acta orthopaedica belgica, 2024, 90, 429-434

doi.org/10.52628/90.3.12777

Comparison of the varus displacement effect of calcar screw in proximal humerus fractures

C. Z. ESENYEL[1,2], E. KURT[1,2], E. TEKSAN[1,2]

[1]Giresun University Medical Faculty, Department of Orthopaedic Surgery; [2]Giresun University, Faculty of Medicine, Gazipaşa Yerleşkesi Debboy Mevkii, P.K.:28200 Merkez-Giresun, Turkey.

Correspondence at: Cem Zeki Esenyel, Giresun University Medical Faculty, Gazipaşa Yerleşkesi Debboy Mevkii, P.K.:28200 Merkez-Giresun, Turkey, Cell Phone: +90 533 356 03 94, Fax: +90 454 310 16 99, Email: esenyel@yahoo.com

The aim of this study is to investigate whether not using the calcar screw in proximal humerus fractures affects functional and radiological outcomes.
Thirty patients (21 females and 9 males) who presented with proximal humerus fractures and were treated with plate-screw fixation were evaluated. The patients were divided into two groups: group 1 included patients with the use of the calcar screw, and group 2 included patients without the calcar screw. Radiological evaluation was performed by measuring the neck-shaft angle on postoperative day 1 and at 1 year in true anteroposterior radiographs. The groups were compared regarding demographic characteristics, functional outcomes, radiological scores, and complications.
The mean age was 60 (27-92) years. In group 1, a mean decrease of 5.2° in the neck-shaft angle was observed (136.1° on postoperative day 1 and 130.6° at 1 year; p<0.05). In group 2, a mean decrease of 3.1° was observed (133.5° on postoperative day 1 and 130.0° at 1 year; p>0.05). There was no significant difference in the change of the humerus neck-shaft angle between the two groups (p>0.05). The mean Constant score was 70.8 in group 1 and 76.7 in group 2, (p>0.05). There was no significant difference in varus displacement and functional outcomes between the groups using and not using the calcar screw in proximal humerus fractures. Good reduction, stable fixation with locking plates, and preservation of soft tissue integrity are crucial to avoid complications and promote healing in proximal humerus fractures.

Keywords: proximal humerus fracture, varus, calcar screw, avascular necrosis, collodiaphyseal angle.

INTRODUCTION

Proximal humerus fractures constitute 5% of all fractures and 45% of humeral fractures[1]. Three- and four-part proximal humerus fractures account for 13-16% of all proximal humerus fractures[2]. These fractures commonly occur in osteoporotic elderly patients due to low-energy trauma and in young patients due to high-energy trauma[3]. The increasing average age of the population and the rise in the number of individuals with osteoporosis have also led to an increase in the incidence of proximal humerus fractures[4]. Approximately 80% of patients with proximal humerus fractures have no or minimal displacement and can be managed conservatively[5]. However, surgical treatment is required for unstable three- or four-part fractures. Anatomical locking plate fixation, intramedullary nails, K-wire tension band method, angular stable fixation plates, or 1/3 tubular plates are preferred fixation methods[5,6]. Anatomical locking proximal humerus plate fixation, especially in elderly individuals with osteoporotic fractures, is considered the gold standard treatment[6].

Screw loosening, humeral head migration (cut-out), and subsequent loss of reduction are common problems in plate-screw fixation[7,8]. Progressive varus angulation is a common complication[8,9]. To prevent these problems, additional techniques have been introduced, including cement application, pinning, the use of fibular grafts, and medial support plates[9,10]. The contribution of the calcar screw to stability has been emphasized, and several biomechanical studies have been conducted to evaluate its effect on stability[11]. However, there is a lack of clinical studies demonstrating the radiological and clinical outcomes of not using the calcar screw. Previous studies have mostly focused on biomechanical and finite element analyses, with a limited number of clinical studies.

