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Research Article

# Functional And Radiological Outcome Of Anterior Bridge Plating In Treatment Of Diaphyseal Humerus Fractures.

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**Abstract: Background:** Diaphyseal humeral fractures require stable fixation while preserving soft-tissue integrity and restoring upper-limb function. Minimally invasive anterior bridge plating (ABP) offers biological fixation with reduced fracture-site disruption. This study evaluated radiological union, functional outcomes, and complications following ABP. ***Materials and Methods***: This prospective observational study included 30 adults with diaphyseal humeral fractures treated using minimally invasive ABP at Narendra Modi Medical College, Gujarat, from May 2021 to October 2024. Radiological union was assessed serially, while functional outcomes were evaluated using RHUM scores at three and six months and Rodríguez-Merchán criteria at six months. ***Results***: The mean age was 38.97 years, with 60% males. Road traffic accidents accounted for 43.3% of injuries. AO type A and B fractures constituted 60% and 40%, respectively. Mean operative duration was 90 minutes. Mean radiological union time was 12.2 weeks, with 90% achieving union within 16 weeks. Three patients (10%) experienced delayed union; all eventually united. Mean RHUM scores improved from 8.63 to 10.86 between three and six months. Rodríguez-Merchán assessment demonstrated excellent outcomes in 60%, good in 26.7%, and fair in 13.3%. One patient (3.3%) developed rotational malunion. No infection, nerve palsy, nonunion, or implant failure was reported. ***Conclusion***: Minimally invasive ABP demonstrated satisfactory fracture union and functional recovery with few complications. It represents a feasible treatment option for selected diaphyseal humeral fractures. Larger comparative studies are warranted.

**Keywords:** Anterior bridge plating, Humeral Fractures; Minimally Invasive Surgical Procedures, Outcome, Union.

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## INTRODUCTION

Diaphyseal humeral fractures account for 1–3% of adult fractures, commonly resulting from road traffic accidents and falls. Treatment aims to achieve union and restore upper-limb function. Functional bracing is effective in selected cases, as demonstrated by Sarmiento et al. [1]. However, unstable or displaced fractures may require surgery. Surgical options include ORIF, intramedullary nailing, and MIPO. Conventional plating provides stable fixation but involves extensive soft-tissue dissection, while nailing may cause shoulder-related complications [2-5]. Kumar et al. reported favourable outcomes with both plating and nailing, although union times and complications differed [6].

Biological fixation preserves periosteal blood supply and surrounding soft tissues. MIPO promotes callus formation through indirect reduction and bridge fixation. Livani and Belangero reported satisfactory healing with minimally invasive bridge plating [2]. Apivatthakakul et al. assessed its anatomical feasibility and neurovascular safety [3], while Zhiquan et al. demonstrated its application in middle- and distal-third humeral fractures [4].

Anterior bridge plating (ABP) uses small incisions and extraperiosteal plate insertion, preserving fracture biology and facilitating early mobilisation. However, neurovascular injury and rotational malalignment remain concerns. Shetty et al. reported favourable outcomes in 32 patients [5], while Mahajan et al. demonstrated satisfactory functional recovery [7]. Similar findings were reported by Tolani et al. [8] and Kumar and Bade [10]. Recent studies support anterior bridge plating, with Pancholi et al. reporting favourable functional outcomes [11] and Sidhu et al. demonstrating 95% fracture union [12]. Neerudi et al. reported encouraging outcomes compared with conventional ORIF [14]. However, methodological differences limit direct comparisons, while randomised trials emphasise balancing functional recovery against surgical risks [9,13].

Further prospective evidence on anterior bridge plating using dynamic compression plates is needed. This study aimed to assess radiological union, functional outcomes, and complications following minimally invasive anterior bridge plating for diaphyseal humeral fractures using radiological assessment, RHUM scores, and Rodríguez-Merchán criteria.

## MATERIALS AND METHODS

**Study Design and Setting**: This prospective observational study was conducted at Narendra Modi Medical College, Gujarat, India, between May 2021 and October 2024. The study included 30 adult patients with diaphyseal fractures of the humerus who underwent surgical fixation using minimally invasive anterior bridge plating (ABP). The study aimed to evaluate radiological fracture union, functional outcomes, and postoperative complications following this technique. All included patients underwent operative treatment and subsequent clinical and radiological follow-up. The minimum reported follow-up was six months.

