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ORIGINAL ARTICLE

Changes in craniofacial morphology, head and neck posture following mandibular setback surgery

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Background and aim: Number of studies evaluating the changes in head position following mandibular setback surgery (MSS) is scarce. This study sought to assess the craniofacial morphology, head and neck posture following mandibular setback surgery.

Materials and methods: This retrospective, longitudinal, semi-experimental study was performed on 35 patients with Class III malocclusion. Radiographs taken at baseline and one year after surgery were retrieved from the medical records of patients. Lateral cephalograms were scanned and landmarks were marked on the first (baseline) radiograph. The second radiograph was superimposed on the first radiograph, true vertical lines or a ruler were considered as parallel images and a line was drawn along the SN from the point S. After superimposition, cephalometric variables were measured using Orthosurger X software (Iran). The mean, standard deviation (SD) and range of changes in each group were calculated. The significance of differences caused by surgery was analyzed using paired t-test.

Results: The total mandibular length, mandibular body length, ramus length, SNB, SN-Pog, A-N-Pog, the angle between the body and ramus and the mandibular plane inclination significantly decreased; while, ANB angle, overjet and overbite significantly increased. No significant change occurred in the head position or cervical vertebra following MSS.

Conclusions: Since changes in the positions of cervical hard tissue were not significant, decreased airway volume following MSS seems to be related to the soft tissue structures namely the tongue, the soft palate and the suprahyoid and cervical muscles.

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Introduction

In the past 40 years, demand for orthodontic treatments has greatly increased. Orthognathic surgery is now a safer option than before due to advances in surgical and computed imaging techniques, rigid internal fixation methods and short hospital stay. At present, surgical procedures are more commonly used for treatment of severe congenital or acquired deformities (1). Orthosurgical procedures not only affect the facial hard and soft tissues, but can also cause changes in the head and neck position and airway status (2). The ability to predict these changes enables the clinician to come up with a precise surgical treatment plan, enhances the patient's knowledge about the treatment and helps acceptance of the outcome by patients. Prediction of treatment outcome is particularly important in Class III patients because improvement of facial profile and appearance is the main goal of orthodontic and orthosurgical treatments in the majority of these patients (3).

Facial muscles, the tongue, hyoid bone, soft tissue and many other structures are directly or indirectly attached to the jaws. Therefore, by jaw repositioning, the position of these structures changes as well. Consequently, the volumes of the oral cavity, nasal cavity and the airways also change leading to alterations in head position in order to compensate for these changes and maintain normal breathing (4). Many studies have reported a reduction in volume and size of the airways following MSS; however, evidence regarding the change in resting position of the head is scarce (5-8).

Therefore, the purpose of this study was to assess the changes in the hard and soft tissues and also the alterations in the resting position of the head in Class III malocclusion patients following orthognathic surgery.

Materials and Methods

This retrospective, semi-experimental study was conducted on 35 patients including 23 females and 12 males with a mean age of 24 years and 4 months. The patients were selected based on the following inclusion and exclusion criteria:

1. Adult patients with dental and skeletal Class III malocclusion who had undergone orthodontic treatment and MSS
2. Availability of the patient's lateral cephalograms taken at baseline (before treatment) and at least one year after surgery. The one-year time point was selected because the post-surgical edema is eliminated by this time and the one-year time period is sufficient for the changes to take place.
3. Only patients who had undergone routine orthognathic surgery were included. Patients suffering from syndromes, cleft lip or cleft plate were not included.
4. The patients had not undergone chin surgery because it could have influenced the anterior facial height and probably the head position.

Lateral cephalograms of patients obtained before the surgery and one year after were collected. All lateral cephalograms of each patient had been taken at the same center. Cephalograms were scanned by a radiographic scanner (Microtech Scan Maker 48bit color, i800). The magnification of cephalograms was first adjusted by matching their dpi scans. Also, the length of a ruler or in case of absence of that, nasal length was used to match the magnification of scanned images.

