ORIGINAL ARTICLE

Comparison of effective factors in loss of reduction after locking plate-screw treatment in humerus proximal fractures

Levent Adıyeke, M.D., Ali Geçer, M.D., Oğuzhan Bulut, M.D.

Department of Orthopedics and Traumatology, Haydarpasa Numune Training and Research Hospital, İstanbul-*Türkiye*

ABSTRACT

BACKGROUND: In proximal humerus fractures, loss of reduction can occur following surgical fixation. The factors that affect loss of reduction in cases treated with locking plates as well as their relationship with the degree of loss of reduction were investigated in this study.

METHODS: The study included 48 patients who underwent surgical treatment with a locking plate for a displaced proximal humerus fracture and experienced loss of reduction during follow-up. According to the degree of reduction loss, patients were divided into two groups as low grade and severe loss of reduction. The following parameters were investigated: Head-neck angle, loss of head height, degree of medial support displacement, screw penetration, implant-to-screw ratio, graft use, calcar screw application for medial support, delayed union/nonunion, arthrosis, and avascular necrosis findings.

RESULTS: In the early period, in Group I (n=27) and Group II (n=21) patients, the mean head-neck angle was 133°±9.9° (118°–141°) and 131°±11.2° (114°–143°), the distance between the head-plate end points was 8.08±2.8 mm and 11.5±3.1 mm, and the displacement between the medial support fracture fragment was 1.19±0.9 mm and 1.69±1.8 mm, respectively. Furthermore, in the late period, the mean head-neck angle was 120°±11.8° (106°–136°) and 112°±13.1° (98°–120°), the distance between the head-plate end points was 5.6±3.2 mm and 6.3±3.3 mm, and the displacement between the medial support fracture fragment was 2.79±1.9 mm and was 6.79±1.9 mm in Group I and Group II patients, respectively. While there was a significant relationship between the amount of medial displacement and changes in neck-shaft angle (p=0.0313) and humeral head height (p=0.0272), there was no significant relationship between the groups in terms of screw ratios, fracture type, and age.

CONCLUSION: Many factors influence loss of reduction in proximal humerus fractures after surgical treatment with a locking plate. Supporting the medial region is particularly critical for maintaining reduction in the post-operative period. Furthermore, a relationship was revealed between the amount of medial displacement and the values of head-neck angle and head height.

Keywords: Fracture reduction; humeral fractures; humeral head; proximal.

INTRODUCTION

Proximal humerus fractures account for approximately 5% of all fractures. These are among the top four fractures that primarily affect adults over the age of 55.[1,2] Because of the increasing occurrence of osteoporotic fractures, proximal humerus fractures with age-related bimodal patterns cause significant morbidity in the elderly population. In most cases, surgical treatment is preferred for fractures that are unstable or displaced. Treatment options include percutaneous nailing, screws, locking plates, and osteosynthesis or arthroplasty.[3] In recent years, osteosynthesis has become more popular as a therapeutic option for the elderly, and it has been claimed that proximal humerus locking plates produce increasingly better results.[4,5] Proximal humerus locking plates facilitate a more rigid osteosynthesis and provide good stability in terms of axial torque, varus orientation, and medial separation forces. Even for humeral heads with weak bone structures, the anatomical contour of the locking plates and low profile and divergent orientation of the screws provide better stability.[6–8]

Cite this article as: Adıyeke L, Geçer A, Bulut O. Comparison of effective factors in loss of reduction after locking plate-screw treatment in humerus proximal fractures. Ulus Travma Acil Cerrahi Derg 2022;28:1008-1015.

Address for correspondence: Levent Adıyeke, M.D.
Haydarpaşa Numune Eğitim ve Araştırma Hastanesi, Ortopedi ve Travmatoloji Kliniği, İstanbul, Türkiye
Tel: +90 216 - 542 32 32 E-mail: leventadiyeke@gmail.com

Ulus Travma Acil Cerrahi Derg 2022;28(7):1008-1015 DOI: 10.14744/tjtes.2022.28742 Submitted: 30.11.2021 Accepted: 10.05.2022

Biomechanical shear forces, on the other hand, affect the shoulder joint, which has the most mobile joint structure in the body. In the literature, post-operative complications are reported to occur with an incidence rate of 6–13%.[9,10] Loss of reduction, implant failure, screw penetration, humeral head avascular necrosis (AVN), and nonunion are all possible complications. In fractures accompanied with osteoporosis and severe fragmentation, it is difficult to avoid loss of reduction. Changes in the postoperative neck-shaft angle (NSA), humeral head height (HHH), mechanical support of the medial region, and fracture type have all been reported as prognostic factors in the previous research.[11,12]

This study aimed to investigate the factors causing loss of reduction in cases treated with locking plate for proximal humerus fractures and these factors to compare in terms of the degree of loss of reduction.

