Original Article

Qualitative Comparison of Stress Distribution of Different Fixation Techniques of Sagittal Split Ramus Osteotomy (SSRO) in Mandibular Setback Surgery in Asymmetric Cases Using Three-Dimensional Finite Element Analysis (FEA)

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ABSTRACT

Background: Bilateral sagittal split osteotomy (BSSO) is the most common procedure in orthognathic Surgey of mandible also in asymmetries. However, the methods of fixation are different. Few studies worked on asymmetric cases especially with the use of finite element analysis (FEA). We aimed to evaluate stress distribution of two different Fixation techniques in mandibular setback surgery in asymmetric cases using FEA.

Methods: A 3-dimensional model of asymmetric mandible was obtained. SSRO with modified osteotomy was simulated unilaterally and another side osteotomized as common. Then differential set back was done and rigid fixation of that modified side with miniplate and monocortical screws was simulated then rigid fixation of other side by different fixation technics include 2 or 3 bicortical screws. With the force of 132N and 300N on the occlusal surface of first molars, the Von Mises Stress (VMS) distribution was calculated.

Results: Stress distribution in threads of screws in use of three bicortical screws was higher than two bicortical screws (161%). VMS distribution in spongy bone of left ramus in use of three bicortical screws was higher than the use of two bicortical screws (78% difference). VMS distribution in cortical bone of mandible body in use of three bicortical screws was significantly higher than the use of two bicortical screws (1.3% difference) (P<0.5).

Conclusion: The use of modified osteotomy and fixation with rigid fixation of two bicortical screws can create a more predictable and uniform stress distribution in mandibular setback surgery in asymmetric cases.

KEYWORDS
Sagittal split ramus osteotomy (SSRO); Asymmetry; Fixation techniques; Mandibular setback surgery; Finite element analysis (FEA)

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INTRODUCTION

Mandibular setback surgery, also known as mandibular retrognathia surgery, is a corrective procedure performed on people with a protruding mandible. This surgery involves repositioning the mandible in order to achieve better facial balance and improve the patient's bite and overall function[1]. During this procedure, the lower jaw is osteotomized and moved backward to correct facial asymmetry or improve occlusion. This can be done through a variety of techniques, including a sagittal split ramus osteotomy (SSRO) or intraoral vertical ramus osteotomy (IVRO)[2]. The SSRO is perhaps the most often-used mandibular osteotomy because it can be used for the correction of mandibular prognathism, retrognathism, and asymmetries[3]. This procedure involves making a sagittal osteotomy in the lower jaw on both sides, which allows the surgeon to reposition and realign the jaw[4]. During an SSRO, the surgeon makes an incision inside the mouth along the anterior oblique line of the lower jaw, exposing the jawbone. Then, using specialized tools, create mandibular osteotomy along the sagittal plane. This allows controlled mobility of the mandibular segments[5]. The surgeon then repositions parts of the mandible to achieve the desired alignment, which can include moving the lower jaw forward or backward. Then in more often times, titanium plates and screws are used to stabilize the displaced parts of the mandible[6]. This procedure is usually performed under general anesthesia. By changing the position of the lower jaw, the goal of this procedure is to correct bite problems, improve facial aesthetics, and improve overall jaw function. Recovery after SSRO may include a short hospital stay, a liquid or soft diet, and the use of pain medications[7]. Swelling and bruising are common in the first few days, which will gradually improve over a few weeks. Regular follow-up visits are important to monitor healing progress and make any necessary adjustments[8].

Mandibular asymmetry refers to a condition in which there is an imbalance or unevenness in the size, position, or shape of the lower jaw (mandible). This condition may occur due to various factors including genetics, developmental problems, and trauma or jaw disorders[9]. Mandibular asymmetry can cause numerous problems, both functional and aesthetic. Treatment options for mandibular asymmetry depend on the severity of the disease and the underlying cause[10]. Non-surgical treatments may include orthodontic treatment, dental restorations, or the use of oral appliances to correct the bite. In more severe cases, surgical procedures such as orthognathic surgery may be necessary to correct the jaw imbalance[11].

Some studies have investigated mandibular advancement or setback surgery but few studies have focused on facial asymmetry[12]. After mandibular osteotomy in patients with asymmetry, bony interference and gaps between the segments are more prevalent and usually the proximal and distal segments do not align themselves passively[12] and this may cause displacement of the condyles medially or laterally within the mandibular fossa during the application of internal fixation devices. Because of that an secondary osteotomy is performed in this study as Ellis investigation on 2007 "through the distal segment just behind the terminal molar, extending from the superior surface of the mandible to the level of the canal of neurovascular bundle" and also this osteotomy often use unilaterally and fixation of that side was by a 4 holes miniplate and 4 monocortical screws so we done in this investigation[13].

Fixation techniques used in SSRO can significantly affect the stability and outcome of the procedure. This includes fixation of the osteotomized segments to allow for proper healing and alignment. Some of the common fixation techniques used in SSRO include: rigid fixation, intermaxillary fixation (IMF), and biodegradable fixation[14]. The choice of fixation method depends on various factors, such as the severity of jaw disharmony, the surgeon's preference, the patient's oral and dental health status, and the expected results of the surgery[15]. It is important for an oral and maxillofacial surgeon to determine the most appropriate fixation method for each individual case.

