Original Article

HEALTH SCIENCES
MEDICINE

DOI: 10.32322/jhsm.1214157
J Health Sci Med 2023; 6(1): 134-139

Functional results of deltoid split minimally invasive osteosynthesis for neer type 3 proximal humerus fractures

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Cite this article as: Bekmezci T, Çepni SK, Batar S, Sisman A. Functional results of deltoid split minimally invasive osteosynthesis for neer type 3 proximal humerus fractures. J Health Sci Med 2023; 6(1): 134-139.

ABSTRACT

Aim: We aimed to evaluate the short-term functional and radiological outcomes of the minimally invasive fixation of three-part proximal humerus fractures without using calcar screws.

Material and Method: Twenty patients were treated with the minimally invasive approach using locking plate-screws. The relationship between the cephalo-diaphyseal angles and the functional outcomes were evaluated.

Results: The mean follow-up time were 22.7 months. The mean Constant-Murley score of the patients was 83.7. The modified Constant-Murley score was excellent in 16 and good in four patients. A statistically significant difference was detected between cephalo-diaphyseal angles.

Conclusion: Osteosynthesis with minimally invasive plate-screw and deltoid splitting application is encouraging with its satisfactory results in three-part fractures of the humerus; however, the total complication rate of 35% should not be ignored. In addition, in order to prevent a significant varus collapse and angular loss, the fracture subgroups should be studied in detail and additional measures should be taken based on the fracture type.

Keywords: Calcar screw, deltoid split, MIPO, proximal humerus fracture

INTRODUCTION

Fractures of the proximal humerus comprise 5% of all fractures. While the conservative treatment results of the non-displaced proximal fractures exhibit 100% of union and excellent functionality, the conservative treatment of the displaced three and four-part fractures result in complications in 48% of the patients, with avascular necrosis in 14% and varus-malunion in 23% (1).

The treatment of osteoporotic fractures with locking plate-screw systems is a popular approach among surgeons (2). Biomechanical studies have shown the superiority of locking plate-screws to intramedullary nails and conventional plates (3,4). However, the rate of complications due to the use of locking plates may reach as high as %48.8 (5). The high rates of complication and low functional scores were associated with the type of the fracture (6). In addition, fracture types without the medial cortex support have a higher risk of varus malunion (7-9). Therefore, the use of calcar screws has been asserted to decrease the secondary reduction loss (8).

In recent years, the deltoid splitting approach has gained popularity with minimally invasive plate-screw osteosynthesis (MIPO) applications (6,8). The deltoid splitting (DS) approach has been suggested as an alternative to the deltopectoral approach due to the lateral placement of the plate and easier management of the greater tuberosity (10,11). However, fixation with calcar screws along the axillary nerve is a technique problem with the DS-MIPO technique (12).

This study was designed with the aim of evaluating the functional and radiological results of the fixation of the three-part proximal fractures employing the DS-MIPO approach without using calcar screws. The cephalo-diaphyseal angular loss and its effect on the functional outcomes, malunion and complications in the postoperative early and late-term were investigated.

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Received: 25.11.2022 **Accepted:** 24.12.2022

MATERIAL AND METHOD

The study was carried out with the permission of Ümraniye Training and Research Hospital Clinical Researches Ethics Committee (Date: 09/04/2021, Decision No: E-54132726-000-7920). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Three-part fractures of the proximal humerus treated between 2013 and 2015 were included in the study. Cases with accompanying injuries, fracture dislocations, splitting of the humeral head, the 'egg shell' appearance of the humeral head due to osteoporosis, and neurological problems were excluded as different methods had been employed in their treatment. A total of 20 patients (4 males, 16 females) with a mean age of 63.9 (range: 43 to 82) years were included in the study. Six patients had valgus-impaction fractures and 14 had procurvatum fractures on the sagittal or varus angulation fractures on the coronal plane.

