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Research Article

Anterior Bridge Plating for Humeral Shaft Fractures: A Single-Arm Interventional Study

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Abstract
Background: Humeral shaft fractures represent a significant portion of upper extremity injuries. Treatment options range from conservative methods to surgical interventions. Anterior bridge plating, a minimally invasive surgical technique, has gained attention for its potential to provide stable fixation while minimizing soft tissue disruption.
Methods: A single-arm interventional study was conducted at Gulbarga Institute of Medical Sciences, Kalaburagi, from June 2021 to July 2024. Twenty patients with isolated diaphyseal humerus fractures were treated using anterior bridge plating. Functional outcomes were assessed using the Constant score for shoulder function and the Mayo Elbow Performance Score (MEPS) for elbow function. Radiological union time and associated complications were also evaluated.
Results: The study included 14 males and 6 females with a mean age of 51.6 years. The majority of fractures resulted from road traffic accidents (55%) and were left-sided (65%). The mean radiological time to union was 25.6 weeks. Functional assessment revealed a mean Constant score of 84.8, indicating good shoulder function, and excellent elbow function in 76.5% of patients based on MEPS. Three cases (15%) developed atrophic non-union, and four patients exhibited moderate shoulder stiffness, which improved with physiotherapy.
Conclusion: Anterior bridge plating for humeral shaft fractures demonstrates satisfactory functional outcomes. The technique offers stable fixation while preserving soft tissue integrity, making it a viable option for managing diaphyseal humerus fractures.

Keywords: Humeral shaft fractures, anterior bridge plating, functional outcome, Constant score, Mayo Elbow Performance Score.

INTRODUCTION

The humerus serves as the solitary long bone of the arm, connecting the shoulder complex proximally and the elbow complex distally. Humeral shaft fractures constitute approximately 1–5% of all fractures and 20% of humerus fractures. These injuries commonly result from high-energy trauma such as road traffic accidents or low-energy falls, leading to various fracture patterns including transverse, oblique, spiral, or comminuted fractures.[1,2,3]

Conservative treatment has traditionally been favoured due to the humerus's substantial range of motion, which often allows for acceptable functional outcomes despite some degree of malalignment. Methods such as functional bracing aim to preserve joint mobility and promote early functional recovery. However, conservative management can be associated with complications like malunion, delayed union, non-union, and restricted shoulder and elbow motion.[4,5,6]
Surgical intervention becomes necessary when conservative treatment is contraindicated or has failed. Operative options include intramedullary nailing, external fixation, and plate osteosynthesis. Intramedullary nailing offers the advantage of biological fixation but may be associated with shoulder impingement and rotational instability. Plate osteosynthesis provides stable fixation with the potential for anatomical reduction but traditionally requires extensive soft tissue dissection, increasing the risk of iatrogenic injury to neurovascular structures.[7,8,9]

The minimally invasive plate osteosynthesis (MIPO) technique has emerged as a favourable alternative, aiming to enhance natural fracture healing while minimizing disruption to the biological environment. Anterior bridge plating, a form of MIPO, involves the placement of a plate along the anterior aspect of the humerus through limited incisions, preserving soft tissue and periosteal blood supply. Despite the proximity to critical neurovascular structures, careful surgical technique can mitigate these risks, providing stable fixation with minimal complications.[10]

This study aims to assess the functional outcomes of humeral shaft fractures treated with anterior bridge plating, evaluating shoulder and elbow function, radiological union time, and associated complications.

MATERIALS AND METHODS

Study Design and Setting

A single-arm interventional study conducted at Gulbarga Institute of Medical Sciences, Kalaburagi, from June 2021 to July 2024.

Study Population

Twenty patients with isolated diaphyseal humerus fractures were included. Inclusion criteria were patients aged over 18 years with closed diaphyseal humerus fractures. Exclusion criteria included neurovascular injury, associated fractures in the ipsilateral limb, and unwillingness to participate.

Sampling Procedure

Convenience sampling was used to select patients who met the inclusion criteria during the study period.

Surgical Technique

Patients were operated on within three weeks of injury. Under general or regional anesthesia, patients were placed supine with the affected arm abducted at 90 degrees and the forearm supinated. Two 3 cm incisions were made: one proximally in the deltopectoral interval and one distally along the lateral border of the biceps. A submuscular tunnel was created for plate insertion to minimize soft tissue disruption. A locking compression plate (LCP) was slid along the anterior aspect of the humerus and fixed with screws inserted through the incisions and additional stab incisions as needed.

