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RESEARCH ARTICLE

A BIOMECHANICAL COMPARISON OF VARIOUS PLATING TECHNIQUES FOR MANDIBULAR CONDYLAR FRACTURES: AN IN VITRO STUDY

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ABSTRACT

Condylar region accounts for 17.5% to 52% of all mandibular fractures. Despite being very common, their treatment remains controversial. Closed reduction as a treatment option for sub condylar fractures has been followed. The study was seen in formalin fixed human cadaveric mandibles. Osteotomised at the subcondylar region the fifteen formalin fixed cadaveric human mandibles have been divided into three groups- Group-A, Group- B, Group-C. Eight formalin fixed cadaver mandibles which were sectioned as hemi-mandibles were used for this study. Comparison of mean forces among the three groups for 1.75mm displacement of segments was done. Results showed P value > 0.05 indicating the test is not significant. This infers that all the three groups have similar clinical stability when tested for clinical end point.

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INTRODUCTION

Condylar region accounts for 17.5% to 52% of all mandibular fractures. Despite being very common, their treatment remains controversial. Closed reduction as a treatment option for sub condylar fractures has been followed for many decades but with delayed return of function, loss of ramal height and the mandible as base in treatment of pan facial fractures has paved the way for open reduction. Even though there is favourable data for the delta, trapezoidal or the double miniplates the additional cost, longer operational time, damage to facial nerve has tilted the bar for the use of single miniplate, despite the complications associated with it such as plate fracture or screw loosening. This ignited the idea to do a biomechanical study to know the stability of the different single miniplates for the treatment of subcondylar fractures in formalin fixed human cadaveric mandibles. The biomechanics of the miniplates was studied by a 3-point biomechanical test model which was developed by Armstrong et al. (2001) to stimulate the functioning mandible which is inexpensive and reproducible. The anatomical variations generally seen in formalin fixed human cadaveric mandibles made us choose them rather than the animal bones and polyurethane models. Osteotomised at the subcondylar region the fifteen formalin fixed cadaveric human mandibles have been divided into three groups in Group-A: titanium 2.0mm 4- holed straight with gap mini adaptation plate with 2x4mm monocortical screws, Group- B: titanium 2.0mm 4-holed straight with gap mini adaptation plate with 2x6 mm bicortical screws, Group-C: titanium 2.0mm 4-holed straight with gap locking adaptation plate with 2x6mm bicortical screws which are subjected to the custom made biomechanical test model to study which group would give a stable method of fixation for the treatment of sub condylar fractures.

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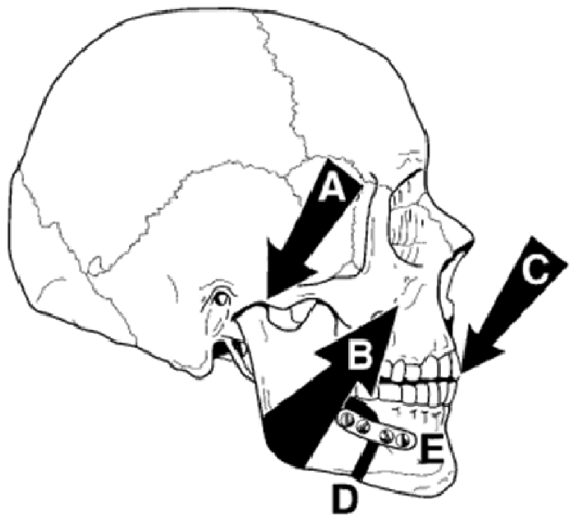
MATERIALS AND METHODS

Method of collection

Eight formalin fixed cadaver mandibles which were sectioned as hemi-mandibles were used for this study.

Osteotomy procedure

All the hemi-mandibles were uniformly sectioned with a saw below the mandibular condyle on the line that connected the deepest portion of the sigmoid notch to a point half of the way between the head of the condyle and inferior border of the mandible. One of the hemi mandibles was discarded due to faulty osteotomy procedure.



Fixation methods

The hemi-mandibles were randomly divided into three groups of five each and are fixed with three different titanium fixation techniques.

Group - A: 2mm 4-holed with gap miniplate with 2x4mm monocortical screws

Group - B: 2mm 4-holed with gap miniplate with 2x6mm bicortical screws.

