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Effects of LeFort I Maxillary Impaction Surgery on surrounding structures in Vertical Maxillary Excess patients- A Review Article.

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Abstract: *The orthognathic surgery is a procedure that aims at improvement of masticatory function, esthetic harmony and structural balance. The Le Fort I osteotomy for the upper jaw repositioning is the most used for correction of vertical maxillary excess.*
The surgical jaw impaction allows correction of the gingival smile, long face syndrome, certain types of skeletal open bite and labial sealing. The maxillary impaction results in self-rotation of the jaw, accompanied by skeletal and soft tissue changes observed in sagittal advance and vertical shortening of the lower face. This review attempts to organize the existing published literature regarding the effects of LeFort I Maxillary Impaction Surgery on hard tissues as well as soft tissues and on temporomandibular joint in Vertical Maxillary Excess patients.
***Key Words**: Vertical Maxillary Excess, LeFort I Osteotomy, Centre of Rotation of Mandible.*

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I. Introduction

Vertical Maxillary Excess(VME) is clinically classified according to presence of anterior open bite, which may be or may not be associated with Oral Habits. VME often results in clockwise rotation of mandible which represents as long mid-facial height. Treatment modality for correction of Vertical maxillary excess may differ depending on the extent of discrepancy.[1] A gummy smile caused by vertical maxillary excess (VME) cannot be treated satisfactorily with adjunctive surgical approaches such as botulinum toxin injection or a crown lengthening procedure. Some orthopedic appliances, such as high-pull headgear or vertical chin cup, have been suggested as substitutes for orthognathic surgery, but their indications have been limited to young growing patients and their success relies on patient compliance.[2,3] Recently, temporary anchorage devices (TADs) have been widely used to correct a gummy smile in non-growing adult patients.[4]

TADs have limited clinical application because of attributes such as too many screws or complicated design, insufficient amount of attainable intrusion. So, to overcome these short-comings, Orthognathic surgeries prove to be an Ideal treatment option.Orthognathic surgery (OS) is a well-known surgical intervention to change and/or correct the facial-related structures. The main indications for OS are to improve function (including malocclusion, mastication, speech, respiratory function, sleep apnoea, and ocular function), minimize the treatment time, and obtain stability following orthodontic treatment, which includes the prevention of relapse. Most of the time, an ideal treatment option for VME is the reduction of the maxillary vertical dimension by LeFort I osteotomy.[5]

It would be interesting to identify the different outcomes of measuring oral function described and the effect of OS on the temporomandibular joint. This is an attempt to explain the post-operative changes after surgery.

II. Effects Of Lefort I Maxillary Impaction Osteotomy

Effects on Mandible:

The superior repositioning of the maxilla will result in concomitant autorotation of mandible which will correct the chief problem. The prediction of autorotation of mandible is done by rotating the mandible in the sagittal view by keeping the point located at the center of condyle assuming the mandibular condyle as center of rotation.

The maxillary impaction surgery causes the mandible to autorotate from its previous original vertical dimensions to a newer vertical dimension as mandible exhibits only rotary movement at this point which results in vertical and sagittal repositioning of the chin. In patients with mandibular deficiency, this sagittal advancement of mandibular autorotation is much favourable as it will result in improved sagittal relationship of the both jaws.

Various studies by T. Sperry concluded that the center of rotation of mandible falls within the general area of mastoid process. The discrepancy between the two centers of rotation, the condylar center, and the mastoid center as it affects a dental landmark, the incisal edge, and a skeletal landmark (pogonion). Analysis of the data was as follows:

1. Each center of rotation exhibited different arcs of closure.
2. The condylar center of rotation always exhibited, a less steep slope in its arc of closure. This was true for both incisal edge and pogonion.
3. Discrepancies in horizontal change per increment of vertical change (impaction) increased with increasing vertical change. Mean change for pogonion and incisal edge at 5 mm. and 10 mm. impactions

The results show clinically significant discrepancies in the horizontal component associated with vertical change. The discrepancy increased with vertical change. For maxillary impaction in the 5 to 10 mm. range, a horizontal discrepancy from the use of the condylar center of rotation may be expected to be 2 to 3 mm. as measured at the occlusal plane. This could represent a significant orthodontic problem in finishing the occlusion.[6]

Many studies in the literature mention the esthetic effects of maxillary Le Fort I impaction related to the resulting mandibular counter clockwise rotation. However, not much is mentioned regarding the effect of molar intrusion on the mandibular plane angle and the resulting esthetic effect.

