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Original Research Article

Functional outcome of anterior bridge plating: a new approach for treating mid shaft humerus fractures

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ABSTRACT

Background: The humerus can be considered the most versatile bone in the human body. Plating can be performed using a classic open approach or minimally invasive methods. Anterior bridge plating with minimally invasive technique in shaft humerus fractures is reported as an acceptable less traumatic and reproducible procedure by several authors. The present study was undertaken to evaluate the efficacy of anterior bridge plating.
Methods: The study was carried out involving 35 patients who met the selection criteria and were operated at the tertiary care centre. A 4.5 mm Locking Narrow DCP (Dynamic Compression Plate) was used to fix these fractures. The assessment of the patients was done based on functional and radiological outcomes periodically. Four patients were lost to follow-up, so the final assessment was done based on 31 cases.
Results: Of the 31 patients in the study, 23 were males and 8 were females. Twenty three of the thirty-one patients (74.1%) had a history of road traffic accidents. The mean radiological fracture union time was 13.2 weeks (range: 10-16 weeks). Shoulder function was excellent in 26 cases (83.8%) and Elbow function was excellent in 28 cases (90.3%).
Conclusions: Mid shaft humerus fractures can be effectively treated with anterior bridge plating with advantages of shorter fracture union time, smaller scars and lower incidence of iatrogenic radial nerve palsies. It also gave better Functional outcome with good patient satisfaction.

Keywords: Minimally invasive plate osteosynthesis, Anterior bridge plating, Midshaft humerus fracture

INTRODUCTION

Shaft Humerus fractures are common among all age group of people resulting from road traffic accidents, trivial trauma, fall from height.[1-3] The humerus can be considered the most versatile bone in the human body as it can successfully be approached in different ways for fracture fixation including functional bracing, plating (posterior, lateral, and anterior), and intramedullary nailing (antegrade and retrograde).[4-8] Shaft humerus fractures can be managed conservatively in the form of immobilization with a splint, slab and cast. Most of the humeral shaft fractures can be managed successfully with functional brace.[9,10] Shaft humerus fractures can be surgically treated in the form of open reduction and internal fixation with a dynamic compression plate. Minimally invasive procedure options include either closed reduction and internal fixation with IMIL nailing or closed reduction and internal fixation with minimally invasive plate osteosynthesis which is carried out in the form of anterior bridge plating.[6,8,11-13]

Recent literature has reported that plating is a better option compared to nailing because of the higher complication rates associated with nailing like rotator cuff tendinopathy and the interference with shoulder functions.[6,14]

Literature is also of the opinion that MIPPO has advantage over conventional plating since there is less soft tissue damage, less or no disruption of periosteal blood supply (reducing the chances of nonunion), less or no chance of iatrogenic radial nerve injury and cosmetically better surgical scar.[15]

Objective of this study was to evaluate the clinical, radiological and functional outcomes of bridge plating in patients with closed midshaft humerus fractures.

METHODS

A prospective study was conducted in a tertiary care hospital (Calcutta National Medical College and Hospital) in Kolkata from May 2022 to November 2023. A total of 35 patients with fracture shaft humerus who met the inclusion criteria were enrolled and treated with anterior bridge plating by minimally invasive technique. A 4.5 mm Locking Narrow DCP (Dynamic Compression Plate) was used to fix these fractures and all the surgeries have been performed by the same surgeon. The cases were followed-up for a minimum period of 18 months to evaluate radiological and functional outcomes. The functional outcomes of shoulder and elbow joints were assessed by UCLA and MEPS respectively. Four patients didn't turn up for follow-up, so the final analysis was done based on 31 cases.

The inclusion criteria included skeletally matured patients with closed, mid shaft fracture of humerus and who consented to participate.

Exclusion criteria included patients with grade 2 (Gustilo-Anderson) onwards open fractures, any associated fractures or polytrauma patients, patients with neurovascular injuries, pathological fractures, concomitant other medical illness such as malignancy, drug addict patients (alcohol and others). Patients who presented more than 2 weeks of injury were also excluded from the study.

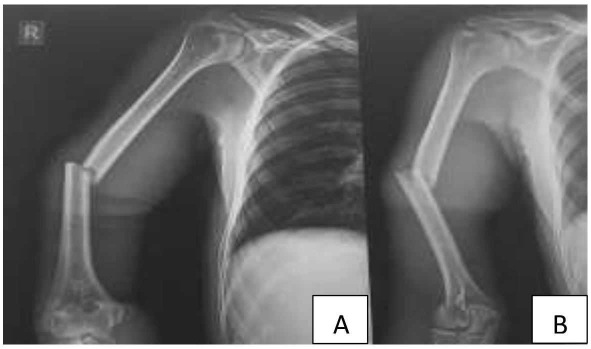

Figure 1 (A and B): Preoperative antero-posterior (AP) and lateral (Lat) X-ray.

