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Educational Corner

Well-Performing Locking Plate Fixation with Calcar Screws Technique in Three-Part Proximal Humorous Fracture: Educational Corner

Seyed Peyman Mirghaderi[1], Sadula Sharifpour[2], Elham Rahmanipour[1], Maryam Salimi[3], Milad Salehi[2], Mohamad Reza Guity[4,*]

[1] Medical Student, Joint Reconstruction Research Center, Tehran University of Medical Sciences, Tehran, Iran
[2] Resident, Joint Reconstruction Research Center, Tehran University of Medical Sciences, Tehran, Iran
[3] General Practitioner, Joint Reconstruction Research Center, Tehran University of Medical Sciences, Tehran, Iran
[4] Associate Professor, Joint Reconstruction Research Center, Tehran University of Medical Sciences, Tehran, Iran

[*] Corresponding author: Mohamad Reza Guity; Joint Reconstruction Research Center, Tehran University of Medical Sciences, Tehran, Iran. Tel: +98-21-61192767, Email: m_guity@yahoo.com

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Background

Proximal humerus fracture (PHF) has an increasing incidence rate in older people falling on their stretched arms (1). Because of the vascular anatomy pattern of the proximal humerus, support of the medial cortex becomes essential (2). According to the recent studies, different strategies can provide medial support, but locking plate fixation is the most widely used technique (3). However, 30% of reoperation is reported due to fixation failure, avascular necrosis (AVN) of the humeral head, and postoperative infections. These complications are because of a lack of medial column appropriate structural support (4-6).

Utilizing the calcar screws in patients treated with locking plates provides optimal medial support and reduces the risk of fixation failure (6). Despite the unknown correct aspects of using screws with a locking plate, such as the effect of the number of screws on the stability of the locking plate, it enhances the rigid fixation and reduces the loss of reduction in complicated fractures (7-10).

Although using calcar screws has become popular among surgeons, improper placement of these screws can lead to adverse effects on medial support. Besides the optimal place of calcar screws, the neck-shaft angle of the humerus and the height of the humeral head are other important criteria that should be noticed to have a successful surgery and prevent calcar screws mispositioning (7).

In this educational corner, we present the case of a three-part PHF that underwent fixation using this technique. We aim to describe the critical points of locking plate fixation with the calcar screws technique in three-part PHF for a successful surgery.

Case Presentation

A 65-year-old man, with diabetes mellitus (DM), weight of 70 kg and height of 170 cm [body mass index (BMI) = 24.2], right-hand dominant, fell from the same level on his right arm two weeks before he came to our clinic in the orthopedic department of Imam Khomeini Hospital, Tehran, Iran. He refused surgery in another center, and he resented with a sling. He had severe pain and a limited range of motion (ROM) in his right shoulder during this period. On examination, the observation revealed a severe valgus.

Radiographs showed a three-part PHF of the greater tuberosity and anatomical neck with metaphyseal impaction, which appeared as a sort of malunion after passing two weeks (Figure 1). The medial hinge had a single disruption, and a head extension of more than 8 mm was observed. It is classified as type B2 in the AO Foundation/Orthopaedic Trauma Association (AO/OTA) classification. In addition, it showed humeral neck external deviation, which results in severe valgus.

Figure 1. A three-part proximal fracture; the fracture of the anatomical neck and greater tuberosity lead to three segments with displacement in the proximal head of the humerus.

Technique

The patient was positioned supine, and the deltopectoral approach was used with preserving the medial hinge (Figure 2).

A proximal humerus internal locking system (PHILOS) and calcar screws (Figures 3A and 3B) were used for fixation and inserting a 5cc bone cube under the greater tuberosity to fill the bone defect. After reducing and fixing the greater tuberosity to the humeral head properly, the proximal humeral part was reduced and attached to the distal part.

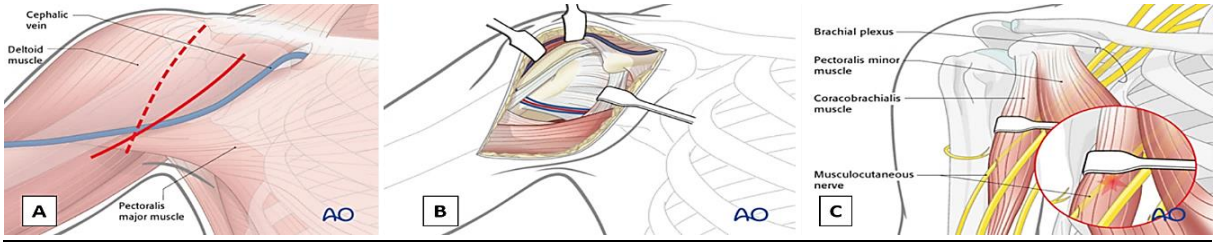

Figure 2. A and B) The deltopectoral approach utilizes the deltoid and pectoralis major muscle plane from the anterior of the shoulder; C) It uses an inner nervous plane between the axillary nerve and the medial and lateral pectoral nerves ["copyright by AO Foundation, Switzerland", "Source: AO Surgery Reference, https://surgeryreference.aofoundation.org" (22)].

