ORIGINAL ARTICLE

Comparison of intramedullary nail and plate osteosynthesis in humerus surgical neck fracture

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ABSTRACT

BACKGROUND: The aim of this study is to compare clinically and radiologically the plate osteosynthesis method and the intramedullary nail (IMN) method, which is currently used in the surgical treatment of surgical neck proximal humerus fractures (PHFs) in which there is no consensus

METHODS: A total of 248 patients who underwent PHF between January 2013 and December 2017 were retrospectively reviewed. Sixty-two patients were included in the study. The results were clinically compared in terms of the amount of blood loss, operative time, and union time. Radiologically, it was compared in terms of intraoperative neck–shaft angle (NSA), final NSA, the American Shoulder and Elbow Surgeons (ASES), and Constant and Visual Analog Scale (VAS) scores.

RESULTS: Two groups were formed: plate and IMN. The groups were similar in terms of age, sex, operation side, and follow-up time. There was no difference between the groups in terms of NSA, final NSA, ASES, Constant, and VAS scores. The amount of intraoperative blood loss, operative time, and union time was shorter in the IMN group.

CONCLUSION: In surgical neck PHF surgery, plate and IMN are methods that show good clinical outcomes. According to this study, the advantages of the IMN method compared with plate osteosynthesis in Neer type II PHF treatment can be listed as less intraoperative blood loss, shorter operative time, and union time.

Keywords: Intramedullary nail; locking plate; osteosynthesis; proximal humerus fracture; two-part fracture.

INTRODUCTION

Proximal humerus fractures (PHFs) are the third most common fractures in elderly patients.[1] However, although they are common, treatment options are still controversial.[2] The treatment of the fracture depends on the extent of fragment displacement, the functional status of the patient, and the age of the patient.[3,4] For non-displaced or minimally displaced fractures, non-operative treatment is the standard option, generally achieving good outcomes.[3,5] Fractures with significant displacement can be treated with many treatment options: percutaneous pinning, plate fixation, intramedullary nailing (IMN), tension band method, hemiarthroplasty, and combined methods.[4] The goal of surgical treatment is to achieve anatomical reduction, stable fixation, and movement in the early post-operative period.[6]

The two most commonly used methods for two-part fractures of the proximal humerus described by Neer are IMN and plate osteosynthesis.[7] The use of a plate offers an advantage in metaphyseal fractures, especially in osteoporotic cases.[4] Complications of this method include subacromial impingement syndrome, which can develop due to screw per-

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foration and loosening, implant failure, infection, and varus malalignment.[8] IMN application is a less invasive technique and is successful in terms of soft tissue and blood supply protection. The disadvantages of this method include the separation of the fracture parts during the application, the inability to provide adequate compression and stabilization in the fracture line, shoulder pain and stiffness development in the shoulder, rotator cuff damage, and loosening of the proximal screws.[9]

In this study, we compared the plate osteosynthesis method used in surgical neck PHFs with the IMN method clinically and radiologically.

MATERIALS AND METHODS

This study was designed retrospectively, and after approval by the ethics committee, the study was started (November 15, 2022-272932). A total of 248 patients treated for PHFs in our hospital, which is a tertiary trauma center, between January 2013 and December 2017 were evaluated. Patients with two-part fractures according to the Neer classification, IMN, or plate applied by us and with a follow-up period of at least 5 years were included in the study. Patients who were treated conservatively, who underwent surgery for fractures other than Neer type-II surgical neck fracture, who preferred methods other than plate or IMN for surgical treatment, who had pathological fractures, who had open fractures or who had fractures of the elbow-distal radius or clavicle on the same side, who had vascular nerve damage, and who had a follow-up period of <5 years were excluded from the study.

A total of 62 patients were included in the study. Of these patients, 32 adults were treated with a locked proximal humerus plate (Philos locking plate system [Proximal Humerus InterLocking System, DePuy Synthes, Solothurn, Switzerland]), and 30 patients were treated with IMN (MultiLoc PHN; Synthes GmbH, Solothurn, Switzerland). The operated cases were divided into two groups, according to the implant selection, the IMN group and the plate group.