**Study Population and Eligibility Criteria**: Patients older than 18 years presenting with fresh humeral shaft fractures of less than two weeks' duration were eligible. Fractures located between 2 cm distal to the surgical neck and 3 cm proximal to the olecranon fossa were included. Both open and closed fractures were considered eligible. Patients with an open physis, pathological fractures, fractures older than two weeks, intra-articular fracture extension, metabolic bone disease, refractures, or primary radial nerve palsy were excluded.

**Preoperative Management**: Following presentation, patients underwent preoperative assessment and temporary immobilization using a U-slab and arm sling. Fractures were categorized according to the AO classification. Definitive surgical fixation was performed within 1–8 days following injury. The operative approach was selected to achieve fracture stabilization while minimizing disruption of the surrounding soft tissues and periosteal blood supply.

**Surgical Technique**: All procedures were performed under regional or general anaesthesia. Patients were positioned supine, with the affected arm abducted to approximately 90° and the forearm maintained in full supination. An image intensifier was positioned on the side of the injured limb to facilitate intraoperative assessment. Minimally invasive anterior bridge plating was performed using a 12-hole narrow 4.5-mm dynamic compression plate (DCP). Two small incisions, each approximately 3 cm long, were made over the anterior aspect of the arm. The proximal incision was placed between the deltoid and biceps muscles, approximately 6 cm distal to the acromion. The distal incision was made along the lateral border of the biceps, approximately 5 cm proximal to the elbow crease. A sub-brachialis, extraperiosteal tunnel was carefully developed between the two incisions. The plate was introduced through this tunnel and advanced across the fracture site without directly exposing the fracture fragments. The dissection was maintained along the anterior or anteromedial surface of the humerus to reduce the risk of radial nerve injury. The musculocutaneous nerve was identified and protected during distal dissection. Fracture reduction was achieved using manual traction, and alignment was assessed under fluoroscopic guidance. A minimum of two bicortical screws were inserted into the proximal and distal main fracture fragments. Rotational alignment was evaluated using the cortical step sign and diameter difference sign. Final implant position and fracture alignment were confirmed fluoroscopically. The operative duration ranged from 60 to 120 minutes, with a reported mean of 90 minutes.

**Postoperative Management and Follow-up**: Immediate postoperative radiographs were obtained to assess fracture alignment and implant position. Wound inspection was performed on the second postoperative day, and sutures were removed on postoperative day 15. Passive shoulder and elbow range-of-motion exercises were initiated from the second postoperative day. Active mobilization was introduced after suture removal, according to patient comfort, under physiotherapy supervision. Patients underwent monthly clinical follow-up, with radiological assessments performed at approximately four-week intervals. The reported follow-up duration ranged from 6 to 20 months.

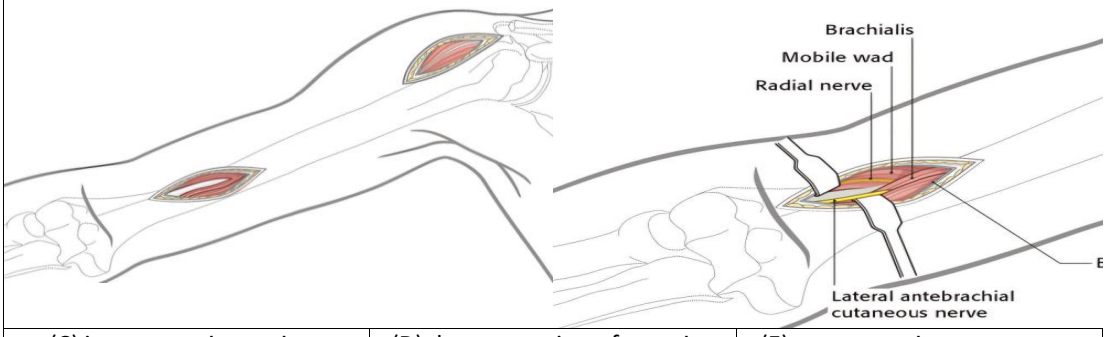
**Outcome Assessment: Radiological outcomes included time to fracture union, delayed union**, nonunion, and malalignment. Serial radiographs were used to monitor fracture healing. RHUM scores were measured at three and six months and functional outcomes using the Rodríguez-Merchán criteria at six months. Postoperative complications, including infection, neurological injury, implant-related problems, and malunion, were documented.

**Statistical Analysis**: Categorical variables were expressed as frequencies and percentages, while continuous variables were presented using the reported means and ranges.