MATERIALS AND METHODS

The findings in this study were obtained by retrospectively evaluating the epicrisis reports and hospital records of patients who underwent surgical treatment with a locking plate for proximal humerus fractures between January 2015 and June 2021. This study was carried out in accordance with the Declaration of Helsinki, and it was approved by the institution's ethics committee. All patients were informed in detail on the treatments, and an informed consent was obtained from each patient. Patients aged 18–92 years who surgically treated with the displacement of two, three, or four fracture segments or loss of reduction were included in the study. Nondisplaced, open, and pathological fractures were excluded from the study. After retrospective analysis, data of 295 patients were obtained. The study included 48 cases with low grade and severe loss of reduction. In terms of the factors affecting the loss of reduction of the patients, the head-neck angle, distance between head-plate endpoints, amount of medial support displacement, calcar screw application, implant-to-screw ratio, graft application, and screw penetration values were assessed. In addition, complications such as nonunion, infection, arthrosis, and AVN were evaluated (Fig. 1).

The patients were divided into two groups according to their loss of reduction values — Group I with low-grade loss of reduction and Group II with severe loss of reduction. Low-grade loss of reduction was defined as an angulation change of up to 10° in the head-neck angle and a change in height loss of up to 5 mm between the humeral head and the plate. An angle change of >10° and a height change of >5 mm between the humeral head and the plate were defined as severe loss of reduction.[11,13]

At the time of admission, all patients underwent anteroposterior (AP) shoulder and transthoracic X-ray, and three-dimensional computed tomography (CT) was performed in

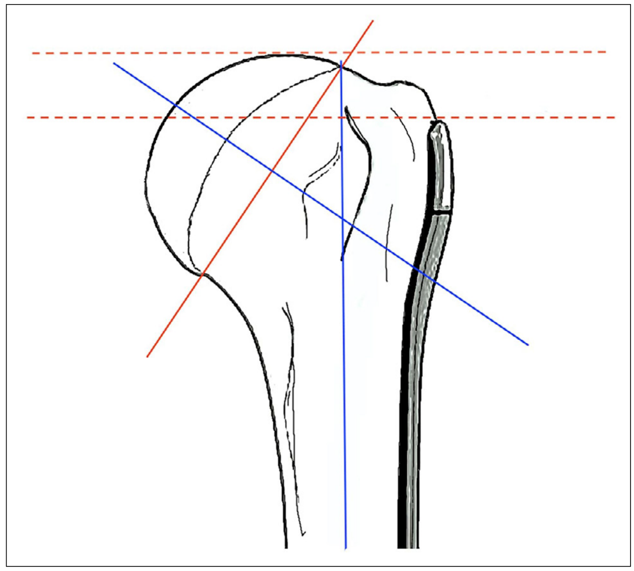

Figure 1. Methods for measuring the proximal region of the humerus. The distance between the red dashed lines was obtained from the head height measurement. The head-neck angle measurement was performed from the angle between the perpendicular blue line drawn from the highest point of the head to the red straight line and the straight blue line drawn parallel to the shaft.

cases with severe fragmentation. Fractures were classified according to Neer and AO Foundation/Orthopaedic Trauma Association (AO/OTA) fracture classifications and based on standard (AP shoulder and transthoracic lateral) X-ray and CT results. All patients were assessed at 2 weeks, 1 month, 3 months, 6 months, and at least 1 year after surgery. Early and late NSA, HHH, amount of medial support displacement, screw penetration, implant-to-screw ratio, graft use, calcar screw application for medial support, delayed union/nonunion, arthrosis, and AVN were examined based on the first X-ray evaluation after surgical treatment and the results of the shoulder AP X-ray and CT examinations performed at the last control.

Surgical Technique

Under general anesthesia, the fractured fragments were accessed using a deltopectoral technique in the chaise lounge posture. The exposed fractured fragments were reduced in anatomical position and temporarily fixed with Kirschner wires over the plate after cleaning the debris and hematoma. A C-arm was used to control the reduction, and the fracture was fixed with a locking plate. All cases were fixed using the Proximal Humerus Interlock System. Head- and calcar-oriented screws were used over the plate until the fracture fragments were fully stabilized, and screws directed to the head center over the plate were used according to the fracture stabilization achieved. The all operations were performed by surgeons with >5 years of experience. Two days following surgery, the patients underwent a postoperative rehabilitation program that included passive range of motion exercises such as pendulum exercises, flexion, and external rotation.

Table 1. Neer and AO fracture type distribution of cases according to age groups

Year	Neer classification			OTA classification							
	Type 2	Type 3	Type 4	A1	A2	A3	B1	B2	B3	C1	C3
20–30	1	1	–	–	1	1	–	–	–	–	–
31–55	2	9	2	1	1	1	2	2	2	1	3
56–75	3	10	12	1	1	2	6	3	7	3	2
>76	2	1	5	–	1	1	–	2	1	1	2

AO/OTA: AO Foundation/Orthopaedic Trauma Association

Six weeks after surgery, all the patients were referred to the physical therapy department for strengthening and stretching exercises.

Statistical Analysis

All analyses have been performed using SPSS v.22.0 (IBM Statistical Package for the Social Sciences, SPSS INC, Chicago, IL, USA). All numeric data were summarized as mean±standard deviation. The Kolmogorov-Smirnov test was used to examine the normality of all parameters. Non-parametric tests were used for non-normally distributed variables. Categorical data were compared using chi-square and Fisher exact tests. Non-normally distributed continuous variables were analyzed with Mann-Whitney U tests. The differences between two radiographic outcomes in the assessment of reduction loss (NSA and HHH) were examined using the Chi-square test. The Fisher exact test was used to examine the effect of fracture type on the radiographic outcome. G-power analysis was used to estimate the minimum sample size needed to observe a significant difference between groups. This level of power would be achieved if the study groups included at least 16 patients. A significant difference was defined as p<0.05.

