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ORIGINAL ARTICLE

Posterior percutaneous plating of the humerus

Khaled M. Balam · Abdallah S. Zahrany

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Abstract
Objective This is a prospective case series study, which was designed to evaluate the clinical outcome of posterior percutaneous plating of the humerus.
Materials and methods From the year 2010 to 2011, 37 patients with middle and distal third humeral fractures who met the inclusion criteria were surgically treated by minimally invasive plate osteosynthesis through posterior approach. Their age ranged from 19 to 43 with an average of 27.8 years. Type of fractures varied from B to C, and all of them were traumatic.
Results Patients were followed up for a period varied from 12 to 24 months with an average of 18. There were no cases of intraoperative complications, infection or metal failure. Union was achieved in all of them within 16–21 weeks with an average of 18. Iatrogenic postoperative temporary neuropraxia of the radial nerve palsy was observed in two patients. All patients achieved normal range of shoulder and elbow motion within 3 months after surgery. The average Quick DASH score at 12-month follow-up was 30. According to patient's satisfaction, all of them returned to the usual pre-injury activity level within 6 months.
Conclusions This study suggests that the principles of minimally invasive plate osteosynthesis can be applied safely through posterior approach of the humerus to treat middle and distal third humeral fractures. This approach has the advantage of preserving the triceps anatomy and function facilitating rapid postoperative rehabilitation.

Keywords Posterior percutaneous plating of the humerus · Radial nerve · Quick DASH

K. M. Balam (✉) · A. S. Zahrany
Department of Orthopedics and Traumatology, Assiut University, Assiut, Egypt
e-mail: khaledbalam@yahoo.com

A. S. Zahrany
Dammam Medical Complex, Dammam, Kingdom of Saudi Arabia

Introduction

The treatment of humeral shaft fractures had a lot of controversy and continued to be a problem in orthopedic surgery. Conservative lines of treatment were described successfully with all their consequences and complications as delayed or nonunion, deformities, prolonged immobilization, shoulder and elbow stiffness [1–5]. Successful treatment of humeral shaft fractures was described using antegrade or retrograde humeral nails [6–8], but it was associated with high incidence of nonunion, delayed rehabilitation, injury of the rotator cuff muscles and even failure [9, 10]. The high-energy trauma induces damage to the endosteal blood supply for the long bone [11]. Trials for the classic open reduction and internal fixation ORIF of long bone aggravate the situation by the iatrogenic damage of the periosteal blood supply [12]. With the advances of medical care and surgical techniques, the minimally invasive plate osteosynthesis (MIPO) technique was used in treating long-bone fractures in both the upper and lower limbs. MIPO technique for treatment of humeral shaft fractures has a lot of advantages, where it preserves the normal biology of bone and soft tissues, less blood loss, lower incidence of neurovascular complications and the postoperative rehabilitation is much better and to avoid prolonged immobilization and the resultant shoulder and elbow stiffness [13–17].

Materials and methods

Thirty-seven adult patients with humeral shaft fractures were included in this study, which was approved by the local scientific committee, from the year 2010 to 2011. Thirty-three of them were male and four female, their age ranged from 19 to 43 with an average of 27.8 according to AO classification, the fracture type was closed and 12 B&C.

The inclusion criteria were adult patients, with unstable fractures as types 12 B and C according to AO classification, patients with poor tolerance and compliance to non-operative treatment and prolonged immobilization, obese persons, associated chest injuries. The exclusion criteria were patients less than 18 years old, pathologic fractures, associated radial nerve palsy, open fractures and patients who were lost to follow-up. All patients were fully informed about the surgical technique, and formal consent for surgery was taken.

Surgical technique

In the operating theater, under general anesthesia, the patient was positioned in the lateral decubitus position with the affected side uppermost and through an arm support to make the posterior surface of the arm fully visualized. Sterilization and draping of the affected limb was done and made sure that the humerus is fully visualized under X-ray control.

The proximal incision and approach

This part of the approach exposes the proximal part of the humerus through the interval between the lateral head of the triceps muscle innervated by the radial nerve and the deltoid muscle innervated by the axillary nerve.