The purpose of this study is to investigate whether there is a true radiological and clinical difference between the groups using and not using the calcar screw in proximal humerus fractures treated with a locking plate, which is considered the gold standard treatment for these fractures.

MATERIALS AND METHODS

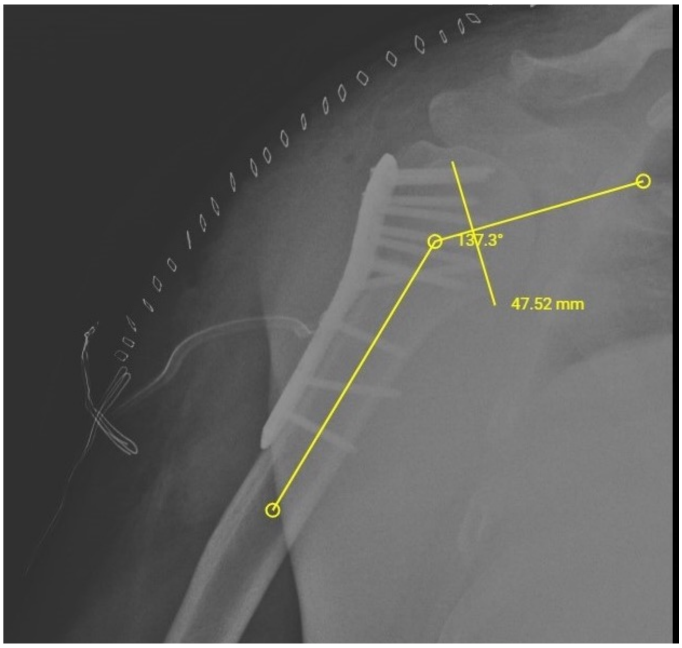
Patients presenting with proximal humeral fractures were retrospectively reviewed in this study. Local ethical board approval was obtained for the study (Decision No: 5, Date: 17/01/2023). Inclusion criteria for the study were patients who had undergone a proximal humeral fracture, had open reduction and fixation with a locking anatomical proximal humerus plate, had complete radiological imaging, and had a minimum follow-up of 12 months.

Exclusion criteria for the study were patients who had previously undergone surgical intervention on the same shoulder, had undergone revision surgery on the affected shoulder, had another fracture in the same upper extremity, had an open fracture, had a pathological fracture, had accompanying neurovascular deficits, had non-standard radiological images, had implants placed in a non-ideal position according to the literature, or were under the age of 18.

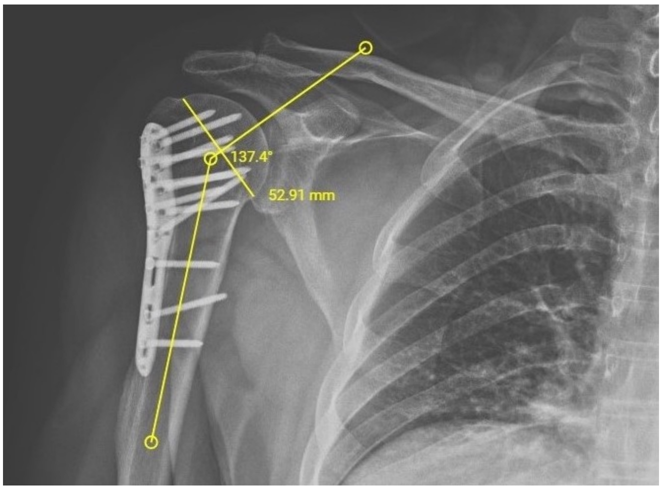
The indication for surgery in patients was evaluated based on Neer's displacement criteria, which included >45° angulation and >1 cm displacement of the fracture fragment, and surgical treatment was applied to unstable fractures.

