

Research Article

A study on surgical management and functional outcome of humerus shaft fractures using anterior bridge plating (ABP) by minimally invasive technique

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Abstract: Introduction: In today's surgical scenario, anterior bridge plating (ABP) of long bone shaft fractures, especially mid- and lower-shaft fractures of the humerus, is becoming popular among orthopaedic surgeons, as it facilitates good alignment of fragments while preserving soft tissue attachment and vascularity, which in turn gives excellent results. This is unlike the previously used approach of proper anatomical reduction, which disturbs soft tissue and vascularity and carries a risk of direct nerve handling and injury to the radial nerve, contributing to relatively high rates of non-union and failure of plate fixation. Intramedullary nailing of the humerus, despite being minimally invasive, is a common cause of rotator cuff damage and impingement in many cases, and has therefore become an unattractive option for treating such fractures. Conservative treatment of these fractures, on the other hand, yields poor results and has become nearly obsolete. With rapid advances in surgical technique, anterior bridge plating (ABP) is gaining popularity among orthopaedic surgeons, as its minimally invasive nature (only two small incisions) protects the soft tissues and thus preserves vascularity and mechanical stability. **Objective:** To study the functional and radiological outcomes of humeral shaft fractures treated with anterior bridge plating using a minimally invasive technique. **Materials and Methods:** A series of 20 patients with humeral shaft fractures was selected for this study. Of the 20 patients (12 males and 8 females), most were within the 20–40-year age group. All patients were treated with an anterior bridge plate using the minimally invasive technique at our institute and were followed up for a period of 1 year and 6 months. The main outcome measures were the UCLA (University of California, Los Angeles) shoulder score and the MEPS (Mayo Elbow Performance Score) for elbow function, along with radiological and clinical assessment. **Results:** The average time to union in our study was 11.6 weeks (range: 8–20 weeks), with a union rate of 93.8%. One case developed non-union and underwent revision surgery, and another case had delayed union at 20 weeks due to distraction at the fracture site during fixation. These results compared favourably with other studies. Shoulder function assessed by the UCLA score averaged 34 ± 1 , and the mean MEPS for elbow function was 97.5. **Conclusion:** ABP provides stability with minimal soft tissue disruption, following MIPO principles. It has shown promising results, with an average fracture union time of 11.6 weeks and a union rate of 93.8%. This method also offers better cosmetic outcomes and fewer complications compared with traditional open reduction techniques.

Keywords: ABP, MIPO, UCLA, MEPS, union.

INTRODUCTION

The rapidly growing population, along with an ever-increasing number of vehicles, has led to a proportionate rise in road traffic accidents. The general incidence of humeral shaft fractures constitutes around 1–3% of all fractures^[1] in the human body, and they account for 14% of all humeral fractures^[2].

Humeral shaft fractures are most often caused by direct trauma, which produces transverse, comminuted, or oblique fracture patterns, whereas twisting injuries typically cause spiral fractures.

In a small percentage of cases, humeral shaft fractures are associated with a vascular injury.

Open fractures are uncommon but can represent serious injuries, particularly when associated with crushing, as in industrial accidents. For thousands of years, some form of external splintage was the only option for fracture management. It is evident that little has changed in the treatment of diaphyseal humeral fractures since ancient times, as these fractures generally heal within a short time. During treatment, patients remain mobile while the shoulder and elbow joints compensate for some degree of malalignment. However, patients in modern times demand faster union rates and an earlier return to pre-injury activities while preserving the function and motion of nearby joints. Many authors have preferred conservative management with a hanging arm cast^[3,4]. In our setup, patients have a habit of sitting cross-legged

and supporting the elbow on their thighs after casting, which defeats the purpose of gravity-assisted fracture alignment. Shoulder and elbow stiffness, non-union, and mal-union are commonly observed with such conservative methods^[5], especially in patients with risk factors such as alcoholism or obesity^[6]. In some cases, however, conservative treatment results in varus deformity and limitation of shoulder and elbow motion, leading to reduced function. Open reduction and internal fixation with plate and screws requires extensive soft tissue stripping and mobilisation of the radial nerve during surgery, with correspondingly high rates of radial nerve palsy^[7].

