

Subgroups and differences of fixation in 3-part proximal humerus fractures

 **Taner Bekmezci, M.D.¹**,  **Serdar Kamil Çepni, M.D.²**

¹Private Practice Orthopaedics and Traumatology, İstanbul-Türkiye

²Department of Orthopedics and Traumatology, Umraniye Training and Research Hospital, İstanbul-Türkiye

ABSTRACT

BACKGROUND: This study aimed to determine the morphological differences of three-part proximal humerus fractures, the group in which plate screw fixation is most frequently used, and to evaluate the functional and radiological results of the methods applied for different subgroups.

METHODS: Twenty-nine patients (6 males and 23 females) with three-part proximal humerus fractures were in the study, with an average age of 64. The patients were in three groups according to their fracture types. Group 1 included eight patients with valgus impaction fracture. Group 2 included eleven patients with easily achieved stability after reduction. Group 3 consisted of ten patients with procurvatum varus angulation, a significant displacement between fragments, and in whom medial cortical continuity was not maintained without fixation. All patients underwent surgery with a minimally invasive deltoid split approach method and locked anatomic plate screw osteosynthesis. In group 1 patients, the space in the area where valgization is present in the head was filled with cortico-cancellous allografts. No grafting or metaphyseal compression took place in Group 2 patients. In group 3 patients, the metaphyseal compression technique was applied to the bone defect area. Cephalodiaphyseal angles (CDA) were measured at the postoperative and final follow-up. The constant Murley score made the functional evaluation.

RESULTS: The patients were followed for an average of 27.6 months, and the union was present in all patients for an average of 3.6 months. Early screw migration was present in three patients, and late screw migration was in one patient. There were twenty-four excellent and 5 good results. CDA decreased from 139.42° to 136.13°. A statistically significant difference was present between the values of Groups 2 and 3 in the final control CDA of the groups.

CONCLUSION: In this study, the functional scores of grafting stable valgus-impacted fractures and metaphyseal compression of unstable fractures with insufficient medial support were as good as stable 3-part fractures. Considering neer type 3 fractures should be evaluated with their subgroups, and fixation and stability-enhancing solutions specific to the groups are essential.

Keywords: Locking plate; minimally invasive plate-screw osteosynthesis; neer type 3; proximal humerus fracture; valgus impacted fracture.

INTRODUCTION

The application of osteosynthesis with plate screws in proximal humerus fractures increased 12 times from 2001 to 2012. It has been ranked first among surgical treatments, with a rate of 30%.^[1] Treatment of Neer Type 3 and 4 fractures (not only surgical but also conservative treatment) is vulnerable

to high complication rates and has low functional results.^[2,3] While 45% of patients treated with plates have Neer Type 3 fractures, 34% have Neer Type 4 fractures. Varus malunion is present in 8–16% of patients, especially in patients with disrupted medial cortical continuity.^[2-4] Although inferomedial cephalic screws (calcar screws) reduce the risk of varus collapse, varus malunion may develop when used.^[5-11]

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Address for correspondence: Serdar Kamil Çepni, M.D.

Department of Orthopedics and Traumatology, Umraniye Training and Research Hospital, İstanbul, Türkiye

E-mail: drserdarcepni@gmail.com

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It may be necessary to fix the tubercles to the plate with suture materials and to correct and support the metaphyseal bone defect with different methods to deal with varus malunion or implant failure. However, it is unclear which technique is more convenient for different fracture types.

In this study, we aimed to determine the morphological differences and to evaluate the functional and radiological results of the methods applied for different subgroups in three-part proximal humerus fractures where plate screw fixation is the most common.

MATERIALS AND METHODS

The authors approved ethical obligations. Informed consent was obtained from all patients. The study protocol was approved by the Ethics Committee (March 08, 2021. Number: B.10.1.TKH.4.34.H.GP0.01/98).

Eighty-two proximal humerus fracture patients treated in 2012–2016 were analyzed. Complex injuries with fracture dislocation, egg-shell head, brachial plexus deficits, and split head components were not in the study. In addition to conservatively treated fractures, cases with a 3-part metaphyseal extension of the humeral head <8 mm or more than 2 mm separation at the medial fracture junction were also not in the study.

