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# Prospective study of clinical, radiological and functional outcome of anterior bridge plating for shaft of humerus fracture

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## ABSTRACT

**Background:** Shaft of humerus (SOH) fracture has been conventionally treated with either open reduction internal fixation with plate osteosynthesis or immobilization as conservative treatment. Intramedullary interlocking nailing (IMIL) and anterior bridge plating (ABP) are both newer modalities of internal fixation for SOH fracture. Rotator cuff irritation is a known complication of IMIL nailing of the humerus. Here, we present clinical, radiological, and functional outcome of SOH fracture fixation by ABP using a minimally invasive method.
**Methods:** Thirty patients with SOH fracture were treated surgically via an anterior minimally invasive plate osteosynthesis (MIPO) approach with ABP. There were 21 male and 9 female patients, and the average age was 38.6±10.45 years. The mechanism of injury was road traffic accidents (60%) and ground level fall (40%). Functional assessments were obtained with University of California at Los Angeles (UCLA) score and mayo elbow performance index (MEPI) during the follow-up period.
**Results:** At the end of 6 months follow-up, 29 (96.7%) patients had excellent to good UCLA and MEPI scores. Varus/valgus angulation was reported in 4 (13.3%) patients. Two patients (6.7%) had radial nerve neuropraxia and delayed union, while 1 (3.3%) patient had screw back-out or loosening. The mean duration of radiation exposure was 178±41.2 seconds. ABP for SOH fractures is a safe and effective treatment modality.
**Conclusions:** This treatment protocol produces high rates of union, excellent functional recovery, and minimal biological disruption.

**Keywords:** Shaft, Humerus, Fracture, ABP, Anterior bridge plating

## INTRODUCTION

Humeral shaft fractures account for 1 to 3% of all fractures in adults and for 20% of all humeral fractures.[1-3] These fractures have an annual incidence from 13 to 14.5 per 100,000 people.[4,5] The goals of treatment include not only solid bone healing but also restoration of limb function and full range of motion as soon as possible. While non-operative management is still the standard treatment for isolated humeral shaft fractures, this method can present unsatisfactory results, such as nonunion and shoulder impairment.[6-9] Furthermore, 14% of patients treated with this method have restricted range of motion and 12.6% have consolidation, with more than 10° of displacement.[10]

Regarding surgical treatment, there is considerable conflict between the need for absolute anatomical reduction and the desire for soft tissue preservation. While classical intramedullary nailing is minimally invasive, it can result in rotator cuff damage, causing shoulder impingement. This can occur either due to subacromial impingement by a prominent nail or scar tissue and/or damage to the rotator cuff in its critical zone of hypovascularity, resulting in tendon tears. Indeed, precise reduction and absolute stable fixation involve a biological

price in terms of soft tissue loss. To overcome this drawback of stable mechanical fixation, several studies have examined the alternative of biological fixation and have found the latter to be superior.[11,12] This has led to advancements in the techniques of biological fixation including the development of stabilization systems.[13,14] Anterior bridge plating, which utilizes the minimally invasive approach popularly known as the minimally invasive plate osteosynthesis (MIPO) technique, is the latest entrant on this list.[15]

The present study aimed to evaluate the radiological outcomes of anterior bridge plating through MIPO of humeral shaft fractures, in terms of time required for radiological union. We also aimed to study the clinical and functional outcomes assessed using the mayo elbow performance index (MEPI) and University of California, Los Angeles (UCLA) scoring systems as well as by clinical examination of the range of motion of the shoulder and elbow joints. Other variables of interest included the duration of surgery and radiation exposure. The study was conducted based on the hypothesis that the anterior bridge plating technique through MIPO of humeral shaft fractures was associated with favorable radiological, clinical, and functional outcomes by virtue of minimal soft tissue dissection.

## METHODS

### *Patients*

This longitudinal prospective study without a control group was conducted between October 2017 and May 2018 at our tertiary care institution after receiving approval from the institutional scientific and ethical committee (RCSMGMCK/Pharmac/Ethics Comm/23/2018). The study complied with the requirements of the declaration of Helsinki. Written informed consent was obtained from all 30 patients with humeral shaft fracture who were included in the study after applying the inclusion and exclusion criteria for anterior bridge plating through MIPO.

The inclusion criteria included skeletally mature patients with closed fractures as well as Gustillo Anderson type I open fractures of the humeral shaft. We excluded patients with pathological fractures, as well as cases with intraarticular extension of the fracture, associated fracture of the same limb radius, ulna, or clavicle, or associated neurovascular injury.