Non-operative treatment options span a wide spectrum, ranging from a simple sling and bandage to the extension cast technique. Even if the fracture unites with some malunion, anterior angulation of $<20^\circ$ and varus of $<30^\circ$ are usually well tolerated. The extensive range of motion offered by the shoulder and elbow joints means that small degrees of malunion do not significantly affect the patient's day-to-day activities.

Several techniques are available for operative fixation of humeral shaft fractures, such as TENS nailing, intramedullary nailing, and plate fixation. Recently, the MIPO technique for humeral fractures has been developed; this does not interfere with the biological union occurring at the fracture site and simply augments the natural healing process. Various neurovascular structures traverse close to the bone, which means that even a minimally invasive approach to the humeral shaft carries some risk. The most serious complication is radial nerve palsy.

Absolute anatomical reduction, achieved by compromising soft tissue and hence vascularity, is becoming a less favoured approach. Precise reduction and absolute stable fixation come at a biological price^[8]. Biological fixation of fractures with soft tissue preservation and near-acceptable reduction is becoming more widely accepted; however, it remains a matter of debate.

Evidence shows that biological fixation is far superior to stable mechanical fixation^[9]. This has driven the development and improvement of biological fracture fixation and stabilisation systems^[10,11]. Treatment of humeral fractures has evolved considerably, along with an understanding of their complications^[12-15].

Minimally invasive plating of a multifragmentary humeral shaft fracture is usually performed through a pair of incisions, one distal and one proximal. The distal incision is usually anterior, splitting the brachialis while avoiding the radial nerve as it penetrates the lateral intermuscular septum. A more lateral distal incision can be used for a plate running down the lateral side, but great care must be taken to avoid damaging the radial nerve. In both cases, the incision must be long enough

for the surgeon to confirm that the radial nerve (laterally) and the median nerve and brachial artery (medially) are protected. Proximal incisions are either anterior, with the plate running along the anterior surface, or lateral, with the plate running laterally or spiralling around to lie anteriorly in its distal extent. Minimally invasive plate osteosynthesis techniques are technically challenging and, while they reduce soft tissue damage, are not without their own risks.

There are two different approaches—anterior and anterolateral—each with a proximal and a distal window.

In the anterolateral approach, the proximal window lies between the biceps and brachialis, and the distal window is made at the lateral border of the biceps, 5 cm proximal to the elbow crease.

The **anterior approach** involves a proximal incision using the deltopectoral approach, while the distal incision is made by splitting the brachialis muscle (deep plane) into medial and lateral halves through the interval between the biceps and brachialis muscles (superficial plane).

Although this approach offers several advantages, including a smaller incision and preservation of the fracture site for biological fixation, it is not without its disadvantages. The musculocutaneous nerve and the radial nerve lie in close proximity to the surgical field. However, both nerves can be adequately protected by making a sufficiently long incision (5–6 cm) and carefully identifying them during the procedure. Additional protection is provided by the split brachialis muscle; when the muscle is retracted, its fibres act as a cushion, protecting the nerves.

Fracture bridging using minimally invasive plate osteosynthesis (MIPO) preserves the fracture haematoma, allowing healing to occur through the formation of periosteal callus. The periosteal blood supply contributes to the outer one-third of the cortical blood supply, and extensive soft tissue stripping during open reduction compromises this vascular supply. Preservation of the fracture haematoma also maintains the pluripotent stem cells with high osteogenic potential. Furthermore, the minimally invasive approach results in less soft tissue stripping, reduced blood loss, lower infection rates, and shorter hospital stays.

The minimally invasive technique for humeral shaft fractures has shown promising results recently^[16-19].

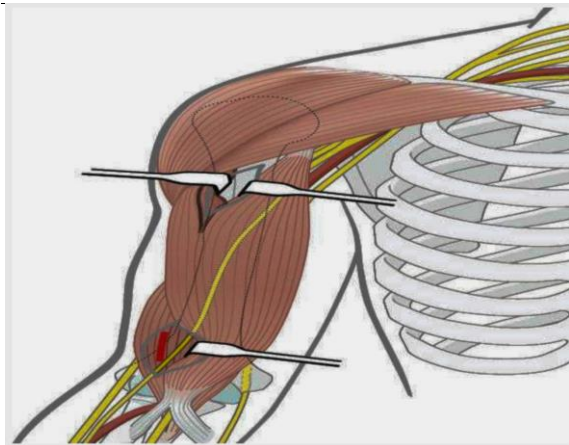


Figure 1: Approach to the anterior aspect of the humeral shaft.

