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The Effect of Calcar Screw Use in Fractures of the Proximal Humerus

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Abstract

Background:
Proximal humerus fractures are common in elderly patients. Locking plates offer stable fixation, but loss of reduction and varus deformity still occur, especially with poor medial support.

Methods:
25 patients treated with PHILOS plates were studied. Calcar screws were used in some cases. Radiographs were assessed for neck-shaft angle and calcar screw position. Shoulder function was measured using the Oxford Shoulder Score.

Results:
91% of optimally placed calcar screws were associated with neck-shaft angles between 130°–150°. Malposition rate was 32%. Fixation failure occurred in 3 patients without calcar screws; none occurred in the calcar screw group.

Conclusion:
Use of calcar screws and achieving a neck-shaft angle between 130°–150° reduces fixation failure. Proper placement improves medial support and patient outcomes.

I) Introduction

Total knee arthroplasty (TKA) Proximal humeral fracture is a common shoulder injury particularly in elderly patients; it accounts for about 15% of all fracture cases in patients aged older than 50 years.1,2 Internal fixation with locking plates is used widely in clinical practice to treat this injury.3 The locking structure and fixation pattern of these plates provide a biomechanical advantage especially for osteoporotic bone.4 However, despite the biomechanical superiority and clinical availability of this treatment approach, several multicenter clinical trials have documented unacceptable rates of reduction loss and varus deformity in proximal humeral fractures treated with locking plates.3,5–7 A common pattern of failure is the increased varus of the humeral head, leading to secondary screw penetration or plate breakage.8 The absence of medial support is a potential biomechanical risk factor for the reduction loss and varus displacement.

Proximal humeral fractures commonly occur, often in elderly patients after a fall, where they are the third most common osteoporotic fracture [1]. In most cases, these fractures are minimally displaced and are effectively treated with conservative treatment. But moderate or severe displacement may require surgical intervention.[2]

Interlocking intramedullary nails or percutaneous fixation with locking plate techniques are routinely used in the treatment of proximal humeral fractures [3, 4]. Relatively speaking, the interlocking intramedullary nail tends to have more complications and higher technical requirements, so that lateral long-type proximal humeral internal locking plate (PHILP) is often used, with satisfactory results [5].
PHILP has achieved satisfactory results in fixation of proximal humeral fractures. Nevertheless, several invalid fixations have also been reported [7–5].

One of the key issues is whether the fracture fixation retains contact with the inferomedial cortical bone and whether to insert two calcar screws along the tangential direction of the inferomedial cortex to strengthen the stability of the fracture and prevent fracture introversion [8].

Locking screws are thought to improve fixation of the head and soft metaphyseal, especially with osteoporotic bone, which are frequently associated with patients who experience these fractures [9].

It is important during minimally invasive surgery to avoid iatrogenic radial nerve injury, and PHILP with a spiral plate is likely to achieve more satisfactory results [10]. A spiral long-type PHILP locking plate can avoid point stripping on the deltoid and interference to radial nerve and has better static biomechanical properties.

The importance of the calcar screws in minimally invasive surgery is debated [11, 12]. The humeral calcar refers to the inferomedial cortical area where the humeral head extends to the surgical neck of the humerus. Morphological and microstructural analysis of the proximal humerus shows that this area is the best in terms of the thickness and density of the cortical bone. Inserting one or two screws along the tangential direction of the inferomedial cortex to enhance the stability of the fracture can prevent the varus of the fracture. This screw is called the calcar screw.[13]

There has been controversy over the treatment of comminuted fractures of the proximal medial humerus [13]. These fractures are associated with re- displacement and with reduction relying on the inferomedial cortical bone at the proximal humerus and calcar screw fixation [14].

Anatomic reduction and firm fixation of the humerus is the basic guarantee of proximal stability [15]. However, while there are many clinical studies that show follow-up data [16–18], with useful recommendations for the management of complex.
proximal humeral fractures [13], few studies have the use of calcar screws in a locked plate configuration was introduced to resolve the issues associated with medial calcar deficiency.9 Although existing clinical data have demonstrated that calcar screws maintain alignment in proximal humeral fractures with unstable medial support reduction loss and varus malunion

continue to occur. been undertaken on the dynamic and static stability of different methods of fixing PHILP [19, 20].

In the present study, we aimed to investigate the effects of contact reduction of inferomedial cortical bone at proximal humerus and placement of calcar screw on the stability of proximal humerus fractures, as well as to address the dynamic and static biomechanics, to provide a theoretical reference for clinical treatment

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The aim of this biomechanical study was to explore the effectiveness of calcar screws in avoiding reduction loss and varus deformity in proximal humeral fractures with unstable medial support.