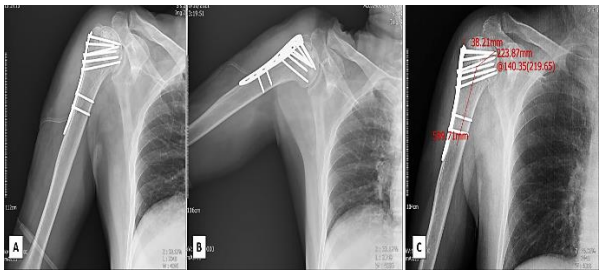

Figure 3. Anterior-posterior (AP) radiography; the proximal humerus internal locking system (PHILOS) plate, and calcar screws have been inserted through the deltopectoral approach; A) shoulder in adduction view; B) Shoulder in abduction view; C) Neck-shaft angle of 140.35°

The rotator cuff insertions' sutures helped manipulations and maintained reduction (Figure 4A). A suture was placed into the subscapularis (i) and the supraspinatus (ii), then into the insertion of the infraspinatus (iii), located just superficially to the bony insertions of each tendon (Figure 4A). A blunt, curved Hohmann retractor was used under the deltoid muscle to facilitate humeral head exposure (Figure 2B). With the aid of a blunt periosteal elevator and digital pressure, the displaced proximal humeral fragment was elevated to correct valgus impaction (Figure 4B). Pulling the supraspinatus and infraspinatus tendons reduced the greater tuberosity (Figure 4C). To fix it, sutures 1 and 3 were tightened and tied (Figure 4D). The reduction and head-neck angle were confirmed by C-arm fluoroscopy and visual control. No additional Kirschner wires (K-wires) were used for stabilizing the humeral head's position. 5 cc of the bone cube was inserted under the greater tuberosity to fill the bone defect.

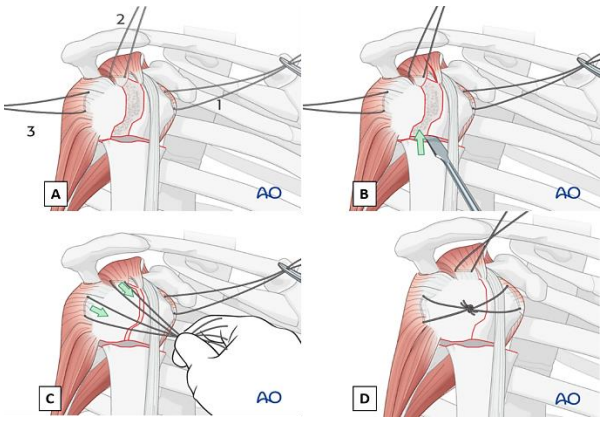

Figure 4. A) Sutures in the rotator cuff insertions, subscapularis tendon (1), supraspinatus tendon (2), and infraspinatus tendon insertions (3); B) Valgus impaction correction; C) Greater tuberosity reduction; D) Greater tuberosity fixation nerves ["copyright by AO Foundation, Switzerland", "Source: AO Surgery Reference, https://surgeryreference.aofoundation.org" (11)]

The plate was installed in the proper position, approximately 5 mm below the highest point of the greater tuberosity, oriented correctly along the humeral axis, and about 3 mm behind the bicipital groove (Figure 5A). A small bicortical fragment 3.5 mm screw was placed with the elongated hole to attach the plate to the humerus. Screw holes for the humeral head were drilled using a fit sleeve, which did not reach the subchondral bone and shoulder joint (Figure 5B). The subchondral bone should be felt with a blunt pin to determine whether the screw is retained within the humeral head. By palpating or tapping against the subchondral bone, its integrity can be confirmed (Figure 5C).

Through the screw sleeve, a locking-head screw was inserted into the humeral head (Figure 5D). In order to have enough strength, six screws were implanted into the humeral head (Figures 3 and 5D). Another bicortical screw was placed into the humeral shaft.

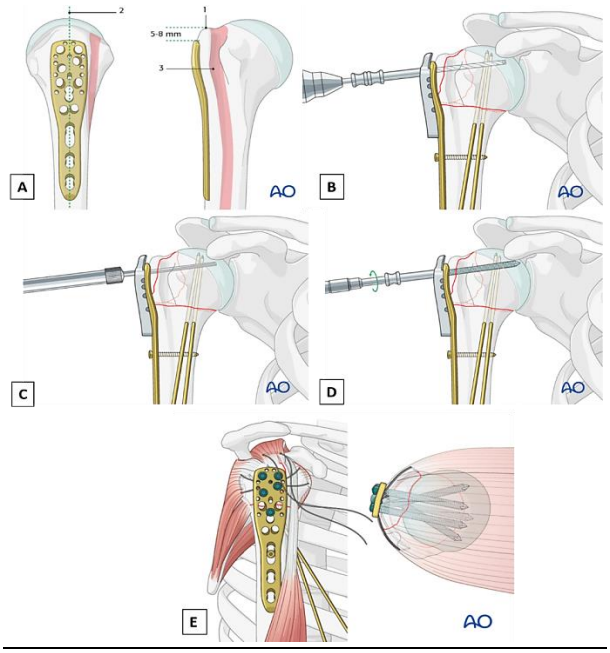

Figure 5. A) Plate correct positioning; B) Drilling holes for the humeral head screws; C) Checking that screw is retained within the humeral head with the blunt pin; D) Palpating or tapping against the subchondral bone to confirm its integrity; E) Locking-head screw was inserted into the humeral head nerves ["copyright by AO Foundation, Switzerland", "Source: AO Surgery Reference, https://surgeryreference.aofoundation.org" (11)]