Nattestad et al observed the computer-simulation model and a mock surgery model indicated that a 2-mm discrepancy in horizontal direction between the plan and the postoperative results noted from a 5-mm mandibular autorotation measuring at the lower incisors if a 20-mm error occurred in locating of the true center of rotation. The further as the determined rotation center away from the true one, the more horizontal discrepancies in predicting mandibular position would be expected. The results of his study demonstrated the similar finding that average of 5mm maxillary impaction had almost 2 mm horizontal positioning error and 1.2 mm vertical positioning error on the postoperative chin position when using the radiographic condylar center of the mandible as the rotation center of mandibular autorotation in the presurgical predictions.

The horizontal movement of the Pog point demonstrated high correlation with the vertical movement of the ANS point and the upper first molar, but not affected by the vertical movement of the PNS point. The horizontal movement of the Pog point was almost in 1:1 ratio to the vertical movement of the ANS point and the U6 point suggesting that the ratio could be used to predict horizontal chin position.

The vertical dimensions of the lower face change via maxillary impaction followed by mandibular autorotation. There are many reports in the literature on the extent of reduction in lower facial height in relation to maxillary impaction. Schendel et al, Bell et al. and Fish et al, who dealt with the question of impaction of the maxilla and autorotation of the mandible at an early stage, recommended a simulation of the outcome using templates on the lateral cephalogram.[7]

Bell et al., Fish et al. and Epker & Fish described a 1:1 ratio between lower-face shortening (cranial movement of the chin prominence) after maxillary impaction and mandibular autorotation.[8]

The esthetic changes resulting from maxillary impaction are mostly related to the degree of mandibular autorotation. Chin position was advanced in all patients who underwent Le Fort I impaction and this was noted in the literature by counter clockwise rotation of the mandible and an increase in SNB and NB-Pog.

Nattestad and Vedtofte noted 10 cases treated by Le Fort I osteotomy without mandibular surgery, to find the center of rotation of the mandibular self-rotation, which was determined later in the analysis of pre- and post-operative lateral cephalograms. The results showed a great individual variation in the centers of rotation of the mandible.

LeFort I maxillary impaction is usually indicated to reduce the lower anterior facial height with concomitant advantages of mandibular autorotation and forward chin movement. The rotation center of the mandible in the study carried out by wang 2006 also showed great interindividual variations, as previous investigators argued. The rotation center in these ten cases located lower than the radiographic condylar center of the mandible, with an average of 19.55 mm below and 2.5 mm behind, where it could locate outside the condyle head.

The inconsistency of the constructed rotation center by Reuleaux method and the radiographic condylar center of the mandible indicated that the mandibular movement might not be the pure rotation but with a combination of roll, translation and rotation. The mandible will follow any changes in occlusion resulting from maxillary impaction or molar intrusion. The noted changes in mandibular and chin position were quite variable and less predictable following molar intrusion, however, the improved esthetics can be appreciated in all patients.[7]

Effect on TMJ

Harper et al in 1990 concluded Improvements in the functional patterns of the joint after orthognathic surgery were shown to occur. Alterations in disk-condyle coordination seem to relate to the nature of the preexisting derangement and to the type of surgical procedure performed. Clicks were more likely to be resolved after prognathic reduction and maxillary impaction surgery than after mandibular advancement or combination maxillary and mandibular surgery. The sagittal split reduction osteotomy is more likely to result in a slight anterior rotation of the condylar head that would predispose it to improved coordination of disk-condyle function. However, the sagittal split advancement osteotomy tends to rotate the condylar head posteriorly and would tend to a disk-condyle incoordination.