Group - C: 2mm 4-holed with gap locking plate with 2x6mm bicortical screws

3-Point biomechanical test

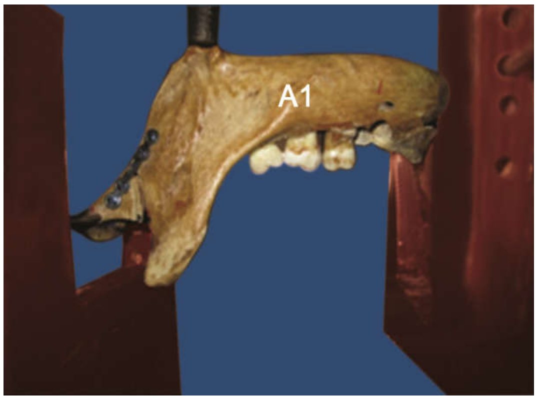
Mandibles are secured on a 3-point biomechanical test device, similar to that design by Armstrong et al 19 which accurately resembles the function of human mandibles. It incorporates the three main forces that act on the mandible while it functions:

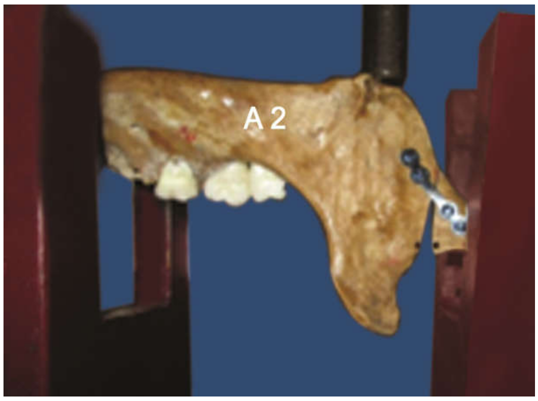
(A) The load placed on the articulating surface of the mandibular condyle.

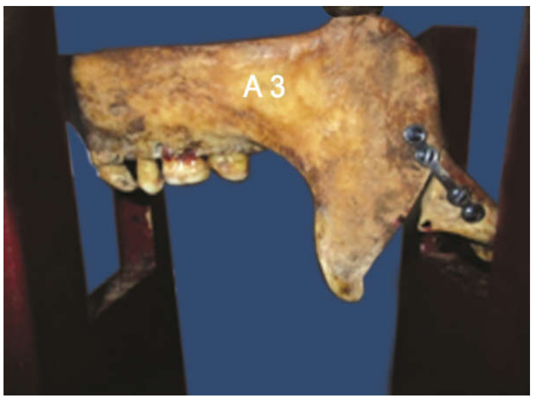
(B) The load is increased by the action of major elevator muscle acting on the angle of the mandible and coronoid process.

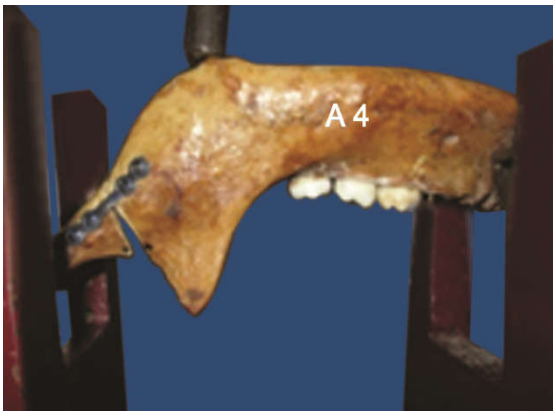
(C) Closure of mouth results in a load being placed on the incisors by a bolus of food.

Adapted to a servo-hydraulic universal testing machine, the three groups were fixed from the mandibular condyle and incisor region. A 2-dimensional schematic representation of the action of the human mandible illustrates the loads generated during function. The hemi-mandibles were fixed at the mandibular condyle and incisor region and then compression loads that stimulated the masticatory loads (N) were applied from the angle of the hemi-mandible until 1.75mm and 3.5 mm displacements were measured. The loads which created the respective displacements were noted. For an accurate measurement of 1.75mm and 3.5mm displacements between the proximal and distal segments a mark is made between the osteotomy site on the upper border of the ramus in the sigmoid notch. The distance between these markings was measured prior to each test with a millimetre surgical compass and 1.75mm and 3.5mm is added to these distances, the loading was recorded by using DAK software during the respective displacements.









adaptation plate (4- holed with gap) and 2.0mm diameter, 4.0mm screws , in sample 1,2,3,4,5 withstood a load of 436N, 448N, 446N, 462N, 464N and a mean of 451.2N. The maximum load required for 1.75mm displacement of segments in Group-B. 2.0mm diameter straight titanium mini adaptation plate (4- holed with gap) and 2.0mm diameter, 6.0mm screws, in sample 1,2,3,4,5 withstood a load of 442N, 446N, 480N, 466N, 443N and mean of 455.4N. The maximum load required for 1.75mm displacement of segments in Group-C. 2.0mm diameter straight titanium locking adaptation plate (4- holed with gap) and 2.0mm diameter, 6.0mm screws, in sample 1,2,3,4,5 withstood a load of 462N, 476N, 468N, 464N, 470N and a mean of 468N. Comparison of mean forces among the three groups for 1.75mm displacement (Clinical end point) of segments was done with (Kruskal -Wallis H- test). Results were shown to have P value > 0.05 indicating the test is not significant. This infers that all the three groups have similar clinical stability when tested for clinical end point.