RESULTS

A total of 48 cases (19 males and 29 females) were included in the study. The mean age of the patients was 61±15 (26–91) years, and their mean follow-up period was 39±12 (12–61) months. The average length of stay in the hospital was 4.4±3.9 (1–12) days. The average time from admission to surgery was 2.9±2.3 (1–7) days. The mean waiting time for surgery was 2.6±1.6 (1–5) days in Group I patients and 3.4±2.7 (1–7) days in Group II patients. In terms of mean waiting time for surgery, there was no significant difference between Group I and Group II patients (p=0.34). After surgery, Group I patients had a mean follow-up duration of 41±14 (12–61) months, whereas Group II patients had a mean follow-up period of 37±11 (14–57) months. In terms of the mean follow-up time, there was no significant difference between the groups (p=0.12).

Patients were divided into four age groups 20–30-year-old (n=2) 4%, 31–55-year-old (n=13) 27%, 56–75-year-old (n=25) 52%, and >76-year-old (n=8), 16% groups. According to the Neer classification, the patients had Neer Type 2 (n=8), 16%, Type 3 (n=21), 43%, and Type 4 (n=19), 39% fractures. All the patients with Neer Type 4 fractures were >50 years of age (two patients aged 53 and 55 from the 31–55-year-old group). The age of the patients and their Neer fracture types had no significant relationship. The distribution of the patients according to the AO/OTA classification was as follows: Group A (n=11), 22.9% (A1 [n=2], A2 [n=4], A3 [n=5]), Group B (n=25), 52%, (B1 [n=8], B2 [n=7], B3 [n=10]), and Group C (n=12), 25%, (C1 [n=5], C3 [n=7]). The age of the patients and their AO/OTA fracture types had no significant relationship. The fracture type (as per the Neer and AO/OTA classifications) distribution and the groups had no significant differences, and the distribution of the data is presented in Table 1 (p=0.61). The mean age of Group I patients was 60±17 (26–91) and Group II patients was 62±12 (42–82)-years-old; there was no significant age difference (p=0.11). Simple falls (21 cases), motor vehicle accidents (17 cases), and falls from a height (10 cases) were among the causes of injury.

For Group I (n=27) patients, in the early period, the mean head-neck angle was 133°±7.6° (113°–141°), the distance between the head-plate endpoints was 8.08±2.8 (5.4–13.6) mm and the displacement between the medial support fracture fragment was 3.19±0.9 (1.5–5.4) mm. In addition, in the late period, the mean head-neck angle was 120°±9.8° (109°–136°), the distance between the head-plate end point was 6.6±2.7 (0.5–9.1) mm and the displacement between the medial support fracture fragment was 3.79±2.2 (1.9–6.8) mm (Fig. 2).

For Group II (n=21) patients, in the early period, the head-neck angle was 131°±8.6° (112°–143°), the distance between head-plate endpoints was 9.5±3.8 (6.4–15.5) mm, the displacement between the medial support fracture fragment was 3.69±2.8 (2.4–6.4) mm. Furthermore, in the late period, the mean head-neck angle was 112°±9.1° (98°–125°), the distance between head-plate endpoint was 6.3±2.3 (1.1–9.2) mm and the displacement between medial support fracture fragment was 5.79±2.9 (4.4–8.4) mm (Fig. 3).

There was a significant correlation between the amount of medial displacement and changes in the early- and late-period NSA (p=0.031) and HHH (p=0.017). There was a significant relationship between the head-neck angle and HHH loss in all cases (Groups I and II) (Fig. 4).

The distribution of graft application was 33% in Group I patients (n=9; autograft: 6 cases, allograft: 3 cases), calcar screw