In this study, 30 patients with three and four-part proximal humeral fractures according to the Neer classification, treated with a locking humerus plate, were included. The patients consisted of 9 males and 21 females, with an average age of 60 years (ranging from 27 to 92). Among them, 11 patients had fractures on the right side and 19 on the left side. According to the Neer classification, 15 patients had a Neer type 3 fracture, and 15 patients had a Neer type 4 fracture. The patients were divided into two groups based on whether a calcar screw was used during surgery. The first group (group 1) included patients who underwent

A. Preoperative X-ray



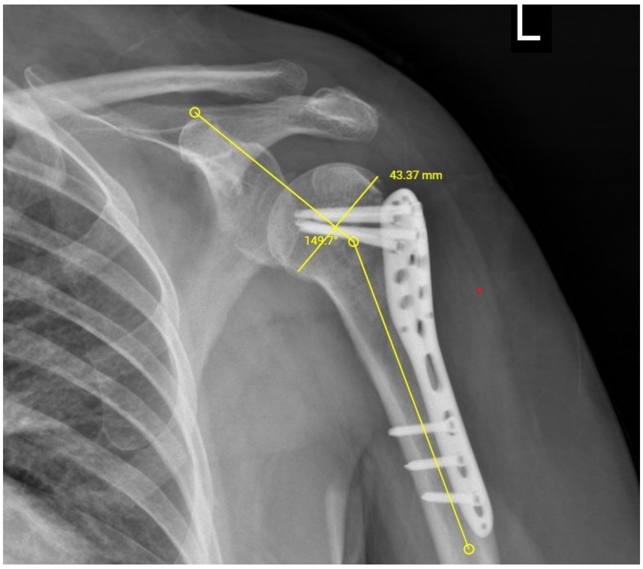
B. Postoperative 2nd-day X-ray with Calcar screw



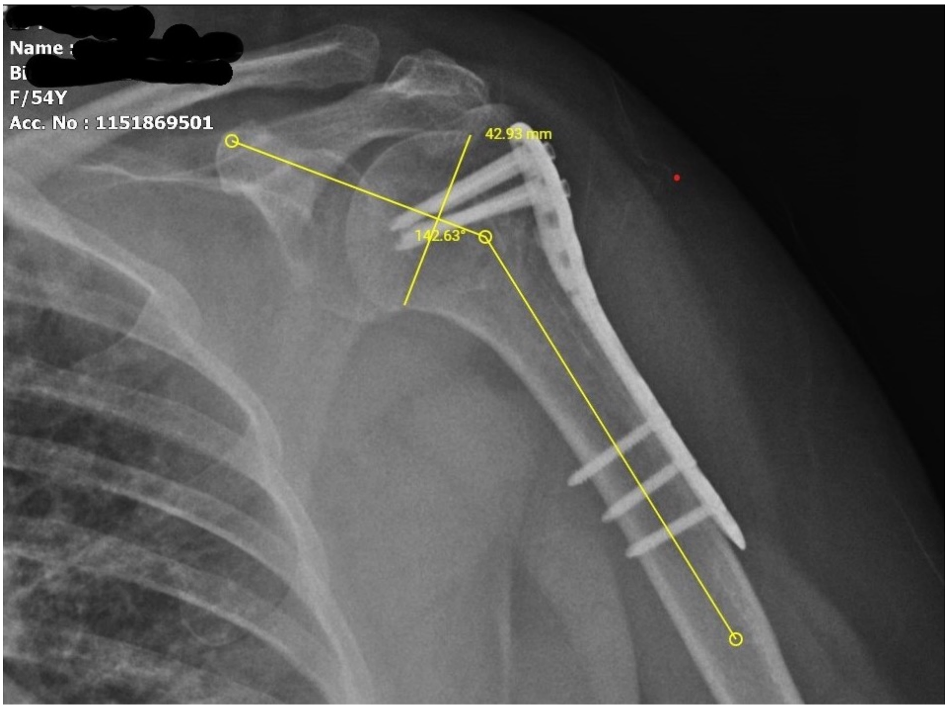
C. Postoperative 1-year X-ray.