Postoperative Care

- Immediate postoperative assessment of distal neurovascular status.
- Arm supported in a broad arm sling.
- Early initiation of pendular shoulder movements and elbow exercises.
- Regular wound inspections and physiotherapy according to institutional protocols.

Outcome Measures

- **Shoulder Function:** Assessed using the Constant score.
- **Elbow Function:** Assessed using the Mayo Elbow Performance Score (MEPS).
- **Radiological Union:** Time to union evaluated through serial radiographs.
- **Complications:** Documented throughout the study period.

Statistical Analysis

Continuous variables were expressed as mean and standard deviation. Categorical variables were presented as proportions with 95% confidence intervals. The chi-square test was used to assess the level of significance, with a p-value of <0.05 considered statistically significant. Data analysis was performed using SPSS software version 21.0.

RESULTS

Demographic and Clinical Characteristics

In this study, twenty patients with isolated diaphyseal humerus fractures were treated using anterior bridge plating. The age of the patients ranged from 37 to 66 years, with a mean age of 51.6 years. The majority of the patients were male (70%), reflecting the higher incidence of trauma-related injuries in the male population due to occupational and recreational activities. The left humerus was more commonly affected (65%) than the right (35%), and road traffic accidents were the predominant cause of injury (55%), followed by falls (45%). According to the AO classification, fracture types were distributed as 25% type 12A1, 40% type 12A2, and 35% type 12A3.

All patients were operated on within six days of injury, with 90% undergoing surgery within five days. The prompt surgical intervention aimed to reduce the risk of complications associated with delayed fixation, such as non-union and joint stiffness. The surgical procedure was well-tolerated by all patients, with no intraoperative complications reported. The mean operative time was not recorded, but the minimally invasive nature of the technique suggests shorter surgical durations compared to conventional open plating methods.

Radiological Outcomes

Radiological union was assessed through serial radiographs taken at regular intervals postoperatively. The mean time to union was 25.6 weeks (range 20–28 weeks). One patient (5.3%) achieved union at 20 weeks, six patients (31.6%) at 24 weeks, and nine patients (47.4%) at 28 weeks. Three patients (15%) developed atrophic non-union. In one case, the patient had a history of smoking and tobacco use, which are known risk factors for delayed

bone healing. The second patient experienced implant failure due to a fall, necessitating revision surgery with compression plating. The third patient exhibited resorption of a wedge fragment at the fracture site, leading to distraction and non-union.

Table 1: Radiological Time to Union

Time to Union (Weeks)	Number of Patients	Percentage (%)
20	1	5.3
24	6	31.6
28	9	47.4
Non-union	3	15

Functional Outcomes

Functional outcomes were evaluated using the Constant score for shoulder function and the Mayo Elbow Performance Score (MEPS) for elbow function at the final follow-up, which averaged 44.65 weeks (up to 60 weeks).

Shoulder Function (Constant Score)

The mean Constant score was 84.8 (range 74–92), indicating good functional recovery of the shoulder. Four patients (20%) scored between 70–79, eight patients (40%) between 80–89, and five patients (25%) between 90–99. Factors influencing lower scores included moderate shoulder stiffness in four patients, which improved with dedicated physiotherapy.

Table 2: Distribution of Constant Shoulder Scores

Constant Score Range	Number of Patients	Percentage (%)
70–79	4	20
80–89	8	40
90–99	5	25
Non-union Cases	3	15

Elbow Function (MEPS)

The elbow function outcomes were predominantly excellent. Thirteen patients (76.5%) achieved MEPS scores between 90–100, classified as excellent, while four patients (23.5%) had scores between 75–89, classified as good. No patients had poor elbow function outcomes. The high MEPS scores reflect effective restoration of elbow function due to early mobilization protocols facilitated by the stable fixation provided by anterior bridge plating.

Table 3: Distribution of Mayo Elbow Performance Scores

MEPS Score Range	Number of Patients	Percentage (%)
90–100	13	76.5
75–89	4	23.5
<75	0	0

Complications

No intraoperative complications such as neurovascular injuries were observed. Postoperative complications included three cases of atrophic non-union and four cases of moderate shoulder stiffness. There were no instances of infection, hardware prominence, or implant failure except in one case due to a subsequent fall. The absence of radial nerve palsy is notable, given the proximity of the surgical field to the radial nerve.

