Photometric Evaluation of Soft Tissue Changes in CLP Patients: Le Fort I Advancement Osteotomy (ALO) Versus Anterior Maxillary Distraction (AMD)

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Abstract

Aim This paper is a comparative photometric evaluation of soft tissue changes in patients with CLP associated with maxillary deficiency treated with conventional Le Fort I advancement osteotomy (ALO) and anterior maxillary distraction (AMD).

Materials and Methods 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. Frontal and profile photographs were used to ascertain the changes post-surgically. Photographs were obtained before treatment and 1 year after surgical correction in both groups.

Results Vertical as well as horizontal changes in pronasale was well observed in both groups. A substantial increase in nasal parameters was noted in case of AMD group in comparison to ALO group. Though maxillary advancement was quite evident in AMD and ALO groups, a significant and consistent change was observed in AMD group. Significant vertical and horizontal changes were seen with respect to subnasale and labrale superius in AMD group.

Conclusion The hard and soft tissue changes produced by AMD by intra oral distractors were being evaluated so far. The results of the above studies have proved the excellence of AMD over conventional osteotomies. The present study goes hand in hand with the research outcomes till date.

Keywords Photometric analysis · Anterior maxillary distraction · Maxillary hypoplasia · Cleft lip · Palate

Introduction

This is in continuation of our study on soft tissue changes in cleft lip and palate patients treated by anterior maxillary distraction (AMD) and conventional Le Fort I osteotomy (ALO) in which cephalometric soft and hard tissue analysis was employed [1]. This is an attempt to re-evaluate the soft tissue changes using frontal and profile photographs.

The prime objective of orthodontic treatment in the early twentieth century was limited to establishing a functional occlusion while little could be done to alter soft tissue aesthetics. With the advent of orthopaedic and craniofacial surgical techniques in the 1960s and 1970s, facial harmony was considered and incorporated as one of the treatment goals [2]. Many researchers recommended that the analysis of the soft tissues should be taken into consideration for the correct evaluation of an underlying skeletal discrepancy because of individual differences in soft tissue thickness [3–5]. Many methods are available for the evaluation of facial changes including anthropometry [6], photogrammetry [7], computer imaging [8] and cephalometry [9]. Numerous analyses have been developed so far to interpret the diagnostic information provided by lateral cephalograms [10–15]. Cephalometric standards for soft tissue profile have been established by Burstone [4], Holdaway [16] and Peck and Peck [17]. However in cephalograms, the soft tissue structures are recorded only in profile and limited to the anterior-most outline. Furthermore, patients are not accustomed to viewing and interpreting cephalograms or their tracings.

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Table 1 Variables considered for analysing frontal photograph

Frontal photograph	
1. Width of nose (al–al)	Maximum width at alar base which should be equal to intercantal width in ideal cases
2. Middle face height (N–Sn)	Otherwise the nose height, measured from soft tissue nasion to subnasale
3. Lower face height (Sn–Gn)	Subnasale to soft tissue gnathion
4. Upper lip length (Sn–Sto)	Distance from subnasale to stomion
5. Lower lip length (Sto–Gn)	Distance from stomion to soft tissue gnathion. Upper to lower lip length ratio should be 1:2 in all ideal cases

Photographs, on the other hand, provide a more conventional documentation of the soft tissues of the face [17, 18]. More emphasis was given for assessment of cephalometric radiographs, leaving only a subjective role for photographs. The recent concerns on radioprotection made photography an effective and valuable tool in soft tissue evaluation. Analysing frontal and profile photographs would permit us to evaluate the changes in sagittal, vertical and horizontal planes which may not be possible with lateral cephalometric analysis. Many researchers have published various soft tissue facial analyses based on standardized photogrammetric method [16, 19–25]. It is not devoid of any disadvantage since the standardization of photograph at each time interval throughout the study is a difficult task. Any error in image standardization may lead to bias which would misinterpret the results.

This is an attempt to investigate the treatment outcome using photographic analysis and to stress the consistency of AMD over conventional Le Fort I osteotomy. The results of the study would impart a better understanding on the frontal and profile facial soft tissue changes brought about by ALO and AMD. Literature reveals several studies on postoperative soft tissue and hard tissue changes in CLP cases treated by orthognathic surgery. Photometric studies were being reported in the literature to evaluate the changes produced by rapid maxillary expansion. No photometric study is so far reported evaluating the post treatment changes on correction of maxillary hypoplasia in cleft patients. This would be valid evidence to every clinician while planning surgical maxillary movements in patients with CLP using simple photographs.