Three-part proximal humeral fractures treated with the deltoid split minimally invasive plate-screw osteosynthesis (DS-MIPO) technique were in the study. A total of 29 patients (6 men-23 women) were in the study sample. The average age was 64 (in the range of 43–82).

The patients were in 3 groups considering the types of fractures. Group 1 included eight patients with valgus impaction fracture. Group 2 had eleven patients with no significant displacement in the tuberculum majus, but displacement between the shaft and head and medial cortical continuity achievement was easy after reduction. Group 3 included ten patients with procurvatum varus angulation and significant displacement between the parts and in whom medial cortical continuity could not be maintained during surgery.

Surgical Technique

The patients were operated on in the beach chair position with an electromechanical arm holder (Spider 2 Limb Positioner, Smith and Nephew, Andover, MA, USA). A 5 cm deltoid split incision was applied from the lateral acromion in the proximal direction. The axillary nerve was found by palpation in the subdeltoid area. A 3 cm incision coincided with the distal of the plate.

Following the control of the fracture alignment by direct and indirect methods, in patients with metaphyseal bone defects (Group 1), the space in the area where the valgization is present in the head, was filled with cortico-cancellous allograft (Figures 1a-b). Grafting or metaphyseal compression was not applied to patients without significant metaphyseal bone defects after reduction (Group 2) (Figures 2a-b). In patients with medial cortical discontinuity (Group 3), the metaphyseal compression technique, the preliminary results of which were studied, was used^[12] (Figures 3a-b). Thus, the potentially-unstable area between the head and shaft was compressed and stabilized. Fixation was complete with an anatomical 5-hole proximal humerus plate placement under the subdeltoid tunnel and locking screws (Philos, DePuy Synthes, Oberdorf, Switzerland). Five polyester non-absorbable suture materials passed through the tuberculum majus (one per supra-infraspinatus tendon insertion) and tuberculum minus (one from the subscapularis tendon insertion) through the plate holes and sewn on it. Thus, a tension band was present in the coronal and axial planes. E-row screw holes (calcar screws) were not used due to the location of the axillary nerve.

Follow-up of Patients

In the first 3 weeks, using arm sling, shoulder pendulum exercises, and actively assisted passive motion exercises were applied. The sling was removed between 3 and 6 weeks. Active range of motion and strengthening exercises were applied after the 6th week, and stretching exercises were applied after the 8th week.

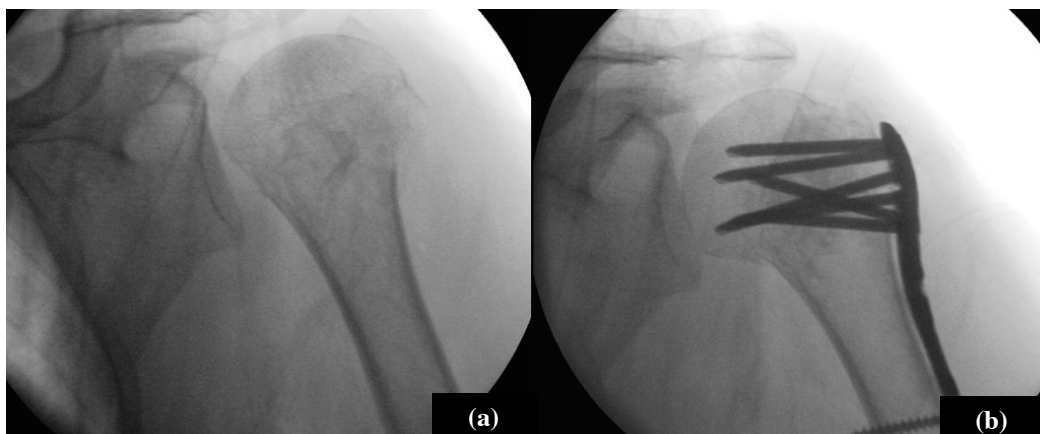


Figure 1. The pre-fixation (a) and post-fixation images (b) of the valgus-impacted fracture in Group 1

