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FORGING FORWARD: A COMPARATIVE ANALYSIS OF THREE SURGICAL STRATEGIES FOR ADVANCEMENT OF THE CLEFT MAXILLA

Dental Science

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ABSTRACT

Background: Maxillary hypoplasia is a frequently observed secondary deformity in individuals born with cleft lip and palate. The impairment of maxillary growth, coupled with extensive postoperative scarring resulting from multiple previous surgeries, brings about maxillary deficiency in all planes. This results in a class III skeletal malocclusion with maxillary hypoplasia, leading to structural imbalance, functional insufficiency, and aesthetic disharmony. Non-surgical treatment options include orthodontics alone or orthopedic protraction using a face mask/reverse pull headgear. The surgical options include conventional orthognathic surgery at the Lefort I level or distraction osteogenesis, either complete or anterior maxillary distraction. This article aims to highlight all the available options for managing this complex deformity, including their merits, demerits, and any adverse effects on speech. **Aim:** To compare three different surgical procedures for managing cleft maxillary hypoplasia. The amount of distraction, stability, effects on velopharyngeal insufficiency, and soft-tissue changes have been evaluated for each procedure. **Objectives:** To compare the treatment outcomes and effectiveness of Anterior Maxillary Distraction (AMD), LeFort I Osteotomy and Total Maxillary Distraction Osteogenesis (DO) to treat cleft maxillary hypoplasia. **Result:** The search resulted in 98 articles out of which 12 articles satisfied the inclusion criteria and qualified for the final review. All studies used standardized lateral cephalograms to measure the advancement. Two studies on maxillary DO used rigid external devices while only 1 study used an internal distractor. Two studies on AMD used rigid external devices, and 4 studies reported the use of tooth-borne appliances. Fixation following Le-fort I was done using miniplates in all the studies. **Conclusion:** Conventional Le-fort I advancement should be reserved for mild cases requiring less than 8 mm advancement, AMD in moderate cases of <10 mm, and DO for severe cases requiring >10 mm advancement or in cases where clockwise movement is desired.

KEYWORDS

INTRODUCTION:

Maxillary hypoplasia is the most encountered secondary deformity as a result of cleft lip and palate with a reported incidence of about 15-50%. The reasons understood for this hypoplasia are twofold, firstly that the cleft maxilla's intrinsic potential of growth is less due to the developmental deficiency. Secondly, the iatrogenic factor created due to the surgical repair of cleft lip and palate causes scarring which inhibits the normal growth of the maxilla. The resulting class III skeletal malocclusion together with maxillary hypoplasia produces structural imbalance, functional insufficiency, and aesthetic disharmony. Two types of options are available to manage this deformity viz non-surgical and surgical. The non-surgical options include Orthodontics alone or orthopaedic protraction using face mask/ reverse pull headgear. The surgical options include conventional orthognathic surgery at Lefort I level or distraction osteogenesis (DO) either complete or anterior maxillary distraction (AMD)[1].

Conventional Le-fort I advancement for treating cleft maxillary hypoplasia has been reported by numerous authors with varying degrees of success. The relapse rate of conventional Le-fort I advancement in cleft patients is estimated to be around 25%–50% compared to 10% in noncleft individuals. The other reported complications include worsening of velopharyngeal insufficiency and inability to achieve the desired advancement due to tissue scarring resulting in compromised functional and esthetic results[2].

Distraction osteogenesis, introduced in 1993, is widely used for maxillary hypoplasia. Polley and Figueroa utilized a rigid external device for maxillary advancement. It offers benefits in cleft orthognathic cases by potentially reducing relapse and allowing greater advancement compared to conventional Le-Fort I procedures. However, drawbacks include hardware failure, extended treatment time leading to compliance issues, and the need for additional surgery to remove the appliance[1].

Anterior maxillary segmental distraction (AMD) for treating maxillary hypoplasia in cleft patients was introduced by Karakasis. Compared to the traditional methods of distraction, it has been reported to have fewer negative effects on velopharyngeal insufficiency[3].

Aim: To compare three different surgical procedures for managing cleft maxillary hypoplasia. The amount of distraction, stability, effects on velopharyngeal insufficiency, and soft-tissue changes have been evaluated for each procedure.