Figure 2: Intraoperative; (a) Around 3 cm both proximal and distal incision, (b) Plate size determined under fluoroscopic guidance, (c) Plate insertion from distal incision.

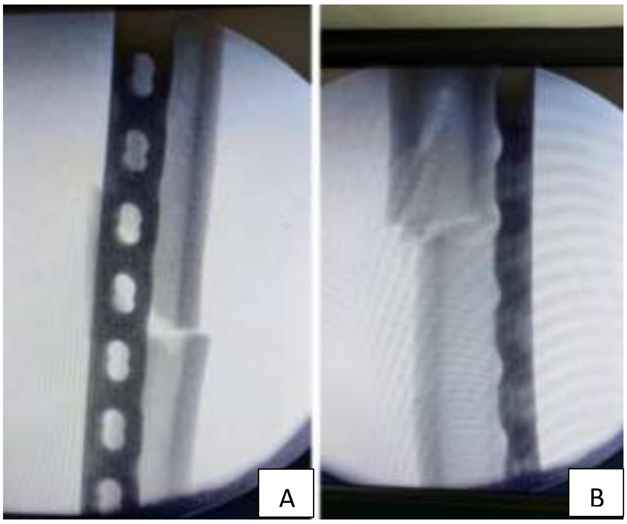

Figure 3 (A and B): Intraoperatively plate position was checked under c-arm guidance.

A preoperative clinical examination of the affected arm was carried in all aspects like abrasions, swelling, contusion, puckering and neurovascular deficit (chiefly Radial nerve status). Antero posterior (AP) and lateral (Lat) radiographs of the humerus with both shoulder and elbow joint were taken (Figure 1). These radiographs were used to classify the fractures and also to decide the appropriate length of implant and planning the surgery.

Operative techniques

Patient were placed in supine position on a radiolucent table with the affected arm in 90-degree abduction and forearm in full supination. No tourniquet was used. A 3 cm longitudinal was made at the interval between the proximal part of the biceps brachii muscle medially and the deltoid muscle laterally. Dissection was then carried down to the humerus, where the anterior border of the humerus distal to the crest of greater tubercle is identified. Distally, another 3-cm incision was made along the lateral border of the biceps muscle approximately 1 cm proximal to the elbow flexion crease (Figure 2). The lateral quarter of the brachialis muscle was then split longitudinally to expose the anterior cortex of the distal humerus and a point located on the anterior middle line just above the coronoid fossa was identified under direct vision. A submuscular extra-periosteal tunnel was made between the brachial musculature and the underlying periosteum with the help of periosteal elevator inserted through the proximal incision and directed distally and then inserted through the distal incision and directed proximally. Now the provisional reduction was done by gentle traction on the arm by keeping the elbow in around 80-degree flexion under C-arm guidance. Then a contoured dynamic compression plate of appropriate size was inserted through the distal incision, passed through the fracture site and till the proximal incision through the submuscular tunnel. Two K-wires were then inserted both proximally and distally through a screw hole of the plate to temporarily fix the plate. Then plate position and fracture reduction were checked under C-arm in both AP and Lateral view (Figure 3). At least 2-3 screws were inserted on either side of the fracture to fix the plate with the bone. Throughout the procedure, radial nerve was neither explored nor manipulated. Fixation and implant placement were confirmed under C-arm and were found to be satisfactory. After giving wash to the wound, closure was done in layers. Immediate post operatively neuro-vascular status was checked and evaluated and found to be intact.

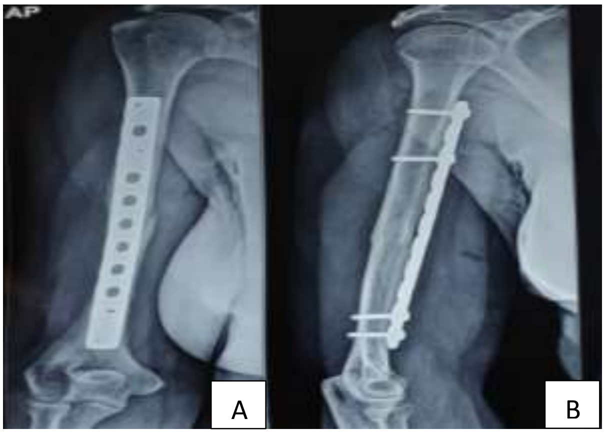

Figure 4 (A and B): 6 months postoperative X-ray.