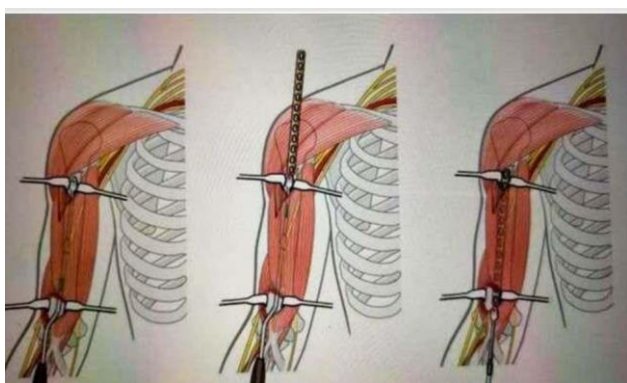


Figure 2: Plate insertion technique.

MATERIALS AND METHODS

Patients presenting to the Department of Orthopaedics between June 2022 and June 2024 were selected for this study.

Inclusion criteria:

- Skeletally mature patients
- Patients with humeral shaft fractures
- Closed fractures
- Intact vascularity
- Minimum 6 months of follow-up

Exclusion criteria:

- Patients with neurovascular injury
- Paediatric patients
- Open fractures
- Patients not fit for surgery

All cases were admitted, and a careful history was elicited to determine the mechanism and severity of injury. General and local examinations were performed, and the findings were entered into a proforma. Care was taken to detect shock and any associated injuries. Full-length anteroposterior and lateral radiographs of the humerus, including the shoulder and elbow, were

obtained to confirm the diagnosis, and a U-slab was applied to all patients.

Preoperative Preparation

1. Once the decision for surgery was made, certain preoperative steps were routinely undertaken.
2. The affected limb was immobilised in a U-slab throughout the preoperative period.
3. Preoperative radiographs were taken in anteroposterior and lateral views, including the shoulder and elbow joints. The fracture pattern was studied, and the technical aspects of surgery were planned accordingly.
4. Consent for surgery was obtained from the patient and attendant after explaining the procedure and its possible complications.
5. Tetanus toxoid and antibiotics were administered.
6. A Xylocaine test dose was given.
7. The operative site was prepared.

Operative Technique

After induction of anaesthesia, the patient is positioned supine on the operating table with the forearm in supination and the arm in 90° abduction. Supination reduces the risk of radial nerve palsy by increasing the distance between the radial nerve and the plate. After preparation and draping, traction is applied and fracture reduction is confirmed under C-arm guidance.

Incision

Two incisions are made: one proximal and one distal. The proximal incision is made between the medial border of the deltoid and the lateral border of the biceps. The distal incision is made at the lateral border of the biceps brachii.

Method

After positioning the patient, the surgeon stands on the cephalad side of the patient, while the C-arm is positioned on the contralateral side. Two incisions are made, one proximally and the other distally. Proximally, a 2–3 cm incision is made between the medial border of the deltoid and the proximal biceps brachii, approximately 5 cm distal to the acromion process. Distally, a 2–3 cm incision is made along the lateral border of the biceps brachii, approximately 5 cm proximal to the elbow flexion crease.

The biceps muscle is retracted to expose the musculocutaneous nerve lying over the brachialis muscle. The musculocutaneous nerve is carefully identified and retracted, following which the brachialis muscle is split down to the bone. The radial nerve is protected by the bulk of the brachialis muscle and by careful placement of the retractors over the muscle. Langenbeck retractors are preferred for distal exposure, as deep insertion of Hohmann retractors may result in neurovascular injury.

After adequate exposure and protection of the neurovascular structures, a submuscular tunnel is created from the proximal to the distal incision using a MIPO elevator or, alternatively, the plate itself. The tunnel is developed carefully in a subperiosteal plane while minimizing trauma to the surrounding soft tissues.

