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Effect of the shape of mini plate on the stability of mandibular fracture

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Abstract

Introduction: Both thickness, width-length and shape of the miniplate along with number and dimensions of the screws play a role for fracture stability however the researches that studied the effect of the shape are few. **Aim:** Aim of this work is to study the effect of the miniplate shape on fracture stability while the other factors are fixed. **Materials and Method:** Specially designed straight and L shaped miniplates both are equal in length, width and number of the holes, used to manage symphyseal fracture of acrylic mandible whether in single or double manners the stability of the fracture was invstigated through bending and torque test. **Results:** L shaped plate was more stable than straight plate on both bending and torque tests. **Conclusion:** Changing the shape of the plate may have a role for fracture stability while other factors are fixed.

Keywords: Biomechanics, Symphyseal, Miniplate.

INTRODUCTION

Mandibular fractures represent the second most common facial fractures after the nasal bone and symphyseal/ parasymphyseal fracture comprises 15.6 to 29.3% of mandibular fractures [1]. Symphyseal fracture can be induced when a trauma is directed towards the symphyseal region where compressive strain develops along the buccal aspect whereas tensile strain develops along the lingual aspect. This produces a fracture that begins in the lingual region and spreads toward the buccal [2] rigid internal fixation is used to restore the form and function of the fractured mandible avoiding the need for intermaxillary fixation. Different fixation systems used to manage the symphyseal and parasymphyseal fracture including miniplates of different shapes and sizes[3]. All fixation systems that can be used for management of the fracture must resists the different moments of force as bending and torsion when a midline fracture is present. The incisor load position (target) acts as a constraint around which the mandible rotates. Activation of the masseteric sling will produce a rotation around an anteroposterior axis of a hemi-mandible (fracture at the midline) because of the point of attachment of the muscle and the curved structure of the mandible. The effect of this rotation and movement will be seen at the midline as separation of the lower border of the mandible greater than separation of the upper border[4,5]. According to tam study on incisal biting, the symphyseal region has the most negative bending moment where compression developed at the superior border and tension at the lower border on molar loading. The symphyseal region reveal torsion moment. The maximum bending moments are 1.5 times higher than the maximum torsion moment. Different miniplates are used for fixation of the symphseal fracture. However, these miniplates are different in shape, length, thickness also the number of the holes. The stability provided by such miniplates may be due to one or more of these factors. So, through this research, the effect of the shape of the miniplate on fracture stability has been studied while other factors are fixed.

MATERIALS AND METHODS

50 synthetic acrylic mandibles were fabricated in Department of Oral and Maxillofacial Prosthodontics, Faculty of Oral and Dental Medicine, South Valley University, Qena, Egypt. Also specially designed titanium miniplates (Fig 1) were fabricated of two different standardized shapes one plate is straight the other is right angle l shaped (fabricated by the Centre of modern techniques and materials Cairo, Egypt). They are equal in length 22mm, in width 4mm, in thickness 1mm and in number of holes, also miniscrews used for plate fixation are equal in diameter (2mm) and in length (7 mm) for superior border and 11mm for the lower border. Where, the mandible osteotomised by surgical saw and ever two halves of the

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mandible fixed by miniplates using acrylic guides. The mandibles are divided into five groups for incisal loading and five groups for unilateral molar loading the 1st group fixed using single straight plate, (figure 3) the second group fixed using single l plate. The third group fixed with double straight plates. The fourth group fixed with double l plates and the fifth group include intact acrylic mandible as control. One each mandible hold firmly in specialized steel gig that permits stable positioning of both condyles in a groove at the upper part of the gig and the two halves of the mandible permitted to move in down word and mediolateral directions through resting on inclined metal plates on both sides of the gig. While the complete gig is firmly fixed to the base of the universal testing machine (figure 2) (computer control electromechanical universal testing machine, model: WDW300D, 380V, 50HZ, 3PH, Serial No 0771, Jinan Testing Equipment, IE Corporation the People Rebublic of China) at mechanical engineering department, Faculty of Engineering, South Valley University, Egypt. The load applied at 1mm/minute, till the moment of failure of the system. Stiffness and yeild load displacement were recorded for reach group. The stiffness means resistance of fixation system to the deformation in response to the applied load. It equals load/displacement, while yield load means Load at which the fixation system deforms permanently without increase in the load. Yield displacement means displacement that occurs on yield load.

