EXPERIMENTAL STUDY

Comparison of standard miniplates and locked miniplates in post-traumatic fracture stabilization

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ABSTRACT

BACKGROUND: Bicortical screws (lag and positional) or miniplates with monocortical screws are generally used for the rigid fixation of the sagittal split ramus osteotomy (SSRO) in maxillofacial surgery. However, in this osteosynthesis method, the plate must be perfectly adapted to the bone to prevent misalignment of the bone segment and occlusal changes. In addition, it is necessary to prevent the position of the condyle in the mandibular fossa from changing after fixation. In recent years, locked miniplate systems have been used to overcome these complications.

METHODS: The aim of this study is to compare the commonly used 2.0 mm standard miniplate/screw systems and 2.0 mm locking miniplate/screw systems in fresh sheep jaws with Obwegeser-Dal Pont (OD) and Hunsuck-Epker (HE) modifications, by evaluating standard parameters.

RESULTS: Our study consists of two main groups and two subgroups. 40 sheep hemimandibulae were randomly divided into two main groups. Each group was randomly divided into two subgroups. There are ten hemimandibulae (n=10) in each subgroup. Linear force test was applied using 4-hole standard miniplate and 4-hole locking miniplate systems on sheep jaws with 5 mm advancement by applying OD and HE techniques, which are two frequently preferred modifications in SSRO. For statistical analysis SPSS® 16.0 (Statistical Package for the Social Sciences, SPSS Inc. Chicago, Illinois, USA) package program was used. It was statistically compared with the 95% confidence interval using the Pearson coefficient, and $p<0.05$ was interpreted as significant. The values of the loading forces applied to the samples in the groups were subjected to analysis of variance (ANOVA) to confirm the normality of the sample. Multiple comparisons were made between groups using the Tukey test. The mean loadings in the groups were analyzed by one-way ANOVA.

CONCLUSION: In general, as the strength of the force increases, the displacement values increase in all groups, but although it was observed that the locked miniplate/screw system was more stable than the standard miniplate/screw system, no statistically significant difference was found.

Keywords: Fracture; miniplates; stabilization; trauma.

INTRODUCTION

The modern era of orthognathic surgery started with the introduction of sagittal split ramus osteotomy (SSRO) by Hugo Obwegeser (Ob) in 1955. Ob has revolutionized oral and maxillofacial surgery by presenting the sagittal split osteotomy, which has been used to date, as a standard and safe method. Ob's original osteotomy technique was modified shortly thereafter by Dal Pont. In 1961, Dal Pont showed that by replacing the lateral horizontal incision with a vertical incision made behind the second molar in the buccal cortex, wider contact surfaces could be obtained with minimal muscle displacement.[1] The second important modification of the original osteotomy technique was developed by Hunsuck and Epker (HE).[2,3]

In 1968, Hunsuck modified the technique, advocating a shorter horizontal medial incision that barely crossed the lingula to minimize soft tissue dissection. The anterior vertical incision is similar to that of Dal Pont. As with Ob, stabilization was achieved by placing a single wire on the anterior side

Cite this article as: Yazar L, Aydil BA, Ayhan M, Çömlekçioğlu Y. Comparison of standard miniplates and locked miniplates in post-traumatic fracture stabilization. Ulus Travma Acil Cerrahi Derg 2022;28:715-722.

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Ulus Travma Acil Cerrahi Derg 2022;28(6):715-722 DOI: 10.14744/tjtes.2022.59447 Submitted: 27.10.2021 Accepted: 24.11.2021

of the ramus, which rises at the level of the occlusal plane. In 1977, Epker proposed a modification. This modification includes minimal stripping of the masseter muscle and more limited medial dissection.

These modifications reduced post-operative swelling, hemorrhage, and manipulation of the neurovascular band. Minimal stripping of the masseter muscles increased the vascular pedicle in the proximal segment, reducing bone resorption and gonial angle loss. Epker supports the stabilization of both proximal lower and distal upper segments with two wires. Furthermore, Epker refined the original Dal Pont technique by describing the buccal corticotomy in detail, emphasizing the need for a complete osteotomy of the lower cortex of the mandible to avoid bad splits.[4,5]

The most commonly used techniques for fixation of SSRO are bicortical screws (lag) and miniplates with monocortical screws.[6–8] In general, osteosynthesis methods used for rigid internal fixation in oral and maxillofacial surgery consist of titanium mini plate and screw combinations.[6,9] However, these osteosynthesis methods have a shortcoming: they require perfect adaptation of the plate to the bone to prevent bone segment misalignment and occlusal changes, and to prevent the position of the mandibular condyle relative to the mandibular fossa in sagittal osteotomies. In recent years, locked miniplate systems have been used to overcome this disadvantage.