The success of SSRO technic depends on the stability and accuracy of the fixation technique used[16]. Various forms of rigid fixation techniques are available for SSRO, including miniplates with monocortical screws, bicortical screws and biodegradable plates. Each technique has its advantages and disadvantages, and the choice of fixation method can significantly affect the postoperative results[17]. Understanding the stress distribution in different fixation techniques is important to optimize stability and minimize complications associated with mandibular

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orthognathic surgery[18].
Three-dimensional Finite Element Analysis (FEA) is a computational method commonly used to evaluate the stress distribution in biological structures such as the mandible under different loading conditions. In the field of mandibular orthognathic surgery, FEA can help predict the mechanical behavior of various fixation techniques and identify areas of potential stress concentration[19, 20].
Therefore, this study aimed to qualitatively compare stress distribution of different fixation techniques of SSRO in mandibular setback surgery in asymmetric cases using three-dimensional FEA.

MATERIALS AND METHODS

We aimed to compare and analyze the stress distribution in different fixation techniques of SSRO in mandibular setback surgery for asymmetric cases using 3D FEA of screws and plates and scans of the mandible. Therefore, a 3D FEA model was made using the CT scan of the mandible of patients with asymmetry. SSRO based on Ellis study in 2007 was performed and three different fixation techniques were evaluated[13]; one miniplate with four screws, two bicortical screws, and three bicortical screws. FEA was performed to evaluate the stress distribution in the mandible and fixation hardware.

ETHICAL APPROVAL

The protocol of the present study was approved by the Research Ethics Committee of Mashhad University of Medical Sciences (No:IR.MUMS.DENTISTRY.REC.1402.011). In order to comply with ethical issues and the principles of confidentiality.

Reconstructing the geometry of the mandible

In this study, computed tomography (CT) scans of the mandible of patients with asymmetric mandible that underwent SSRO for mandibular setback surgery were used. CT scan images with a distance of 1 mm between the slices (1 mm cut), cortical and spongy bone models and teeth were prepared by Mimics software (Mimics, Materialize NV, Version 21) and S Matic. That was capable for processing DICOM files. Then, the mandible was segmented using image processing algorithms to separate the bone structure from the surrounding tissues and then a 3D model of these components was created using the Calculate 3D command Finally, the mandible was converted into a three-dimensional (3D) model suitable for finite element analysis (FEA).
SSRO osteotomy according to the instructions given by Ellis 2007 with the secondary osteotomy (through the distal segment just behind the terminal molar, extending from the superior surface of the mandible to the level of the neurovascular canal) was done unilaterally on the right side of model and another side with common SSRO (Abwegezer technique and Epker modification) [13]. Then the right side of the mandible was moved back by 5 mm and the left side by 3 mm. for simplifying the models with FEA, the osteotomized segment of proximal that located distally to second molar, was eliminated on the right side. In the next step, the geometry of 4-hole miniplates with a diameter of 2 and 6 and 11 mm titanium screws with a diameter of 2 mm, from Radman Darman Kian Company (Mashhad, Iran) was measured in all dimensions as a 3D scan and using Solidworks software (Solidworks, Dassault Systemes Version 2019) to designed as three-dimensional models of ASTM alloy (Ti_6A_4V F136_12a).

Compilation of 3D models

At this stage, all 3D models in Stl format exported from Mimics and Trimetic software were converted into parts in Stp format in Geomagic software and ready to be transferred to Ansys finite element analysis software (Ansys, Canonsburg ver.19.2) then the components were assembled on each other.
In this study, two models were performed on the mandible parts; 1) fixation on the right side with a 4-hole 2mm miniplate and 4 numbers of 6 mm monocortical screws with 2mm diameter (based on Ellis advice 2007) and the left side with two numbers of 11 mm bicortical screws (2mm diameter) in vertical arrangement with 20 mm distance) fixation on the right side with a 2mm miniplate with 4 holes and 4 numbers of 6mm monocortical screws with 2mm diameter (based on Ellis advice 2007) and the left side with 3 numbers of 11 mm bicortical screws (2mm diameter) in inverted L arrangement with 10 mm distance in superior part and 20 mm distance from upper to lower screws. In addition, two analyzes were performed for each fixation, which included 1) a force of 132 N on the occlusal surface of the first

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molars of both sides, and 2) a force of 300 N on the occlusal surface of the first molars of both sides. The quantity and location of applied forces were determined based on previous studies in this field[21]. Moreover, the mandible condyles were fixed in all models and a total of 4 analyzes were performed.

FEA

3D mandibular models were imported into FEA software with defined fixation techniques. Appropriate material properties, including elastic modulus and Poisson's ratio, were assigned to bone and stabilizing materials, which was a Young's modulus of 13700 and Poisson's ratio of 0.3 for cortical bone, the Young's modulus of 1370 and Poisson's ratio of 0.3 for spongy bone, the Young's modulus of 117000 and Poisson's ratio of 0.33 for screws and plate (titanium). Additionally, the total number of elements in the model was equal to 410669 tetrahedral elements and the number of nodes was equal to 706738. Then the boundary conditions were defined to simulate occlusal load and physiological conditions. Eventually, the FEA software solved the equations showing the stress and strain distribution in the lower jaw models.

