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Original Article

Comparison of Clinical Outcomes of Orthogonal Versus Single Posterior Plating for Internal Fixation of Distal Humeral Extra-Articular Fractures

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ABSTRACT

Objective: Complications are frequently linked to traditional treatment strategies for distal humeral fractures such as dual column plating. The study's objective is to compare outcomes of osteosynthesis by a single dorsolateral plate in extra-articular distal humeral fractures with conventional bi-columnar fixation in terms of clinical results and radiological union.

Study Design: Prospective Comparative Study.

Place and Duration of Study: Department of Orthopedic Surgery, Combined Military Hospital, Rawalpindi Pakistan, from Oct 2022 to Sep 2023.

Methodology: Forty skeletally matured patients, with closed distal humeral extra-articular fractures were sequentially enrolled into two groups. All patients underwent open reduction internal fixations of fractures using the same Alonso-Llames approach with single dorsolateral plating in group A and dual orthogonal plating in group B. Monthly follow-ups were ensured. Mayo Elbow Performance Score and Oxford Elbow Score were included to assess functional recovery, and a plain radiograph was used to evaluate union.

Results: In group A, all fractures 20(100%) united successfully without any secondary displacement after a mean timeframe of 5.5 months. In group B, union rate of 19(95%) was observed (p=0.31). Postop pain was recorded to be significantly less in single plating.(VAS at 2 weeks p=0.006 and 4 weeks)(p=0.012). Higher elbow range of motion was restored with uni columnar fixation (124.90±3.64) than bicoulmnar construct (116.00±3.64)(p<0.001). Both functional scores were found to be considerably better in dorsolateral palting [MEPS=92.50 (100.00–85.00), OES=91.67 (95.83–85.93)] as compared to orthogonal plating (MEPS=85.00) (93.75–85.00), OES=80.20 (85.41–72.91)] (MEPS) p=0.021, OES (p<0.001).

Conclusion: The current study suggests that single posterior plating is a dependable and recommended method as it yields similar union rates with improved clinical outcomes and fewer complications.

Keywords: Distal Humerus, Extra-Articular, Orthogonal Plating, Paratricipital Approach, Single-Column Fixation.

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INTRODUCTION

Approximately 33% of humerus fractures and 2% of all adult fractures are distal humerus fractures.[1] The articular section of the distal humerus is supported by a two-column arrangement, with the medial column absorbing 40% of the stress and the lateral column carrying 60% of the load.[2] Because of their peri-articular position, minute distal fragment size, the accompanying comminution, and the weakened nature of the bone in geriatric population, these fractures present as challenging cases for treating surgeons. Restoring alignment and achieving stable fixation are the primary aims of treatment for these fractures in order to integrate early elbow range of motion (ROM), which is essential for a favorable functional outcome.[3]

Various approaches for the treatment of these fractures are postulated, and proponents of both conservative and surgical themes are mentioned. Conservative options include plaster cast immobilization and functional bracing while plate osteosynthesis and intramedullary nailing are modalities of surgical intervention. Although functional bracing is an acceptable treatment option for shaft of humerus fractures, it is not suitable for distal humeral fractures owing to the difficulty in controlling the angulation of distal fragments. Sarmiento reported 16% malunion and 4% nonunion in his series of functional bracing for comminuted extra-articular fractures of the distal third humerus.[4] Prolonged immobilization is cumbersome, resulting in delayed return to work and stiffness of the elbow joint.[5]

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A more consistent and dependable alignment and possibly a quicker return to function appear to be provided by the surgical management, iatrogenic injury of radial nerve, and infections are major concerns.[6] Locking intramedullary nailing is again an inconvenient option for treating extraarticular distal humeral fractures. Distal humerus' flat cross section and small medullary canal increase the risk of iatrogenic fragmentation of distal piece during nail progression. Moreover, small distal part allows inadequate distal locking resulting in an overall unstable construct. Compression plating is a well-established and effective surgical technique for treating distal humerus fractures, and plate osteosynthesis offers clear advantages in this regard.[7]

Research over intra-articular variants of these injuries has largely influenced the treatment guidelines. Classically, to achieve a stable construct using 4.5mm LCP while fixing shaft fractures, it is advisable to purchase 8 cortices (4 screws) on either side of fracture.[7] In case of distal humerus fractures, it is impossible at the far end due to the small distal fragment with a curved anterior surface and olecranon fossa posteriorly. Therefore, they are usually fixed with dual distal humeral bi-columnar anatomical plates (3.5mm) in an orthogonal (90–90) or parallel (180°) fashion, as it grants several points of fixation into small-size distal fragments.[8]

