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Comparison of self-tapping and self-drilling screws in open reduction of mandible fracture

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ABSTRACT

Objective: The purpose of this study is to assess the early postoperative stability of screw systems with mini plates in the treatment of open reduction mandibular angulus fractures.

Material and Method: This study consisted of 3 groups of mini plate or screw fixation: a 1.6 mm diameter drill for Group 1, a 1.2 mm diameter drill for Group 2, and self-drilling screws without drilling in Group 3. We used 9 hemimandibles, 9 plates, and 36 screws in each group. We compared the self-tapping and self-drilling screw systems while maintaining the plate system constant. We generated angulus fractures in 27 hemimandibles taken from 14 sheep mandibles. We separated the samples into 3 groups, each with 9 hemimandibles. All the screws used in the study were 2 mm in diameter and 5 mm in length. We used the servo hydraulic test unit to apply force to the hemimandibles. We applied forces of 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, and 150 N to the hemimandibles and recorded the resulting displacements. Data were analyzed with IBM SPSS V23, and conformity to normal distribution was evaluated by the Shapiro-Wilk test.

Results: There was no difference between the groups in terms of the amount of displacement that occurred as a result of the applied forces.

Conclusion: In the treatment of mandibular fractures with open reduction, surgeons should focus on plate-related parameters rather than self-drilling and self-tapping of screws, or drill diameter.

Keywords: Self-drilling screw, self-tapping screw, mandible fracture, open reduction

INTRODUCTION

Traumas of the maxillofacial complex are prevalent health problems and require attention (1,2). Among these injuries, mandible fractures are the most common facial skeletal injuries (3). Mandible fractures are twice as prevalent as midface fractures, accounting for the majority of injuries presented to oral and maxillofacial surgeons (3,4). By localization, mandibular fractures are classified as symphysis, parasymphysis, corpus, angulus, ramus, condylar process, coronoid process, and alveolar process fractures. Mandibular fractures in the angulus region are the second most frequent type with the second highest complication rate, after condylar process fractures (5-7). When the fracture segments of a mandibular angulus fracture are directed upwards, downwards, or posteriorly, the segments may show displacement with muscle straining. In the treatment of angulus fractures, the open reduction and internal fixation approaches offer the basic conditions for functional jaw motions with proper occlusion (8).

Today, mini-plate and screw systems are routinely used among open reduction and internal fixation methods in the treatment of such fractures (9,10). Functionally stable fixation (Champy technique) and maximum rigid fixation have been the focus of interest among maxillofacial surgeons (11,12). In the Champy technique, the ideal osteosynthesis site for the angulus region is the external oblique ridge (12). Various combinations of monocortical screws and plates are used for the fixation of angulus fractures (13). Only the outer cortex of the bone is screwed with mini-plates of varied lengths and numbers of holes. For stable fixation, a four-hole mini-plate with two screws on either side of the fracture is usually sufficient. The Champy technique is gradually becoming the standard choice for the treatment of mandibular angulus fractures. Monocortical screws are used in this technique to avoid injuring the tooth roots or the alveolar nerve.

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Self-tapping screws are commonly utilized in the open reduction of mandible fractures after drilling a pilot hole with the maximum screw diameter. Pre-drilling is a standard process in the self-tapping system, but it has drawbacks, including the danger of drill damage to nerves and tooth roots, a loose screw fit, and thermal necrosis of the bone, owing to drilling (14). Self-drilling screws, on the other hand, have a simple wood screw geometry and do not require a pilot hole (15). Self-drilling screws can be placed without drilling the bone because they contain sharp ends and threads that follow an axis of rotation all the way up to the screw head (16). Self-drilling screws can be utilized without a problem for up to 2-mm-thick bones, but in thicker bones, the danger of screw breaking increases (17).

Throughout our usual clinical practice, we noticed that self-drilling screws fit more tightly. We undertook this research to see if self-drilling screw systems provide an advantage over self-tapping screw systems in the open reduction of mandible fractures. The hypothesis of this research is that mini-plate screw systems applied with self-drilling screws and self-tapping screws after 1.2 mm drilling will show less displacement compared to mini-plate systems applied with self-tapping screws after 1.6 mm drilling. We could not discover any studies testing the use of self-drilling screws in an open mandibular reduction in our literature search. In this regard, our research is the first in the literature.

MATERIAL AND METHOD

We used 14 sheep mandibles from 9-11-month-old sheep bred in similar conditions. We separated them from their midlines after cleaning the soft tissues on their surfaces and obtained 28 hemimandibles. To avoid problems in the placement of the experimental setup and the findings of the biomechanical tests, we cut the front section of the mental foramen. We kept the hemimandibles in a humidified freezer at -15°C until all the tests were finished. We created a 1 cm fracture with an electric jigsaw in front of the most concave point of the ascending ramus, at an angle of -45 degrees with respect to the occlusal plane. We determined the fracture lines with a fixed pencil.