In our clinic, surgical treatment is used for varus fractures when the displacement is more than 0.5 mm in bipartite PHFs. The choice of implant is based on the preference of the treating surgeon. All patients were operated by the same surgeon. All cases were operated on under general anesthesia in the beach chair position by a single surgeon. In patients with nails, the delta-split approach was used. After a skin incision of approximately 4 cm, the deltoid fibers were separated, and the supraspinatus tendon was reached. The humerus head was reached by separating 2 cm toward the tendon fibers. The entry point was at the top of the humerus head. The reduction was performed, and its success was evaluated in two planes under fluoroscopy. The absence of varus below 120° was accepted as adequate reduction. The nail length was 160 mm in all patients. The nail diameter was 8 or 9.5 mm. After nail insertion, at least three screws were inserted proximally, and two screws were applied distally in all cases.

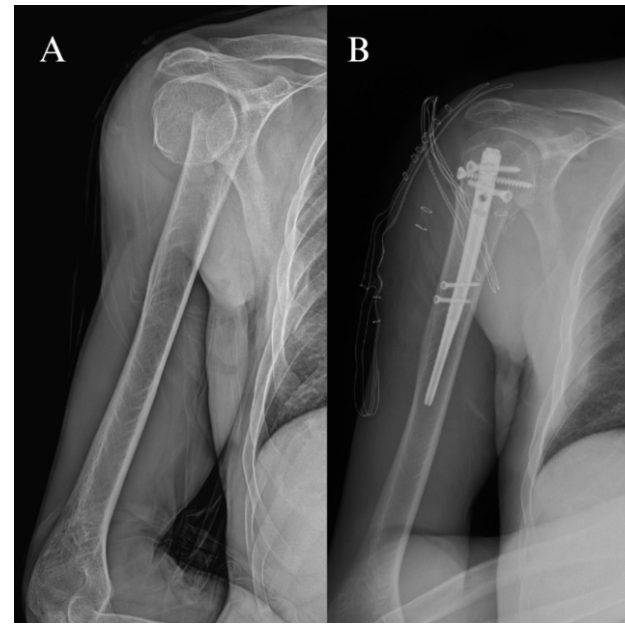

Figure 1. Treatment of two-part proximal humerus fracture with intramedullary nailing method. **(a)** Pre-operative radiography, **(b)** Post-operative radiography

Subsequently, the supraspinatus tendon was repaired with non-absorbable sutures (Fig. 1).

The deltopectoral approach was used in all cases with plate. After exposure to the fracture, non-absorbable sutures were placed in the supraspinatus, infraspinatus, and subscapularis tendons. After the fracture was reduced and the quality of the reduction was confirmed by fluoroscopy, the plate was placed. The absence of varus below 120° was accepted as adequate reduction. At least eight screws were placed unicortically in the proximal region, and at least two screws were placed bicortically in the distal region. The sutures were knotted through the plate (Fig. 2).

All patients were advised to wear shoulder arm sling for 6

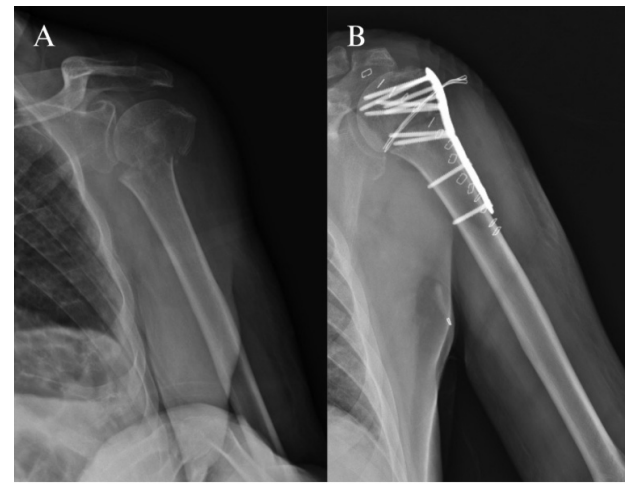

Figure 2. Treatment of two-part proximal humerus fracture with plate method. **(a)** Pre-operative radiography, **(b)** Post-operative radiography

Table 1. Distribution of qualitative variables between groups and comparison of analysis results

	Group		P-value
	Plate (n=32)	IMN (n=30)	
Age	65.41±7.49	64.30±6.47	0.537
Gender			
Male	10 (31.3)	14 (46.7)	0.325
Female	22 (68.8)	16 (53.3)	
Injured side			
Right	18 (56.3)	16 (53.3)	1.000
Left	14 (43.8)	14 (46.7)	
Follow-up time (month)	65.34±3.65	65.07±3.16	0.409

IMN: Intramedullary nail.

weeks after surgery. Passive joint movements of the shoulder began on the 2nd post-operative day. Shoulder movements were taught by a physiotherapist. Active joint movements were started in the 6th week.