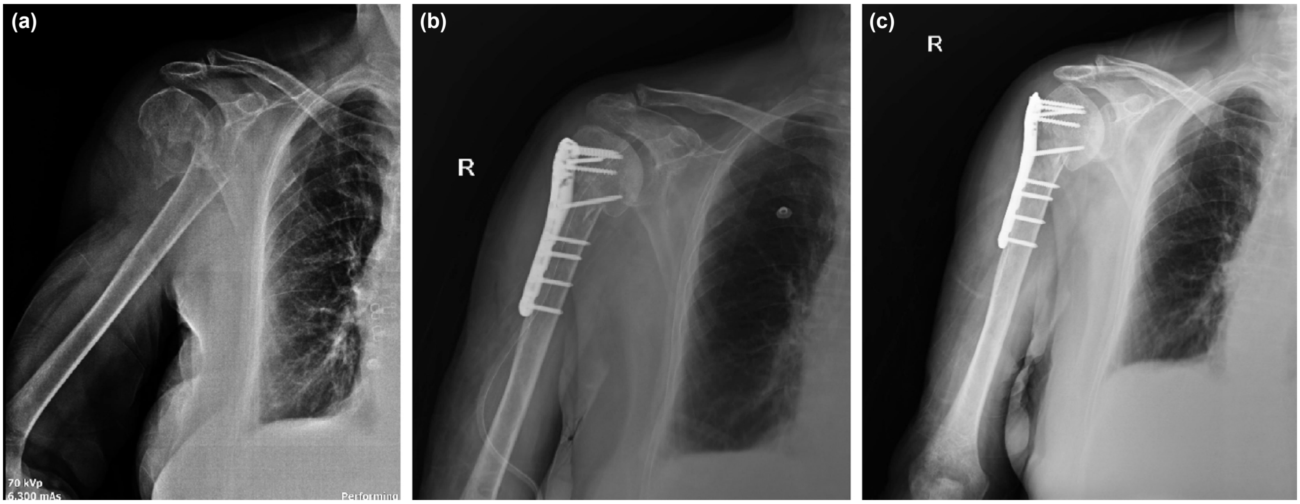

Figure 2. (a-c) Two-part fracture according to Neer fracture classification. Early head-neck angle: 121°, head height: 6.4 mm. Head-neck angle was found to be 112°, and the head height was 2.1 mm at the post-operative 4th month.

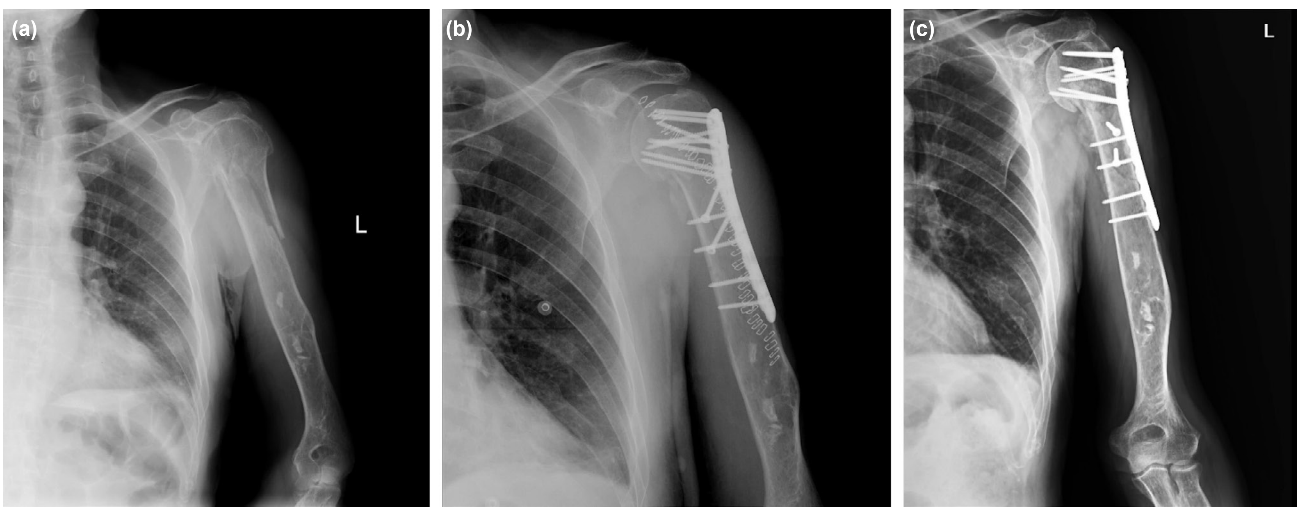

Figure 3. (a-c) Three-part proximal humerus fracture according to the Neer classification. Early postoperative NSA: 136° and HHH: 13.8 mm. In the post-operative 3rd-month outpatient control, NSA was found to be 118°, and HHH was 8.6 mm. In addition, a cutout was observed in the calcar support screw.

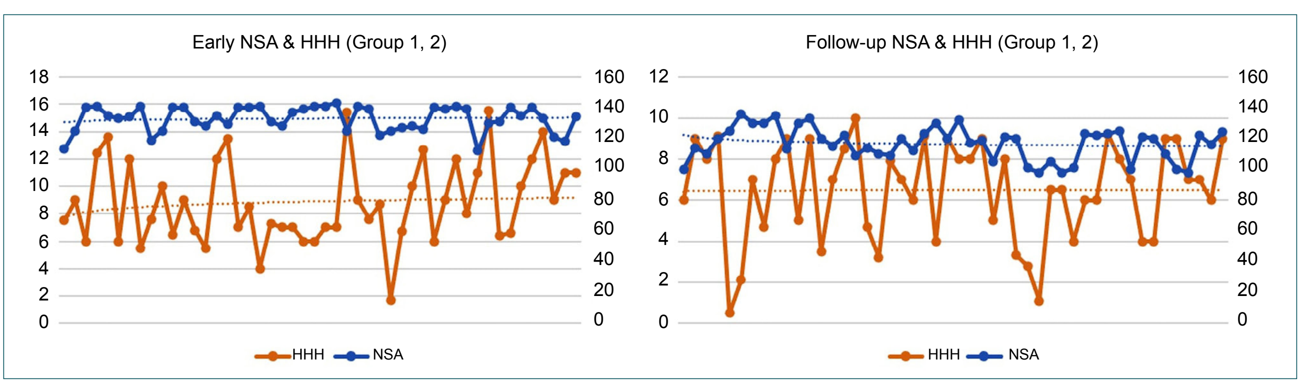

Figure 4. Distribution of NSA and HHH values evaluated in the early period and during follow-ups in Group I and Group II patients.

