surgery: clinical morbidities and surgical relapse. *Plast Reconstr Surg* 118:996–1008
7. Cheung LK, Chua HD (2006) A meta-analysis of cleft maxillary osteotomy and distraction osteogenesis. *Int J Oral Maxillofac Surg* 35:14–24
8. Chung CS, Kau MC (1985) Racial differences in cephalometric measurements and incidence of cleft lip with or without cleft palate. *J Craniofac Genet Dev Biol* 5:341–349
9. 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* 38:1237–1243
10. 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
 11. Baek SH, Lee JK, Lee JH, Kim MJ, Kim JR (2007) Comparison of treatment outcome and stability between distraction osteogenesis and LeFort I osteotomy in cleft patients with maxillary hypoplasia. *J Craniofac Surg* 18:1209–1215
 12. Guyette TW, Polley JW, Figueroa A, Smith BE (2001) Changes in speech following maxillary distraction osteogenesis. *Cleft Palate Craniofac J* 38:199–205
 13. Chua HD, Cheung LK (2012) Soft tissue changes from maxillary distraction osteogenesis versus orthognathic surgery in patients with cleft lip and palate—a randomized controlled clinical trial. *J Oral Maxillofac Surg* 70:1648–1658
 14. Cohen SR, Rutrick RE, Burstein FD (1995) Distraction osteogenesis of the human craniofacial skeleton: initial experience with a new distraction system. *J Craniofac Surg* 6:368–374
 15. Gilmore SI, Hofman SM (1966) Clefts in Wisconsin: incidence and related factors. *Cleft Palate J* 3:186–199
 16. Lowry RB, Trimble BK (1977) Incidence rates for cleft lip and palate in British Columbia 1952–1971 for north American Indian, Japanese, Chinese and total population: secular trends over twenty years. *Teratology* 16:277–283
 17. Trenouth MJ, Laitung G, Naftel AJ (1999) Differences in cephalometric reference values between five centres: relevance to the Eurocleft study. *Br J Oral Maxillofac Surg* 37:19–24
 18. Grolin RY, Cohen MM, Hannekam R (2007) *Syndromes of the head and neck*, 4th edn. Oxford University Press, New York
 19. Rajabian MH, Sherkat M (2000) An epidemiological study of oral clefts in Iran: Analysis of 1669 cases. *Cleft Palate Craniofac J* 37:191–196
 20. Wolford LM, Cassano DS, Cottrell DA, El Deeb M, Karras SC, Goncalves JR (2008) Orthognathic surgery in the young cleft patient: preliminary study on subsequent facial growth. *J Oral Maxillofac Surg* 66:2524–2536
 21. Dolanmaz D, Karaman AI, Ozyesil AG (2003) Maxillary anterior segmental advancement by using distraction osteogenesis: a case report. *Angle Orthod* 73:201–205
 22. Gualini C (2007) Advancement of maxillary anterior segment by distraction osteogenesis (DO): a case report. *Prog Orthod* 8:54–61
 23. Iida S, Yagi T, Yamashiro T, Okura M, Takada K, Kogo M (2007) Maxillary anterior segmental distraction osteogenesis with the dynaform system for severe maxillary retrusion in cleft lip and palate. *Plast Reconstr Surg* 120:508–516
 24. Choi HY, Hwang CJ, Kim HJ, Yu HS, Cha JY (2012) Maxillary anterior segmental distraction osteogenesis with 2 different types of distractors. *J Craniofac Surg* 23:706–711
 25. Okcu KM, Sencimen M, Karacay S, Bengi AO, Ors F, Dogan N, Gokce HS (2009) Anterior segmental distraction of the hypoplastic maxilla by a tooth borne device: a study on the movement of the segment. *Int J Oral Maxillofac Surg* 38:817–822
 26. Richardson S, Agni NA, Selvaraj D (2011) Anterior maxillary distraction using a tooth-borne device for hypoplastic cleft maxillas—a pilot study. *J Oral Maxillofac Surg* 69:e542–e548
 27. Gunaseelan R, Cheung LK, Krishnaswamy R, Veerabahu M (2007) Anterior maxillary distraction by tooth-borne palatal distractor. *J Oral Maxillofac Surg* 65:1044–1049
 28. Posnick JC, Dagsy AP (1994) Skeletal stability and relapse patterns after Le Fort I osteotomy fixed with mini plates: the unilateral cleft lip and palate deformity. *Plast Reconstr Surg* 94:924–932
 29. Wen-ChingKo E, Figueroa AA, Polley JW (2000) Soft tissue profile changes after maxillary advancement with distraction osteogenesis by use of a rigid external distraction device: a 1 year follow up. *J Oral Maxillofac Surg* 58:959–969
 30. Tindlund RS, Rygh P (1993) Soft tissue profile changes during widening and protraction of the maxilla in patient with cleft lip and palate compared with normal growth and development. *Cleft Palate Craniofac J* 30:454–468
 31. Muradin MS, Rosenberg A, van der Bilt A, Stoelinga PJ, Koole R (2009) The effect of alar cinch sutures and V-Y closure on soft tissue dynamics after Le Fort I intrusion osteotomies. *J Cranio-maxillofac Surg* 37:334–340
 32. Rachmiel A, Aizenbud D, Peled M (2006) Distraction osteogenesis in maxillary deficiency using a rigid external distraction. *Plast Reconstr Surg* 117:2399–2406
 33. Cohen SR, Burstein FD, Stewart MB, Rathburn MA (1997) Maxillary-mid face distraction in children with cleft lip and palate: a preliminary report. *Plast Reconstr Surg* 99:1421–1428
 34. Figueroa AA, Polley JW, Friede H, Ko EW (2004) Long-term skeletal stability after maxillary advancement with distraction osteogenesis using a rigid external distraction device in cleft maxillary deformities. *Plast Reconstr Surg* 114:1382–1392