Analysis and comparison of stress

The stress distribution in each fixation technique was quantitatively analyzed and compared. The stress concentration and high stress areas among stabilization techniques were also identified and compared. Moreover, areas of higher stress in each fixation technique were identified ($P<0.5$).

RESULTS

The characteristics of the materials used in this study are provided in Table 1.
Furthermore, the results related to stress on different parts are shown in Table 2.
Model 1: fixation on the right side with a 4-hole miniplate and 4 numbers of monocortical screws and the left side with two numbers of bicortical screws and a force of 132 N on the occlusal surface of the first molars of both sides.
Model 2: fixation on the right side with a 4-hole miniplate and 4 numbers of monocortical screws and the left side with two numbers of bicortical screws and a force of 300 N on the occlusal surface of the first molars of both sides.
Model 3: fixation on the right side with a 4-hole miniplate and 4 numbers of monocortical screws and the left side with 3 numbers of 11 mm bicortical screws and a force of 132 N on the occlusal surface of the first molars of both sides.
Model 4: fixation on the right side with a 4-hole miniplate and 4 numbers of monocortical screws and the left side with 3 numbers of 11 mm bicortical screws and a force of 300 N on the occlusal surface of the first molars of both sides.

Table 1: Material properties used in the study

Part	Young's modulus (MPa)	Poisson's ratio
Cortical bone	13700	0.3
Cancellous bone	1370	0.3
Teeth	20000	0.3
Titanium (plate and screws)	117000	0.33

Table 2: Results related to stress on different parts

Part	Model 1	Model 2	Model 3	Model 4
Left cortical ramus	153.04	347.83	152.94	347.58
Right cortical ramus	98.92	224.82	98.90	224.77
Cortical body	138.59	314.98	140.45	319.21
Left spongy ramus	12.47	28.35	22.31	50.70
Right spongy ramus	17.77	40.38	17.77	40.38
Spongy body	25.32	57.56	25.33	57.57
Screws	397.35	903.08	1040.40	2364.60
Screws and plate	Plate:377.03 Screw:571.85	Plate:856.89 Screw:1299.70	Plate:376.96 Screw:571.74	Plate:856.72 Screw:1299.40

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The cortical and spongy bone were modeled by Mimix and Trimetric software (Figure 1).
The screws and plate models were also created in SOLIDWORKS software. Additionally, the total number of elements in the model was equal to 410669 tetrahedral elements and the number of nodes was equal to 706738. The tension distribution model of mandible with one miniplate on the right side and two bicortical screws on the left side containing the loading force of 132 N on the first molars has been demonstrated in Figure 2.A-C
In addition, the tension distribution model of mandible with one miniplate on the right side and two bicortical screws on the left side containing the loading force of 300 N on the first molars has been depicted in Figure 3A-C.
The tension distribution model of mandible with one miniplate on the right side and three bicortical screws on the left side containing the loading force of 132 N on the first molars has been demonstrated in Figure 4A-C.
Moreover, the tension distribution model of mandible with one miniplate on the right side and three bicortical screws on the left side containing the loading force of 300 N on the first molars has been depicted in Figure 5A-C.
Applying 300N force in all models the VMS distribution (MPa) is about 127% higher than 132N force as that was predictable because of the FEA analysis is a homogenous and linear survey. with a P value of 0.5 and However, significant issues are that the VMS distribution in spongy bone of left ramus in use of three bicortical screws (22.31 and 50.7) was significantly higher than the use of two bicortical screws (12.47 and 28.35) which means 78% difference. ($P<0.5$). As in spongy bone of right ramus VMS distribution was the same in use of two or three bicortical screws (17.77 and 40.38) means zero percent difference. VMS distribution in cortical bone of left ramus is poorly higher in use of two bicortical screws (153.04 and 347.83) than three bicortical screws (152.94 and 347.58) which means 0.06% difference. the VMS distribution in cortical bone of right ramus is insignificantly higher in use of two bicortical screws (98.92 and 224.82) than three bicortical screws (98.9 and 224.77) which means 0.02% difference ($P<0.5$). The VMS distribution in cortical bone of body when use of three bicortical screws (140.45 and 319.21) was higher than the use of two bicortical screws (138.59 and 314.98) which means 1.3% difference. And also VMS distribution in spongy bone of body in use of three bicortical screws (25.33 and 57.57) was higher than the use of two bicortical screws (25.32 and 57.56) which means 0.03% difference. Stress distribution in miniplate when use of three bicortical screws (376.96 and 856.72) is poorly lower than the use of two bicortical screws (377.03 and 856.89) which means 0.01% difference. Stress distribution in threads of screws in use of three bicortical screws (1040.4 and 2364.6) is higher than two bicortical screws (397.35 and 903.08) which means 161% difference that was so significant. ($P<0.5$).