Table 2. Distribution of findings by age and fracture type within groups

	Fracture type and age/(n)		Head-neck angle (Mean±SD); n		Head-plate endpoint distance (Mean±SD); n		Implant-to-screw ratio (Mean±SD); n		Calcar screw (Mean±SD); n		Graft use (n)		Screw pe-netration (n)		Arthrosis (n)	
Group I	Type 2	20–30 year	8±1.13/6	7±1.12/2	2.8±1.8/6	3±0;2/2	0.76±0.07/6	0.71±0.06/2	5/6	2/2	2/6	-/2	2/6	-/2	-/6	-/2
	Type 3	31–55 year	7.5±1.8/13	6.7±2.09/7	2.7±1.3/13	2.57±1.13/7	0.73±0.10;/13	0.78±0.09/7	5/13	4/7	4/13	1/7	1/13	1/7	1/13	-/7
	Type 4	56–75 year	6±3.4/10	8±1.68/13	3.8±1.6/10	2.2±1.5/13	0.73±0.15/10	0.71±0.09/13	3/10	5/13	3/10	5/13	2/10	2/13	1/10	1/13
		>76 year		7.3±1.5/4		1.6±2.3/4		0.75±0.2/4		2/4		3 /4		2/4		1/4
Group II	Type 2	20–30 year	14.5±3.19/2	–	5.5±1.2/2	–	0.78±0.09/2	–	1/2	–	1/2	–	1/2	–	-/2	–
	Type 3	31–55 (n)	16.5±2.8/8	13.8±2.3/6	5.8±1.12/8	6.2±1.6/6	0.81±0.10/8	0.76±0.09/6	5/8	4/6	5/8	4/6	2/8	2/6	1/8	-/6
	Type 4	56–75 year	16.7±1.3/9	14.4±2.9/12	6.6±0.5/9	5.2±0.7/12	0.81±0.03/9	0.83±0.04/12	4/9	5/12	5/9	5/12	3/9	3/12	2/9	1/2
		>76 year		16.6±2.6/4	–	6.3±2/4	–	0.79±0.13/4		1/4		2/4		1/4		2/4

SD: Standard deviation.

application was 48% (n=13), screw penetration was 18% (n=5), and arthrosis was 7% (n=2). However, the rate of graft application was 52% in Group II patients (n=11; autograft: 7 cases, allograft: 3 cases, and synthetic graft: 1 case), calcar screw application was 47% (n=10), screw penetration was 23% (n=6), and arthrosis was 14% (n=3). While there was no significant difference between the groups in terms of screw penetration, calcar screw application, and arthrosis, a significant difference was observed in terms of graft use. The most common complication (occurring in 11/48 [22.9%] cases) among all cases was screw penetration due to fracture displacement and loss of reduction; both loss of reduction and AVN was observed in two screw penetration cases. In Group I patients, the mean plate length was 110±13 (95–150) mm and the mean implant-to-screw ratio was 0.74±0.10 (0.11–1), whereas in Group II, the mean plate length was 120±22 (95–185) mm and the implant-to-screw ratio was 0.81±0.09 (0.64–0.94). Table 2 shows how the findings were distributed. There was no significant difference between the groups in terms of the screw ratios. Implant failure (breakage of plate) and infection-related complications were not observed in any of the patients in either of the groups.

DISCUSSION

Patient-related factors such as fracture type, fragmentation and displacement, and osteoporosis as well as non-patient-related factors such as reduction and surgical fixation failure can affect the loss of reduction after treatment of patients with displaced proximal humerus fractures.[11,12,14] The goal of surgical treatment is to achieve and maintain a satisfactory reduction while also enabling movement of patients in the early period, thereby enabling full functional recovery. Locking plates provide secure fixation in the proximal humerus, even in cases of weak bones, with their anatomical contour, low profile, and divergent orientation of the screws.[15] Despite advancements in locking plates and other equipment, complication rates associated with these techniques can still reach 15%.[6,16,17] Micic et al.[18] investigated the potential risk factors associated with loss of reduction in patients over the age of 65 years and evaluated nine patients who experienced type a loss of reduction and implant failure in the 1st month after surgery. In this study, eight patients experienced locking plate/screw system failure due to loss of reduction in the direction of varus, and one patient experienced a loss of reduction due to mechanical failure of the plate and fracture type. Because there is a risk of mechanical and biological failures for varus angulation in the early period, particularly in cases of medial cortical fragmentation, the authors used an autogenous bone graft for the medial bone defect and tension band sutures on the tubercle to provide additional stability. Krappinger et al.[19] examined 67 cases and found that in 13 of them (19.4%), insufficiency developed after fixation. It has been stated that the absence of anatomical reduction, lack of medial cortical support, being over 63-years-old, and local bone mineral density of <95 mg/cm^3 are risk factors. In their study, they stated that the rate of loss of reduction was 71.4% in those with the presence of three risk factors and 85.7% in those with four risk factors; the most common causes of failure were loss of reduction and screw penetration. In our study, there was a significant relationship between loss of medial support and loss of reduction, and there was a significant relationship between the groups in terms of graft use. In addition, it was observed that the need for graft use was higher in older patients.

For most fractures, loss of reduction is more common in older patients. In our study, the most cases of loss of reduction in proximal humerus fractures with the use of locking plate was observed in the 56–75 age group (52%). Severe loss of reduction often occurs in older patients; however, in this study, it occurred in three patients aged <50. Age was found to have a significant relationship with loss of reduction as per univariate analysis, but there was no significant difference between groups as per multivariate analysis. In addition, although age, fracture type, and degree of displacement affected loss of reduction, there was no significant relationship between age and fracture distribution according to the Neer and AO/OTA classifications.

