Cephalometric Evaluation of Facial Soft Tissue Changes after Orthodontics and Bimaxillary Orthognathic Surgery Treatment in Patients with Skeletal Class III Discrepancy

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Abstract

Background: Severe skeletal class III malocclusions usually need a combined treatment of orthodontics and orthognathic surgery. Knowing about changes occurred during these treatments lead to improve facial esthetics and better treatment results.

Objectives: This study was done to determine cephalometric changes of facial soft tissue after combined treatment in patients with skeletal class III problem.

Methods: 25 patients with skeletal class III discrepancy who needed a combined treatment, were selected. Changes in nasolabial angle, upper lip and lower lip to E-line distance, angle of convexity, lip-chin-throat angle and lower anterior facial height were measured before and 6-12 months after surgery. Changes in parameters were analyzed with Paired t-test.

Results: Upper lip to E-line distance (P < 0.0001) and angle of convexity (P < 0.001) changed significantly following surgical procedures while changes of other parameters were not significant.

Conclusions: Clinical changes in the soft tissue following a combination of orthodontic treatment and orthognathic surgery in patients with skeletal class III discrepancy are significant while these changes mostly improves esthetics of patient’s facial profile.

Keywords: Orthognathic Surgery, Angle Class III Malocclusion, Cephalometry

1. Background

Deformities like severe skeletal class III discrepancy often need a combined treatment of orthodontics and orthognathic surgery to improve facial esthetics, proportionate patient profile and reach an appropriate function (1-3). The increased tendency towards facial esthetics and soft tissue profile is due to the fact that facial beauty has been known as the most important factor in physical attractiveness and beauty (4). A successful surgical treatment plan for patients who need orthognathic surgery not only includes hard tissue but also should consider the cephalometric analysis of the soft tissue that indicates the defective skeletal structure beneath it. As the thickness of the facial soft tissue is highly variable and various shapes and forms of teeth and bones are available as well, the results of the mentioned analysis can be highly different from the soft tissue appearance. Thus, a method is required to provide a comprehensive cephalometric analysis of the soft tissue in addition to that of the hard tissue (5). It is obvious that our first goal in patients with severe skeletal class III discrepancy is to enhance esthetic outcomes and increase patient satisfaction. So if we can predict soft tissue changes after surgery, the rate of success can increase.

2. Objectives

This study was done to determine cephalometric changes of facial soft tissue after bimaxillary orthognathic surgery in patients with skeletal class III discrepancy.

3. Methods

This case-control study was done by measuring soft tissue parameters before and after treatment. 25 patients
Chalipa J et al. (21 females and 4 males, mean age: 21.6) were selected among patients with severe skeletal class III disharmony and long face in Tehran University of Medical Science who needed a combined treatment of orthodontics and bimaxillary orthognathic surgery (mandibular setback and maxillary advancement and impaction). All patients were of Iranian race. The average duration of treatment was 34 ± 8 months. Their lateral cephalograms were available in archive, so no ethical considerations needed. Patients with syndromes, lip or palate cleft, history of trauma and any plastic surgery like rhinoplasty or genioplasty were excluded from study.

All patients were treated with a similar orthodontic treatment protocol. Lateral cephalograms were taken immediately before and 6 - 12 months after surgery in natural head position (NHP) (6), centric occlusion and relaxed lips (7) and traced by one trained operator, manually on an acetate tracing paper. Frankfort plan (FH) was considered as horizontal reference line and Glabella-perpendicular to FH line was assumed as vertical reference line. For increasing reliability, cephalograms were traced again after one month by the same person. Intra-examiner reliability was estimated high (85%). Figures 1 and 2 showed pre-surgical and post-surgical lateral cephalograms of a patient included in the study. Note the changes that occurred in soft tissue parameters.

6 cephalometric parameters were analyzed in this study including:
1. Nasolabial angle (angle between columella tangent and upper lip tangent.)
2. Upper lip to E-line distance
3. Lower lip to E-line distance (The lower lip would be 2 mm behind the line, and the upper lip 4 mm behind the line.)
4. Angle of convexity (an angle which is formed by soft tissue glabella, subnasale, and soft tissue pogonion.)
5. Lower anterior facial heigh (a distance between the subnasal and soft tissue menton.)
6. Lip-chin-throat angle (which is formed by lower lip, submental tangent and neck tangent)

3.1. Statistical Analysis
For statistical analysis SPSS (statistical package for social sciences) software version 21/0 was used. Due to the quantitative nature of parameters and following a normal distribution, Paired t-test was used to compare changes of parameters before and after treatment.

3.2. Ethical Considerations
As pre-treatment and post-treatment lateral cephalograms were available in archive, any ethical consideration was needed.

4. Results
This study was done on 25 patients including 4 males and 21 females (16 % vs 84%).

Pre-operative nasolabial angle was 100.66 ± 8.66°. This parameter was reduced to 98.09 ± 9.8 after surgery. The average reduction was 2.29° (P = 0.21).