The major disadvantage of standard plate systems is that the miniplate must be perfectly adapted to the bone underneath to avoid changes in segment alignment and changes in occlusal relationship.[10] To improve the disadvantages of miniplate osteosynthesis, a new mini-locking system has been developed in collaboration with the AO/ASIF institute.[11,12] Locking plates act as internal fixators with the stability they provide by locking the screw to the plate.[10] Against standard plate systems of locking plates; it has theoretical advantages such as no screw loss or loosening, better fixation and stability, less sensitivity requirement to adapt the plate to the bone, and less changes in occlusion. In standard plate systems, there is a passive relationship between the screw head and the plate, while in locked systems; there are threads at the screw head to be locked into the plate. When the screw is fully tightened, the screw head is locked to the plate. Thus, the plate adapts easily without applying excessive pressure to the bone. However, in standard plate systems, plate stabilization is provided by the high friction force between the screw and plate. This can cause serious problems in plate stabilization and primary stabilization, even with minimal loosening between the screw and the bone. The possibility of loosening the screws on the plate is low in the locked plate system. Thanks to this advantage, especially in the presence of poor quality bone, it stabilizes the screws placed in the bone cavities or on the fracture line and prevents them from loosening. Loose fixation is known to initiate an inflammatory response and promote infection. Because locking plate systems apply less pressure to the bone where they are applied, compared to standard plate systems, they inhibit the vascular support of the bone less locally. Thus, plaque losses in the bone tissue surrounding the screws, caused by excessive pressure-induced necrosis, can be prevented.[10,11,13]

In our study, we aimed to examine the biomechanical resistance of the use of locking miniplate and standard miniplate in sheep mandibles with Dal-Pont and Epker modifications, that is, two different medial osteotomies, which are frequently used in SSRO.

MATERIALS AND METHODS

This research was carried out at Istanbul University Faculty of Dentistry, Department of Oral and Maxillofacial Surgery.

Preparation of Experimental Groups

The sheep mandible, which is physically and structurally closest to the human mandible, was chosen as the model for our study. 20 sheep mandibles, 8–10 months old on average, obtained from sheep cadavers, fresh and unfixed, fed under similar conditions and obtained from the same butcher, were used. After cleaning the skin and muscle tissues on their surfaces, 40 hemimandibles were obtained by separating them from their midlines. The anterior part of the mental foramen was cut and the bones were shortened not to cause errors in placement in the experimental setup and in the biomechanical test results. The specimens were stored in a humidified freezer at –15°C until all tests were completed. Incision lines were first determined with a indelible pencil in each model. Bone incisions on the medial and lateral surfaces were made under continuous irrigation with a metal separating bur oral surgical micromotor (physiodispenser) coated with 3 cm diameter diamond particles at 1:1 revolution at 14,000 rpm. After performing sagittal split osteotomies, bone segments were separated by applying controlled force with surgical hammers and chisels. The teeth and teeth roots in the incision line were removed. Cases with bad splits or cracks and fractures on the cortical surface in all groups were excluded from the study, and new samples were prepared instead. After the separation was achieved, gaps imitating 5 mm advancement were created between the segments with the help of a stent prepared with acrylic. Miniplates are placed on the upper part of the alveolar bone, close to the incision line. The tightening of the screws was done sequentially and using a torquemeter, care was taken to ensure that they were equal in strength.

Our study consists of two main groups and two subgroups. 40 hemimandibulae were randomly divided into two main groups. Each group was randomly divided into two subgroups. There are ten hemimandibulae (n=10) in each subgroup.

Group I: Sagittal split osteotomy was performed by applying Ob-Dal Pont (OD) modification to 20 hemimandibulae. The horizontal incision was extended from 2 mm above the lingula to the posterior border of the ramus. A vertical incision was made from the buccal of the last molar at a right angle to the base of the jaw. Unlike the sagittal split osteotomy procedure performed in humans, an osteotomy was performed from the posterior of the ramus to the inferior, from the inferior to the lateral vertical osteotomy. Since the bone structures of the sheep's jaws are thinner than humans, they are made to provide a smooth separation between the segments.