Head-neck angle is an important radiographic factor for evaluating postoperative outcomes of patients with proximal humerus fractures. A previous study showed that the mean NSA of the normal humerus was 134.7°±29°. Another study showed that the mean post-operative NSA was 130° using plain radiography.[20,21] The risk of loss of reduction has also been shown to be influenced by low postoperative NSA value.[10,11] Displacement of the humeral head in the direction of the varus in the early stages of fracture healing following surgical treatment predisposes the implant to stress load and early implant failure as well as further varus displacement. According to Owsley and Gorczyca[22] patients with a post-operative head-shaft angle loss higher than 10° experienced a loss of reduction of 25% in 53 cases treated with a proximal humerus locking plate. In addition, they indicated that loss of reduction occurred in 36% of cases, intra-articular screw penetration occurred in 23% of cases, and AVN occurred in 4% of cases in their study. Similarly, no complications related to infection, implant failure (breakage of plate), or nerve injury were observed in our study. However, associated loss of reduction occurred in eight patients in Group I (mean NSA: 119°±4°) and five patients in Group II (mean NSA: 117°±2°) with low head-neck angle in the early period. It was observed that there was a significant relationship between head-neck angle and head height loss between the groups.

Similar to NSA, the HHH is an important parameter in determining the functional outcome of proximal humerus fractures and varus malunion.[10,13] The perpendicular distance between the top of the head and the top of the plate was used to determine HHH. HHH and NSA were found to have a positive correlation in our study. It is recommended that the distance between the highest point of the plate and the highest point of the humeral head should be approximately 10 mm during the locking plate placement. It has been reported that a very small value in HHH and the plate application site change may cause subacromial compression, and larger values of HHH may affect the placement of medial support screws.[6,8,16] Bai et al.[23] reported HHH change to be a risk factor for loss of reduction and reported that a change of ≥5 mm may lead to poor shoulder functions. It has also been reported in similar studies that there is a relationship between changes in HHH and NSA.[13,24]

In proximal humerus locking plate applications, the screw configuration has a significant impact on the risk of screw penetration and fixation failure. According to Fletcher et al., each screw row plays a particular role in the finite element model analysis, and the presence of more screws lowers periscrew stresses. They also recommended using calcar screws whenever possible to maximize spacing between the screws.[25] The use of a calcar screw is critical for keeping the medial support in place. Early loss of reduction and varus deformity in the proximal humerus might occur if medial cortical contact is not provided and medial support is not re-established. The rate of calcar screw application was 52% in Group I patients, with 8% screw penetration rate, whereas it was 62% in Group II patients, with 18% screw penetration rate. In their study, Erhardt et al.[26] investigated the effect of screw location, number of screws, and calcar screw application on screw perforation in proximal humerus fractures using cadavers. In cases with impaired medial support, they found that increasing the number of humeral head screws and using inferomedial calcar support screws reduced the rate of screw perforation. In our study, among all patients, the implant-to-screw ratio was higher in Group II patients. However, there was no significant difference between the groups in terms of screw penetration numbers and implant-to-screw ratios.

In cases with cancellous bone loss accompanied with osteoporosis, it is recommended to place a supporting graft at the humeral head and medial metaphyseal junction.[27,28] According to Matassi et al.,[29] using an intramedullary fibular allograft in conjunction with locking plate fixation to provide medial support and minimize varus misalignment in patients with displaced proximal humerus fractures shows encouraging outcomes. In our study, graft use was high (68%) in Group II patients. In cases with cancellous bone loss in the medial metaphyseal region, support was provided with the application of graft (allo or autografts) and calcar screw.

Data on loss of reduction after locking plate application in patients with proximal humerus fractures are limited in the literature, and most research consists of small case numbers and case series. Therefore, we believe that our findings will contribute to the existing literature on the treatment of proximal humerus fractures.

There were some limitations in this study. First, this study included few parameters that we believe are important in the assessment of the postoperative loss of reduction. Furthermore, a comparison of failure rates and patient functions could have been conducted for the use of the locking plate technique in the treatment of proximal humerus fractures; more research is needed to determine which other post-operative loss of reduction parameters should be evaluated. Second, this was not a multicenter study. Fracture reduction and open fixation results were limited the current team clinical experience.

Conclusion

Stable fixation is necessary to maintain reduction after surgical treatment with a locking plate in patients with unstable and comminuted proximal humerus fractures. Surgical techniques (calcar support screw, medial cortical reduction, rigid fixation, and graft application) should be considered to restore optimal treatment and biomechanical stability. Furthermore, considering the patient's characteristics (age, fracture type, and bone quality) will aid in avoiding complications and attaining better clinical outcomes.

Ethics Committee Approval: This study was approved by the Haydarpaşa Numune Training and Research Hospital Clinical Research Ethics Committee (Date: 01.11.2021, Decision No: HNEAH-KAEK 2021/KK/286).

Peer-review: Internally peer-reviewed.