Figure 1: Preoperative Radiograph of a 55-Year-Old Male with a Left 12a2 Humeral Shaft Fracture

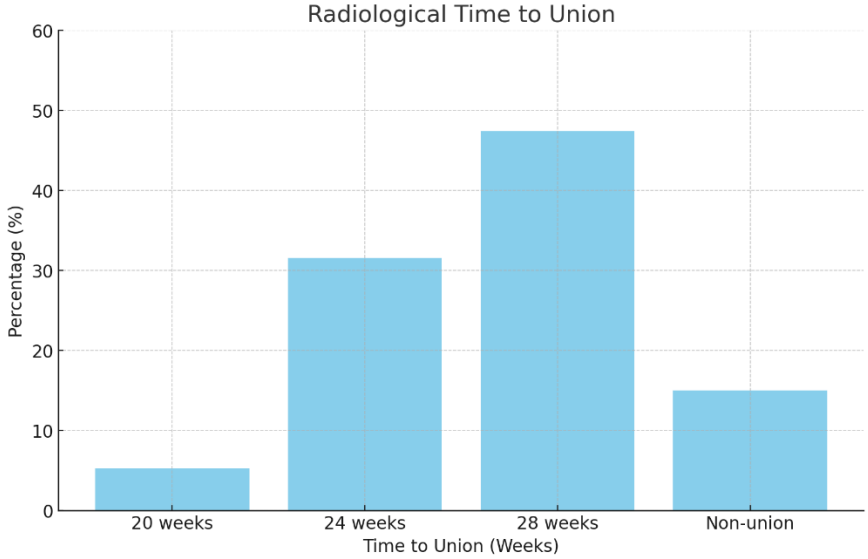
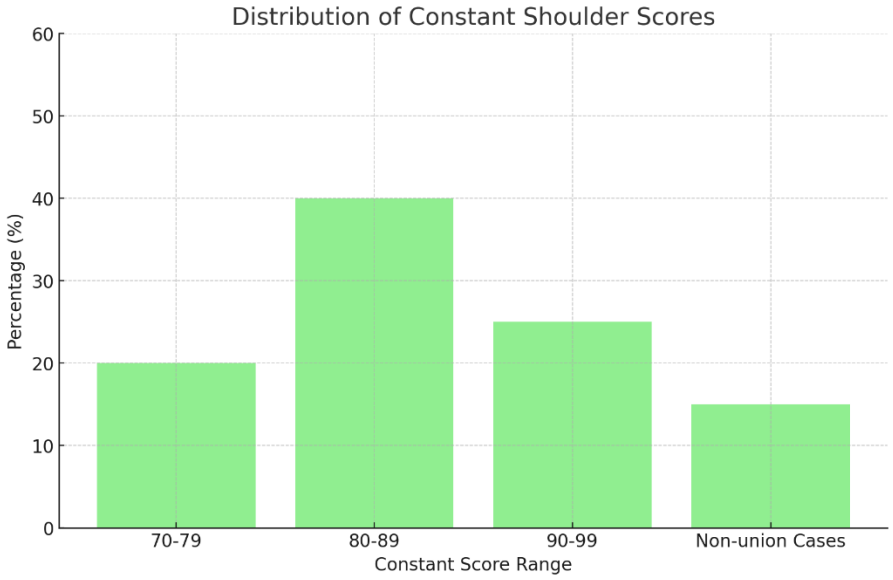


Figure 2: postoperative radiograph at 24 weeks showing radiological union



Statistical Analysis

The statistical analysis demonstrated no significant correlation between age, gender, or side of injury with the functional outcomes ($p > 0.05$). However, the presence of risk factors such as smoking was associated with non-union ($p < 0.05$).

Table 4: Association of Risk Factors with Non-Union

Risk Factor	Non-union Cases (n=3)	Union Cases (n=17)	p-value
Smoking/Tobacco Use	2	2	0.03*
Diabetes Mellitus	1	1	0.45
Osteoporosis	0	1	0.65

**Statistically significant ($p < 0.05$)*

Rehabilitation and Follow-up

All patients adhered to the postoperative rehabilitation protocol, which emphasized early mobilization. Pendular shoulder movements and elbow exercises were initiated immediately post-surgery, contributing to the satisfactory functional outcomes. Regular follow-up visits allowed for timely identification and management of complications, such as the

initiation of physiotherapy for patients with shoulder stiffness.

