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Geometrically Investigating the Effect of Maxillary Posterior Impaction on Mandible Autorotation in Patients with Anterior Openbite Using Proplan CMF Software on Available CT Scans

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ABSTRACT

Introduction: Posterior impaction of the maxilla leads to spontaneous rotation of the mandible and these rotations are often accompanied by soft tissue and skeletal changes. The present research aims to determine the effects of posterior impaction of the maxilla on mandible's Autorotation in patients with anterior open bite.

Materials and Methods: Using a 3D reconstructed model of 25 patients with anterior open bites, this descriptive study is conducted. The construction model of the posterior segment of the mandible design was subjected to 2, 3, 5, and 7mm posterior impaction of the maxilla around the ANS axis without any mandibular intervention, using the available CT scan and ProPlan CMF software. Following this, the autorotation and anterior open bite correction were assessed. A basic linear regression test was used to examine the effects of various variables on the anterior open bite closure at various impaction rates.

Results: The rise, in impact rate led to an increase in the byte closure rate. With 2, 3, 5 and 7mm posterior impaction of the maxilla, the bite closure was not significantly affected by maxilla length, mandible length, U1-SN angle, ANS-PNS angle with the maxillary occlusal plane, or mandibular incisor angle with the mandibular plane. Nevertheless, during the 5mm posterior maxillary impaction procedure, there was a 0.2mm increase in the open bite closure for every 1 degree increase in IMPA; this number is statistically significant. ($p<0.001$).

Conclusion: The amount of bite closure increased along with the posterior impaction of the maxilla. All other variables did not significantly affect bite closure rate, with the exception of the IMPA variable in 5mm impactions.

Keywords: Maxillary posterior impaction; Mandible autorotation; Anterior open bite; ProPlan CMF software.

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Introduction

Under normal circumstances, the lower incisors are vertically aligned and spaced 1 to 3mm apart from the upper incisors. When there is no vertical overlap—that is, when the posterior teeth are fully occluded but the anterior teeth are still spaced apart—this condition is known as an open bite. Numerous factors, such as anomalies in the development of the jaws, genetic predispositions, nail biting, tongue, lip, or thumb sucking, can contribute to this disorder [1]. Numerous conditions, including dental, skeletal, neurological, and respiratory issues, can contribute to this anomaly [2-5]. Because of this anomaly's high recurrence rate, treatment for it can be quite complex [6,7]. Patients seek treatment primarily for aesthetic reasons, though it can cause problems with eating and speech [5].

There are various treatment options for this condition, the most important of which are myofunctional therapy, orthodontic procedures, surgical interventions or a combination of these approaches [8]. An open anterior bite is when the teeth overlap by at least 1mm when the jaw is closed. When skeletal abnormalities are the cause of the open bite, a combination of orthodontic and orthognathic surgery. For patients, with an anterior open bite this surgical procedure involves Le Fort I osteotomy and posterior impaction of the maxilla [5,9]. This method involves making an incision in the upper buccal sulcus, performing an osteotomy to free the maxilla and then by removing the posterior portion of the maxillary bone, it moves upward in the posterior part, causing mandibular rotation and ultimately closing the bite open [9]. Conditions like long face syndrome, gummy smiles (excessive gum display), decreases in lower face height, skeletal open bite correction, and lip sealing can all be treated with maxillary impaction surgery [10]. Maxillary impaction can cause the lower jaw to auto-rotate forward naturally as originally observed by Schendel et al. (1976) [11]. These spontaneous jaw rotations are often linked to changes, in both soft tissues and bone structure as can also be observed in mandibular advancement or a reduction in the lower face's vertical height [12]. In the field of deformity surgery, it is crucial to be able to predict the changes that will occur in both the structure and soft tissues [13]. Over the decades advancements in virtual planning technology and software have made it possible to anticipate the outcomes of such surgeries. One notable software tool that has emerged is CMF Proplan, specifically designed for planning purposes. By utilizing virtual treatment imaging alongside engineering expertise this software has been proven to enhance outcomes and reduce reconstruction time notably. Initially introduced in 2011, CMF Proplan is now widely utilized across Europe and America [14]. The primary objective of this study is to assess how maxillary impaction effects mandibular autorotation in patients with an anterior open bite, through geometric analysis, using the ProPlan CMF software based on available CT scans.