II) Methods

A) Patient Selection and Data Collection:

All proximal humeral fractures treated in our institution between April 2017 and November 2020 were identified through the hospital information system. All analyses were conducted in accordance with the relevant guidelines and regulations of the local ethics committee.

Fractures meeting the following criteria were included in the study:

1) Acute unilateral fractures.
2) Treated by open reduction and internal fixation using the same locking plate (PHILOS plate; DePuy Synthes, Oberdorf, Switzerland).
3) Use of at least one calcar screw.
4) Complete medical and radiological records available, including preoperative anteroposterior (AP) radiographs and CT scans, as well as AP radiographs taken on the first postoperative day.

Exclusion criteria were:

1) Cases involving revision surgery.
2) Patients with prior trauma or surgery involving the same shoulder.
3) Radiographs in which the calcar screw position could not be clearly identified.

Once included, medical and radiological data were extracted from the hospital system.

A total of 25 patients were included (14 males and 11 females), with a mean age of years (range: 22 to 71).
Calcar screws were found to be mispositioned in 8 fractures and optimally positioned in 17, resulting in a malpositioning rate of 32% (8/25).

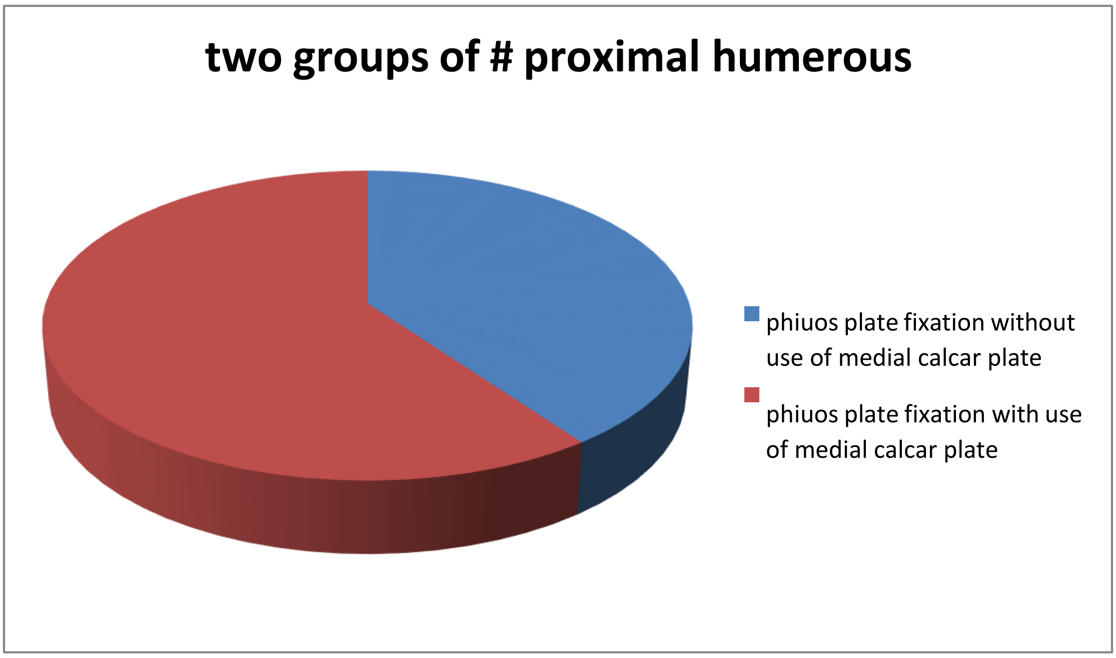
` Potential risk factors were divided into two groups:

1) PHILOS plate fixation with use of medial calcar screws.

2) PHILOS plate fixation without use of medial calcar screws.

B) Patient-Reported Outcomes

Shoulder pain and function were assessed using a validated Norwegian version of the Oxford Shoulder Score (OSS), which consists of 12 questions scored 0 (worst) to 4 (best). The OSS was graded as poor (<36 points), good (36–41 points), or excellent (>41 points).



Each OSS question uses a 5-response Likert scale where 1 is the best response and 5 is the worst. The total score ranges from 12 (least symptomatic) to 60 (most symptomatic).

