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COMPARATIVE STUDY

Evaluation of Mechanical Resistance After Fixation of Mandibular Condylar Fracture with Single and Double Miniplates: A Comparative In Vitro Study

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Abstract
Objectives

1. To evaluate the efficacy of two plating system in comparison with single plating system
2. To study the biomechanical behaviour of single and two plating system when compression load is applied.

Materials and Methods Twenty hemimandibles were divided into two groups A and B of ten each. A subcondylar fracture was created. Group A was stabilized by single adaptation plating technique and group B by double adaptation plating technique and both the groups were tested for stability by using universal testing machine.
Results Higher mean displacement was observed in Group A compared to Group B, but the difference in mean displacement between the two groups was not statistically significant ($p > 0.05$). Higher mean load was recorded in group B compared to group A and the difference in mean load between them was found to be statistically significant ($p < 0.001$).
Conclusion The present study demonstrated that double adaptation plating technique had greater resistance to compression load than single adaptation plating technique and it shows more favorable biomechanical behavior.

Keywords Condylar fracture · Mechanical resistance · Plating system · Fixation system

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Introduction

In this fast moving world man has come up with newer ideas, newer machines and newer discoveries making him fastest moving animal on the earth and all of it being behind the wheels of machine. With all high speed modes of transportation, a fairly large number lands up in road traffic accidents [1, 2].

Road traffic accidents are responsible for majority of the patients reporting with maxillofacial trauma. Mandibular fractures are more common among fractures in maxillofacial region. Among mandibular fractures, condylar region is the most frequent site accounting for about 25–35 %. Condylar fractures arise mainly through injury from a traumatic impact on the chin and seldom arise from direct trauma unless accompanied by fracture of zygoma. Injury to condylar region deserves special consideration apart from rest of the mandible because of anatomical differences and healing potential [1, 2].

Condylar fractures are classified according to anatomical location and according to degree of dislocation of

articular head by Spissel and Schroll. Given the unique geometry of the mandible and temporomandibular joints, these fractures can result in marked pain, dysfunction and deformity if not recognized and treated appropriately [3, 4].

There has been considerable controversy regarding the treatment of condylar fractures, either they should be treated conservatively or surgically. There are complications associated with both types of treatment. Historically and most commonly condylar process fractures have been managed by closed techniques/nonsurgically [3–5].

According to generally accepted guidelines, intracapsular fractures of mandibular condyle are presently treated with a closed functional therapeutic regimen. Commonly employed methods are using a maxillomandibular fixation for a period of time or functional therapy with interarch elastics to maintain the pretraumatic occlusal relationship [4, 5].

Those preferring closed reduction, claim that functional recovery is to the same extent after open or closed reductions and also morbidity associated with surgical treatment could be avoided. According to literature low subcondylar fractures should be treated by open reduction, as there is early recovery of function, less incidence of malocclusion and adequate inter incisal mouth opening than those treated by closed reduction [4, 5].

With the advent of rigid internal fixation using titanium plates and screws which enable the stabilization of such fractures, acceptance of the surgeon and the expectancy of patients have lead to a resurgence of interest in open reduction for mandibular condylar fractures [6, 7].

Clinical effectiveness of internal fixation plates and screws in mandibular trauma, orthognathic and reconstructive surgery is well accepted and documented. To better understand the biomechanics of mandibular fixation and to develop improved fixation devices and techniques, experimental investigations are often used to quantify and evaluate function in in vitro environment. Very few biomechanical behavior analyses of different condylar fixation modalities appear in the literature [6–9].

The purpose of this study was to comparatively evaluate the resistance of two different plating techniques for open reduction and internal fixation of mandibular condylar process fractures.

Methodology

This is an in vitro study conducted on cadaveric mandibles in Department of Oral and Maxillofacial Surgery, The Oxford Dental College and Hospital, Bangalore. The mandibles were obtained from anatomy Department of Bangalore Medical College and Research Institute, Bangalore. Ten mandibles were selected based on the following criteria:

Fig. 1 Armamentarium used in study

1. Mandibles with a rigid outer and inner cortex and a trabecular medullary space.
2. Mandibles of uniform width.
3. Mandibles with uniform posterior height from highest point of condyle to a parallel line passing through base of mandible.

Armamentarium (Fig. 1)

1. Marker pencil
2. Band saw
3. Drill bit 1.7 mm
4. Straight hand piece
5. Stainless steel plate 2 mm, 4 holes with gap
6. Screws 6 mm
7. Plate blender
8. Plate holder
9. Screw holder
10. Screw driver
11. Irrigating syringe and saline

Evaluation Criteria

Mandibles were loaded at the condylar region with compression force ranging from 0 to 200 N. The experimental end point was established at a distance of 10 mm, with experiment being finished even without total collapse of system.