Gentle traction is then applied by the assistant with the elbow flexed to 90° and the forearm maintained in supination to maximize the distance between the radial nerve and the plate. Fracture reduction is confirmed using the C-arm, following which the plate is advanced carefully through the submuscular tunnel while avoiding injury to the surrounding neurovascular structures. Traction helps restore the length, alignment, and rotational profile of the fracture.

Typically, two screw holes are exposed through each of the proximal and distal incisions. These holes are drilled, and screws are inserted after confirming the plate position on the bone under fluoroscopic guidance. Initially, the screws are left loosely tightened to allow final confirmation of plate positioning using the image intensifier. Once satisfactory alignment and plate position are confirmed, the screws are fully tightened, and at least two to three bicortical screws are inserted both proximally and distally to achieve stable fixation. The wound is then thoroughly irrigated with normal saline, followed by layered wound closure. Postoperative antibiotics are administered according to the institutional protocol.

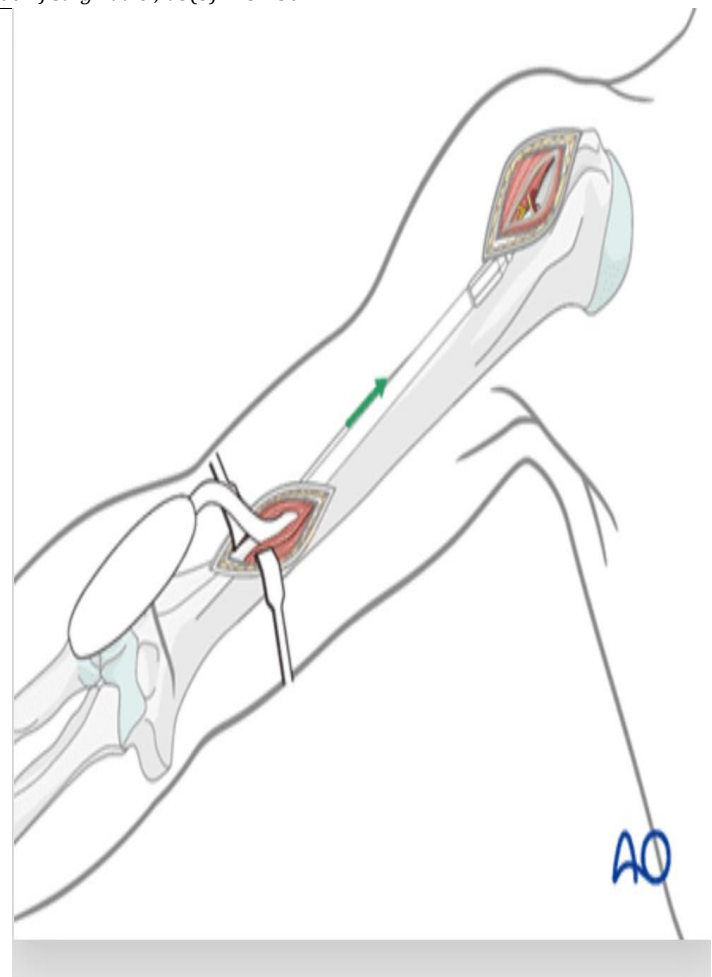


Figure 4: Intraoperative photograph showing the proximal and distal incision sites.

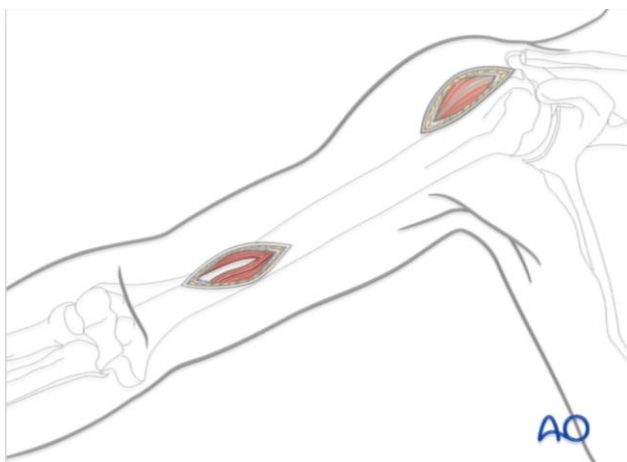


Figure 3: Schematic diagram showing the proximal and distal incision sites.