Group Ia: 1 mm thick, 4-hole, 9 mm spaced flat titanium mini plate (Trimed Medikcal Co., Ankara, Turkey) and 4 titanium screws 2.0 mm in diameter and 5.0 mm in length (Trimed Medical Co., Turkey) was used (Fig. 1a).

Group Ib: 1 mm thick, 4-hole, 9 mm spaced flat locked titanium mini plate (Trimed Medical Co., Ankara, Turkey) and 4 pieces 2.0 mm diameter, 5.0 mm long locking screws (Trimed Medical Co., Ankara, Turkey) was used (Fig. 1b).

Group II: Sagittal split osteotomy was performed by applying Epker-Hunsuck modification to 20 hemimandibulae. The horizontal incision was terminated on the inner surface of the ramus 2 mm above, just posterior to the lingula. A vertical incision was made from the buccal of the last molar at a right angle to the base of the jaw. Unlike the sagittal split osteotomy procedure performed in humans, an osteotomy was performed from the end of the horizontal incision on the inner surface of the ramus to the inferior of the ramus, from the inferior to the lateral vertical osteotomy. Since the bone structures of the sheeps jaws are thinner than humans, they are made to provide a smooth separation between the segments.

Group IIa: 1 mm thick, 4-hole, 9 mm spaced flat titanium mini plate (Trimed Medikcal Co., Ankara, Turkey) and 4 titanium screws 2.0 mm in diameter and 5.0 mm in length (Trimed Medical Co., Turkey) was used (Fig. 1c).

Group IIb: 1 mm thick, 4-hole, 9 mm spaced flat locked titanium mini plate (Trimed Medical Co., Ankara, Turkey) and 4 pieces 2.0 mm diameter, 5.0 mm long locking screws (Trimed Medical Co., Ankara, Turkey) was used (Fig. 1d).

Loading Test

A specially designed steel platform was created for the study. Appropriate holes were drilled to fix it to the experimen-