Materials and Methods

This research uses a descriptive method concentrating on 3D reconstructed models of individuals, with anterior open bites. A total of 25 cases with anterior open bite who underwent surgery at the advanced maxillofacial research center at Shariati Hospital between January 20, 2020 and January 20, 2021 were included in the investigation. The research protocol was approved by the ethics committee of the Faculty of Dentistry, at Tehran University of Medical Sciences (approval code; IR.TUMS.DENTISTRY.REC.1401.020). In Figure 1 the CT scan images display a 11.6mm width open bite reconstruction using ProPlan CMF software. The software used existing CT scans to depict an impaction of the maxilla by 2mm (Figure 2), 3mm (Figure 3), 5mm (Figure 4) and 7mm (Figure 5), with no intervention in the mandible. The study evaluated the mandibular autorotation and the extent of correction of the open bite. For each patient, the angle between palatal plane and occlusal plan of maxilla (Figure 6), length of mandible (Co-Gn), length of maxilla (Co-A), the angle of maxillary central incisors to the cranial base (U1-SN) and the angle of the lower incisors to the mandibular plane (IMPA) was measured and recorded. In Figure 7, 3D cephalometric analysis using soft Proplan CMF software is shown. Figure 7 illustrates a cephalometric analysis conducted using Proplan CMF software. Additionally, we compared the amount of open bite both before impaction and after impaction, by 2, 3, 5 and 7 millimeters. STATA 17 was the software used for data analysis. Important statistics were computed, including the minimum and maximum values, the interquartile range, the mean, the median, and spread metrics like deviation. The measurements of bite closure post impaction were assessed at 2mm, 3mm, 5mm and 7mm. We used a Shapiro-Wilk test ($p<0.05$) to verify that the data fit into a normal distribution. Using a straightforward linear regression analysis, the effects of several factors on the degree of bite closure after varying degrees of maxillary impaction were investigated.

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Results

In Table 1, the rate of bite closure following maxillary posterior impaction with different values is presented. In maxillary posterior impaction of 2mm, mean of bite closure ± standard deviation was equal to 2.18±1.1811mm, in maxillary posterior impaction of 3mm was 3.38±1.2821mm, in maxillary posterior impaction of 5mm was 5.55±1.9329mm, and in maxillary posterior impaction of 7mm, the rate of bite closure in patients was estimated as 11.0±0mm. On the other hand, the amount the initial open bite of the patients was equal to 4.836.2±2.4464mm. The outcomes of the basic linear regression test, which looked into how different factors affected the bite closure in the 2mm maxillary posterior impactions, are shown in Table 2. The amount of bite closure in the 2mm posterior impaction of the maxilla was not significantly affected by mandible length (p=0.83), angle between the central maxillary incisor and skull base (U1-SN) (p=0.218), angle between the mandibular incisors and mandibular plane (IMPA) (p=0.848), or maxilla length (p=0.183). Furthermore, when performing a 2mm posterior maxilla impaction, the angle between the palatal plane and the maxillary occlusal plane (ANS-PNS) had no statistically significant impact on the bite closure. (p=0.526).

The results of a basic linear regression analysis of the effects of different factors on open bite closure during 3mm posterior maxillary impaction are presented in Table 3. The amount of bite closure in the 3mm posterior impaction of the maxilla was not significantly affected by mandible length (p=0.336), angle between the central maxillary incisor and skull base (U1-SN) (p=0.296), angle between the mandibular incisors and mandibular plane (IMPA) (p=0.313), or maxilla length (p=0.628). Furthermore, when performing a 3mm posterior maxilla impaction, the angle between the palatal plane and the maxillary occlusal plane (ANS-PNS) had no statistically significant impact on the bite closure. (p=0.649). The results of a basic linear regression analysis of the effects of different factors on open bite closure during 5mm posterior maxillary impaction are presented in Table 4. The amount of bite closure in the 5 mm posterior impaction of the maxilla was not significantly affected by mandible length (p=0.271), maxilla length (p=0.532), angle between the central maxillary incisor and skull base (U1-SN) (p=0.997) and the angle between the palatal plane and the maxillary occlusal plane (ANS-PNS) (p=0.15); but the angle between the mandibular incisors and mandibular plane (IMPA) has significant effect on bite closure when performing 5mm posterior maxillary impaction. (p<0.001) There is a statistically significant increase in bite closure of 0.25mm for every 1 degree increase in IMPA in 5mm maxillary impaction.