Upper lip to E-line distance was -7.31 ± 2.88 mm before surgery, but it was increased significantly after surgery (-4.18 ± 2.31 mm). The average increase was 3.2 mm (P < 0.0001).

Lower lip to E-line distance reduced insignificantly after surgery (P = 0.42). It was -4.44 ± 3.79 mm at first and after 6 - 12 months it was estimated -1.89 ± 2.89 mm. It fell about 0.52 mm on average (P = 0.52).

Angle of convexity which is formed by soft tissue glabella, subnasal, and soft tissue pogonion was 8.74 ± 7.9° before treatment and changed to 15.4 ± 8.18°. It increased approximately 7.43° (P < 0.0001).

Lower anterior facial height was 56.78 ± 3.05 mm before surgery and it was 58.03 ± 3.15 mm that changed 1.09mm. According to statistical analysis, it was a non-significant change (P = 0.12).

Lip-chin-throat angle changed insignificantly, after treatment. It was 105.11 ± 14.05° at first and changed to

Figure 1. Lateral Cephalometry of a Patient Before Surgery

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109.88 ± 12.49. The mean increase in this angle was 7.13° (P = 0.07).

Reported numbers have two decimal places because they are mean values of each parameter.

Statistical analysis of parameters and mean changes of them are written in Tables 1 and 2, respectively.

According to these findings all parameters changed after surgery but according to statistical analysis only changes in upper lip to E-line distance and angle of convexity were significant. (P < 0.0001) By the way, all changes occurred in order to improve facial esthetics.

5. Discussion

This study was done on patients with severe skeletal class III malocclusion who received a combined treatment of orthodontics and orthognathic surgery to achieve functional and esthetic goals. The measured values were obtained from archive like studies done by Altug-Atac et al. (2008) (8) and Momeni et al. (2012) (9). Analysis was done by assessment of lateral cephalograms taken before and 6 - 12 months after surgery. Pretreatment radiographs were also used in order to overcome misinterpretations resulting from the presence of brackets, which may present a problem in any study evaluating soft tissue changes, especially in the lips (8). Studies about long term soft tissue changes after combined treatments have shown that although soft soft-tissue changes occur after orthognathic surgery but they are minimal and there are no significant differences between average annualized soft tissue changes (8, 10-12). We found that all investigated parameters changed after surgery. Changes in upper lip to E-line distance and angle of convexity were significant. Other parameters changed insignificantly but their change helped to improve facial esthetics after surgery.

According to Gjorup et al. (1991), considerable facial changes and improvement took place after the surgical procedure (13). Ghassemi et al. (2014) by evaluation of soft and hard tissue changes after bimaxillary orthognathic surgery in class III patients reported that the distance from upper lip to E-line increased by 2.6 mm after surgery (P < 0.001), while, the lower lip distance to E-line decreased slightly by 0.9 mm (P < 0.01) (14). These results were also observed in our study. Nasolabial angle was decreased by 9.5° after surgery (P < 0.001). In our study, changes in nasolabial angle was insignificant.

E-line (Ricketts esthetic line) is a line drawn between Pn-Pog’. Usually it is expressed that upper lip must be 4 mm behind this line, while lower lip is 2 mm behind it (15). Ricketts (1961) emphasized that this parameter can affect by age, sex and etc (16). In our study, post-operative upper lip to E-line distance was 4.18 mm which was in the normal range. In Yun et al. (2015) study about two-jaw surgeries in cleft patients, the mean minimal distance between E-line and the upper lip was 6.52 mm before surgery and 1.81 mm after surgery (17). This result is similar to our findings and Kerr and Lin study (1998) that announced upper lip to E-line distance decreased after surgery, significantly (18). In spite of our study, lower lip to E-line distance also reduced significantly in that research.

Nasolabial angle reduced 2.29 degree on average in our study. It was 100.66 ± 8.66° immediately before surgery and became 98.09 ± 9.84° after surgery which was not significant. The mean nasolabial angle was 72.7° before surgery. It was increased to 88.7° after surgery in Yun study (17). According to Ghassemi et al. naso-labial angle was decreased by 9.5° after surgery (P < 0.001) (14). This finding confirmed our results but reduction was more than our study. In a study done by Enacar the results suggested that the soft tissue ratios seen in double-jaw surgery were similar to those in mandibular setback surgery alone, with the exception of the changes in nasal tip projection and the upper lip area (19). The authors proposed that changes of nasolabial angle after bimaxillary class III surgery was unpredictable. Jacobsone et al. observed 11.2 degree increasing in this angle following surgery (20). In another study done by Marsan (2009) it was found that the increase in nasolabial angle was correlated with the decrease in ANS-
Table 1. Central Diffusion Index of Parameters Before and After Treatment