C) Surgical Technique

1) **Patient Positioning**: Place the patient in the beach chair or supine position on a radiolucent table. Position the fluoroscope to visualize the proximal humerus in two planes (AP and lateral/axial). Prepare the arm for intraoperative mobilization.
2) **Approach and Reduction**: Use a deltopectoral approach.
Reduce the fracture fragments properly for optimal bone healing and function. Closed reduction may be done before prepping in some cases. Confirm reduction under image intensifier guidance. Kirschner wires can be used as joysticks for reduction and temporary fixation, ensuring they do not interfere with plate placement.
3) **Implantation and Suturing**: Provisionally reduce the tubercles using sutures through the insertions of the subscapularis, infraspinatus, and supraspinatus muscles. These sutures help stabilize fragments when fixing to the plate.
4) **Plate Positioning**: Place the plate 2–4 mm posterior to the bicipital groove and 5–7 mm distal to the top of the greater tubercle. Align properly to the humeral shaft. Use the PHILOS aiming device to determine plate position. Insert a Kirschner wire into the proximal guide hole beneath the rotator cuff, aimed at the proximal joint surface.
5) **Drilling and Screw Insertion**: Use a 2.5 mm drill bit with a 3.5 universal drill guide to drill through both cortices. To set screws neutrally, press the drill guide down in the non-

threaded hole; to obtain compression, place it at the opposite end of the non-threaded hole, avoiding downward pressure on the spring-loaded tip.
Insert an appropriate 3.5 mm cortex screw using a hexagonal or Stardrive T15 screwdriver and PHILOS Long Plate. Plate holes distal to section E are LCP combi-holes.
Insert locking screws with the matching screwdriver mounted on a 1.5 Nm torque limiter. Insert screws manually or with a power tool until a click is heard. If using a power tool, reduce speed when tightening the locking screw head into the plate.

III) Results:

angle in the patients with a malpositioned screw was clearly different from that in the optimal position group. Those in the malpositioned group were likely to have either a varus or valgus reduced head while a neutral reduced head was likely to be combined with an optimal position of the screws. Furthermore, in the range of 130° to 150°, 91% (133/146) of calcar screws were in the optimal position. In other words, if the angle was reduced to within the range of 130° to 150° during surgery, there was a 91% possibility that the screws would be optimally placed.
Patients with an intact medial column of the proximal humerus were more often operated without calcar screws, and these fractures were more often approached by deltoid split. Patients with preoperative varus (HSA < 105°(were more often fixated in residual varus malalignment)HSA < 120°) compared to those who presented with a preoperative HSA >105° (8 of 11 (73%) versus 33 of 17019) ;(% < 0.001). Three

patients with PHF treated with a locking plate required a reoperation (%12) due to fixation failure, one patient complicated by superficial surgical site infection and 1 (4%) due to avascular necrosis of the humeral head. In addition, 4 (16%) patients underwent hardware removal due to presumably implant-related local shoulder pain.

Patients operated without calcar screws more often required a reoperation than those who received calcar screws (3 of 15 (13%) versus 0 of ;(%2) 10.

Patients operated without calcar screws had a 3 fold increased risk of a reoperation due to fixation failure compared to those who received calcar screws.

Fixation of the humeral head with a residual varus malalignment (HSA < 120°) also increased the risk of reoperations due to fixation failure.

The interrater agreement for measurements of the postoperative HSA was excellent (ICC There were 132 of 148 (89%) patients who completed the.] (95% CI) = 0.91 (0.88–0.93) [17 OSS questionnaire. The median long-term shoulder function was 40 (IQR 27–46). OSS was available for 19 of 31 (61%) patients who needed a reoperation and for of 117 (97%) patients who did not undergo secondary surgery.

Patients who did not require secondary surgery had a significantly better shoulder score than those who underwent a reoperation (median OSS (IQR) = 41. (versus 25 (13–32); p < 0.001 (46–33)

Complication	No calcar screws	With calcar screws

Fixation failure	3	0
Superficial infection	0	1
Local shoulder pain	2	2
Total	5	3

Complication

IV) Discussion

To the best of our knowledge, this is the first study to report risk factors for malpositioning of calcar screws in these patients Both pre- and intraoperative factors were included in the study and the only related factor which we identified was the neck-shaft angle, which if correctly reduced during surgery would significantly reduce the rate of malpositioning of calcar screws.

According to the diagram of the distribution of the neck-shaft angles, we recommend that surgeons should reduce the angle to between 130° and 150° during surgery, resulting in a high possibility that the calcar screws could be placed in optimal position.

