



Short-Term Outcomes of Orthogonal Plating Using a One-Third Tubular and Reconstruction Plate Construct for Supracondylar Intercondylar Humerus Fractures: A Prospective Case Series

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Abstract

Background Parallel or orthogonal plating is used to treat supracondylar intercondylar (SCIC) fractures of the humerus.

Aim The aim of the study is to determine the short-term functional outcomes of orthogonal plating in adult patients with SCIC fractures of the humerus and the factors affecting these outcomes.

Methods We conducted a prospective study between 2017 and 2020, following approval from the Institutional Ethics Committee. Twenty-six patients, aged 20 to 70 years, were included in the study. Patients with open fractures, severe soft tissue injuries, or comminution were excluded. We performed orthogonal plating for fixation. The outcomes were analyzed using the rating of Jupiter et al. Mann–Whitney U and Kruskal–Wallis tests were used to analyze the factors affecting the outcomes.

Results Most patients were males aged between 20 and 29 years. Most of the patients underwent surgery between 18 and 24 hours. The low T-type fracture pattern was the most common. Among male patients, 10 were rated as excellent, three as good, and one as fair. However, among females, four received excellent ratings, four received good ratings, three received fair ratings, and one received poor ratings. Males had a significantly better rating than females (p -value of 0.03). Younger patients had better outcomes (p -value of 0.04). The mode of injury and laterality were not significantly associated with the final rating (p -value >0.05).

Conclusion Orthogonal plating ensures stable fixation and good outcomes for SCIC fractures of the humerus. We got better outcomes in younger patients.

Keywords

- fractures of the distal humerus
- supracondylar intercondylar fractures of the humerus
- orthogonal plating
- parallel plating
- bicolunar fixation

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ملخص المقال باللغة العربية

النتائج قصيرة المدى للتثبيت الصفيحي المتعامد باستخدام صفيحة أنبوبية لثلية وصفيحة إعادة بناء لعلاج كسور العضد فوق اللفافة بين اللقميتين: دراسة مستقبلية لسلسلة حالات

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الخلفية: عد التثبيت الصفيحي المتوازي أو المتعامد من الأساليب الجراحية الشائعة لعلاج كسور العضد فوق اللفافة بين اللقميتين، حيث يهدف إلى تحقيق ثبات ميكانيكي يسمح باستعادة الوظيفة والشفاء المبكر.

الهدف: تقييم النتائج الوظيفية قصيرة المدى للتثبيت الصفيحي المتعامد لدى البالغين المصابين بكسور العضد فوق اللفافة بين اللقميتين، مع تحديد العوامل المؤثرة في هذه النتائج.

الطريقة: أجريت دراسة مستقبلية خلال الفترة من 2017 إلى 2020 بعد الحصول على موافقة لجنة الأخلاقيات المؤسسية. شملت الدراسة 26 مريضاً تراوحت أعمارهم بين 20 و 70 عاماً. استُبعدت الحالات ذات الكسور المفتوحة أو الإصابات الشديدة في الأنسجة الرخوة أو التفتت العظمي. تم تحليل النتائج وفق معايير جيسي بي. جوبيتر وآخرين. استُخدم اختبار مان-ويتني يو واختبار كروسكال-واليس للتحليل الإحصائي للعوامل المؤثرة على النتائج.

النتائج: كان معظم المرضى من الذكور الذين تتراوح أعمارهم بين 20 و 29 عاماً، وخضع أغلبهم للجراحة خلال 18-24 ساعة من الإصابة. كان الكسر من النوع T المنخفض الأكثر شيوعاً. صُنِّفت النتائج الوظيفية لعشرة من الذكور على أنها ممتازة، ثلاثة جيدة، وواحدة مقبولة. أما بين الإناث، فقد صُنِّفت النتائج الوظيفية لأربع حالات على أنها ممتازة، وأربع جيدة، وثلاث مقبولة، وحالة واحدة ضعيفة. أظهرت النتائج تحسناً أفضل لدى الذكور مقارنة بالإناث بدلالة إحصائية ($P < 0.03$) كما حقق المرضى الأصغر سناً نتائج وظيفية أفضل ($P < 0.04$). من ناحية أخرى، لم يكن نمط الإصابة أو الجانب المصاب مرتبطاً إحصائياً بالنتائج النهائية.

الاستنتاج: يوفر التثبيت الصفيحي المتعامد ثباتاً ميكانيكياً جيداً ونتائج وظيفية مشجعة في علاج كسور العضد فوق اللفافة بين اللقميتين، مع أفضلية واضحة لدى المرضى الأصغر سناً.