Immediate post op care

Post operatively patients were kept in shoulder arm pouch for 6 weeks. Patients were encouraged to carry out active movements of wrist and elbow joints and shoulder pendulum exercises from day 3. On post op day 14 all sutures were removed. Passive and active-assisted shoulder ROM exercises were started under supervision of a physiotherapist at 2 weeks after surgery. Active abduction beyond 90° and active rotation were allowed at 3-4 weeks after surgery. The patient was allowed to gradually resume preoperative activities with muscle strengthening and return to full spectrum of activities at 9-12 weeks after surgery.

Figure 5: Functional shoulder movements; (a) external rotation, (b) forward flexion, (c) internal rotation at 6 months post-op.

Figure 6: (a) Elbow movements at 6 months post-op, (b) Small healed scar.

Follow up care

Follow-up was done at 4 weeks from the date of surgery, then monthly for the next 6 months. In each follow-up visit full length skiagram of the operated arm was taken in both AP and Lateral view to see radiological union (Figure 4). Union was defined as the presence of bridging callus in 3 of the 4 cortices seen on the anteroposterior and lateral radiographic views of the humerus. Alignment was also assessed on the final anteroposterior and lateral radiographs of the humerus.

The functional outcome for elbow was measured by Mayo's elbow performance score (MEPS) which is graded as excellent - ≥90 points, good -75-89 points, fair-60-74 points and poor <60 points, and the functional outcome of shoulder was measured by UCLA (University of California at Los Angeles) shoulder score system which is graded as excellent 34-35 points, good 29-33 points, fair 21-28 points, and poor 0-20 points.

A patient satisfaction questionnaire was administered and the patients were asked to answer at the end of the study. Answers were collected in yes/no format only. Questionnaire was (1) absence of pain and discomfort (2) is he okay with function of limb (3) is he happy with life and resuming of pre-trauma activity (4) likelihood of recommendation of same procedure to others. Patient was called fully satisfied if he answered all questions as yes, satisfied if he answered first three questions as yes and deemed as not satisfied if he answered only first two questions as yes.

Statistical analysis

Data was entered in Microsoft excel after data collection. Excel was used to generate tables. Descriptive statistics such as mean, SD and percentage was used to present the data.

RESULTS

Out of 31 cases, majority of the patients belong to the age group 25-35 years and mean age was 37.12 years. Most of the patients were male 23 cases (74.1%) and involved dominant arm in 20 cases. Road traffic accident (RTA) was the most common mode of injury, found in 23 cases (74.1%), two patients sustained injury following direct blow by blunt object (stick/lathi) hit on the arm and rest patients had a history of fall. We had twelve cases of A3 type; nine cases of B2 type; four cases of B1 type; three cases each of B3 and C1 type of fracture according to AO classification (Table 1).

The mean surgical time was 77.09 minutes (range: 60–90 minutes) and mean radiation exposure was 76.45 seconds (range: 50–100 seconds). The average blood loss during surgey was 70.16 ml. The mean radiological fracture union time was 13.2 weeks (range: 10–16 weeks) (Table 2).

Shoulder function based on the UCLA score was found to be excellent in 26 (83.8%) cases, good in 4 cases (12.9%), fair in one case (Figure 5). Similarly, 28 (90.3%) cases had excellent outcome based on MEPS, while 2 cases had good and one case had fair outcome (Figure 6 and Table 3).

Table 1: Demographic characteristics of patients (n=31).

Characteristics		Number of patients	Percentages
Age (in years)	<25	2	7.5
	25-35	13	41.9
	36-45	10	32.2
	46-55	4	12.9
	>55	2	7.5
Sex	Male	23	74.2
	Female	8	25.8
Mode of injury	Road traffic accidents	23	74.2
	Fall	6	19.3
	Direct blow	2	7.5
Classification (AO)	A3	12	38.7
	B1	4	12.9
	B2	9	29.2
	B3	3	9.6
	C1	3	9.6

Table 2: Demonstration of intraoperative variables and union time.

Characteristics	Mean	Range
Operative time(minutes)	77.09	60-90
Blood loss(ml.)	70.16	50-100
Radiation exposure (seconds)	76.45	50-100
Union time (weeks)	13.2	10-16

Table 3: Distribution of functional outcome score (n=31).