The landmarks were then marked on the first radiograph. The second radiograph was then traced and landmarks were marked on it. The second radiograph was superimposed on the first radiograph, true vertical lines or a ruler were considered as parallel images and a line was drawn along the SN from the point S. After superimposition, the variables were measured. Measurements were made using Orthosurger X software. The accuracy of this software has been confirmed in previous studies (9, 10). Next, changes in 44 cephalometric variables (including 27 angular and 17 linear cephalometric variables) in 8 groups (cranial base, maxilla, mandible, jaw to jaw relationship, the teeth, natural head position (NHP), cervical vertebral inclination and reference lines) were analyzed according to Sollow analysis (11)(Figures 1).

After data collection, their normal distribution was tested using the Shapiro-Wilk test. The equality of variances was confirmed using Levene’s test. Considering the normal distribution of data and equality of variances, the mean, SD, minimum and maximum values before the surgery and one year after that were calculated for each group. The mean, SD, minimum and maximum values of the changes caused by surgery in each group were also calculated and their significance was analyzed using paired t-test. All tests were carried out using SPSS version 15.

Figure 1. Cephalometric variables used in the study according to the definitions by Sollow

Results

The mean and SD of hard tissue changes in the cranial base, maxilla, mandible and teeth are summarized in Table 1. As demonstrated in Table 1, no significant change occurred in the cranial base in sagittal and vertical dimensions one year after MSS.

In the maxilla, the Ptm-ANS distance that indicates the length of the maxillary base significantly increased. The Ptm-A distance also increased; but this increase was not statistically significant. The SNA and SN-ANS angles significantly increased; while the maxillary plane inclination relative to SN did not change significantly.

In the mandible, significant reductions occurred in the total mandibular length, mandibular body length and ramus length. Also the SNB, SN-Pog and ramus-body angles as well as the mandibular plane inclination significantly decreased. The ANB angle significantly increased while A-N-Pog angle, overjet and overbite significantly decreased.

According to Table 2, showing the mean and SD of changes in the head position and cervical vertebral inclination, the changes in angles between the CVT (the line connecting the most inferior-posterior point on the body of the 4^{th} cervical vertebra to the most posterior point on the odontoid process) and the Frankfurt plane (FH), true horizontal plane, NSL and NL were not significant. Since these angles determine the head position, their unchanged position indicates no or insignificant change in the head position at one year following MSS.

With regard to changes in the neck position, the cranio-cervical angle (between OPT and NSL) and the angle between the OPT and the true horizontal plane, that indicates cervical extension, both increased. However, these increases were not significant.

Table 3 shows the changes in reference lines before and after the surgery. These lines remained relatively unchanged following MSS.

Landmarks	SD	Mean change	p value
N-S	2.7	0.509	**0.614**
N-Ba	5.1	0.351	**0.728**
N-Ar	4.3	1.33	**0.192**
N-Sp	3.9	-1.47	**0.884**
N-Gn	6.4	-0.036	**0.972**
S-Pm	3.06	0.425	**0.674**
S-tGo	4.6	1.823	**0.07**
S-Ba	3.8	0.56	**-0.179**
S-Ar	2.6	0.422	**0.676**
NSBa	3.5	0.850	**0.401**
NSAr	3.5	2.567	**0.015**
Sp-Pm	3.75	3.616	**0.001**
Ss-Pm	3.37	1.955	**0.059**
SN-Sp	5.36	3.651	**0.001**
SNSs	4.32	2.210	**0.034**
NSL/NL	3.83	0.57	**0.572**
PrNSs	2.49	0.570	**0.572**
Pgn-Cd	6.41	5.911-	**0.000**
Ar-tGo	3.95	-3.636	**0.04**
Pg-tGo	3.64	2.38-	**0.00**
SNSm	3.45	5.186-	**0.00**

SNPg	3.45	4.508-	**0.00**
NSL/ML	4.52	2.401-	**0.022**
ML/RL	6.94	-1.701	**0.098**
CL/ML	4.51	0.236	**0.815**
Sp-Gn	5.46	0.280	**0.781**
SSNsM	2.81	7.764	**0.00**
SsNPg	3.83	4.631-	**0.00**
NL/ML	6.85	1.631	**0.112**
ILs/NL	9.02	-7.310	**0.94**
ILi/ML	7.0	-1.17	**0.32**
Overjet	1.37	0.007-	**0.000**
Overbite	1.64	3.368	**0.002**

