Available online at www.sciencerepository.org

Science Repository

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

Vahiheh Sadat Alizadeh[1], Ludovica Nucci[2], Mona Farahmand[3], Hamidreza Mahaseni Aghdam[4], Ali Fateh[5], Abdolreza Jamilian[6*] and Fabrizia d'Apuzzo[7]

[1]Department of Orthodontics, Faculty of Dentistry, Cranio Maxillofacial Research Center, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran

[2]Orthodontic Program, Multidisciplinary Department of Medical-Surgical and Dental Specialties, University of Campania Luigi Vanvitelli, Naples, Italy

[3]Department of orthodontics, Department of Orthodontics, Faculty of Dentistry, Cranio Maxillofacial Research Center, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran

[4]Department of Oral and Maxillofacial Surgery, Department of Orthodontics, Faculty of Dentistry, Cranio Maxillofacial Research Center, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran

[5]Executive Manager of Craniomaxillofacial Research Center, Tehran Dental Branch. Islamic Azad University, Tehran, Iran

[6]Department of Orthodontics, Faculty of Dentistry, Cranio Maxillofacial Research Center, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran

[7]Orthodontic Program, Multidisciplinary Department of Medical-Surgical and Dental Specialties, University of Campania Luigi Vanvitelli, Naples, Italy

ARTICLE INFO

Article history:
Received: 24 February, 2020
Accepted: 16 March, 2020
Published: 25 March, 2020

Keywords:
Surgical borderline case
maxillary advancement
mandibular setback
soft tissue profile

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 underwent: 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.

Correspondence to: Abdolreza Jamilian, Department of Orthodontics, Faculty of Dentistry, Cranio Maxillofacial Research Center, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran; Tel: 009822052228; E-mail: info@jamilian.net

http://dx.doi.org/10.31487/j.DOBCR.2020.01.08

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 facial profile esthetics is affected by five major components namely the forehead, nose, lips, chin and neck position [10]. Moreover, the lip thickness, lip tonicity, inclination of incisor teeth and lip height can all affect the soft tissue changes and consequently the facial attractiveness after treatment [11].

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 anesthetic 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 XXXXXXXXXX. The 50 consecutive patients (mean age of 29 ± 4 years) were divided into two groups based on the type of surgical treatment underwent: 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<0.84 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.
vii. No previous orthodontic treatment or surgical intervention.

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 inferius 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 inner 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 (SeN'-Pal), 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 XXXXXXXXXX. The two extraoral photos were showed 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	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 Eline and lower lip to Eline had significant changes in the mandibular setback group P<0.002, P<0.05 respectively. Nasolabial angle significantly decreased in the maxillary advancement. While, they did not show any significant changes in mandibular setback group.

SNA significantly increased after surgery only in the maxillary advancement group. SNB decreased postoperatively in the mandibular setback group (P<0.004), ANB and wits appraisal increased after surgery in both groups significantly. Y-axis (N-S-Gn), GO GN-SN increased in the maxillary advancement P<0.01, P<0.02 respectively but these two parameters did not have any 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	28.4±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	**Changes**		
Indices	**Maxillary advancement**	**Mandibular setback**	**P *value***
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 Line	4.3±2.8	2.2±3.5	0.249
Lower lip to E Line	-0.2±1.8	-0.1±1.5	0.332
Lip chin-throat angle	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
U1-NA (mm)	-1.9±1.4	0.2±1.4	0.072
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 patiens)	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)	
	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	
Laypeople	5.7±0.6		6.1±0.7	

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]. Sonego *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]. Abeltins *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]. Abeltins *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 1 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.

Acknowledgements

None.

References

1. Ghassemi M, Hilgers RD, Fritz U, Modabber A, Ghassemi A (2017) Maxillary advancement versus mandibular setback in class III dentofacial deformity: are there any differences in aesthetic outcomes? *Int J Oral Maxillofac Surg* 46: 483-489. [Crossref]
2. Eslami S, Faber J, Fateh A, Sheikholaemmeh F, Grassia V et al. (2018) Treatment decision in adult patients with class III malocclusion: surgery versus orthodontics. *Prog Orthod* 19: 28. [Crossref]
3. Janson G, De Souza JE, Barros SE, Andrade Junior P, Nakamura AY (2009) Orthodontic treatment alternative to a class III subdivision malocclusion. *J Appl Oral Sci* 17: 354-363. [Crossref]
4. Harrington C, Gallagher JR, Borzabadi Farahani A (2015) A retrospective analysis of dentofacial deformities and orthognathic surgeries using the index of orthognathic functional treatment need (IOFTN). *Int J Pediatr Otorhinolaryngol* 79: 1063-1066. [Crossref]
5. Proffit WR, Phillips C, Turvey TA (2012) Stability after mandibular setback: mandible-only versus 2-jaw surgery. *J Oral Maxillofac Surg* 70: e408-e414. [Crossref]
6. Jamilian A, Cannavale R, Piancino MG, Eslami S, Perillo L (2016) Methodological quality and outcome of systematic reviews reporting on orthopaedic treatment for class III malocclusion: Overview of systematic reviews. *J Orthod* 43: 102-120. [Crossref]
7. Jamilian A, Showkatbakhsh R, Behnaz M, Ghassemi A, Kamalee Z et al. (2018) Tooth-borne distraction osteogenesis versus conventional Le Fort I in maxillary advancement of cleft lip and palate patients. *Minerva Stomatol* 67: 117-124. [Crossref]
8. Arad I, Jandu J, Bassett P, Fleming PS (2011) Influence of single-jaw surgery vs bimaxillary surgery on the outcome and duration of combined orthodontic-surgical treatment. *Angle Orthod* 81: 983-987. [Crossref]
9. Jamilian A, Kiaee B, Sanayei S, Khosravi S, Perillo L (2016) Orthodontic Treatment of Malocclusion and its Impact on Oral Health-Related Quality of Life. *Open Dent J* 10: 236-241. [Crossref]
10. Moles DR, Cunningham SJ (2009) A national review of mandibular orthognathic surgery activity in the National Health Service in England

