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An Assessment of Interrelationship between Surgical Superior Repositioning of the Maxilla and Lower Incisors Inclination Change after Mandibular Autorotation

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ABSTRACT

Background and Objective: Correction of vertical maxillary excess (VME) via superior surgical repositioning of the maxilla can lead to counterclockwise rotation of the mandible along with alteration of jaw relationship and dental occlusion. The aim of this study was to determine the interrelationship between surgical superior repositioning of the maxilla and lower incisors inclination change after mandibular autorotation.

Methods: In this correlational study, 13 patients with Class II malocclusion, mandibular plane angle greater than 27 degrees, and fully-erupted lower second molars were examined. Superior maxillary repositioning of 4mm was simulated on lateral cephalometric radiographs and maxillary dental models. Degree of mandibular autorotation was then predicted on lateral cephalograms, considering radiographic center of the condyle as the center of rotation, and on semi-adjustable articulator, measuring the articulator's upper arm inclination change in degrees by digital inclinometer. As lower incisors rotate on the same arc of rotation as the mandible, measuring mandibular autorotation also indicates the amount of change in lower incisors' inclination.

Findings: Mean (standard deviation) values of mandibular autorotation and lower incisors' inclination change after 4mm superior repositioning of the maxilla were 3.38±0.93 and 2.63±0.83 degrees based on Prediction Planning and Model Planning techniques, respectively. The difference between two methods was statistically significant ($p<0.05$).

Conclusion: After superior repositioning of the maxilla, the counterclockwise rotation of the mandible causes the retroclination of the lower incisors, which should be considered in the cephalometric prediction before surgery.

Keywords: *Vertical Maxillary Excess, Anterior Openbite, Lefort I Osteotomy, Molar Intrusion, Mandibular Autorotation.*

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Introduction

Vertical Maxillary Excess (VME) is one of the most challenging malocclusions to treat, especially after completion of growth (1, 2). This pattern of growth causes the mandible to rotate downward and backward during facial development, resulting in excessive lower anterior facial height, anterior open bite tendency, and retroclination of mandibular incisors due to lower lip pressure (1, 3). The classical surgical approach for the treatment of VME is superior repositioning of the maxilla through a Lefort I osteotomy, often in conjunction with mandibular bilateral sagittal split osteotomy and repositioning of the bony chin; however, in milder cases, successful closure of the anterior open bite and acceptable facial aesthetics can be achieved through a combination of skeletally anchored intrusion of maxillary posterior teeth and lower border osteotomy (3).

Superior surgical repositioning of the maxilla, and to a lesser degree intrusion of maxillary posterior teeth via skeletal anchorage, may lead to upward and forward rotation of the mandible. This counterclockwise rotation of the mandible is known as Mandibular Autorotation, which plays an important role in creating the desired changes, such as reducing facial height, increasing chin prominence, reducing Overjet, and increasing Overbite (4). In addition, counterclockwise rotation of the mandible will decrease following superior repositioning of the maxilla and subsequent mandibular autorotation (1).

Predicting treatment results is one of the essential prerequisites before starting treatment, especially in patients who undergo combined orthodontic treatment and orthognathic surgery; In these patients, in addition to the dental relations, changes are also made in the skeletal structures and soft tissues of the face (5-7). The exact amount of linear (mm) and angular (degree) changes of the dental and skeletal structures along with the relative changes of the facial soft tissue profile can be predicted using the prediction planning method on the lateral cephalometric radiograph, and before finalizing the treatment plan, it is possible to examine the desired movements using dental models (1).

Considering that there is a tendency to reduce the relative inclination of the mandibular incisors with the superior repositioning of the maxilla followed by the autorotation of the mandible, in the pre-surgical preparation phase, some amount of proclination should be created in the lower incisors so that the position and axial inclination of the incisors are correct after rotation of the mandible (1). The aim of this study is to investigate the relationship between the superior repositioning of the maxilla and the changes in the axial inclination of the lower incisors after autorotation of the mandible using two methods of lateral cephalometric radiography (Prediction Planning) and dental model (Model Planning) so that in the preoperative preparation stage, changes be applied to prevent excessive retroclination of mandibular incisors after surgery.

Methods

After being approved by the ethics committee of Babol University of Medical Sciences with code IR.MUBABOL.REC.1400.113, this cross-sectional study was conducted on 13 patients who referred to the orthodontic department of Babol Dental School for orthodontic treatment. The criteria for including participants were as follows: Class II malocclusion, with or without the presence of VME, mandibular plane angle greater than 27 degrees, and fully-erupted lower second molars.