We are also the first to report the rate of calcar screw malpositioning in clinical practice (24%). This rate was much higher than the rate of complications after the fixation of proximal humeral fractures with a plate,18 so it should be considered as a major surgical error. We found that the demographics of the patients and the type of fracture had no influence on the position of the calcar screws, which means that the error cannot be related to the type of fracture or the quality of the bone. If the neck-shaft angle can be satisfactorily reduced, even in patients.

with severely osteoporotic bone or complicated fractures calcar screws could be inserted appropriately. Schnetzke et al15 reported that the quality of reduction influences the outcomes of AO type C fractures. Zderic et al19 showed that malreduction was related to the position of the screws and implant failure.19

However, we did not find that the quality of reduction was related to the position of calcar screws, but the fractures with well-reduced neck-shaft angles (one of the criteria of the quality of reduction) tended to have appropriately placed screws, which has been shown to aid rehabilitation.8 According to the diagram showing the distribution of the neck-shaft angles, the previous criteria for defining reduction by restoring this angle to between 110°- and 150° was not a guarantee of optimal positioning of the calcar screws. From our results, the range of 130° to 150° seemed better (91% vs 87% of the optimal position.

The neck-shaft angle and height of the humeral head are two commonly used criteria which help to evaluate the quality of reduction and fixation when a proximal humeral fracture is treated with a locking plate.11 The height of the humeral head can also, to some degree, reflect the position of the implant Clearly, if the plate is placed too proximally or too distally.

the calcar screws would be outside the optimal region. Recent studies which reported that the position of calcar screws was related to the strength of fixation, and cadaveric outcomes also assumed that good positioning of the plate would make it easier to place the calcar screws within the optimal area.8,11 However we did not find that the humeral head height was related to malpositioning.

Our findings were based on clinical cases and all plates were placed in a satisfactory position. No plate was placed much higher than the great tuberosity to prevent subacromial impingement and in no patients did the humeral head height exceed 3 cm. This means that, in practice, most of the calcar screw malpositioning was not attributed to the position of the plate. Inadequate reduction of the neck-shaft angle was the main reason. This inadequate restoration of the neck-shaft angle should be considered in the design of future in vitro biomechanical models of calcar screw malpositioning.

The experience of the surgeon did not seem to be responsible for malpositioning of the screws. According to our univariate adjusted logistic results, the rates of malpositioning associated with different grades of surgeon were significantly different.

However, in the multivariate regression model, the significance was lost. This could be explained by the fact that the difference observed by univariate analysis was the result of the influence of the reduction. In other words, the reason why grade III surgeons had a lower rate of malpositioning was because they tended to achieve better neck-shaft angles. It has been previously reported that the learning curve affects the quality of reduction and outcome in orthopaedic procedures.20–22 Multivariate analysis revealed that reduction of the neck-shaft angle was more important than the experience of the surgeon for the positioning the calcar screws.

Thus, if the neck-shaft angle was well reduced, the calcar screws tended to be in an optimal position, regardless of the grade of the surgeon.

We also found that restoration of medial support was not an independent factor for the position of the calcar screws.

This was an interesting finding because the aim of using calcar screws is to increase medial support. If medial support was not well restored, we could still insert calcar screws in an optimal position and provide medial support appropriately.

Previous authors have confirmed that satisfactory clinical outcomes can be obtained by enhancing the medial calcar using screws.1,2,6,18,23

Our results support the use of this technique in the management of fractures in which it is difficult to restore medial support intraoperatively. It was notable that among the 43 patients with comminuted medial hinges, 30 were augmented with fibular allografts, four with medial plates, and nine without additional augmentation. The procedures involving medial plates were performed by one grade III surgeon and the calcar screws in these patients were all placed in the optimal position. The small number of cases prevents statistical analysis, but whether a medial-plate technique helps to lower the rate of screw malpositioning is worth further study.

This study has limitations. First, it is retrospective with no sample size estimation, and we do not know whether the number of patients is sufficiently large.

According to statistical principles, for a study involving four variables, a sample size of 40 would meet the most stringent estimations24 and we have 49patients with malpositioning

Secondly, only one type of locking plate was used, and it was designed with angle stable screws rather than angle variable screws. However, in many implant designs, calcar screws have a fixed trajectory relative to the plate. This design can provide more rigid fixation as the plate and locked screws have a predefined geometry. Thirdly some factors which may also influence the position of calcar screws, such as the surgical approach25 and the diameters of humeral head and shaft,8 were not included in our analysis. The main reason is that almost all the patients in this study (199/203) ،(%98) were treated using a routine deltopectoral approach؛ the other four were treated using an anterolateral delta splitting approach, and the diameters of the humeral head and shaft are not commonly used measurements in routine clinical work with loose hardware, (3) type and position of implants, and (4) state of skin and previous scars.

V) Conclusion

Simultaneous The use of calcar screws, as well as the absence of postoperative varus malalignment, significantly reduced the risk of fixation failure.

We, therefore, recommend the use of calcar screws and to avoid residual varus malalignment to improve the medial support of proximal humeral fractures treated with a locking plate.

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