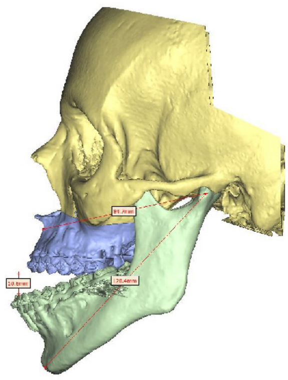

Figure 1. Reconstruction of primary anterior open bite of 11.6mm in CT scan images using from ProPlan CMF software (also maxilla length of 84.7mm and mandible length of 120.4mm is visible).

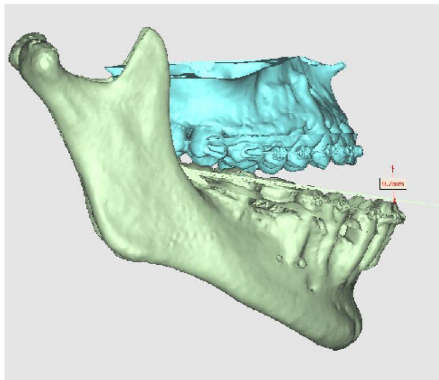

Figure 2. Reconstruction of anterior open bite by 9.7 mm after 2mm of posterior impaction in Patient's CT scan using ProPlan CMF software.

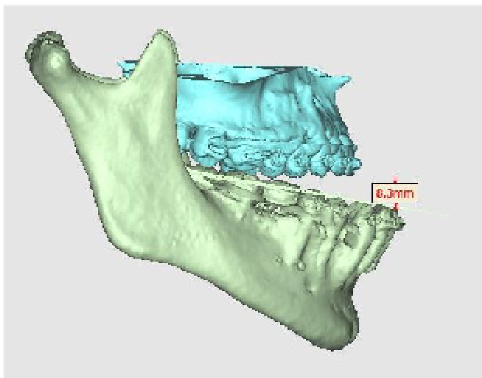

Figure 3. Reconstruction of anterior open bite equal to 8.3mm after 3mm of posterior impaction in Patient's CT scan using ProPlan CMF software (bite closure following posterior maxillary impaction through autorotation of the mandible).

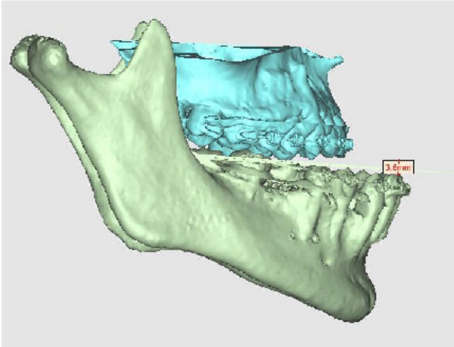

Figure 4. Reconstruction of anterior open bite equal to 3.6mm after 5mm posterior impaction in Patient's CT scan using ProPlan CMF software (bite closure following posterior maxillary impaction through autorotation of the mandible).

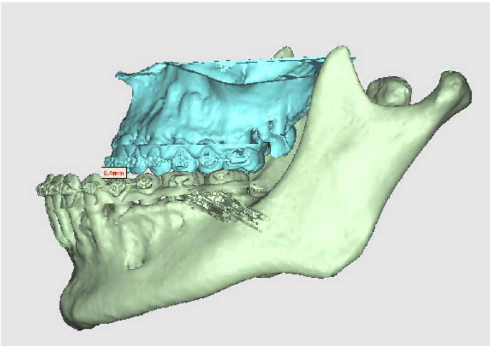

Figure 5. Anterior open bite reconstruction equal to 0.4 mm after 7mm posterior impaction in Patient's CT scan using ProPlan CMF software.