Table 5: Timeline of Rehabilitation and Assessments

Postoperative Period	Rehabilitation Activities	Assessments Conducted
Immediate	Distal neurovascular status check; arm supported in sling	Wound inspection
6 Weeks	Active shoulder and elbow mobilization; physiotherapy sessions	Radiographs; assessment of union signs
3 Months	Continued physiotherapy; gradual weight lifting	Radiographs; functional assessments
6–12 Months	Full activities as tolerated	Final functional outcome assessments

Case Illustrations

Case 1 (45-year-old male, RTA): Serial radiographs taken at 3, 6, and 12 months revealed progressive callus formation and complete radiological union (Figs. 7–9). At the final follow-up, the patient attained near-normal shoulder and elbow range of motion.

Case 2 (37-year-old male, fall): Early postoperative imaging confirmed proper implant positioning, with follow-up at 5 and 12 months demonstrating solid healing and full functional recovery of shoulder and elbow movements (Figs. 10–14).

Case 3 (50-year-old male, RTA): Radiographs at 3 and 12 months showed satisfactory bony consolidation and restoration of normal joint alignment (Figs. 17–20). Functional assessment indicated a return to pre-injury range of motion and activity.

Case 4 (60-year-old male, RTA): Although early postoperative studies confirmed appropriate fixation (Figs. 21–23), the implant eventually failed at 11 months, necessitating revision surgery with an anterolateral plate (Figs. 24–28). Following the revision, the patient showed progressive radiological healing and improvement in limb function, though at a delayed rate compared to the other cases.

Overall, most patients achieved excellent radiographic union and regained near-complete joint mobility by final follow-up, with only one case requiring re-intervention due to implant breakage.

