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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

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Abstract

Ten unembalmed adult sheep mandibles were used. The mandibles were sectioned in the midline, followed by sagittal split ramus osteotomies to obtain 20 hemimandibles. Each distal segment was advanced 5 mm on each hemimandible. Ten of the specimens were fixed with 4-hole extended 2.0 mm titanium miniplates and screws and the other 10 were fixed with 4-hole extended 2.0 mm locking miniplates/screws. Each fixed specimen was mounted on a servo-hydraulic testing unit with the fixation device, and was tested to a range of forces of 0–140 N. The displacement values (mm) under 20, 60, 120, and 140 N were compared with the help of the Mann–Whitney *U*-test, and there were no significant differences between them at any force tested. Locking miniplate/screws and standard miniplate/screws showed similar displacement values at the range of forces tested.
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Keywords: Sagittal split ramus osteotomy; Titanium miniplates; Locking screw/plates

Introduction

Since the 1950s most mandibular skeletal deformities have been treated with sagittal split ramus osteotomy (SSRO),[1,2] and many rigid fixation systems have been promoted to provide stability. Standard 2.0 mm titanium miniplates or screws, or both, have been widely used since that time. To improve on these, minilocking plate and screw systems were introduced. The theoretical advantages of these compared with conventional plating are: no loosening of screws, greater stability, need for less precision in adaptation of the plate, and less alteration in occlusion. The mechanical stability of fractured mandibles fixed with locking plate/screw systems has been evaluated in a few studies,[3,4] but not after orthognathic surgery.

The purpose of this study was to compare the stability of 2.0 mm standard miniplates/screws with that of 2.0 mm locking plates/screws for the fixation of SSRO in sheep mandibles.

Materials and methods

Ten unembalmed adult sheep mandibles were used, and mandibles of similar size were chosen to avoid confounding variables. Coronoid processes and anterior bone segments were removed to adapt the mandibles correctly to the fixation device. The mandibles were sectioned in the midline followed by SSRO as modified by DalPont and Hunsuck to create 20 hemimandibles with a fissure cone bur, a reciprocal

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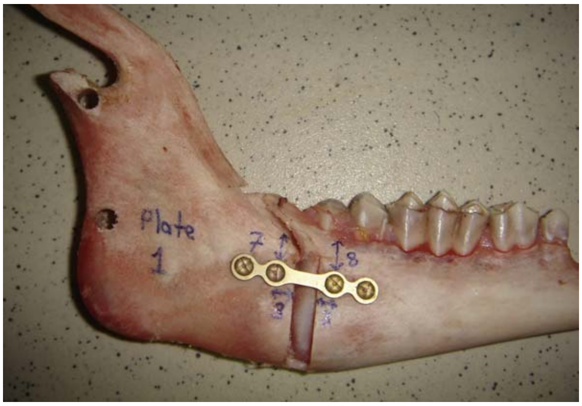

Fig. 1. Sheep mandible fixed with standard miniplate/screws.

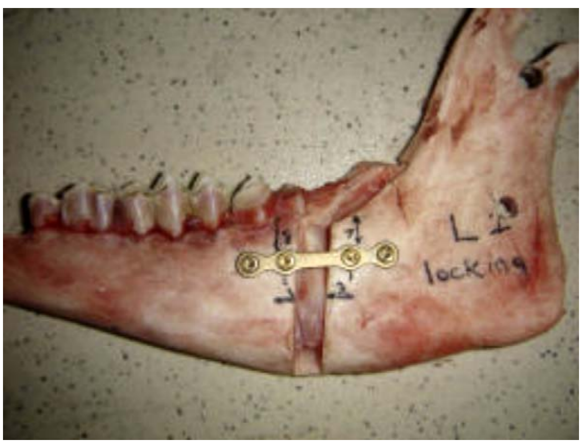

Fig. 2. Sheep mandible fixed with locking plate/screws.

saw, and osteotomes. The horizontal osteotomy was made 2 mm above the lingula and the vertical cut of the sagittal split was made 5 cm away from the posterior border of the ascending ramus. The distal segment was advanced 5 mm and then they were randomly divided into two groups.[5]

Ten of the specimens were fixed with 4-hole extended 2.0 mm titanium miniplates and screws and the other 10 with 4-hole extended 2.0 mm titanium minilocking plates/screws (Figs. 1 and 2).