Methodology

Twenty patients aged 18 years and above with CLP (irrespective of location and extend of cleft) requiring maxillary advancement were included in the study (10 patients in

Table 2 Variables considered for analysing profile photograph

Lateral photograph	
1. Pronasale (PRN)	Anterior-most point at the tip of the nose
2. Soft tissue nasion (N)	The point of maximum concavity between forehead and nose in the midline
3. Labralesuperioris (LS)	Point indicating mucocutaneous border of upper lip
4. Labraleinferioris (LI)	Median point in the lower margin of lower membranous lip
5. Sulcus labiisuperioris (SLS)	Point of greatest concavity in the midline of upper lip between sub nasale and labralesuperioris
6. Sulcus labiinferioris (SLI)	Point of greatest concavity in the midline of lower lip between labraleinferius and soft tissue pogonion
7. Soft tissue pogonion (PG)	Most prominent point on the chin in the mid sagittal plane
8. Subnasale (SN)	Point at which columella merges with the upper lip in the mid sagittal plane
9. Stomion (ST)	Point of upper and lower lip junction in the midline
10. Menton (ME)	Lowest point on the contour of the soft tissue chin
11. Vertical reference line—porion vertical	Vertical line passing through the point poriondrawn parallel to plump line
12. True horizontal	A line perpendicular to vertical reference line

each group). 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 groups for treatment by distraction or by conventional orthognathic surgery. Maxillary advancement ranged from 6 to 10 mm in ALO group and 8–12 mm in AMD group as determined by preoperative assessment. The present report focuses on assessing the post-surgical soft tissue changes in all 3 planes. The changes in the soft tissue were assessed by comparing frontal and profile photographs taken preoperatively (T_1), and 2 year after surgery (T_2).

The patient was made to sit upright with relaxed lips. Camera was positioned on the tripod and the distance from the subject to the camera lens was fixed (70 cm). The camera setting was kept unchanged during all exposures. This assures consistent perspective for all subjects and similar reproduction ratios. While taking the photograph, a 12 inch scale was positioned near the patient's face on a stable platform. The image was adjusted to a 1:1 ratio by enlarging or reducing the photograph to the ruler's actual size. All

photographs were taken by same individual, using the same camera in natural head position. Photographs of each subject were analyzed by 10 orthodontists to test the reliability of landmark locations. Cronbach's alpha test demonstrated an acceptable reliability for the measurements recorded. The average magnitude of intra-investigator error between repeated measurements ranged from 0.5 to 1.0 mm. Facial photographs were evaluated using the few parameters described by Farkas et al. [27] and profile photographs using the variables explained by Lundstrom et al. [28] to judge the soft tissue perfection attained in both ALO and AMD. The variables considered are explained in Tables 1 and 2.

Statistical Analysis

The pre- and post-surgical frontal and profile photographs were analyzed to determine the soft tissue changes achieved in both AMD and ALO groups. The mean and

standard deviation of each of the parameters considered in the study are listed in Tables 3, 4 and 5. The pre and post-surgical values were compared in each group using 2-sample *t* test. The *p* value suggested the soft tissue improvement achieved in ALO and AMD.

Results

Frontal Photographic Analysis

The changes with regard to nose height, nose width, lower facial height, upper lip length and lower lip length were evaluated. The results are listed in Table 3. T_2 value was compared to T_1 to analyze the soft tissue change achieved post-surgically. Nose height (N–Sn) was significantly (*p* value 0.05) reduced by 3.24 mm in ALO group compared to 1.83 mm in AMD group. Nasal widening was very

Table 3 The mean and standard deviation of pre-operative and post-operative values on frontal photographic analysis in AMD and ALO groups

	AMD				ALO			
	Mean pre Rx (T_1)	Mean post Rx (T_2)	Difference ($T_2 - T_1 = D$)	<i>p</i> value	Mean pre Rx (T_1)	Mean post Rx (T_2)	Difference ($T_2 - T_1 = D$)	<i>p</i> value
Nose height (N–Sn)	51.18 (0.16)	49.35 (0.35)	−1.83	1.16	50.71 (0.26)	47.47 (0.19)	−3.24	0.05**
Nose width (al–al)	39.39 (0.76)	40.39 (0.91)	1.00	0.074	39.15 (0.39)	43.67 (0.86)	4.52	0.032**
Lower facial height (Sn–Gn)	70.9 (0.25)	72.04 (0.66)	1.14	0.43	72.14 (0.44)	69.86 (1.16)	−2.28	0.32
Upper lip length (Sn–Sto)	21.31 (0.18)	20.89 (1.10)	−0.42	0.69	21.28 (1.02)	20.78 (1.10)	−02.50	0.81
Lower lip length (Sto–Gn)	50.17 (1.06)	49.80 (0.96)	−0.37	0.28	50.22 (1.32)	49.94 (1.07)	−0.28	0.30