Objectives: To compare the treatment outcomes and effectiveness of Anterior Maxillary Distraction (AMD), LeFort I Osteotomy and Total Maxillary Distraction Osteogenesis (DO) to treat cleft maxillary hypoplasia.

MATERIAL AND METHODS:

A literature search was carried out using PubMed, Scopus, and Web of Science to identify articles reporting conventional LF-I advancement, maxillary DO, and AMD for the management of cleft maxillary hypoplasia. Medical subject headings terms used in the search were cleft and orthognathic with maxillary hypoplasia or maxillary advancement or cleft lip, cleft palate or orthognathic surgery or distraction osteogenesis or maxillary distraction.

Selection criteria:

The following inclusion criteria were chosen initially to select potential articles from the published abstract results: (1) Human clinical trials; (2) No medically compromised patients and no diseases; (3) No individual case reports (4) Articles reporting results of conventional Le-fort I advancement, maxillary distraction osteogenesis and AMD for management of cleft maxillary hypoplasia.

Data were extracted on the following items: year of publication, study design, follow-up, number and mean age of patients, mean amount of advancement achieved, stability of the results with a mean followup, latency, rate and rhythm, and consolidation period for distraction, effects on velopharyngeal insufficiency, soft tissue changes and authors' inference.

RESULTS:

The search strategy resulted in 98 articles on conventional Le-fort I advancement, maxillary distraction osteogenesis and AMD. After selection according to the inclusion criteria, 12 articles qualified for the

final review analysis.

All the studies included patients with complete unilateral or bilateral cleft palate. The surgery was performed after alveolar bone grafting and the completion of skeletal maturation. Hand-wrist radiograph was used to access the skeletal maturation.

The range of follow-up was from 6 months to 5 years. The immediate follow-up was within 1 month of surgery for conventional Le-fort I advancement and within 1 month after completion of distraction for AMD and distraction osteogenesis of the maxilla.

In the studies that evaluated maxillary distraction osteogenesis, 2 of them used rigid external device, [3, 4, 12] while 3 study used internal distractor [1, 6, 9] for distraction.

For AMD, 2 studies used rigid external device, [2, and 5] 4 studies [7, 8, 10, and 11] reported the use of tooth-borne appliances. Fixation following Le-fort I was done using miniplates in all the studies. Table 2 summarize the results of all the studies included in this review.

Table 2: Results of all studies included in this review:

Sl No	Author and year	Surgical method	Observation/Findings
1	Burstein et al. (2015)	DO	All patients had successful placement of the devices. Distraction distances were between 15.0 and 30.0mm with a mean of 18.0 mm. Operating times were<2 hours. Hardware exposure occurred in 2 cases but did not affect the final outcome. Four patients had significant velopharyngeal incompetence and required surgery. There were no clinically significant relapses, infections, or adverse effects.
2	Li et al. (2015)	AMD	All the distractions successfully corrected the midfacial deformities with no velo pharyngeal insufficiency or speech deterioration. The mean overjet increased by 14.28 mm. Statistically significant ($P < 0.05$) improvement was seen between pre-op and post-distraction and 2 years later.
3	Painatt et al. (2017)	DO	Mean maxillary advancement was 14 mm. The lower facial height, incisor exposure, upper airway and nasolabial angle were significantly increased. After 1−year follow−up, there was a significant maxillary relapse of 3.20 mm. However, the soft−tissue profile and upper airway remained stable.
4	Sahoo et al. (2014)	DO	The SNA, facial contour angle, and nasolabial angle improved. There was a significant improvement in the facial profile from concave to straight or convex. The dental crossbite was corrected and stable occlusion achieved. In two cases the existing oronasal communication was accentuated leading to nasal regurgitation of fluids.
5	Zheng et al. (2018)	AMD	Patients with midfacial hypoplasia treated using intranasal bone-borne traction hook distraction. Within the cohort of 110 patients the average advancement of A-point was 9.9 ± 4.2 mm was seen in AMD. The average changes of sella-nasion-point A (SNA) was 8.89 ± 4.30 degrees. The A point-nasion-B point (ANB) also showed increase.
6	Plazaa et al. (2015)	DO	A mean advancement of 3-10mm was obtained with a 10–15% relapse 6 months later. This was stable over 2 years and the soft tissue relapse correlated with the bony changes.
7	Richartds on et al. (2016)	AMD	At 6 months follow-up, a statistically significant improvement of 62%, 64%, 50%, 68% and 70% in VPI, resonance, nasal air emission, articulation and intelligibility, was noted respectively, with worsening in all the parameters seen in a single patient (2%).
8	Richartds on et al. (2016)	AMD	The mean advancement was 9.42 mm. 95.23% showed stable results at 6 months with a relapse rate of 4.76%. The complication rate was 25.17% with bleeding being the most common intra- and postoperative complication.
9	Chacko et al. (2013)	DO	The significant amount of maxillary advancement was achieved. In one case 2 mm of relapse was noted. There was no worsening of speech.
10	Qian et al. (2023)	AMD	Significant increases in SNA, ANB, ANS and A were observed. After distraction, a significant decrease in overjet and an increase in overbite were obtained. Anterior tipping of the upper incisors, significant anterior movement and increase in the nasolabial angle were noted.
11	Lin et al. (2018)	AMD	The average SNA, NA-FH, ANS-PNS (millimeter), and Overjet (millimeter) have change to 80.41º, 89.51º, 55.64 mm, and 2.52 mm, respectively. Mean maxillary advancement was 13.80mm with maintenance of speech quality and velopharyngeal function.
12	Dua et al. (2014)	DO	Mean advancement of maxilla was 13.4 mm. A mean of 2.3 mm horizontal relapse was observed after 1 year. Bone formation at the pterygomaxillary region was noted. Post-consolidation cusp fossa occlusion was maintained in all cases. A significant reduction in the facial concavity by 26.1º, anterior movement of upper lip, and improvement of the nasolabial angle by 17.2º was observed.