Figure 1. — Radiographs of patients in Group 1.

A. Preoperative X-ray



B. Postoperative 1st-day X-ray without Calcar screw



C. Postoperative 1-year X-ray.

Figure 2. — Radiographs of patients in Group 2.

open reduction and internal fixation using a calcar screw as described in the literature (Figure 1 A, B, C) [12, 13]. Group 1 consisted of 5 males and 10 females, with an average age of 58.4 years (ranging from 40 to 84), and among them, 7 had fractures on the right side and 8 on the left side. According to the Neer classification, 7 patients had a type 3 fracture, and 8 patients had a type 4 fracture.

The second group (group 2) included patients who underwent open reduction and internal fixation without using a calcar screw (Figure 2 A, B, C). Group 2 consisted of 4 males and 11 females, with an average age of 61.2 years (ranging from 27 to 92), and among them, 4 had fractures on the right side and 11 on the left side. According to the Neer classification, 6 patients had a type 3 fracture, and 9 patients had a type 4 fracture.

The humeral head-neck angle was measured on true shoulder AP radiographs taken on the first postoperative day and at one year of follow-up for patients with a minimum follow-up of one year (Figures 1 and 2).

The Constant-Murley scoring system was used for clinical evaluation at the one-year follow-up. In the measurement of the humeral shaft-neck angle, the angle between a line drawn perpendicular to the anatomical neck and a line passing through the midpoint of the humeral head articular surface and the anatomical axis of the humeral shaft was measured.

The surgical procedure was performed by an orthopedic specialist under fluoroscopy control in the beach chair position using a deltopectoral approach. After open reduction of the humeral head and tubercles, the position and height of the locking plate were checked with fluoroscopy. The plate was compressed to the humeral shaft with one cortical screw after temporary plate fixation with K-wires. For the locking screws in the humeral head, a single cortical screw was used. The calcar screw was inserted obliquely into the inferomedial quadrant of the humeral head as described in the literature (Figure 2). Adequate medial cortical contact was ensured from the medial side. After the completion of screw placement, fluoroscopic controls were performed with standard anterolateral and lateral images.

During the postoperative period, patients were placed in a shoulder sling. In the physiotherapy and rehabilitation process, passive pendulum shoulder joint exercises were started on the first postoperative day, passive-assisted movements were initiated at the third week, and active-assisted movements were started at the end of the sixth week.

Data analysis was performed using the Statistical Package for the Social Sciences version 16 (SPSS). The normal distribution of variables was examined using histogram graphs and the Kolmogorov-Smirnov test. Nonparametric variables were compared between groups using the Mann-Whitney U test and the Kruskal-Wallis test. The paired t-test was used for evaluating normally distributed repeated measurements in dependent groups. Fisher's Exact or Chi-Square test was used for comparing categorical data. A significance level of $p<0.05$ was considered statistically significant.

RESULTS

The demographic characteristics are shown in Table I. In Group 1, there was an average decrease of 5.2° in the neck-shaft angle (136.1° on the first postoperative day and 130.6° at one year, $p<0.05$). In Group 2 (without a calcar screw), an average decrease of 3.1° was observed (133.5° on the first postoperative day and 130.0° at one year; $p>0.05$). There was no significant difference in the change of the humerus neck-shaft angle between the two groups ($p>0.05$) (table II). The average Constant score was 70.8 in Group 1 and 76.7 in Group 2, with no significant difference between the groups ($p>0.05$) (table III). In one patient in whom a calcar screw was used, avascular necrosis was observed during follow-up, leading to intra-articular screw penetration. The average follow-up period was 34 months (ranging from 32 to 36 months).