Any maneuver that would force the condylar head in a posterior or superior direction may precipitate an internal derangement in a joint that is already predisposed to incoordination. The findings of mandibular hypomobility after orthognathic surgery may be explained in terms of TMJ internal derangement. The results of condylar pathway tracing studies support the finding by Storum and Bell of a higher incidence of hypomobility after mandibular advancement osteotomy but improved function after LeFort I osteotomy and mandibular reduction osteotomy.[9,10]

Effect on musculature and movement of the mandible

Zarrinkelk in 1995 studied Functional and Morphologic Alterations Secondary to Superior Repositioning of the Maxilla from which he concluded that the Mandibular movements during mastication are not much affected by surgery. Maximum lateral excursions during mastication were significantly lower than for controls at 6 weeks postoperatively. In fact, the major trend in all of the mandibular movement measurements was toward a decrease at 6 weeks postoperatively. None of the measurements was significantly different from normal values by the 6-month postoperative visit.[11]

In a study of mandibular range of motion before and after orthognathic surgery, Zimmer et al have shown that Le Fort I osteotomy has little or no effect on maximum incisal opening or other excursions but, if combined with mandibular surgery, reduction in mobility occurs similar to that observed in cases with mandibular surgery alone.

Vertical midfacial reduction produces an autorotation of the mandible by which the elevator muscles may become shortened. Because the muscles are not lengthened, one would not expect either active or passive distracting forces on the repositioned maxilla from the mandibular musculature. Therefore, it is not surprising that superior repositioning of the maxilla by LeFort osteotomy is probably the most stable orthognathic surgical procedure.[12] However, with the autorotation of the mandible, the biomechanics of the jaw may be altered.

Throckmorton and coworkers (1984) demonstrated in a two-dimensional biomechanical model, that superior repositioning of the maxilla should improve the mechanical advantage of the mandibular elevator musculature. They defined the mechanical advantage of a muscle in terms of the perpendicular distance from condyle to muscle over the. perpendicular distance from condyle to load. Indeed, the major effect of raising the maxilla is to decrease the distance between the point of bite and the condyle. They showed that since the insertions of the masseter and temporalis muscles are closer to the condyle than the molars, the amount of movement of these points during autorotation is less than the movement at the molars. Thus, the moment arms of the muscle are less affected by the rotation than is the moment arm for bite load. They demonstrated that the impaction of the maxilla resulted in an increased mechanical advantage for the temporalis muscle, while the mechanical advantage of the masseter muscle stayed the same" the moment arm for the masseter muscle decreased at approximately the same rate as that of the bite force. The reverse is true when the maxilla is repositioned inferiorly.[13]

Theoretically, long-faced individuals who have undergone correction of vertical maxillary excess should, therefore, be better able to produce occlusal forces given a constant muscular activity. Unfortunately, clinical investigations have not been able to corroborate these hypotheses. Johnston and coworkers (1984), evaluated a small sample of individuals with vertical maxillary excess using EMG and bite force measured before and after superior repositioning of the maxilla. Half the subjects had substantial decreases in EMG activity for a given bite force, and half had increases; only one patient reached the values predicted by the biomechanical model.

Proffit and colleagues in 1989, measured bite force before and at various intervals after superior repositioning of the maxilla in 9 patients. They found great variability in occlusal force after surgery. Further, the calculated change in mechanical advantage of the masseter and temporalis muscles using Throckmorton's model was very small postoperatively. No patient showed a change in mechanical advantage greater than 10%. Once again, although bite force was affected by this surgical procedure, the magnitude and direction of the changes were unpredictable.[14]

In 1989 Boyd et al, in a study of 2 patients with vertical maxillary excess on whom preoperative and postoperative biopsies were analyzed, have shown that the histochemical characteristics of the superficial masseter muscle undergoes minimal change in fiber distribution or fiber size after superior repositioning of the maxilla. Of note was the lack of any changes in the muscles, such as fiber atrophy or pathologic changes that might adversely affect function. They concluded that autorotation of the mandible resulting from maxillary surgery had no clinically significant effect on the fiber composition of the elevator muscles.

Patients with vertical maxillary excess have weaker facial and masticatory musculature than normal individuals. It has been postulated that the weaker musculature may contribute to the development of the characteristic facial skeleton. Proffit et al reported that VME patients who underwent superior repositioning of the maxilla had a substantial increase in their maximum molar bite force 1 year after surgery. This supports the results seen in Zarrinkelk's study where patients at 1 year had significantly higher bite forces than preoperatively and were no longer deficient when compared with controls. Bite forces increased by 18% at the molar position over 2 years. For all bite positions combined, the forces increased an average of 52.3% over the 3-year study.