DISCUSSION

In the comprehensive care of cleft patients, managing cleft maxillary hypoplasia constitutes an arduous feat for cleft surgeons. Despite an array of research being conducted on this subject at cleft centers around the globe, there still remains room for ambiguity on the clinical outcomes of various maxillary advancement procedures.[1]

From the three techniques described in this review, it would be immature to conclude that one technique is better over another. Each has its own place in the management of maxillary hypoplasia; however, there are merits and demerits for all[4].

Age of intervention:

Strong evidence suggests that surgical advancement of the maxilla should be deferred till skeletal maturity. All the articles reviewed had their lower age limit set at 16 years for females and 18 years for males except two. One in which the lower age limit as low as 15 years. Moreover, the other in which hand wrist radiograph was used to determining the skeletal maturity[5].

The upper age limit could not be ascertained by this review as there was a marked variance among different studies. However, the mean age group of all studies was between 15.1 and 21.7 years.

All patients undergoing maxillary advancement had a successful alveolar bone grafting prior to maxillary advancement surgery.

Amount of maxillary advancement:

Chacko et al. in their meta-analysis have stated that the required amount of advancement in a cleft maxilla is often more as compared to a noncleft maxilla. Moreover, there is restriction in the advancement of cleft maxillary due to scarred palatal tissues[9].

In this review, the authors observed that the mean maxillary

advancement achieved following conventional Le-fort I advancement was between 5.17 mm and 8.4 mm.

For distraction osteogenesis, maxillary advancement ranged from 6.59 mm to 16.5 mm. For anterior segmental distraction, it ranged from 6 mm to 14.8 mm. It is evident that the maximum amount of advancement can be achieved from distraction osteogenesis followed by AMD[12].

Conventional Le-Fort I advancement yields limited results. Authors propose combining it with bilateral sagittal split osteotomy setback for deficiencies exceeding 6 mm, suitable for borderline cases. However, this approach has limitations, and significant setbacks may compromise the profile

Direction of maxillary movement:
Cleft maxilla usually has hypoplasia in all three dimensions, namely, antero-posterior, vertical as well as transverse. When addressing the maxillary deficit, the vector of movement preferred is not in a true horizontal direction, but as advancement along with the clockwise rotation of the maxilla to increase the vertical height[7].

The transverse discrepancy can be addressed with surgically assisted palatal expansion; however, this procedure remains out of the scope of this review.

Downward movement of the maxilla by conventional Le-fort I osteotomy is considered as highly unstable. The use of interpositional bone grafts from iliac crest and calvarium have decreased the likelihood of relapse; however, the results achieved as are far from ideal[8].

Plazaa et al. have reported that a significantly greater downward movement is possible with distraction osteogenesis as compared to conventional Le-fort I.