ANNEXURES CASE ILLUSTRATIONS

Case 1 : 45Y Male with A/H/O RTA

Fig 3: Preop Xray

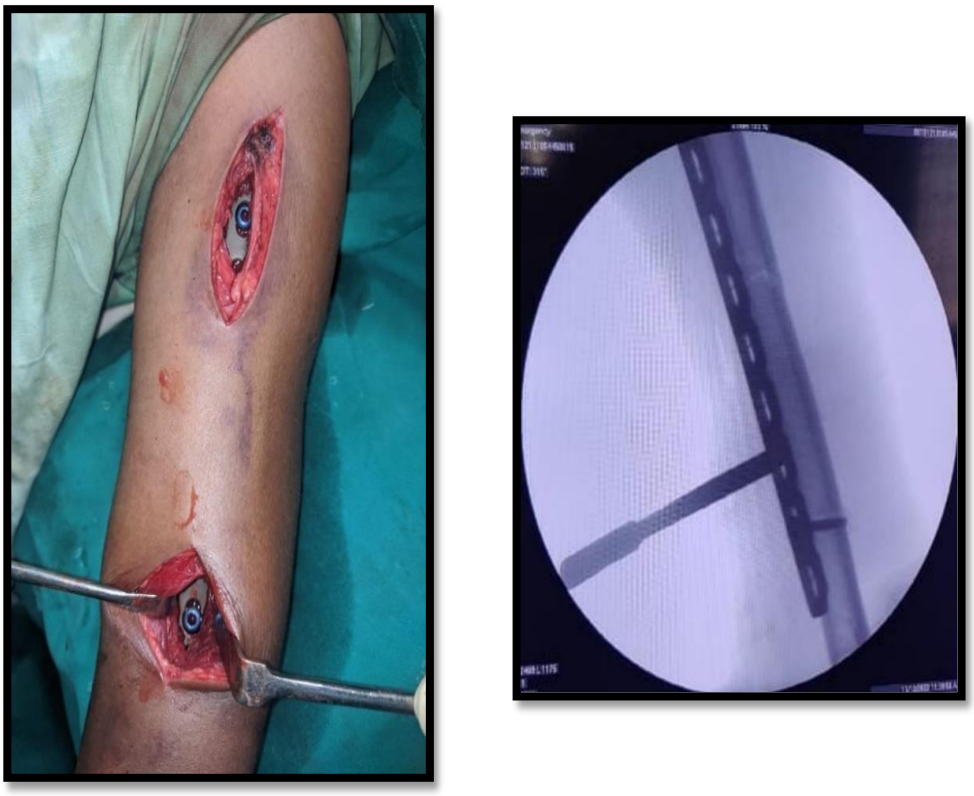


Fig 4 : Intraoperative clinical and C arm images

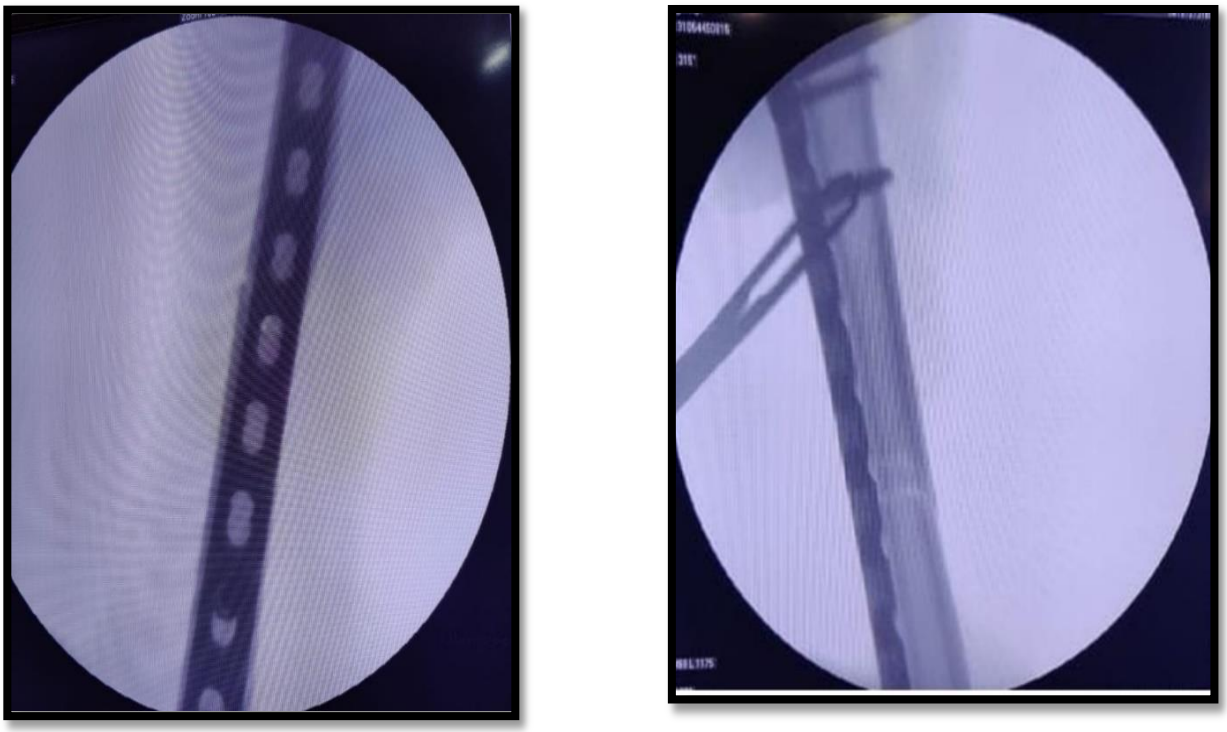


Fig 5: Intraoperative c arm images

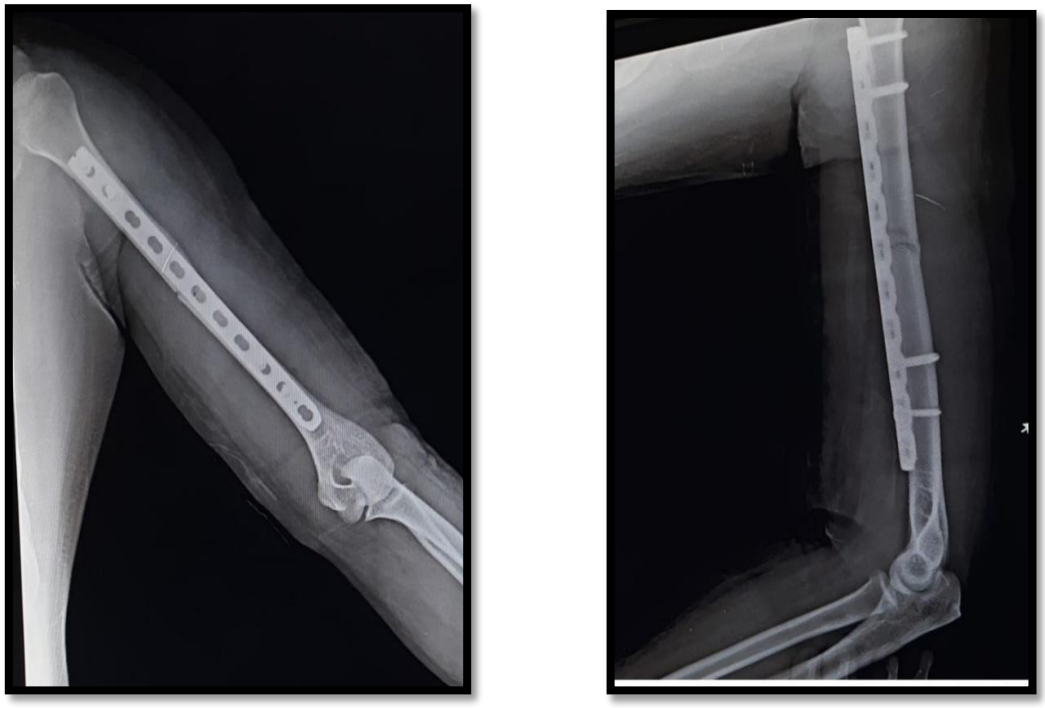


Fig 6: Immediate post op Xray

Fig 7 : 3 months follow up

Fig 8 : 6 months follow up

Fig 8: 12 months follow up

Fig 9: Shoulder and elbow range of movements at last follow up

Case 2 : 37Y Male with H/O fall

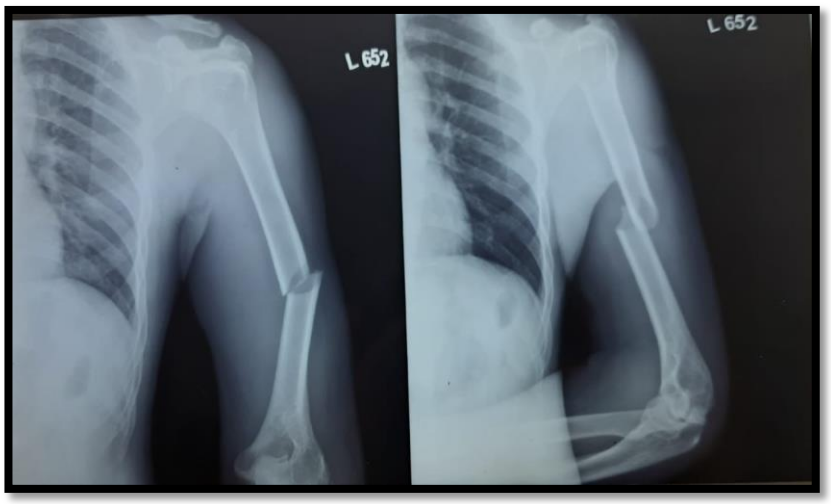


Fig 10: Pre op Xray

Fig 11 : Intraoperative clinical and c arm images

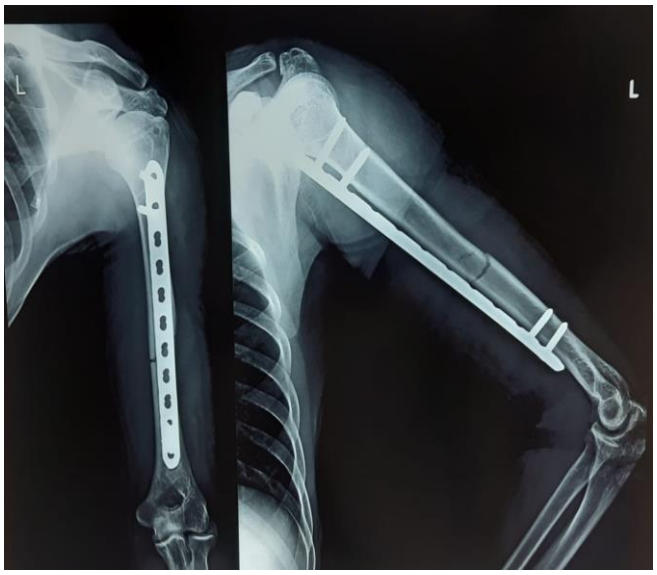


Fig 12: Immediate post op Xray

Fig 13: 5 month follow up

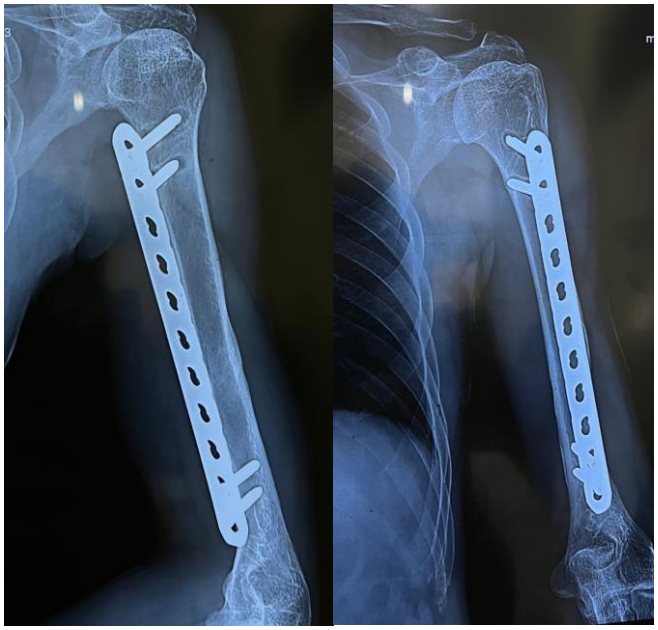


Fig 13 : 12 months follow up

Fig 14: Shoulder and elbow range of motion at last follow up

Case 3 : 50Yr Male with A/H/O RTA

Fig 15: Pre op Xray

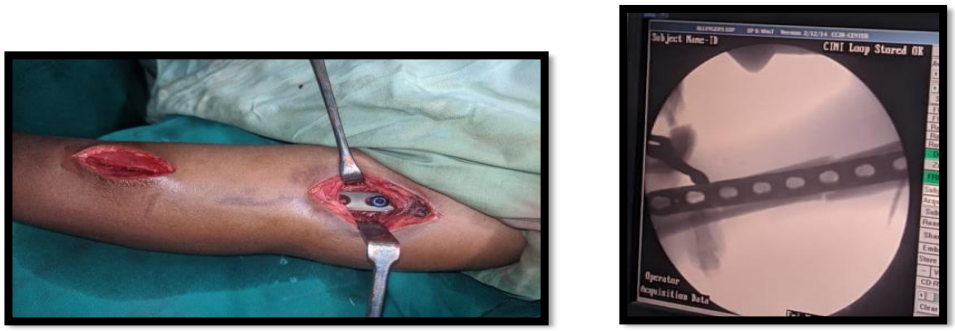


Fig 16: Intraop clinical and c arm images