Skin incision was designed on the posterior aspect of the proximal part of the arm, 5-cm distal to the posterior aspect of the acromion and on the posterior border of the deltoid. Superficial dissection incises the deep fascia of the arm in line with the skin incision to visualize the posterior border of the deltoid and the lateral head of the triceps. Deep dissection was carried out through the triceps muscle to visualize the V-shaped area between the lateral and long heads. Carefully explore the radial nerve. Extra-periosteal dissection and release of the radial nerve from the surrounding structures were carried out to prepare the proximal part of the plate bed. With a tunneler, complete the proximal plate bed and pass it distally along the posterior surface of the humerus.

The distal incision and approach

Make the distal incision, about 5 cm in length over the postero-lateral aspect of the arm 2-cm proximal to the lateral humeral condyle. Incise the triceps along the plane of its muscle fibers to the extra-periosteal humeral surface (Figs. 1, 2).

With a tunneler, expose the extra-periosteal posterior–lateral surface of the humerus, pass it proximally and smoothly to communicate with the proximal bed. Now, the tunnel or posterior bed is ready to accommodate the posterior plate.

Plate insertion

A large, fragment, long plate (usually 14 or 16 holes) was inserted from the distal part of the approach and going proximally extra-periosteally in front of the radial nerve. Withdraw the plate from the proximal approach in front of the radial nerve.

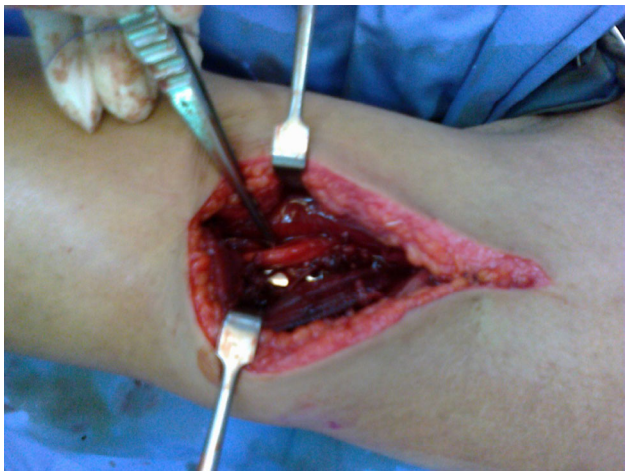

Fig. 1 Exploration of the radial nerve at the proximal humerus and the plate underneath the nerve

Fig. 2 At the end of surgery with MIPO for fracture humerus

Plate fixation

Insert a 4.5-mm cortical screw to the proximal part of the plate proximal to the level of the radial nerve. Under X-ray control, do indirect reduction in the humeral shaft fractures and then fix a distal screw from the distal approach. Now, the relationship between the humerus and the plate was established, adjustment of any mal-reduction was carried out at this stage. When fracture reduction and plate position are accepted, complete the proximal and distal screw fixation, usually 3–4 screws were required (Figs. 3, 4). Closure in layers for the proximal and distal wounds and apply a broad arm sling. The recorded blood loss during surgery varied from 50 to 100 cc with an average of 80, and operative time varied skin-to-skin from 50 to 90 min with an average of 70, and there was no intraoperative complication.

Results

From the year 2010 to 2011, we treated 37 patients with humeral fractures using the MIPO technique. Male-to-female ratio was 8–1. Their age ranged from 19 to 43 with an average of 27.8. Patients were followed up for a period ranging from 12 to 24 months with an average of 18 months. According to the AO classification, all patients had types B and C diaphyseal fractures.

The duration of surgical intervention varied from 50 to 90 min with an average of 70, with minimal blood loss (average 80 cc) and no recorded major intraoperative complications. Broad arm sling was applied for all patients after surgery for 2–3 weeks with gradual active restoration of shoulder and elbow joints motion.

Fig. 3 Fracture distal third of the humerus with big butterfly

Fig. 4 Posterior plate fixation using MIPO technique

Two patients developed transient postoperative radial nerve palsy, which recovered within 8 weeks. The postoperative radiological assessment revealed that four patients had 5-degree varus deformity in the coronal plane. There was no postoperative infection or metal failure in all patients.