Surgical Technique

All patients were operated in the beach chair position and under interscalene block and general anesthesia using an electromagnetic limb positioner (Spider 2; Smith & Nephew, Andover, MA, USA). The fluoroscope was sterilely placed to obtain a true anteroposterior view of the shoulder and kept stationary throughout the surgery. Deltoid splitting was performed 5 cm lateral of the proximal acromion. The axillary nerve exiting the quadrilateral space was palpated. First, the tubercle fragments were attached to the plate with sutures. In all cases, the plate was placed two millimeters behind the biceps tendon in the lateral plane and 5-8 millimeters distal to the upper end of the humerus in the sagittal plane. Plate placement was checked with fluoroscopy. An incision 3 cm to the distal of the plate was made to confirm the locking of the distal part of the plate on the sagittal plane. Alignment was achieved under fluoroscopy control with direct and indirect reduction methods. Then, temporary reduction was achieved with two Kirshner wires applied superiorly. In necessary cases, the continuity of the medial calcar was ensured with the help of a periosteal scraper applied from the fracture line. Reduction quality and continuity of medial calcar were confirmed by fluoroscopy in all cases. In patients with a metaphyseal defect, a cancellous graft of 15-30 cc was placed between the humeral head and greater tuberosity. A tunnel was created beneath the deltoid muscle group and axillary nerve and the anatomical 5-hole locking proximal humerus plate (Philos; DePuy Synthes, Oberdorf, Switzerland) was placed. Due to the location of the axillary nerve, 3.5 mm locking screws were used on the A1, A2, B1, B2, C1, C2 and D sections. The E section for calcar screws was left unused. 3.5 mm cortical, 4 mm spongious, and 3.5 mm locking screws were used in the distal. Three cases with valgus impaction fractures and one case with varus-procurvatum fracture patient were treated with allografts while six cases with varus-procurvatum fractures were managed by the metaphyseal compression technique (**Figure 1, 2**).

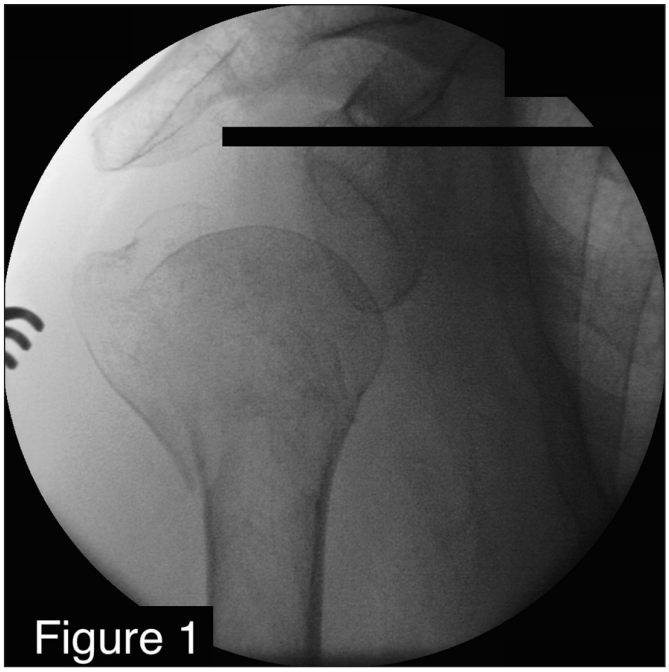


Figure 1. Valgus impaction fracture with displaced tuberculum majus was observed.