The vector of movement for AMD is limited by the arch form. Though some degree of the downward movement is possible at the anterior nasal spine without significantly disturbing the curve of Spee, the posterior nasal spine remains static.

Relapse:
The amount of relapse for maxillary advancement in noncleft patients was reported to be near 10% following conventional orthognathic surgery However, relapse is much more for maxillary advancement in cleft patients. This could be due to the resilience of the scarred tissues, which exert a pull on the advanced maxilla leading to a higher relapse. In this review, we have observed the relapse following conventional orthognathic surgery was from 21.63% to 63%. For distraction osteogenesis of the maxilla, it ranged from 22% to 45%. And for AMD, it was relatively low, ranging from 4.6% to 7%[10].

This review suggests AMD to be the most stable procedure amongst the three; however, literature on relapse following AMD was scarce.

A correlation was noted between the amount of advancement and corresponding relapse for all three techniques. More the advancement attempted lead to a higher relapse.

Types of distractors:
It would be astute to realize the profoundness of the effect the distractor has on the clinical outcomes of AMD and distraction osteogenesis of the maxilla.

For AMD, tooth-borne palatal distractors have been reported with a fairly acceptable rate of clinical success. Patient compliance is highly favourable. However, the stability and vector control during advancement is of concern. Moreover, it is supported on the molar teeth; hence, the health of teeth should be favourable for designing this type of distractor.

This review does not suggest any inferiority of tooth-borne palatal distractors over rigid external devices in terms of the amount of distraction. However, the vector of movement was more favourable for AMD with the rigid external device.

Rigid external device is gaining incremental popularity in maxillary distraction due to its stability over internal distractors. It derives its support from the calvarium and hence it is firmer and more robust. It has shown superiority to internal distractors in terms of vector control and stability for distraction osteogenesis of the maxilla, the outcome of which is that a greater amount of advancement is possible. The obvious disadvantage is of patient compliance, which has significantly restricted its use[11].

Velopharyngeal incompetence:
Most of the patients suffering from cleft palate have mild to moderate velopharyngeal insufficiency. As per the report of Burstein et al. there is a general belief that velopharyngeal insufficiency worsens with advancements >10 mm for conventional Le-fort I advancement and 15 mm for distraction osteogenesis of the maxilla. They consider that slow movement in distraction osteogenesis of the maxilla tends to stretch the tissues and hence results in lesser worsening of velopharyngeal insufficiency. A study by Hongliang li further supports this inference, in which he has reported less deterioration in velopharyngeal function following distraction osteogenesis compared to conventional Le-fort I advancement[7].

Richardson et al in their study comparing AMD and Le-fort I, have reported a significant increase in velopharyngeal insufficiency following conventional Le-fort I advancement while no change following AMD[8].

Chacko et al. used the Pitsburg's speech score to evaluate the speech and velopharyngeal function in Le-fort I advancement. Their inference was that the greater the amount of advancement, greater was the deterioration in the speech.[9]

In this review, we could not evaluate the long-term results of whether the velopharyngeal insufficiency improves with time.

Soft-tissue changes:
The final surgical outcome is assessed by the soft tissue changes that result after the orthognathic procedure. Hence, it would be prudent to assess the superiority of the three procedures in terms of their soft-tissue response.

In a study comparing distraction osteogenesis of the maxilla and Le-fort I, Harada et al. have concluded that soft-tissue changes were significantly greater following distraction osteogenesis of the maxilla not only due to greater advancement in the distraction osteogenesis of the maxilla group but also due to a higher soft tissue to hard tissue ratios for advancement. They believe that gradual stretching of tissues results in a better soft tissue response to maxillary advancement leading to a greater amount of advancement in the lip and greater change in the naso-labial angle.

CONCLUSION
In managing cleft maxillary hypoplasia, it is extremely crucial to select the surgical procedure for advancement of the maxilla.

We can evidently conclude that conventional Le-fort I advancement should be reserved for mild cases, i.e. ≤8 mm.

AMD should be preferred in moderate cases of <10 mm. A requisite for AMD using palatal distractor is that it should be firmly supported by the posterior teeth, and the vector should be favourable for distraction.

Distraction osteogenesis is to be used for discrepancies requiring >10 mm advancement or in cases where clockwise movement is desired. Relapse is considerably higher in these cases; hence, over correction of the defect should be considered.

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