Functional restoration of active elbow and shoulder motion was encouraged as soon as possible from the second day of surgery. The Quick DASH scoring was used for functional assessment after surgery, and all data were recorded at 3, 6, 9 and 12 months postoperatively. The Quick Dash scoring is simple functional scoring using 11 items to determine disability of the arm, shoulder and hand. At least 10 of the 11 items must be completed for a score to be calculated. The assigned values for all completed responses are simply summed and averaged, producing a score out of five. This value is then transformed to a score out of 100 by subtracting one and multiplying by 25. This transformation is done to make the score easier to compare to other measures scaled on a 0–100 scale. A higher score indicates greater disability. During follow-up, and on physiotherapy program, there is gradual improvement and restoration of normal function of the upper limb. At 3-month follow-up Quick Dash scoring varied from 60 to 70 with an average of 64 and it gradually improved on 6-month follow-up to reach an average of 34 and at 9- and 12-month follow-up, all patients had full functional recovery of the arm, shoulder and hand (Tables 1, 2).

Radiological assessment for all patients was done during outpatient follow-up (Figs. 5, 6). Radiological union was observed when bone trabeculae or cortical bone has

Table 1 Quick DASH scoring (simplified)

	Difficulty				
	No	Mild	Moderate	Severe	Unable
1. Opening a tight jar	1	2	3	4	5
2. Doing household chores (e.g., floor washing)	1	2	3	4	5
3. Carrying a bag	1	2	3	4	5
4. Wash your back	1	2	3	4	5
5. Kitchen activities	1	2	3	4	5
6. Recreational or working activities as hammering	1	2	3	4	5
7. Interference with the normal social activities	1	2	3	4	5
8. Interference with the Usual working activities	1	2	3	4	5
9. Arm, shoulder, hand pain	1	2	3	4	5
10. Tingling arm, shoulder, hand	1	2	3	4	5
11. Pain interfering with sleep	1	2	3	4	5

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response

Quick DASH scoring = (summation of responses/no.) 1 × 25

Table 2 Time required to radiological union

Time to union	Number of patients	(%)
Up to 16 weeks	20	54
16–21 weeks	15	40.5
21–27 weeks	2	5.5

crossed the fracture site. Union is defined as delayed when healing has not advanced at the average rate for the location and type of fracture usually between 3 and 6 months.

With regular follow-up, complete radiological union was observed in 35 patients in 16–21 weeks with an average of 18. Two patients failed to have complete radiological signs of healing after 21 weeks and considered to have delayed union. One session of extracorporeal shock-wave therapy (ESWT) was prescribed for them to enhance bone healing. Solid radiological union was observed for both of them at the 27th week.

Nonunion was defined according to the Food and Drug Administration panel as "established when a minimum of 9 months has elapsed since fracture with no visible progressive signs of healing for 3 months." Nonunion and metal failure was not recorded in all of them.

Radiological follow-up for all patients revealed, starting evidence of union within 6 weeks (Figs. 5, 6). Radiological

Fig. 5 Posterior plate fixation using MIPO technique

Fig. 6 Follow-up X-ray after 6 weeks

union was defined as the presence of continuous radiologically evident bone trabeculae and callus in three bone cortices in both antero-posterior and lateral views. Complete radiological union was observed in 20 patients (54 %) within 16 weeks. Fifteen patients attained complete radiological union within 16–21 weeks (Fig. 7). For the last two patients with delayed union for more than 21 weeks, shock-wave therapy was done to enhance bone healing with successful results. All patients attained complete radiological union within a period ranging from 16 to 27 weeks. Nonunion and metal failure was not recorded in all of them.

Fig. 7 Follow-up X-ray after 24 weeks with evident boney union

Discussion

Although conservative treatment continues to be one of the most commonly accepted forms of management for humerus shaft fracture, it has a lot of disadvantages, where the use of immobilization can lead to stiffness in the shoulder and elbow and high incidence of delayed or non or mal-union [1–5]. Intramedullary, nailing is one of the treatment options in proximal humeral shaft fractures. However, it had been shown that this treatment carries a slightly higher risk of failed fixation, especially in comminuted and osteoporotic patients, delayed or nonunion and a lot of shoulder complications [6–10]. Open reduction and internal fixation for diaphyseal long-bone fractures require extensive soft tissue dissection and complications [6].