## RESULTS

(A) Schematic illustration of proximal and distal surgical incisions

(B) anatomical illustration of the distal surgical approach and relevant neurovascular structures;




(C) intraoperative patient positioning

(D) demonstration of anterior plate positioning and surgical incision sites;

(E) postoperative appearance of the surgical wounds.



**Demographic and Fracture Characteristics:** A total of 30 patients underwent minimally invasive anterior bridge plating for diaphyseal humeral fractures. The study included 18 males (60%) and 12 females (40%), with a mean age of 38.97 years (range: 18–80 years). Most patients (66.7%) were aged 21–50 years. Road traffic accidents were the leading cause of injury (43.3%). Right-sided fractures accounted for 60% of cases. According to the AO classification, 18 fractures (60%) were type A and 12 (40%) were type B, with no type C fractures. All patients underwent anterior bridge plating within 1–8 days of injury. The mean operative duration was 90 minutes (range: 60–120 minutes). The reported follow-up period ranged from 6 to 20 months.

**Table 1. Demographic and injury characteristics of the study population (n = 30)**

| Characteristic | Category | n (%) or value |
|---|---|---|
| **Age** | Mean | 38.97 years |
| **Age** | Range | 18–80 years |
| **Age group** | 21–50 years | 20 (66.7%) |
| **Sex** | Male | 18 (60.0%) |
| | Female | 12 (40.0%) |
| **Injury mechanism** | Road traffic accident | 13 (43.3%) |
| | Other mechanisms, combined | 17 (56.7%) |
| **Fracture side** | Right | 18 (60.0%) |
| | Left | 12 (40.0%) |
| **AO fracture type** | Type A | 18 (60.0%) |
| | Type B | 12 (40.0%) |
| | Type C | 0 (0.0%) |

**Radiological Outcomes:** The mean radiological union time was 12.2 weeks. Union occurred within 16 weeks in 27 patients (90%), while three patients (10%) experienced delayed union, subsequently achieving complete union. All 30 fractures ultimately united, with no reported nonunion. One patient (3.3%) developed external rotational malunion.

**Functional Outcomes:** The reported mean RHUM score increased from 8.63 at three months to 10.86 at six months, representing a numerical improvement of 2.23 points. According to the Rodríguez-Merchán criteria, more than 50% of patients achieved excellent functional outcomes at six months. Four patients (13.3%) had fair outcomes, while none had poor outcomes. The exact distribution of excellent and good outcomes was not available. The patient with rotational malunion had a RHUM score of 12 and a fair Rodríguez-Merchán outcome; corrective osteotomy was advised.

**Table 2. Radiological and Functional Outcomes following anterior bridge plating (n = 30)**

| Parameter | Findings |
|---|---|
| **Mean operative time** | 90 minutes |
| **Mean radiological union time** | 12.2 weeks |
| **Union within 16 weeks** | 27 (90%) |
| **Delayed union** | 3 (10%) |
| **Final fracture union** | 30 (100%) |
| **Mean RHUM score, 3 months** | 8.63 |
| **Mean RHUM score, 6 months** | 10.86 |
| **Rodríguez-Merchán: Excellent** | 18 (60.0%) |
| **Rodríguez-Merchán: Good** | 8 (26.7%) |
| **Rodríguez-Merchán: Fair** | 4 (13.3%) |
| **Rodríguez-Merchán: Poor** | 0 (0.0%) |
| **Rotational malunion** | 1 (3.3%) |

**Postoperative Complications:** Three patients (10%) developed delayed union, and one (3.3%) experienced rotational malunion. No postoperative infections, radial or musculocutaneous nerve injuries, implant-related complications, or nonunions were reported.

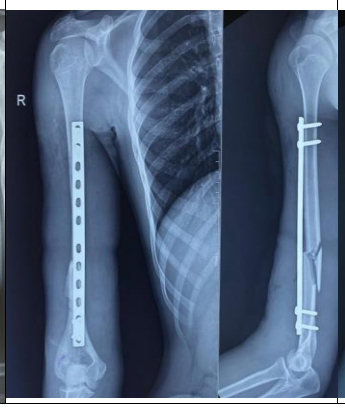
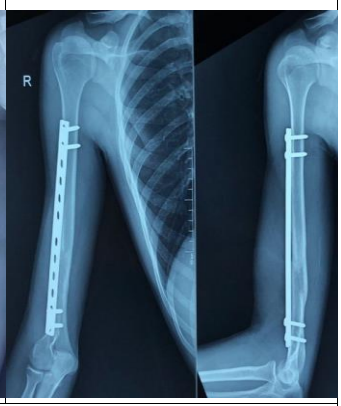
**Table 3. Postoperative complications (n = 30)**

| Complication | n (%) |
|---|---|
| **Delayed union** | 3 (10.0%) |
| **External rotational malunion** | 1 (3.3%) |
| **Nonunion** | 0 (0.0%) |
| **Surgical-site infection** | 0 (0.0%) |
| **Radial nerve palsy** | 0 (0.0%) |
| **Musculocutaneous nerve palsy** | 0 (0.0%) |
| **Implant-related complications** | 0 (0.0%) |
| | |