Authorship Contributions: Concept: L.A., A.G.; Design: A.G., O.B., L.A.; Supervision: A.G., O.B., L.A.; Resource: A.G., L.A.; Materials: A.G., O.B., L.A.; Data: A.G., O.B., L.A.; Analysis: L.A.; Literature search: A.G., O.B., L.A.; Writing: A.G., O.B., L.A.; Critical revision: A.G., O.B., L.A.

Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study has received no financial support.

REFERENCES

1. Bergh C, Wennergren D, Möller M, Brisby H. Fracture incidence in adults in relation to age and gender: A study of 27,169 fractures in the Swedish fracture register in a well-defined catchment area. PLoS One. 2020;15:e0244291. [CrossRef]
2. Launonen AP, Lepola V, Saranko A, Flinkkilä T, Laitinen M, Mattila VM. Epidemiology of proximal humerus fractures. Arch Osteoporos 2015;10:209. [CrossRef]
3. Repetto I, Alessio-Mazzola M, Cerruti P, Sanguineti F, Formica M, Felli L. Surgical management of complex proximal humeral fractures: Pinning, locked plate and arthroplasty: Clinical results and functional outcome on retrospective series of patients. Musculoskelet Surg. 2017;101:153–8.
4. Klug A, Harth J, Hoffmann R, Gramlich Y. Surgical treatment of complex proximal humeral fractures in elderly patients: A matched-pair analysis of angular-stable plating vs. reverse shoulder arthroplasty. J Shoulder Elbow Surg 2020;29:1796–803. [CrossRef]
5. Beks RB, Ochen Y, Frima H, Smeeing DP, van der Meijden O, Timmers TK, et al. Operative versus nonoperative treatment of proximal humeral fractures: A systematic review, meta-analysis, and comparison of observational studies and randomized controlled trials. J Shoulder Elbow Surg 2018;27:1526–34. [CrossRef]
6. Jabran A, Peach C, Ren L. Biomechanical analysis of plate systems for proximal humerus fractures: A systematic literature review. Biomed Eng Online 2018;17:47. [CrossRef]
7. Cruickshank D, Lefaivre KA, Johal H, MacIntyre NJ, Sprague SA, Scott T, et al. A scoping review of biomechanical testing for proximal humerus fracture implants. BMC Musculoskelet Disord 2015;16:175. [CrossRef]
8. Schliemann B, Wähnert D, Theisen C, Herbort M, Kösters C, Raschke MJ, et al. How to enhance the stability of locking plate fixation of proximal humerus fractures? An overview of current biomechanical and clinical data. Injury. 2015;46:1207–14. [CrossRef]
9. Barlow JD, Logli AL, Steinmann SP, Sems SA, Cross WW, Yuan BJ, et al. Locking plate fixation of proximal humerus fractures in patients older than 60 years continues to be associated with a high complication rate. J Shoulder Elbow Surg 2020;29:1689–94. [CrossRef]
10. Kavuri V, Bowden B, Kumar N, Cerynik D. Complications associated with locking plate of proximal humerus fractures. Indian J Orthop 2018;52:108–16.
11. Jung SW, Shim SB, Kim HM, Lee JH, Lim HS. Factors that ınfluence reduction loss in proximal humerus fracture surgery. J Orthop Trauma 2015;29:276–82. [CrossRef]
12. Solberg BD, Moon CN, Franco DP, Paiement GD. Locked plating of 3-and 4-part proximal humerus fractures in older patients: The effect of initial fracture pattern on outcome. J Orthop Trauma 2009;23:113–9.
13. Jia XY, Chen YX, Qiang MF, Zhang K, Li HB, Jiang YC, et al. Postoperative evaluation of reduction loss in proximal humeral fractures: A comparison of plain radiographs and computed tomography. Orthop Surg 2017;9:167–73. [CrossRef]
14. Hertel R. Fractures of the proximal humerus in osteoporotic bone. Osteoporos Int 2005;16:65–72. [CrossRef]
15. 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;69:1235–42. [CrossRef]
16. Hardeman F, Bollars P, Donnelly M, Bellemans J, Nijs S. Predictive factors for functional outcome and failure in angular stable osteosynthesis of the proximal humerus. Injury 2012;43:153–8. [CrossRef]
17. Jung WB, Moon ES, Kim SK, Kovacevic D, Kim MS. Does medial support decrease major complications of unstable proximal humerus

