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COMPARISON OF THE EFFECT OF TWO SURGICAL TECHNIQUES ON THE BIOMECHANICAL STRENGTH OF BICORTICAL SCREWS AND MINIPLATES IN THE ADVANCEMENT OF POLYURETHANE MANDIBLES

POLİÜRETAN ALT ÇENELERİN İLERLETİLMESİNDE İKİ CERRAHİ TEKNİĞİN BİKORTİKAL VİDA VE MİNİPLAKLARIN BİYOMEKANİK DAYANIMINDAKİ ETKİSİNİN KARŞILAŞTIRILMASI

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ABSTRACT

Objective: This study aims to compare the biomechanical strength of miniplate and bicortical screw fixation in polyurethane mandibles with bilateral sagittal split osteotomy using either the Obwegeser-DalPont (ODP) or Hunsuck-Epker (HE) surgical cutting techniques.

Materials and Method: Thirty-two (N=32) polyurethane mandible models were created from data obtained from a tomographic image of a patient. In these models, 4mm advancements were made using ODP and HE cutting techniques. For fixation, 1mm thick, 4-hole, 9mm spaced straight titanium mini plates and 8 titanium screws, 2mm in diameter and 5mm in length, or 6 bicortical screws, 2mm in diameter, were used. Based on the cutting and fixation techniques, four groups were formed, each with 8 (n=8) mandible models. These groups were named M-EPKER, M-DALPONT, B-EPKER, and B-DALPONT, respectively. Fixed models were placed in a universal testing machine, and linear, continuous, and progressively increasing forces were applied from the cutting region. Force magnitudes required to reach displacement values of 1mm, 3mm, and 5mm for the test interface were measured in Newtons (N) and statistically compared.

Results: To reach the 1mm displacement level of the test models, the B-EPKER group required a higher force magnitude than the M-EPKER group ($p<0.05$). At the 3mm level, the B-DALPONT group demonstrated higher force values compared to the M-DALPONT group ($p<0.05$). Similarly, at the same level, the B-EPKER group reached higher force values than the M-EPKER group ($p<0.05$). At the 5mm level, both groups using bicortical screws achieved higher values compared to the group using mini plates ($p<0.05$).

Conclusion: Within the limitations of this experimental study, it can be concluded that fixation procedures with bicortical screws in polyurethane models with mandibular advancement, regardless of the surgical technique, are more durable than those with mini plates.

Keywords: Epker, DalPont, mini plate, bicortical screw, orthognathic surgery

ÖZ

Amaç: Bu çalışmanın amacı Obwegeser-DalPont (ODP) ya da Hunsuck-Epker (HE) cerrahi kesi yöntemleri kullanılarak bilateral sagital split osteotomi uygulanan poliüretan alt çenelerde miniplak ve bikortikal vida fiksasyonlarının biyomekanik dayanımını karşılaştırmaktır.

Gereç ve Yöntem: Bu çalışmada bir hastanın tomografik görüntüsünden elde edilen verilerle üretilen 32 adet (N=32) poliüretan alt çene modeli kullanılmıştır. Bu modellerde ODP ve HE kesi teknikleri kullanılarak 4mm ilerletme yapılmıştır. Fiksasyon için 1 mm kalınlığında, 4 delikli, 9mm aralıklı 2 adet düz titanyum mini plak ve 8 adet 2mm çapında, 5mm uzunluğunda titanyum vidalar ya da 2mm çapında 6 adet bikortikal vida kullanılmıştır. Çalışmada kesi ve fiksasyon tekniklerine göre her birinde 8 (n=8) alt çene olan 4 grup oluşturulmuştur. Bunlar sırasıyla M-EPKER, M-DALPONT, B-EPKER ve B-DALPONT olarak isimlendirilmiştir. Fikse edilmiş modeller bir evrensel test cihazına yerleştirilerek kesiciler bölgesinden doğrusal, devamlı ve giderek artan kuvvet uygulanmıştır. Deney arayüzünün 1 mm, 3mm, 5mm yer değiştirme değerlerine ulaşması için gereken Newton (N) cinsinden kuvvet büyüklükleri ölçülmüş ve istatistiksel olarak karşılaştırılmıştır.

Bulgular: Deney modellerinin 1 mm yer değiştirme seviyesine ulaşması için B-EPKER grubunda M-EPKER grubuna göre daha yüksek kuvvet büyüklüğü gerekli olmuştur ($p<0,05$). 3mm seviyesinde ise B-DALPONT grubu M-DALPONT grubuna göre daha yüksek kuvvet değerlerine dayanım göstermiştir ($p<0,05$). Aynı seviyede B-EPKER grubu M-EPKER grubuna göre daha yüksek kuvvet değerlerine ulaşmıştır ($p<0,05$). 5mm seviyesinde ise her iki kesi tekniğinde de bikortikal kullanılan grup, miniplak kullanılan gruba göre daha yüksek değerlere ulaşmıştır ($p<0,05$).