الكلمات المفتاحية: كسور العضد البعيد؛ كسور العضد فوق اللفافة بين اللقميتين؛ التثبيت الصفيحي المتعامد؛ التثبيت الصفيحي المتوازي؛ التثبيت ثلاثي العمود.

Introduction

Supracondylar intercondylar (SCIC) fractures of the humerus are complex injuries. Comminution, loss of articular integrity, osteoporosis, and inadequate fixation can lead to many complications. Bicolumnar fixation with plates is the most accepted method of treatment. We can place the plates in either a parallel or orthogonal fashion. Parallel plating is better than orthogonal plating in elderly osteoporotic patients.¹ The principle of fixation is anatomic reduction and stable fixation, but it is not easy to achieve in all cases.²

Surgical fixation is indicated for most SCIC fractures of the distal humerus, as the results of nonoperative treatment are poor. Undisplaced fractures, elderly individuals with osteoporosis and comminution, and those with ipsilateral hemiplegia are the candidates for nonoperative treatment.³ The primary goal of surgical fixation is to facilitate early mobilization. However, attaining normal elbow function remains a challenging task. There are two methods of plate placement—parallel plating, where plates are placed on the sagittal borders 180° apart, and orthogonal plating, where one plate is placed in a sagittal plane and the other in the coronal plane at a 90/90 orientation. There are conflicting reports regarding the advantages of parallel versus orthogonal plating. Some reports suggest that there are no differences in outcomes between the two techniques.^{4,5} Parallel plating, however, results in greater stiffness, higher ultimate load to failure, and a shorter time to union.⁶

It is our observation that the lateral supracondylar ridge of the humerus in our population is thin. Placing bulky plates on this column can be challenging; we typically use a one-third tubular plate on the lateral column. We utilize a specific

orthogonal plating technique by putting a one-third tubular plate on the lateral surface of the lateral column and a reconstruction plate on the posterior surface of the medial column. We hypothesize that orthogonal plating can achieve a good functional outcome for SCIC fractures of the distal humerus. Our aim is to determine the short-term functional outcomes of patients with SCIC fractures of the distal humerus in adults treated with orthogonal plating, as well as the factors that affect these outcomes.

Methods

We conducted a prospective study after obtaining approval from the Institutional Ethics Committee. Between July 2017 and June 2020, we conducted the study at a tertiary care teaching hospital. All adult patients with SCIC fractures during the study period were selected. We included patients aged 20 to 70 years who underwent fracture fixation within 24 hours and excluded those with severe soft tissue injury, articular comminution, open fractures, osteoporosis, or other ipsilateral limb fractures.

Thirty-one patients with SCIC fractures of the distal humerus were treated during the study period. We excluded one open fracture, one with an associated lower-end radius fracture, one with severe soft tissue injuries, and two patients with osteoporosis with articular comminution. Our study population consisted of 26 patients with SCIC fractures of the distal humerus.

SCIC distal humerus fractures are intra-articular fractures with T, Y, or H configurations. We classified the fractures via the Mehne and Matta classification.⁷ The outcomes were evaluated via the Jupiter rating system. These criteria assess

Table 1 Jupiter et al's rating for the outcomes of distal humerus fractures

Rating	Range of movement (degrees)		Pain	Disability
	Loss of extension	Loss of flexion		
Excellent	<15	>130	None	None
Good	<30	>120	Slight	Minimal
Fair	<40	>90	With activity	Moderate
Poor	<40	>90	Variable	Severe

pain, disability, and range of movements. Both physical and radiological assessments are performed. They rated the outcomes as excellent when the degree of loss of extension was less than 15° and the degree of flexion was more than 120°, and good when the degree of loss of extension was less than 30°. The degree of available flexion was more than 120°, rated as fair when the degree of loss of extension was less than 40°. The degree of flexion was 90 to 120°, and rated as poor when the degree of loss of extension was more than 40°, and the degree of flexion was greater than 90°. An elbow with a normal or near-normal range of motion, and nosymptoms, was rated as excellent. A good rating was given to an elbow with good or excellent movements, despite some subjective symptoms. In contrast, a poor rating was given for both limited mobility and function. Postoperative complications were also assessed.⁸ We took the measurements with a goniometer (►Table 1).