Procedure

Cadaveric hemimandible was stabilized on a flat surface and posterior height of the mandible was measured with a pachymeter, from the highest point of condyle to a parallel line passing through the base of the mandible.

Fig. 2 Subcondylar fracture of mandible

Fig. 3 Double and single adaptation plating technique

This was standardized so that the fracture line would pass through the lowest point of sigmoid notch till half the height of the posterior border of mandible, simulating a high subcondylar fracture.

The hemimandibles were sectioned uniformly using a steel disk coupled to flat base and an electric micro motor (Fig. 2). The experimental samples were divided into two groups A and B of 10 hemimandibles each and then fixed using two different fixation techniques: group A fixed using single stainless steel plate of 2 mm thickness with 4-hole and four 2 mm × 6 mm stainless steel screws and group B with two separate stainless steel plates of 2 mm thickness with 4-hole and four 2 mm × 6 mm stainless steel screws in each one (Fig. 3).

Both the mandibular groups were submitted to linear loads in medial to lateral and anterior to posterior directions in an INSTRON 441 servo-hydraulic machine for testing materials (Figs. 4 and 5).

A speed of 1 mm/min was established to apply a progressive load on system, during which value of resistance against compression was obtained from peak and final

Fig. 4 INSTRON 441 servo-hydraulic machine—test setup

Fig. 5 Load being applied in linear direction

loads, and forced displacement was gauged by analysis of these 2 movements. Final displacement was established at a distance of 10 mm.

After completion of study, mandibles were disposed in the same way followed for disposal of human organic waste.

Results

The current study was conducted with the aim of determining the strength of fixation provided by double and

Table 1 Comparison of single and double adaptation plates with respect to load scores in anterior to posterior direction by *t* test

Group	Mean	SD	t-value	*p* value
Single adaptation plate	50.0000	9.8489	−12.8598	0.0000*
Double adaptation plate	130.0000	9.8234		

* $p < 0.05$

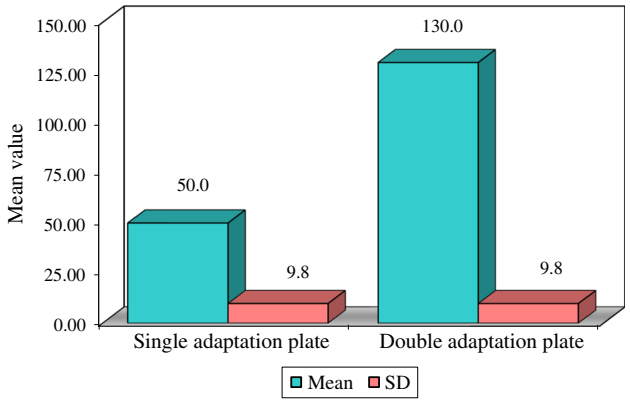

Fig. 6 Comparison of single and double adaptation plates with respect to load scores in anterior to posterior direction

single adaptation plating techniques in fixation of the mandibular condylar fractures. Displacement of the fracture fragments was measured in millimeters at the loads of 0 to 200 N applied across the fracture line by using universal testing machine.

Null Hypothesis

There was no significant difference in the load scores in anterior to posterior direction between two single and double adaptation plates i.e. $\mu_1 = \mu_2$.

Alternate Hypothesis

There was a significant difference in the load scores in anterior to posterior direction between two single and double adaptation plates i.e. $\mu_1 \neq \mu_2$.

Statistical Test Used

t test.

Decision Criterion

p value with the level of significance was compared. If $p < 0.05$, the null hypothesis was rejected and the alternate hypothesis was accepted. If $p \geq 0.05$, the null hypothesis was accepted.

Table 2 Comparison of single and double adaptation plates with respect to displacement (mm) scores in anterior to posterior direction by *t* test

Group	Mean	SD	t-value	*p* value
Single adaptation plate	1.9300	0.0791	14.2295	0.0000*
Double adaptation plate	1.2300	0.0765		

* $p < 0.05$

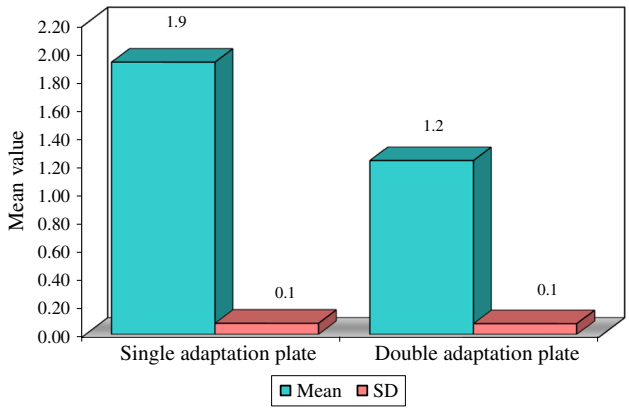

Fig. 7 Comparison of single and double adaptation plates with respect to displacement (mm) scores in anterior to posterior direction

Computations

Tables 1–4 give us the various computations and the *p* value.