Sonuç: Bu deneysel çalışmanın sınırları dâhilinde, alt çene ilerletmesi yapılan poliüretan modellerde cerrahi teknik fark etmeksizin bikortikal vida ile yapılan fiksasyon işlemlerinin miniplak ile yapılanlara göre daha dayanıklı olduğu söylenebilir.

Anahtar Kelimeler: Epker, DalPont, miniplak, bikortikal vida, ortognatik cerrahi

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INTRODUCTION

Orthognathic surgical techniques are commonly employed in the treatment of dentofacial deformities (1). Among these, the bilateral sagittal split osteotomy (BSSO) technique is a preferred method for correcting asymmetries and deformations in the lower jaw. Its advantages include ease of application, rapid healing of the region between bone segments, no scar tissue formation as it is applied intraorally, and a low risk of facial nerve damage (2). BSSO is a complex osteotomy performed in three different planes. Over the years, various modifications have been proposed for the anatomical positions of the cutting lines (3). The most significant difference among them is the position of the cutting lines on the medial and lateral surfaces (4).

Among these modifications, the Obwegeser/DalPont (ODP) or Hunsuck/Epker (HE) osteotomies are techniques often used, particularly in procedures involving the advancement or setback of the lower jaw. In the ODP technique, two horizontal cuts are made on the lingual and buccal cortices above the mandibular foramen, and these cuts are connected by a vertical cut. Subsequently, the HE method was developed, considering that extending the medial cortical cut to the mandibular foramen was sufficient. The first osteotomy is performed horizontally on the inner surface of the ramus, approximately 0.5-1cm above the mandibular foramen, in a diagonal direction similar to the course of the external oblique line, moving anterior, buccal, and downward. The endpoint of the diagonal osteotomy in the anterior direction ends at the level of the lower molars. The osteotomy process is completed by making a vertical cut between this point and the basal process of the mandible. After reaching the cancellous bone with osteotomies, the ramus is separated from the mandibular body using osteotomes. The neurovascular bundle consisting of the inferior alveolar artery and nerve remains in the mandibular body. After the cuts are completed, the body and ramus are brought to the desired position and fixed with fixation methods (5).

Rigid internal fixation is performed after BSSO to stabilize the distal and proximal segments, accelerating healing, enabling the patient to begin mandibular function as early as possible after the operation without the need for maxillomandibular fixation, and minimizing relapse. To achieve these goals, bicortical screws or monocortical miniplate-screw systems can be used. When choosing between these, certain factors are considered. Bicortical screws may be preferred when there is a mismatch between the distal and proximal bone segments. Furthermore, in cases where there is a lack of alignment between the buccal cortex and condylar position control, it has been reported that in addition to bicortical screws, one or two mini plates may be required. Bicortical screw fixation is less hardware-intensive and, therefore, more cost-effective. However, in fixation with bicortical screws, holes are made in the lingual cortex of the distal segment, which can lead to lingual nerve injuries. This is less common in miniplate-screw fixations (6). Another advantage of the miniplate fixation method is that it does not require the use of a cheek retractor. In cases of malposition during the operation, correction is easier with the miniplate-screw method compared to the bicortical screw method (7).

When reviewing the literature, it becomes evident that there are numerous clinical or experimentally designed studies on plate-screw systems and bicortical screws used in BSSO fixation. However, there is no consensus on which fixation method is suitable and effective for which surgical technique. Surgeons often rely on their clinical experience when choosing a fixation method. However, the anatomical positions of the osteotomy lines can affect the strength. Therefore, this experimental study aims to compare the biomechanical strength of miniplate and bicortical screw fixations in polyurethane BSSO models prepared using ODP and HE surgical cutting lines. The tested null hypothesis in this study is that there is no difference in the force magnitudes required for the entire system to reach displacement levels of 1mm, 3mm, or 5mm when force is applied over the anterior cutting edge to BSSO models prepared with ODP and HE surgical cutting lines and fixed with mini plates or bicortical screws (8-10).

MATERIAL and METHODS

Ethical approval

This study protocol was reviewed and approved by the İstanbul University Faculty of Dentistry Clinical Research Ethics Committee (Date: 02.04.2021, No: 102).