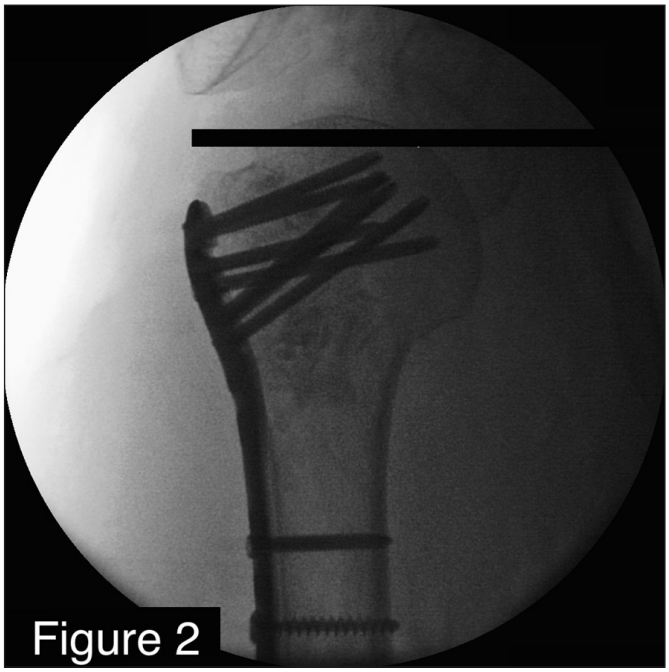


Figure 2. Fracture reduction and grafting was performed.

Follow-up After Surgery

The patients were given arm sling for three weeks postoperatively. Shoulder pendulum exercises, active assisted passive motion exercises and elbow-wrist ROM exercises were performed. The patients were examined at the 3rd, 6th, 12th, 16th week and final follow-up visits.

Assessment of the Results

Postoperative early-term and late-term cephalo-diaphyseal angles (CDA and LCDA) were measured for assessment of the radiological outcomes. Constant-Murley scores for the operated shoulder (CMS) and for the contralateral shoulder (CCMS) and the difference between two shoulders (DCMS) were noted for the assessment of functional outcomes (7,13). Normal distribution of the variables was checked with the Kolmogorov-Smirnov test. The relationship between the CDA and LCDA was assessed using the paired t-test. Pearson's correlation analysis was employed for evaluating the relationship between the CDA-LCDA and CMS-DCMS. The statistical significance level was set at $p<0.05$ (MedCalc Software Belgium 1993-2016).

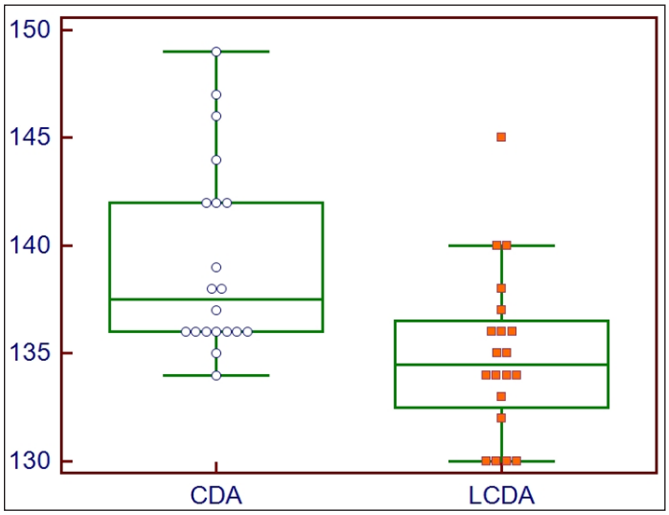
RESULTS

The mean follow-up period and time to union were 22.7 (range: 8 to 44) and 3.2 (range: 3 to 8) months, respectively. No infection or non-union was observed in any patient. Migration of the B2 screw was observed in two patients (10%) in the early-term. Screw removal was performed in these two cases by reoperation. Four patients (20%) developed anterior deltoid deficiency which lasted up to six months. These patients were followed up with anterior deltoid training and electrostimulation.

Mean angular losses of 11° (range: 0° to 15°) in forward elevation, 12° (range: 0° to 15°) in abduction, and 8° (range: 0° to 10°) in adduction and external rotation versus the contralateral shoulder were observed (**Table 1**).

The mean CMS was 83.7 (range: 72 to 96), CCMS was 91.4 (range: 82 to 100) and DCMS was 7.25 (range: 0 to 19). The CMS and CCMS was found in correlation with age (p=0.0004 and p=0.0001) while DCMS showed no correlation (p=0.6815). Based on the DCMS, 16 patients had excellent and four had good results.