A significant difference was observed between single and double adaptation plates with respect to load scores in anterior to posterior direction ($t = -12.8598$, $p < 0.0$). It means that, the significant higher load scores in anterior to posterior direction was seen in double adaptation plate as compared to single adaptation plate (Table 1; Fig. 6).

A significant difference was observed between single and double adaptation plates with respect to displacement (mm)scores in anterior to posterior direction ($t = -12.8598$, $p < 0.0$). It means that, the significant lower displacement (mm) scores in anterior to posterior direction was seen in double adaptation plate as compared to single adaptation plate (Table 2; Fig. 7).

A significant difference was observed between single and double adaptation plates with respect to load scores in medial to lateral direction ($t = -2.4962$, $p < 0.0$). It means that, the significant higher load scores in medial to lateral direction was seen in double adaptation plate as compared to single adaptation plate. (Table 3; Fig. 8).

A significant difference was observed between single and double adaptation plates with respect to displacement scores in medial to lateral direction ($t = -2.4962$,

Table 3 Comparison of single and double adaptation plates with respect to load scores in medial to lateral direction by *t* test

Group	Mean	SD	t-value	*p* value
Single adaptation plate	12.0000	5.7009	−2.4962	0.0372*
Double adaptation plate	21.0000	5.7009		

* $p < 0.05$

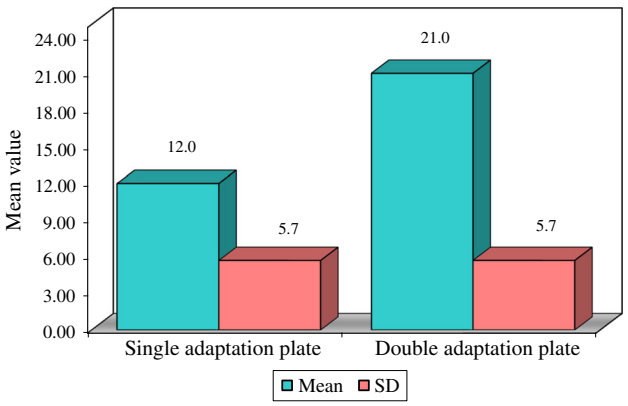

Fig. 8 Comparison of single and double adaptation plates with respect to load scores in medial to lateral direction

Table 4 Comparison of single and double adaptation plates with respect to displacement (mm) scores in medial to lateral direction by *t* test

Group	Mean	SD	t-value	*p* value
Single adaptation plate	1.5400	0.0825	6.7890	0.0001*
Double adaptation plate	1.1500	0.0985		

* $p < 0.05$

$p < 0.0$). It means that, the significant lower displacement scores in medial to lateral direction was seen in double adaptation plate as compared to single adaptation plate. (Table 4; Fig. 9).

Discussion

The mandible is largest and strongest bone of face. It has horse-shoe shaped body which houses the teeth. Fractures of the mandible can be classified according to location as symphysis, parasymphysis, body, angle, ramus, condylar, coronoid, and dentoalveolar. The neck of the condyle which is the anatomically most constricted area below the condylar head is the weakest site in mandible and hence is the most common site of fracture i.e. 39 % followed by parasymphysis, angle, body, symphysis and coronoid process [1, 2].

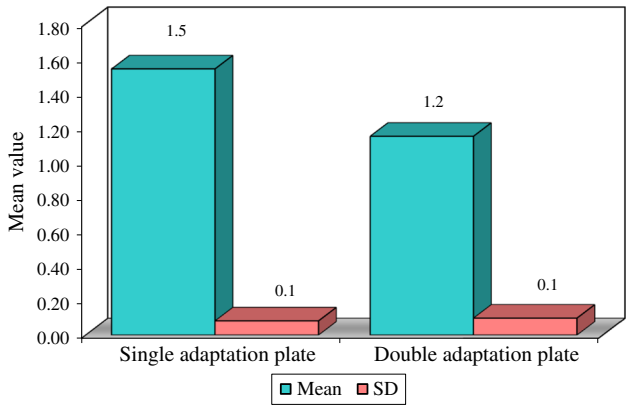

Fig. 9 Comparison of single and double adaptation plates with respect to displacement (mm) scores in medial to lateral direction