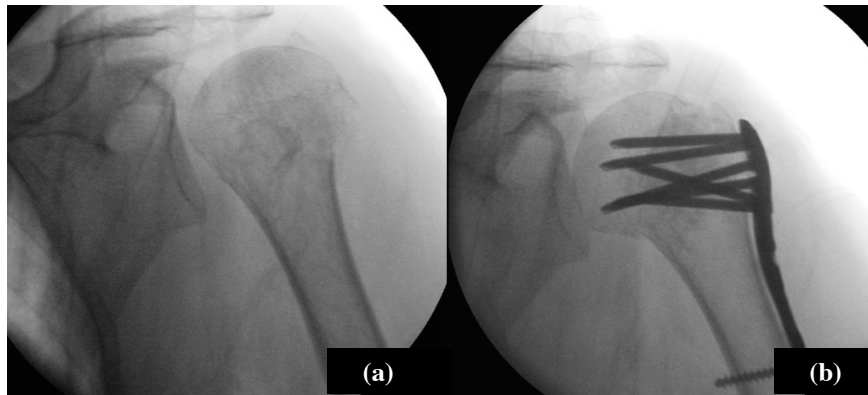


Figure 2. In Group 2, there is a pre-fixation (a) and post-fixation image (b) of the fracture with medial cortical support

Statistical Analysis

The postoperative cephalodiaphyseal angle (CDA) and final control CDA (LCDA) were measured from shoulder true anteroposterior radiography. For functional evaluation, the Con-stant Murley score (CM) and the delta constant murley (DCM) score, known as the relative difference to the opposite shoulder, were used.^[13,14]

The Kolmogorov&Smirnov test evaluated the distribution of data and paired t-test assessed the change in CDA and LCDA measurements. Pearson correlation analysis evaluated the relationship between radiological evaluations and functional scores (CDA-LCDA and DCM). The Kruskal-Wallis test assessed the distribution of CM, DCM, CDA, and LCDA findings according to the groups (MedCalc Software Belgium 1993–2016).

RESULTS

The patients were followed for an average of 27.6 months (12–48), and the union was present in all patients for an average of 3.6 months (3–8). Early screw migration was present in three patients (10%), and late screw migration was pres-

ent in one patient (3%). Compared to the opposite shoulder, forward flexion loss, abduction loss, and adduction loss of external rotation averaged 10, 13, and 11°, respectively.

There were 24 excellent and five good results in the DCM score. The averages of CDA and L-CDA were 139.4° (134–149) and 136.13° (130–145), respectively (Table 1). Although the CDA and L-CDA measurements remained within the physiological limits, the angular change was statistically significant ($P<0.05$) (Fig. 4).

While the CDA measurement did not correlate with the DCM score, the LCDA measurement correlated with the DCM score (Table 2). There was no statistically significant difference in the distribution of CM score, DCM score, and CDA findings in different groups. However, in the distribution of LCDA values according to the groups, a statistically significant difference was observed between the values of Group 2 and Group 3 ($P<0.05$) (Table 2 and Fig. 5).

DISCUSSION

The study aimed to emphasize the importance of morphological subtypes and to define specific treatment methods for

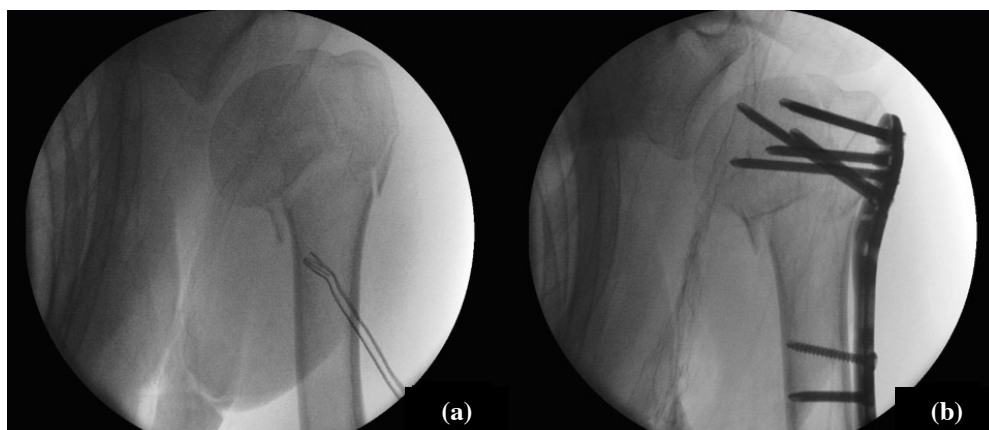


Figure 3. Pre-fixation (a) and post-fixation images (b) of the fracture in Group 3 without medial cortical support