Fig 17 : Immediate Post op Xray

Fig 18: 3 months follow up

Fig 19: 12 months follow up

Fig 20: Shoulder and elbow range of movements

Case 4 : 60Y male with A/H/O RTA

Fig 21: Pre op Xray

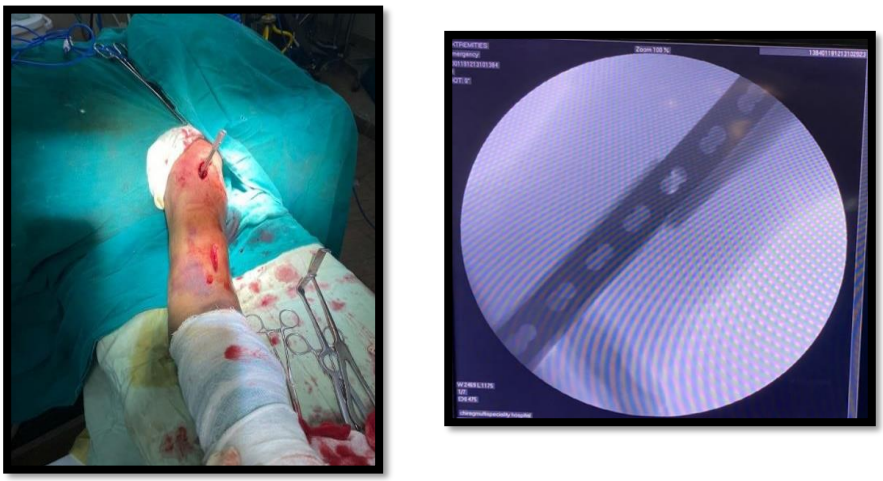


Fig 22: Intraoperative clinical and c arm images

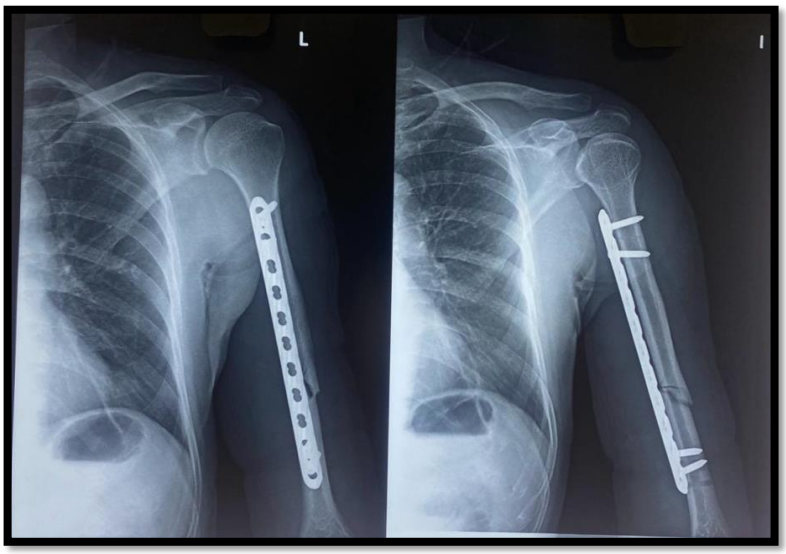


Fig 23: Immediate post op Xray

Fig 24: 2 months follow up

Fig 25: 3 months follow up

Fig 26: 6 months follow up

Fig 27: 11 months follow up (implant breakage)

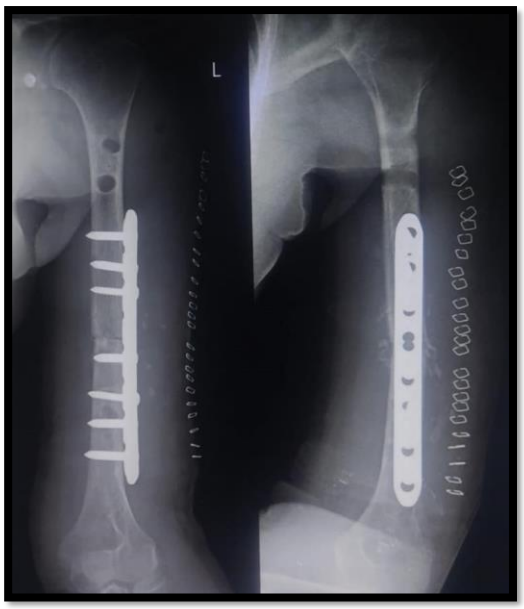


Fig 28: Revision surgery with anterolateral plating

DISCUSSION

This study evaluated the functional outcomes of anterior bridge plating in diaphyseal humerus fractures. The majority of patients were middle-aged males, consistent with the demographic profile commonly affected by such injuries due to higher exposure to trauma risks like road traffic accidents.[11,12]