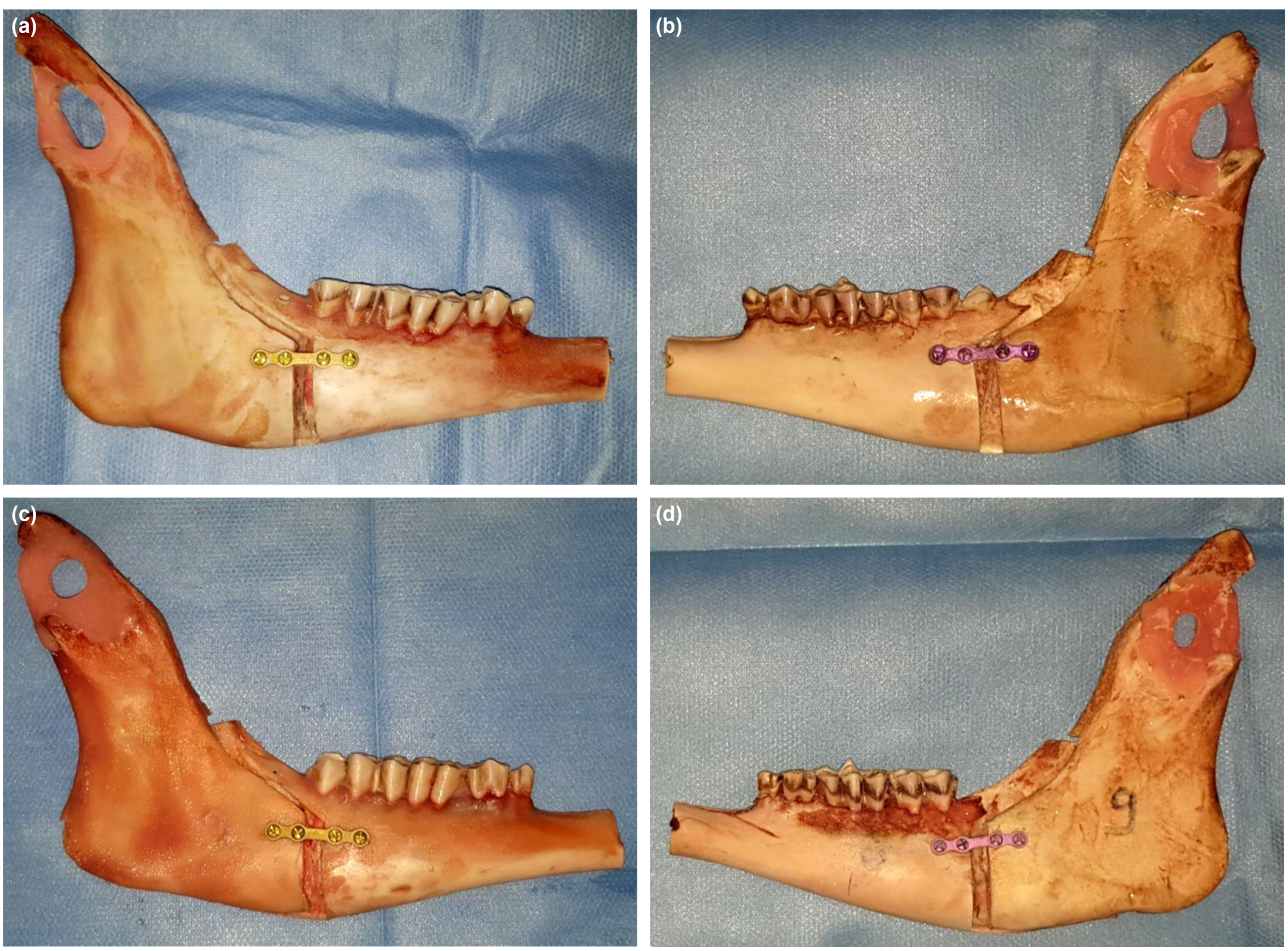

Figure 1. (a) Group Ia standard miniplate application. **(b)** Group Ib locked miniplate application. **(c)** Group IIa standard miniplate application. **(d)** Group IIb locked miniplate application.

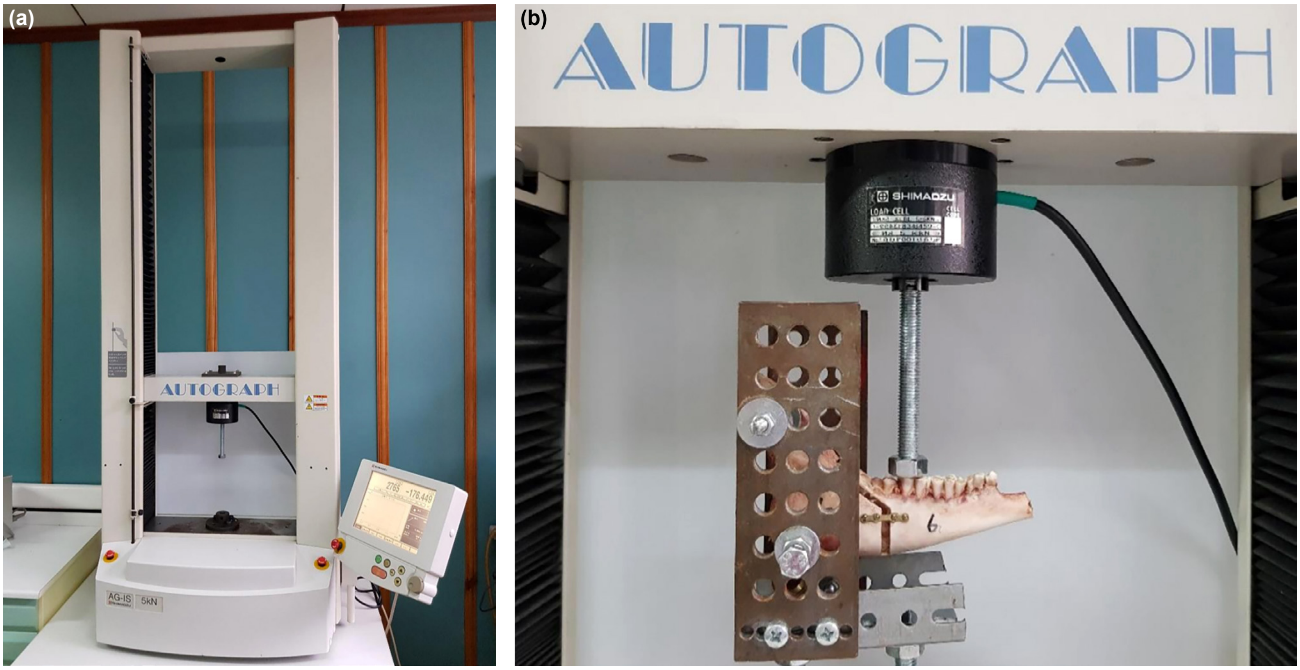

Figure 2. (a, b) Servohydraulic test device (Universal Autograph AGS®, Shimadzu Scientific Instruments, Kyoto, Japan).