In the first stage (Prediction Planning), after receiving informed consent and performing lateral cephalometric radiographs in Natural Head Position, radiographs were traced by one person; Then, a separate tracing of the upper jaw was prepared in order to simulate the superior repositioning of the maxilla by 4 mm on the cephalogram. After fixing the tracing of the maxilla in the new position, the amount of autorotation of the mandible was measured using a separate tracing from the lower jaw and considering the center of the condyle as the center of rotation (the rotation of the tracing of the lower jaw until the contact of the occlusal surface of the posterior teeth of the maxilla and mandible was performed) (Figure 1). In the second stage (Model Planning), after preparing alginate molds from both jaws, the centric relation was recorded using Bimanual Manipulation Technique. The dental models of the maxilla and mandible were prepared using Dental Model Stone Type III and were trimmed in order to achieve a uniform height at the mesiobuccal cusp points of the first molar, canine and incisors. In the next step, the position of the maxillary arch relative to the hinge axis of the condyles was recorded by Facebow (Self-Centering Hanau Springbow, Item No. 010328-000, Whip mix Corporation, USA) to facilitate the correct transfer of the maxilla model to the articulator. For this purpose, first, the impression of the occlusal surface of the maxillary teeth was created on the soft wax placed on the upper surface using bite fork, and after the stable placement in the correct place, the temporal arm of the set was adjusted in such a way that it was parallel to the Interpupillary Line in the frontal view, and in the profile view, it was almost along the infraorbital rim. The dental models of the maxilla and mandible were transferred to the Semi-adjustable Articulator (Hanau Wide-Vue Semi-adjustable Articulator, Item No. 010885-000, Whip Mix Corporation, USA) with the help of the Facebow record and the recorded centric relation, and white plaster was placed in the remaining space between dental models and articulator baseplate (Figure 2).

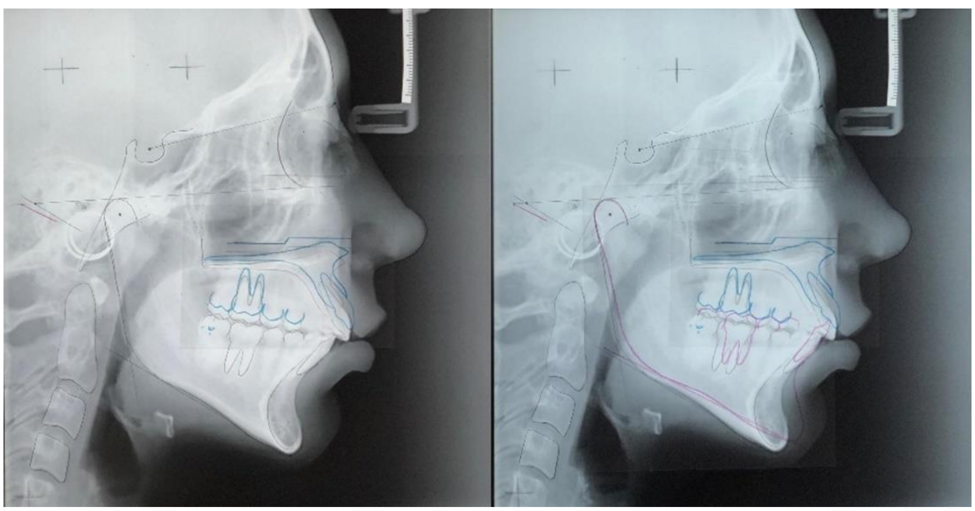

Figure 1. Cephalometric prediction of mandibular autorotation following superior repositioning of the maxilla

Figure 2. Maxillary and mandibular units after trimming on semi-adjustable articulator

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In the next step, after separating the maxilla and mandible units from the articulator, horizontal and vertical reference lines were drawn on them; Two horizontal reference lines were drawn in Dental Model Stone and white plaster with a distance of 15-20 mm from each other and parallel to the baseplate of the articulator. Vertical reference lines were drawn in the area between central incisors, cusp tip of canines, buccal groove of first molars and tuberosity or retromolar area (two lines on each side and adjacent to alveolar ridge) and perpendicular to horizontal reference lines.

At this stage, with the help of Erickson Model Table (Erickson Model Block and Platform Model Measuring Kit, Denar or Twin Pin Hanau, USA), the initial vertical position of the maxilla model was recorded at the middle point of the two central incisors and the tip of the mesiobuccal cusp of the first molars. Following that, maxillary dental model was separated from its base and trimmed to reduce its height in order to make superior repositioning of the maxillary unit possible. Total vertical change of 4 mm was applied to the maxillary dental model by means of Erickson Model Table, similar to radiographic prediction planning procedure. The repositioned maxillary unit was secured with rose wax and placed back onto the articulator. A custom-made digital inclinometer was attached to the upper arm of the articulator and set at "zero" degree. Then, loosening of the articulator vertical pin screw was performed to reestablish the contact between maxillary and mandibular incisors. The magnitude of the articulator's upper arm rotation, visible on the inclinometer screen, was recorded as it would be indicative of the degree of mandibular autorotation after superior repositioning of the maxillary unit (Figure 3).

