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Treatment of Proximal Humeral Fractures Using Minimally Invasive Plate Osteosynthesis

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Abstract

Background: Proximal humeral fracture (PHF) is a common orthopedic injury that constitutes 4% - 5% of all fractures. An appropriate treatment for PHF is very challenging. Minimally invasive surgery (MIS) techniques are presented to reduce soft tissue damage and save biological tissues at the fracture site. The current study aimed at investigating the clinical, functional, and the radiographic results, as well as complications of the surgical treatment of PHF with minimally invasive plate osteosynthesis (MIPO).

Methods: 24 patients with proximal humeral fracture, classified according to Neer classification, aged over 18 years, from 2013 to 2014, with closed and displaced pattern underwent surgery by MIPO technique. In the follow-up period, patients were clinically evaluated using the criteria for the arm, shoulder, and hand disabilities (DASH score) and visual analogue scale (VAS). All complications related to the surgery and fracture healing were recorded.

Results: Data regarding the 24 studied patients with the mean age of 57.6 ± 4.11 years were analyzed. In the current study, one patient presented superficial wound infection. Three patients had axillary nerve injury (12.5 %). In two cases subacromial impingement (SAI) due to greater tuberosity avulsion was observed. The motion range of forward flexion, abduction, and external rotation were 141 ± 39, 129 ± 31, and 28 ± 22 degrees, respectively. In the final visit, the average DASH and VAS scores were 3.6 ± 2.21 and 3.1 ± 1, respectively.

Conclusions: Considering the reasonable functional and radiological results, low pain intensity, and finally low incidence of complications after surgery, the MIPO technique can be properly employed to treat proximal humeral fractures.

Keywords: Proximal Humeral, Fracture, Minimally Invasive, Osteosynthesis

1. Background

Proximal humeral fracture (PHF) is a common orthopedic injury, especially in the elderly. PHF constitutes 4% - 5% of all fractures and 45% of humeral fractures (1). Although these injuries caused by high energy trauma are observed in young people, they are considered as the third most common type of fracture due to osteoporosis, after hip and distal radius fractures (2). Currently, there is no evidence-based guideline to treat PHF and few randomized clinical studies are performed. Various treatment options including nonsurgical treatment, open reduction and internal fixation (ORIF), and hemiarthroplasty as well as a wide variety of fracture morphologies make the performance of prospective randomized studies very difficult (3, 4). According to recently published Cochrane review, no evidence-based recommendation can be offered to treat PHF (5). In recent years, minimally invasive surgery (MIS) techniques are developed to reduce soft tissue damage and preservation of total bone blood supply (6).

Application of MIS techniques to treat proximal humeral fractures resulted in good outcomes (4, 7-14). The proximity of neurovascular structures to the humeral bone led to concerns about MIS techniques (4). The current study aimed at investigating the clinical, functional, and the radiographic outcomes, as well as complications associated with minimally invasive plate osteosynthesis (MIPO) of PHF.

2. Methods

The current study was conducted on all patients with two-, three-, or four-part PHF according to Neer classification that underwent surgery by the MIPO technique in Taleghani Hospital affiliated to Shahid Beheshti University of Medical Science, Tehran, Iran from 2013 to 2014 (15) (Figure 1). The exclusion criteria were age below 18 years, previous upper limb fracture on the same side, multiple trauma, pathological fractures, open fractures, and nerve or vascular damages (4, 12).