Nonetheless, the incidence of non-unions and infections is considerable with double-plating procedures, despite the high functional results. This is attributable to extensive soft tissue dissection, periosteal stripping, and extended surgery duration.[9.] Furthermore, ulnar neuritis is reported in up to 51% of patients with dual-plating technique.[10] To minimize the operating time and devitalization of soft tissue, a single lateral column fixation by posterior paratricipital approach has been proposed for such fractures. Using a single dorsolateral distal humerus plate is alleged to confer sufficient strength to the construct and, therefore, can allow early physical therapy and potentially faster rehabilitation.[11]

We conducted this prospective study to evaluate and compare the early functional and radiological outcomes of open reduction and single-column fixation of extra-articular distal humerus fractures with the dual plating technique. We hypothesize that single-column plating would still provide equivalent results in terms of fracture union, alignment, and joint function while minimizing implant-related complications in comparison to dual plating.

METHODOLOGY

This prospective comparative study was conducted at the author's institution, Combined Military Hospital, Rawalpindi Pakistan, from Oct 2022 to Sep 2023 after obtaining ethical approval from the institutional ethical review board (IRB # 467). Written consent was obtained from every participant of the study before enrollment.

The sample size was calculated using SPSS Version 28, considering the power of study as 80%, α as 0.05, and the mean of single posterolateral plating group as 75.8±12.8 and that of dual orthogonal plating group as 88.0±10.112 for hypothesis with a group size ratio of 1, a sample size of 16 per group was calculated, which was rounded off to 20 per group. Thus, making a total sample size of 40.

Inclusion Criteria: The patient cohort consisted of 40 patients with extra-articular distal humerus fractures. All skeletally mature patients with closed extra-articular distal humerus fractures with intact distal neurovascular status, presenting within 2 weeks of injury were included in this study.

Exclusion Criteria: Patients with open fractures, pathological fractures, non-unions, intra-articular fractures, or floating elbow injuries were excluded from the study.

Patients were randomly assigned to single dorsolateral plating (Group A) and dual orthogonal plating (Group B) according to the odd-even order of hospital admission, thus two groups with 20 cases per group were formed. All patients were operated on within 48 hours of admission. The fractures were classified on the anteroposterior and lateral radiographs using AO Classification on admission (Table-I).

The distal end of Dorsolateral Distal Humerus Plate (DHP) has an anatomically contoured angular offset, allowing posterior application on lateral column and preventing impingement of olecranon fossa. In the case of dual orthogonal plating, an additional Medial Distal Humeral Plate is utilized. It is also pre-contoured anatomically to be applied on the medial surface of the medial distal humeral column. These plates have increased locking screw density at the distal end, which provides a stable construct and allows for early rehabilitation. Shafts of these plates have combi-holes for diaphysis.

All patients were operated under general anesthesia in lateral decubitus position. The injured arm was placed on a well-padded radiolucent bolster allowing elbow flexion up to 120°. The fracture was exposed via the posterior midline incision using Alonso-Llames approach.[13] The radial nerve was dissected and slung proximally at lateral intermuscular septum and spiral groove; the ulnar nerve was also identified and followed along medial intermuscular septum proximally and up to cubital tunnel distally. The status of both nerves was documented in every case. The tricep was also lifted from posterior aspect of the humerus and adequate fracture visualization was achieved. After reducing fracture with clamps, K wires and lag screws (wherever possible) were used for provisional fixation. The appropriate length of plate was positioned centrally on posterior aspect of the humerus shaft, sliding under radial nerve while distal end was placed lateral to olecranon fossa and inferiorly up to capitellum. Medial plate was positioned over the common flexor origin and medial collateral ligament distally in an orthogonal fashion to the former plate. Fixation was completed in accordance after the final position, being verified under C-arm. Afterwards, the radial nerve was relocated superficial to implant and the ulnar nerve was retained in its original position, with the wound closure in layers. Surgery time was recorded.

Postoperatively distal neurovascular status was recorded. All patients underwent supervised physiotherapy beginning on first postoperative day with gentle mobilization of shoulder and elbow. Within a week following surgery, range-of-motion exercises, both assisted active and gentle passive, were initiated. Subsequent weight-bearing and resistance rehab was permitted following the radiographic demonstration of bone union. Monthly follow-up of patients was ensured with standard orthogonal radiographs analysing fracture reduction and union and implant failure. Clinical union was declared when tenderness at fracture site subsided and was deemed radiologically united upon bridging of at least three of the four cortices, demonstrated on two orthogonal scans. Clinical follow-up included assessment of infection and complications, charting elbow range of motion with goniometer, in comparison with contralateral arm, patient satisfaction, and residual pain.

