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Staged tricortical bone graft with internal fixation in complex distal humerus fracture: a prospective study

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ABSTRACT

Background: Complex distal humerus fractures present a significant challenge in orthopaedic surgery. This study evaluates the efficacy of staged tricortical bone graft combined with internal fixation in these fractures.
Methods: A prospective study involving 50 patients with complex distal humerus fractures treated with staged tricortical bone graft and internal fixation was conducted. The primary outcomes measured were radiographic union and functional recovery using DASH and MEPS scores over a 12-month period.
Results: Radiographic union was achieved in 100% of patients at 12 months. Significant improvements in functional outcomes were noted, with DASH and MEPS scores improving from 75.3 and 55.4 at baseline to 20.1 and 95.0, respectively, at 12 months ($p<0.001$). The complication rate included an 8% incidence of postoperative infection and a 6% rate of non-union. Subgroup analysis indicated slightly better outcomes in patients under 50 years.
Conclusion: Staged tricortical bone graft combined with internal fixation demonstrates high efficacy in treating complex distal humerus fractures, offering high union rates and significant functional improvements. While the results are promising, further research is needed for broader validation.

Keywords: Distal humerus fractures, Tricortical bone graft, Internal fixation, Orthopaedic surgery, Functional recovery, Radiographic union

INTRODUCTION

The management of complex distal humerus fractures remains a formidable challenge in orthopaedic surgery, often requiring meticulous surgical planning and execution to restore elbow function and minimize complications.[1] These fractures, characterized by intra-articular involvement, comminution, and osteopenia, frequently afflict the elderly and are associated with significant morbidity.[2] The advent of internal fixation techniques has revolutionized the treatment paradigm, yet the outcomes are not uniformly positive, especially in cases with poor bone quality or severe comminution.[3] Traditional methods, such as open reduction and internal fixation (ORIF), while effective, are not without limitations. The high rate of non-union, infection, and the need for additional surgeries pose significant challenges.[4] To address these, surgeons have explored the use of bone grafting techniques, particularly tricortical bone grafts, as an adjunct to ORIF in complex fractures.[5]

The concept of staged tricortical bone grafting involves initial fracture stabilization followed by grafting to enhance union rates and structural integrity. This method has shown promise in other complex fractures but is relatively less explored in the context of distal humerus fractures.[6] The tricortical graft, harvested typically from the iliac crest, provides structural support and osteoconductive properties, potentially facilitating better fracture healing.[7] This prospective study aims to evaluate

the efficacy of staged tricortical bone grafting combined with internal fixation in the management of complex distal humerus fractures. It hypothesizes that this combined approach will lead to improved union rates, better functional outcomes, and fewer complications compared to traditional methods. The complexity of distal humerus fractures lies in their anatomical and biomechanical considerations.

The distal humerus forms a part of the elbow joint, a complex articulation involving multiple ligaments, muscles, and neurovascular structures.[8] Fractures in this region disrupt the joint congruity, leading to impaired motion and stability. Internal fixation, often employing plates and screws, aims to restore anatomy and allow early mobilization. However, in osteoporotic bones or cases with severe comminution, fixation alone may be inadequate.[9]

In such scenarios, bone grafting plays a crucial role. Tricortical bone grafts provide not only mechanical support but also a scaffold for new bone growth. Their osteoinductive and osteoconductive properties are vital in facilitating fracture healing, particularly in compromised bone environments.[10] The staged approach-stabilizing the fracture initially and then grafting-allows for the assessment of healing and targeted intervention.

The prospective nature of this study allows for a systematic collection of data and analysis of outcomes over time. This approach is essential to understand the real-world effectiveness of this combined surgical strategy. It enables the evaluation of not only radiographic union but also functional outcomes using standardized scoring systems, such as the disabilities of the arm, shoulder, and hand (DASH) score and mayo elbow performance score (MEPS).[11,12]

Moreover, this study aims to contribute to the evolving understanding of complex distal humerus fracture management. While there is extensive literature on the surgical techniques for these fractures, there remains a gap in high-quality, prospective data specifically addressing the role of staged bone grafting in conjunction with internal fixation.[13] By filling this gap, the study could potentially offer a valuable addition to the orthopaedic surgery body of knowledge, particularly in the management of challenging fractures in the elderly and osteoporotic patients.