| Variables                        | N  | Mean  | SD  | Min | Max |
|---------------------------------|----|-------|-----|-----|-----|
| Nasolabial angle before treatment | 25 | 100.66| 8.66| 82  | 117 |
| Nasolabial angle after treatment | 22 | 98.09 | 9.84| 80  | 112 |
| Upper Lip to E-Line before treatment | 24 | 7.31 | 2.88| -12 | 0   |
| Upper Lip to E-Line after treatment | 22 | -4.18| 2.31| -8  | 5   |
| Lower Lip to E-Line before treatment | 25 | -1.44| 3.79| 8   | 5   |
| Lower Lip to E-Line after treatment | 22 | 1.89 | 2.98| -7  | 4   |
| Convexity angle before treatment | 25 | 8.74 | 7.9 | -2.5| 26  |
| Convexity angle after treatment | 22 | 15.4 | 8.38| -15 | 26  |
| LAFH before treatment           | 25 | 56.78| 4.05| 51.6 |63.6 |
| LAFH after treatment            | 22 | 58.03| 3.15| 50  | 64.7|
| Lip-chin-throat angle before treatment | 18 | 105.11|14.05|86   |138  |
| Lip-chin-throat angle after treatment | 16 | 109.88|12.49|88   |138  |

Table 2. Changes of Parameters Before and After Treatment

| Variables                        | Mean   | Standard Error | P Value |
|---------------------------------|--------|----------------|---------|
| Nasolabial angle before treatment | -2.29  | 1.76           | 0.21    |
| Nasolabial angle after treatment |        |                |         |
| Upper Lip to E-Line before treatment | 3.2    | 0.56           | 0.0001  |
| Upper Lip to E-Line after treatment |      |                |         |
| Lower Lip to E-Line before treatment | -0.52  | 0.64           | 0.42    |
| Lower Lip to E-Line after treatment |      |                |         |
| Convexity angle before treatment | 7.43   | 1.99           | 0.001   |
| Convexity angle after treatment |        |                |         |
| LAFH before treatment           | 1.09   | 0.68           | 0.12    |
| LAFH after treatment            |        |                |         |
| Lip-chin-throat angle before treatment | 7.13   | 3.49           | 0.07    |
| Lip-chin-throat angle after treatment |      |                |         |

Gn distance. The mean increase in this angle was just 1.9 degree (21). Khamash et al. showed that the nasolabial angle increased (1.88°) because of columella upturning in cases of maxillary advancement (22).

Lip-chin-throat angle didn't increase significantly. It was 105.11 ± 14.05 in pre-surgery measurements and increased to 109.88 ± 12.49 degree. According to Ghassemi, similar results were seen. Changes in this angle was significant in their study (23). This angle has an important role in esthetics and it must be surveyed in orthognathic surgery cases. But in former studies, the importance of its changes was not counted.

According to our study most of soft tissue parameters became normal after surgical treatment of class III patients. According to Mobarak et al., changes in the soft tissue profile following small setbacks were less predictable compared to large setbacks and females demonstrated greater soft tissue movement in response to skeletal repositioning compared to males (24). Soft tissue reactions after orthognathic surgery maybe associate with factors like the amount of deformity, soft tissue thickness, muscular stretch and etc (25, 26).
In a 5 year follow up of patients by Lee et al. after superior repositioning of maxilla by LeFort I osteotomy, it was said that in both jaws, long-term changes in soft tissue landmarks exceeded hard tissue changes, meaning soft tissue points tended to move downward even if hard tissue points were stable (27). Increasing in soft tissue thickness may lead to lower accuracy in prediction of soft and hard tissue correlations. So surgeons must pay attention to soft tissue features of their patients and use the data to predict profile changes after surgeries like LeFort I osteotomy or mandibular surgeries.

Most of our sample size were females. This indicates that females accepted orthognathic surgery treatment plans more than males (26). Apart from the facial proportions, the degree of convexity or concavity of facial profile and their sequence seem to be important for the esthetic effects. “Male” profiles in contrast to “female” profiles exhibited more conspicuous facial features such as pronounced convexity and concavity (28). Our study didn’t counted sexual differences but in a study by De Smit et al. it was concluded that there is no difference in profile esthetic perceptions between males and females (29).

One of our major limitations was that achieving a sufficient number of eligible patients required a lot of time. The authors proposed that other studies can be done to assess changes in other related soft tissue landmarks after such treatments. Moreover, evaluation of facial soft tissue changes over time more than 12 months after treatment can be the subject of another article.

5.1. Conclusion

This study was about changes in soft tissue parameters after orthognathic surgery in patients with skeletal class III problem. It was concluded that:

1. Nasolabial angle decreased 2.29° on average after surgery.
2. Upper lip to E-line distance increased 3.2 mm and lower lip to E-line distance decreased 0.52 mm following surgery.
3. Angle of convexity also increased 7.43°.
4. Lower anterior facial height increased about 1.09.
5. Lip-chin-throat angle increased about 7.13 degree.
6. Changes in angle of convexity and upper lip to E-line was significant (P < 0.0001) where as other changes were not significant in statistical analysis.
7. Clinical soft tissue changes after orthodontics and orthognathic surgery treatments in severe skeletal class III patients are obvious and these changes improve patient’s esthetics.

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