Research Article

Hard and Soft Tissue Changes in Patients with Borderline Class III Malocclusion after Maxillary Advancement or Mandibular Setback Surgery: A Cross-Sectional Study

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Abstract

Background: The primary aim of this study was to assess the esthetic profile and hard and soft tissue changes in patients with borderline class III malocclusion after maxillary advancement or mandibular setback surgery. The secondary aim was also to evaluate the patients’ face attractiveness after different surgical treatment.

Materials and Methods: This observational cross-sectional study evaluated 50 patients with borderline class III malocclusion with a mean age of 29 ± 4 years treated from 2014 to 2019. They were divided into two groups based on the type of surgical treatment undergone: 13 patients were treated with mandibular setback (4 males, 9 females), and 37 patients with maxillary advancement (16 males, 21 females). Hard and soft tissue parameters were measured pre and postoperative evaluation. Frontal and profile photographs of these patients were judged by 15 orthodontists, 15 oral and maxillofacial surgeons, and 15 laypeople before and after surgery. The most and the least attractive profiles were scored 10 and 0, respectively. T-test was used to analyze normally distributed data while Mann-Whitney test for non-normally distributed data. The Kruskal-Wallis test was used to compare the esthetic judgement between the three groups of observers. Pairwise comparisons were carried out using the Mann-Whitney test.

Results: Nasolabial angle, SNA, U1/NA (°), U1/NA (mm), L1/NB (°) and L1/NB (mm) were significantly different between the two groups p<0.04, p<0.001, p<0.001, p<0.005, p<0.07, p<0.08, p<0.01 respectively Orthodontists, oral and maxillofacial surgeons, and laypeople all gave a lower score to mandibular setback and higher score to maxillary advancement in terms of facial profile esthetics (P<0.001).

Conclusion: Some cephalometric parameters were significantly different between the two groups. The maxillary advancement seemed to provide better results in facial profile esthetics than mandibular setback for patients with borderline class III malocclusion.

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Introduction

Class III malocclusion is a complex condition in terms of diagnosis and treatment planning [1, 2]. In the recent years, the demand of class III patients for surgical correction of their malocclusion has greatly increased [3-7]. The treatment goals in correction of class III malocclusion should include achieving optimal function and esthetics, long-term stability of outcomes and selecting a surgical procedure with minimal complications. Patient satisfaction should also be considered since it is an important factor affecting the quality of oral health [8, 9].

The final postoperative esthetic result is determined by the quality of treatment procedure, soft tissue compatibility and patient expectations [12, 13]. The lips and the chin are two major components influenced by the mandibular setback and maxillary advancement surgery [13-16]. One important reason for the increased frequency of surgical procedures of the maxilla is to achieve long-term stability of the results [4, 5]. Selection of the jaw for the surgical procedure generally depends on the position of the maxilla and mandible. There is often controversy among the orthodontists and oral and maxillofacial surgeons in selection of mandibular setback or maxillary advancement as the surgical procedure of choice for management of borderline class III patients. This can cause significant changes in facial indices [17]. Soft and hard tissue changes following the maxillary advancement or mandibular setback surgery in borderline class III patients are among the main concerns of orthodontists and maxillofacial surgeons. Incorrect selection of the type of surgical procedure can result in aesthetic changes in the hard and soft tissues and subsequent dissatisfaction of patients and discouragement of the clinicians [1].

Considering the existing controversy regarding the choice of the surgical treatment of patients with borderline class III malocclusions, the primary aim of this study was to assess the esthetic profile and hard and soft tissue changes after maxillary advancement or mandibular setback surgery. The secondary aim was also to evaluate the patients’ face attractiveness after different surgical treatment.

