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Original Article

Evaluation of trapezoidal-shaped 3-D plates for internal fixation of mandibular subcondylar fractures in adults

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ARTICLE INFO

Article history:

Received 30 June 2015

Accepted 28 July 2015

Available online 15 August 2015

Keywords:

Trapezoidal condylar plates

Condylar fracture

Open reduction

ABSTRACT

Aims: The purpose of this study is to evaluate the clinical results and to assess the efficacy, stability, and rigidity of trapezoidal 3-D plates for osteosynthesis in adult mandibular subcondylar fracture patients.

Methods: This study included 15 cases of trauma having mandibular subcondylar fractures, in which open reduction and internal fixation are indicated. After selecting patient according to the inclusion criteria, all patients underwent open reduction and rigid fixation. Fracture was then stabilized using 4 hole, 2.0 mm trapezoidal-shaped 3-D titanium plates using retromandibular incision. Postoperative clinical examination was carried out on 3rd day; 1st, 2nd, and 4th weeks; and 3rd and 6th months.

Results: The results of this study suggest that the fixation of mandibular subcondylar fracture with trapezoidal-shaped 3-D plates provides three-dimensional stability and carries low morbidity.

Conclusion: Patients with gross displacement of condylar fragment, major reduction in posterior facial height, and deranged occlusion can be successfully managed by open reduction of condylar fracture and its fixation using 3-D plates.

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<http://dx.doi.org/10.1016/j.jobcr.2015.07.005>

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1. Introduction

Mandibular condylar fractures are the most commonly encountered mandibular fractures, being 17.5–52%^{1–4} of all mandibular fractures. The most common unilateral fracture is subcondylar, and the most common bilateral fracture is of the condylar heads,⁵ mostly caused by direct trauma, but may also be due to indirect forces. Treatment of condylar fractures depends on physical and imaging evidence of the fracture, extent of injury (whether unilateral or bilateral), the level of fracture, the degree of displacement and dislocation, the size and position of the fractured condylar segment, and the dental malocclusion, etc.

In 1924, Perthes carried out the first surgical treatment of a condylar fracture. Surgical treatment has been advocated to reapproximate the fractured segments and to avoid complications like open bite, retrognathia, pain, reduced lateral or protrusive mobility, and deviation on opening.^{6,7} Open reduction aims at anatomical repositioning and rigid fixation of the fragments, occlusal stability, rapid return to function, maintenance of vertical ramus dimension, no airway compromise, and less long-term temporomandibular joint dysfunction.^{8,9}

Bilateral condylar fractures cause most malocclusions.¹⁰ It is believed that once condylar nonunion has occurred, conservative treatment is ineffective and joint is prone to arthritic sequelae.¹¹ Open reduction and internal fixation of condylar fractures is an acceptable method, as it prevents the complications associated with closed reduction like shortening of ramus, deviation of jaw on opening, occlusal discrepancies, formation of false joint, which functions for condylar movement in glenoid fossa, and late-term complications.

Stable fixation is very important as the interfragmentary mobility can lead to nonunion, fibrous union, or temporomandibular disorders. Fixation with very rigid miniplates provides more stability than transosseous wiring.^{12,13} Although single miniplates can be adequate if the fragments are aligned properly, functional forces actually exceed the rigidity of one miniplate, and therefore the use of two has been proposed. Alternatively, a single 2.4 mm plate or a single 2.0 mm mini-dynamic compression plate may be used for fixation of condylar fractures, as they offer more resistance to

rotation and 3-point bending.^{14,15} However, in the condylar neck, the amount of bone is not always adequate to permit placement of 2–3 screws per fragment. To overcome this problem, various plate designs have been put forward.

A single L, Y plate, or 3-D plate has been used in the treatment of condylar fractures,¹⁶ which confirm to the tensile stress pattern at the condylar neck region. Trapezoidal condylar plate (TCP) is such a 3-D plate shaped for adaptation in the anatomically constricted region of condylar neck. TCP is placed with one arm parallel to the condylar axis and second arm parallel to the mandibular notch. Hence, this plate meets the criteria of 2 single miniplates with reduced hardware, leading to a less infection rate.¹⁶

The aim of this study was to evaluate the efficacy of single trapezoidal 3-D miniplates in subcondylar fractures.