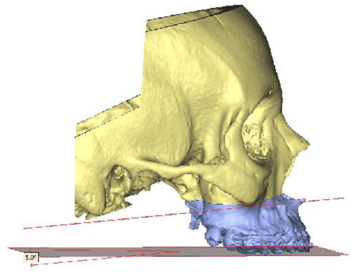

Figure 6. The angle of 5.8 degrees between the palatal plane and the maxillary occlusal plane.

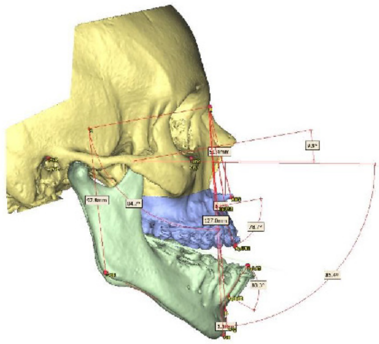

Figure 7. 3D cephalometric analysis using Proplan CMF software.

Table 1. The rate of bite closure in patients following maxillary posterior impaction with different values.

Posterior maxillary impaction	N	Mean	Standard deviation	Minimum	Maximum	Percentile 25	Percentile 50	Percentile 75
2mm	25	2.18	1.1811	0.3	4.9	1.5	2	2.8
3mm	20	3.38	1.2821	1.3	6	2.5	3	4.4
5mm	10	5.55	1.9329	2.3	8.6	4	5.8	7
7mm	2	11	0	11	11	11	11	11
Initial open bite	25	4.836	2.4464	1.5	3.4	3.4	4.1	5.2

Table 2. The results of the simple linear regression test to investigate the effects of different variables on bite closure in 2mm posterior maxillary impaction.

Variable	Coefficient Regression	Standard error	The number of t	P value	confidence interval average
Maxillary length	-0.0586	0.0427	-1.37	0.183	-0.03-0.15
Mandibular length	0.0052	0.0236	0.22	0.825	-0.04-0.05
U1-SN	0.0378	0.0378	1.27	0.218	-0.01-0.02
IMPA	0.0070	0.0360	0.19	0.848	-0.07-0.08
ANS-PNS	0.0399	0.0621	0.64	0.526	-0.09-0.17

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Table 3. The results of the simple linear regression test to investigate the effects of different variables on bite closure in 3mm posterior maxillary impaction.

Variable	Coefficient Regression	Standard error	The number of t	P value	confidence interval average
Maxillary length	-0.0259	0.0524	-0.049	0.628	-0.08-0.14
Mandibular length	0.0269	0.0272	0.99	0.336	-0.03-0.08
U1-SN	0.042	0.0374	1.08	0.296	-0.04-0.12
IMPA	0.0437	0.0421	0.04	0.313	-0.04-0.13
ANS-PNS	0.0337	0.0727	-0.46	0.649	-0.12-0.19

Table 4. The results of the simple linear regression test to investigate the effects of different variables on bite closure in 5mm posterior maxillary impaction.

Variable	Coefficient Regression	Standard error	The number of t	P value	confidence interval average
Maxillary length	0.0747	0.1143	0.65	0.532	-0.19-0.34
Mandibular length	0.0729	0.0617	1.18	0.271	-0.07-0.22
U1-SN	-0.0004	0.0862	0	0.997	-0.19-0.20
IMPA	0.2584	0.0508	5.09	0.001	0.14-0.38
ANS-PNS	0.2909	0.1825	1.59	0.15	-0.13-0.71