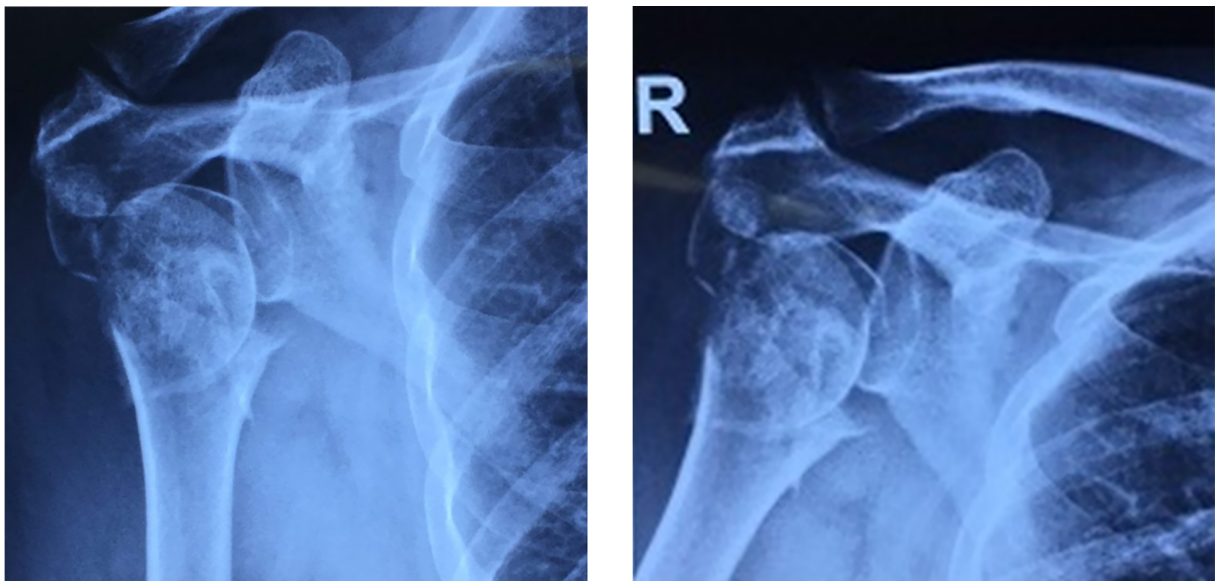

Figure 1. Shoulder radiographies of the anterioposterior and the lateral views

The institutional review board (IRB) of Taleghani Hospital approved the current study protocol and informed consent was obtained from the patients. All patients underwent shoulder standard radiography and computed tomography (CT) scan (Figure 2). Finally, 24 patients were enrolled in the study.

All the surgeries were performed by the same senior surgeon. The patients were placed in a semi-sitting position. After preparation and draping, a 3-cm incision was made on the lateral edge of the acromion centered over humeral head.

Deltoid muscle split and the proximal edge of greater tuberosity appeared under the subdeltoid bursa. The lesser and greater tuberosity were taken by the polydioxanone (PDS) thread. The threads were then passed through the holes of the proximal humeral anatomical plate (Figure 3). To obtain anatomical reduction, a pin was inserted in humeral head, and restoration of medial calcar, varus-valgus alignment, and rotational deformity were attempted (Figure 4).

At this stage, axillary nerve protected with subperiosteal dissection; then, the plate was passed underneath the nerve. Distal and the proximal screws were placed through small incision as threads tension was maintained (Figure 5). Finally, PDS threads were sutured together on the plate. After wound closure, the shoulder was immobilized by a sling. The patient was allowed to perform active flexion and extension of the elbow, two days after the surgery. Early range of motion was done for all patients. After two weeks, if the radiographic images were acceptable, abduction and external rotation movements were initiated.

Patients were visited for clinical and radiographic evaluations the 2nd and 4th week after the surgery and then, monthly. During post-surgery visits, surgery wound and the patient's performance were assessed, and plain radiography was taken.

The patients were followed up until complete fracture union. Radiographic union evidenced the lack of cortical discontinuity (16). The patients were asked to attend the hospital 12 months after the surgery. During the final visit, the motion range of abduction, forward flexion, and external rotation were measured. Functional results were evaluated with disability of arm, shoulder, and hand score (DASH score). A visual analogue scale (VAS) was used to assess pain. All complications after surgery, such as wound dehiscence, infection, avascular necrosis (AVN) of the humeral head, hardware failure, and subacromial impingement (SAI) were recorded. Incidence of neurovascular problems following the surgery was carefully documented.

3. Results

Out of the 24 patients under study, 17 were male and seven were female. The mean age of the patients was 57.6 $\pm$ 4.11 years. Eight patients had a two-part fracture, 13 patients had a three-part fracture, and three patients had a four-part fracture. All patients were followed up for 12 months. In the current study, nonunion or delayed union was not recorded and all the fractures healed in 8 - 16 weeks. One patient had a superficial wound infection and was cured