over a nine year period: part 1--service factors. *Br J Oral Maxillofac Surg* 47: 268-273. [Crossref]

11. Mobarak KA, Krogstad O, Espeland L, Lyberg T (2001) Factors influencing the predictability of soft tissue profile changes following mandibular setback surgery. *Angle Orthod* 71: 216-227. [Crossref]
12. Mucedero M, Coviello A, Baccetti T, Franchi L, Cozza P (2008) Stability factors after double-jaw surgery in Class III malocclusion. A systematic review. *Angle Orthod* 78: 1141-1152. [Crossref]
13. Abeltins A, Jakobsone G, Urtane I, Bigestans A (2011) The stability of bilateral sagittal ramus osteotomy and vertical ramus osteotomy after bimaxillary correction of class III malocclusion. *J Craniomaxillofac Surg* 39: 583-587. [Crossref]
14. Abdelrahman TE, Takahashi K, Tamura K, Nakao K, Hassanein KM et al. (2011) Impact of different surgery modalities to correct class III jaw deformities on the pharyngeal airway space. *J Craniofac Surg* 22: 1598-1601. [Crossref]
15. Modarai F, Donaldson JC, Naini FB (2013) The influence of lower lip position on the perceived attractiveness of chin prominence. *Angle Orthod* 83: 795-800. [Crossref]
16. Ghassemi M, Ghassemi A, Showkatbakhsh R, Ahmad SS, Shadab M et al. (2014) Evaluation of soft and hard tissue changes after bimaxillary surgery in class III orthognathic surgery and aesthetic consideration. *Natl J Maxillofac Surg* 5:157-160. [Crossref]
17. McNeill RW, Proffit WR, White RP (1972) Cephalometric prediction for orthodontic surgery. *Angle Orthod* 42: 154-164. [Crossref]
18. Sonego CL, Bobrowski AN, Chagas OL Jr, Torriani MA (2014) Aesthetic and functional implications following rotation of the maxillomandibular complex in orthognathic surgery: a systematic review. *Int J Oral Maxillofac Surg* 43: 40-45. [Crossref]
19. Marsan G, Oztas E, Kuvat SV, Cura N, Emekli U (2009) Changes in soft tissue profile after mandibular setback surgery in Class III subjects. *Int J Oral Maxillofac Surg* 38: 236-240. [Crossref]
20. Paek SJ, Yoo JY, Lee JW, Park WJ, Chee YD et al. (2016) Changes of lip morphology following mandibular setback surgery using 3D cone-beam computed tomography images. *Maxillofac Plast Reconstr Surg* 38: 38. [Crossref]
21. Kim M, Lee DY, Lim YK, Baek SH (2010) Three-dimensional evaluation of soft tissue changes after mandibular setback surgery in class III malocclusion patients according to extent of mandibular setback, vertical skeletal pattern, and genioplasty. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 109: e20-e32. [Crossref]
22. Jung YJ, Kim MJ, Baek SH (2009) Hard and soft tissue changes after correction of mandibular prognathism and facial asymmetry by mandibular setback surgery: three-dimensional analysis using computerized tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 107: 763-771. [Crossref]
23. Raucci G, Pachêco Pereira C, Grassia V, d'Apuzzo F, Flores Mir C et al. (2015) Maxillary arch changes with transpalatal arch treatment followed by full fixed appliances. *Angle Orthod* 85: 683-689. [Crossref]
24. Raucci G, Elyasi M, Pachêco Pereira C, Grassia V, d'Apuzzo F et al. (2015) Predictors of long-term stability of maxillary dental arch dimensions in patients treated with a transpalatal arch followed by fixed appliances. *Prog Orthod* 16: 24. [Crossref]