The mean CDA and LCDA were 139.25° (range: 134° to 149°) and 134.95° (130° to 145°), respectively. A statistically significant difference was detected between the CDA and LCDA ($p<0.0001$) (**Graphic**) One patient (5%) had 6° of varus. This patient did not encounter any nonunion or implant failure; however, developed migration of the B2 screw from the posterior.



Graphic. A statistically significant difference was detected between the early cephalo-diaphyseal angle (CDA) and late cephalo-diaphyseal angle (LCDA).

In evaluation of the functional and radiological functions, neither the CMS nor the DCMS were found to correlate with the CDA or LCDA (p=0.2474) (p=0.0882) (p=0.2600) (P=0.1520).

DISCUSSION

The functional results were excellent in 16 and good in four DS-MIPO patients. Although their occurrences have been reported in the literature, complications of impingement, nonunion, malunion, or infection due superior positioning of the plate was not observed in our DS-MIPO series (14,15).

Table 1. Demographics & clinic results

Sex	4 male	16 female	
Fracture type	6 Valgus impaction	14 Procurvatum varus	
Age	Mean 63.9	10.6 SD	Range 43-82
Follow	Mean 22.7	11.6 SD	Range 8-44
Union time	Mean 3.2	1.11 SD	Range 3-8
Forward flexion diffirence	Mean 11	2.88 SD	Range 0-15
Abduction diffirence	Mean 12	3.12 SD	Renge 0-15
External rotation diffirence	Mean 8	2.73 SD	Renge 0-10
Constant Murley score	Mean 83.7	7.94 SD	Renge 72-96
Contrlateral constant Murley score	Mean 91.4	5.60 SD	Renge 82-100
Delta constant Murley score	Mean 7.25	4.99 SD	Renge 0-19
Cephalo diaphysier angle	Mean 139.25	4.43 SD	Renge 134-149
Late Cephalo diaphysier angle	Mean 134.95	3.85 SD	Renge 130-145

The Constant-Murley scores of both the operated and healthy shoulders were found to decline with the age of the patients. The delta Constant-Murley score was an independent variable of age. In their series of 23 DS-MIPO patients, Barco et al. (14) observed that the CMS was lower in patients above 65 years of age in comparison to those younger than 65. However, the scores of the contralateral shoulder and their relationship with age were not investigated in their study.

The aim of this study was to assess whether the stability could be preserved with the use of calcar screws and to investigate the effects of instability (LCDA-CDA difference) on the clinical outcomes. The difference between the LCDA and CDA pointed out to the probability of small angular losses (mean: 4.4 °, range: 0° to 6°). However, the LCDA measurements in all patients were within the normal range (125° to 140°) (16,17). In addition, the functional scores did not correlate with this angular change. This disassociation might be explained with the distribution of the CDA and LCDA within physiological limits.

Few studies in the literature have compared the early and late-term CDA outcomes in DS-MIPO patients. Altman et al. (12) treated 21 patients employing the DS-MIPO technique without calcar screws and found no significant difference between the early and late-term CDA outcomes, a finding in contrast to ours. Their intraoperative measurements had a mean of 139° (range: 123° to 156°) and their follow-up measurements had a mean of 138° (range: 123° to 159°); with only 11 patients in their series with a Neer Type 3 fracture. Similarly, Sohn et al.(6) investigated the CDA changes in their 62-patient series, with Neer Type 3 fractures in 24, and observed no statistically significant difference. The angular loss in Type 4 fractures was more significant in comparison to Type 3 and Type 2 fractures. The mean early and late-term Neer CDA measurements in Type 3 patients were 131°±2° (range: 115° to 144°) and 138°±2° (range: 110° to 147°), respectively.

Although we did not use calcar screws in our study, we took other precautions we thought might be useful for a rigid fixation. One of them was grafting for the valgus impaction fractures and the other was metaphyseal compression for the varus procurvatum fractures.

The dead space technique with grafting is an important factor in rigidity of the fixation. Therefore, in order to increase the stability of the valgus impaction fractures, the use of allograft-autograft-tricalcium phosphate has been recommended (7,18-21). Thus, in order to increase the rigidity of the fixation, we used grafting in three patients with valgus impaction fractures.