Materials and Methods

For this observational cross-sectional study, the data of subjects with borderline class III malocclusion ranged between 18 and 40 years treated from 2014 to 2019 were recruited from the files of the Orthodontic Department at the University of XXXXXXXXXXX. The 50 consecutive patients (mean age of 29 ± 4 years) were divided into two groups based on the type of surgical treatment undertaken: 13 patients were treated with mandibular setback (4 males, 9 females), and 37 patients with maxillary advancement (16 males, 21 females). T-test showed that 2 groups were matched at the base line ANB < 0.8, Wits < 0.82. Hard and soft tissue parameters were measured pre and postoperatively on the lateral skull cephalometrics. Frontal and profile photographs of these patients were also evaluated by 15 orthodontists, 15 oral and maxillofacial surgeons, and 15 laypeople before and after surgery. The information was handled according to the requirements and recommendations of the Declaration of Helsinki. Ethical approval was obtained from the Local Research Ethics Committee (No 2335) and all subjects gave their written informed consent.

The inclusion criteria were as follows:

i. Sella-Nasion-A (SNA) ≤ 78, Sella-Nasion-B (SNB) ≥ 82, A-Nasion-B (ANB) ≤ 0.
ii. Class III molar relationship.
iii. No mandibular shift.
iv. Concave facial profile.
v. Negative overjet.
vi. No congenital disease or endocrine disorders.

Thirty-seven patients underwent maxillary advancement while thirteen patients had mandibular setback at the XXXXXXXXXXX. Soft tissue parameters including the upper lip length (from the subnasale to the most inferior portion of the upper lip at the midline), lower lip length (from the stomion to the labiomental fold), upper lip to E line [E line was drawn from pronasal (Pn) to soft tissue pogonion (Pog)], lower lip to E line, lip-chin-throat angle [formed by the lip-chin line (labrale inferior and pogonion) and submental tangent], nasolabial angle (the angle formed by the intersection of the tangents of the columella and the upper lip), and soft tissue facial angle (the angle formed by the intersection of soft tissue nasion-soft tissue suprapogonion line with the Frankfort horizontal plane), and hard tissue parameters including SNA (the angle between the anteroposterior position of the maxilla and the anterior cranial base), SNB (the angle between the anteroposterior position of the mandible), ANB (the angle indicative of the magnitude of the discrepancy between the maxilla and mandible), the Wits appraisal (Ao-Bo), Y-axis (N-S-Gn), gonial angle, Go-Gn-Sn, N-Me (anterior facial height), S-Go (posterior facial height), the Jarabak index (S-Go-Me), inclination angle (Sn’-P’al), U1-SN (°), U1-NA (°), U1-NA (mm), L1-Mand (IMPA), L1-NB (°), L1-NB (mm) and interincisal angle were measured before and after surgery.

The frontal and profile pictures of the face were also evaluated by 15 orthodontists, 15 oral and maxillofacial surgeons, and 15 laypeople randomly recruited at the XXXXXXXXXXX. The two extraoral photos were shown singularly as hard copy to each examiner in a quiet and bright room, without any external influence. The evaluators were blinded to the type of surgical treatment of the subjects, and they were only asked to subjectively judge each picture, scoring the most attractive profile with 10 and the least attractive profile with 0.

Statistical Analysis

The Kolmogorov-Smirnov test was used to assess the normal distribution of data regarding hard and soft tissue indices. T-test was used to analyze the normally distributed data while the Mann-Whitney test was used to analyze the non-normally distributed data. The Kruskal-Wallis test was used to compare the esthetic profile between the three groups of observers. Pairwise comparisons are carried out using the Mann-Whitney test. Intraclass correlation coefficient (ICC) was calculated to determine the inter-observer agreement. Level of
significance was set at 0.05. Data were analyzed using SPSS version 22 (SPSS Inc., IL, USA).