The two groups were compared intraoperatively in terms of the duration of surgery, the amount of blood aspirated and the amount of perioperative blood loss as measured by the number of sponges, and the adequacy of reduction on the first post-operative radiograph. The groups were compared in terms of wound site problems, complications, and duration of the union at the 1st month, 3rd month, 6th month, 1st year, and 5th year after surgery. Fracture healing was accepted as cortical union on anterior-posterior and lateral radiographs and the absence of pain on palpation.[10] Radiographic and clinical scores were compared at the 5th-year controls. The intraoperative neck–shaft angle (NSA) and final NSA were used to evaluate radiological outcomes. Clinical outcomes were assessed using the American Shoulder and Elbow Surgeons (ASES) scores, constants, and Visual Analog Scale (VAS) scores.

Statistical Analysis

Statistical analysis of the data was performed using IBM SPSS Statistics version 22 software. The Kolmogorov–Smirnov test was used to determine whether the quantitative variables were fit for normal distribution. Independent groups were compared using independent samples t-test for normally distributed variables and Mann–Whitney U-test for non-normally distributed variables. The relationship between qualitative variables was examined using Chi-square analysis. The descriptive statistics of the quantitative variables that were compatible with the normal distribution were expressed as the mean ± standard deviation, and the descriptive statistics of the quantitative variables that were not normally distributed were expressed as the median (25th–75th percentile). Descriptive statistics of qualitative variables were expressed as frequencies (%). The results were considered significant at $P<0.05$.

RESULTS

The study was conducted with 62 patients who met the inclusion criteria. While the number of patients with plate was 32 (51.6%), the number of patients with IMN was 30 (48.4%). Age, sex, side, and follow-up time were similar in the two groups (P=0.537, P=0.325, P=1,000, and P=0.409, respectively) (Table 1).

The blood loss was higher in patients who underwent plate than in those who underwent IMN (P≤0.001). The operative time was longer in the plate group (P=0.012). Union time was shorter in the IMN group than in the plate group (P=0.003). There was no significant difference between the groups in terms of intraoperative NSA, final NSA, final ASES, final Constant, and VAS scores (P=0.699, P=0.269, P=584, P=0.092, and P=0.732, respectively) (Table 2).

When the complications were examined, wound infection occurred in seven cases in the plate group and one case in the IMN group. In all cases, oral antibiotic treatment was given, and the infection spontaneously regressed without the need for a second operation. Heterotopic ossification was observed in one case with plate, whereas it was observed in two cases with IMN. No additional surgery was performed in those who developed heterotrophic ossification. Screw backout was observed in two cases in the plate group, whereas it occurred in one case.

Screw insertion penetration was observed in one case, and screw backout was observed in two cases in the IMN group. In the IMN group, penetration of the screw at insertion was not observed in any case. Avascular necrosis (AVN) was observed in two cases with plates/screws, whereas it occurred in one case with IMN. While adhesive capsulitis was observed in one case with one plate, it was seen in a case with IMN. It was observed in three patients who underwent non-union plate and one patient who underwent IMN. No complicated union was observed in the controls. There was no difference between the groups in terms of general complications (P=0.702) (Table 2).