Sample size determination

As no similar publication with this research was found, a pilot study was conducted using 5 models in each group (n=5) to obtain data for effect size calculation. Using G*Power software, with an effect size of 0.63, a 0.05 error probability, and an 80% power level (1-β), and data entered as 4 groups, the non-centrality parameter was calculated as 12.99, the critical F value as 2.94, and the total number of subjects as 32 (N=32) (11). Therefore, it was decided to have 8 models in each experimental group (n=8).

Polyurethane model construction

A cone-beam computed tomography of a patient planning for mandibular advancement was selected from the archive. The volumetric dataset was prepared to include the entire mandible. Then, sections with a thickness of 1 mm were prepared and saved in DICOM format. These were opened in 3D SLICER v4.11 software (https://www.slicer.org/). The mandible was segmented using both automatic thresholding and manual techniques to exclude the mandibular teeth. The acquired data were saved in stereolithography format. The surface of this virtual model was cleaned with Autodesk Meshmixer v3.5 (RRID: SCR_015736) software and printed into a physical model using a FormLabs Form 2 SLA 3D printer (FormLabs Inc., Boston, MA, USA). This primary model was sent to a commercial anatomical model manufacturer (Selbones Inc., Kayseri, Türkiye) for mold preparation using molding silicone. After curing, the primary model was removed from the mold. Then, a 1:1 mixture of polyol and isocyanate was injected into the mold cavity. After curing, the model was removed from the mold and cleaned.

Preparation of cutting lines and fixation

In this study, surgical cuts were made according to the ODP and HE techniques. First, cutting lines were drawn with a permanent marker on two primary polyurethane models, and silicone molds were prepared accordingly. These molds were used for standardization in each model. Fissure burs with a diameter of 2mm, a piezoelectric device, and an electric motor were used for making cuts on the medial and lateral surfaces. Controlled force was applied with surgical chisels and mallets for complete separation of the bone segments. In the HE-cut groups, the horizontal cut on the inside of the ramus was extended to the mandibular foramen. In the ODP-cut groups, the cut on the inside of the ramus was extended to the posterior border.

After the cuts were completed, guides for advancement were prepared for the two primary models with different cutting lines, each having four different advancement procedures. A 4mm advancement was performed in each model using these guides. Subsequently, models distributed to random groups were fixed with a total of 2 straight titanium mini plates (Medplates, Ramed Med., Izmir, Türkiye) with a 2.0mm hole diameter and a 9mm gap, and a total of 8 monochromatic screws (Medplates, Ramed Med., Izmir, Türkiye) with a diameter of 2.00mm and a length of 5mm, with one plate on each side, or a total of 6 bicortical screws (Medplates, Ramed Med., Izmir, Türkiye) with a diameter of 2mm and a length of 13mm, with 3 on each side, placed in a reverse L configuration.

Experimental Groups and Testing Setup

According to the surgical cutting method and fixation system applied, in the groups where HE technique cuts were made and miniplate-screw systems were used for fixation, the group was named M-EPKER, and in the groups where bicortical screws were used, it was named B-EPKER. In the groups where ODP technique cutting lines were created and fixed with miniplate-screw systems, the group was named M-DALPONT, and in the groups where bicortical screws were used, it was named B-DALPONT. Accordingly, a total of 4 groups, each with 8 models (n=8), were created (Figures 1-4).

Models were randomly selected and placed on a platform specially made of stainless steel. The mandibles were horizontally fixed with a stainless-steel pin passing through both condyles. Additionally, the base of both angulus regions was placed on another pin parallel to the first one (Figure 5). Contact points were marked to ensure that all models were fixed in the same position. This platform was placed on a universal testing machine with a 50kg load cell (AG-IS, Shimadzu Corp., Kyoto, Japan). A non-pointed tip was used to apply linear, continuous, and gradually increasing force to the mandibles from the anterior cutting edge. As a result of this process, a load-displacement graph was drawn digitally. Using this graph, the force magnitudes required for each mandibular model to reach displacement levels of 1mm, 3mm, and 5mm were recorded (1 N=9.03kg).

