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Displaced humeral shaft fracture: Plating versus intramedullary nailing- A prospective cohort study

Mehdi Teimouri [1], **Mohammad Ali Tahririan** [1], **Mehdi Izadi** [1], **Sahar Sadat Lalehzar** [1], **Mohammad Mahdi Emami** [2], **Sayyed Yazdan Asadi** [1*]

[1] Department of Orthopedic Surgery, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran
[2] School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran

[*] **Corresponding author: Sayyed Yazdan Asadi.** Department of Orthopedic Surgery, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran. **Email:** yazdan.asadi@ymail.com

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Abstract

Background: Displaced humeral shaft fractures are among the most frequent long-bone fractures that often require surgical fixation. However, the optimal surgical method remains controversial.

Objectives: This study aimed to compare the outcomes of open reduction and internal fixation (ORIF) with plating versus intramedullary nailing (IMN).

Methods: This prospective cohort study included patients undergoing surgery for displaced humeral shaft fractures at Kashani Hospital, Isfahan, Iran, between 2020 and 2022. Demographic and clinical data were collected. Patients were evaluated postoperatively using the Visual Analogue Scale (VAS), Constant-Murley Score, the Mayo Elbow Performance Index (MEPI), and union time. Complication rates and surgical duration were also recorded.

Results: Of 85 patients, 43 received plating and 42 underwent nailing. The plating group had higher rates of infection (superficial: 21.4%, deep: 9.5%) and nerve damage (23%) compared to the nailing group (0% and 3%, respectively). Reoperation was required in 9% of plating cases compared to 3% in the nailing group. Shoulder impingement occurred only in the nailing group (33%). The nailing group had a shorter operative time (63.8 ± 8.3 min vs. 94.1 ± 11.2 min) and a faster fracture union (15.3 ± 2.2 weeks vs. 18.8 ± 2.1 weeks). Functional and pain scores showed statistically significant differences, favoring nailing in terms of MEPI, while favoring plating in terms of the Constant-Murley score.

Conclusions: Both ORIF with plating and IMN achieved satisfactory outcomes. However, intramedullary nailing may be preferable in patients at high risk of nonunion due to faster recovery and lower complication rates.

Keywords: Humeral shaft fracture, Plating, Intramedullary nailing, Fracture union, Functional outcomes.

Introduction

The reported prevalence of displaced humeral fractures accounts for approximately 1-2% of total fractures.[1-3] The most common cause of fractures is car accidents. Moreover, less than 10% is due to sports trauma.[4] In the study of Kim et al., the annual prevalence of arm fractures in the United States is increasing and will double in 2030 compared to 2008.[4]

Humerus fracture treatment varies by surgeon preference and patient factors.[3] The approach to most humerus shaft fractures is non-surgical.[5,6] The two most accepted and widely used methods for surgery are open reduction and internal fixation (ORIF) with plating, and nailing. Moreover, there is no single determining factor in choosing the surgical method. In three studies since 2000, the results of these two methods have been compared, and the results are significantly different.[7-10] Similarly, the shoulder stiffness function was worse and more painful in the nailing group than in the plating group and the elbow function was worse in the plating group.[8] In another study on 44 patients, plating was introduced as the method of choice, and nailing was associated with more complications and shoulder stiffness.[10] In contrast, Changulani et al., observed more complications in patients

treated with plating and recommended nailing.[7]

According to a comparative study evaluating ORIF with plating versus close reduction and internal fixation (CRIF) with nailing for humeral shaft fractures, open reduction and internal fixation with a dynamic compression plate (DCP) remain the best treatment for unstable fractures of the shaft of the humerus. Fixation by an intramedullary nail (IMN) may be indicated for specific situations but is technically more demanding and has a higher rate of complications.[11]

In a meta-analysis comparing open plate fixation and nailing for humeral shaft fractures, they reported nailing was associated with a lower risk of infection and postoperative radial nerve palsy, a shorter operation duration, and possibly faster fracture union. Nail fixation does have a drawback as it may cause shoulder impingement requiring additional treatment. Notably, there are few absolute changes, and practically all radial nerve palsy patients experienced a spontaneous recovery. Both therapy approaches are capable of producing satisfactory results.[12]

Totally, humerus fractures are significant injuries with implications for arm function and quality of life. The choice between non-surgical and surgical treatment depends on various factors, including fracture stability and individual patient considerations. Both ORIF with plating and nailing have their advantages and disadvantages, and the decision should be made in consultation with a healthcare professional to ensure the best possible outcome for the patient.[12]

No previous study in our country has directly compared these two surgical methods. Therefore, the aim of the present study was to compare ORIF with plate and nailing method in displaced fractures of the humeral shaft.

Objectives

The aim of the present study was to compare ORIF with plating and the nailing method in displaced fractures of the humeral shaft.