Discussion

Maxillary impaction surgery can result in mandible autorotation and forward chin movement by lowering the lower anterior height of the face. The impact of maxilla impaction on mandibular reaction has been a topic of much recent discussion. Furthermore, anterior cranial movement is said to cause the mandible to autorotate [15-17]. This study used pre-existing CT scans to examine the effects of maxillary posterior impaction on mandibular autorotation in patients with anterior open bite using geometric analysis and ProPlan CMF software. The current study's findings show that when the maxilla is posteriorly impactioned by 2mm around the anterior nasal spine (ANS), the average byte closure is equal to 2.18mm; when the maxilla is posteriorly impactioned by 3mm, the average byte closure is equal to 3.38mm; when the maxilla is posteriorly impactioned by 5mm, the average byte closure is equal to 5.55mm; and when the posterior impaction of the maxilla occurs at a rate of 7mm, the rate of bite closure in patients was equal to 11.0mm. The rates of maxillary impaction are also correlated with spontaneous rotation (autorotation) of the mandible. Consequently, the values of bite closure increase with the extent of impaction in the maxilla. This is due to the fact that the posterior and anterior parts of the maxilla are raised to different degrees during impaction surgery. The maxillary posterior part is typically more impacted than the anterior part in patients with frontal open bites in order to facilitate bite closure; So maxillary impaction change the position of the mandible and improved the patient's open bite's occlusion and aesthetics [17]. The axis of mandible rotation is positioned close to the mandibular center of rotation during maxillary impaction surgery, not on the condyles [18]. Consequently, there is a bigger decline in the anterior height of the lower face compared to its posterior height [19]. Moreover, during impaction surgery, the mandible's autorotation results in a decrease in both the mandible plane angle and the articular angles [20]. The results of our study also showed a reduction in anterior lower face height and vertical proportion after maxillary impaction surgery, but there was no detectable reduction in posterior face height at this time. Furthermore, in the present study, there were no significant effects of the different variables on the degree of bite closure and mandibular autorotation. Following maxillary impaction and the establishment of a fixed occlusion, autorotation of the mandible is a clinical and cephalometric consequence [21-23]. Wessberg and colleagues. In their 1982 study, demonstrated that the mandible's autorotation is a biological result and a component of a mechanism that is controlled by the central nervous system. They named this phenomenon "occlusal programming feedback" [22]. With 2, 3, 5 and 7mm posterior impaction of the maxilla, the bite closure was not significantly affected by maxilla length, mandible length, U1-SN angle, ANS-PNS angle with the maxillary occlusal plane, or mandibular incisor angle with the mandibular plane. Nevertheless, during the 5mm posterior maxillary impaction procedure, IMPA has significant effects on the extent of bite closure. Therefore, the role of these variables in the extent of bite closure in maxillary impaction surgery was rejected. In the research by Peleg and colleagues. In patients undergoing Le Fort I maxillary impaction surgery for vertical maxillary excess, the prognosis of mandibular autorotation was examined in (2019) and no relationship was found between the degree of maxillary impaction and the presence of autorotation [24].

The mandibular center of rotation is the fundamental problem in determining the values of mandibular autorotation during maxillary impaction surgery. The line joining the center of each side's condyle is the mandible's center of rotation in this study. Nadjmi and companions. (1998) developed a method to predict the mandibular autorotation center [15] and demonstrated that in cases of maxillary impaction, the mandible's rotational center is located in the center of the condyles. As a result, it is possible to replicate the mandibular rotation using a template by measuring the degree of maxillary impaction in lateral cephalograms. Sperry 1998 also stated that the primary factor influencing the mandible's position was the surgeon's experience. The rotation center of the mandible is frequently found in the posterior of the condyle cavity, according to findings by Nattestad and associates (1991 and 1992) [25,26]. The condylion (the highest point on the condyle), the condyle center, and the Sperry point (the most posterior position in the condyle cavity) were the three distinct centers for mandibular rotation in a study involving fifteen patients with Maxilla impaction that was conducted by Brayan et al. (1994).