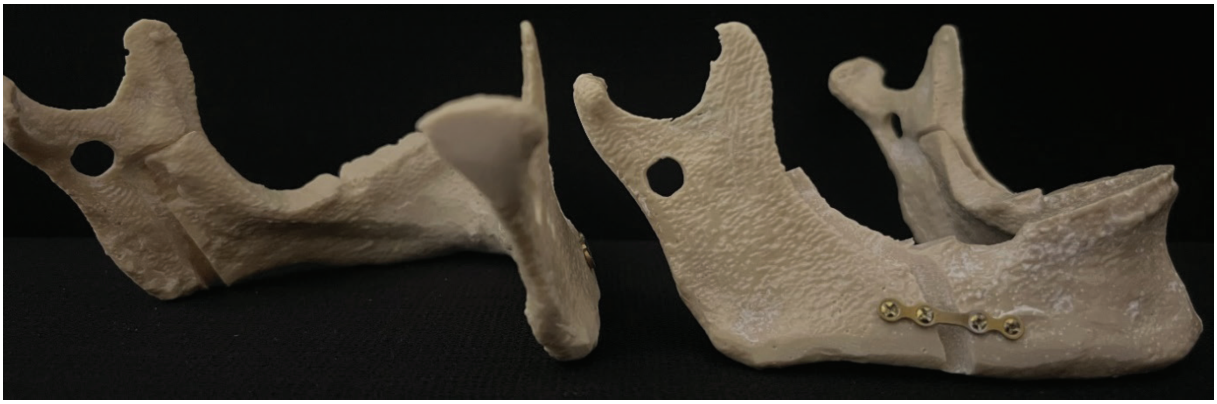

Figure 1: Model belonging to the M-EPKER group

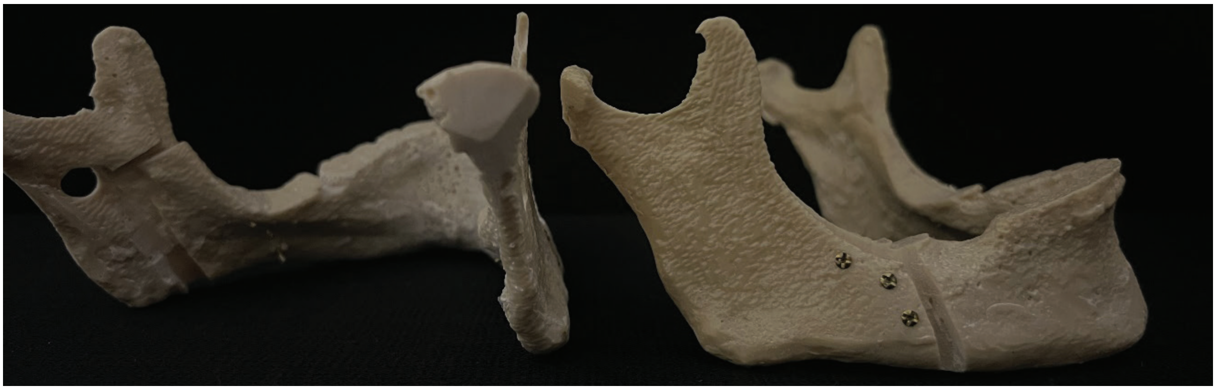

Figure 2: Model belonging to the B-EPKER group

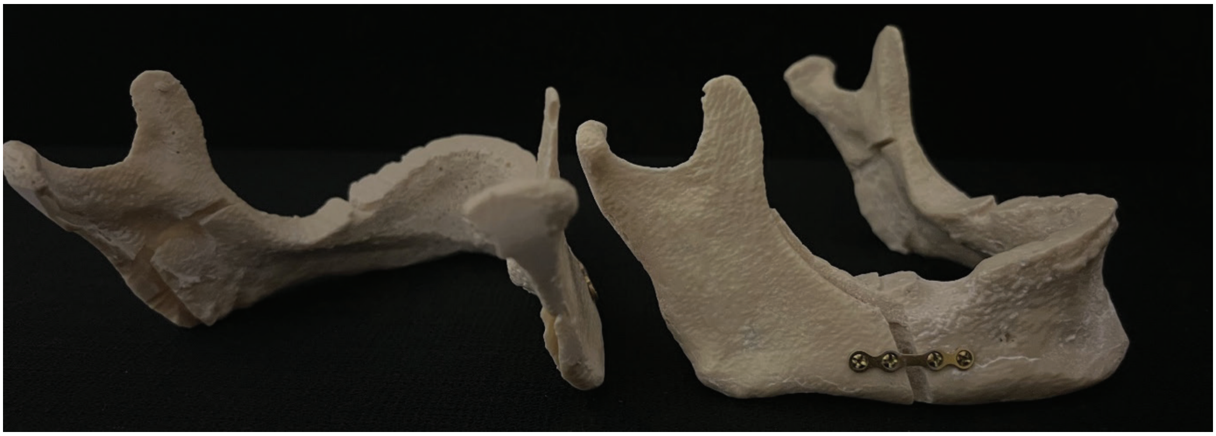

Figure 3: Model belonging to the M-DALPONT group

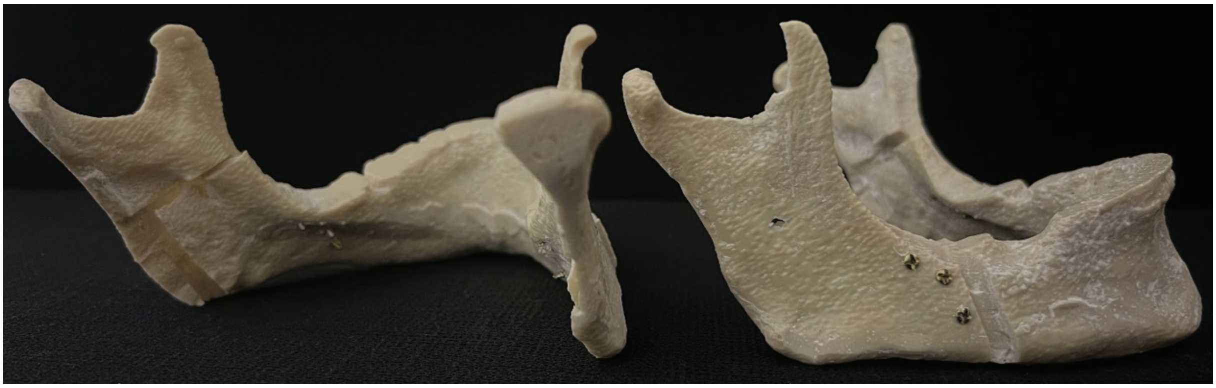

Figure 4: Model belonging to the B-DALPONT group

Figure 5: Placement of the model in the setup

Statistical analysis

In this study, statistical analyses were performed using the NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA). Descriptive statistical methods (mean, standard deviation) were used to evaluate the data. The distribution of variables was checked with the Shapiro-Wilk normality test, and the homogeneity of variances was checked with the Levene test. Since the distribution of groups was normal, and variances were homogeneous, a one-way analysis of variance was used for multiple comparisons, and the Tukey HSD test was used for pairwise comparisons. A confidence interval of 95% was set, and p<0.05 values were considered statistically significant.

RESULTS

At the 1 mm displacement level, the strength of the B-DALPONT group was found to be statistically significantly higher than the M-DALPONT group (p=0.046). At the 3mm displacement level, the strength of the B-EPKER group was statistically significantly higher than the M-EPKER group (p=0.026). The strength of the B-EPKER group was also found to be statistically significantly higher than the M-DALPONT group (p=0.002). Similarly, at the same level, the strength of the B-DALPONT group was found to be statistically significantly higher than the M-DALPONT group (p=0.008). At the 5mm