Procedures with dead animal or tissue, slaughterhouse materials, waste fetuses are not subject to HADYEK permission.

There were 3 groups in our study, each with 9 hemimandibles. In all three groups, we used a 1-mm-thick, 4-hole, 9-mm-spaced flat titanium mini-plate (Trimed, Turkey).

Group 1: For this group, we drilled holes in the bone with a 1.6 mm diameter drill and fixed it using 4 titanium self-tapping screws (Trimed, Turkey) with a diameter of 2.0 mm and a length of 5.0 mm.

Group 2: For this group, we drilled holes in the bone with a 1.2 mm diameter drill and fixed it using 4 titanium self-tapping screws with a diameter of 2.0 mm and a length of 5.0 mm (Trimed, Turkey).

Group 3: For the last group, we fixed the bones using 4 titanium self-drilling screws with a diameter of 2.0 mm and a length of 5.0 mm (Trimed, Turkey) without drilling into the bone.

We marked and standardized the place where the mini-plates would be located in the regions defined by Champy (in the buccal cortex of the external oblique edge) (12). We used a drill to open the screw holes with a physiodispenser and continual irrigation during the self-tapping screw fixation process. All screws were placed by the same surgeon. To prevent degradation, we kept the hemimandibles in saline water during the fixation process. All procedures, including artificial fracture generation, fixation, and use of servo hydraulic device, were completed within 24 hours.

We built a specially designed steel platform for the experiment. In the mandibular notch regions, we drilled an appropriate hole to fix the hemimandibles to the experimental platform, which was then put on support from the angulus region. We emulated the TME by inserting a horizontal bar through this hole in the notch region. We simulated a pterygomasseteric sling by placing the hemimandible on an abutment from the angulus region. We fixed the 3rd point anteriorly from the mental region. We then placed the hemimandibles on the experimental platform with the occlusal plane parallel to the ground, placing this setup on the servo hydraulic testing device (MTS Criterion: Model 42) and preparing it for loading over the molar teeth (**Figure 1**). The servo hydraulic tester performed a linear, non-cyclic displacement at a rate of 1 mm/s. We first calibrated the device at 10 N force, then increased the force up to 150 N. We recorded the displacement values for every 10 N increase in force.

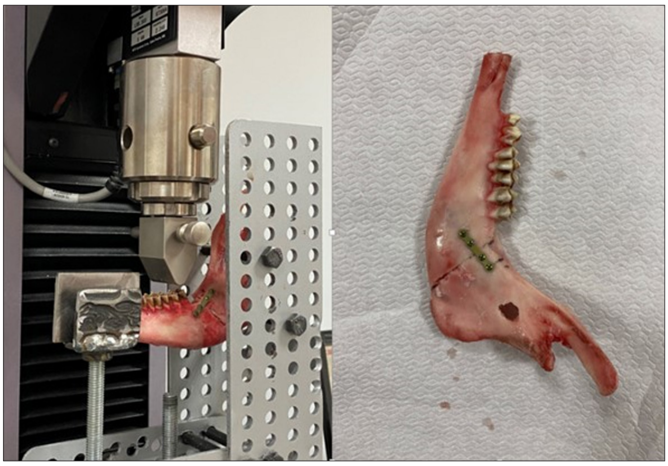

Figure 1. Servo hydraulic tester and the hemimandible prepared for the test

Statistical Analysis

The data were analyzed using IBM SPSS V23. Conformity to normal distribution was evaluated by the Shapiro-Wilk test. To compare displacement measures between groups, we used a one-way analysis of variance and presented the data as mean±standard deviation. Level of significance was taken as $p<0.05$.

RESULTS

None of the study models failed during testing and all met the biomechanical criteria. The **table** below shows the mean and standard deviation of the displacement values of the 3 groups under various forces. In general, as the amount of force increased, the displacement values increased in all groups.

Table. Comparisons by groups

	Self-Drilling	Self-Tapping 1.2 mm	Self-Tapping 1.6 mm	Test ist.[1]	p
	mean±SD	mean±SD	mean±SD		
Displacement at 30N (mm)	0.683±0.561	0.684±0.479	0.562±0.358	0.197	0.823
Displacement at 60N (mm)	1.201±0.95	1.063±0.607	0.836±0.394	0.643	0.535
Displacement at 90N (mm)	1.474±1.008	1.399±0.564	1.079±0.437	0.777	0.471
Displacement at 120N (mm)	1.719±1.022	1.804±0.734	1.391±0.546	0.682	0.515
Displacement at 150N (mm)	1.993±1.054	2.232±1.117	1.704±0.663	0.675	0.519

[1]One-way analysis of variance, SD: standard deviation

Some of the displacement values did not differ between the groups at certain forces; these were 30N (mm) ($p=0.823$), 60N (mm) ($p=0.535$), 90N (mm) ($p=0.471$), 120N (mm) ($p=0.515$), and 150N (mm) ($p=0.519$).