The aforementioned study did not find any differences among these three centers for autorotation of the mandible. Based on Bryan et al. Because each patient has a unique craniofacial morphology, the mandibular rotation center varies, making precise identification of the center of rotation essential to optimal treatment outcomes. All three points of mandibular rotation can be used to determine varying amounts of autorotation [16]. Sperry & Associates (1982) and Bryan et al. (1994) stated that it is impossible to predict with certainty the results of orthosurgical procedures, especially the amount of mandibular autorotation. Also the problems in identifying the center of rotation is also one of the reasons why mandibular autorotation extent cannot be anticipated during maxillary impaction surgery [13,27]. Moreover, after maxillary impaction surgery and mandibular autorotation, the vertical dimensions of the lower face alter. Various studies have reported a correlation between maxillary impaction and lower facial height reduction rate. Schendel along with others [10,11] examine the outcomes of maxillary impaction surgery and mandible autorotation in the initial post-operative period. They also simulate post-operative outcomes using particular templates on lateral cephalograms. Lee and associates. (1996) documented comparable modifications to hard and soft tissue structures following maxillary impaction treatments [28-30].

It has been stated that when the maxilla is the only area operated on, the mandible naturally rotates to create a new occlusion; this phenomenon eventually leads to the soft tissue adjusting to the hard texture. Studies have shown that there is a 1:1 ratio between the mandibular autorotation following maxillary impaction and the shortening rates of the lower face (cranial movement of chin protrusion) [28,29]. ProPlan CMF software was employed in this study to measure the amount of anterior open byte changes following posterior maxillary impaction around the anterior nasal spine (ANS). In addition to being an extremely powerful soft tissue prediction tool, this software can be used to consult with patients and justify procedures prior to surgery. Because ProPlan CMF software is commercially available, clinicians can find it useful and appropriate. Knoops and associates tested the accuracy of several software programs, including ProPlan CMF in 2019 and it was found that this software is very accurate for three-dimensional prediction with continuous displacements and it is able to adjust soft tissue parameters [31].

Based on the findings of Mojdehi et al. (2001) maxillary impaction surgeries have specific effects on the mandibular position, as demonstrated by the results of the current study [20]. Additionally, a study found that a 2.7mm Maxilla impaction causes the mandible to autorotate forward 3.3 degrees to the front. Additionally, pre-operative estimates showed that 5mm of maxillary impaction would cause the chin to move 2mm forward and grow 1/2mm shorter vertically when the mandible's autorotation center aligns with the condyles' radiographic center [25]. In a study by Mojdehi and colleagues. (2001) found that an impaction of the maxilla

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by 3.2mm anteriorly and 1.3mm posteriorly causes a rotation of the mandible by 3.2 degrees [20]. Reddy et al. (2021) in a systematic review protocol examined the rate of mandibular autorotation following maxillary impaction in patients with gummy smiles. The results showed that intrusion of the maxilla and autorotation of the mandible have a clear effect on the final position of the mandible and chin, with an upward impaction of the maxilla by 1mm shifting the chin by 0.2mm in the horizontal direction and 0.6mm in the vertical direction [32]. Predicting outcomes using cephalometric landmarks necessitates identifying these landmarks and tracing them accurately.

During overlay and carrying out calculations, some errors may occur [33]. Conversely photoencephalometry and video imaging methods can also be susceptible to inaccuracies [34]. The effect of surgery in specific landmarks cannot be interpreted as an isolated event and doing so may lead to inconsistent outcomes [35]. It's important to take into account the changes in hard tissue, which should be interpreted cautiously and with an eye toward possible errors. Conventional cephalometric landmarks in the jaw, however, typically favor the dental system over other basal skeletal structures. Concurrently, surgery typically modifies cephalometric landmarks, particularly in the maxilla; post-surgery fixation also modifies landmarks as well. Taking into account the cephalometric assessments conducted in the study, reveals an interconnection among growth patterns, effects of pre-operative and post-operative orthodontic procedures, surgical modifications, bone structures and positioning of landmarks.

Accordingly, research indicates that orthodontic treatments and growth processes are closely related and frequently occur together with surgical procedures. Given that this study was conducted in a single center, another study involving more homogeneous populations at similar developmental and age stages is necessary. Additionally, there remains a need to compare intraoperative clinical results and values with the advantages of Proplan CMF software through an investigation with a larger sample size.