level, the attachment strength of the B-EPKER group was statistically significantly higher than the M-EPKER group (p=0.008). The attachment strength of the B-DALPONT group was found to be statistically significantly higher than the M-EPKER group (p=0.027). The attachment strength of the B-EPKER group was also statistically significantly higher than the M-DALPONT group (p=0.001). Furthermore, the attachment strength of the B-DALPONT group was found to be statistically significantly higher than the M-DALPONT group (p=0.004). There were no statistically significant differences in the strengths of the other groups (Table 1, 2).

Table 1: Mean ± standard deviation values of the forces required for the test groups to reach displacement levels of 1mm, 3mm, and 5mm, and the results of the one-way analysis of variance for each group (ANOVA)

Group	1mm (Mean.±S.D. N)	ANOVA	3mm (Mean±SD, N)	ANOVA	5mm (Mean±SD, N)	ANOVA
M-EPKER	10.21±2.22	F=3.84 **p=0.02**	21.93±5.67	F=7.57 **p=0.001**	33.41±9.12	F=9.27 **p<0.0001**
B-EPKER	12.29±2.32		29.52±5.68		46.76±8.14	
M-DALPONT	9.45±1.67		19.36±3.68		30.29±4.66	
B-DALPONT	12.44±2.33		28.21±4.80		44.84±7.74	

N: Newton, M: Miniplate, B: Bkortical screw, SD: Standard deviation, mm: Millimeter

Table 2: p-values obtained from pairwise comparisons using the Türkiye HSD test for the groups. Statistically significant values are indicated in bold

Groups	1mm	3mm	5mm
M-EPKER**/**B-EPKER	0.242	**0.026**	**0.008**
M-EPKER**/**M-DALPONT	0.895	0.737	0.845
M-EPKER**/**B-DALPONT	0.188	0.082	**0.027**
B-EPKER**/**M-DALPONT	0.063	**0.002**	**0.001**
B-EPKER**/**B-DALPONT	0.999	0.953	0.958
M-DALPONT**/**B-DALPONT	**0.046**	**0.008**	**0.004**