All patients received 1.5 g of cefuroxime injection 30 minutes before surgery, which was continued for 48 hours postoperatively. Patients were positioned in lateral decubitus, with the injured limb placed on a pillow, the elbow flexed to 90°, and the forearm hanging. Surgeries were performed under a supraclavicular block using a posterior approach. The ulnar nerve was identified and protected. A V-shaped osteotomy of the olecranon was performed approximately 2 cm below the tip of the olecranon, after which the fracture site was identified. The articular surface was reduced and temporarily stabilized with K-wires. After that, the articular fragment was fixed to the distal humerus via K-wires. Definitive fixation was performed if the reduction was satisfactory under fluoroscopic examination. Intercondylar pieces were fixed with one or two partially threaded screws or multiple screws in comminuted fractures. The distal fragment was reduced and fixed to the shaft using orthogonal plating. A 3.5

one-third tubular plate was placed on the posterior side of the lateral column, and a reconstruction plate on the medial surface of the medial column. The olecranon osteotomy was performed with tension band wiring (►Fig. 1A–E). Ulnar nerve transposition was performed in all patients. We used a pneumatic tourniquet in all the cases. Postoperatively, the elbow and forearm were supported with an arm sling. We started early passive elbow mobilization as soon as the patient tolerated it. Patients were discharged on the 3rd day, and sutures were removed on the 12th postoperative day. After suture removal, patients were sent to our physiotherapy department for further active and passive mobilization. Follow-up visits were conducted monthly for the first 3 months and then every 2 months until the final follow-up at 1 year.

Demographic parameters, including age, sex, mode of injury, side of involvement, time delay before surgery, and associated injuries, were noted. Radiographs were taken to classify the injuries and assess union or any other complications during follow-up. We evaluated the range of movements, pain, and disability during the follow-up. The data were entered into Microsoft Excel, and statistical analysis was performed via SPSS version 18. The Mann–Whitney U test and the Kruskal–Wallis test were used for statistical analysis. A *p*-value less than 0.05 with a confidence interval of 95% is significant.

Results

The majority of the patients were males (54%). Eleven patients were between 20 and 29 years old (42.92%). Six patients sustained injuries due to road traffic accidents, and the rest due to falls. The left side was commonly affected. Twenty patients had no associated injuries. Only one patient

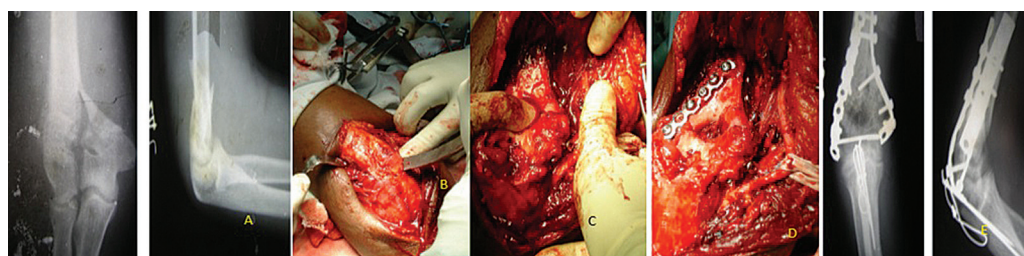


Fig. 1 The radiograph of the left elbow showing a Y-shaped fracture of the distal humerus: anteroposterior (left) and lateral (right) views (A). Posterior approach with olecranon osteotomy (B). Temporary reduction of the fracture (C). Fixation of the fracture with orthogonal plating (D). Postoperative X-rays anteroposterior (left) and lateral (right) views (E).

Table 2 The demographic factors, nature of injury, and timing of operation of the study population

Age	Range	Number	%	
	20–29	11	42.92	
	30–39	6	23.8	
	40–49	3	11.54	
	50–59	1	3.84	
	60–69	3	11.5	
	70	2	7.96	
Gender	Male	14	54	
	Female	12	46	
Mode of injury	Fall	20	76.92	
	RTA	6	23.07	
Side	Right	11	42	
	Left	15	58	
Associated injuries	None	20	76.92	
	Pneumothorax	1	3.84	
	# Clavicle	1	3.84	
	# both bones leg	2	7.69	
	Jone's #	1	3.84	
	# lower radius	1	3.84	
Occupation	Male	Manual labor	8	
		professionals	4	
		Students	2	
	Female	Home maker	12	
Time of surgery after injury	0–6 h	1	3.85%	Good ⁽¹⁾
	7–12 h	9	34.62%	Excellent ⁽⁷⁾ Good ⁽²⁾
	13–18 h	4	15.38%	Excellent ⁽³⁾ Good ⁽¹⁾
	19–24 h	12	46.15%	Excellent ⁽⁴⁾ Good ⁽³⁾ Fair ⁽⁴⁾ Poor ⁽¹⁾