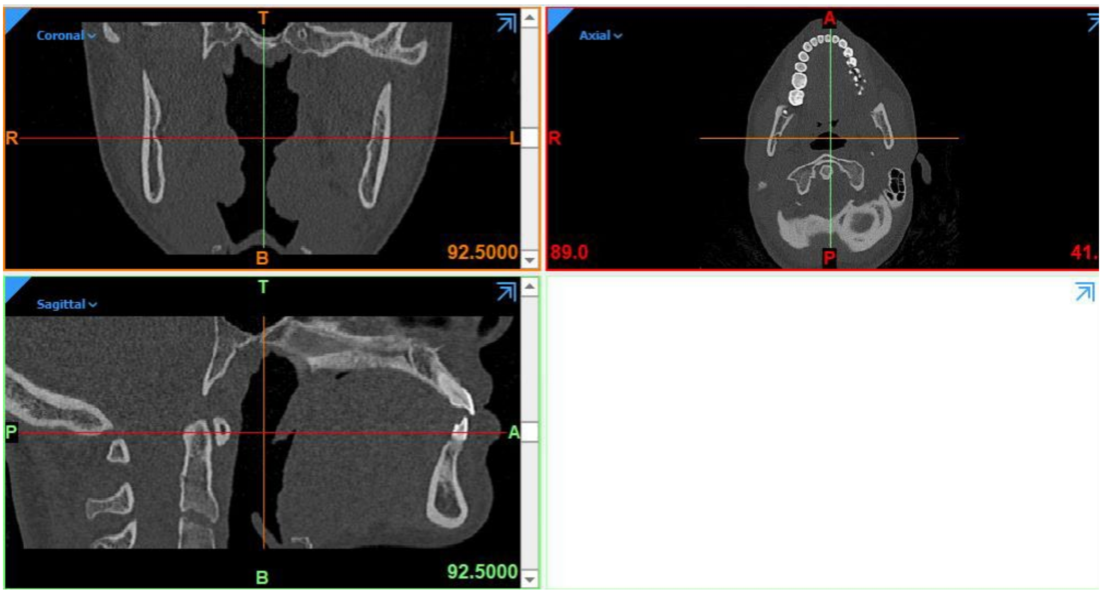

Figure 1: The modeled cortical and spongy bone using Mimix and Trimetric software

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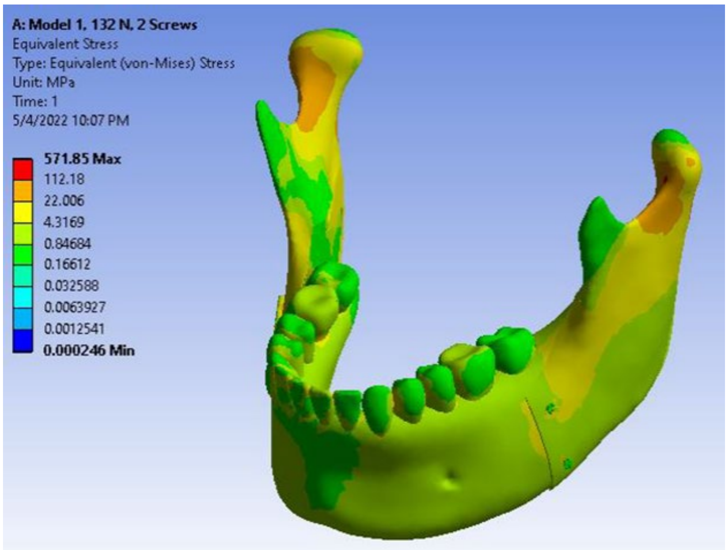

Figure 2: A) The overall tension distribution model of mandible with one miniplate on the right side and two bicortical screws on the left side (Loading force of 132 N on the first molars)

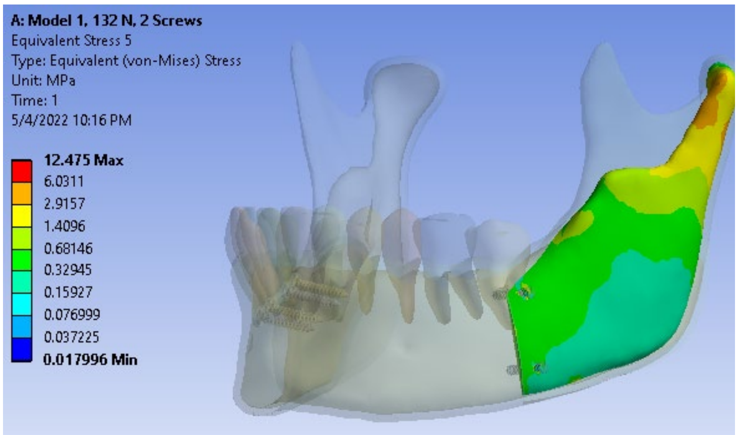

Figure 2: B) The tension distribution model of the spongy bone of left ramus with one miniplate on the right side and two bicortical screws on the left side (Loading force of 132 N on the first molars)

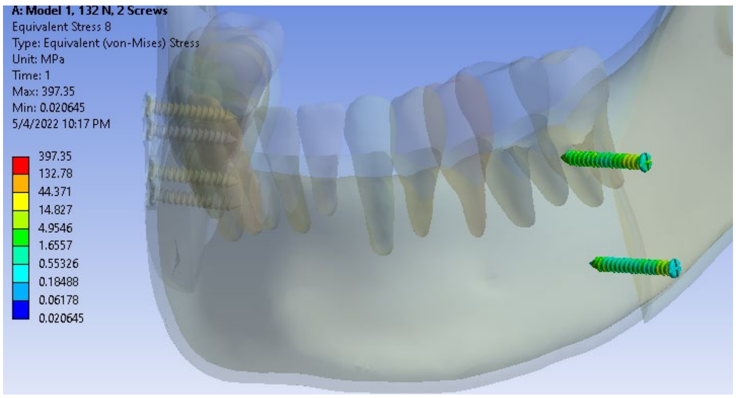

Figure 2: C) The tension distribution model of the bicortical screws with one miniplate on the right side and two bicortical screws on the left side (Loading force of 132 N on the first molars)

