A Prospective Study of Strut versus Miniplate for Fractures of Mandibular Angle

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Abstract

This prospective randomized clinical trial compared the treatment outcomes of strut plate and Champy miniplate in fixation of mandibular angle fractures. Patients with mandibular angle fracture were consented and enrolled into this study. Exclusion criteria include patients with severely comminuted fractures. The patients were randomly assigned to receive the strut plate or Champy miniplate for angle fracture fixation. Patient demographics, fracture characteristics, operative and postoperative outcomes were collected prospectively. Statistical analysis was performed to evaluate the significance of the outcome.

A total of 18 patients were included in this study and randomly assigned to receive either the strut plate or Champy miniplate. Out of which five patients were excluded postoperatively due to complex fracture resulting in postoperative maxillomandibular fixation. The final enrollment was 13 patients, $N = 6$ (strut) and $N = 7$ (Champy). There was no statistically significant difference in the pretreatment variables. Nine of these patients had other associated facial fractures, including parasymphseal and subcondylar fractures. Most of the (11) patients had sufficient follow-up after surgery. Both groups exhibited successful clinical unions of the mandibular angle fractures. The complications associated with the mandibular angle were 20% in the strut plate group and 16.7% in the Champy group. One patient in the strut plate group had a parasymphseal infection, requiring hardware removal.

The strut plate demonstrated comparable surgical outcome as the Champy miniplate. It is a safe and effective alternative for management of mandibular angle fracture.

Keywords

- ▶ mandibular angle fracture
- ▶ miniplate fixation
- ▶ Champy technique
- ▶ Strut plate fixation

The mandibular angle is the most common location for mandibular fractures from blunt trauma to the face,^{1–3} and accounts for 23 to 42% of all mandibular fractures.⁴ Inherent anatomical vulnerabilities make this location particularly prone for injury. It is thin in cross-section relative to the ramus and body,^{5,6} and experiences a complex convergence of torsional and shear forces.^{7,8} In addition, its direct proximity to the third molar poses another risk when tooth impaction occurs. Because of these complicating factors, management can be particularly challenging, and associated

with the highest rate of complications, estimated to range from 0 to 32%.^{9–11}

Although a spectrum of techniques has been proposed in the past literature, no consensus has been reached. Currently, the Champy technique, with a single miniplate across the external oblique ridge to achieve a nonrigid, functional fixation, has become a widely accepted method, obviating the need for postoperative maxillomandibular fixation (MMF).^{12,13} An alternative method is the use of a single 2 mm strut plate, which demonstrated excellent biomechanical properties and clinical

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Figure 1 Two methods of angle fixation. Left, 2.0 mm 10-hole Delta Strut plate. Right, 2.0 mm miniplate (Stryker Orthopaedics, Kalamazoo, MI).

results in recent years.^{14–16} In this investigation, we compared the efficacy of these two techniques in a randomized prospective clinical trial.

Patients and Methods

Prospective Randomized Clinical Trial

The prospective study was conducted in a county hospital that serves as a level I trauma center for a large urban population. Eighteen consecutive patients aged between 20 and 48 years (all males) with mandibular angle fractures were evaluated. Patients with severely comminuted fractures were excluded. Preoperatively, each patient was evaluated using computed tomography scans to ascertain fracture location. Each patient received a number generated by a random number generator (Stattek.com). Even-number patients received the strut plate (10-hole strut plate, Stryker Orthopaedics, Kalamazoo, MI); odd-number patients received the Champy miniplate (Champy, Stryker Orthopaedics) (►Fig. 1). Patient consent was acquired. Five patients were excluded postoperatively from the study due to complex fixation requiring MMF. The resulting patient population includes $N = 6$ (strut) and $N = 7$ (Champy).

At the time of admission, patients were managed with intravenous antibiotics prophylactically and optimized for surgical operation. All fractures were reduced and fixed intraorally. The strut plates were fixed percutaneously. Other associated mandibular fractures, when present, were managed intraorally using miniplate fixation. Postoperatively, a soft nonchew diet with supplementation was initiated. A panoramic radiograph was repeated before discharge. Clinic follow-ups were scheduled for three time intervals—1 to 2 weeks, 4 to 6 weeks, and 6 months postoperatively. Repeat panoramic radiograph was obtained during each follow-up.

Data were prospectively collected including patient and treatment characteristics. Comparative statistics of categorical variables was performed using Fisher Exact Test. Parametric data were analyzed using Student *t* test. Differences were considered statistically significant if *p* value is less than 0.05.

Surgical Technique

After induction of general anesthesia, each patient was prepared and draped in the standard fashion. A shoulder roll was placed, and the head hyperextended. Occlusion was established and secured with MMF. Any loose or damaged

third molar in the line of fracture was extracted. The fracture was exposed through an intraoral approach. The periosteum was elevated and fracture site curettaged and reduced. The strut plate was placed across the fracture site and secured with monocortical drilling and screw placement using a percutaneous approach with a trocar and cheek retractor. Miniplates were placed with the intraoral Champy approach along the external oblique ridge. After fixation, the intermaxillary fixation wires were cut and occlusion reassessed. All subcutaneous incisions were closed with plain gut, and all oral mucosal incisions were repaired with Vicryl sutures (Ethicon, Inc., Somerville, NJ).