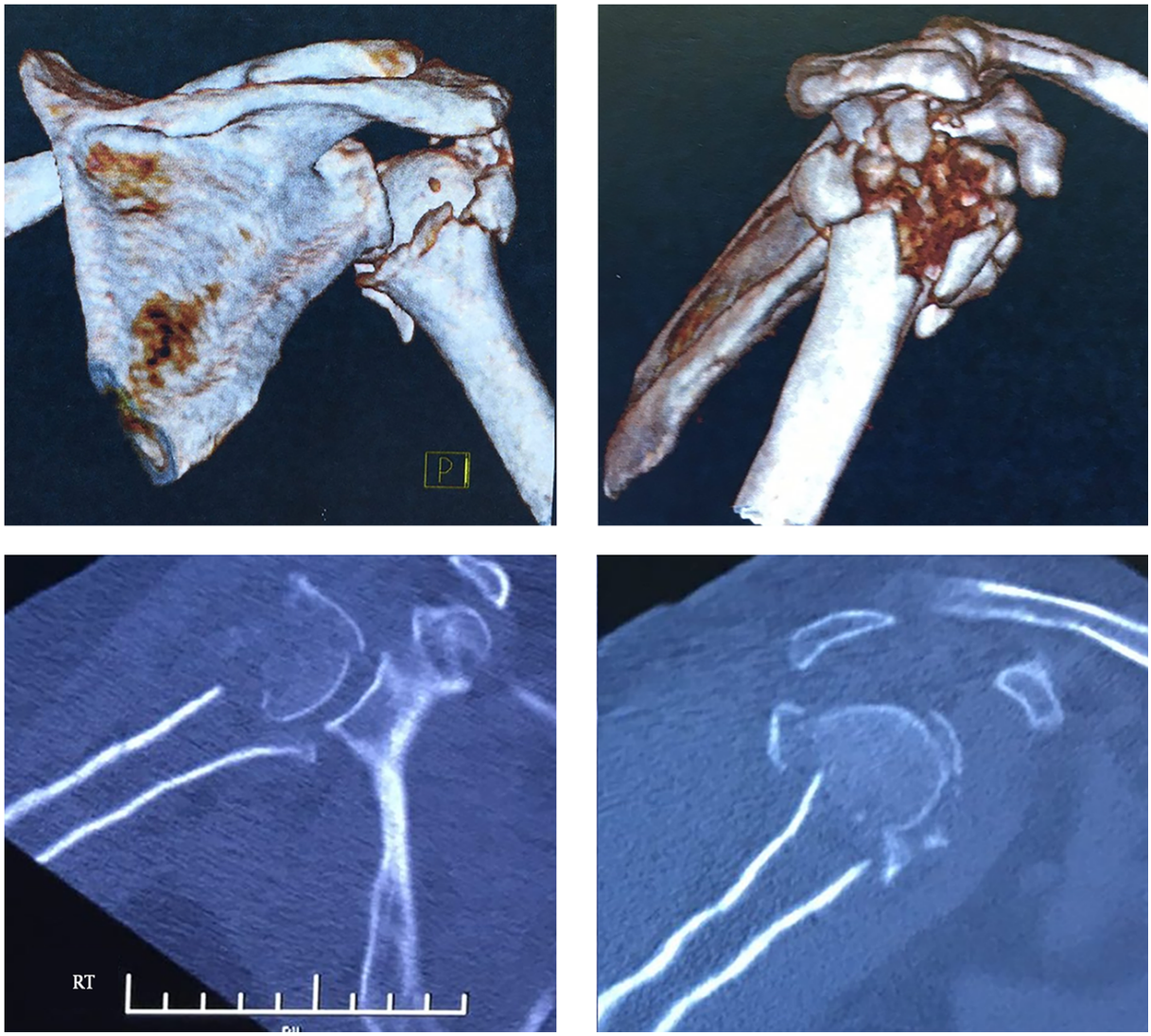

Figure 2. CT scan demonstrates right proximal humeral fracture

completely with oral antibiotics. Axillary nerve injury was observed in three patients after surgery (12.5%), recovered within four months. In the current study, none of the patients had osteonecrosis of the humeral head or hardware failure during the 12-month follow up. In two cases, greater tuberosity avulsion occurred, which led to SAI. Mean motion range of forward flexion, abduction, and external rotation were 141 $\pm$ 39, 129 $\pm$ 31, and 28 $\pm$ 22 degrees, respectively. After one year, the average DASH score was 3.6 $\pm$ 2.21. In addition, pain score according to VAS was 3.1 $\pm$ 1. Only two patients occasionally needed sedatives to relieve pain. Wound complications were observed only in one patient who was treated well and there was no problem.

4. Discussion

There are various treatments for PHF, which can be used on the basis of the type of fracture, patient age, and bone quality. There is no consensus about the method of treatment in such fractures. Today, the application of monoaxial and polyaxial plates to treat fractures with three- and four-part fractures is increasingly growing (17). Other instruments used for the fixation of PHF did not provide the desired results due to their limited purchase (18). Since the locking plates allow suitable rigid fixation, rehabilitation could be started as soon as possible (19).