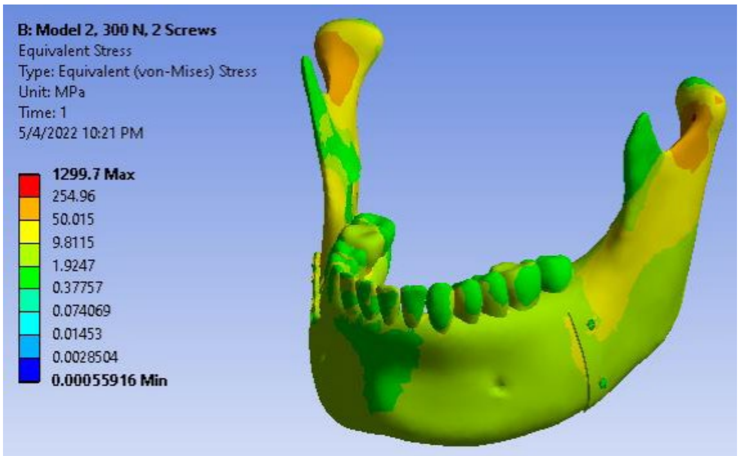

Figure 3: A) The overall tension distribution model of mandible with one miniplate on the right side and two bicortical screws on the left side (Loading force of 300 N on the first molars)

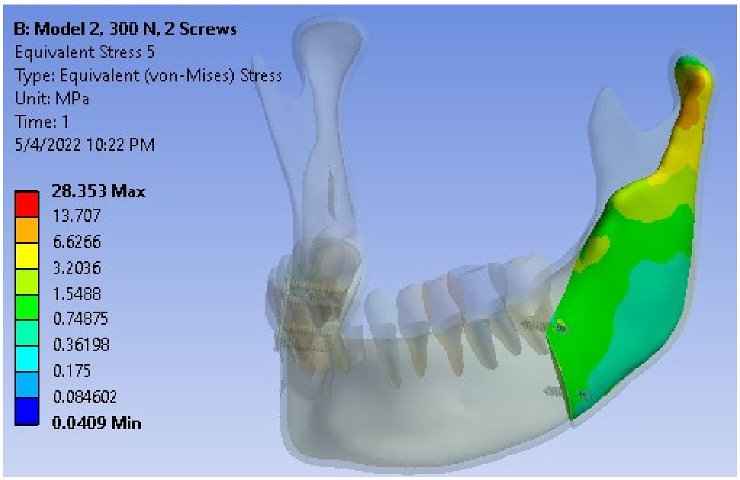

Figure 3: B) The tension distribution model of spongy bone of left ramus with one miniplate on the right side and two bicortical screws on the left side (Loading force of 300 N on the first molars)

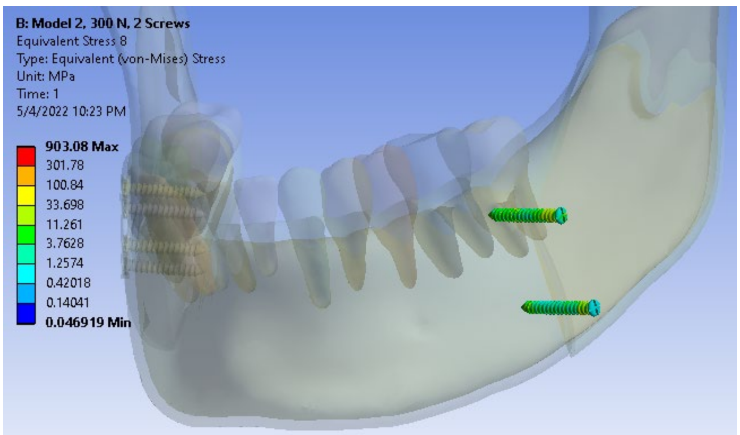

Figure 3: C) The tension distribution model of bicortical screws with one miniplate on the right side and two bicortical screws on the left side (Loading force of 300 N on the first molars)

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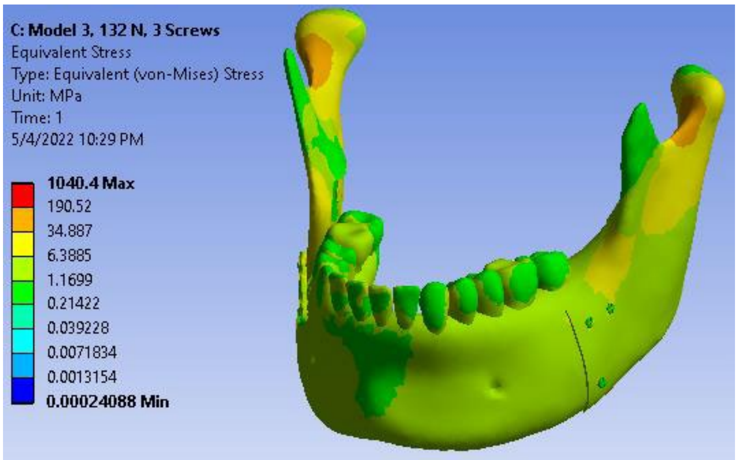