Statistical Analysis

The results were analysed by ANOVA test using software OriginPron 8.5.

RESULTS

Through this study, 50 acrylic mandibles, 60 miniplates along with 360 miniscrews were used as regards the anterior region loading (bending test) there were no significant differences between the groups as regards the stiffeness as regard the stiffness, however the mean of stiffness of L shaped group (49.014±15.14752 N/mm) is greater than that of single straight plate (78.155±62.28315). also double L plates group showed stiffness mean (60.69±23.08145) greater than that of the double straight plates (57.708±16.26875) while the mean of the stiffness of the control group (64.37±31.30369) is greater than the other groups and it is clear that the mean of stiffness of any double group is greater than the single group of the same plate type (table 1) As regards the molar loading loading (torsion test) there were no significant differences between the groups as regard the stiffness. However, the mean of stiffness of single L shaped group (92.295±48.40944 N/mm) is greater than that of single straight plate (78.155±62.28315 N/mm). Also double L plates group showed stiffness mean (176.664±97.68842 N/mm) greater than that of the double straight plates (160.5975±57.08732 N/mm) while the mean of the stiffness of the control group (187.35±114.65061 N/mm) is greater than the other groups and it is clear that the mean of stiffness of any double group is greater than the single group of the same plate type (table 2).

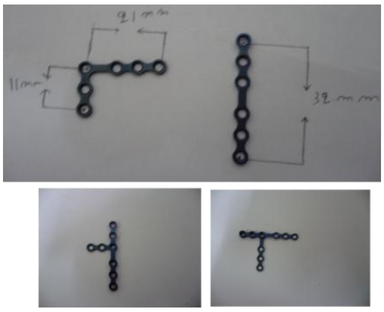

Figure 1: Straight miniplate, L shaped miniplate. They are equal in all dimensions

Figure 2: electromechanical computerized testing machine

Figure 3: Single straight plate tension at lower border compression at superior border on incisal loading

Figure 4: Single L plate tension at lower border and compression at superior border on incisal loading

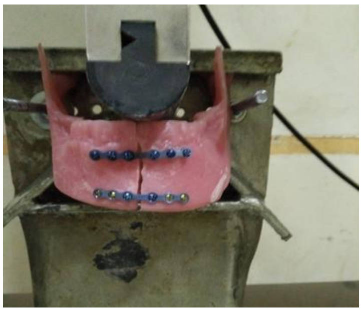

Figure 5: Double straight plates tension at lower border and compression at superior border on incisal loading

Figure 6: Double L shaped straight plates tension at lower border and compression at superior border on incisal loading