2. Materials and methods

This study included 15 cases of mandibular subcondylar fracture alone or in combination with fracture elsewhere in the mandible or midface, who reported to our Department of Oral and Maxillofacial Surgery. All these were treated by open reduction and internal fixation using 2.0 mm trapezoidal-shaped 3-dimensional titanium miniplate. The study was conducted after obtaining the approval of the ethical committee of college and informed written consent from the participants. Adult patients with mandibular subcondylar fracture, who consented for the surgical treatment and postoperative follow-up, were included in this study. Condylar head fractures (intracapsular fractures), pediatric patients, patients unfit for surgery, those who could not be followed up postoperatively over a minimum period of 6 months, and those who did not consent for surgery were excluded from the study. Miniplates, Orthomax, having a profile height of 2 mm were used (Figs. 1 and 2).

A thorough medical history was recorded to rule out any significant systemic conditions. Clinical examination was carried out as per protocol. Routine preoperative investigations included radiographs like ortho-pantomogram and PA view of mandible. Radiographs were assessed for the degree of displacement of the fracture fragments (Fig. 3). Erich's arch bar was fixed.

Fig. 1 – Armamentarium.

Fig. 2 – Trapezoidal condylar plate (TCP) with 6 and 8 mm screws.

Fig. 3 – Preoperative radiograph.

Fig. 4 – Marking of incision.

where patients were periodically recalled on 3rd day; 1st, 2nd, and 4th weeks; and 3rd and 6th months postoperatively.

Patients were evaluated for any signs of malocclusion, facial nerve injury, or infection with local rise in temperature, inflammation, and pus discharge. Radiographic evaluation with OPG was done on the 3rd postoperative day and 3rd and 6th months (Figs. 7-9). Data were statistically analyzed using SPSS (Statistical Package for Social Sciences) Version 15.0 Software. A “p” value less than 0.05 indicated a statistically significant result.

3. Results

All the patients had a uneventful postoperative period and were discharged on the third day after surgery. Age of patients ranged from 18 to 50 years. More than half the patients (66.7%) were aged between 21 and 40 years, mean age of 29.07 ± 14.19

Fig. 5 – Surgically exposed fracture site.

Fig. 6 – Placement of TCP.

Surgery was performed under general anesthesia with naso-endotracheal intubation. Reduction and stabilization of other mandibular fractures were done first, if present. Retro-mandibular incision was used to expose the subcondylar fracture. The skin was marked prior to the injection of a vasoconstrictor (Fig. 4). Fracture site was exposed and identified (Fig. 5) and reduced in normal anatomic position using bone-holding forceps. Maxillo-mandibular fixation was done. Fracture fragments were fixed with TCP using 6 or 8 mm screws (Fig. 6). Follow-up period was of at least 6 months,

Fig. 7 – Postoperative OPG 3rd day.

Fig. 8 – Postoperative OPG 3rd month.

years (Fig. 10). Road traffic accident was most common etiology in our study (46.7%) followed by interpersonal violence (26.7%) and fall (26.7%). In our study, mandibular parasymphysis fracture was the most common associated injury ($n = 9$; 60%).

Preoperative mean pain score was 5.8 ± 0.39 . At 3rd day postoperatively, it dropped to 3.47 ± 0.32 , thus showing a statistically significant change of 2.33 ± 0.18 ($p < 0.001$). One month postoperatively, mean pain score was 0.53 ± 0.3 , thus showing a mean change of 5.27 ± 0.34 from day 1, which is statistically significant ($p < 0.001$). By the end of follow-up at 3 and 6 months, none of the patients reported any pain (Fig. 11).

Preoperatively, 13 (87%) patients had malocclusion. Mouth opening of all patients ranged from 34 to 42 mm, with mean mouth opening recorded as 36.13 mm following plate placement. In our study, none of the patients had malocclusion postoperatively. We did not observe any hardware failure or permanent nerve injury. If there was any transient facial nerve injury, it improved within a month.

4. Discussion

Closed reduction has been associated with shortening of ramus, deviation of jaw on opening, occlusal discrepancies, formation of false joint, and late complications, leading to internal derangement of the joint. Today, open reduction and internal fixation of condylar fractures is the acceptable method in the management of condylar fracture, especially

Fig. 10 – Distribution of subjects according to age.

Fig. 11 – Clinical assessment of patients according to pain at different time intervals.

in cases with gross displacement of condylar fragment, major reduction in posterior facial height, and deranged occlusion.

The principle behind open reduction and internal fixation using miniplate osteosynthesis is “functionally stable osteosynthesis”^{17,18} Champy determined the ideal line of osteosynthesis in the region of mandibular body, but no such line was proposed in the region of condyle because of limited data. Meyer¹⁹ attempted to fill this void to determine the ideal line of osteosynthesis in the region of condyle. During biting forces in the region of molars, strain lines were detected in the condylar region. Hence, adaptation of single 4-hole miniplate, as was initially proposed, did not provide dynamic osteosynthesis and resulted in fracture of the plate during function. Two-plate fixation (a miniplate parallel to condylar axis and second

Fig. 9 – Postoperative OPG 6th month.

miniplate parallel to mandibular notch) met with the fulfillment of dynamic osteosynthesis, but adaptation of 2 miniplates in the region of condylar axis is difficult due to the constriction of condylar neck. Hence, use of TCP has been proposed in open reduction and internal fixation of the condylar fractures.