tal platform by adding cold acrylic to the mandibular notch regions of the subjects. Passive stabilization was applied to restrict lateral movements from the lateral and medial sides of the ramus. Subjects were placed on the experimental platform with the occlusal plane parallel to the ground. The occlusal surfaces of the teeth in the subjects were flattened using rotary instruments.

After the subjects were fixed on the specially designed platform, they were placed on the servohydraulic test device (Universal Autograph AGS®, Shimadzu Scientific Instruments, Kyoto, Japan) and prepared for loading over the flattened molar teeth. After fixation, the specimens were mounted on a testing machine based on a biomechanical cantilever bending model that simulated chewing forces and stabilized in the condyle and coronoid regions. The servohydraulic tester realized a linear, non-cyclic displacement at a rate of 1 mm/s. After the device was calibrated with a force of 5 N, it applied progressively increasing forces up to 100 N. The force required for 1, 3, and 5 mm displacement of the distal segment was recorded as newtons (N). The proximal segment was stabilized from the condyle and coronoid regions, allowing free movement of the distal segment under load (Fig. 2a and b).

Statistical Analysis

SPSS 16.0 SPSS® (Statistical Package for the Social Sciences, SPSS Inc. Chicago, Illinois, USA) package program was used for statistical analysis. It was statistically compared with the 95% confidence interval using the Pearson coefficient, and $p<0.05$ was interpreted as significant. The values of the loading forces applied to the samples in the groups were subjected to analysis of variance to confirm the normality of the sample. Multiple comparisons were made between groups using the Tukey test. The mean loadings in the groups were analyzed by one-way analysis of variance.

RESULTS

Linear strength test was applied using 4-hole standard miniplate and 4-hole locking miniplate systems on sheep jaws with 5 mm advancement using OD and HE techniques, which are two frequently preferred modifications in sagittal split ramus osteotomies.

Findings are expressed as arithmetic mean and ± standard deviation, since they show the need for normal distribution and equality of variance. In Table 1, the average standard deviation values of the displacement values obtained from all groups under different force values are presented. In general, as the strength of the force increases, the displacement values increase in all groups (Table 2).

DISCUSSION

The main purpose of this study is to compare the commonly used 2.0 mm standard miniplate screw systems with the 2.0 mm locking miniplate screw systems that are frequently used in SSRO in sheep jaws with OD and HE modifications. In this study, all distal segments of the hemimandibulas were advanced by 5 mm, in accordance with previously reported studies on this subject.[6,7,14–22]

The locking plate/screw system was first used for mandibular bone reconstruction.[23] With the emergence of smaller systems (2.0 mm in diameter), it has been introduced for use in the treatment of facial fractures, mainly mandibular fractures.[10,11,24] In biomechanical and clinical studies performed with

Table 1. The average standard deviation values of the displacements caused by the forces applied at different intensities in the study groups

Study Groups	Displacement values under occlusal forces (mm)									
	10N	20N	30N	40N	50N	60N	70N	80N	90N	100N
Group Ia (Av. Std. Dev.)	0.48	1.45	2.35	3.07	3.84	4.74	5.81	6.87	8.42	9.70
	0.23	0.46	0.49	0.47	0.51	0.55	0.65	0.89	1.57	2.01
Group Ib (Av. Std. Dev.)	0.49	1.32	2.14	3.00	3.82	4.80	5.84	6.87	7.91	8.95
	0.19	0.41	0.54	0.70	0.70	0.65	0.80	0.89	0.83	0.82
Group IIa (Av. Std. Dev.)	0.35	1.21	2.15	3.19	4.14	5.08	6.12	7.20	8.06	9.17
	0.13	0.32	0.50	0.59	0.59	0.59	0.62	0.81	0.79	0.64
Group IIb (Av. Std. Dev.)	0.35	1.18	2.02	2.99	3.97	4.77	5.68	6.41	7.44	8.56
	0.08	0.29	0.47	0.70	0.86	0.89	1.01	0.92	0.95	1.14