Table 2. Comparison of intraoperative, post-operative clinical, and radiological results between the groups

Variable	Group		P-value
	Plate (n=32)	IMN (n=30)	
Volumes of blood loss (mL)	250 (200–300)	175 (100–212.50)	<0.001
Surgical duration (min)	102.81±25.65	86.67±23.39	0.012
Union time (week)	12 (10.50–14)	10 (9–11.50)	0.003
Incision problem			
No	25 (78.1)	29 (96.7)	0.054
Yes	7 (21.9)	1 (3.3)	
Complications			
Heterotopic ossification	1 (9.1)	2 (25)	-
Screw out	2 (18.2)	2 (25)	
Screw penetration	1 (9.1)	0	
Osteonecrosis	3 (27.3)	2 (25)	
Adhesive capsulitis	1 (9.1)	1 (12.5)	
Non-union	3 (27)	1 (12.5)	
General complications			
No	21 (65.6)	22 (73.3)	0.702
Yes	11 (34.4)	8 (26.7)	
Intraoperative NSA (°)	139.06±9.61	140±9.38	0.699
Final NSA (°)	135.19±10.36	137.97±9.18	0.269
Final ASES	85 (70–90)	85 (82.50–95)	0.584
Final Constant	82 (76.50–92)	89 (78–92.75)	0.092
VAS	1 (0–2)	1 (0–2)	0.732

IMN: Intramedullary nail; NSA: Neck–shaft angle; ASES, American Shoulder and Elbow Surgeons; VAS: Visual Analog Scale.

DISCUSSION

When the literature is examined, there are many studies comparing plate and IMN, whereas there are very few studies comparing these two techniques in two-part PHFs.[11-13] Therefore, we think that our study is valuable. The most important finding of our study is that the amount of blood loss during surgery, time of union, and duration of surgery were significantly lower in the IMN application for the two-part PHF group than in the plate group.

Two-part PHFs are complicated by deforming forces acting on the treatment of fractures, and there is no consensus on the option of fixation in surgery. In their study comparing 15 IMN and 14 plate patients, Trepat et al.[12] found no difference in terms of functional outcomes, while the need for post-operative blood transfusion was higher in the plate group. In our study, it was observed that the amount of bleeding was higher in the plate group, but no comparison was made in terms of transfusion. However, Trepat et al.[12] did not determine a cutoff value for transfusion in their study. Therefore, we think that it is more valuable for us to look at the amount of bleeding. Lekic et al.[11] found no difference in terms of clinical outcomes in their study of 24 patients who underwent 12 IMN and 12 plates for two-part PHFs. In another similar study, Sharma et al.[13] found that although there was no difference between the two groups in terms of 1st-year clinical ASES score and radiological evaluations, the duration of surgery and forward elevation measurements were significantly lower in the IMN group. Similar to this study, the duration of surgery in our study was also short in the IMN group. In our study, we did not evaluate forward flexion. Rotator cuff injury may be reported in these studies as a reason for the low forward flexion in the IMN group. Many studies emphasize the development of complications such as rotator cuff tendon damage, subacromial impingement, and protrusion in the interlocking screw after IMN application.[14,15] There is also a study by Gracitelli et al.[16] suggesting that the treatment of rotator cuff injuries caused by IMN intraoperatively is effective. While we were providing an opening, we repaired the part with rotator cuff injury with non-absorbable sutures. However, although Rochet et al.[17] found 62.1% scar tissue on the cuff in their ultrasound examination of the cases after IMN application, it was reported that the satisfaction level of the cases in terms of functionality was 89.6%, which did not correlate with this value.[14] Since there is a similarity in terms of clinical scores in the two groups in our study, we think that we see functional results that match the study by Rochet et al.[17] In spite of the fact that discussions about rotator cuff injuries in PHF patients who underwent IMN continue today, the absence of a specific evaluation on this topic in our study is one of its lim-

itations. There are comparisons of IMN and plate osteosynthesis methods in the treatment of PHFs in the literature. In the studies conducted by Gradl and Konrad on this topic, it was found that there was no significant difference between the two groups in terms of functional outcomes and post-operative complication rates.[18,19] Gradl et al.[18] reported that the most common complications after plate applications were malunion and fracture displacement, and the most common complication after IMN application was proximal screw perforation. Konrad et al.[20] reported that malunion and non-union were the most common complications regardless of plate or IMN application. In similar studies, it has been reported in the literature that the non-union rate is independent of implant selection.[18,21] Non-union has been commonly associated with smoking, excessive displacement, early mobilization, failure to achieve surgically appropriate reduction, and delayed surgery.[22,23] In addition, it has been reported in the literature that fracture correlates with varus–valgus displacement, smoking history, and delayed surgery increase in the risk of AVN.[24,25] Similar to these results, studies have been reported. The most common complications in the plate group that there is no difference between the two methods used in surgery in terms of complications.[26,27]

In our study, the results consistent with the literature were found in terms of complication rates. The most common complications in the plate group were non-union, AVN, and screw dislodgement. Heterotrophic ossification, screw penetration, and adhesive capsulitis were also observed. In the IMN group, non-union, AVN, and adhesive capsulitis occurred as complications. When the two groups were compared, no difference was found between them in terms of complication rates.