Table I. — Demographic data

	Calcar Screw	Without Calcar Screw
Age	58,4 (40-84)	61,2 (27-92)
Gender Male Fmale	 5 10	 4 11
Side R L	 7 8	 4 11
Neer fracture type Type 3 Type 4	 7 8	 6 9

Table II. — Change in neck-shaft angle

	Post-op 1st day neck-shaft angle	Post-op 1st year neck-shaft angle	Change	P-value
Group 1	136.1	130.6	5.2	<0,05
Group 1	133.5	130	3.1	>0,05

Table III. — Inter-group comparison

	Group 1	Group 2	
Varus displacement	5.2	3.1	p> 0.05
Constant-Murley Score	70.8	76.7	p>0.05

DISCUSSION

Proximal humeral fractures are the third most common osteoporotic fractures and the surgical treatment of these fractures has increased approximately fourfold in recent years compared to previous years. One of the challenges in surgical treatment is achieving and maintaining the reduction of the fracture fragments due to the forces exerted by the muscles attached to the bone. For many years, three or four-part fractures were considered prone to non-union for both conservative treatment and fixation, and Neer suggested arthroplasty for these types of fractures. However, with the development of locking plates, better outcomes were reported for surgical fixation in elderly patients with complex fractures[14]. In our study, all proximal humeral fractures treated with plate osteosynthesis were Neer type 3 and type 4 fractures. However, in both type 3 and type 4 fractures, providing medial support with the calcar screw was reported to be challenging.

In this study, patients who underwent surgery with or without the use of a calcar screw were clinically and radiologically examined. There was no statistically significant difference between the groups using and not using a calcar screw regarding age, gender, fracture type, and clinical and radiological findings. During surgery, no patient had their capsule dissected. The main blood supply to the humeral head is through the anterior circumflex artery, but research has shown that after a fracture, the posterior circumflex artery comes under pressure[15,16]. Since blood supply reaches the humeral head by passing through the capsule, the better the preservation of the capsule during surgery, the higher the success of the treatment. Hertel et al. reported in their study that an increase in the posteromedial contact area leads to improved blood supply to the humeral head and reduced necrosis, highlighting a strong connection between medial support and blood supply[17].

In proximal humerus fractures, medial cortical contact is crucial for stability. Previous biomechanical studies have shown that achieving stability by fixing the fragments in varus and providing medial cortical support is essential for these fractures[18]. Considering the importance of medial support, Gardner et al. applied a fibular graft to restore medial support[19]. In multi-fragment fractures, inadequate medial column stabilization can be the cause of early reduction loss and failure[20, 21].

A recent study has shown that anatomical fracture reduction with a locking plate significantly improves functional outcomes and reduces complication rates in unstable and displaced proximal humerus fractures containing the anatomical neck. Furthermore, the use of an oblique locking screw (calcar screw) in the inferomedial quadrant of the proximal humeral fragment has been shown to prevent fixation failure[7,22, 23].

In a study by Juan Agedelo et al., it was suggested that if the head-shaft angle is ≥120° in postoperative radiographs, there will be no fixation loss, but if it is <120°, early failure may occur[24]. In our study, when neck-shaft angles were compared at early postoperative and 1-year follow-up, no significant difference was found for both groups. Similarly, there was no significant difference when the two groups were compared clinically.

Although there are numerous biomechanical studies on the use of calcar screws in the medical literature, there is a lack of clinical studies[8,25,26].

As mentioned by Gardner et al.[27], when examining the surgical treatment and outcomes of proximal humerus fractures, it is important to limit soft tissue dissection to preserve the soft tissues in the region since they need to be nourished for the fragments to heal.

As for the limitations of our study, they include a small number of cases, its retrospective nature, being conducted in a single center, and having a limited follow-up period. A more comprehensive prospective study would provide more reliable results.