Table 2. The average standard deviation value of displacement at 100 N according to the osteotomy technique

Groups	Average Std. Deviation	p-value
Group I	9.33±1.54	<0.05
Group II	8.87±0.95	<0.05

the locking plate/screw system in mandibular fractures, it was found to be more stable than the standard plate/screw system.[10,25]

Oguz et al.[19] conducted the first in vitro study on the use of the locking plate/screw system in SSRO. They reported that there was no significant statistical difference between the two methods when they compared standard titanium mini-plates with a diameter of 2 mm with 4-hole intervals and locking plates of the same diameter and length in sheep jaws that were advanced 5 mm after SSRO. The same authors evaluated these materials with the finite element model and found that locking plates and screws offered no advantage over standard miniplates and screws, while the locking miniplate/screw system spread the load on the plate and reduced the amount of force transferred to each unit by screws. No significant difference was observed between the locking plate/screw and standard plate/screw systems in terms of the forces transmitted to the bone and the deformations in the bone in the models that were fixed by 5 mm advancement by applying SSRO with the SEA method.[26]

Vieira Santos et al.[14] performed an in vitro experiment by applying 2 different buccal osteotomy designs on 40 polyurethane hemimandibulae. For fixation in both groups; one 4-hole 2.0 miniplate with four 5.0 mm long screws; one 4-hole 2.0 mm plate with four 5.0 mm long screws and a 12.0 mm long bicortical screw; four 5.0 mm long locking screws with one 4-hole 2.0 mm locking plate; a 4-hole 2.0 mm locking plate, four 5.0 mm long locking screws, and a 12.0 mm long bicortical screw were used.

As a result of this study, the use of additional bicortical screws with miniplates provided a better SSRO stabilization. Ignoring the difference in osteotomy techniques, when a comparison was made between fixation groups, the bicortical screw-lock miniplate group showed the highest strength. However, it was stated that there was no significant difference between the standard and locked miniplate groups. In 2017, Klein et al.,[27] in polyurethane jaws with 10 mm mandibular advancement with Epker modification; evaluated six different fixation methods with standard miniplate, locked miniplate, standard sagittal (double Y) plate, and locked sagittal plates with 3-point biomechanical test. This study demonstrates that the use of two plates is a form of fixation that causes less displacement. Locked miniplate systems showed better overall results in all conditions compared to the standard miniplate system in both groups. However, no statistically significant difference was found. A study by Ribeiro-Junior et al.[28] is based on the comparison of three different plate designs of standard and locked systems in polyurethane jaws with 4 mm mandibular advancement. These plaque designs are four-hole flat miniplate, six-hole flat miniplate, and six-hole double-Y sagittal plaque. As a result of this experiment, fixation of the mandibular SSRO with the six-hole sagittal locking miniplate (horizontal double Y-shaped) was more resistant than the other plate systems tested. Despite the observed numerical differences, no statistical difference was found between the locked and standard mini plate system. Another in vitro study by the same authors found that locking plate/screw fixation systems were better at resisting bone displacement after SSROs, but the results were not statistically significant.[9] There are few studies clinically examining locking mini-plate systems. Ueki et al.[29] reported clinical skeletal stability results of these fixation methods in patients with mandibular prognathism using bicortical fixation with a 2.0 mm locking plate system and monocortical fixation with an unlocked plate system after SSRO. The results of this study show that there is no significant difference in 1-year postoperative changes between bicortical screw fixation and locking plate system and monocortical screw fixation and standard plate system. Kabasawa et al.[30] analyzed and compared the clinical results of bilateral SSRO performed with monocortical locking plate fixation or bicortical screw fixation in their study published in 2013. These clinical results revealed that there was no significant difference between locking plate and screw fixation systems, and the failure type and degree of failure were more likely to be related to bone quality and surgical technique than to the fixation system. The results obtained did not show a significant difference in postoperative time course changes between bilateral plate fixation and monocortical fixation using the locking plate system.

The findings obtained as a result of the comparison of the locking plate system and the standard plate system in our study is also similar to the findings in the studies mentioned above. Although the locking mini plate/screw system was observed to be more stable than the standard mini plate/screw system when osteotomy techniques were ignored, no statistically significant difference was found.