TCP is shaped for adaptation in the anatomically constricted region of condylar neck. TCP is placed with one arm parallel to the condylar axis and second arm parallel to the mandibular notch. Hence, this plate met the criteria of 2 single miniplates, but with a reduced hardware. This plate provides three-dimensional stability because of its design. Infection rate is less because of the reduced hardware and requires reduced exposure as compared to 2–4 hole straight miniplate.

Titanium 3-D plating system was developed by Farmand²⁰ to meet the requirements of semirigid fixation with lesser complications. The 3-D plate is a misnomer as the plates are not three-dimensional but hold the fracture fragments rigidly by resisting the forces in three dimensions namely shearing, bending, and torsional forces. The basic concept of 3-D fixation²⁰ is that a geometrically closed quadrangular plate secured with bone screws creates stability in three dimensions. The stability is gained over a defined surface area and is achieved by its configuration and not by thickness or length, and also the large free areas between the plate arms and minimal dissection permit good blood supply to the bone.

Our study evaluated the osteosynthesis in mandibular subcondylar fracture with trapezoidal-shaped 3-D miniplates. The results of this study indicate that the trapezoidal-shaped 3-D miniplates can be a good alternative for osteosynthesis in mandibular subcondylar region. In our study, the majority of patients were male (80%) and 67% were of age group 20–40 years, which is in concordance with study conducted by Mitchell.²¹ The major etiological factors in our study were road traffic accident (47%), followed by interpersonal violence (27%), and fall (26%). Similar findings were also observed by Singh.²² Higher incidence of road traffic accident can be explained by the fact that there are no comprehensive rules for traffic safety in our country as seen in western countries. These need to be formulated and strictly enforced.

Infection was not observed in any of our cases, similar to Singh.²² However, Hammer²³ reported an infection rate in more than one-third (35%) of the group stabilized with a single adaptation miniplate. Thus, it can be presumed that stability in three-dimensional is important for the prevention of infection, the criteria which TCP fulfills.

Evidence of hardware failure was observed radiographically till sixth month postoperatively. Hardware failure in our study was 0%. Contrastingly in other studies,²⁴ plate fracture was exclusively observed in cases stabilized with single miniplate. The reason for hardware failure may be that this plate is located on the compression strain lines when placed conventionally along the condylar neck and goes completely against the principles of functionally stable osteosynthesis. TCP is placed with one arm parallel to the condylar axis and second arm parallel to the mandibular notch, thus providing stable osteosynthesis and minimizing the rate of hardware failure.

Mandibular parasymphysis fracture was the most common associated injury (60%), similar to findings of Sawazaki,²⁵ who showed that multiple mandibular fractures are more common

and symphyseal fractures were significantly associated with mandibular condyle fractures. Higher incidence of mandibular symphysis/parasymphysis can be explained by the prominent anatomical position of mandible in maxillofacial skeleton.

Earlier resolution of pain in our patients can be attributed to better stability of the fragments provided by TCP. Restoration of occlusion is one of the most important goals of the management of fractures of dentofacial region. The effect of not restoring the occlusion to its original condition is disabling and can cause severe effects especially on the temporomandibular joint.

In our study, we also found that trapezoidal-shaped 3-D plates are very convenient to apply in subcondylar fracture area and provided good stability. The results of this study suggest that the fixation of mandibular subcondylar fracture with trapezoidal-shaped 3-D plates provides three-dimensional stability and carries low morbidity.

The small sample size and limited follow-up could be considered as the limitations of this study, but all incision sites healed uneventfully and were less conspicuous by the third month follow-up. However, a larger number of cases should be studied over a longer period of time for better postoperative analysis. It is recommended to have a multicenter study with large number of patients and correlation among these studies to authenticate our claims.

5. Conclusion

Patients with gross displacement of condylar fragment, major reduction in posterior facial height, and deranged occlusion can be successfully managed by open reduction of condylar fracture and its fixation using 3-D plates.

Ethical approval

Ethical approval was received from Institutional Ethical Committee.

Conflicts of interest

The authors have none to declare.