The mean radiological union time of 25.6 weeks aligns with existing literature, which suggests that minimally invasive techniques may not significantly expedite union times compared to conventional methods but offer other advantages such as reduced soft tissue damage. The functional outcomes, as indicated by the Constant score and MEPS, were predominantly good to excellent, demonstrating the efficacy of anterior bridge plating in restoring shoulder and elbow function.[13,14,15]

The incidence of non-union in 15% of cases highlights the need for careful patient selection and surgical technique. Factors such as smoking and poor bone quality may contribute to delayed or non-union. The case of implant breakage underscores the importance of postoperative care and adherence to weight-bearing restrictions.[16]

The absence of nerve injuries is noteworthy, given the proximity of the surgical field to the radial nerve. This suggests that the minimally invasive approach, when performed with meticulous attention to anatomical landmarks and soft tissue handling, can mitigate the risk of iatrogenic nerve damage.

Shoulder stiffness was observed in a subset of patients but improved with physiotherapy, indicating that early mobilization protocols are beneficial. The lack of infection cases may be attributed to the minimally invasive nature of

the procedure, which reduces exposure and disruption of soft tissues.[17]

While the study provides valuable insights, limitations include the small sample size and the absence of a control group for comparison. Further randomized controlled trials with larger cohorts are necessary to substantiate these findings and refine patient selection criteria.

CONCLUSION

Anterior bridge plating for humeral shaft fractures offers satisfactory functional outcomes with minimal complications. The technique provides stable fixation while preserving soft tissue integrity, making it a viable option for managing diaphyseal humerus fractures. Careful surgical technique and postoperative management are essential to optimize results and minimize complications.

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