** *p* value < 0.05 indicates statistical significance

Table 4 The mean and standard deviation of pre-operative and post-operative values on lateral photographic analysis in AMD group

AMD group	Mean pre Rx (T_1)	Mean post Rx (T_2)	<i>p</i> value
Horizontal			
Nasal prominence (PO-PRN/PO-N × 100)	108.7 (0.52)	117.5 (0.46)	0.04**
Upper jaw prominence (PO-SLS/PO-N × 100)	93.5 (0.75)	105.3 (0.48)	0.022**
Lower jaw prominence (PO-SLI/PO-N × 100)	98.6 (0.75)	98.1 (0.49)	0.094
Upper/lower jaw (PO-SLS/PO-SLI × 100)	96.3 (1.16)	105.4 (0.30)	0.039**
Lip relationship (PO-LS/PO-LI × 100)	95.2 (0.38)	101.4 (0.72)	0.04**
Chin eminence (PO-PG/PO-SLI × 100)	100.2 (0.59)	99.1 (0.68)	0.11
Chin prominence (PO-PG/PO-N × 100)	101.3 (0.65)	101.9 (0.29)	0.094
Facial convexity (PO-LS/(1/2)(PO-N + PO-PG) × 100)	91.4 (0.96)	103.7 (1.16)	0.02**
Vertical			
Upper/lower face height (N-SN/SN-ME × 100)	80.1 (1.16)	78.2 (0.49)	0.073
Upper/lower jaw height (SN-ST/ST-ME × 100)	42.8 (0.69)	42.3 (0.14)	0.12
Vertical/horizontal			
Face height/depth height (N-ME/PO-PG × 100)	107.5 (0.34)	109.3 (0.48)	0.13

** *p* value < 0.05 indicates statistical significance

Table 5 The mean and standard deviation of pre-operative and post-operative values on lateral photographic analysis in ALO group

ALO group	Mean pre Rx (T ₁)	Mean post Rx (T ₂)	<i>p</i> value
Horizontal			
Nasal prominence (PO-PRN/PO-N × 100)	110.5 (0.54)	116.1 (0.96)	0.06
Upper jaw prominence (PO-SLS/PO-N × 100)	92.6 (0.55)	100.2 (0.49)	0.049**
Lower jaw prominence (PO-SLI/PO-N × 100)	98.3 (0.78)	99.9 (0.28)	0.091
Upper/lower jaw (PO-SLS/PO-SLI × 100)	96.7 (0.64)	100.5 (0.99)	0.073
Lip relationship (PO-LS/PO-LI × 100)	95.4 (0.81)	98.4 (0.68)	0.06
Chin eminence (PO-PG/PO-SLI × 100)	100.3 (0.52)	100.5 (0.43)	0.15
Chin prominence (PO-PG/PO-N × 100)	98.9 (1.04)	100.1 (0.90)	0.09
Facial convexity (PO-LS/(1/2)(PO-N + PO-PG) × 100)	93.9 (1.02)	101.5 (0.97)	0.05**
Vertical			
Upper/lower face height (N-SN/SN-ME × 100)	79.3 (0.38)	79.9 (0.52)	0.097
Upper/lower jaw height (SN-ST/ST-ME × 100)	42.3 (0.15)	42.2 (0.43)	0.10
Vertical/horizontal			
Face height/depth height (N-ME/PO-PG × 100)	108.6 (0.82)	108.4 (0.75)	0.17

Fig. 1 Measurements on frontal photograph

significantly evident in ALO group (4.52 mm, *p* value 0.032) in contrast to 1 mm in AMD group. Mild increase lower facial height was observed in distraction group (1.14 mm) whereas in ALO group lower facial height was decreased (−2.28 mm) though the change was statistically insignificant. No remarkable change in lip length was observed in both groups (Fig. 1).

Profile Photographic Analysis

Profile photographs were analyzed in horizontal and vertical planes and the results are enumerated in Tables 4 and 5. Nasal prominence improved remarkably in AMD group (*p* value 0.04) in contrast to ALO group (*p* value 0.06). Though upper jaw prominence increased significantly in both groups, the change was more obvious in AMD group (*p* value 0.022). Upper to lower jaw relationship was found aesthetically better in AMD (*p* value 0.039) than ALO group (*p* value 0.073). Lip relationship was significantly better in AMD (*p* value 0.04) than ALO group (*p* value 0.06). A remarkable, significant (*p* value 0.02) and consistent change in facial profile was observed in AMD (*p* value 0.02) than ALO group (*p* value 0.05). No clinically evident and statistically significant change was observed with lower jaw as well as chin prominence. Upper to lower facial height proportion did not vary much in ALO group. In AMD group due to the mild increase in LFH in contrast to ALO, a statistically insignificant mild decrease in the ratio was observed. Upper to lower jaw height did not show any much change in both the groups. Mild increase in face height to depth ratio was noticed with AMD in contrast to ALO (Fig. 2).