Varus fractures possessing problem for the continuity of the medial cortex are also a challenge to providing balance. The use of calcar screws has been recommended especially in varus type fractures (8,9). Moreover, in addition to calcar screws, structural allografts are used in order to increase the rigidity of fixation (22,23). Fibular and femoral allografts are other options (1,24). In their study simulating a metaphyseal defect, Yang et al. (9) found that metaphyseal compression and/or calcar screws increased the rigidity of fixation. Six patients in the study had varus-procurvatum angular deformity and instability was observed due to metaphyseal destruction. Instead of grafting or using calcar screws, metaphyseal compression was performed, as suggested by Yang et al. (9).

Despite the presence of varus deformity, which could be interpreted as a radiological anomaly and to have clinical significance, one (5%) of our patients developed a varus angulation of 6° that led to a LCDA of 132°. Late-term screw migration was present as a secondary finding of deformity; however, we had good outcomes according to DCMS. We performed no metaphyseal compression in fixing the varus medial cortex defect of this patient and tried to increase the stability using allografts.

Due to its anatomical proximity, DS-MIPO surgery has a special significance for the axillary nerve. The distance between the axillary nerve and the lateral of the acromion, from the posterior edge of the acromion, varies between 79 (range: 65 to 90) and 72 (range: 60 to 85) mm. This distance has a statistically significant relationship with the humeral length (25). The EMG studies on the axillary nerve, performed following anterolateral fixations using the minimally invasive approach, presented subclinical findings which do not affect functionality (26). Some MIPO studies have recounted transient axillary nerve dysfunction rates of 2-5%. However, no permanent functional complications were reported and the criteria or definition for deltoid functional deficiency have not been defined in these studies (10,27). Axillary nerve dysfunction may go unnoticed as active movement is not recommended until 3 to 6 weeks after surgery and the patients try to avoid performing such moves. In our study, anterior deltoid deficiency, lasting up to six months in four (20%) patients, was observed. The patients had no difficulties with passive joint range of motion; however, they could not initiate abduction or forward elevation while on foot but perform forward elevation while lying down. These findings were considered clinically diagnostic factors for anterior deltoid deficiency. The patients were followed with anterior deltoid training and electrostimulation. Three patients showed signs of clinical recovery on the 12th, 12th and 16th weeks, respectively, and another one on the sixth month.

The screws in two patients (10%) were removed at the 6th and 8th months due to migration and joint mobilization was performed under anesthesia. DS-MIPO applications are prone to screw migration as in the deltopectoral approach (5,6,10). While early-term screw migration takes place during intraoperative screw insertion and is a key element for intraoperative radiological evaluation, late-term screw migration is secondary to the collapse of the fragment or varus deformity and points out to insufficient rigidity of the fixation (14,28).

One of the weaknesses of our study was the heterogeneity due to subgrouping of the three-part fractures under different characteristics. Grafting of the dead space in valgus impaction fractures in order to avoid the collapse of the head and fixation via metaphyseal compression in instable varus fractures where cortical continuity is failed have proved their support in achieving stability, however, this support could not be quantified. In this context, the consequences of not using calcar screws remain unclear. In addition, the lack of diagnosis and follow-up of the axillary nerve dysfunction via EMG can be considered another important weakness.

CONCLUSION

Fixation of the three-part proximal humerus fractures using the MIPO plate-screw approach without calcar screws returned excellent functional results in 80% and good results in 20% of the patients. Although varus angular losses within physiological limits did not affect the functional scores, the total rate of complications was 35%. Further studies are required to evaluate the support of grafting and metaphyseal compression, if any, on stability.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Ümraniye Training and Research Hospital Clinical Researches Ethics Committee (Date: 09/04/2021, Decision No: E-54132726-000-7920).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The author has no conflicts of interest to declare.

Financial Disclosure: The author declares that this study has received no financial support.

Author Contributions: The author declares that he has participated in the design, execution, and analysis of the paper, and he has approved the final version.

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