The management of the mandibular condylar fractures includes conservative as well as surgical methods. Conservative management is immobilizing the mandible by intermaxillary fixation which is achieved by dental wiring and arch bars. The surgical management of mandibular fractures involves intra or extraoral opening of the fracture site and direct osteosynthesis with transosseous wires, lag screws, bone plates, Luhr's Vitallium compression plate, dynamic compression plate (DCP), eccentric dynamic compression plate (EDCP), reconstruction plate, monocortical non compression mini plates and 3-dimensional (3D) plates [2, 3, 11].

The key to fracture healing is rigid fixation of bone to bone contact. Any mobility at the fracture site can lead to infection, malunion or even non-union. There are several forces acting on the mandibular condylar process during function in different directions. Re-establishment of the pretraumatic occlusion as well as normal mandibular motion is essential in the treatment of condylar fractures [3, 4, 11].

Decisions on management of mandibular condyle fractures remain a major topic of oral and maxillofacial surgery practice. Some variables affect the decision of closed versus open treatment. This includes the level of fracture, the degree and direction of displacement of the fractured segments, the age and medical status of the patient, concomitant facial fractures, and the presence and status of dentition [4, 6, 7].

The majority of fractures of the mandibular condyle heal with functionally acceptable results after closed treatment. This method is simpler and easier to perform and in most instances is as effective, if not more effective, as open reduction, with less potential morbidity. The main reasons for open reduction and internal fixation of condylar fractures are to permit primary healing of unreducible or

unstable fractures and to avoid intermaxillary fixation. Absolute indications for open reduction are rare. Relative indications primarily include adults with persistent malocclusion and condyles displaced out of the fossa [8–10].

The application of a single mini adaptation plate fixation for condylar fracture was introduced by Pape et al. and became popular without any in vitro testing. Ellis reported plate fracture or screw loosening after application of single miniplate for condylar fracture and mentioned that single miniplate fixation might be insufficient for this area [5, 6, 9].

There are biomechanical and clinical studies suggesting that the 2 miniplate fixation techniques provide functionally stable fixation for fractures of the mandibular condylar process. Choi and Yoo in their study concluded that double adaptation plating technique proved to be 4 times stronger than single adaptation plate [7].

According to studies conducted by Asprino et al. [11], Tomainaga et al. [12], Gealh et al. [13], higher mean load was recorded in double adaptation system as compared to that of single adaptation system and the difference in mean load between them was found to be statistically significant. Double adaptation plating technique for fixation of mandibular condylar fracture has provided favorable biomechanical behavior in relation to anteroposterior and mediolateral peak load as compared to single adaptation plating technique. Hence, stability of fixation of condylar fractures is greatly enhanced by the placement of an additional miniplate when exposed to the forces of mastication.

The internal fixation devices tested in this study included 4-hole single adaptation plate with 6 mm screws and two 4-hole adaptation plates with 6 mm screws. Results from this comparative study between two different plating techniques for mandibular condylar fracture suggested that higher mean load was recorded in double adaptation plating system compared to single adaptation plating system and the difference in mean load between them was found to be statistically significant ($p < 0.001$). Mean load taken by double adaptation plating system was about 130 N and that by single adaptation plating system was 50 N in anteroposterior direction.

Conclusion

This study has demonstrated that the placement of plates is an important variable in treatment of mandibular condylar fractures. Stability of fixation of condylar fractures is greatly enhanced by the placement of an additional miniplate when exposed to the forces of mastication.

In this in vitro study, double adaptation plating technique for fixation of mandibular condylar fracture has provided the most favorable biomechanical behavior in relation to anteroposterior and mediolateral peak load as compared to single adaptation plating technique.

Summary

Twenty hemimandibles were divided into two groups A and B of ten each and subcondylar fractures were created. Group A was stabilized by single adaptation plating technique and group B by double adaptatation plating technique. Both the groups were tested for stability by using universal testing machine. Mandibles were subjected to compression force at the condylar region that simulates masticatory loads ranging from 0 to 200 N. The experimental end point was defined as loss of integrity of bone-screw-plate system.

Results from this comparative study suggested that higher mean load was recorded in double adaptation system as compared to that of single adaptation system and the difference in mean load between them was found to be statistically significant. Hence, stability of fixation of condylar fractures was greatly enhanced by the placement of an additional miniplate when exposed to the forces of mastication.

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