fractures treated with locking plate? BMC Musculoskelet Disord 2013;14:102. [CrossRef]
18. Micic ID, Kim KC, Shin DJ, Shin SJ, Kim PT, Park IH, et al. Analysis of early failure of the locking compression plate in osteoporotic proximal humerus fractures. J Orthop Sci 2009;14:596–601. [CrossRef]
19. Krappinger D, Bizzotto N, Riedmann S, Kammerlander C, Hengg C, Kralinger FS. Predicting failure after surgical fixation of proximal humerus fractures. Injury 2011;42:1283–8. [CrossRef]
20. Jeong J, Bryan J, Iannotti JP. Effect of a variable prosthetic neck-shaft angle and the surgical technique on replication of normal humeral anatomy. J Bone Joint Surg Am 2009;91:1932–41. [CrossRef]
21. Goldberg RW, Williamson DF, Hoyen HA, Liu RW. Humeral version and neck-shaft angle correlated with demographic parameters in a study of 1104 cadaveric humeri. J Shoulder Elbow Surg 2020;29:1236–41.
22. Owsley KC, Gorczyca JT. Fracture displacement and screw cutout after open reduction and locked plate fixation of proximal humeral fractures. J Bone Joint Surg Am 2008;90:233–40. [CrossRef]
23. Bai L, Fu ZG, Wang TB, Chen JH, Zhang PX, Zhang DY, et al. Radiological evaluation of reduction loss in unstable proximal humeral fractures treated with locking plates. Orthop Traumatol Surg Res 2014;100:271–4.
24. Lee CW, Shin SJ. Prognostic factors for unstable proximal humeral fractures treated with locking-plate fixation. J Shoulder Elbow Surg 2009;18:83–8. [CrossRef]
25. Fletcher JW, Windolf M, Richards RG, Gueorguiev B, Varga P. Screw configuration in proximal humerus plating has a significant impact on fixation failure risk predicted by finite element models. J Shoulder Elbow Surg 2019;28:1816–23. [CrossRef]
26. Erhardt JB, Stoffel K, Kampshoff J, Badur N, Yates P, Kuster MS. The position and number of screws influence screw perforation of the humeral head in modern locking plates: A cadaver study. J Orthop Trauma 2012;26:188–92. [CrossRef]
27. Kim SH, Lee YH, Chung SW, Shin SH, Jang WY, Gong HS, et al. Outcomes for four-part proximal humerus fractures treated with a locking compression plate and an autologous iliac bone impaction graft. Injury 2012;43:1724–31. [CrossRef]
28. Somasundaram K, Huber CP, Babu V, Zadeh H. Proximal humeral fractures: The role of calcium sulphate augmentation and extended deltoid splitting approach in internal fixation using locking plates. Injury 2013;44:481–7. [CrossRef]
29. Matassi F, Angeloni R, Carulli C, Civinini R, Di Bella L, Redl B, et al. Locking plate and fibular allograft augmentation in unstable fractures of proximal humerus. Injury 2012;43:1939–42. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Humerus proksimal kırıklarında kilitli plak-vida ile tespit sonrası redüksiyon kaybında etkili faktörlerin karşılaştırılması

Dr. Levent Adıyeke, Dr. Ali Geçer, Dr. Oğuzhan Bulut

Haydarpaşa Numune Eğitim ve Araştırma Hastanesi, Ortopedi ve Travmatoloji Kliniği, İstanbul

AMAÇ: Proksimal humerus kırıklarında cerrahi tespit sonrası redüksiyon kaybı meydana gelebilmektedir. Bu çalışmada, kilitli plak ile tedavi edilen olgularda redüksiyon kaybında etkili faktörler ve redüksiyon kaybı derecesi ile ilişkisi analiz edildi.
GEREÇ VE YÖNTEM: Deplase proksimal humerus kırığı nedeniyle kilitli plak ile cerrahi tedavi uygulanan ve takiplerde redüksiyon kaybı meydana gelen 48 olgu çalışmaya alındı. Hastalar redüksiyon kaybı derecelerine göre iki gruba ayrıldı. Erken ve geç dönem baş boyun açısı, baş yükseklik kaybı, medial destek deplasman miktarı, vida penetrasyonu, implant-vida oranı, greft kullanımı, medial destek kalkar vida uygulanımı, kaynama gecikmesi/kaynamama, artroz ve AVN bulguları incelendi.
BULGULAR: Erken dönem baş-boyun açısı Grup I (n=27) hastalarda ortalama 133°±9.9 (118°–141°), baş-plak uç nokta arası mesafe 8.08±2.8 mm, medial destek kırık fragman arası deplasman 1.19±0.9 mm iken geç dönem baş-boyun açısı ortalama 120°±11.8 (106°–136°), baş-plak uç nokta arası mesafe 5.6±3.2 mm, medial destek kırık fragman arası deplasman 2.79±1.9 mm olarak bulundu. Grup II (n=21) hastalarda erken dönem baş-boyun açısı ortalama 131±11.2 (114°–143°), baş-plak uç nokta arası mesafe 11.5±3.1 mm, medial destek kırık fragman arası deplasman 1.69±1.8 mm iken geç dönem baş-boyu açısı ortalama 112°±13.1 (98°–120°), baş-plak uç nokta arası mesafe 6.3±3.3 mm, medial destek kırık fragman arası deplasman 6.79±1.9 mm olarak bulundu. Medial yer değiştirme miktarı ile NSA (p=0.0313) ve HHH'deki (p=0.0272) değişiklikler arasında istatistiksel olarak anlamlı bir ilişki görülürken gruplar arasında kullanılan vida oranları, kırık tipi ve yaş ile anlamlı ilişki görülmedi.
TARTIŞMA: Proksimal humerus kırıklarında kilitli plak ile cerrahi tedavi sonrası redüksiyon kaybında birçok faktör etkili olmaktadır. Özellikle medial bölge desteğinin sağlanması ameliyat sonrası dönemde redüksiyon devamlılığı için önemli olup medial deplasman miktarı ile baş-boyun açısı ve baş yükseklik değerleri arasında ilişki olduğu görülmüştür.
Anahtar sözcükler: Humerus başı; humerus kırık; kırık redüksiyon; proksimal.

Ulus Travma Acil Cerrahi Derg 2022;28(7):1008-1015 doi: 10.14744/tjtes.2022.28742