underwent surgery within the first 6 hours. Most patients underwent surgery between 18 and 24 hours. Of the ten cases operated on within 12 hours, seven had an excellent outcome, and two had a good result. The remaining 16 patients were operated on after 12 hours; of these seven had an excellent outcome, four had a good outcome, four had a fair outcome, and one had a poor outcome. There was no significant correlation between the time delay in operation and the outcome (p -value 0.073) (►Table 2). Low T-type fractures were the most common (30.77%), while no H-type fractures were observed (►Table 3).

In accordance with the criteria of Jupiter et al, 14 patients achieved excellent outcomes, seven had good outcomes, four had fair outcomes, and one had poor outcome (►Table 4). Among male patients, 10 were rated as excellent, three as good, and one as fair. However, among females, four received excellent ratings, four received good ratings, three received

fair ratings, and one received poor ratings (►Fig. 2A–D). Males had a significantly better rating than females did (p -value of 0.03). All patients in the 30 to 39-year age group and seven in the 20 to 29-year age group had excellent

Table 3 The type of fractures according to Mehne and Matta classification

Type	No. of patients	%
High T	3	11.54
Low T	8	30.77
Y	2	7.69
H	0	0
Medial Lambda	10	38.46
Lateral Lambda	3	11.54

Table 4 The outcome of the study participants according to Jupiter et al's rating

Grading	No: of patients	Percentage
Excellent	14	53.85
Good	7	26.92
Fair	4	15.38
Poor	1	3.85

outcomes. Patients in the 3rd and 4th decades had significantly better outcomes than those in the other groups (p -value 0.04). The mode of injury and laterality were not significantly associated with the final rating. Similarly, there was no significant correlation between the number of related injuries and the duration of surgery.

The type of fracture had no association with the outcomes. Among the 10 patients with medial lambda fractures, seven had excellent results, one had good results, and two had fair results. Among the eight patients with low-T fractures, four were rated as excellent, and two were rated as good or fair. Among the three lateral lambda fractures, one had an excellent outcome, and the other two had good results. Medial lambda and low-T-type fractures contributed to approximately 11 excellent results. The only poor case was a high-T-type fracture. A total of 53.5% of the good to excellent results out of a total of 80.8% were from low-T and medial lambda fractures.

For fixation of the distal fragment, we used 3.5 mm fully threaded cancellous screws in four patients where minimal comminution of the trochlea was present. All the others were fixed with 16 mm threaded lag screws, and the fracture fragments were compressed. In 15 patients, a second screw was placed to prevent rotation. Among the 15 patients with two fixed screws, seven had excellent outcomes, four had good outcomes, three had fair outcomes, and one had a poor outcome. Among the seven patients with single screws, six had excellent outcomes.

We observed two cases of superficial wound infection, which subsided with antibiotics. There was a K-wire backout in four patients during rehabilitation. We removed the K-wires and continued the rehabilitation. Neither of these complications affected the outcomes. One patient did not cooperate with the mobilization procedure, resulting in non-union and poor outcomes.

Discussion

The results of our study indicated that using orthogonal plating with a one-third tubular plate on the lateral column and a reconstruction plate on the medial column can provide stable fixation and lead to good functional outcomes. We found that younger patients tended to have better results compared with older individuals. There was no significant correlation between gender, cause of injury, fracture type, or the type of implant used for fixation and the outcomes. Furthermore, although all patients underwent surgery within 24 hours of their injury, comparisons between those who had surgery within the first 12 hours and those who had surgery after 12 hours showed no significant differences in outcomes.

Dual-plating osteosynthesis is the standard treatment for SCIC fractures of the distal humerus.⁹ There is debate about whether plates should be oriented orthogonally or parallel to each other. Orthogonal plating, as described by Jupiter et al, allows for an early range of motion due to its stability, but studies in the late 1990s indicated a 20 to 25% unsatisfactory outcome rate. In response, O'Driscoll proposed parallel plating, which offers better fixation of the distal fragment by enhancing stability. Modern contoured locking compression plates have shown that both techniques yield similar outcomes.¹⁰ While neither method has significant differences in complications, orthogonal plating may be more effective for coronal fractures, and parallel plating is preferred for distal fractures.¹¹ Ultimately, successful fixation depends on achieving anatomic reduction and stable fixation while allowing for early mobilization.¹² We preferred orthogonal plating for our patients because in our population, the lateral supracondylar ridges of the humerus are narrower. As a result, during internal fixation, we placed a 3.5-mm one-third tubular plate on the posterior surface of the lateral column. Additionally, we used a reconstruction plate along the medial border of the medial column to secure the distal fragment to the shaft.