CONCLUSION

When comparing the groups of patients who underwent surgery with and without a calcar screw for proximal humerus fractures, we observed no significant difference in varus displacement and functional outcomes during follow-ups. As mentioned in the literature for these fractures, we emphasize the importance of achieving good reduction, fixation of fracture fragments with locked plates without damaging the surrounding soft tissues, and preserving the integrity of the soft tissues. Proper plate-screw fixation should aid in the healing process. Even with perfect plate-screw fixation, failure can occur if healing does not take place. Therefore, preserving the integrity of soft tissues is even more critical to prevent complications such as impaired blood supply and avascular necrosis.

Author contribution statement: CZE contributed to study design, data collection, and analysis, manuscript writing, and revisions. ET contributed to the literature review, data analysis and interpretation, manuscript writing, and revisions, contributed to the data collection, data analysis, and manuscript revisions. EK contributed to the data interpretation, manuscript writing, and manuscript revisions.

Ethics: Ethics Committee Approval: Approval for the study was granted by the Clinical Research Ethics Committee of Giresun University Faculty of Medicine.

Declarations of interest: None.

Financial Disclosure: None.

REFERENCES

1. Lind T, Krøner K, Jensen J. The epidemiology of fractures of the proximal humerus. Arch Orthop Trauma Surg. 1989;108(5):285-7.