Methods

Study design and setting

This prospective study was performed at Kashani medical and education center affiliated with Isfahan University of Medical Sciences during 2020-2022. The study was conducted on patients with humeral shaft fracture with displacement, who underwent ORIF or nailing. These patients were followed for an average of six months.

Inclusion and exclusion criteria

The inclusion criteria were fractures of 2/3 of the middle of the shaft of the humerus.

The exclusion criteria were patients with open fractures, chronic underlying diseases or diseases that interfere with fracture healing such as diabetes, past medical history of disease or decreased range of motion in shoulder or elbow, diseases that interfere with the results of the study, including neck injuries and radiculopathy (diagnosis with a history and examination), patients who do not consent to participate in the study, those who did not participate in the study until the end and did not come for follow-up sessions.

Sample size

The sample size was determined for the primary outcome, the 12-month DASH score. The calculation was based on a minimal clinically important difference of 10 points, as validated for humeral fractures,[12] and an expected standard deviation of 15 points. With 80% power and an alpha of 0.05, 36 patients per group were required. Accounting for a 15% attrition rate, the sample was inflated to 40 patients per group. Thus, a total of 80 participants were enrolled to ensure adequate power to detect a meaningful difference in functional outcome between plating and nailing cohorts.

$$n = \frac{2 \times \sigma^2 \times (Z_{\alpha/2} + Z_{\beta})^2}{\Delta^2}$$

A convenience sampling method was used to select the patients. Patients were assigned to treatment groups based on the day of their surgery: those who underwent surgery on an odd-numbered day were assigned to the plating group, and those who underwent surgery on an even numbered day were assigned to the nailing group.

Data collection

In this study, 103 patients with a mid-shaft humeral fracture (involving two-thirds of the shaft) who presented to Kashani Medical Center between April 2020 and April 2022, met the inclusion criteria, and underwent either plate or intramedullary nail surgery were followed up. These patients were assessed for eligibility. Before following up, eighteen patients were excluded due to underlying diseases. Data were obtained from 85 patients including two groups, 43 patients were in the plating group and 42 patients were in the nailing group. All patients' demographic and baseline clinical characteristics, were extracted from patients' medical records. The surgery approach was anterolateral for all patients. In the first month after surgery, follow-up was every two weeks, then the follow-up would continue in the third, fourth, fifth, and sixth months after surgery. Radiography was performed in the third and sixth months after surgery. Patients who had symptoms including pain and tenderness in the fracture site, no evidence of healing and

callus formation in radiography after six months and compared to previous radiographs, advanced union had not been achieved, were considered nonunion.

The Constant-Murley score (CMS) is a 100-point scale composed of several individual parameters.[13] The Constant-Murley score was introduced to determine the functionality after the treatment of a shoulder injury, which contains four subscales: pain (15 points) (filled by the patient), activities of daily living (20 points) (filled by the patient), strength (25 points) (evaluated by the orthopedic surgeon who did not know about the type of the surgery) and range of motion: forward elevation, external rotation, abduction and internal rotation of the shoulder (40 points), which should be performed without help.[14] The higher the score, the higher the quality of the function.[15] Subjective findings (severity of pain, activities of daily living, and working in different positions) of the participants are responsible for 35 points and objective measurements (AROM without pain, measurements of internal and external rotation via reference points and measurement of muscle strength) are responsible for the remaining 65 points.[16]

In French, a validated translation has been published. The time needed to complete the Constant-Murley test is between 5 and 7 minutes.[17] The Constant-Murly questionnaire was a valid instrument for evaluating outcomes in patients with a humeral shaft fracture and high reliability when performing the strength measurement.[18,19]

The Mayo Elbow Performance Score (MEPS) or Mayo Elbow Performance Index (MEPI) is an instrument used to test the limitations, caused by pathology, of the elbow during activities of daily living (ADL). This specific test uses 4 subscales: Pain (0-45 points), Range of Motion (arc of motion of the arm. humeroulnaris) (to be completed by healthcare provider) (5-20points), Stability(0-10points), Daily Function (5 points for every five activities containing comb hair, feed self, hygiene, can do shirt, and can-do shoes). MEPS can be used to measure which treatment works best for different conditions. MEPS is a 4-part test where clinical information is rated based on a 100 points scale.[20] Validity testing showed the system of Ewald et al. and the Mayo elbow-performance index to be the most discriminating, the system of Pritchard to be the least discriminating, and the system of The Hospital for Special Surgery and the system of Broberg and Morrey to be intermediate.[21]

Statistical analysis

The obtained data were analyzed using the Statistical Package for the Social Sciences (SPSS) software (version 24.0; SPSS Inc., Chicago, IL, USA). Demographic and clinical characteristics of patients were reported as frequency (percentage) for qualitative variables and mean ± standard deviation (SD) for quantitative variables. Qualitative variables between the study groups were compared using the Chi-squared test and Fisher's exact test. Normality of distribution in quantitative variables was assessed using the Shapiro-Wilk test. Normally distributed quantitative variables were compared between the study groups using the independent t-test, paired t-test and repeated-measures ANOVA.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki. The study protocol was approved by the Research and Ethics Committees of Isfahan University of Medical Sciences (REC number: IR.MUI.MED.REC.1399.210).