Characteristics	Excellent (no. case)	Good (no. of case)	Fair (no. of case)
UCLA score	26	4	1
MEPS	28	2	1

Table 4: Distribution of patient satisfaction after treatment.

Patient's satisfaction after treatment	Number of patients
Fully satisfied	23
Satisfied	7
Not satisfied	1
Total	31

According to questionnaire-based satisfaction quotient, 23 patients (74.1%) were fully satisfied, 7 patients (22.5%) were satisfied and one patient was not satisfied (Table 4).

There was one case of superficial infection, which healed with local care and antibiotics. Two patients had tingling over the lateral aspect of forearm due to injury to musculocutaneous nerve, which resolved spontaneously over a period of 8-12 weeks.

DISCUSSION

Albrecht Haller (1708-1777) proposed the hypothesis that bone was deposited in reaction to injury caused by the vascularity surrounding the reparative zone and Hunter (1728-1793) agreed with Haller's observations.[16] A fundamental component of minimally invasive fracture surgery is this early recognition of the role of the vasculature in fracture repair. MIPO techniques are gaining popularity as minimally invasive approaches for treating fractures continue to progress. The first case of MIPO for supracondylar femoral fractures was described by Krettek and Tscherne in 1996.[17] Significant deformation forces can be tolerated by long plates that span a wide zone of fragmentation and have only brief fixing on either end of the bone. Because the bending loads are spread out over a large section of the plate, there is less stress per unit area, which lowers the chance of the plate failing. The entire structure becomes elastic, allowing for the successful bridging of even minor fractures.[18,19]

MIPO has been documented earlier with fair outcomes for humeral shaft fractures. MIPO is superior to plate fixation and open reduction for humeral fractures by preserving the periosteal circulation while reducing the amount of soft tissue stress caused by open surgery. When a plate is applied to the bone using an open approach, it disrupts the local vascularization, resulting in osteonecrosis beneath the implant. This can lead to non-healing or delayed healing. In a study by Paris et al the rate of fracture non-union in conventional plate fixation was 5.8%.[20] When the implant is removed, there is a genuine risk of refracture due to poor primary bone healing in the absence of callus formation.[21,22] In our series, the union time for fractures was 13.2 weeks which is better than that reported by Zhiquan et al.[23]

The radial nerve's course is well described in text and literature.[24,25] Apivatthakakul et al reported that the mean distance between the closest portion of a plate and the radial nerve is 3.2 mm when the plate is positioned on the anterior side of the humeral shaft.[26] Furthermore, it was observed by Apivatthakakul et al that the radial nerve moved medially, nearer the distal end of the plate, when the forearm was pronated, putting it at danger of iatrogenic damage.[26] That is why, it is important to keep the forearm in its supinated position during the procedure. In our study, we didn't observe any case of radial nerve injury. Ziran et al compared the results between traditional plating and MIPO for mid and distal humeral shaft fractures and found that radial nerve injury occurred in 31.3% in conventional plating and none in MIPO.[27]

Apivatthakakul et al reported that the danger zone of musculocutaneous nerve is located between 18.37% and 42.67% of the humeral length away from the lateral epicondyle.[28] In our study, we had two cases of neuropraxia of musculocutaneous nerve. It happened mainly due to excessive traction during plate positioning at the small distal incision which was made to avoid opening of the fracture site. The nerve can be protected by retracting the biceps medially.

The functional outcomes assessed by UCLA shoulder score and MEPS system in the affected shoulder and elbows were consistent with the literature.[21,29,30] In this study, shoulder function was excellent in 26 (83.8%) cases. The remaining cases had good and fair results. Similarly, 28 (90.3%) cases had excellent outcome based on MEPS. Most importantly, this function was achieved by 6 months postoperatively and all the patients regained full strength and returned to normal activities within 6 months post-surgery. This MIPO technique was also associated with less operative scar and better cosmesis and thus provide high patient's satisfaction which was also reflected in this study.

The limitation of the study was that we did not have any control group for comparison or another group treated with some other technique for humeral diaphyseal fracture fixation. A larger multicenter study with control groups will help us to arrive at a definitive conclusion.

CONCLUSION

Anterior bridge plating via MIPO is a complex technique and require a relatively long learning curve. However, the results are good and reproducible and there are few risks. The plate placement and indirect reduction requires experience. Using this anterior bridge plating instead of other traditional plating and nailing methods is laudable, even though randomized controlled trials are required. This anterior bridge plating technique is less traumatic and provide satisfactory outcomes in patients. Therefore, we would recommend considering this procedure as one of the treatment options in patients with closed mid shaft humerus fractures without any nerve palsy.

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