Table 1: Changes in hard and soft tissue cephalometric parameters in maxillary advancement.

| Indices                      | Pre-surgery | Post-surgery | P value |
|------------------------------|-------------|--------------|---------|
| Upper lip length             | 20.9±9.7    | 23.2±8.6     | 0.007   |
| Lower lip length             | 50.2±4.1    | 48.4±6.1     | 0.049   |
| Upper lip to E Line          | -7.2±2.8    | -3.1±3.9     | 0.001   |
| Lower lip to E Line          | -2.3±2.9    | -2.4±2.8     | 0.818   |
| Lip chin-throat angle        | 109.7±5.9   | 110.3±3.2    | 0.7     |
| Nasolabial angle             | 100.6±6.8   | 94.1±5.5     | 0.050   |
| SNA                          | 79.3±3.4    | 83.4±1.2     | 0.001   |
| SNB                          | 80.6±2.2    | 80.1±4.8     | 0.859   |
| ANB                          | -2±1.4      | 3.2±1.0      | 0.001   |
| Wits appraisal               | -4.8±2.5    | 0.1±1.9      | 0.001   |
| Y-axis (N-S-Gn)              | 67.7±4.3    | 69.4±4.7     | 0.001   |
| Gonial angle                 | 127.6±3.7   | 128.6±2.5    | 0.085   |
| Go-Gn-Sn                     | 32.9±6.5    | 34.9±6.9     | 0.002   |
| N-Me (Ant face h)            | 119.7±8.9   | 120.1±8.3    | 0.700   |
| S-Go (post-Face h)           | 79.1±5.5    | 75.1±9.2     | 0.001   |
| Jarabak index                | 64.5±3      | 62.6±3.1     | 0.001   |
| Inclination angle            | 83.9±3.1    | 83.1±3.8     | 0.194   |
| U1-SN (°)                    | 109±9.1     | 107.9±9.1    | 0.578   |
| U1-NA (°)                    | 29.4±4.8    | 22.9±4.1     | 0.001   |
| U1-NA (mm)                   | 5.2±2.6     | 3.3±3.7      | 0.004   |
| L1-Mand (IMPA)               | 85.8±7.6    | 87.9±6.1     | 0.160   |
| L1-NB (°)                    | 22.7±6.7    | 24.8±6.1     | 0.086   |
| L1-NB (mm)                   | 3.9±2.5     | 4.7±2.9      | 0.067   |
| Interincisal angle           | 129.3±2.1   | 129.8±1.9    | 0.799   |

Results

Tables 1, 2 and 3 show pre and post-surgical cephalometric changes in maxillary advancement, mandibular setback, and between 2 groups respectively. The upper lip length, lower lip length, upper lip to E line increased in the maxillary advancement group P<0.007, P<0.04, P<0.001 respectively. The upper lip length, lower lip length did not have any significant changes in mandibular setback group. The upper lip to E line and lower lip to E line had significant changes in the mandibular setback group. The changes in the Jarabak index were significant in the maxillary advancement group P<0.001, but not in the mandibular setback group. The U1-NA (°) and the U1-NA (mm) significantly decreased in the maxillary advancement group, while these two parameters did not show any significant changes in mandibular set back. The L1-NB (mm) significantly decreased in the mandibular setback group while this parameter showed no change in the maxillary advancement group. (Tables 1 & 2).

Table 2: Changes in hard and soft tissue cephalometric parameters in mandibular setback.