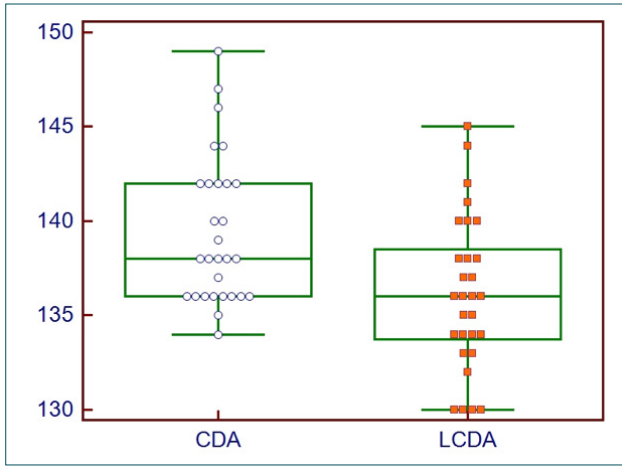


Figure 4. Although the cephalodiaphyseal angle and late cephalodiaphyseal angle (LCDA) remained within normal limits, a statistically significant difference was present with the paired t test ($P<0.0001$)

subtypes in stability problems in plate-screw osteosynthesis of 3-part proximal humerus fractures.

Patients with the following characteristics were not in the study as a subgroup because they did not have plate screw osteosynthesis: Type 3 fractures, known to have a high risk of avascular necrosis, whose metaphyseal distance is shorter than 8 mm, or who have separation of more than 2 mm at the medial fracture junction.^[15] Similarly, fractured dislocations and head split fractures were not the targets of the study, as the intactness of the head may affect functional results.

The CM score may also vary depending on age and sex in pa-

Table 1. Radiological and clinical findings are present with their standard deviations

Variable	Mean	SD	Range
Constant Murley Scor	83.89	7.91	68–96
Delta constant Murlcore	7.06	5.05	0–21
Cephalo diaphysier angle	139.4	3.9	134–149
Late cephalo diaphysier angle	136.13	4.06	130–145

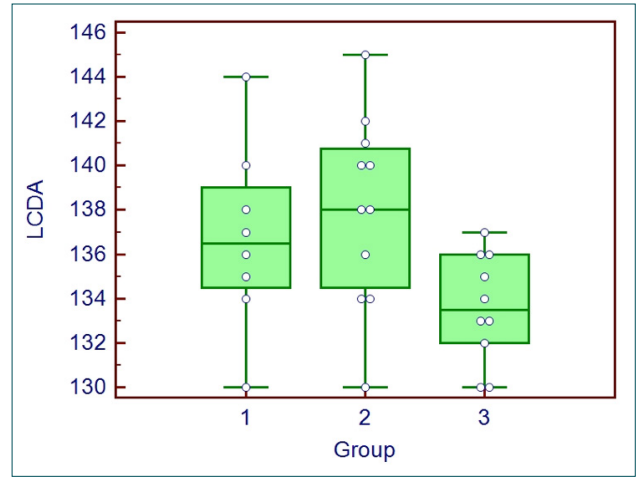


Figure 5. The distribution of late cephalodiaphyseal angle (LCDA) measurements according to the groups with the Kruskal-Wallis test was evaluated. A statistically significant difference was present between Groups 2 and 3 ($P<0.05$)

tients' intact shoulders.^[13,16] For this reason, the DCM score was used in the study to express functional scores with an age-independent factor. The DCM scores of the operated 29 patients, according to Fabre, gave 24 (82.7%) excellent and 5 (17.3%) good results.^[14] The distribution of functional scores (CM, DCM) according to the groups did not make a significant difference. Hence, similar goals in functional scores were achieved in the three different treatment groups.