Postsurgical Management

Antibiotics (clindamycin phosphate) were continued postoperatively for 5 to 7 days. Chlorhexidine mouth rinse was provided for all patients. All patients with MMF had wires removed at 2 weeks. Elastics were used in patients requiring occlusal guidance postoperatively.

Results

Consecutive male patients (18) with mandibular fractures were consented and enrolled in the study. Five patients were excluded postoperatively due to need for MMF, therefore 13 patients (age range 20–47 y) were included in the data analysis. Seven of these patients were randomly assigned to receive the Champy miniplate (►Fig. 2), while six were assigned to receive the strut plate (►Fig. 3). One patient was switched from the Champy plate to the strut plate perioperatively because the miniplate could not adequately stabilize the fracture.

There is no statistically significant difference in pretreatment patient characteristics (►Table 1). Patients (10) presented with associated facial fractures, including fractures of the parasymphiseal region ($n = 8$), subcondylar region ($n = 1$), maxilla ($n = 1$), and zygomatic arch ($n = 1$). Majority (84.6%) of the fractures were caused by assault, out of which 69.2% of the patients complained of some degree of mental nerve dysesthesia and 38.5% of the fractures were open with facial or oral lacerations (►Table 2).

Operative findings, including third molar characteristics, difficult of fixation and surgery time, are listed in ►Table 3. There was no statistically significant difference between the two treatment groups. Seven patients had partial ($n = 2$) or complete ($n = 5$) impaction of the third molar. All underwent

Figure 2 Fixation using Champy miniplate at the external oblique ridge. (A) Right mandibular angle fracture status post fixation, at 6 weeks follow-up. (B) Same fracture at 6 months follow-up demonstrating clinical bone union.

molar extraction. On average, the total surgery time for patients treated with strut plates was longer than the Champy plates (1.7 vs. 0.7 h), though the operations of both treatment groups were rated similar in difficulty by the primary surgeon. Majority (84.6%) of the cases were rated easy to intermediate.

On an average, patient follow-up was longer in the strut plate group than the Champy Plate group (19.4 vs. 11.8 wk, $p = 0.37$). Two patients were lost to follow-up. Two patients had complications of the mandibular angle fixation postoperatively (►Table 4). One patient had exposure of the strut

Figure 3 Fixation using strut Plate. (A) Right mandibular angle fracture at 6 weeks follow-up. (B) Sample fracture at 6 months follow-up.

Table 1 Patient characteristics

	Strut plate (n = 6)	Champy plate (n = 7)
Age (y)	28 (20–45)	28 (20–47)
Race		
White	–	1
Black	6	3
Hispanic	–	3
Social factors		
Incarceration	–	–
Homeless	–	–
Comorbidities		
Alcohol abuse	1	1
Smoking	1	1
Non-IV drug abuse	1	2
IV drug abuse	–	1
DM	–	–
HIV	–	–
Cancer	–	–

Abbreviations: DM, diabetes mellitus; HIV, human immunodeficiency virus; IV, intravenous; y, year(s).

Table 2 Fracture characteristics

	Strut plate (n = 6)	Champy plate (n = 7)
Angle fracture		
Left	5	5
Right	1	2
Associated fracture(s)	5	5
Parasymphiseal	5	3
Subcondylar	–	1
Maxilla	–	1
Zygoma	1	–
Cause of fracture		
Assault	5	6
Accident	1	1
Neural deficits		
None	2	2
Hypoesthetic	4	4
Anesthetic	–	1
Contamination		
Closed	5	3
Open	1	4

Table 3 Operative findings

	Strut plate (n = 6)	Champy plate (n = 7)
Third molar characteristics		
Impaction	3	2
Partial impaction	1	1
Eruption	2	4
Tooth fracture	4	3
Tooth decay	–	1
Periodontitis	–	1
Root exposure	3	2
Molar extraction	4	3
Difficulty of surgery		
Easy	3	3
Intermediate	2	3
Difficult	1	1
Total surgery time (h)	1.7	0.7

Abbreviation: h, hour(s).

Table 4 Postoperative complications

	Strut plate (n = 5)	Champy plate (n = 6)	p-Value
Follow-up time (wk)	19.4	11.8	0.37
Complications (angle)			
Infection	–	–	–
Dehiscence	–	–	–
Plate exposure	1	–	0.25
Loose hardware	–	1	0.34
Palpable hardware	–	1	0.34
Nonunion	–	–	–
Hardware removal	1	1	0.89
Total complications (number of patients)	1 (20%)	1 (16.7%)	0.89
Complications (parasymph)			
Infection	1	–	0.25
Dehiscence	–	–	–
Plate exposure	–	–	–
Loose hardware	1	–	0.25
Palpable hardware	–	–	–
Nonunion	–	–	–
Hardware removal	1	–	0.25
Total complications (number of patients)	1 (20%)	0 (0%)	0.25
Malocclusion	1	1	0.89

Abbreviation: wk, week(s).