Discussion

Correction of maxillary deficiency with CLP requires a team approach. Orthodontic treatment followed by the surgical correction of maxillary hypoplasia is usually performed after the cessation of mandibular growth [28, 29]. Presently distraction osteogenesis (AMD) has become a

Fig. 2 Landmarks on lateral photograph

mainstream surgical technique in treatment of jaw deficiencies [10]. Published cephalometric post treatment results in series of case reports and research papers have proved AMD to produce better results than conventional Le Fort I surgery [1, 28–34]. In the present study routine frontal and profile photographs were analysed to compare the soft tissue changes in both ALO and AMD.

The decrease in nose height can be attributed to the upward movement of the anterior nasal spine in both AMD and ALO groups. But the upward movement of nasal spine is more pronounced in ALO group since the maxilla is moved on an inclined plane during ALO [30]. Nasal widening was predominant with conventional Le Fort I maxillary advancement even though alar cinch suturing and V–Y closure have been done [31]. Lesser upward movement of subnasale may be the reason for mild alar base widening in AMD in contrast to ALO group. Since the maxillary advancement takes place in one stretch soft tissue response may not be good in ALO whereas it is over a period of time in AMD allowing better soft tissue adaptation following advancement. Large surgical movement of cleft maxilla is possible in AMD with better soft tissue adaptation.

In AMD group mild distal tipping of maxillary molars with minimal extrusion on activation of the rapid maxillary expander in majority of cases, combined with anticlockwise rotation of anterior maxilla leads to an increase in lower facial height. This is in correlation with previous studies reported [30]. Auto rotation of the mandible due to upward movement of maxilla attribute to the decrease in

lower facial height in ALO group [30]. The post treatment rotation of palatal plane in AMD cases may be due to the difficulty in deciding the optimal distraction direction [6]. This can be well eliminated by positioning of the distractor with the force vector parallel to the palatal plane [32]. The molar tipping and extrusion can be prevented by reinforcing the anchorage (including both the 1st and 2nd molars). Though incisor visibility improved invariably, upper lip length did not vary in both groups which is in correlation with the findings of Sunitha et al. [31].

Nasal prominence was significantly better enhanced in AMD group. Distraction allows large surgical movement of cleft maxilla which very well explains the greater horizontal soft tissue change in AMD group. Chua and Cheung [9] reported that the cleft maxilla after distraction was clearly more stable than that after orthognathic surgery, which could explain why DO group had better nasal projection. Upper jaw prominence was remarkably improved in AMD group than ALO group. Previous studies reported that soft tissue response varied with different types of cleft lip [8]. But the sample size considered in the study was too small to evaluate the soft tissue change with specific type of cleft. Lower jaw prominence did not exhibit much change in AMD but mildly increased in ALO group which could be due to the auto rotation of maxilla after Le Fort I advancement procedure. Considering upper to lower jaw, a lesser ratio was achieved in ALO group. Comparatively lesser upper jaw prominence added with mild increase in lower jaw prominence accounted for the lesser ratio in ALO group. Upper to lower jaw ratio observed post distraction were almost similar to the results published by Lundstrom et al. in Swedish population [28].

Lip relationship remarkably improved in AMD group. Though upper lip advanced anteriorly, a slight fall back of lower lip was observed in AMD which could be attributed to the increase in lower facial height. Tindlund and Rygh [10] also reported that in distraction cases larger upper lip advancement was observed, while lower lip goes backwards. In ALO, mild advancement of lower lip due to auto rotation of mandible was seen.

No change in chin prominence was observed in both groups. Though mandibular rotation is observed in ALO and AMD, the post treatment change in parameters PO–PG and PO–SLI occurs in same proportion. Chin prominence decreased in AMD as a result of clockwise rotation of mandible due to molar tipping and extrusion. Autorotation of mandible in ALO leads to minimal increase in chin prominence though the difference is statistically insignificant. Patients with maxillary hypoplasia exhibit an anteriorly divergent concave profile. A great degree of correction in profile is achieved by conventional osteotomies as well as distraction osteogenesis. Since distraction allows larger

anterior movement of maxilla, profile is better improved in AMD group than ALO group.

Conclusion

Though significant soft tissue changes were clearly observed in both the groups, soft tissue enhancement was more prominent and consistent in cases treated with AMD. AMD remarkably improved the soft tissue profile of the patient with improved facial balance and aesthetics. An appreciable upper anterior tooth show and better lip relationship was achieved. The concave facial profile was greatly improved. The result of the above study reassures the reliability of distraction osteogenesis in treatment of cases with maxillary hypoplasia associated with cleft lip and palate.

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