Although higher CDAs showed better functional scores with Pearson correlation analysis, no significant difference was observed in the distribution of functional scores to the groups due to angular losses in the physiological limits.

The first of the significant statistical findings of the study was that the CDAs obtained after fracture fixation decreased during follow-up. Different authors describe the measurement of CDA in varying angular limits. Boileau and Walch reported that the normal limits of CDA, as inclination, should be within 122–135°. ^[17] Vijayvargiya et al. stated that the CDA, as a head-shaft angle, was normal between 125° and 145°. ^[18] The mean CDA and LCDA were 139.4 and 136.13°, respectively, in this study. Although the angular change was statistically significant, it was within physiological limits. More

Table 2. The correlation of radiological findings (CDA-LCDA) with clinical findings (DCM) was evaluated with the Pearson correlation test and the distribution of radiological (CDA-LCDA) and clinical findings

Variables	Pearson korelasyon with delta constant Murley	Kruskal-wallis test on difference between groups
Cephalo diaphysier angle	P=0.09	P=0.0846
Late cephalo diaphysier angle	P=0.0317	P=0.0306 (Group 2–3)
Constant Murley	–	P=0.2021
Delta constant Murley	–	P=0.1196

importantly, the angular loss was more evident in Group 3 than in Group 2. The angular changes of Group 1 fractures were not statistically significant with those of Groups 2 and 3. When clinical studies on proximal humerus fractures are examined, the studies had heterogeneous groups, and algorithms for subtypes were not considered adequately. Similar to this study, Acklin et al. observed a statistically significant difference between the early and late head-shaft angulation degrees in their series of 97 DS-MIPO cases.^[9] The series consisted of 2-3-4 fragmented fractures. There were no data on the distribution of angular losses according to fracture types or on angular losses with clinical signs. Although the authors reported 7.2% secondary screw perforation, they did not provide information about the presence of varus malunion. Similarly, Lin et al. observed varus collapse requiring revision surgery in 2 patients where calcar screws were not applied and in 1 patient where calcar screws were applied in their series of 86 patients, in which they compared the DS-MIPO and deltopectoral approaches.^[19] However, the precautions taken except for the calcar screw were not clear. Among the studies, we found that the most detailed examination of the angular distribution according to fracture types was made in the series of 62 patients by Sohn and Shin, including Neer Types 2, 3, and 4. The authors evaluated early and late CDA measurements.

According to the examination of CDA angular changes by fracture type with the Kruskal-Wallis test, the angular loss detected in type 4 fractures was more significant than in type 3 and 2 fractures. Varus collapse was prevented by applying calcar screws in 16 cases and fibular allografts in 3 patients. In only one example, a varus collapse developed despite the application of a calcar screw. Early and late CDA measurements for Neer Type 3 fractures were an average of 131° (115–144) and a mean of 129° (110–147), respectively, but this change was not evaluated.^[10]

Group 1 consisted of valgus-impacted proximal humerus fractures. The impaction caused by the valgization of the head in the metaphysis makes this group relatively stable. On the other hand, with the correction of the head, a dead space occurs in the impaction area. When grafting does not happen, the tuberculum majus can become stuck in this cavity, or the head can return to the valgus position. This subgroup is the most well-defined of all proximal humeral fractures. Robinson and Atalar contributed to stability by filling the dead space with allograft or synthetic grafts.^[20-22]

Group 2 had fractures with medial cortical continuity, and sagittal and coronal plan deformities improved with closed reduction under fluoroscopy. Grafting was not performed due to the absence of significant decomposition and metaphyseal impaction in the tuberculum majus. Among the three groups, both CDA and LCDA averages were the highest.

Group 3 consisted of unstable fractures with metaphyseal de-

fects, especially with medial cortical discontinuity. This group reached a certain balance by applying impaction on the fracture line to increase stability. However, due to the inability to provide strong stability as in Group 2 fractures, they suffered angular loss, albeit within the physiological limits. Group 3 had the lowest average CDA and LCDA among the three groups.

One of the limitations of this study is the limited distribution of the number of cases by the group. On the other hand, we think that the homogeneity of the groups in terms of fracture morphology and treatment type strengthens the study. Therefore, the reflections of different treatments applied to the functional score and radiological findings can be measured.