Data analysis was performed in SPSS version 25 using paired sample t-test and Pearson correlation coefficient. A P-value less than 0.05 was considered to be statistically significant.

Figure 3. Articulator's upper arm inclination change following maxillary unit superior repositioning measured by the digital inclinometer

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Results

This study comprised 13 patients (12 female, 1 male) with Class II malocclusion, mandibular plane angle greater than 27 degrees, and fully-erupted lower second molar. The mean age of participants was 25.5±6.1 years (minimum 12 years, maximum 35 years).

The initial Frankfort Mandibular plane Angle (FMA) was 29.15±2.51 degrees on average. Following simulation of maxillary superior repositioning on lateral cephalometric radiographs and subsequent counterclockwise rotation of the mandible, the mean FMA diminished to 25.76±2.11 degrees. The amount of change in FMA, which was indicative of mandibular incisors inclination change as well, was 3.38±0.93 degrees on average with prediction planning method.

Superior repositioning of the maxillary dental models has led to a mean change of 2.63±0.82 degrees in the articulator's upper arm inclination, which was indicative of the anticipated amount of mandibular autorotation as well as the lower incisors inclination change.

Based on the results of paired sample t-test, the difference in the mean of autorotation of the mandible and changes in the axial inclination of the lower incisors based on the two methods of Prediction Planning and Model Planning was statistically significant (p=0.036) and there was a very insignificant correlation between the means of these two methods. In relation to the expected changes in axial inclination, there were low incisors (RR ~ 0.156, p=0.612).

Discussion

In the present study, after moving the upper maxilla by 4 mm and considering the radiographic center of the condyle as the center of rotation, an average decrease of 3.38±0.93 degrees in the plane angle of the mandible (FMA) was observed. This shows the axial inclination changes of lower incisors after mandible autorotation. After superior repositioning of the maxilla model by 4 mm, the amount of rotation of the upper arm of the maxilla until the re-establishment of incisor contact with each other was 2.63±0.83 degrees on average, which indicates the possible rate of autorotation of the mandible and the reduction of the inclination of the lower incisors after the superior repositioning of the maxilla.

In the study of Deguchi et al., the average counterclockwise rotation of the mandible following 3 mm intrusion, 2 mm intrusion of maxillary molars, and 1 mm intrusion of mandibular molars was 3 degrees (8). In the study of Akan et al., the average reduction of FMA and SN-Go.Gn after intrusion of maxillary posterior teeth by 3.4 mm by Zygomatic Miniplates was 3.8 degrees (9). According to the study of Erverdi et al., on average, the intrusion of the maxillary posterior dentoalveolar segment by Zygomatic Miniplates was 3.6±1.4 mm with a decrease in the SN-Go.Gn angle by 3±1.5 degrees (10). The results of the three recent studies are somewhat similar to the results of the present study, which indicate the success of skeletal anchors in creating skeletal changes similar to superior repositioning of the maxilla.

In a study by Kim et al., where 21 patients with anterior open bite were treated with intrusion of maxillary molars by Miniscrew, the average intrusion of maxillary molars (reduction of U6-PP) was 2.2 mm, which was caused by counterclockwise rotation of the mandible and reduction of SN-Go.Me angle by 2.7 degrees (11). In this study, higher values of mandibular autorotation than the amount of intrusion were reported, which can be attributed to the rotation center different from the radiographic center of the condyle (the location of the mandibular rotation center of each patient was determined individually by the Reuleaux method). However, the mandibular response in the anterior, posterior and vertical dimensions is largely influenced by the type and amount of superior repositioning of the maxilla (12).

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According to the results of Paired Sample Correlation, the average values of Mandible Autorotation based on two methods of Prediction Planning and Model Planning, have a very insignificant correlation with each other; This issue can be partially attributed to potential errors in the Model planning method. Moreover, by choosing the radiographic center of the condyle as the center of rotation of the mandible, individual variations in the TMJ structure and the ligaments connected to it will not be considered (13, 14). The existence of these variations can limit the rotation of the lower jaw as a free object and affect its rotation center during autorotation. In addition, determining the rotation center of the mandible during autorotation is based on the two-dimensional cephalometric image, while the lower jaw is a three-dimensional structure; Therefore, the prediction made may not reflect the actual rotation of the mandible, which causes the increase of inter-individual differences (15). However, considering the relatively equal changes in the angle of the mandible plane and the axial inclination of the lower incisors after superior repositioning of the maxilla based on the rotation matrices, the average autorotation of the mandible can be used to estimate the axial inclination changes of the lower incisors.

Based on the results of this study, one millimeter of superior repositioning of the maxilla can lead to counterclockwise rotation of the mandible and retrocline of the lower incisors by 0.85 degrees based on Prediction Planning and 0.65 degrees based on Model Planning, which should be considered in orthodontic preparation before surgery.

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