| Indices                      | Pre-surgery | Post-surgery | P value |
|------------------------------|-------------|--------------|---------|
| Upper lip length             | 18.7±9.7    | 20.7±6.2     | 0.061   |
| Lower lip length             | 46.1±4.2    | 45.1±3.2     | 0.771   |
| Upper lip to E Line          | -5±2.4      | -2.8±2.2     | 0.002   |
| Lower lip to E Line          | 2.1±3.4     | 1.1±2.3      | 0.050   |
| Lip chin-throat angle        | 111.9±6.5   | 118.6±5.7    | 0.041   |
| Nasolabial angle             | 94.1±7.2    | 91.1±7.2     | 0.084   |
| SNA                          | 82.7±3.5    | 83±2.6       | 0.710   |
| SNB                          | 83.4±4.4    | 81.2±3.1     | 0.004   |
| ANB                          | -1.7±1.5    | 2.3±2.2      | 0.001   |
| Wits appraisal               | -4.1±2.3    | -0.2±1.6     | 0.001   |
| Y-axis (N-S-Gn)              | 65.3±2.3    | 67.4±2.4     | 0.023   |
| Gonial angle                 | 127.6±5.9   | 127.1±6.6    | 0.283   |
| Go-Gn-Sn                     | 29.6±6.0    | 29.9±4.4     | 0.521   |
| N-Me (Ant face h)            | 119.1±6.3   | 120.1±7      | 0.516   |
| S-Go (post-Face h)           | 79.8±6.9    | 81.7±1.3     | 0.166   |
| Jarabak index                | 66.4±5.7    | 66.9±7.4     | 0.548   |
| Inclination angle            | 85.3±5.9    | 85.4±4.2     | 0.395   |
| U1-SN (°)                    | 110±4.2     | 110.6±3.9    | 0.325   |
| U1-NA (°)                    | 28.5±3.9    | 24.8±4.9     | 0.941   |
| U1-NA (mm)                   | 5.2±3.5     | 5.2±3.3      | 0.822   |
| L1-Mand (IMPA)               | 91.6±1.6    | 90.8±7.8     | 0.832   |
| L1-NB (°)                    | 27.5±5.9    | 25.5±9.8     | 0.201   |
| L1-NB (mm)                   | 6.2±2.1     | 5.2±2.3      | 0.029   |
| Interincisal angle           | 125.6±8.8   | 123.8±9.1    | 0.246   |

Tables 3 shows that nasolabial angle, SNA, U1-NA (°), U1-NA (mm), L1-NB (°) and L1-NB (mm) had significant changes between two groups. A correlation coefficient was calculated for the data after two weeks, which was found to be 0.9 and indicated no significant change between the two groups. Table 4 showed the mean score of facial attractiveness which was given by orthodontists, maxillofacial surgeons and laypeople in two different surgical procedure. Comparison of profile esthetics revealed that all three groups gave a higher esthetic score to the patients treated with maxillary advancement group. Mann-Whitney test showed that the difference between the surgical procedures in 3 evaluated groups were significant.

The score given to maxillary advancement by the orthodontists was the lowest in comparison with maxillofacial surgeons and the laypeople. The score given by the laypeople was higher than that of other two groups regarding to maxillary advancement. In (Table 5) Kruskal-Wallis test revealed that, this difference between 3 evaluating person was significant regarding to maxillary advancement (P<0.01) and also regarding to mandibular set back. The interobserver agreement was found to be moderate. The highest agreement was found to be between orthodontists and surgeons (ICC=0.471 P=0.046) followed by the agreement between surgeons and laypeople (ICC=0.452, P=0.056), and the one between orthodontists and laypeople (ICC=0.421, P=0.074).
Table 3: Changes in hard and soft tissue cephalometric parameters between maxillary advancement and mandibular setback.

| Surgery          | Maxillary advancement | Mandibular setback | P value |
|------------------|-----------------------|--------------------|---------|
| Indices          |                       |                    |         |
| Upper lip length | 2.4±2.9               | 1.3±2.1            | 0.721   |
| Lower lip length | -1.5±2.4              | -1.3±2.7           | 0.197   |
| Upper lip to E   | 4.3±2.8               | 2.2±3.5            | 0.249   |
| Lower lip to E   | -0.2±1.8              | -0.1±1.5           | 0.332   |
| Lip chin-throat  | 1.1±2.6               | 6.1±4.7            | 0.834   |
| Nasolabial angle | -5.1±4.3              | -3.6±3.4           | 0.049   |
| SNA              | 3.2±3.7               | 0.2±2.5            | 0.001   |
| SNB              | -0.6±1.2              | -2.2±2.6           | 0.176   |
| ANB              | 5.2±2.2               | 4.2±3.6            | 0.118   |
| Wits appraisal   | 4.2±3.4               | 4.1±3.9            | 0.344   |
| Y-axis (N-S-Gn)  | 1.5±1.7               | 1.2±1.7            | 0.728   |
| Gonial angle     | 1.4±1.1               | -1.9±2.1           | 0.378   |
| Go-Gn-Sn         | 1.9±2.7               | 0.2±1.7            | 0.032   |
| N-Me (Ant face h)| 1.1±1.3               | 1.6±2.2            | 0.964   |
| S-Go (post-Face h) | -3.4±4.8        | 2.3±2.7            | 0.05    |
| Jarabak index    | -2.3±0.9              | 0/1±2.1            | 0.023   |
| Inclination angle| 0.2±1.8               | 0/1±1.1            | 0.269   |
| U1-SN (°)        | -1.4±1.3              | 0.3±1.4            | 0.609   |
| U1-NA (°)        | -6.8±4.3              | -0.3±1.6           | 0.005   |
| L1-Mand (IMPA)   | 1.9±2.4               | -0.6±1.3           | 0.364   |
| L1-NB (°)        | 2±2.1                 | -1.7±2.4           | 0.082   |
| L1-NB (mm)       | -0.8±1.6              | -1.5±1.6           | 0.017   |
| Interincisal angle| 0.1±1.1              | -1.5±1.7           | 0.474   |