The purpose of treating PHF is to achieve anatomical reduction through rigid fixation, while minimizing damage to the soft tissue (20). MIPO technique links the two

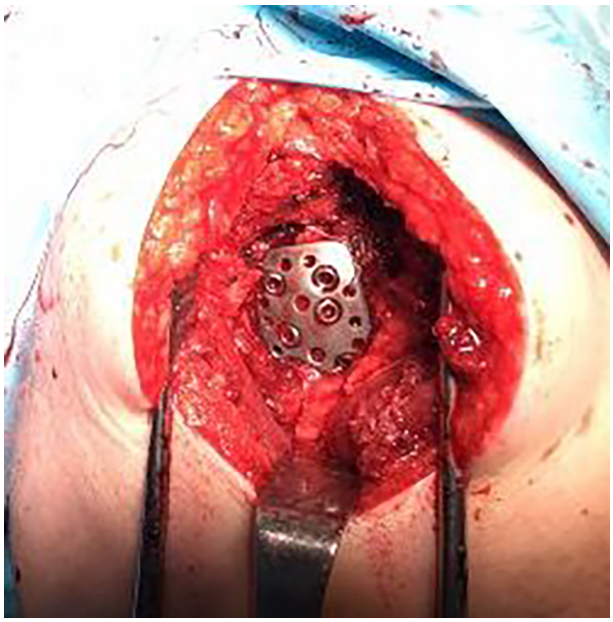

Figure 3. Skin incision and exposure of the right proximal humeral fracture; PDS thread passed through the holes of the proximal humeral anatomical plate

methods of percutaneous fixation and ORIF; while benefiting from the advantages of both methods (21).

It should certainly be noted that in addition to claims made about the possibility of the early return of patients after the fixation of the humeral head with the MIPO method, Bockmann et al., after examining the mid-term results of this technique in 71 patients, stated that although less invasive surgical fixation have remarkable results regarding the improvement of performance in the first six months as well as an acceptable rate of complications, the recovery period is very long and most patients feel pain or do not return to the pre-injury activity level (12). One of the major concerns in PHF surgeries is the axillary nerve injury. Some previous studies showed that if the length of deltoid splitting along its fibers is less than 6 cm, there is no risk for nerve damage (22, 23). Altman et al., Bockmann et al., Imarisio et al., Vundelinckx et al., Rodderer et al., Tauber et al., Brunner et al., Falez et al., Vijayvargiya et al., and Fattoreto et al., in their studies conducted in recent years did not report any cases of nerve damage caused by surgery in the fixation of PHF through the MIPO technique (7, 8, 10-12, 14, 16, 24-26). Unlike these studies, however, in the current study, iatrogenic injury of the axillary nerve was observed in 12.5% of the patients, which was temporary and improvements were observed in all of them after four weeks. These findings may indicate the need for a learning curve for the accurate performance of fixation in the proximal humerus through the MIPO technique.

Another important concern in PHF surgery is vascular injury. The posterior humeral circumflex artery, which feeds the proximal humeral, is usually damaged at the time of fracture or during surgery (27, 28). Despite concerns that exist in this case, evidence indicates the possibility of vascular supply damage to the humeral head, which is followed by the osteonecrosis of the humeral head and is less in the MIPO technique. In the current study, similar to the studies conducted by Altman et al., Bockmann et al., Imarisio et al. and Vijayvargiya et al., no cases of the humeral head AVN were observed during the final visit (8, 12, 16, 25). In other similar studies, however, the incidence of the humeral head AVN was reported 1.4% - 11% (7, 10, 11, 14, 24, 26). The incidence of the humeral head AVN after treatment with various methods, including non-surgical treatment, ORIF, external fixation, and nailing is reported 0% - 52%, which is highly variable (1). It seems that various factors that contribute to this difference in the AVN report include the difference in fracture type, the definition of AVN (partial necrosis), need for revision, and the term of investigation. It should, however, be noted that the MIPO technique can be associated with a reduced incidence of AVN or the least rate of AVN in this technique is acceptable.

Altman et al. showed that the fixation of PHF after two years was associated with good reduction quality in 86% of the patients (16). In a study by Bockmann et al., the constant score improved significantly in the six months between the visit after the surgery and the final visit (5.4 years after surgery), but the daily living activities score did not reach the extant level before the fracture (12). Ruchholtz et al., treated 80 patients with PHF by the MIPO technique; after six months, the functional and the clinical outcomes in the patients were desirable (4). Also, in recent studies, Falez et al., Vijayvargiya et al., and Fattoreto et al., demonstrated satisfactory functional and radiological outcomes after treatment of PHF by MIPO technique (24-26).