After fixation, the radiograph (Figure 3C) revealed a neck-shaft angle of 140.35°, a humeral head height of 38.21 mm, the head-shaft displacement of ≤5 mm, and the great tuberosity displacement of ≤5 mm.

After a 6-month follow-up, the patient had an

acceptable functional outcome [Oxford Shoulder Score (OSS) = 52 out of 60] and minimal pain [Visual Analogue Scale (VAS) pain = 3]. In the follow-up, radiographs showed complete union with no collapse, no varus deformity with neck-shaft angle = 140.80°, and the humeral head height of 34.78 mm (Figure 6). No complications were observed, such as frozen shoulder, loss of reduction and fixation, and painful motion.

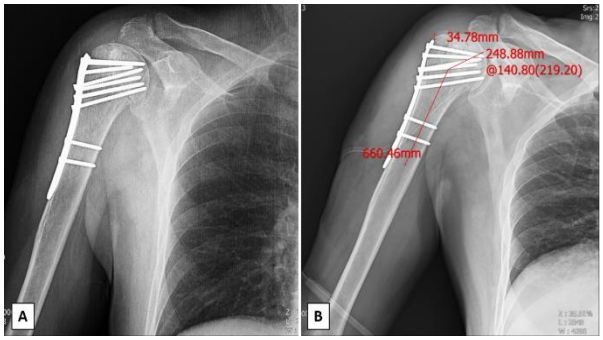

Figure 6. A) Complete healing of the fracture without collapse; B) Appropriate neck-shaft angle of 140.80°

Discussion

The operative or non-operative treatment in PHF depends on various factors. Based on the recent research, the absolute indications for operative treatment are three to four-part fractures, dislocations, unstable or head-splitting fractures, pathologic fractures, open fractures, and fractures that cause neurovascular injuries (12). The conservative approach is most beneficial in a stable or minimally dislocated fracture (13, 14). Although surgery in displaced fractures of the proximal humeral head is demanding, it remains the most effective treatment. Among all surgical options, the locking plate systems are mostly preferred, which improve the resistance to failure by merging angular and axial stability (15-17). Since these plates cannot compromise blood supply in the periosteum of the humerus, recently, calcar screws were added to locking plates to provide adequate medial support (18, 19).

The PHILOS plate and calcar screws are the most commonly used treatment for PHF. Mispositioning of calcar screws in this technique has a remarkable rate of 24%, higher than the rate of complications after plate fixation without screws (20). According to the previous studies, the optimal position of calcar screws significantly increases the medial supply and, by extension, decreases the fixation failure (21). The placing of these screws differs between surgeons. The optimal position based on recent studies is the inferomedial quarter of the humeral head (7).

Mispositioning is affected by different potential factors. First of all, it seems that the place of screws is the most influential factor in the operation outcome. The other most related identified criterion in quality of reduction and fixation is the neck-shaft angle of the humerus. The recommended angle that calcar screws are placed in the optimal position is between 130° and 150°. Appropriate position of calcar screws can improve the outcomes of AO type C fractures and rehabilitation of all patients. The combination of the neck-shaft angle and the height of the humeral head can increase the effectiveness of locking plate reduction for patients (22). On anteroposterior (AP) radiographs of the shoulder, the distance between the top of the humeral head and the plate is determined (13). This radiographic distance can be used to interpret the adequacy of reduction (13).

It seems that the grade and experience of surgeon plays a critical role in the outcome of surgery; however, recent studies showed that it does not result in significant differences (7). Other factors such as demographic characteristics of patients, quality of bone, or type of fractures did not influence calcar screw position, so the surgical errors cannot be caused by them (7). Regardless of the surgeon's experience, the calcar screws will be positioned optimally as long as the neck-shaft angle is reduced.

This technique can also be used even if medial support is not well restored. Although previous research showed that enhancing medial calcar using screws could increase rehabilitation and clinical outcomes, Wang et al. confirmed that inserting calcar screws was not related to restoring medial support (7). This means that calcar screws provide a medial supply and might have other essential effects on the pathophysiology of PHFs that need to be investigated in future studies.

Conclusion

A PHILOS plate with calcar screws is the best-known treatment for fixation in PHF, and the key factors which influence the outcome of surgeries are neck-shaft angle and the height of the humeral head. These can affect the mispositioning of calcar screws and, by extension, the rehabilitation of patients.

Conflict of Interest

The authors declare no conflict of interest in this study.

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