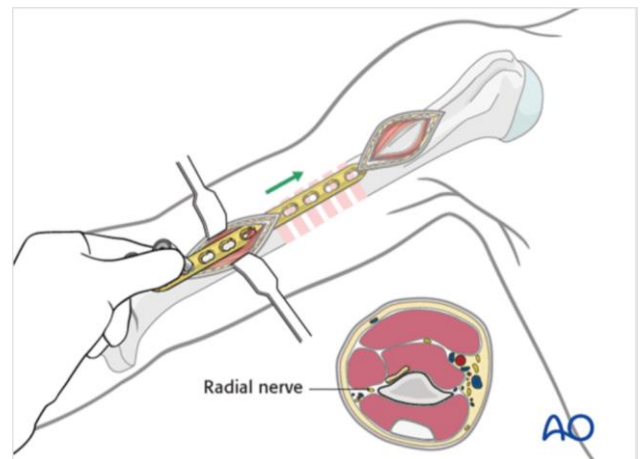


Figure 5: Passage of the plate through the submuscular tunnel.

Postoperative Protocol

1. Neurovascular status is checked postoperatively.
2. The operated limb is supported in a broad arm sling.
3. The wound is inspected on the second postoperative day.
4. At one week postoperatively, passive flexion up to 45°–60° is initiated.
5. Sutures are removed on postoperative day 12.

6. At one month postoperatively, passive flexion up to 90° is achieved.
7. At 6 weeks postoperatively, active mobilisation is started.
8. Weight-lifting is permitted as tolerated.
9. Check radiographs are taken at 1, 3, and 6 months to assess union.

Postoperative Scoring System

Clinical Assessment:

1. University of California, Los Angeles (UCLA) Shoulder Score^[20]

All patients were assessed postoperatively at 1-month, 3-month, and 6-month follow-up, and the score was calculated at each visit. The score is calculated out of 35 points based on the following 5

parameters:

- Pain: 10 points
- Function: 10 points
- Active forward flexion: 5 points
- Strength of forward flexion: 5 points
- Satisfaction of the patient: 5 points

2. Mayo Elbow Performance Score (MEPS)^[21]

All patients were assessed postoperatively at 1-month, 3-month, and 6-month follow-up, and the score was calculated at each visit. The score is calculated out of 100 points based on the following 4 parameters:

- Pain: 45 points
- Activity of daily living: 25 points
- Stability: 10 points
- Range of motion: 20 points

Radiological Assessment:

- Degree of angulation at the fracture site
- Evidence of union at the fracture site

Based on the anteroposterior and lateral radiographic views, union was accepted as the presence of bridging callus in three of the four cortices with absence of pain. Any loss of fracture reduction was also assessed on these radiographs.

RESULTS

This study included 20 cases of humeral shaft fracture treated with anterior bridge plating using a minimally invasive technique.

Table 1: Age distribution

Age distribution	Number of Patients	Percentage
<20 years	1	5%
21–40 years	14	70%
41–60 years	5	25%
Total	20	100%

Table 2: Sex distribution

Sex distribution	Number of Patients	Percentage
Male	12	60%
Female	8	40%
Total	20	100%

Table 3: Side involvement

Side involvement	Number of Patients	Percentage
Right	14	70%
Left	6	30%
Total	20	100%