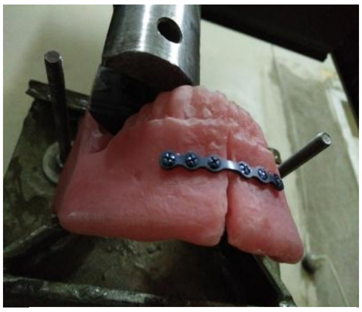

Figure 7: Single straight showing torsion on molar loading

Figure 8: Single straight showing torsion on molar loading

Figure 9: Double straight plates on molar loading

Figure 10: Double L plates on molar loading

Figure 11: Intact mandible on molar loading

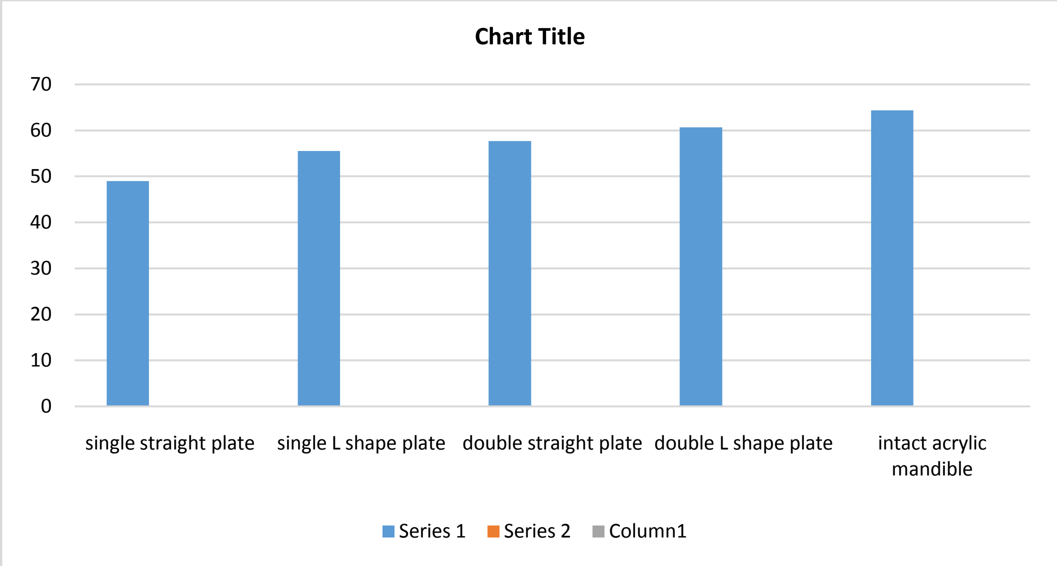

Chart 1: Showing stiffness of different fixation systems on bending

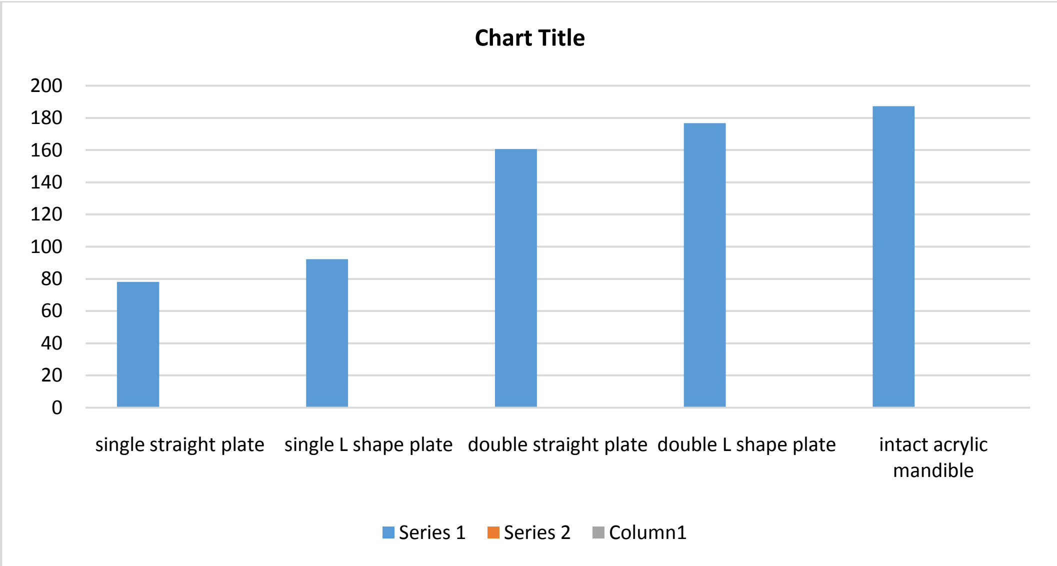

Chart 2: Showing stiffness of different fixation systems on bending

Table 1: Showing the results of bending test* in mean and standard deviation

Group	Displacement at yield load (mm)	Yield load (N)	Stiffness (N/mm)*
Single straight plate	10.606±3.5419	511.52833	49.014±15.14752
Single Lshaped plate	9.668±3.54572	505.95±60.07008	55.538±13.76845
double straight plate	8.62±2.85517	452±192.24984	57.708±16.26875
double Lshaped plate	8.88± 2.56164	495.5±229.41992	60.69±23.08145
Intact mandible	10.254±4.91382	522±119.24764	64.37±31.30369