Table 1. Comparison of changes in the cranial base, maxilla, mandible, jaw to jaw relationship and the teeth before and after surgery

Landmarks	**SD**	**Mean change**	**p value**
CVT/FH	5.85	1.552-	**0.130**
CVT/HOR	6.04	0.393	**0.697**
CVT/NL	5.97	0.300	**0.766**
CVT/NSL	5.13	0.968-	**0.340**
OPT/FH	6.10	.502-٠	**0.619**
OPT/HOR	7.39	0.913	**0.368**

OPT/NL	5.83	0.100	**0.610**
OPT/NSL	6.14	0.47	**0.921**

Table 2. Comparison of changes in cervical vertebral inclination and the head position before and after surgery

Landmarks	SD	Mean change	p value
NSL/VER	5.03	1.051	**0.301**
FH/VER	5.47	1.838	**0.075**
NL/VER	7.07	547.0	**0.588**

Table 3. Comparison of changes in reference lines before and after surgery

Discussion

Cephalometric radiography has long been used as a diagnostic tool to assess the morphological changes that occur in the craniofacial region. Computed tomography (CT) has a unique potential for three-dimensional (3D) image reconstruction of craniofacial structures. However, in a study by Powell and Riley (1990), the reliability of CT scan and cephalometry for evaluation of the posterior airway and head position was reported to be high (12). Miles et al. (1995) stated that the majority of landmarks used for the assessment of the airways and facial structures can be very well observed on these radiographs irrespective of their quality (13). Thus, cephalometry can be used as a suitable tool for the assessment of head position and facial structures.

Most studies regarding the changes in craniofacial structures and head position following surgery have used intracranial reference planes such as SN and FH for superimposition of pre- and post-surgical lateral cephalograms. However, these planes are subjected to change as the result of surgery as well as biological alterations. Therefore, using them as reference planes can yield false results (14, 15). If the cephalogram is obtained at the NHP, the extracranial true vertical line can be used as the reference plane. In long-term, this line is more stable than intracranial planes and the validity and reproducibility of its superimposition have been confirmed in several studies (16, 17). Thus, in the current study, the true vertical line was used as the reference plane.

Changes in the craniofacial morphology following the MSS, as expected, mainly include correction of mandibular prognathism (decreased SNA, total mandibular length and mandibular body length), correction of overjet (increased ANB) and improved facial profile (decreased ANPog). Similar results have been reported by previous studies indicating that MSS can effectively correct the skeletal pattern and facial profile of Class III patients in long-term (19-22).

Based on our results, following MSS, an anti-clockwise rotation occurs in the mandibular plane relative to the cranial base (decreased NSL-ML) and also in the ramus plane followed by bite closure and increased overbite. Similar results were reported by Soonshin and Achilleos (19, 20). Decreased PNS-Ptm distance in a study by Soonshin and increased ANS-Ptm distance in our study indicate increased length of the maxillary base following MSS in Class III patients. Due to the changed position of the surrounding soft tissues such as the tongue, muscles and in general the functional matrix, the loads applied to the maxilla will be out of their previous balance and may cause its remodeling. Increased SNA angle reported in our study and those of Soonshin and Achilleos seems to be related to this finding (19, 20).

Wenzel et al. in 1989 found a significant association between the mandibular morphological changes and the head position following surgery. Achilleos in 2000 suggested that cranio-cervical extension, specified by increased NSL/OPT angle, may be a compensatory mechanism for decreased airway volume that occurs following MSS. However, more recent studies like the ones by Soonshin and Aydemir did not report a significant change in the head position or cervical inclination following MSS. In the current study, similar results to those of Soonshin and Aydemir were obtained. Although the NSL/OPT angle averagely increased, this increase was not statistically significant (19-22).

Conclusion

Mandibular setback surgery can effectively correct the skeletal pattern and facial profile of Class III patients in long-term. Since changes in the position of hard tissues in the cervical region were not significant, decreased airway volume following MSS seems to be related to the soft tissue structures namely the tongue, the soft palate, the suprahyoid muscles and the cervical muscles.

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