Conclusion

In this study, the functional scores from grafting stable valgus-impacted fractures and applying metaphyseal compression to unstable-medial support fractures were as good as the functional scores of stable 3-part fractures. In addition to obtaining higher CDAs in the early period, Stable 3-part fractures cause less angular loss in the late period and provide better functional scores. The CDAs of unstable fractures disappeared over time. However, the fact that they remain within physiological limits also seems encouraging. Considering Neer type 3 fractures with their subgroups and generating solutions specific to each group is essential.

Ethics Committee Approval: This study was approved by the Umraniye Training And Research Hospital Clinical Research Ethics Committee (Date: 08.03.2021, Decision No: B.10.1.TKH.4.34.H.GP.0.01/98).

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Conflict of Interest: None declared.

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ORJİNAL ÇALIŞMA - ÖZ

Üç parçalı proksimal humerus kırıklarında altgruplar ve tespit farklılıkları

Dr. Taner Bekmezci,¹ Dr. Serdar Kamil Çepni²

¹Özel Muayenehane, Ortopedi ve Travmatoloji, İstanbul

²Ümraniye Eğitim ve Araştırma Hastanesi Ortopedi ve Travmatoloji Kliniği, İstanbul

AMAÇ: Bu çalışmada, plak vida ile tespitin en sık kullanıldığı grup olan üç parçalı proksimal humerus kırıklarının morfolojik farklılıklarının belirlenmesi ve farklı vakalarda uygulanan yöntemlerin fonksiyonel ve radyolojik sonuçlarının değerlendirilmesi amaçlandı.

GEREÇ VE YÖNTEM: Üç parçalı proksimal humerus kırığı olan 29 hasta (6 erkek-23 kadın) değerlendirildi. Ortalama yaş 64 idi. Hastalar kırık tiplerine göre 3 gruba ayrıldı. Grup 1, valgus impaksiyon kırığı olan sekiz hastayı içeriyordu. Grup 2, redüksiyon sonrası kolayca stabilite sağlanan 11 hastayı içeriyordu. Grup 3, prokurvatum varus açılması, fragmanlar arasında önemli yer değiştirmesi olan ve fiksasyon olmadan medial kortikal devamlılığın sağlanamadığı on hastadan oluşuyordu. Tüm hastalar minimal invaziv deltoid split yaklaşım yöntemi ve kilitleti anatomik plak vida osteosentezi ile ameliyat edildi. Grup 1 hastalarda başın valg olduğu alan kortiko-kansellöz allogreft ile dolduruldu. Grup 2 hastalarına greftleme veya metafizer bası uygulanmadı. Grup 3 hastalarda kemik defekti bölgesine metafizyal kompresyon tekniği uygulandı. Ameliyat sonrası ve son takipte sefalodiyafiz açıları ölçüldü. Fonksiyonel değerlendirme için Constant Murley skoru kullanıldı.

BULGULAR: Hastalar ortalama 27.6 ay takip edildi ve ortalama 3.6 ayda tüm hastalarda kaynama görüldü. Üç hastada erken vida migrasyonu, bir hastada geç vida migrasyonu izlendi. 24 mükemmel ve 5 iyi sonuç gözlemlendi. Sefalodiyafiz açıları 139.42 dereceden 136.13 dereceye düştü. Son kontrol sefalodiyafiz açılarının gruplara dağılımında grup 2 ve grup 3 değerleri arasında istatistiksel olarak anlamlı fark gözlemlendi.

TARTIŞMA: Bu çalışmada, greftleme stabil valgus impakte kırıkların fonksiyonel skorlarının ve medial desteği yetersiz olan stabil olmayan kırıkların metafizyal kompresyonunun stabil 3 parçalı kırıklar kadar iyi olduğunu bulduk. Neer tip 3 kırıklar alt grupları ile birlikte değerlendirilmeli, gruplara özel tespit ve stabilite artırıcı çözümler düşünülmelidir.

Anahtar sözcükler: Kilitleti plak; proksimal humerus kırığı; MIPO; Neer tip 3; valgus impakte kırık.

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