**Table 4: Comparison of the present study with other studies**

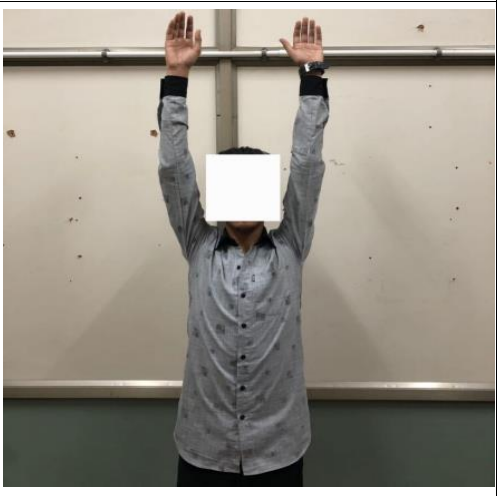
| Study | Mean union time | Major outcomes |
|---|---|---|
| Present study (2021–2024) | 12.2 weeks | 100% final union; 86.7% excellent/good Rodríguez-Merchán outcomes |
| Livani & Belangero (2004) [2] | 8–12 weeks in most cases | Good functional recovery; one case had more prolonged healing |
| Shetty et al. (2011) [5] | 12.9 weeks | 84.3% excellent UCLA shoulder outcomes |
| Kumar et al. (2012) [6] | 6.9 months plating; 8.7 months nailing | Plating and nailing compared; different fixation techniques |
| Mahajan et al. (2016) [7] | 45 days reported mean | 95.8% primary union; 4.17% nonunion |
| Sidhu et al. (2024) [12] | Mostly 12–16 weeks | 95% primary union; 82.5% excellent shoulder outcomes |
| Neerudi et al. (2026) [14] | ABP reported to favour earlier union | Nonunion: ABP 1/40; ORIF 2/40 |

**Case 1: Radiological and functional outcomes following anterior bridge plating of a humeral shaft fracture**

| A) Preoperative | B) Postoperative | C) Follow-up radiographs at 10 months |
|---|---|---|
|  |  |  |

Clinical photographs

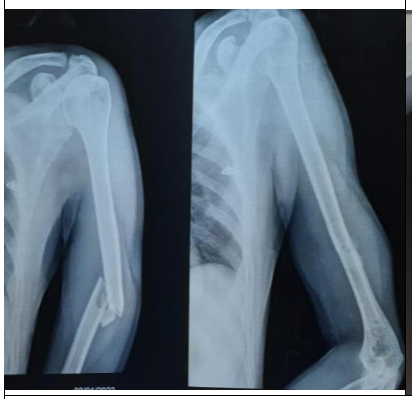
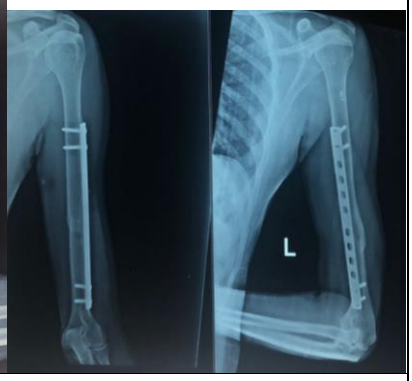




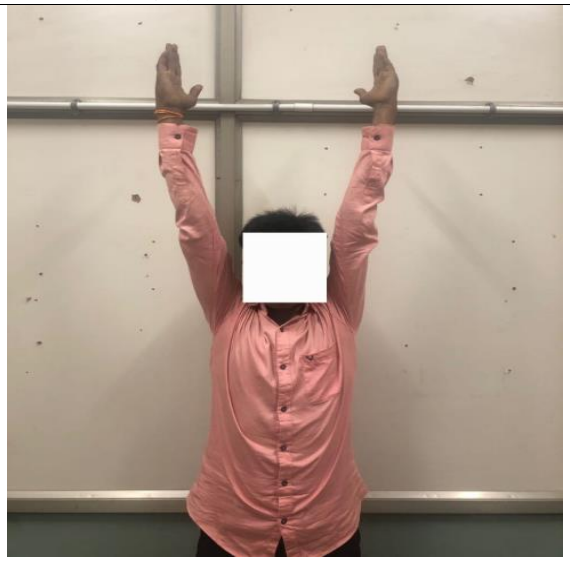




**Case 2: Radiological and Functional Outcome at 10 Months**

| A) Preoperative | B) Postoperative | C) Follow-up radiographs at 10 months |
|---|---|---|
|  |  |  |