Figure 2 shows the mean displacement values for all groups. We found no significant difference between the groups and the amount of displacement increased as the amount of force increased.

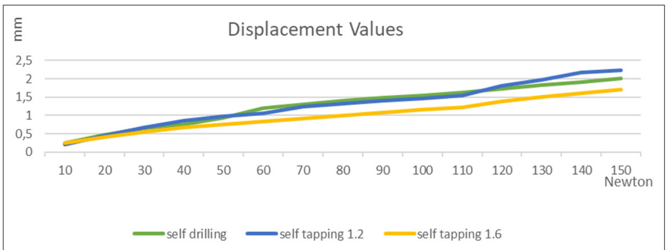

Figure 2. Mean displacement-force graph

DISCUSSION

We used sheep mandibles to compare the early postoperative stability of screw systems in mini-plates used in the treatment of mandible angulus fractures with open reduction. According to our results, we found no difference between the groups, therefore not confirming our hypothesis. The sheep mandible was chosen because it has a Haversian system that is comparable to the human mandible, and it is physically, structurally, and anatomically similar to the human mandible (18). Furthermore, the structural qualities of the bone are intact when used fresh rather than fixed (19,20).

Despite being the largest and strongest of the facial bones, the mandible is broken two to three times more frequently than the other facial bones (1,21). Angulus fractures are the most common of all mandible fractures (5,22,23). Although there are many studies on the treatment of mandibular angulus fractures, no consensus has been established on the best treatment strategy, and research into the ideal treatment method is still ongoing (24). These techniques often involve fixing the bone segments at the lower border of the mandible using a single mini-plate fixation, two mini-plate fixations, bicortical screw applications, or a single reconstruction plate, depending on the case. Among these, the Champy technique is the most widely accepted (12,25). Gear et al. (26) report that single mini-plate treatment has become more popular for mandibular angulus fractures. The use of non-compression, single mini-plate, and monocortical screw fixation on the upper border of the mandible offers less complication rates, according to the general approach to fixation of mandibular angulus fractures (27-32). We designed our study based on this treatment modality adopted by many surgeons.

Gerlach et al. (33) examined bite forces for the molar teeth in patients with fractures of the mandibular angulus treated with mini-plate osteosynthesis and found forces of 90 N at the first week and 148 N at the sixth week. We measured the amount of displacement caused by a 10 N increase in bite force, up to 150 N. Heidemann et al. (34) report that the torque applied during screw insertion increases as the drill diameter used in self-tapping screws decreases. Because self-drilling screws involve no drilling, additional force is needed. We compared self-drilling screws with 1.2 mm and 1.6 mm drills to self-tapping screws without drilling, while maintaining the plate system fixed.

There was no difference between the three groups. Out literature review yielded no study comparing displacement against tensile forces among self-drilling and self-tapping screws. In 1998 , Heidemann et al. (34) investigated the torques and tensile forces of self-drilling and self-tapping screws in polyvinylchloride, wood, and pig mandibular bones. The authors observed different torques in each group and found a difference in displacement against tensile forces in 2 mm thick bone in the mandibular cortex, although no difference in the 3 mm thick cortical bone (34). Sancar et al. (35) found that cortex thickness was greater than 2 mm in the angulus region posterior to the mandible. We examined the amount of displacement among self-drilling and self-tapping screws against occlusal forces in sheep mandible, which is very similar to the human mandible. In mini-plate screw systems used in the treatment of mandibular fractures, we observed a decrease in the amount of displacement against the occlusal forces by strengthening the drill area where the self-tapping screws are placed (36). In our study, we used 2 mm diameter screws. In our experiments, there was no difference in movement following tensile forces for self-tapping screws after drillings equivalent to 60% (1.2 mm) and 80% (1.6 mm) of the screw diameter. Research has shown that increasing the size of the pilot drill up to 85% of the screw diameter has no effect on the movement caused by tensile forces, as reported by Heidemann et al. (34). These findings are consistent with our results.

CONCLUSION

During the fixation of the jaws with mini-plate screws, the opinion among surgeons is that the tighter the screws are, the stronger the fixation will be. However, our study has demonstrated that this is not the case. Thus, in the treatment of mandible fractures, surgeons should focus on plate-related parameters rather than self-drilling, self-tapping screws, or drill diameter.

ETHICAL DECLARATIONS

Ethics Committee Approval: Procedures with dead animal or tissue, slaughterhouse materials, waste fetuses are not subject to HADYEK permission.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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