Possible explanations for the slight improvement in muscle efficiency and significant improvement in bite force could include the contribution of other muscles involved in mastication. It is well known that the medial pterygoid is involved in adduction of the mandible, and it could have increased its level of activity after surgery. However, in isolated maxillary surgery, the muscles of mastication are only minimally traumatized and a compensatory increase in activity of a muscle to offset the effects of trauma is unlikely.[15]

Effect on Soft Tissue

Analysis of soft-tissue profile changes associated with total surgical maxillary intrusion reveals many significant correlations between hard-tissue and soft-tissue changes in both the horizontal and vertical dimensions. Upper lip change and horizontal soft-tissue chin change can be predicted closely from the surgically produced hard-tissue change.

With the maxilla intruded and moved posteriorly, the base of the nose and the upper lip move superiorly and posteriorly from their preoperative positions. The lip rotates posteriorly about Subnasale(SN) with an over-all increase in the nasolabial angle.

The predicted ratio of posterior movement of Labrale Superius(LS) to posterior movement of 1 was found to be approximately 0.67. Schendel and others' found this ratio to be 0.76, while Bell and Dann' reported it to be approximately 0.66. The response of Superior Labial Sulcus(SLS) and Sn to 1 retraction was a posterior movement only half as much as LS at a soft-tissue/hard-tissue movement ratio of 0.33. Thus, with maxillary retraction and intrusion, the posterior movement ratio of LS is greater than that of SLS or Sn, resulting in an increase in the nasolabial angle. This increase is slightly reduced by the fact that the columella of the nose moves upward more toward Sn than Pronasale(Pn) when the maxilla is moved superiorly. Had conventional orthodontic retraction been used, the nasolabial angle would have increased greatly, since only the incisor and A point would have been affected.

With surgery, because of movement of the entire maxilla, the soft tissue at the base of the nose is also retracted, resulting in a smaller increase in the nasolabial angle. However, because of the retraction of this soft-tissue area, there is a resultant increase in the prominence of the nose.

Following intrusion of the maxilla straight up without horizontal movement, the lip and base of the nose along with Pn move superiorly and forward. Even though the position of the maxilla is not appreciably changed in the horizontal direction, the upper lip moves anteriorly without a major angular change. This unexpected finding is due indirectly to the intrusion of the maxilla. The lip is more effectively "supported forward" by the maxillary incisor subsequent to the intrusion since it occupies a more anterior position than the preoperative lip support, the anterior alveolus. The nasolabial angle is slightly decreased as a result of the response of the columellar tangent to superior positioning of the maxilla alone. As stated before, this columellar response includes more upward movement of the base of the nose at Sn than Pn following maxillary intrusion.

The prediction of the horizontal change in the soft-tissue chin was based on simple regression equations alone. Multiple regression equations were not used, since the movement of the soft-tissue chin in relation to the underlying bony chin proved to be much less complex in nature than upper lip change relative to maxillary intrusion. Following superior repositioning of the posterior maxilla, all osseous mandibular structures, autorotated on an arc about the condylar axis. As reported by Schendel and others, soft-tissue points Inferior Labial Sulcus(ILS) and Soft tissue pogonion (PgS) rotated on the same arc in a 1: 1 ratio with B point and Pg, respectively.

The vertical and horizontal change of the lower lip (LI) in relation to the movement of its underlying hard-tissue counterpart was much more complicated than the simple 1: 1 response reported with the chin. With mandibular autorotation, LI fell inside the arc of rotation. As a result, the lip unfolded from ILS superiorly, increasing the labiomental angle.

With posterior maxillary intrusion, the mandible would be allowed to autorotate. The more the mandible was autorotated, the more LI would be positioned superiorly and forward, which would allow the lower lip to approximate the upper incisor. As a result, the protraction or retraction of would concomitantly influence the position of LI in the horizontal dimension.

These relationships and others were only slightly correlated. The apparent lack of better correlations may be due to differences in muscular tonus of the lower lip on the preoperative and postoperative radiographs of the same patient. Inconsistent tonus of the muscles of the lower lip and chin would most probably affect the position of LI rather than ILS and PgS, since the latter are more tightly bound to the underlying tissues.