### *Methods*

The anterior approach was used to perform MIPO surgery using skin incisions of approximately 3 cm proximally as well as distally. An extraperiosteal tunnel was prepared and the plate was slid into place following manual reduction, after which it was fixed with two or three bicortical screws proximally and distally.

**Figure 1: Placement of the anterior bridge plate, showing skin incision, soft tissue dissection, and plate insertion from distal to proximal.**

### *Methods of assessment*

Radiographs of the humerus (anteroposterior and lateral views) were obtained on postoperative day 1 as well as at follow-up at 1 month, 3 months, 6 months, and until the time of fracture union. The clinical and functional outcomes of the procedure, using the MEPI score for the elbow and UCLA score for the shoulder, were assessed from postoperative day 3 till the time of discharge on postoperative day 13, as well as at each follow-up. In addition, the duration of surgery and duration of radiation exposure were recorded.

**Figure 2: Fluoroscopic image.**

**Figure 3: Preoperative radiograph of the arm (anterior-posterior view).**


**Figure 4: Radiograph of the arm on postoperative day 1 (anterior-posterior view).**

### *Statistical analysis*

Categorical variables are expressed as counts and percentages, and numerical variables are expressed as mean±standard deviation (SD). Associations among study groups were assessed using the Fisher's test, student's t test, and chi-square test. A p value of less than 0.05 was considered significant.

## RESULTS

The mean age of patients was 38.6±10.45 years. There was male preponderance at 70%.

### *Radiological outcomes*

Fracture union was observed in the majority of the patients (18 of 30, 60%) at 9-12 weeks postoperative; union occurred in 7 (23.3%) and 3 (10%) patients at 5-8 weeks and ≤4 weeks postoperative, respectively. Only 2 (6.7%) fractures took >12 weeks to unite, due to smoking and osteoporosis (Table 1).

**Table 1: Time to radiological union following anterior bridge plating through MIPO of humeral shaft fractures.**

| Time to radiological union (weeks) | N | Percent (%) |
|---|---|---|
| **≤4** | 3 | 10.0 |
| **5-8** | 7 | 23.3 |
| **9-12** | 18 | 60.0 |
| **>12** | 2 | 6.7 |
| **Total** | 30 | 100.0 |

### *Clinical and functional outcomes*

### *Postoperative MEPI score*

The MEPI score was classified as follows: a score of >90 was graded as excellent, 75-89 as good, 60-74 as fair, and <60 as poor. At 6 months, almost all (29 of 30, 96.7%) patients had an excellent MEPI score, while only one patient had a good score (Table 2). There was no significant difference in MEPI scores over time (p>0.05).

**Table 2: Postoperative MEPI score at discharge and at each follow-up.**

| MEPI score | On discharge | | 1 month | | 3 months | | 6 months | | p value |
|---|---|---|---|---|---|---|---|---|---|
| | N | Percent (%) | N | Percent (%) | N | Percent (%) | N | Percent (%) | |
| **Excellent (>90)** | 24 | 80.0 | 25 | 83.3 | 27 | 90.0 | 29 | 96.7 | |
| **Good (75–89)** | 2 | 6.7 | 3 | 10.0 | 2 | 6.7 | 1 | 3.3 | |
| **Fair (60–74)** | 4 | 13.3 | 2 | 6.7 | 1 | 3.3 | 0 | 0 | >0.05 |
| **Poor (<60)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| **Total** | 30 | 100.0 | 30 | 100.0 | 30 | 100.0 | 30 | 100.0 | |

### *Postoperative UCLA score*

The UCLA score was classified as follows: >27 points was graded as excellent to good and <27 as fair to poor. At discharge, 26 (86.7%) patients had an excellent to good score while the remaining 4 (13.3%) patients had a fair score. The UCLA score at 6 months was excellent or good in almost all (29 of 30, 96.7%) patients while only one patient had a fair score (Figure 5). There was no significant difference in UCLA scores over time (p>0.05).

### *Range of motion*

The difference in range of motion between operated and non-operated sides was statistically significant (p<0.05). However, there was no clinical difference in subjective postoperative range of motion.