Table 4: Mean score of esthetic profile given by orthodontists, maxillofacial surgeons and laypeople to patient profiles in the two groups of mandibular setback and maxillary advancement.

| Examiner          | Mandibular setback (n=13 patients) | Maxillary advancement (n=37 patients) | P value |
|--------------------|-------------------------------------|---------------------------------------|---------|
|                    | Mean ± SD | Mean ± SD |                        |         |
| Orthodontists      | 4.5±0.5   | 5.2±0.7   | 0.002                 |         |
| Oral and maxillofacial surgeons | 6.1±0.7   | 7.4±0.7   | 0.001                 |         |
| Laypeople          | 5.7±0.6   | 6.1±0.7   | 0.001                 |         |

Table 5: Comparison of the esthetic profile and frontal view of patients in the two groups according to the opinion of the three groups of examiners.

| Examiner          | Mandibular setback (n=13 patients) | Maxillary advancement (n=37 patients) | P value |
|--------------------|-------------------------------------|---------------------------------------|---------|
|                    | Mean ± SD | P value | Mean ± SD | P value |         |
| Orthodontists      | 4.5±0.5   | 0.001   | 5.2±0.7   | 0.001   |         |
| Oral and maxillofacial surgeons | 6.1±0.7   | 7.4±0.7   | 0.001     |         |
| Laypeople          | 5.7±0.6   | 6.1±0.7   | 0.001     |         |

Discussion

This study aimed to assess the esthetic profile and hard and soft tissue changes in borderline class III patients after maxillary advancement and mandibular setback surgery. The results showed that maxillary advancement was preferred to mandibular setback for borderline class III patients since all three groups of orthodontists, oral and maxillofacial surgeons and laypeople gave a higher score to the esthetic appearance of patients in the maxillary advancement group. In line with our findings, Ghassemi et al. compared maxillary advancement and mandibular setback surgery for skeletal class III patients and found that maxillary advancement had greater effect on the nose, cervical length and upper lip [1]. However, their study had a small sample size and the two groups of patients were not matched. Moreover, their study was conducted in Germany and a number of factors, such as experience and expertise of the surgeons and race of patients, were quite different from our study.

Proffit et al. performed maxillary advancement and increased the airway width [5]. They added that this surgical procedure enhanced the esthetic appearance of the nasolabial fold and cervical region. Another study reported that minimal vertical change following maxillary advancement caused forward rotation of the mandible and positively changed the cervical length [5]. Sonoge et al. recommended that surgeons should limit the mandibular setback to 5 mm and correct the remaining gap by maxillary advancement irrespective of the SNA or SNB angles [18]. Ablens et al. evaluated the stability of bilateral sagittal ramus osteotomy and vertical ramus osteotomy after bimaxillary correction of class III malocclusion and reported that this procedure enhanced the esthetics of the subcervical region, improved the function and had stable long-term results [13]. Ablens et al. Abdelrahman et al. and Modarai et al. showed that maxillary advancement yielded more stable results and caused spontaneous rotation of the mandible [13-15]. McNeill et al. showed that mandibular advancement by Le Fort I osteotomy caused prominence of the nose tip by decreasing the length of the nasal angle [16]. Despite the small sample size of the abovementioned studies, their findings were mostly in line with ours. Conversely, Marsan et al. evaluated changes in soft and hard tissues following mandibular setback [19]. They showed that mandibular setback effectively created an orthognathic profile in adult class III patients with mandibular prognathism.