In the study by Bu et al.,[28] it was found that the duration of surgery, blood loss, and time to the union were lower in the IMN group. In a meta-analysis of 2699 subjects, it was found that intraoperative bleeding was better in terms of operative time, post-operative complications, time to fracture union, and post-operative infection.[29] In our study, there was no statistically significant difference between the plate and IMN groups in terms of incision problems, non-union, infection, and general complications. In the IMN application, blood loss during surgery, time to union, duration of surgery, and rate of post-operative discomfort were significantly lower than in the plate group.

In their study, Wang et al.[30] found that there was no difference between plate and IMN application in terms of Constant score. In a prospective randomized study, plate and IMN applications were compared in PHF surgery, and no difference was found in the Constant and VAS scores.[31] In our study, both the groups were comparable in terms of Constant score, ASES score, and VAS score.

We are aware that this study has some limitations. These include variables such as a retrospective design, a lack of a rehabilitation program, relatively few cases, a lack of assessment regarding rotator cuff injury, and differences in bone quality in osteoporotic cases. The results of this study may prove useful in planning future multicenter studies in large case groups involving a longer period.

Conclusion

It has been found that even though both implant choices result in good results in surgical neck PHF treatment, IMN is thought to be a better choice owing to the shorter operative time, reduced intraoperative bleeding, and reduced time to union.

Ethics Committee Approval: This study was approved by the Adnan Menderes University Faculty of Medicine Clinical Research Ethics Committee (Date: 15.11.2022, Decision No: 272932).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: A.S.; Design: Ö.A.; Supervision: C.P.; Research: A.Ç.; Data: S.Ö.S.; Analysis: A.Ş.; Literature search: Ö.A.; Writing: A.Ş.; Critical revision: S.Ö.S.

Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Humerus cerrahi boyun kırıklarında intramedüller çivi ve plak osteosentezinin karşılaştırılması

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AMAÇ: Çalışmanın amacı, literatürde fikir birliği olmayan cerrahi boyun proksimal humerus kırıklarının (PHK) cerrahi tedavisinde kullanılan plak yöntemi ile intramedüller çivi (İMÇ) yönteminin klinik ve radyolojik olarak karşılaştırılmasıdır.
GEREÇ VE YÖNTEM: Ocak 2013-Aralık 2017 yılları arasında PHK nedeniyle başvuran 248 olgu retrospektif olarak incelendi. Altmış iki olgu çalışmaya dahil edildi. Sonuçlar klinik olarak kan kaybı miktarı, cerrahi süre, kaynama süresi açısından karşılaştırıldı. Radyolojik olarak ise Intraoperatif Neck-Shaft Açısı(NSA), final NSA, American Shoulder and Elbow Surgeons(ASES), Constant ve Visuel Analog Scale(VAS) skorları açısından karşılaştırıldı.
BULGULAR: Plak ve İMÇ olarak iki grup oluşturuldu. Gruplar yaş, cinsiyet, operasyon tarafı, takip süresi açısında benzerdi. NSA, final NSA, ASES, Constant ve VAS skorları bakımından gruplar arasında fark yoktu. IMÇ grubunda intraoperatif kan kaybı miktarı, cerrahi süre ve kaynama süresi daha kısa idi.
TARTIŞMA: Cerrahi boyun PHK cerrahi tedavisinde plak veya IMÇ iyi klinik sonuçlar gösteren yöntemlerdir. Bu çalışmaya göre; intraoperatif daha az kan kaybı ortaya çıkması, daha kısa sürede cerrahinin tamamlanması ve daha kısa sürede kaynama görülmesi plak yöntemine göre İMÇ yönteminin avantajıdır.
Anahtar sözcükler: İki parçalı kırık; intramedüller çivi; kilitli plak; osteosentez; proksimal humerus kırığı.

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