Figure 4: A) The overall tension distribution model of mandible with one miniplate on the right side and three bicortical screws on the left side (Loading force of 132 N on the first molars)

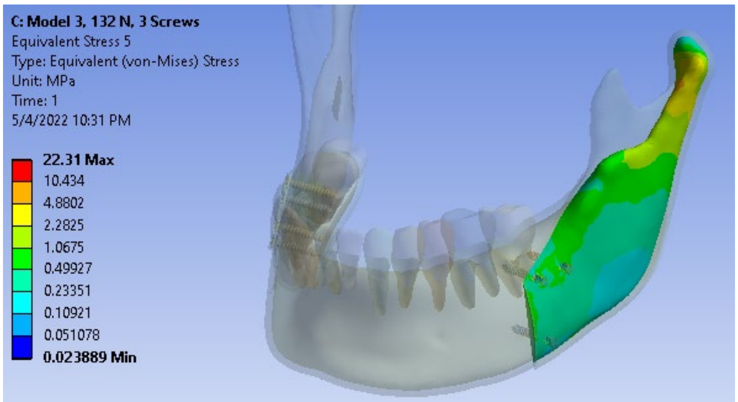

Figure 4: B) The tension distribution model of spongy bone of left ramus with one miniplate on the right side and three bicortical screws on the left side (Loading force of 132 N on the first molars)

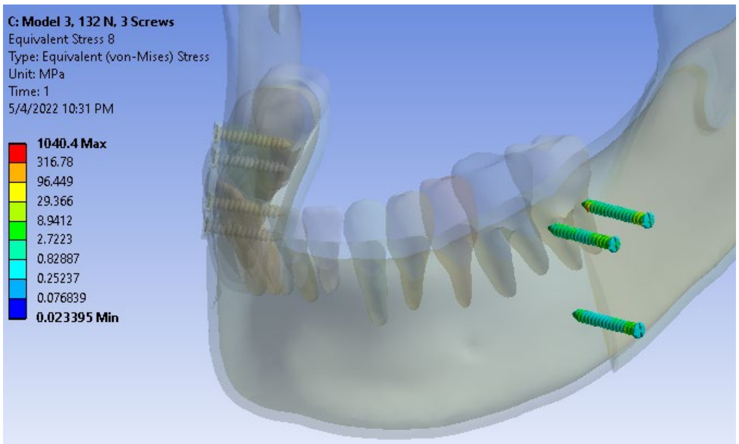

Figure 4: C) The tension distribution model of bicortical screws with one miniplate on the right side and three bicortical screws on the left side (Loading force of 132 N on the first molars)

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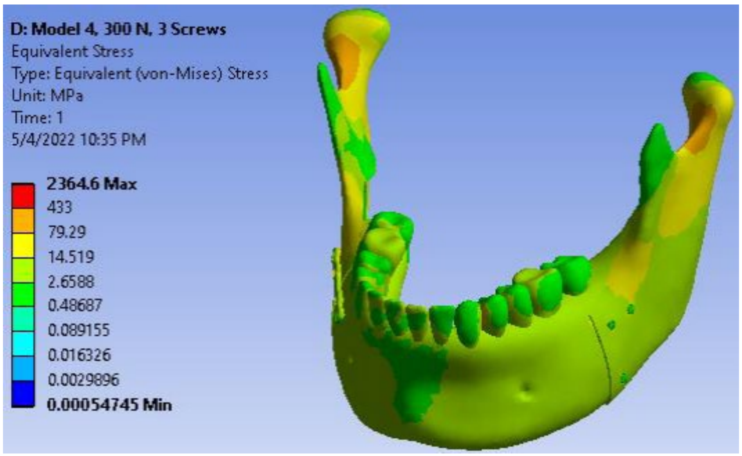

Figure 5: A) The overall tension distribution model of mandible with one miniplate on the right side and three bicortical screws on the left side (Loading force of 300 N on the first molars)

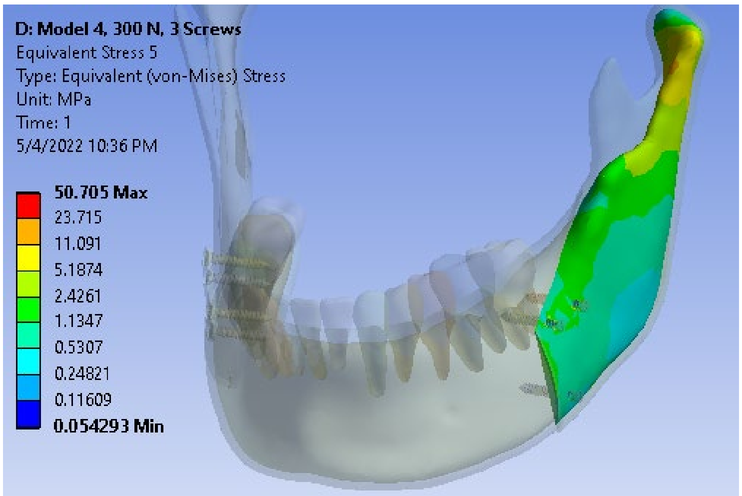

Figure 5: B) The tension distribution model of spongy bone of left ramus with one miniplate on the right side and three bicortical screws on the left side (Loading force of 300 N on the first molars)