Conclusion

The amount of bite closure (mandible autorotation) increases in proportion to the amount of maxillary posterior impaction surgery. All investigated variables, with the exception of the IMPA variable in impactions of only 5mm, have no discernible effects on the amount of bite closure.

Conflict of Interest

There is no conflict of interest to declare.

References

[1] Reichert I, Figel P, Winchester L. Orthodontic treatment of anterior open bite: a review article—is surgery always necessary? Oral and maxillofacial surgery. 2014; 18:271-7.

[2] Greenlee GM, Huang GJ, Chen SS-H, Chen J, Koepsell T, Hujoel P. Stability of treatment for anterior open-bite malocclusion: a meta-analysis. American journal of orthodontics and dentofacial orthopedics. 2011; 139(2):154-69.

[3] Sherwood K. Correction of skeletal open bite with implant anchored molar/bicuspid intrusion. Oral and maxillofacial surgery clinics of North America. 2007; 19(3):339-50.

[4] Deguchi T, Kurosaka H, Oikawa H, Kuroda S, Takahashi I, Yamashiro T, et al. Comparison of orthodontic treatment outcomes in adults with skeletal open bite between conventional edgewise treatment and implant-anchored orthodontics. American Journal of Orthodontics and Dentofacial Orthopedics. 2011; 139(4):S60-S8.

[5] Burford D, Noar JH. The causes, diagnosis and treatment of anterior open bite. Dental update. 2003; 30(5):235-41.

[6] Bisase B, Johnson P, Stacey M. Closure of the anterior open bite using mandibular sagittal split osteotomy. British Journal of Oral and Maxillofacial Surgery. 2010; 48(5):352-5.

[7] Kim YH. Anterior openbite and its treatment with multiloop edgewise archwire. The angle orthodontist. 1987; 57(4):290-321.

[8] Mizrahi E. A review of anterior open bite. British journal of orthodontics. 1978; 5(1):21-7.

[9] Sandler PJ, Madahar AK, Murra A. Anterior open bite: aetiology and management. Dental update. 2011; 38(8):522-32.

[10] Schendel SA, Eisenfeld J, Bell WH, Epker BN, Mishelevich DJ. The long face syndrome: vertical maxillary excess. American journal of orthodontics. 1976; 70(4):398-408.

[11] Schendel SA, Eisenfeld JH, Bell WH, Epker BN. Superior repositioning of the maxilla: stability and

soft tissue osseous relations. American journal of orthodontics. 1976; 70(6):663-74.

[12] Steinhäuser S, Richter U, Richter F, Bill J, Rudzki-Janson I. Profile changes following maxillary impaction and autorotation of the mandible. Journal of Orofacial Orthopedics/Fortschritte der Kieferorthopädie. 2008; 69(1):31-41.

[13] Sperry TP, Steinberg MJ, Gans BJ. Mandibular movement during autorotation as a result of maxillary impaction surgery. American journal of orthodontics. 1982; 81(2):116-23.

[14] Sasaki R, Rasse M. Mandibular reconstruction using ProPlan CMF: a review. Craniomaxillofacial Trauma & Reconstruction Open. 2017; 1(1):s-0037-1606835.

[15] Nadjmi N, Mommaerts MY, Abeloos JV, De Clercq CA. Prediction of mandibular autorotation. Journal of oral and maxillofacial surgery. 1998; 56(11):1241-7.

[16] Hosseinzadeh Nik T, Emdadian Razavi ES, Modarresi A. A Retrospective Cephalometric Evaluation on Location of Center of Mandibular Autorotation after Le Fort I Superior Repositioning Osteotomy. Iranian Journal of Orthodontics. 2014; 9(1):37-42.

[17] Watted N, Wieber M, Reuther J. Treatment of a Class II deformity with skeletal open bite and lateroocclusion. Clinical Orthodontics and Research. 2001; 4(1):50-9.