Peak et al. evaluated the changes in lip morphology following mandibular setback in class III patients [20]. They demonstrated that the frontal view of the lip area did not change significantly after surgery. However, the upper lip surface increased in the profile view and the lower lip landmark moved backward and upward. Kim et al. three-dimensionally evaluated the soft tissue changes following mandibular setback in class III and showed increased length of the upper lip and decreased length of the lower lip in hypodivergent patients after mandibular setback surgery and genioplasty [21]. The soft tissue convexity in the paranasal region in hyperdivergent group was more than that in the hypodivergent one after the mandibular setback surgery. Jung et al. evaluated the soft and hard tissue changes after correction of the mandibular prognathism and facial asymmetry by the mandibular setback surgery and demonstrated that mandibular prognathism was significantly corrected after surgery in both groups with symmetrical and asymmetrical face [22]. The changes in hard and soft tissues were greater in the transverse and anteroposterior dimensions compared with the...
vertical dimension, and this can also be noted in patients treated with nonsurgical orthodontic treatments [23, 24].

A limitation of this study was the retrospective design. Thus, the type of surgical procedure may not be able to correctly determine the quality of treatment, and patient status in terms of the severity of malocclusion may affect the quality of treatment. However, the shortcomings were not considered to obtain more accurate results. For instance, a high number of hard and soft tissue parameters were evaluated avoiding bias and evaluated the effect and magnitude of change in the parameters both quantitatively and qualitatively using the Sign test. Also, the profile and frontal view esthetics of patients was evaluated by three groups of examiners. The highest scores were given by the laypeople and the lowest by orthodontists. The Kruskal-Wallis test showed that the difference in this respect was significant among the three examiner groups. Pairwise comparisons by the Mann-Whitney test showed that the difference between oral and maxillofacial surgeons and laypeople was not significant but orthodontists had significant differences with each of the other two groups.

Our findings demonstrated that maxillary advancement had a great effect on the nose, cervical length and the upper lip. The distance between the upper lip and the esthetic line was significantly different between the two groups of maxillary advancement and mandibular setback, depending on the gender of patients. Maxillary advancement was more commonly performed for female patients while the situation was reverse for male patients. One possible reason may be the opinion of the surgeons regarding the anesthetic appearance of the double chin which may develop following mandibular setback surgery. However, further studies are required on this topic. Clinical trials are required to compare esthetic outcomes in borderline class III patients following mandibular setback and maxillary advancement surgery.

Conclusion

Nasolabial angle was significantly decreased in maxillary advancement; however, it did not show any significant changes in mandibular set back. SNA was significantly increased in maxillary advancement. Some dental measurement such as U1/NA (°), U1/NA (mm), L1/NB (°) and L1/NB (mm) were significantly different between two groups. The maxillary advancement surgical treatment showed more favorable esthetic outcomes in borderline class III patients. These findings should be considered when deciding on jaw selection for osteotomy in these patients.

Ethics Approval and Consent to Participate

Ethical approval was obtained from Orthodontic Department at the University of XXXXXXXXXX (No 2335).

Consent

Consent for publication all subjects gave their written informed consent.

Availability of Data and Material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing Interest

None.

Funding

None.

Author Contributions

VSA was responsible for case selection, data collection, LN and FA were responsible for literature review, and final approval of the article. MF and HMA were responsible for tracing of lateral Cephalograms, data interpretation. Statistical analysis AJ was responsible for study design, study concept, administration, writing and corresponding author. AF was responsible for drafting, data interpretation and critical revision.

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