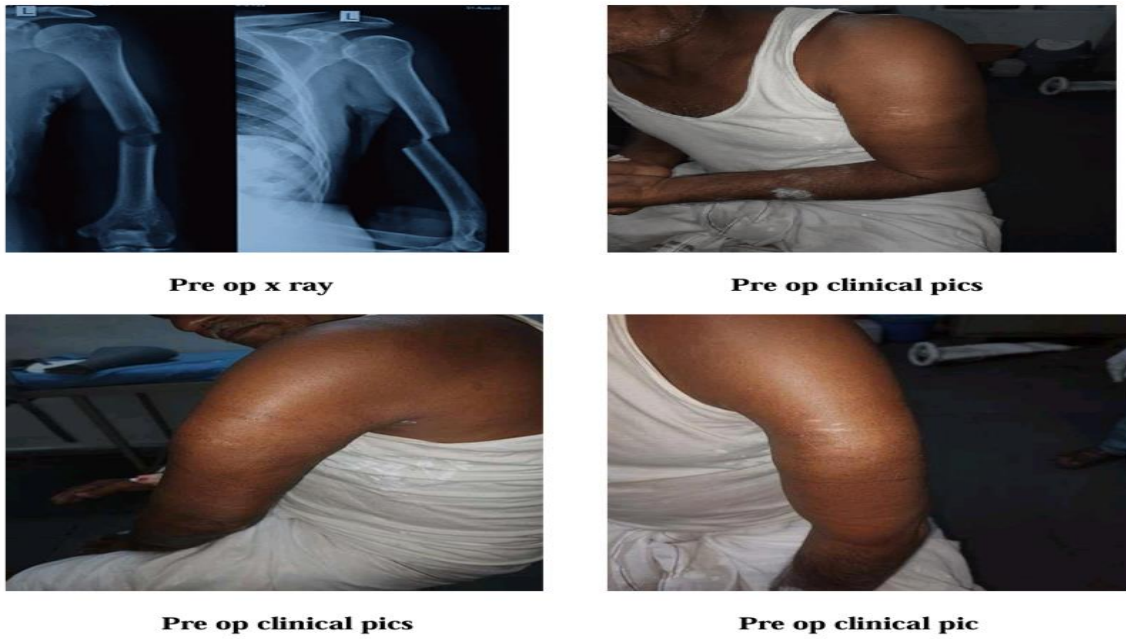
Table 4: Shoulder and elbow range of motion

Range of motion (ROM)	Number of Patients	Percentage
Full ROM	18	90%
Decrease ROM	2	10%
Total	20	100%

Clinical and Functional Outcomes

Of the 20 patients followed up for 1.5 years, 12 were male and 8 were female. The mean age was 37 years (range: 18–60 years), and 14 of the 20 patients (70%) had a right-sided fracture. The mean surgical time was 86 minutes (range: 65–110 minutes), and the mean blood loss was 136 ml (range: 100–180 ml). The mean time to radiological union was 11.6 weeks