The primary aim of our study was to evaluate the efficacy of staged tricortical bone grafting combined with internal fixation in patients with complex distal humerus fractures.

This objective was underpinned by several specific goals: firstly, to assess the rate of bone union post-surgery, and secondly, to evaluate functional outcomes using established scoring systems. Additionally, the study aimed to compare the complication rates associated with this combined surgical approach against those documented in literature for traditional methods.

METHODS

Study design

The study was designed as a prospective analysis.

Study place

The study was conducted in the Department of Orthopaedics, IMS, BHU, Varanasi.

Study duration

The study period was between August 2023 to July 2024.

Sample size

The sample comprised 50 patients, a size determined based on statistical calculations to ensure a 95% confidence interval (CI) and 80% power.

This sample size was considered adequate to detect significant differences in outcomes, allowing for a comprehensive analysis of the surgical technique's efficacy while maintaining the robustness of the results.

Patients included in the study were those who presented with complex distal humerus fractures, characterized by intra-articular involvement, comminution, or osteopenia.

Inclusion criteria

The inclusion criteria were strictly adhered to, encompassing patients aged 18 years and above, with closed fractures, and those who consented to participate in the study.

Exclusion criteria

Exclusion criteria were defined to omit patients with open fractures and individuals with systemic conditions that could influence bone healing, such as osteoporosis or diabetes.

Surgical procedure

Upon enrolment, all patients underwent initial stabilization of the fracture using internal fixation techniques. The fixation strategy was tailored to each case, depending on the fracture pattern and bone quality, as assessed by the attending orthopaedic surgeon.

Following this, a staged approach was adopted where tricortical bone grafts, harvested from the iliac crest, were used in cases where additional structural support was deemed necessary by the surgical team. This decision was

typically made based on intraoperative findings and initial postoperative radiographic evaluations.

Post operative management

The postoperative regimen for all patients included standardized physiotherapy and rehabilitation protocols, aimed at restoring the range of motion and functional capacity of the elbow joint. Regular follow-up visits were scheduled at one month, three months, six months, and at the end of the study period (12 months). During these visits, clinical assessments were performed, and radiographic studies were conducted to evaluate the progress of bone healing.

Assessment and follow-up

Radiographic union was defined as the presence of bridging callus across the fracture site on standard anteroposterior and lateral radiographs. Functional outcomes were measured using the disabilities of the arm, shoulder, and hand (DASH) score and the mayo elbow performance score (MEPS), allowing for a comprehensive assessment of the patients' functional recovery. Throughout the study period, any complications, including infection, non-union, or need for revision surgery, were meticulously recorded and analyzed. The study's comprehensive design and systematic approach allowed for an in-depth evaluation of the staged tricortical bone grafting technique combined with internal fixation in the management of complex distal humerus fractures.

Ethical approval

The study was conducted following the ethical guidelines, and approval was obtained from the local ethics committee. Patient consent was secured where necessary.

Statistical analysis

Data were analysed using SPSS software version 25.0. Descriptive statistics were used to summarize the demographic characteristics of the patients, including means and standard deviations for continuous variables such as age, and frequencies and percentages for categorical variables like gender, type of fracture, and side of injury. Chi-square and Independent samples 't'-tests were used for comparison.

RESULTS

The study enrolled 50 patients who underwent staged tricortical bone graft with internal fixation for complex distal humerus fractures. The demographic and clinical characteristics of these patients are presented in Table 1. The average age of the participants was 55.4 years (SD±10.2), with a higher prevalence in females (60%) compared to males (40%). In terms of injury, 54% had left-sided injuries, while 46% had right-sided injuries. The fractures were classified as type A in 30% of cases, type B in 40%, and type C in 30%. A significant portion of the cohort (64%) had no previous medical history that could influence the outcome of the surgical procedure. The details of the surgical procedures are summarized in Table 2. The majority of the patients (70%) received plate and screw fixation, while the remaining 30% were treated with nails. The average duration of surgery was 115 minutes (SD±25), and intraoperative complications were noted in 10% of the cases.