Age and gender significantly impact the outcomes of distal humerus fractures. Young patients usually suffer SCIC fractures from high-energy injuries, while older patients typically sustain them from low-energy injuries. Osteoporosis in older individuals often leads to fracture comminution and fixation failures, resulting in poorer outcomes.¹³ Older patients recover differently from younger ones, impacting their mobility and quality of life.¹⁴ Achieving

**Fig. 2** Postoperative functions of left elbow – pronation (A), supination (B), extension (C), and flexion (D).

a stable and functional elbow after distal humerus fractures is challenging, even for experienced surgeons.¹⁵ In younger patients with healthy bone density, the risk of fixation failure is reduced, and improved outcomes can be anticipated.^{16,17} The results were more favorable for patients under 40 years of age in our study. The incidence of distal humerus fractures is higher in younger males, but as age advances, the incidence among females increases due to postmenopausal osteoporosis. A recent study showed women with distal humerus fractures had a significantly higher DASH score compared with men after surgical treatment.¹⁸ A significantly better outcome was found in males in our series. Pajarinen and Björkenheim reported inferior outcomes for males.¹⁹

Early surgical fixation is associated with better outcomes, including improved range of motion, faster healing, and reduced stiffness. These benefits may result from initiating rehabilitation sooner.²⁰ There are few studies on the outcomes of early versus delayed fixation in adults with SCIC fractures. We divided our patients into two groups: those who were operated on within 12 hours and those who were operated on after this time. Our results showed no significant difference in outcomes as long as surgery was performed within 24 hours, which may be attributed to our small sample size. In children, delays of over 12 hours do not increase hospital stays, operation time, or complications, but early surgery can reduce the need for open reduction.^{21,22}

The stability of articular fracture fixation is essential for the outcomes of SCIC fractures. O'Driscoll emphasizes that adequate fixation requires the use of more screws, engaging multiple fragments, utilizing longer screws, and interdigitating them in the distal fragments.²³ A retrospective study indicated that using three or fewer screws for the distal articular fragment significantly raises the risk of non-union and fixation failure in AO/OTA type C fractures.²⁴ In our study, we used 3.5 mm fully threaded cancellous screws and 16-mm lag screws for fixation. There was no statistically significant difference in outcomes between single and double screw fixation; however, improved outcomes with single screw fixation may be attributed to less intra-articular injury.

Mechanical failure can occur in 7 to 27% of surgically treated SCIC fractures of the humerus. Poor bone quality, the mechanical properties of the plates and screws, and postoperative physiotherapy are the primary factors contributing to implant failure. Preoperative or postoperative ulnar neuropathy can sometimes occur. There is an 8.6% risk of developing heterotopic ossification in surgically treated SCIC fractures. Concomitant head injury, delayed fixation, prolonged immobilization, and the use of bone graft substitutes are some of the predisposing factors. Elbow stiffness is the most common complication. Approximately one-third of patients will lose the functional arc of movements. A total of 2 to 10% of patients develop non-union, especially between the distal fragment and the shaft. Failure to adhere to the principles of fixation, poor bone stock, high-energy trauma, and bone loss makes elderly patients prone to non-union. Intraarticular and extraarticular malunions can occur in up to 30% of cases. Superficial and deep wound infections and problems related to olecranon osteotomy are other complications.²⁵ In our

series, there were two cases of superficial infection and four complications related to olecranon osteotomy.

Our study has several limitations. First, our sample size was small, and we excluded patients with severe comminution in the articular and metaphyseal regions. Although we applied the principle of perpendicular plating for all patients, we did not have any comparative groups for reference. This smaller sample size may impact subgroup analyses concerning fracture types and the number of screws used for the fixation of articular fragments. We hope that future studies with a larger patient cohort will provide further insights into the use of orthogonal plates for treating SCIC fractures of the humerus.

Conclusion

Our study demonstrates that using orthogonal plating with a one-third tubular plate on the lateral column and a reconstruction plate on the medial column yields stable fixation and favorable outcomes, particularly in younger patients. Factors such as gender, fracture cause, fracture type, and implant choice do not significantly affect the outcomes.

Conflict of Interest

None declared.

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