Each fixed specimen was mounted on a servo-hydraulic testing unit (TST 2500 mxe, ELISTA Electronic Informatic System Design Ltd., Istanbul, Turkey), which records the results on the computer, has a 2500 kg load cell (maximum load capacity 5000 kg), 1/3000 relative load capacity, and is sensitive to changes of at least 20 μm and 0.5–200 mm/min speed in a transverse direction.[6–8]

A 2 mm steel wire was positioned 1 cm posterior to the vertical cut of the osteotomy in the inferior mandible. To reduce the prestress, 10 N preload was applied to all hemimandibles with the steel wire. Each specimen was subjected to a force range of 0–140 N. The displacement values (mm) under 20, 60, 120, and 140 N were compared (Table 1).

Table 1
Displacement values (mm) at all forces.

Type of plate	Model no.	Displacement (mm)			
		20 N	60 N	120 N	140 N
Miniplate	1	2.11	5.16	7.20	7.76
	2	0.82	2.50	5.48	6.25
	3	1.43	3.06	4.43	4.97
	4	2.50	4.43	6.38	6.90
	5	0.40	1.31	2.46	2.76
	6	2.45	4.16	5.83	6.40
	7	2.16	4.62	6.83	7.40
	8	1.57	3.75	6.82	7.35
	9	0.73	2.55	4.01	4.72
	10	0.93	2.50	3.78	4.16
Locking plate	1	2.31	4.83	6.76	7.17
	2	1.18	6.12	7.50	7.83
	3	1.18	3.26	5.07	5.43
	4	1.70	5.47	7.11	7.43
	5	1.10	2.40	3.57	3.88
	6	0.97	2.15	3.36	3.66
	7	3.65	5.55	7.36	7.60
	8	1.36	2.51	4.38	4.93
	9	0.71	1.75	2.65	2.97
	10	0.67	1.80	2.91	3.31

Statistical analysis

The significance of differences between the groups was assessed with the assistance of the Mann–Whitney U-test. Probabilities of less than 0.05 were accepted as significant.

Results

Displacement values at 20 N were similar, and those at 60, 120, and 140 N were slightly higher in the conventional system, but not significantly so.

Discussion

Conventional mini plates/screws have been available for over 30 years, and need exact contact between bone and plate. If this intimate contact cannot be achieved, screws may loosen and occlusion and stability may change.[9] To overcome these disadvantages, locking mini plate/screw systems were introduced.[3,4,10]

The biomechanical comparison of these two systems was done by Gutwald et al.[11] in 1999, and they found that locking plates were more stable in angle fractures. They also concluded that increased stability was a result of the fixation technique and this simplified bending and decreased torsion of the plate.

The first clinical study of the locking plate/screw system to our knowledge was published by Ellis et al. in 2002.[12] They used a 2.0 mm locking plate/screw system in 80 fractures in 59 patients, and stated that this technique was simple and provided sound fixation in all cases.

In contrast to these papers, Chiodo et al.[13] compared the failure strength of 2.0 locking compared with 2.0 conventional miniplates in a laboratory model and found no differences. They hypothesised that the type and degree of failure is more likely to be related to the quality of the bone and the surgical technique than the fixation system.

The studies mentioned above are all related to the stability of fractures after fixation using the locking system. In the present study the biomechanical comparisons of conventional and locking plates were made on simulated SSRO at different bite forces. Calculation of yield load is important in a biomechanical investigation. Maximum bite forces after SSRO have been measured by many authors. In our study displacement values were measured up to 140 N. Two weeks after orthognathic surgery Harada et al. founded the occlusal forces about 60.8–41.5 N for men and 69.6–29.4 N for women; 8 weeks after operation the values were 184.7–89.0 N and 199.1–88.5 N, respectively.[14]

In the locking system, the screws are locked to the plate and inserted into the bone at the same time, and this may increase the primary stability. As screws are locked to the plate overtightening or loosening of screws is not possible, but the surgeon will not be aware of a loose or non-functioning screw in the fracture line. Although angled insertion of screws is possible with the conventional system, 90° angulation and a drill guide is needed to be able to insert the screws into the plate. Extraoral access or a stab incision is generally necessary for insertion of plates and screws.

Ellis et al.[12] provided a sound fixation in all their patients with locking plates and screws, and in the present study the security of fixation was similar with the locking and the conventional plates and screws. Although the locking system does not need perfect adaptation, standard miniplates have to be adapted precisely. If the plates are not adapted precisely, then the locking system seems to be more advantageous as it does not displace the fractured segments. However, the results of ideal and non-ideal adaptation have not been tested in this study. All the plates were bent to simulate perfect adaptation.

We found that the stability of the conventional and locking systems were similar after simulated SSRO and 5 mm advancement. Although the difference when occlusal forces were applied up to 60 N was not significant, the conventional system was more stable. However, when the force exceeded 60 N the locking system was more stable.

The main weakness of this study is that the comparison was made only in hemimandibles; complex bilateral movement of the mandible, particularly during chewing, may affect the final results.

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