Functional outcome was evaluated by the 'Mayo Elbow Performance Score (MEPS),[14,15] and 'Oxford Elbow Score (OES)[16] questionnaires at the final follow-up. MEPS is physician-based while OES is a patient-reported rating system. Both scoring systems range from 0 (worst disability/ least function) to 100 (least disability/highest function). Secondary outcomes of interest include duration of surgery, early post-op VAS, Flexion Extension Arc, Union rates, and time to union.

SPSS (Statistical Product and Service Solutions) software version 26 [Chicago, IL: SPSS, Inc.; 2019] was used for analysis of data. For continuous variables, Mean±SD was calculated while frequency and percentage were calculated for categorical variables. To analyze statistically significant difference between variables of Single vs Dual Plating groups, Chi Square and Independent sample t test/Mann Whitney U test were used. Less than 0.05 was the threshold for a statistically significant *p*-value.

RESULT

A total number of forty patients were enrolled in the study, with 20 undergoing single dorsolateral plating (Group A) while the rest were treated with dual orthogonal plating (Group B). The mean age of patients in Group A was 43.85 years (range, 19-65 years), and that in Group B was 42.95 years (range, 19-67 years). The predominant mode of injury was road traffic accidents while the rest of the cases were attributed to falls or assault. Rest of the demographic data of patients enrolled in the study are summarized in Table-II.

Table-I: AO Classification of Fractures of Study Patients

Fracture Subtype	No. of patients = n(%)
12A1	4(10%)
12A2	3(7.5%)
12B2	4(10%)
12B3	6(15%)
12C2	3(7.5%)
12C3	4(10%)
13A2	8(20%)
13A3	8(20%)
Total	40(100%)

In addition to the functional scoring systems, duration of surgery, early post-op VAS at 2 and 4 weeks, maximum flexion-extension arc restored, union rates, and time to achieve radiological union were also documented and compared between two groups.

The mean duration of surgery in group A was 115±16.69 min (87–135 min) while in group B was 152.60±19.20 (122–175 min) (p<0.001). Average follow-

up period in both groups was 7.88±1.48 months (6–10 months), with a six-month minimum duration. Patients in Group A reported considerably less pain on the VAS Scale at 2- and 4 weeks post-op as compared to Group B patients (p=0.006, p=0.012).

Table-II: Summary of Basic Demographics Data (n=40)

		Single Plating Group (n=20)	Dual Plating Group (n=20)
Age (Years)		43.85±13.59	42.95±13.48
Gender	Male	15(75%)	16(80%)
	Female	5(25%)	4 (20%)
Mode of Injury	RTA	11(55%)	11(55%)
	Fall	7(35%)	6(30%)
	Assault	2(10%)	3(15%)
Side	Right	9(45%)	13(65%)
	Left	11(55%)	7(35%)
Extremity Involved	Dominant	11(55%)	12(60%)
	Non-Dominant	9(45%)	8(40%)

Table-III: Comparison of Clinical Outcomes between Single and Dual Plating Group (n=40)

Group	Single Dorsolateral Plating (Group A) (n=20)	Dual Orthogonal Plating (Group B) (n=20)	p-value
Duration of Surgery (Mins)	115.00±16.69	152.60±19.20	<0.001
Union (%)	20(100%)	19(95%)	0.31
Time to Union (Month)	5.10±1.61	5.55±1.70	0.253
VAS at 2 weeks Post Op	5.00(7.00–3.25)	7.00(7.75–6.00)	0.006
VAS at 4 weeks Post Op	4.00(5.00–3.00)	5.50(7.00–4.00)	0.012
Final MEPS	92.50(100.00–85.00)	85.00(93.75–85.00)	0.021
Final OES	91.67(95.83 –85.93)	80.20(85.41–72.91)	<0.001
Mean Flexion (Degrees)	130.95±2.62	126.35±2.79	<0.001
Mean Extension (Degrees)	6.05±2.46	10.35±3.20	<0.001
Flexion Extension Arc (Degrees)	124.90±3.64	116.00± 3.64	<0.001

Both arms of study exhibited similar union rates. All patients in Group A went on to union, while the union rate in Group B was 95.0%. There was no statistically significant variation in the union rates. (p=0.31). Moreover, either technique didn't have a discernable impact on mean time to radiological union (p=0.253).

On the 6th month follow-up, Group A (single plating) had a superior arc of motion than Group B. In Group B (dual plating), the mean elbow flexion attained was 126.35°±2.79° and the mean elbow extension was 10.35°±3.20°. In Group A, the mean elbow flexion achieved was 130.95°±2.62° and the mean elbow extension was 6.05°±2.46°. Elbow flexion, extension, and flexion-extension arc differences between the groups were determined to be statistically significant (p<0.001).

Similarly, functional outcome assessed by the Mayo Elbow Performance Score and Oxford Elbow Score was found to be statistically better in single plating group, as compared to dual plating (p=0.021, p<0.001).