Minimally invasive plate osteosynthesis (MIPO) has gained popularity with satisfactory clinical outcomes in the treatment of long-bone fractures. MIPO for humeral shaft fractures, however, could be a surgically dangerous procedure because of the risk of radial nerve injury. In 2005, Apivatthakakul et al. [16] had published cadaveric study on MIPO of the humerus through an anterior approach. The results of this study showed that it is possible to treat humeral shaft fractures by the MIPO method using an anterior approach. The relationship between the anterior plate and the radial nerve varies according to supination pronation positions due to crossing of the nerve from the posterior to anterior compartment of the arm. From the anatomical point of view, the radial nerve is in direct relationship to the posterior surface of the humerus at the spiral groove. The posterior humeral surface can be subdivided into three parts which are proximal and distal to the radial nerve and middle part that is related to the nerve. This is the anatomical principle for the MIPO of the humerus through posterior approach, where the posterior surface of the humerus has three zones, namely proximal and distal fixation zones and middle or biological zone that is related to the radial nerve.

In our series, 37 patients with traumatic comminuted diaphyseal humeral shaft fractures were treated by posterior percutaneous plating of the humerus through MIPO technique with successful results. Intraoperative difficulties included tunnel or bed preparation for the plate and can be managed by doing sufficient release of the radial nerve to avoid any tension on the nerve during plate insertion. The second difficulty is the direction of plate insertion, whether from proximal to distal or the reverse. It was difficult to insert the plate from proximal to distal due to two main factors, which are the bulkiness of the deltoid muscle and the second is the requirement to do more tension to elevate the radial nerve to allow passage of the plate from proximal to distal. This difficulty can be managed by doing plate insertion in a reverse manner from distal to proximal in its bed in front of the radial nerve, and it will pass smoothly without nerve tension. These difficulties explained the presence of two cases of temporary neuropraxia of the radial nerve due to tension and insufficient release of the radial nerve. Complete recovery of radial nerve function was observed within 8 weeks.

All patients showed convenient early postoperative rehabilitation, radiological union was observed in 35 of them within a period varied from 16 to 21 weeks with an average of 18 weeks. Two patients had delayed union which responded to shock-wave therapy and fully united at 27 weeks. Minimally, 5 ° varus at the fracture site was observed in four patients and required no further interference. All patients returned to their original work and daily activity within 20–33 weeks with an average of 24 weeks.

In 2004, Livani and Belangero [18] described their results using MIPO technique in patients, fourteen of the 15 fractures healed within 8–12 weeks and two with varus mal-alignment within 5–10 °. In 2007, Jiang et al. [19] reported the use of a similar MIPO technique in 21 patients, union was observed in 19. In 2007, Zhiquan et al. [20] reported on 13 patients with similar MIPO technique, all fractures healed with mal-alignment within 8 °. All previously mentioned MIPO of the humerus had no associated radial nerve palsy.

To compare the results of MIPO through posterior approach with those through anterior approach, the incidence of radial nerve palsy was recorded in two patients out of 37 (5.4 %). It was recorded in the earlier cases, temporary, with spontaneous recovery within 8 weeks and was attributed to insufficient radial nerve release and avoided in the consequent cases. None of the patients from other series who were operated up on through anterior approach had this complication. At the same time, fractures of the distal third of

the humerus cannot be operated through an anterior approach, and consequently, the use of posterior approach is inevitable. The time required for bone union was longer for posterior approach, and it was attributed to the underlying type of fractures. None of the fractures in our series had nonunion or metal failure, and this is comparable to other studies. Varus mal-alignment was comparable to other studies and within 5°.

To compare the results of MIPO of humeral shaft fractures through posterior approach with the ordinary open reduction and internal fixation, MIPO had the advantage of less blood loss, preservation of triceps function, rapid and convenient postoperative rehabilitation. In five large series for the ordinary open reduction and internal fixation, 361 fractures by Foster et al. [21], McKee et al. [22], Vander Griend et al. [23], Bell et al. [24] and Tingstad et al. [25] had union rate 96.7 % and early functional restoration of the upper limb. These figures are comparable to our results.

At the same time, this study had some shortcomings as small number of patients, the associated morbidity as regarding radial nerve palsy and delayed union is relatively high. Also, we are in need to teach this technique to junior orthopedic doctors allover many trauma centers to make it more popular.

Conclusions

The principles of MIPO technique can be applied safely to treat traumatic comminuted humeral shaft fractures through posterior percutaneous approach. This technique has many advantages as minimal intraoperative blood loss, preservation of the triceps function and rapid postoperative rehabilitation. At the same time, the morbidity of this approach is relatively high as regards the incidence of radial nerve palsy and delayed union.

Conflict of interest None declared.

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