In the current study, performance results according to the DASH score were acceptable and satisfactory as well. The shoulder range of motion was perfectly suitable for daily activities, and in the final visit the patients experienced slight pain and mostly did not need to take sedatives.

It should be noted that MIPO technique is very effective to treat PHF and have favorable clinical and radiographic results. As required in randomized studies, the results of the employed method were compared with other methods, in particular ORIF, in order to obtain a clear view about its advantages and disadvantages. Currently, there are very few comparative studies available.

One of these studies, recently published by Chiewchantanakit and Tangsripong, stated that compared with conventional techniques, using the MIPO technique to treat PHF was associated with shorter surgery time, less blood loss, shorter hospital stay, and faster union of fractures (9).

Repetto et al. performed a study to compare the clinical results and associated complications of differ-

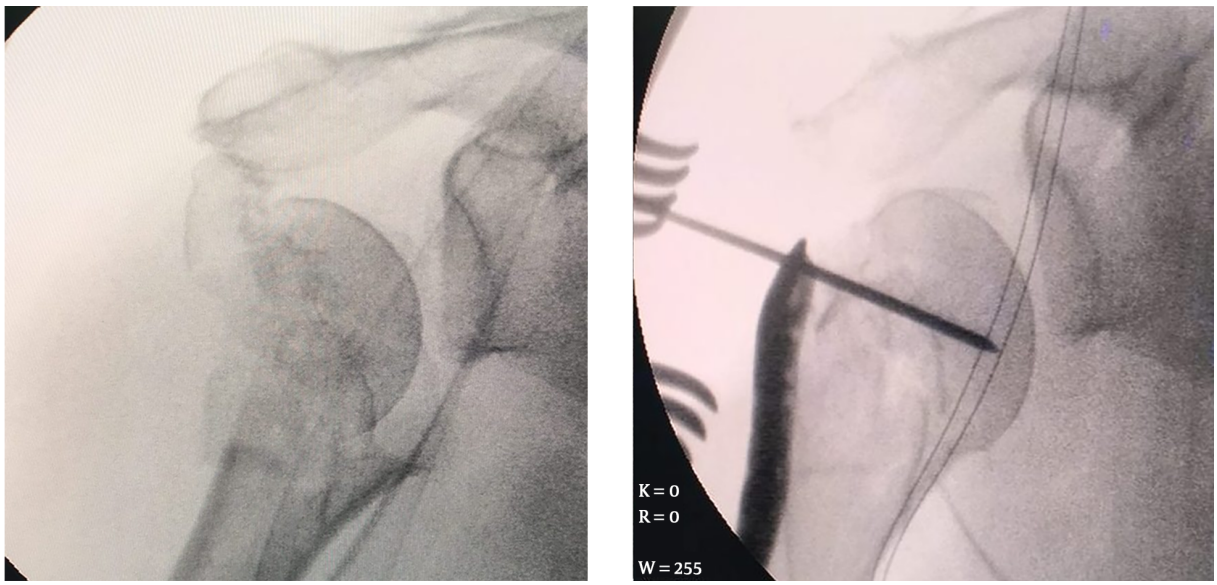

Figure 4. Anatomical reduction with a pin inserted in the head of the humerus

Figure 5. Proximal and distal screws placed in the proximal humeral anatomical plate

ent surgical treatments of complex PHF including hemiarthroplasty, locked plate, and reversed shoulder arthroplasty in 92 patients. No significant differences were observed between postoperative range of motion, complication rate, and overall revision rate of the treatment groups at the end of follow-up (29).

Similar to all other studies, the current study also had its limitations. It seems that future studies with larger sample sizes can provide more reliable results. In addition, in the current study, there was no control group, and patients were followed up for a short time.

4.1. Conclusion

According to the optimal performance results, the acceptable range of motion, the lower pain intensity and the low rate of complications after surgery, the MIPO technique can be employed to effectively to treat PHF.

Footnotes

Authors' Contribution: Study concept and design: Mohammad Ali Okhovatpour; acquisition of data: Adel Ebrahimpour; analysis and interpretation of data: Reza Zandi; drafting of the manuscript: Mohammad Reza Minator Sajjadi; critical revision of the manuscript for important intellectual content: Mehrdad Sadighi; statistical analysis: Amin Karimi; administrative, technical, and material support: Pejman Moradi.

Ethical Considerations: The patients were assured that their information would be submitted for publication, and their consent was obtained. The IRB of Taleghani Hospital affiliated to Shahid Beheshti University of Medical Sciences approved the current study protocol (ethical code: IR.SBMU.MSP.REC.1394.115).

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