REFERENCES

1. Zachariades N, Papavassiliou D, Papademetriou J, Koundouris J. Fractures of the facial skeleton in Greece. *J Maxillofac Surg.* 1983;11:142–144.
2. Bochlogyros PN. A retrospective study of 1,251 mandibular fractures. *J Oral Maxillofac Surg.* 1985;43:597–599.
3. Zachariades N, Papavassiliou D. The pattern and aetiology of maxillofacial injuries in Greece. *J Cranio-Maxillofac Surg.* 1990;18:251–254.
4. Silvennoinen U, Iizuka T, Lindqvist C, Oikarinen K. Different patterns of condylar fractures: an analysis of 382 patients in a 3-year period. *J Oral Maxillofac Surg.* 1992;50:1032–1037.
5. Killey HC. *Fractures of the Mandible*. Bristol: Wright & Sons; 1974.

6. Jeter TS, Van Sickle JE, Nishioka GJ. Intraoral open reduction with rigid internal fixation of mandibular subcondylar fractures. *J Oral Maxillofac Surg.* 1988;46:1113–1116.
7. Lachner J, Clanton JT, Waite PD. Open reduction and internal rigid fixation of subcondylar fractures via an intraoral approach. *Oral Surg.* 1991;71:257–261.
8. Zhang X, Obeid G. A comparative study of the treatment of unilateral fractured and dislocated mandibular condyle in the rabbit. *J Oral Maxillofac Surg.* 1991;49:1181–1190.
9. Ellis III E, Simon P, Throckmorton GS. Occlusal results after open and closed treatment of fracture of the mandibular condylar process. *J Oral Maxillofac Surg.* 2000;58:260–268.
10. Lindahl L. Condylar fractures of the mandible. *Int J Oral Surg.* 1977;6:12–21.
11. Pereira MD, Marques A, Ishizuka M, Keira SM, Brenda E, Wolosker AB. Surgical treatment of the fractured and dislocated condylar process of the mandible. *J Craniomaxillofac Surg.* 1995;23:369–376.
12. Iizuka T, Lindqvist C, Hallikainen D, Mikkonen P, Pauku P. Severe bone resorption and osteoarthritis after miniplate fixation of high condylar fractures. *Oral Surg.* 1991;72:400–407.
13. Zachariades N, Papademetriou J, Rallis G. Mandibular fractures treated by bone plating and intraosseous wiring. A comparative study. *Rev Stomatol Chir Maxillofac.* 1994;95: 386–390.
14. Hammer B, Schier P, Prein J. Osteosynthesis for condylar neck fractures: a review of 30 patients. *Br J Oral Maxillofac Surg.* 1977;35:288–291.
15. Choi BH, Yi CK, Yoo JH. Clinical evaluation of 3 types of plate osteosynthesis for fixation of condylar neck fractures. *J Oral Maxillofac Surg.* 2001;59:734–737.
16. Meyer C, Martin E, Kahn JL, Zink S. Development and biomechanical testing of a new osteosynthesis plate (TCP®) designed to stabilize mandibular condylar fractures. *J Craniomaxillofac Surg.* 2007;35:84–90.
17. Champy M, Wilk A, Schnebelen JM. Treatment of mandibular fractures by means of osteosynthesis without intermaxillary immobilization according to F.X. Michelet's technic. *Zahn MundKieferheilkd Zentralbl.* 1975;63:339–341.
18. Champy M, Lodde JP. Syntheses mandibulaires: localisation des syntheses en fonction des contraintes mandibulaires. *Rev Stomatol.* 1976;77:971–976.
19. Meyer C, Kahn JL, Boutemi P, Wilk A. Photoelastic analysis of bone deformation in the region of the mandibular condyle during mastication. *J Craniomaxillofac Surg.* 2002;30:160–169.
20. Farmand M. Three dimensional plate fixation of fractures and osteotomies. *Fac Plast Surg Clin North Am.* 1995;3(1):39–56.
21. Mitchell DA. A multicentre audit of unilateral fractures of mandibular condyle. *Br J Oral Maxillofac Surg.* 1997;35: 230–236.
22. Singh G, Mohammad S, Das S. Trapezoidal condylar plate: report of 15 cases in the management of mandibular subcondylar fracture. *J Adv Med Dent Sci.* 2013;1(2):13–18.
23. Hammer B. Osteosynthesis of condylar neck fracture: a review of 30 patients. *Br J Oral Maxillofac Surg.* 1997;35: 288–291.
24. Choi B-H, Yi C-K. Clinical evaluation of 3 types of plate osteosynthesis for fixation of condylar neck fractures. *J Oral Maxillofac Surg.* 2001;59:734–737.
25. Sawazaki R, Lima SM, Asprino L, Moreira RW, de Moraes M. Incidence and pattern of mandibular condyle fractures. *J Oral Maxillofac Surg.* 2010;68:1252–1259.