M: Mini plate, B: Bikortical screw, mm: Millimeter

DISCUSSION

In this study, the biomechanical strength provided by plate-screw and bicortical screw systems used for the stabilization of mandibular advancements in BSSO models prepared with two different surgical cutting techniques was compared. Testing the hypothesis under clinical conditions requires a significant number of cases, which is challenging to achieve. Therefore, the experiment was preferred to be conducted in a laboratory setting. To investigate biomechanical strength in this environment, virtual or physical models are used. Virtual models are generated from tomographic data and are used in methods such as finite element analysis. These techniques are more focused on design applications in engineering sciences. Since this study involved materials with known characteristics that are commercially available, physical models were preferred. These models should mimic the lower jaw in terms of both shape and content. In addition, the morphology of facial bones affects both the frequency of fracture occurrence and the strength of plate-screw systems. Therefore, selecting an appropriate master model for the experiment is necessary. While human cadaver lower jaws are the most suitable material for modeling, their use is limited due to the lack of an adequate number and ethical concerns. Therefore, in vitro experiments have used sheep cadaver lower jaws, bovine and porcine rib bones, red oak, resin, and various other materials. In this study, the polyurethane models used were prepared from tomographic data obtained from an orthognathic surgery patient, poured into a silicone mold, and thus closely resembled clinical conditions in terms of morphological features and shape. Furthermore, it has been reported that rigid polyurethane foams with polyol and isocyanate mixture show similar resistance to insertion and removal as natural bone (12). In this experimental setup, forces were applied from the incisor region. Although in some studies, forces are applied over the first molar teeth, it can be assumed that, in clinical conditions, patients may avoid this due to their proximity to the cutting lines. Furthermore, the incisor region is preferred because it is farther from the molar region, resulting in a longer lever arm. This was considered a possible situation that might negatively affect the strength of the structure.

In vitro experiments in which the biomechanical strength of plate-screw systems is examined are usually designed based on values obtained from clinical studies. It is reported that there is a significant decrease in chewing forces in patients after orthognathic surgery (13). Gerlach and Schwarz reported that the average chewing force was 69.91N one week after the miniplate fixation of mandibular angle fractures and increased to 130.43N at six weeks (14). Similarly, Harada et al. reported that the average chewing forces of mandibular prognathism patients were 66.5N at two weeks and 128N at four weeks after surgery, and they mentioned that the chewing forces were even higher than the preoperative values after six months (15). Joos and Vassalli reported that the extent of advancement and fixation method affected relapse and emphasized the need for high compression strength in the early postoperative period (16). In our study, the range of force magnitudes was selected based on this information to make the experiment more clinically relevant. On the other hand, two different approaches are used to evaluate the results. The first approach is to compare the displacement values obtained at each 10N force increment. The second approach divides the displacement into levels, such as 1mm, 3mm, and 5mm, and evaluates the force magnitudes required to reach these levels. In the second approach, the focus is on relapse values accepted in the clinical setting. Proffit et al. defined movements greater than 2mm in the horizontal and vertical planes and angular changes exceeding 2 degrees as relapse (17). Pepersack and Chausse reported that a 1.5mm movement of the lower jaw should be considered a relapse (18). Based on this information, force magnitudes required for the displacement values of 1, 3, and 5mm were compared to improve the similarity of the experimental setup to clinical conditions.

Clinical and laboratory studies examining fixation methods used after orthognathic surgery yield different results. Dolanmaz et al. compared the strength of titanium and absorbable plates in 5mm mandibular advancements performed with the Dalpont surgical technique on sheep jaws. They applied forces ranging from 10N to 140N to the jaws and reported a significant difference in plate strength between 10N and 50N, stating that titanium plates provided higher stability (19). Oğuz et al. compared standard titanium mini plates with locking plates in the same experimental setup and reported no statistically significant difference between the two methods. However, they noted that standard mini plates were preferable for loads up to 60N, and locking plates were superior for loads exceeding 60N (20). In our study, mini plates and bicortical screw systems were used to conform to routine clinical practices. These systems can be used together or individually for mandibular advancements. Both systems have their advantages and disadvantages, depending on their characteristics. When miniplate systems are used, there is less risk of trocar scarring on the face, and the risk of lingual nerve damage is lower. Additionally, making corrections is easier when malposition is detected. However, the plates need to be adapted to the bone surface appropriately; otherwise, the position may change when the screws are tightened. Bicortical screw fixation ensures that segments are compressed, and this leads to the resistance of irregular surfaces to cutting and compression forces. Bicortical screws can be preferred when there is insufficient conformity between bone segments. Bicortical screw fixation requires less hardware, which reduces the cost. Particularly, the use of three bicortical screws extending linearly to the upper border in the reverse L configuration, as preferred in this study, is considered an appropriate fixation approach (21). When the diameters of bicortical screws are evaluated in terms of stability, there is no significant difference in diameters, and small-diameter screws are sufficient for patient comfort (22, 23). In this study, standard material dimensions were preferred, and systems were evaluated when used individually, which is more suitable for this study since the study involved standard materials and shapes.