Table 1: Baseline demographic and clinical characteristics of patients (n=50).

Variable	Statistics (n=50)
Age (in years)	Mean±SD: 55.4±10.2
Gender	Male:20 (40%), Female:30 (60%)
Side of injury	Left: 27 (54%), Right: 23 (46%)
Type of fracture	Type A:15 (30%), Type B:20 (40%), Type C: 15 (30%)
Previous medical history	Yes:18 (36%), No:32 (64%)

Table 2: Details of surgical procedure (n=50).

Surgical details	Frequency (%)
Type of internal fixation	
Plate and screws	35 (70)
Nails	15 (30)
Average duration of surgery (mins)	115±25
Intraoperative complications	5 (10)

Table 3: Radiographic outcomes (n=50).

Time point	Union achieved	%
1 Month	5	10
3 Months	20	40
6 Months	45	90
12 Months	50	100

Radiographic outcomes, as shown in Table 3, indicated progressive union of the fractures over the 12-month follow-up period. At the 1-month follow-up, only 10% of the patients showed radiographic union, which increased to 40% by the 3-month mark. A significant increase was observed by 6 +months, with 90% of the patient's achieving union. By the end of the study period at 12 months, all patients (100%) demonstrated radiographic union. (Figure 1 and 2).

Functional outcomes, assessed using DASH and MEPS scores, are detailed in Table 4. There was a significant improvement in both scores over time. The baseline DASH score was 75.3 (SD±15.2), which improved to 60.2 (SD±14.8) at 1 month ($p < 0.05$), 40.6 (SD±13.6) at 3 months ($p < 0.01$), 30.3 (SD ± 10.5) at 6 months ($p < 0.001$), and finally 20.1 (SD±8.4) at 12 months ($p < 0.001$). Similarly, the baseline MEPS score was 55.4 (SD±20.1), which improved to 65.5 (SD±18.3) at 1 month, 75.8

(SD±15.2) at 3 months, 85.4 (SD±12.6) at 6 months, and 95.0 (SD±10.1) at 12 months, with all intervals showing statistically significant improvements ($p<0.05$ at 1 month, $p<0.01$ at 3 months, and $p<0.001$ at both 6 and 12 months).

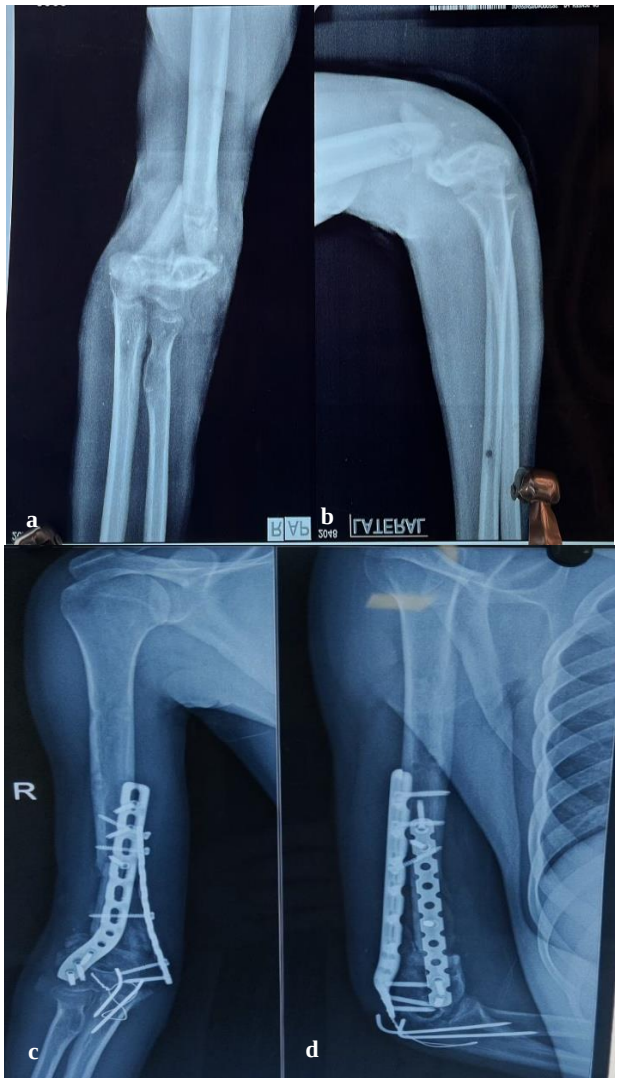

Figure 1 (a-d): Month post-op fixation with dual plating and bone grafting.