DISCUSSION

Condylar fractures in the past were mostly treated with closed reduction for many years but due to various complications and decreased compliance of the patients the idea of early return of function has become the cynosure of treating these fractures. Mandible forming the base in pan-facial fractures where maintaining the pre-traumatic ramal height becoming a necessity, recently most of surgeons and many associations dealing with condylar fractures are preferring open reduction as treatment of choice. Various hardwares are used in treating these condyles depending on various factors such as site of fracture, displacement of fracture and number of fracture lines. The idea of miniplates in treating the condylar fractures in lines of Champy has opened new doors in approaching the fractures .Various permutations and combinations of using miniplates depending upon the sizes (two holed or four holed), shapes (straight, delta, rectangular, trapezoidal, square, etc), number (single or double), technique (lag screws, positional screws etc) and last but not the least the various sites (parallel to the posterior border, parallel to the sigmoid notch , parallel to the anterior border etc) has promoted numerous studies in this regard. However, the efficacy of these different devices

Table 2. Maximumload required for 1.75 mmdisplacement of segments

Group	Sample 1	Sample 2	Sample	SAMPLE 4	SAMPLE 5	Mean	Standard deviataion	D.F	Chi Square	P Value
GROUP A	436 N	448 N	446 N	462 N	464 N	451.2N	11.71N	2	4.107	0.128
GROUP B	442 N	446 N	480 N	466 N	443 N	455.4N	16.88N			
GROUP C	462 N	476 N	468 N	464 N	470 N	468N	5.48N			

Group fixation techniques

Group A: Five hemi-mandibles are fixed with 2.0mm diameter straight titanium miniplate (4-holed with gap) and 2.0mm diameter, 4.0mm screws.

Group B: Five hemi-mandibles are fixed with 2.0mm diameter straight titanium miniplate (4-holed with gap) and 2.0mm diameter, 6.0mm screws.

Group C: Five hemi-mandibles are fixed with 2.0mm diameter straight titanium locking plate (4-holed with gap) and 2.0mm diameter, 6.0mm screws.

RESULTS

The maximum load require for 1.75mm displacement of segments in Group-A: 2.0mm diameter straight titanium mini

varies widely in terms of bio functionality and the approaches to fix them to enhance the stability, but some of the techniques are associated with increased risk of facial nerve injury. A biomechanical study was needed to throw light on which plating technique was the most successful in fulfilling the criteria of ease of application, better stability with lesser complications. Polyurethane models, bovine ribs, photo-elastic resin, sheep & porcine mandibles have anatomic and structural differences when compared to human mandibles, therefore the data derived from these models cannot be appropriate. David Kohn et al stated that, the mandibles withstand greater shear stresses than the bovine ribs and synthetic bone substitutes. Recently formalin fixed cadaveric mandibles are taken for the study even though their physical properties are altered because of their natural variations which are similar to human mandibles they were chosen for the study. Most of the in vitro biomechanical studies used a 2-point biomechanical test model, in which one side of the specimen was fixed and other side was suspended like a cantilevered beam. But the mechanics of the human mandibles during function is more complex than a cantilevered beam. Usage of these 2-point models cannot accurately simulate the action of masticatory muscles during mandibular movements.

Limitations of the study

It is difficult to simulate the biomechanics of mandible during function in an experimental environment. So we do not expect that the biomechanical results presented in this study would determine the substantial immediate change in the application of fixation method. The study considered only compressive loads at the angle of the hemi-mandible to evaluate the stability of fixation methods. But in vivo loading of the mandible is more complex, with all the bending, torsional and shearing forces acting simultaneously. The osteotomy cut made manually at the subcondylar region is not the same as in the clinical cases, so the biomechanics might vary.

Conclusion

This in vitro biomechanical comparative study was done in 15 cadaveric hemi mandibles equally divided into three groups of five each subjected to 3-point biomechanical testing after osteotomizing the subcondylar region to mimic subcondylar fracture and fixing with (Group-A): titanium 2.0mm 4- holed straight with gap mini adaptation plate and 2x4mm monocortical screws, (Group-B): titanium 2.0mm 4-holed straight with gap mini adaptation plate and 2x6 mm bicortical screws and (Group-C): titanium 2.0mm 4-holed straight with gap locking adaptation plate and 2x6mm bicortical respectively. The results concluded that there is no significant difference in the biomechanical stability between the three groups which suggests that all the three plating systems are equally efficient in the management of subcondylar fractures. As these results cannot be co related to the clinical application it may be suggested that a bigger sample size and a good biomechanical study test model where in the results can be applied clinically.

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