One of the most salient findings of this investigation was the variability of soft-tissue response to hard-tissue movement. Variation in individual skeletal patterns and consequent variation in orthodontic, surgical, and suturing procedures may account for some of this variability. The tonicity of the facial musculature can vary with skeletal pattern and influence the integumental response to dental and skeletal changes.[16]

Mansour et al analyzed 14 maxillary impactions and seven advancements followed at least six months and reported numerous correlations, notably mandibular soft to hard tissue correlations of 1.0 and superior movement of upper lip to incisor of 0.4. Quast et al discussed the desirability of long term (at least 1.5 years post surgery) patient follow-ups to develop accurate prediction data. They basically agreed with the findings of Lines and Steinhauser but recognized the variability of hard and soft tissue spatial changes, particularly noting the added variability of predicting short to long term events.

Soft tissue changes generally associated with maxillary impaction were changes in the nasal tip, increases in alar base width, shortening of lip length, and changes in maxillary lip position concurrent with horizontal movements of the maxilla.[17]

Schendel and Eisenfeldl had an average mean follow-up of 14 months with a sample of 36 patients. In David Sarver’s study, sample size was 36 patients with a mean follow-up of 49.5 months. Superior movement of the upper lip to the maxillary incisor was only 0.38 mm, which is an extremely small movement. The measure change at 12 months was 0.15 mm, which even smaller. Tomlak had a longer follow-up period, but only 10 patients were included in the study. He found no upper lip length change less than 1% upper lip thickness change.

Soft-tissue reaction to surgical impaction can be variable. Most Of the studies have shown very little soft-tissue change and this study certainly agrees with the literature. The comparison of the 12-month postoperative groups to the 5-year records show no significant differences. It would therefore be safe to say that soft-tissue changes noted 12 months after LeFort I impaction will probably be stable for at least 5 years.[18]

Stability after Le Fort I impaction surgery

It has been suggested that the stability should be reported as a percentage of patients with a significant post-treatment change for the given treatment.[19]

Accordingly, ‘highly stable’ denotes the condition when less than 10% of the patients have a significant post-treatment change, and ‘stable’ denotes the condition when less than 20% of the patients have a significant post-treatment change and almost none have major post-treatment changes.

Patients with anterior open bite have been found to have significantly increased odds for temporomandibular disorders.[20] Specifically, Milosevic and Samuels (1998, 2000) found that patients with overbite less or equal to 2.4 mm had significantly more protrusive posterior contacts than those with overbite greater than 2.4 mm. These authors concluded that ‘overbite of not less than 2 mm should be considered an orthodontic treatment goal’.[21]

Long-face patients appear to be at a higher risk of long-term skeletal relapse, probably for at least two reasons. These patients usually require a large amount of mandibular advancement, which is known to be a risk factor in the absence of adequate muscular adaptation. In addition, patients with preoperative high mandibular plane angle have an elevated risk for unfavourable condylar remodelling or condylar resorption with bite opening after surgical-orthodontic treatment.[22,23]

Mandibular changes after open bite closure by orthognathic surgery may negatively impact the long-term stability of the closure. While the maxilla showed similar minor changes in both groups, confirming previous findings, the mandible considerably rotated posteriorly, with increases in the SNB and mandibular plane angles. Adaptive changes in the dentition have been found to occur as the result of partial compensation for unfavourable skeletal changes.[24–26]

III. Conclusion

Superior repositioning of the maxilla via LeFort I Maxillary Impation has proved to be a useful method of treating patients with vertical maxillary excess. It is indicated primarily in patients with lip incompetence, excessive exposure of maxillary anterior teeth, long lower facial height, contour-deficient chin, and either Class I or Class II malocclusion.The mandible will follow any changes in occlusion resulting from maxillary impaction.

In any facial reconstructive surgery, the importance of the orofacial muscles upon form, function, and esthetics must be recognized. Once this fact is acknowledged, these muscles can be manipulated to advantage by the surgeon. The undesirable effects seen in the perioral area following some maxillary osteotomies can be avoided. Predictable lip response to surgery can also be obtained, thus eliminating surgical prediction problems. Last, certain abnormal anatomic conditions of the perioral facial muscles can be corrected by controlled surgical repositioning of the muscles.

Future standardized studies will help us make accurate predictions following maxillary impaction.

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