Figure 4 Champy plate fixation demonstrating loosening of hardware 8 months after surgery. Hardware was subsequently removed. As there was clinical union of the fracture, no additional fixation was required.

plate located at the intraoral incision during his 1 week postoperative follow-up. He underwent wash out and primary repair in clinic under local anesthesia. Subsequent follow-up at 6 weeks and 6 months demonstrated good bone union with no evidence of infection, recurrence of dehiscence or loose hardware.

The other patient with a complication underwent fixation with the Champy miniplate. His initial clinical follow-up was uneventful. He returned 8 months postoperatively complaining of palpable hardware at the angle. No history of pain or swelling at the affected cheek and no history of fever. Panorax demonstrated loosening of the Champy plate with three missing screws (►Fig. 4). The plate itself was intact. No evidence of inflammatory changes suggestive of abscess or infection. The mandibular angle fracture was well-healed with appropriate bone union. He underwent hardware removal. No additional fixation was necessary.

One patient in the strut plate fixation group demonstrated infection of the parasymphyseal fracture site 1 month postoperatively. He underwent incision and drainage initially, and subsequent removal of the loose hardware at the parasymphyseal location. Surgical finding revealed good bone union and no need for additional fixation. There was no involvement of the strut plate at the mandibular angle. His recovery was uneventful.

Discussion

The goal of mandibular angle fixation is to restore occlusion and functionality with minimal disability and complication. Three major factors influence primary bone union—viable bone fragments, immobilization, and a small fracture gap.^{10,17} Traditionally, these requirements are achieved by rigid fixations using large bone plates with bicortical bone screws, to prevent any motion across the fracture during function. In 1973, Michelet et al¹⁸ first introduced the concept of using a small, malleable noncompression plate with monocortical screws. Champy et al¹⁹ subsequently validated this technique by placement of a miniplate along the superior border of the mandible.

More recently, in a series of studies, Ellis popularized the concept of “functionally stable fixation” of the mandibular angle fracture, using a single 2.0 mm miniplate fixed to the

external oblique ridge via an intraoral incision.^{9,10,20–22} In addition, he noted an inverse relationship between the rigidity of fixation and the incidence of postoperative complications.¹⁰ In his 2010 prospective study, Ellis demonstrated a significantly higher incidence of wound healing problems in fixations using two miniplates than those using a single miniplate (22.2 vs. 3.2%, respectively, $p < 0.01$).¹⁰ In the context of Ellis's 1994 finding that 1.3 mm malleable noncompression miniplates have an unacceptable rate of plate failure,²⁰ the question appears to be "how much fixation is enough?"

Strut Plate

Although the strut plate is relatively new in the management of mandibular angle fractures, it has demonstrated good clinical results in the literature.^{15,16} The curved and buttressed miniplate design allows for three-dimensional fixation with superior torsional stability, which when combined with its malleability can better withstand the complex multidirectional forces present at the angle during function. Biomechanical studies demonstrated load bearing ability comparable to the two-miniplate system, and significantly higher load bearing ability than the single miniplate.²³ Clinical studies demonstrated a 5.4 to 8.2% postoperative infection rate,^{15,16} with no incidence of hardware failure, malocclusion or mal/nonunion. Our own study demonstrated comparable results.

Ease of application is also an issue. From a technical standpoint, application of a single miniplate is clearly the simplest procedure for treating an angle fracture. Application of a strut plate along the buccal cortex is more difficult, although easier than applying two separate miniplates or a longer reconstruction plate. Additionally, it does not demonstrate the high incidence of local wound complications seen with the miniplate along the oblique ridge. In his studies, Ellis has documented problems with plate exposure requiring hardware removal.²⁴ This is due to the proximity of the plate to the incision. This is rarely seen with the strut plate as it is covered by the masseter along the buccal cortex, well away from the incision.

Due to limited literature reports, it remains unclear where the strut plate lies on the spectrum of rigid fixation. Theoretically, the strut plate may be the perfect union of both worlds. The two-layered design mimics the rigidity of two miniplates, and withstands more stress and prevents plate failure. Yet its flexibility and single-plate design may minimize transfer of stress onto the cortical bone. Additional clinical and biomechanical studies are necessary to substantiate these theories.

Although our series is limited in several areas, particularly the small sample size which detracted from the statistical power of our data, the results seem to indicate that the strut plate is comparable in surgical outcome to the Champy miniplate. Both techniques demonstrated successful clinical union of angle fractures, with no case of postoperative mal/nonunion or infection at the angle. A larger study sample size will be necessary to determine if one is superior to the other.

Conclusion

Fixation of mandibular angle fracture using the strut plate is comparable in surgical outcome as the miniplate Champy technique. The strut plate is a safe and effective alternative to the single miniplate. Appropriate training and experience will optimize the operative result.

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