Takahashi et al. examined stress areas when different numbers and locations of plates were placed on models that underwent advancement using the Dal Pont (OD), Obwegeser-Trauner (OT), and Obwegeser (OB) methods in the mandibles using finite element analysis. They found less stress on the plates and around the screws in models using the OD method compared to the OT and OB techniques, and they emphasized the high retention of plates placed near the upper limit of the mandible at the osteotomy line (24). They attributed this to the fact that the OD technique shortens the segment acting as a lever arm. Puricelli et al. used computer-assisted simulations with vertical cuts made closer to the mental foramen and reported that increased medullary bone contact resulted in reduced stress distribution and an advantageous effect in stress reduction (25). Şirin et al. compared double and single miniplate fixation techniques in sheep mandibles for Trauner-Obwegeser (TO) and Obwegeser-Dal Pont (OD) techniques. As a result, they reported that the OD technique provided higher strength with a single plate and emphasized that early postoperative stability achieved through surgical techniques could be different even if the fixation techniques were similar. They suggested that the OD technique could be advantageous (26). In this study, there were no bicortical screws, and sheep mandibles were used unilaterally. In our study, it was observed that using a single plate in both techniques, there was no difference in strength. The discrepancy between these two studies may be due to the use of fully mandibular polyurethane models with superior shape similarity in our study and the application of loads only in the incisor region. In the absence of muscles and other soft tissues in the experimental environment, the strength of the fixation systems is dependent on the interaction between the screw, plate, and bone or the material that mimics it. When forces are applied to the incisor region due to mastication, the corpus mandibula is forced to rotate medially bilaterally, causing a reduction in the distance between the first molar teeth. This situation could limit the single-plate-bearing models when the fixation lines are intact. This study has some limitations. Firstly, the study used only one lower jaw model, two fixation systems, two cutting techniques, and a 5mm advancement range. Therefore, the validity of the findings is limited to these scenarios. The model used in the study does not include factors such as muscle involvement, callus, and other tissues that reduce the movement between the segments. In addition, the linear and gradually increasing force application technique used in the study does not fully mimic the complex biting and chewing movements of the lower jaw. Although polyurethane models can mimic the lower jaw in terms of shape, they differ in material properties. For these reasons, the findings of this study may differ from those conducted under clinical conditions.

CONCLUSION

Within the limits of this study, it can be concluded that, in polyurethane mandibles undergoing BSSO procedures using either Dalpont or Epker techniques and fixed with mini plates or bicortical screws, the surgical technique does not have a significant effect on strength. Furthermore, regardless of the preferred cutting techniques, bicortical screw systems are more likely to provide higher strength compared to miniplate usage.

Ethics Committee Approval: This study was approved by İstanbul University Faculty of Dentistry Clinical Research Ethics Committee (Date: 02.04.2021, No: 102)

Peer Review: Externally peer-reviewed.