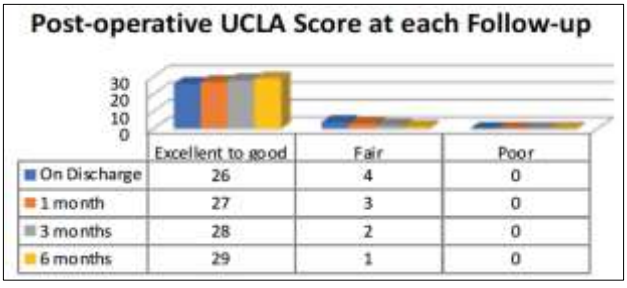


**Figure 5: Postoperative UCLA scores at discharge and at each follow-up.**


**Figure 6: (a) sutured wound, (b), (d) and (f): postoperative range of shoulder movement at 3 month, (c) postoperative range of movement of elbow at 3 month, (g) postoperative radiograph of the arm (anterior-posterior and lateral view) at 3 months, and (h) radiograph of arm on postoperative day 1 (lateral view).**

***Duration of surgery and duration of radiation exposure***

Mean duration of radiation exposure was 178.7±41.2 seconds. While 10 (33.3%) patients were exposed to radiation for 100-150 seconds, a similar number (9, 30%) was exposed for 150-200 seconds (Table 3). Eleven (36.7%) patients were exposed for 200-250 seconds.

**Table 3: Radiation exposure in patients treated with anterior bridge plating through MIPO of humeral shaft fractures.**

| Radiation exposure (seconds) | N | Percent (%) |
|---|---|---|
| **100-150** | 10 | 33.3 |
| **150-200** | 9 | 30.0 |
| **200-250** | 11 | 36.7 |
| **Total** | 30 | 100.0 |

***Complications***

Varus/valgus angulation occurred in 4 (13.3%) patients. Once case each of radial nerve neuropraxia, delayed union, and screw back out/loosening occurred.

## DISCUSSION

In recent times, MIPO and intramedullary nailing have emerged as popular procedures for surgical biologic fixation. In the treatment of humeral shaft fractures, MIPO using an anteriorly placed plate is advantageous since neither the fracture site nor the radial nerves need to be dissected. In contrast, intramedullary nailing involves insertion of the nail into the bone marrow cavity, including the fracture segment. Furthermore, while intramedullary nailing may lead to major shoulder pathology over time, the rotator cuff is spared in anterior bridge plating.[27] Indeed, the primary advantage of anterior bridge plating is the combination of stability with minimal soft tissue and periosteal disruption.[16,17,22,23] Additionally, unlike posterior plating, it requires a smaller incision and adheres to the MIPO principle, which makes it biologically and cosmetically preferable. Moreover, anterior bridge plating affords relative and elastic stability, which is superior to the absolute rigidity offered by open reduction and internal fixation using the posterior approach. This is because in the former, healing takes place by secondary healing and callus formation, which is stronger, whereas the latter involves primary healing without callus formation.[17,24,26] Furthermore, the purpose of using a long plate in anterior

bridge plating is to decrease the stress per unit area by distributing it over a larger surface area.[25] Therefore, the plate placed on the anterior tensile surface can withstand a larger amount of rotational and bending stresses than the shorter plate. In the present study, we found that the anterior bridge plating technique through MIPO of humeral shaft fractures was associated with favorable radiological (time required for radiological union), clinical, and functional (MEPI scores, UCLA scores, and range of motion) outcomes. Most of the fractures (60%) in our study were united in 9-12 weeks. Similar observations were noted in the studies of Sharma et al, Vegad et al, Ibrahim et al, and Mahajan et al.[18,20,21,26]

At discharge, 26 (86.7%) patients had an excellent to good UCLA score while the remaining 4 (13.3%) patients had a fair score. At 6 months' follow-up, 29 (96.7%) patients had an excellent to good score while only 1 (3.3%) patient had a fair score. There was no significant difference in UCLA score ($p>0.05$). This is similar to the findings of Vegad et al and Ibrahim et al.[20,21] At discharge, 24 (80%) patients had an excellent MEPI scores while 2 (6.7%) and 4 (13.3%) patients had good and fair scores, respectively. At 6 months' follow-up, 29 (96.7%) patients had excellent scores while only 1 (3.3%) patient had a good score. There was no significant difference in MEPI score as per the chi-square test ($p>0.05$). This is comparable to the studies of Mahajan et al and Sharma et al.[18,26] Although the difference in the range of motion between the operated and non-operated sides was statistically significant, there was no clinical difference in subjective postoperative strength.

In the present study, we found varus/valgus angulation in 13.3% patients and one case each of radial nerve neuropraxia, delayed union, and screw back out/loosening. These complications were similar to those in the studies by Sharma et al and Mahajan et al.[18,26]

The current study was limited by the lack of a comparison group and by the short duration of follow-up.

## CONCLUSION

We found that the anterior bridge plating technique through MIPO of humeral shaft fractures was associated with favorable radiological (time required for radiological union), clinical, and functional (MEPI scores, UCLA scores, and range of motion) outcomes. Anterior bridge plating for mid-shaft humerus fractures is a safe and effective treatment modality yielding high rates of union, excellent functional recovery, minimal biological disruption, and better cosmesis.

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