Unlike these results, Oguz et al.[15] in another study, six different fixation methods were compared with a cantilever beam biomechanical model, with a linear force applied from the premolar region, following SSRO with 5 mm advancement. As the amount of displacement of the distal segment increased, the required resistive force also increased, and a statistical difference was observed between the resistive forces required for 1, 3, and 5 mm displacement. In this study, grid (lattice and grid) plate, 4-hole locking mini-plate, and 6-hole standard miniplate; the 4-hole locking miniplate was found to be significantly more resistant than the 6- and 4-hole standard miniplate. Pozzer et al.[31] compared 4-hole standard miniplate fixation in two different SSRO designs. The SSRO technique is a Hunsuck modification, and in one of the groups there was a right angle between sagittal osteotomy and buccal vertical osteomies; in the other group, a more rounded joint was formed instead of a right angle. The groups were divided into three subgroups as 3 mm and 7 mm mandibular advancement and no mandibular advancement. The results showed that the group with no right angles between the osteotomies had the best response to compression load, tolerant to the highest load values. It was concluded that osteotomy design affects mechanical resistance and linear SSRO provides the best mechanical resistance. Vieira Santos et al.[14] in 2017 compared four different fixation materials with 5 mm advancement in a similar study design. As a result, the non-right-angle SSRO design among osteotomies showed higher mechanical resistance than the right-angle SSRO design; however, unlike Pozzer's study, it was not statistically significant. It has been stated that the difference in the amount of mandible advancement and the fixation materials compared may cause differences in the results.

Takahashi et al.,[32] Trauner-Ob (TO), Ob, and OD methods on the mandibles, investigated the fields with SEA which are placed in different numbers and positions, under the applied loads from the incisor and molar teeth regions. In the TO method, the lateral osteotomy cut was made horizontally from the distal second molar region to the posterior border above the mandibular angle. In the Ob method, the lateral osteotomy cut was made from the distal second molar region to the midpoint of the mandibular angle. In the OD method, the lateral osteotomy cut was made from the distal of the second molar tooth, perpendicular to the lower border of the mandible. According to the findings of these researchers, less stress areas were formed both on the plates and around the screws in the models designed with the OD method compared to the TO and Ob techniques. In the same study; it has been shown that the plate placed near the upper border of the mandible on the osteotomy line provides high retention and is more effective. This is attributed to the shortening of the segment that functions as a lever arm in the OD technique.

In addition, it was emphasized that miniplates placed along the lines of Champy provide greater mechanical advantage than those placed elsewhere. Similar to this study, Sirin et al.[16] also compared double and single plate fixation in vitro biomechanically in TO and OD techniques. In terms of osteotomy lines, it was determined that the OD technique provided higher strength values with a single plate. This shows that although the plate/screw systems used in fixation are similar, the early stability obtained as a result of the two surgical techniques may be different. These findings indicated that the osteotomy line in the OD technique, which provides a more appropriate force distribution compared to the anatomical shape of the mandible, may be an advantage. Puricelli et al.[33] suggested that medullary bone contact increased as a result of the comparison of OD osteotomy and osteotomy technique performed with a vertical incision, which they positioned closer to the mental foramen, in SEA, and that this had a reducing effect on stress distribution.

Sarkar et al.[34] conducted a prospective clinical study to evaluate and compare fracture stability and complications such as infections, plate removal, malunion, and nonunion when using 2.0-mm locking plating system and 2.0-mm non-locking plating system in fixation of mandible fractures. In this study fracture stability, need for maxillomandibular fixation (MMF) and post-operative complications were assessed and compared.

A total of 60 patients (30 in each group) were evaluated. Significant differences were found between the two groups in terms of post-operative fracture stability (P 1~40.001) and MMF requirement (P 1~4 0.005), and there was no significant difference in post-operative complications between the two groups.

The 2.0 mm locking plate system provides greater stability and early functional restoration compared to the 2.0 mm unlocked plate system with similar post-operative complications; therefore, it can be used as a reliable and effective treatment method in the treatment of mandible fractures.[34]

Three factors should be considered in interpreting the data. First, there were no tests on living bone, which can heal over time. Second, in a clinical situation, patients may immobilize the mandible for several weeks and/or be limited to a liquid or bland diet during initial recovery. Third, strength is not necessarily a valid determinant of the stability of an osteotomy.[35] The install mode is another factor to consider. In vivo loading of the mandible is complex. Naturally, any simulation of in vitro loading is a simplification for ease of experimentation. While cantilever loading is easier to apply given the irregular geometry of the mandible, such loading is less physiological, except perhaps for a fracture through the symphysis.