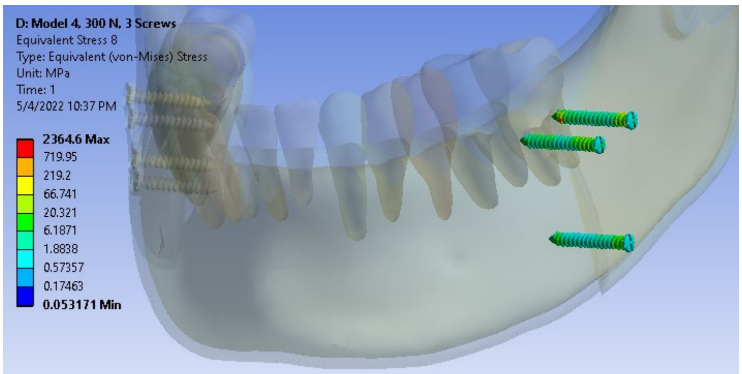

Figure 5: C) The tension distribution model of bicortical screws with one miniplate on the right side and three bicortical screws on the left side (Loading force of 300 N on the first molars)

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In asymmetric cases, the use of the three bicortical screws stabilization technique leads to more stress concentration in adjacent areas, remnant mandible bone and also in threads of screws themselves. This could potentially increase the risk of the plate breaking or the screw coming loose. On the other hand, the use of bicortical screws fixation leads to a uniformly distributed stress pattern and reduces the risk of failure. Overall tension in use of two bicortical screws was the lowest and then the most stable fixation thechnic was the use of two bicortical screws.

The use of bicortical screws can create a more predictable and uniform stress distribution in mandibular setback surgery in asymmetric cases. This can potentially reduce the risk of failure and improve treatment outcomes.

DISCUSSION

This study aimed to compare and analyze the stress distribution in different fixation techniques of SSRO in mandibular setback surgery for asymmetric cases using 3D FEA.

As we know one of the most difficult dentofacial deformities to correct with surgery is facial asymmetry. Because several factors should be considered when developing the treatment plan. Aside from aesthetic considerations, stability of the osteotomized segments also should be a part of the primary concern in performing the operation[22].

SSRO is a common surgical technique in mandibular orthognathic surgery, especially for correction of skeletal asymmetry. The success of this method depends on the stability and accuracy of the fixation technique used[16]. Osteosynthesis involves the use of plates and screws to stabilize the moving parts of the mandible. Plate and screws osteosynthesis provide more rigid fixation compared to wire osteosynthesis, resulting in better stress distribution along the osteotomy site. This allows better control over the position and fixation of parts. Stress is primarily concentrated around screws and plates. In some cases, screw-only fixation may be used without plates. This technique involves using screws alone to secure moving parts. Stress distribution with screw-only fixation can vary depending on the number and location of screws used. It is important to ensure adequate stability and avoid excessive stress concentration around the screws[23].

In mandibular setback surgery, a plate and screw system are usually used to stabilize the position of the mandible. Distribution of stress on the plate and screws is important to ensure proper healing and prevent complications. The distribution of stress on the plate and screws depends on various factors, including the type and design of the plate used , the number and location of the screws, the thickness and quality of the bone, and the forces applied to the jaw during normal function[24]. In general, plates and screws improve bone stability and healing by evenly distributing stresses on the bone surface. During mandibular setback surgery, the plate and screws are placed along the upper or lower borders of the mandible and securely fixed to the bone. The screws are usually placed at a specific angle to maximize purchase in the bone and ensure stable fixation[25]. The stress distribution on the plate and screws can be influenced by factors such as occlusal forces during chewing and biting, muscle forces during jaw movements, and biomechanical considerations. Ideally, the plate and screws should withstand the forces applied to the jaw during operation without experiencing excessive stress concentrations[26]. If the stress concentration is too high, it can lead to complications such as screw loosening, plate fracture, or bone loss around the screw. The stress distribution on the plate and screws is affected by the number and location of screws, as well as the design and material of the plate[26].

Ohba et al. conducted a study with the aim of investigating the skeletal stability of the osteotomized parts after SSRO in patients with facial asymmetry by the physiological positioning method (without fixation)[26]. Thirty patients with asymmetry and prognathism of the mandible were treated with this method (lingual osteotomy was performed in short form) and after placing the proximal and distal parts in their desired place, they were placed in IMF without internal fixation, and the patients started physiotherapy from the second day after the surgery. Short lingual osteotomy along with physiological positioning can provide good dental and skeletal stability in asymmetric patients (due to less bone interference) and relapse occurs less after the operation[3].