2. Rose SH, Melton LJ 3rd, Morrey BF, Ilstrup DM, Riggs BL. Epidemiologic features of humeral fractures. Clin Orthop Relat Res. 1982 Aug;(168):24-30.
3. Hohmann E, Keough N, Glatt V, Tetsworth K. Surgical treatment of proximal humerus fractures: a systematic review and meta-analysis. Eur J Orthop Surg Traumatol. 2023 Aug;33(6):2215-2242.
4. Kannus P, Palvanen M, Niemi S, Parkkari J, Järvinen M, Vuori I. Osteoporotic fractures of the proximal humerus in elderly Finnish persons: sharp increase in 1970-1998 and alarming projections for the new millennium. Acta Orthop Scand. 2000 Oct;71(5):465-70.
5. Egol KA, Ong CC, Walsh M, Jazrawi LM, Tejwani NC, Zuckerman JD. Early complications in proximal humerus fractures (OTA Types 11) treated with locked plates. J Orthop Trauma. 2008 Mar;22(3):159-64.
6. Chow RM, Begum F, Beaupre LA, Carey JP, Adeeb S, Bouliane MJ. Proximal humeral fracture fixation: locking plate construct ± intramedullary fibular allograft. J Shoulder Elbow Surg. 2012 Jul;21(7):894-901.
7. Bayrak A, Duramaz A, Koluman A, Kural C, Ziroğlu N, Gözügül K, Peker G. Does plate-screw density affect the functional outcomes in the treatment of proximal humerus fractures? Ulus Travma Acil Cerrahi Derg. 2022 Jun;28(6):824-831.
8. Namdari S, Voleti PB, Mehta S. Evaluation of the osteoporotic proximal humeral fracture and strategies for structural augmentation during surgical treatment. J Shoulder Elbow Surg. 2012 Dec;21(12):1787-95.
9. Kennedy J, Feerick E, McGarry P, FitzPatrick D, Mullett H. Effect of calcium triphosphate cement on proximal humeral fracture osteosynthesis: a finite element analysis. J Orthop Surg (Hong Kong). 2013 Aug;21(2):167-72.
10. Neviaser AS, Hettrich CM, Beamer BS, Dines JS, Lorich DG. Endosteal strut augment reduces complications associated with proximal humeral locking plates. Clin Orthop Relat Res. 2011 Dec;469(12):3300-6.
11. Egol KA, Sugi MT, Ong CC, Montero N, Davidovitch R, Zuckerman JD. Fracture site augmentation with calcium phosphate cement reduces screw penetration after open reduction-internal fixation of proximal humeral fractures. J Shoulder Elbow Surg. 2012 Jun;21(6):741-8.
12. Mehta S, Chin M, Sanville J, Namdari S, Hast MW. Calcar screw position in proximal humerus fracture fixation: Don't miss high! Injury. 2018 Mar;49(3):624-629.
13. Padegimas EM, Zmistowski B, Lawrence C, Palmquist A, Nicholson TA, Namdari S. Defining optimal calcar screw positioning in proximal humerus fracture fixation. J Shoulder Elbow Surg. 2017 Nov;26(11):1931-1937.
14. Solberg BD, Moon CN, Franco DP, Paiement GD. Surgical treatment of three and four-part proximal humeral fractures. J Bone Joint Surg Am. 2009 Jul;91(7):1689-97.
15. Sergent A, Rouleau DM, Beauvais É, Ménard J, Petit Y, Leduc S, Laflamme GY. Quantitative localization of the entry point of the lateral ascending branch of the anterior circumflex humeral artery: a high definition CT-scan radiological study. Surg Radiol Anat. 2020 Mar;42(3):233-237.
16. Brooks CH, Revell WJ, Heatley FW. Vascularity of the humeral head after proximal humeral fractures. An anatomical cadaver study. J Bone Joint Surg Br. 1993 Jan;75(1):132-6.
17. Hertel R, Hempfing A, Stiehler M, Leunig M. Predictors of humeral head ischemia after intracapsular fracture of the proximal humerus. J Shoulder Elbow Surg. 2004 Jul-Aug;13(4):427-33.
18. Lescheid J, Zdero R, Shah S, Kuzyk PR, Schemitsch EH. The biomechanics of locked plating for repairing proximal humerus fractures with or without medial cortical support. J Trauma. 2010 Nov;69(5):1235-42.
19. Gardner MJ, Boraiah S, Helfet DL, Lorich DG. Indirect medial reduction and strut support of proximal humerus fractures using an endosteal implant. J Orthop Trauma. 2008 Mar;22(3):195-200.
20. Huttunen TT, Launonen AP, Pihlajamäki H, Kannus P, Mattila VM. Trends in the surgical treatment of proximal humeral fractures - a nationwide 23-year study in Finland. BMC Musculoskelet Disord. 2012 Dec 29;13:261.
21. Iannotti JP, Ramsey ML, Williams GR Jr, Warner JJ. Nonprosthetic management of proximal humeral fractures. Instr Course Lect. 2004;53:403-16.
22. Gardner MJ, Weil Y, Barker JU, Kelly BT, Helfet DL, Lorich DG. The importance of medial support in locked plating of proximal humerus fractures. J Orthop Trauma. 2007 Mar;21(3):185-91.
23. Wang Q, Sheng N, Rui B, Chen Y. The neck-shaft angle is the key factor for the positioning of calcar screw when treating proximal humeral fractures with a locking plate. Bone Joint J. 2020 Dec;102-B(12):1629-1635.
24. Agudelo J, Schürmann M, Stahel P, Helwig P, Morgan SJ, Zechel W, Bahrs C, Parekh A, Ziran B, Williams A, Smith W. Analysis of efficacy and failure in proximal humerus fractures treated with locking plates. J Orthop Trauma. 2007 Nov-Dec;21(10):676-81.
25. Bai L, Fu Z, An S, Zhang P, Zhang D, Jiang B. Effect of Calcar Screw Use in Surgical Neck Fractures of the Proximal Humerus With Unstable Medial Support: A Biomechanical Study. J Orthop Trauma. 2014 Aug;28(8):452-7.
26. Yang P, Zhang Y, Liu J, Xiao J, Ma LM, Zhu CR. Biomechanical effect of medial cortical support and medial screw support on locking plate fixation in proximal humeral fractures with a medial gap: a finite element analysis. Acta Orthop Traumatol Turc. 2015;49(2):203-9.
27. Gardner MJ, Griffith MH, Dines JS, Lorich DG. A minimally invasive approach for plate fixation of the proximal humerus. Bull Hosp Jt Dis. 2004;62(1-2):18-23.