[18] Zarrinkelk HM, Throckmorton GS, Ellis III E, Sinn DP. Functional and morphologic alterations secondary to superior repositioning of the maxilla. Journal of oral and maxillofacial surgery. 1995; 53(11):1258-67.

[19] Hatcher JE. Effects of Surgical Orthodontic Treatment on Natural Head Posture and Position: Texas, UNITED STATES; 1988.

[20] Mojdehi M, Buschang PH, English JD, Wolford LM. Postsurgical growth changes in the mandible of adolescents with vertical maxillary excess growth pattern. American Journal of Orthodontics and Dentofacial Orthopedics. 2001; 119(2):106-16.

[21] Epker BN, Fish LC. Surgical superior repositioning of the maxilla: what to do with the mandible? American Journal of Orthodontics. 1980; 78(2):164-91.

[22] Wessberg GA, Washburn MC, LaBanc JP, Epker BN. Autorotation of the mandible: Effect of surgical superior repositioning of the maxilla on mandibular resting posture. American journal of orthodontics. 1982; 81(6):465-72.

[23] Tanne K, Sachdeva R, Sakima T. Mandibular autorotation associated with Le Fort I total maxillary osteotomy. The Journal of Osaka University Dental School. 1987; 27:21-30.

[24] Peleg O, Mijiritsky E, Manor Y, Inchingolo F, Blinder D, Mortellaro C, et al. Predictability of mandibular autorotation after Le Fort I maxillary impaction in case of vertical maxillary excess. Journal of Craniofacial Surgery. 2019; 30(4):1102-4.

[25] Nattestad A, Vedtofte P. Mandibular autorotation in orthognathic surgery: a new method of locating the centre of mandibular rotation and determining its consequence in orthognathic surgery. Journal of cranio-maxillofacial surgery. 1992; 20(4):163-70.

[26] Nattestad A, Vedtofte P, Mosekilde E. The significance of an erroneous recording of the centre of mandibular rotation in orthognathic surgery. Journal of Cranio-Maxillofacial Surgery. 1991; 19(6):254-9.

[27] Bryan D. An investigation into the accuracy and validity of three points used in the assessment of autorotation in orthognathic surgery. British journal of oral and maxillofacial surgery. 1994; 32(6):363-72.

[28] Bell WH, Creekmore TD, Alexander R. Surgical correction of the long face syndrome. American journal of orthodontics. 1977; 71(1):40-67.

[29] Fish LC, Wolford LM, Epker BN. Surgical-orthodontic correction of vertical maxillary excess. American journal of orthodontics. 1978; 73(3):241-57.

[30] Lee D, Bailey L, Proffit W. Soft tissue changes after superior repositioning of the maxilla with Le Fort I osteotomy: 5-year follow-up. The International journal of adult orthodontics and orthognathic surgery. 1996; 11(4):301-11.

[31] Knoops P, Borghi A, Breakey R, Ong J, Jeelani N, Bruun R, et al. Three-dimensional soft tissue pre-

 DOI: 10.18502/jcr.v11i2.17030

diction in orthognathic surgery: a clinical comparison of Dolphin, ProPlan CMF, and probabilistic finite element modelling. International journal of oral and maxillofacial surgery. 2019; 48(4):511-8.

[32] Reddy SGK, Ibrahim HM, Bhardwaj S, Potdar S, Kumar A, Uppal A, et al. Autorotation of the mandible as sequelae to maxillary intrusion: A systematic review. Journal of Pharmacy and Bioallied Sciences. 2021; 13(Suppl 2):S947-S51.

[33] Baumrind S, Miller D, Molthen R. The reliability of head film measurements: 3. Tracing superimposition. American journal of orthodontics. 1976; 70(6):617-44.

[34] Sarver DM, Johnston MW, Matukas VJ. Video imaging for planning and counseling in orthognathic surgery. Journal of oral and maxillofacial surgery. 1988; 46(11):939-45.

[35] Brammer J, Finn R, WH B, Sinn D, Reisch J, Dana K. Stability after bimaxillary surgery to correct vertical maxillary excess and mandibular deficiency. 1980.