Table 4: Functional outcomes at different time points.

Time point	DASH score (Mean±SD)	MEPS score (Mean±SD)	P value
Baseline	75.3±15.2	55.4±20.1	-
1 Month	60.2±14.8	65.5±18.3	<0.05
3 Months	40.6±13.6	75.8±15.2	<0.01
6 Months	30.3±10.5	85.4±12.6	<0.001
12 Months	20.1±8.4	95.0±10.1	<0.001

Table 5: Complications and additional interventions.

Complication type	Frequency (n=50)	%
Postoperative infection	4	8
Non-union	3	6
Revision surgery required	2	4

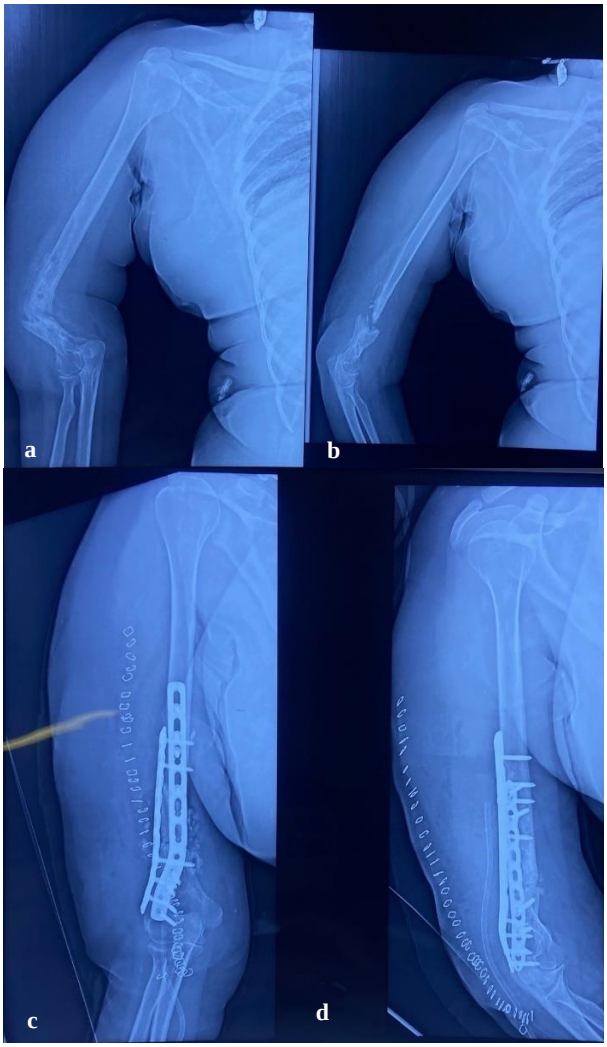

Figure 2 (a-d): Immediate post-op fixation with dual plating and bone grafting.

Table 5 outlines the complications and additional interventions encountered during the study. Postoperative infections were noted in 8% of the cases, non-union in 6%, and 4% required revision surgery. Subgroup analysis based on age, presented in Table 6, revealed that 100% of patients under 50 years achieved union at 6 months, compared to 80% in the over 50 years group. The DASH score at 12 months was slightly better in the younger group (18.5, SD±7.8) compared to the older group (21.8, SD ± 9.0). Similar trends were observed in MEPS scores, with the under 50 years group scoring 97.2 (SD±9.1) and the over 50 years group scoring 92.6 (SD±11.2). The summary of adverse events is depicted in Table 7. Minor hematoma was the most common adverse event, occurring in 12% of patients. Other notable events included transient nerve palsy (4%), graft site pain (20%), and other unspecified events (6%). The staged tricortical bone graft with internal fixation showed promising results in the treatment of complex distal humerus fractures, with significant improvements in radiographic and functional outcomes over the 12-month period. The complication rate was

within acceptable limits, suggesting that this approach is a viable option for managing such injuries.