Kamil Hassan et al. designed a investigation with the aim of comparing 3 internal fixation techniques in BSSO using the FEA method[27]. First, SSRO osteotomy was performed with the Obwegeser

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technique and Epker modification on the mandible model, and fixation between the parts: bicortical screw with a diameter of 2 mm and an inverted L arrangement, a miniplate with a diameter of 1.7 mm, 4 holes, and 4 monocortical screws and a miniplate with a diameter 2 mm, 4 holes and 4 monocortical screws were tested in 3 surgical positions with 3 mm setback, 3 mm advancement, and 7 mm advancement of the mandible (9 models). Then the models were subjected to forces of 50, 75 and 100 N in the incisor area and 100, 200 and 300 N in the molar area. Two mm diameter bicortical screws had the least tension and displacement in all mandibular movements and therefore were more rigid[27]. The buccal and lingual cortex of the mandible are included, and the lowest stability among the three methods was for the 1.7 mm thickness miniplates, especially in larger movements and displacements of the mandible. The results of their study confirmed the results of the present study.

Lee et al. designed a study aimed at biomechanical evaluation of magnesium-based absorbable screw systems in BSSO using 3D Finite Element Analysis. A three-dimensional model of the mandible was designed, and after the BSSO osteotomy, the distal part was moved forward or backward by 10 mm, and then by 12 mm bicortical screws (3, 4, and 5 screws) was fixed. 3 bicortical screw systems were used, which included titanium screws, Inion CPS screws and magnesium based resorbable screws. The diameter of the screws was 2 mm for titanium and 2.2 mm for magnesium and 2.5 mm for Inion. In this study, a force of 132 N was applied to the occlusal surface of the first molar. In mandible advancement surgery, 5 magnesium screws can provide the stability of the parts like 3 titanium screws, but 3 or 4 magnesium screws are not enough[21].

Furthermore, Sakarat et al. conducted a study with the aim of the most appropriate pattern of stress distribution in BSSO surgery after fixation with absorbable screws and plates by FEA method[29]. They designed a mandible model and after performing BSSO osteotomy, the proximal and distal parts were fixed by 8 fixation models (one absorbable screw, 2 absorbable screws with vertical arrangement, 2 absorbable screws with horizontal arrangement, 3 absorbable screws with L arrangement, 3 absorbable screws with inverted L arrangement, one mini-plate with 2 screws, one mini-plate with 4 screws and two parallel mini-plates with 4 screws each). Then, the force of 75, 135 and 600 N was applied on the occlusal surface of the posterior teeth and the stress distribution pattern was evaluated. From their study, 2 parallel mini-plates with 4 screws each were the strongest and 1 absorption screw and 1 mini-plate with 2 screws were the weakest fixation patterns in BSSO surgery[28].

In another study, Edward Ellis designed a study with a purpose of a method to passively align the sagittal ramus osteotomy segments. He said that in asymmetric cases after BSSO the proximal and distal segments do not always align themselves passively to one another, this causes a gap formation between the segments and also displacement of condyle medially or laterally. Therefore, he suggested a secondary osteotomy through the distal segment just behind the terminal molar, extending from the superior surface of the mandible to the level of the neurovascular canal. The main benefit to using a secondary osteotomy is that it eliminates completely any tendency for the fragments to interfere with one another, eliminating all areas of premature contact so that the proximal segment can be passively rotated into contact with the distal segment. Another potential benefit from using the secondary osteotomy is that it might cause less displacement of the mandibular condyle by completely eliminating any potential bony interference between the segments. Moreover, this osteotomy is more often used unilaterally and fixed with miniplate and monocortical screws. Hence, because of this reasons, this is a modification osteotomy that we used in our study[13].

This study had several strengths, such as the use of mathematical technologies and software to enhance accuracy and reduce sampling variations, as well as the graphical adaptation of data analysis for better comprehension. This study was based on finite element analysis and used scanned screws and plates that may not fully replicate in vivo conditions.

CONCLUSION

The use of two different fixation techniques including 2 Bicortical screws and 3 Bicortical screws lead to different stress distributions along the SSRO sections in asymmetric cases. The choice of fixation technique can significantly affect the stress distribution in mandibular setback surgery. The use of 2 Bicortical screws to stabilize the SSRO segments resulted in

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a stiffer structure and lower stress concentration around the screw threads. Two bicortical screws may provide more stable fixation with a reduced risk of stress-related complications. Other Fixation techniques including 3 Bicortical screws showed higher stress concentrations around the fixation devices and mandible bone. This indicated a potential risk of stress-related complications such as plate fracture, screw loosening or bone loss in these cases. Based on the stress distribution comparison, it is important to carefully select the appropriate fixation method based on individual patient characteristics and specific clinical needs. This decision should consider biomechanical aspects such as stress distribution to minimize the risk of postoperative complications. In general, this study showed the importance of choosing the appropriate fixation technique in sagittal split ramus osteotomy for mandibular setback surgery in asymmetric cases. 3D finite element analysis provides valuable insights into the stress distribution associated with various fixation techniques and assists clinicians in making informed decisions for optimal patient outcomes.
Clinical studies and long-term follow-up are necessary to confirm these findings and determine the optimal fixation technique in BSSO surgery in asymmetric cases. Overall, this study contributes to the field of orthognathic and maxillofacial surgery and has the potential to improve patient outcomes and care.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests.

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