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REFERENCES

1. Arcuri F, Giarda M, Stellin L, Gatti A, Nicolotti M, Brucoli M, et al. Basic and advanced operative techniques in orthognathic surgery. A textbook of advanced oral and maxillofacial surgery. IntechOpen Rijeka 2013;697-718.
2. Sato FR, Asprino L, Consani S, de MM. Comparative biomechanical and photoelastic evaluation of different fixation techniques of sagittal split ramus osteotomy in mandibular advancement. J Oral Maxillofac Surg 2010;68(1):160-6.
3. Patel PK, Novia MV. The surgical tools: the LeFort I, bilateral sagittal split osteotomy of the mandible, and the osseous genioplasty. Clin Plast Surg 2007;34(3):447-75.
4. Ylikontiola L. Neurosensory disturbance after bilateral sagittal split osteotomy. Doctoral thesis, University of Oulu Faculty of Dentistry, Oulu Finlandiya 2002.
5. Teltzrow T, Kramer FJ, Schulze A, Baethge C, Brachvogel P. Perioperative complications following sagittal split osteotomy of the mandible. J Cran Maxillofac Surg 2005;33(5):307-13.
6. Al-Moraissi EA, Ellis E. Stability of bicortical screw versus plate fixation after mandibular setback with the bilateral sagittal split osteotomy: a systematic review and meta-analysis. Int J Oral Maxillofac Surg 2016;45(1):1-7.
7. Kuik K, De Ruiter M, De Lange J, Hoekema A. Fixation methods in sagittal split ramus osteotomy: a systematic review on in vitro biomechanical assessments. Int J Oral Maxillofac Surg 2019;48(1):56-70.
8. Rughubar V, Vares Y, Singh P, Filipsky A, Creanga A, Iqbal S, et al. Combination of rigid and nonrigid fixation versus nonrigid fixation for bilateral mandibular fractures: a multicenter randomized controlled trial. J Oral Maxillofac Surg 2020;78(10):1781-94.
9. Ellis E 3rd, Miles BA. Fractures of the mandible: a technical perspective. Plast Reconstr Surg 2007;120(7 Suppl 2):76S-89S.
10. Pandey V, Bhuti O, Nagori SA, Seith A, Roychoudhury A. Management of mandibular angle fractures using a 1.7 mm 3-dimensional strut plate. J Oral Biol Craniofac Res 2016;6(1):35-40.
11. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. Behav Res Meth 2009;41(4):1149-60.
12. Ribeiro-Junior PD, Magro-Filho O, Shastri KA, Papageorge MB. In vitro evaluation of conventional and locking miniplate/screw systems for the treatment of mandibular angle fractures. Int J Oral Maxillofac Surg 2010;39(11):1109-14.
13. Throckmorton GS, Buschang PH, Ellis E, III. Improvement of maximum occlusal forces after orthognathic surgery. J Oral Maxillofac Surg 1996;54(9):1080-6.
14. Gerlach KL, Schwarz A. Bite forces in patients after treatment of mandibular angle fractures with miniplate osteosynthesis according to Champy. Int J Oral Maxillofac Surg 2002;31(4):345-8.
15. Harada K, Watanabe M, Ohkura K, Enomoto S. Measure of bite force and occlusal contact area before and after bilateral sagittal split ramus osteotomy of the mandible using a new pressure-sensitive device: a preliminary report. J Oral Maxillofac Surg 2000;58(4):370-3.
16. Joss CU, Vassalli IM. Stability after bilateral sagittal split osteotomy advancement surgery with rigid internal fixation: a systematic review. J Oral Maxillofac Surg 2009;67(2):301-13.
17. Proffit WR, Philips C, Turvey TA. Stability following superior repositioning of the maxilla. Am J Orthod Dentofacial Orthop 1987;92(2):151-61.
18. Pepersack WJ, Chausse JM. Long-term follow-up of the sagittal splitting technique for correction of mandibular prognathism. J Maxillofac Surg 1978;6(2):117-40.
19. Dolanmaz D, Uckan S, Isik K, Saglam H. Comparison of stability of absorbable and titanium plate and screw fixation for sagittal split ramus osteotomy. Br J Oral Maxillofac Surg 2004;42(2):127-32.
20. Oguz Y, Saglam H, Dolanmaz D, Uckan S. Comparison of stability of 2.0 mm standard and 2.0 mm locking miniplate/screws for the fixation of sagittal split ramus osteotomy on sheep mandibles. Br J Oral Maxillofac Surg 2011;49(2):135-7.
21. Ochs MW. Bicortical screw stabilization of sagittal split osteotomies. J Oral Maxillofac Surg 2003;61(12):1477-84.
22. Armstrong JEA, Lupointe HJ, Hogg NJV, Kwok AD. Preliminary investigation of the biomechanics of internal fixation of sagittal split osteotomies with miniplates using a newly designed in vitro testing model. J Oral Maxillofac Surg 2001;59(2):191-5.
23. Sarkarat F, Ahmady A, Farahmand F, Fateh A, Kahali R, Nourani A, et al. Comparison of strengths of five internal fixation methods used after bilateral sagittal split ramus osteotomy: An in vitro study. Dent Res J (Isfahan) 2020;17(4):258-265.
24. Takahashi H, Moriyama S, Furuta H, Matsunaga H, Sakamoto Y, Kikuta T. Three lateral osteotomy designs for bilateral sagittal split osteotomy: biomechanical evaluation with three-dimensional finite element analysis. Head Face Med 2010;26:6:4.
25. Puricelli E, Fonseca JS, de Paris MF, Sant'Anna H. Applied mechanics of the Puricelli osteotomy: a linear elastic analysis with the finite element method. Head Face Med 2007;3:38.
26. Sirin Y. SMB, Limani E., Soley S. Effects of two different sagittal split osteotomy techniques on in-vitro biomechanical strength of titanium plates. J Dent Fac Istanb Univ 2011;45:67-73.