Table 2: Showing the results of torque test** in mean and standard deviation

Group	Displacement at yield load (mm)	Yield load (N)	Stiffness (N/mm) **
Single straight plate	8.8±5.4191	557.5±165	78.155±62.28315
Single Lshaped plate	7.525±3.45579	570±34.64102	92.295±48.40944
double straight plate	3.75±1.21244	555±57.44563	160.5975±57.08732
double Lshaped plate	4.11± 2.16365	582.5±53.15037	176.664±97.68842
Intact mandible	4.1325±3.34408	530±52.91503	187.35±114.65061

DISCUSSION

Through biomechanical test we can expect the behavior of different fixation systems for the mandibular fracture under standardized conditions that would be useful in making decisions clinically [6]. Through this study we have selected the mandibular symphyseal fracture to study the effect of plate shape on stability of the fracture because this area is continuously exposed to both bending and torsional moments. Through this study specialized jig was designed to permit positioning of the mandible in stable ground, and allow the movement of the mandible in both downward and Medio lateral direction on application of incisal or molar loading. The amount of mandibular displacement throughout the gig depends only on the fixation system because it is the only variable factor. While, the other conditions are the same in all cases as regard the substrate of the mandible and the gig contents. The typical negative bending moment was obtained on incisal loading where there is gap widening at the lower border and compression at the superior border. Rudderman *et al* [4] stated that When a mandibular midline fracture is present, the incisor load position (target) acts as a constraint around which the mandible rotates. Activation of the masseteric sling will produce a rotation around an anteroposterior axis of a hemi mandible (fracture at the midline) because of the point of attachment of the muscle and the curved structure of the mandible. The effect of this rotation and movement will be seen at the midline as separation of the lower border of the mandible greater than separation of the upper border, also on unilateral molar loading torsional movement of the mandibular halves was obvious.

Through this study, there was no significant difference between the L shaped plate and straight shaped plate (keeping in mind that they are equal in all dimensions). But the L shaped plate is showed more stability than straight one and this may be due to provided stability on the third dimensions. Double L shaped plate showed more stability than double straight plates system and this may be due to the result closed square construct that surround the fracture by double L shaped plates. Superiority of three dimensional plate on conventional plate was also concluded.

According to study of Haug *et al* 2001 [7], there was significant difference between the three dimensional plate and double straight plate on molar loading the same was stated through the study of Kalfarentzos *et al* 2009 [8]. But these studies did not standardize the dimension of the different plates, so that the significant stability provided by the three dimensional plates may be due to increased number of the screws or interconnecting bar amount and the resulted stability not absolutely due to different shape.

Although the using double L shaped plates may not be the usually used system for management of mandibular symphyseal fracture but we are obligated to use this system because we compare the effect of the plate shape otherwise the site of the fracture. Through this study acrylic mandibular substrate has been used because it has good physical properties, cheap, available and can be molded to different structures. Kamevama *et al* 1989 [9] used acrylic resin bars as substrates to study different fixation systems for management of mandibular fractures. Also, Feller *et al* 2002 [10] used acrylic models in their experimental study to evaluate combination of microplate and miniplatefor osteosynthesis of mandibular fracture. According to the study of Vieriu *et al* 2015 [11], acrylic resin can be used for creation of mandibular models for the purpose of biomechanical study.

CONCLUSION

Through this study, it can be concluded that change of the shape of the plate may play a favorable role in stability of the fracture keeping other factors fixed as dimension of the plate and number and dimension of the screw of the screws.

Conflict of interest: None.

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