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Pre op x ray

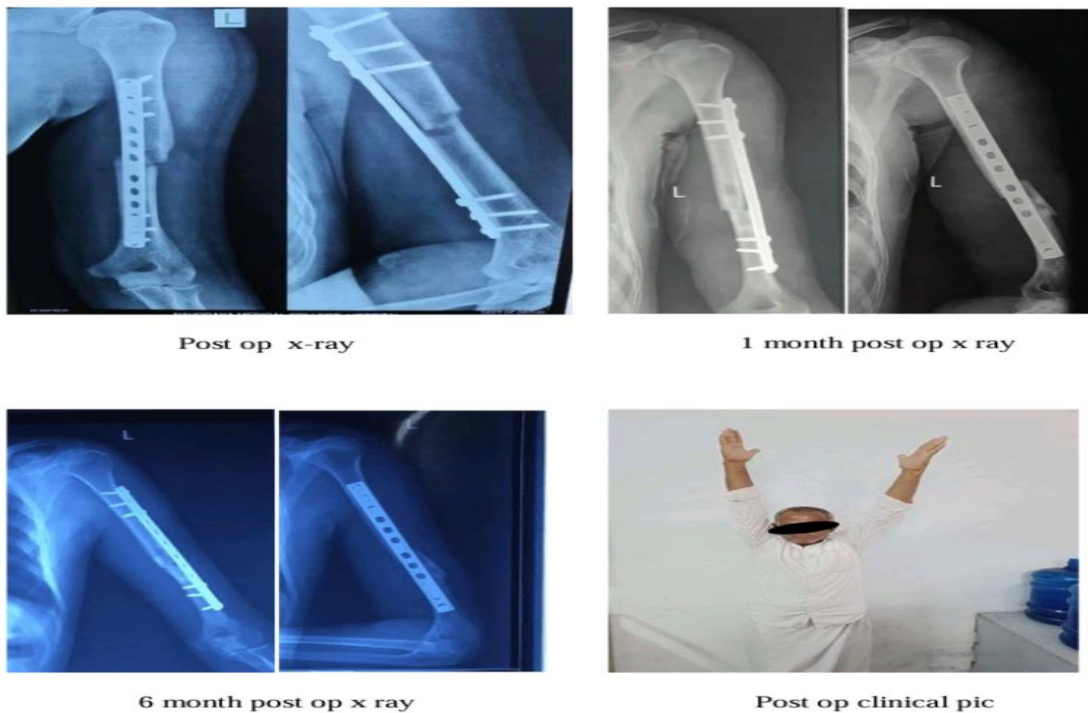
Pre op clinical pics

Pre op clinical pics

Pre op clinical pic

Figure 6: Preoperative radiograph showing the humeral shaft fracture.

Figure 7: Immediate postoperative radiograph showing fixation with the anterior bridge plate.



Post op x-ray

1 month post op x ray

6 month post op x ray

Post op clinical pic



Post op clinical pic



Post op clinical pic



Post op clinical pic



Post op clinical pic

Figure 8: Follow-up radiograph showing fracture union.

DISCUSSION

Conservative treatment is successful in achieving union rates of more than 90% and is still preferred for isolated, low-energy trauma leading to humeral shaft fractures. Initially, conservative treatment was used for displaced spiral and oblique humeral shaft fractures. In transverse and short oblique fractures, however, the contact area between fracture fragments is much smaller and fracture instability is relatively high, leading to a greater number of delayed unions and non-unions. Another major disadvantage of conservative treatment is stiffness of the adjacent joints, especially the shoulder, which requires a prolonged rehabilitation period. Operative treatment is known to improve fracture healing, fracture alignment, and functional outcome in patients with high-energy trauma. Open reduction and plate osteosynthesis is an accepted surgical option; its main disadvantage is that it requires extensive tissue dissection and soft tissue stripping, with attendant complications. Plate osteosynthesis also requires mobilisation of the radial nerve during both insertion and removal, with high rates of secondary radial nerve palsy. Open reduction also disturbs the fracture haematoma, which further prolongs fracture healing and delays surgical outcome.

The technique of minimally invasive plate osteosynthesis (MIPO) was first described by Tschern and Krettek in 1996 for the treatment of supracondylar femoral fractures.^[22] Since then, it has been increasingly adopted for the management of various long bone fractures.

Although the procedure requires considerable surgical expertise and has a steep learning curve, the MIPO technique has proven to be reproducible and applicable to most types of humeral shaft fractures. Its major advantages over conventional open plating include lower rates of iatrogenic nerve injury, minimal disruption of the periosteal blood supply, and reduced soft tissue dissection. Despite the technical challenges associated with indirect fracture reduction and plate insertion, anterior bridge plating of the humeral shaft can be performed safely. The technique employs biological fixation by bridging the fracture site and securing the plate only at the proximal and distal fragments, thereby preserving the fracture biology.

Excellent to good functional outcomes have been reported with sub-brachialis anterior bridge plating, with minimal soft tissue complications and results comparable to those achieved with other established fixation methods.^[23] In contrast, conventional open plating requires extensive soft tissue stripping, which compromises the local blood supply and may lead to cortical osteonecrosis beneath the plate. This vascular disruption has been associated with delayed union and non-union, with reported non-union rates of approximately 5.8%.^[24]

The fracture union achieved in the present series demonstrates the effectiveness of fixation using indirect reduction techniques. This method maintains fracture

alignment through small incisions and emphasizes relative stability rather than absolute stability, thereby promoting secondary bone healing through abundant callus formation.

In conclusion, the present series demonstrates that anterior minimally invasive bridge plating is an effective, reliable, and cosmetically superior treatment option for humeral shaft fractures. The technique offers the advantages of smaller surgical scars, preservation of fracture biology, minimal soft tissue disruption, and satisfactory functional outcomes. Although the procedure is technically demanding and requires a substantial learning curve, the clinical results are encouraging and reproducible. Therefore, MIPO represents a safe, effective, and acceptable treatment modality for appropriately selected humeral shaft fractures.

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