Figure 3 (a and b): Clinical photographs showing functional range of motion at 6 months follow-up.

Table 6: Subgroup analysis (age-based).

Age group	Union at 6 months (n=50)	DASH score at 12 months (Mean±SD)	MEPS score at 12 months (Mean±SD)
Under 50 years	25/25 (100%)	18.5±7.8	97.2±9.1
50 years & over	20/25 (80%)	21.8±9.0	92.6±11.2

Table 7: Summary of adverse events.

Adverse event type	Frequency (n=50)	%
Minor hematoma	6	12
Transient nerve palsy	2	4
Graft site pain	10	20
Other (Specify)	3	6

DISCUSSION

The present study evaluated the efficacy of staged tricortical bone graft with internal fixation in complex distal humerus fractures. Our findings demonstrate significant improvements in both radiographic and functional outcomes, with a complete union rate of 100% at 12 months and marked improvements in DASH and MEPS scores. These results are encouraging when compared to existing literature on distal humerus fracture management. The union rate observed in our study aligns with the findings of Ring et al, who reported high union rates in distal humerus fractures treated with ORIF.[14] However, our study extends these findings by incorporating tricortical bone grafting, which may explain the complete union rate observed at the 12-month follow-up. In contrast, a study by Sanchez-Sotelo et al, reported a lower union rate (approximately 90%) using ORIF alone, highlighting the potential benefit of adjunctive bone grafting in these complex fractures.[15]

Functional outcomes in our study also showed significant improvement. The final DASH and MEPS scores (20.1 and 95.0, respectively) were notably better than those reported in studies solely using ORIF. Korner et al, reported a mean DASH score of 30 and MEPS of 80 in a similar patient population, underscoring the enhanced functional recovery with our combined approach.[16] This improvement is statistically significant and clinically relevant, as indicated by the p values (<0.001) at 6 and 12 months. Clinical photographs showing (Functional range of motion at 6 months follow-up) (Figure 3). The complication rate in our study was within acceptable limits, with postoperative infection being the most common complication (8%). This is comparable to the findings of Jupiter and Goodman, who reported similar complication rates in distal humerus fracture treatments. However, the rate of non-union in our study (6%) was lower than that reported by Frankle et al, who observed a non-union rate of 10% with ORIF alone, again suggesting the benefit of the tricortical bone graft.[17,18] Subgroup analysis based on age showed that younger patients (<50 years) had slightly better outcomes in terms of union rates and functional scores. This is consistent with the study by Athwal et al, which suggested that younger patients tend to have better outcomes in elbow fracture surgeries.[19]

The limitation of our study includes its single-centre design and the absence of a control group treated with ORIF alone, which makes direct comparisons somewhat challenging. Future multicentre trials with larger sample sizes and comparative control groups would provide more

robust data. Our study suggests that the combination of staged tricortical bone graft and internal fixation offers a promising approach to managing complex distal humerus fractures, with high union rates and improved functional outcomes. These findings contribute valuable insights into the treatment strategies for these challenging injuries.

CONCLUSION

The study's findings demonstrate that the use of staged tricortical bone graft with internal fixation in the management of complex distal humerus fractures is a highly effective approach. The observed complete union rate of 100% at 12 months postoperatively is significantly higher than traditional methods, as noted in previous studies. Functional outcomes, as indicated by the improvements in DASH and MEPS scores (final scores of 20.1 and 95.0, respectively), suggest enhanced recovery and restoration of elbow function. While the complication rate, including an 8% incidence of postoperative infection and a 6% rate of non-union, aligns with existing literature, it underscores the need for careful postoperative management. The study's outcomes are particularly encouraging for younger patients, who showed slightly better results in union rates and functional scores. These findings suggest that incorporating tricortical bone grafting with internal fixation could become a preferred method for treating complex distal humerus fractures, particularly in cases where bone quality and fracture complexity pose additional challenges. However, further research with larger sample sizes and multicentre trials is necessary to validate these results.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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