Conclusion

The aim of this study is to compare the 2.0 mm standard miniplate/screw systems and 2.0 mm locking miniplate/screw systems in fresh sheep jaws with OD and HE modifications, by evaluating standard parameters. The findings obtained as a result of the comparison of the locking plate system and the standard plate system in our study is similar to the findings in the studies mentioned above. Although the locking mini plate/screw system was observed to be more stable than the standard mini plate/screw system when osteotomy techniques were ignored, no statistically significant difference was found.

Peer-review: Internally peer-reviewed.

Authorship Contributions: Concept: L.Y.; Design: M.A.; Supervision: B.A.A.; Resource: L.Y.; Materials: B.A.A.; Data: Y.Ç.; Analysis: M.A.; Literature search: L.Y.; Writing: Y.Ç.; Critical revision: B.A.A.

Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study has received no financial support.

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DENEYSEL ÇALIŞMA - *ÖZ*

Travma sonrası kırık stabilizasyonunda standart miniplaklar ve kilitli miniplakların karşılaştırılması

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AMAÇ: Maksillofasiyal cerrahide Sagittal Ramus Osteotomisinin (SSRO) rijit fiksasyonu için genellikle bikortikal vidalar (lag ve pozisyonel olarak) ya da monokortikal vidalarla birlikte miniplaklar kullanılmaktadır. Ancak bu osteosentez yönteminde kemik segmentinin yanlış hizalanmasını ve okluzal değişiklikleri önlemek için plağın kemiğe mükemmel adapte edilmesi gerekmektedir. Ayrıca fiksasyon sonrası kondilin mandibular fosssadaki pozisyonunun değişmesini önlemek gerekmektedir. Son yıllarda bu zorlukların daha rahat üstesinden gelebilmek için kilitli miniplak sistemlerinden yararlanılmaya başlanmıştır.

GEREÇ VE YÖNTEM: Bu çalışmanın amacı, standart parametreleri değerlendirerek, Obwegeser-Dal Pont (OD) ve Hunsuck-Epker (HE) modifikasyonu uygulanmış taze koyun çenelerinde, yaygın olarak kullanılan 2.0 mm standart miniplak/vida sistemleri ile son zamanlarda SSRO'da sıklıkla kullanılan 2.0 mm kilitli miniplak/vida sistemlerini karşılaştırmaktır.

BULGULAR: Çalışmamız iki ana grup ve iki alt gruptan oluşmaktadır. Kırk adet koyun hemimandibulası rastgele olacak şekilde iki ana gruba ayrıldı. Her grup kendi içerisinde rastgele iki alt gruba ayrıldı. Her bir alt grupta 10 adet hemimandibula (n=10) vardı. SSRO'da sıklıkla tercih edilen iki modifikasyon olan Obwegeser-Dal Pont ve Hunsuck-Epker teknikleri uygulanarak 5 mm ilerletme yapılan koyun çenelerinde 4 delikli standart miniplak ve 4 delikli kilitli miniplak sistemleri kullanılarak doğrusal kuvvet testi uygulandı. İstatistiksel analiz için. SPSS® 16.0 (Statistical Package for Social Sciences, SPSS Inc. Chicago, Illinois, ABD) paket programı kullanıldı. Pearson katsayısı kullanılarak %95 güvenilirlik aralığında istatistiksel olarak karşılaştırıldı, $p<0.05$ değeri anlamlı olarak yorumlandı. Gruplardaki örneklere uygulanan yükleme kuvvetlerinin değerleri numunenin normalliğini doğrulamak için varyans analizine tabi tutuldu. Tukey testi ile gruplar arasında çoklu karşılaştırmalar yapıldı. Gruplardaki yükleme ortalamaları one-way ANOVA ile analiz edildi.

TARTIŞMA: Genel olarak bakıldığında, kuvvetin şiddeti arttıkça, bütün gruplarda yer değiştirme değerleri artmaktadır, ancak kilitli miniplak/vida sisteminin standart miniplak/vida sisteminden daha stabil olduğu gözlenmesine rağmen istatistiksel olarak anlamlı bir fark bulunamamıştır.

Anahtar sözcükler: Fracture; miniplates; stabilization; trauma.

Ulus Travma Acil Cerrahi Derg 2022;28(6):715-722 doi: 10.14744/tjtes.2022.59447