Clinical photographs









## DISCUSSION

This prospective study evaluated anterior bridge plating in 30 patients, demonstrating a mean union time of 12.2 weeks, 100% eventual union, and 86.7% excellent or good functional outcomes, consistent with previous studies [2,5,7,12]. The mean age was 38.97 years, with 60% males, comparable to Shetty et al. [5] and Mahajan et al. [7]. Road traffic accidents accounted for 43.3% of injuries, while 60% of fractures were AO type A and 40% type B.

The mean operative duration was 90 minutes, comparable to 91.5 minutes reported by Shetty et al. [5]. A 12-hole, 4.5-mm dynamic compression plate was inserted through two 3-cm incisions. Livani and Belangero described similar biological fixation principles [2], while Zhiquan et al. demonstrated MIPO feasibility in middle- and distal-third humeral fractures [4].

The mean radiological union time was 12.2 weeks, comparable to 12.9 weeks reported by Shetty et al. [5]. Livani and Belangero demonstrated satisfactory healing following bridge plating [2], while Sidhu et al. reported 95% union, mostly within 12–16 weeks [12]. Kumar and Bade also observed favourable radiological outcomes [10], supporting the effectiveness of MIPO in fracture consolidation. Three patients (10%) experienced delayed union, but all eventually achieved union, with no nonunion. In contrast, Mahajan et al. reported 4.2% nonunion [7], while Sidhu et al. reported 5%, requiring further intervention [12]. These findings are encouraging but require cautious interpretation due to the small sample size.

The mean RHUM score improved from 8.63 at three months to 10.86 at six months. According to Rodríguez-Merchán criteria, 60% achieved excellent, 26.7% good, and 13.3% fair outcomes, with 86.7% achieving excellent or good results. Shetty et al. reported excellent shoulder and elbow outcomes in 84% and 81%, respectively [5]. Mahajan et al. [7] and Pancholi et al. [11] also demonstrated favourable functional recovery following anterior bridge plating. Sidhu et al. reported excellent UCLA shoulder and Mayo elbow scores in 82.5% and 77.5% of patients, respectively [12]. Kumar and Bade also demonstrated satisfactory functional recovery [10]. However, differences in functional scoring systems, follow-up duration, and rehabilitation protocols limit direct comparisons between studies.

No postoperative infection, nerve palsy, implant failure, or nonunion was reported. However, one patient (3.3%) developed external rotational malunion. Apivatthakakul et al. highlighted neurovascular risks associated with humeral MIPO [3], emphasising the importance of careful dissection, plate positioning, and intraoperative alignment assessment. Kumar et al. reported favourable outcomes with plating and nailing, with differences in union and complications [6]. The FISH trial found no significant functional difference between surge4y and bracing at 12 months, despite higher nonunion rates with bracing [9]. Oliver et al. reported similar findings [13]. Neerudi et al. observed nonunion in 1/40 ABP and 2/40 ORIF patients, favouring ABP outcomes [14]. However, the absence of a control group in the present study prevents conclusions regarding comparative superiority.

## CONCLUSION

This prospective observational study demonstrated favourable radiological and functional outcomes following minimally invasive anterior bridge plating for diaphyseal humeral fractures in 30 adult patients. The mean radiological union time was 12.2 weeks, with 90% of fractures achieving union within 16 weeks. All fractures ultimately united, although three patients experienced delayed union and one developed rotational malunion. Functional assessment at six months demonstrated excellent outcomes in more than half of the patients, while four patients had fair outcomes. No cases of nonunion, postoperative infection, neurological injury, or implant-related complications were reported. These findings suggest that anterior bridge plating may be a useful surgical option for appropriately selected humeral shaft fractures. However, the small sample size, absence of a comparison group, and limitations in outcome reporting restrict the generalizability of the findings. Larger prospective comparative studies with standardized functional and radiological assessments are warranted.

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