One patient 1(5%) in the Dual Plating Group had iatrogenic radial nerve palsy(neuropraxia), which recovered completely in 3 months as assessed by nerve conduction studies. Two patients 2(10%) reported severe ulnar neuritis in group B and consequently had the medial plate removed prematurely. One out of them eventually acquired a delayed union but the other one went into non-union. No superficial or deep infection was reported. Two patients 2(20%) with orthogonal implants insisted on the removal of hardware due to pain and irritation but after being informed of the hazards, they decided against having a second operation.

DISCUSSION

Despite the advancements in modern orthopedics, managing distal humerus fractures is still challenging for trauma surgeons. There are limited options for internal fixation as these fractures are usually multi-fragmented, occurring in osteopenic bone. Despite intervention, results are often associated with restricted elbow motion, joint weakness, and pain. Since the elbow joint permits the hand to carry out daily tasks like feeding and personal hygiene, it should be painless, stable, and mobile. The literature does not pay as much attention to these fractures as it does to the more complicated intra-articular type C fractures, Nevertheless, they are responsible for 25% of distal humerus fracture cases.[17]

Historically, surgical restoration of distal humeral fractures has relied on dual-column plating as the gold standard of care.[18,19] To achieve fracture union and retain alignment, it was believed that two plates were required to offer numerous points of fixation into the short distal portion. With single-lateral column plating, similar union rates and clinical outcomes were observed in our trial, refuting the idea that bi-columnar plating is necessary for AO/OTA 13 A2 and A3 fractures. In every single plating case of our series, at least five locking screws through the dorsolateral

plate engaging the distal block were enough to hold the fixation firmly, until fracture united.

The idea of single-column dorsolateral plate osteosynthesis has been studied. In a study from China by Yang *et al.,* in 2012, he treated nineteen distal humeral extra-articular fractures with lateral column fixation with a 4.5mm metaphyseal plate which was positioned on the posterolateral column distally and obliquely placed proximally on the posterior aspect of the shaft. Every single case resulted in an uncomplicated union with ideal alignment and retained elbow and shoulder function.[20] Parmaksızoğlu *et al*.,[21] from Istanbul, Turkey in 2016, explored single column construct with an anterolateral approach utilizing a customized 4.5mm implant fashioned for the medial distal tibia to match the anatomy of the distal humerus to gain necessary fixation into the short distal segment. In their series, all,[23] patients had an uneventful union, with no complications noted.[21] To further solidify the concepts, a study done in India by Aggarwal *et al*., in 2013, further investigated the single versus double-plate fixation in a comminuted distal humerus intraarticular injury.[22] They noted a significant reduction in surgery time and cost with single plating, but no difference in functional outcome, with both techniques.[22]

As depicted in this study as well, bicolumnar plating is far more time-consuming in either orthogonal or parallel modes as compared to simple plate fixation.[22,23] Reduction in duration of procedure inevitably translates into decreased exploitation of anatomic planes, consequently bare minimum blood loss. This renders patients decreased post-operative pain and swelling, allowing patients early rehabilitation.

On the other hand, dual plating results in extensive tissue devitalization and extended surgery time, setting the grounds for fracture non-unions and infections. Moreover, complications like ulnar neuritis and hardware-related patient complaints have always been associated with dual plating. As much as 51% of cases have been observed to experience ulnar neuritis after distal humerus internal fixation.[10] Dissection at medial end and positioning of a medial plate close to the cubital tunnel are likely the causes. Even with transposition of ulnar nerve at conclusion of distal humerus dual plating, Chen *et al*., observed that ulnar neuritis occurred in about 10% of instances.[10] Higher incidence of iatrogenic radial nerve injury has been reported in literature with dual plating.[24] Even with the same surgical approach, less iatrogenic radial nerve palsy is attributable to less hardware-related tension with single plating.

LIMITATIONS OF STUDY

Notwithstanding the comparative aspect of the trial, the study's constraints encompass the comparatively limited sample size and absence of randomization. Further insight into this topic will come from a sizable multicentre randomised control trial contrasting single and dual plating alternatives.

CONCLUSION

Augmented stability of construct in distal humerus dual plating comes at the cost of mutilation of anatomic planes. Single-column fixation has been shown to produce encouraging outcomes in both union as well as patient-specific scores, with minimal soft tissue dissection and surgery time, resulting in early range of motion while minimizing complications. Therefore, surgeons ought to adopt a rational strategy; cautious preoperative preparation is essential for selecting the apposite implant and so optimize the result.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

BAQ & MSA: Data acquisition, data analysis, critical review, approval of the final version to be published.

AMK & HFR: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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