Results

From 2020 until 2022, 103 patients entered our study, and data obtained from 85 patients were analyzed after applying the exclusion criteria. A total of 85 participants were examined in the study. The participants in this study were in the plating groups with 43 participants and a nailing group with 42 participants. Table-1 compares the demographic characteristics of the participants according to the study groups. There is no significant difference between the mean of age and frequency of gender in the two study groups (P>0.05).

Table-1. Comparison of demographic characteristics of the participants according to the study groups

Variable	Plating (Mean ± SD)	Nailing (Mean ± SD)	P-value
Age*	34.3±4.5	35.9±3.4	0.08
Gender**	**N (%)**	**N (%)**	
Male	34 (79 %)	34 (81 %)	0.82
Female	9 (21 %)	8 (19 %)	

* Independent t-test was used to compare the data in two groups. **Chi-square test was used to compare data in two groups. The significance level is less than 0.05.

Table-2 compares the variables of Type A (fractures are extraarticular and unifocal) and B (fractures are extraarticular and bifocal), Nonunion [Figure-1 and 2], Nerve damage, Need for reoperation, Impingement and Infection two study groups. The AO/OTA 2007 classification is based on the severity and articular/ extraarticular and unifocal/bifocal pattern of the fracture, defining two main types (A, B).[22,23] In the plating group, 3

patients had both non-union and deep infection and one patient in this group had only deep infection. In the nailing group, one patient had non-union. Overall, there were four patients in the plating group and one in the nailing group required reoperation. All superficial infections were managed and treated with antibiotics. The results of Table-2 show that there was no significant difference between Type A and B, Nonunion, Need for reoperation in the two groups (P>0.05). However, a significant difference was observed between impingement and infection in the two groups (P<0.05). Most of the patients with impingement complications were treated with conservative treatment in the form of corticosteroid therapy, physiotherapy and NSAIDs. Additionally, there was a significant difference between nerve injuries in the two groups and it was significantly more in the plating group (p= 0.008). In this study, spontaneous recovery was achieved for patients with nerve damage.

Table-3 compares the mean duration of surgery and average union time in two study groups. As the results of Table 3 show, the mean duration of surgery and average union time in the plating group were significantly higher than in the nailing group (P<0.05).

Table-4 compares Constant-Murley Score and Mayo Elbow Performance Index in 3 months and 6 months after surgery in two groups. The results show that a significant difference was observed 3 months and 6 months after surgery in the Mayo Elbow Performance Index between both groups (P<0.05) and in the plating group were significantly lower than the nailing group. Moreover, these results show that the mean of Constant-Murley Score at 3 months and 6 months after the surgery in the nailing group were significantly lower than the plating group (P<0.05).

Figure-1. Non-union of humeral shaft fracture with nail

Figure-2. Non-union of humeral shaft fracture with plate

Table-2. Determining and comparing the frequency of variables of Type, Nonunion, Nerve damage, Need for reoperation, Impingement, Infection in two study groups

Variable		Plating N (%)	Nailing N (%)	P-value
Type	A	26 (60 %)	32 (76 %)	0.11*
	B	17 (40 %)	10 (24 %)	
Nonunion	Yes	3 (7 %)	1 (3 %)	0.617**
	No	40 (93 %)	41 (97 %)	
Nerve damage	Yes	10 (23 %)	1 (3 %)	0.008**
	No	33 (77 %)	41 (97 %)	
Need for reoperation	Yes	4 (9 %)	1 (3 %)	0.362**
	No	39 (91 %)	41 (97 %)	
Impingement	Yes	0	14 (33 %)	0.001**
	No	43 (100 %)	28 (67 %)	
Infection	Superficial infection	9 (21.42 %)	0	0.001**
	Deep infection	4 (9.52 %)	0	

*Chi-square test was used to compare data in two groups. The significance level is less than 0.05. **Fisher's exact test was used to compare data in two groups. The significance level is less than 0.05

Table-5 compares the mean VAS score at 1, 3, and 6 months after surgery and in two plating and nailing groups. The test results show that over time, the mean VAS score has decreased significantly (P<0.05). Moreover, the mean VAS score in the plating group was significantly lower than in the nailing group (P<0.05) [Figure-3].

Table-3. Determining and comparing the mean of duration of surgery and average union time in two study groups

Variable	Plating (Mean ± SD)	Nailing (Mean ± SD)	P-value
Average union time (weeks)	18.8±2.07	15.29±2.2	0.001
Duration of surgery (minutes)	94.14±11.2	63.8±8.26	0.001

Independent t-test was used to compare the data in two groups. The significance level is less than 0.05

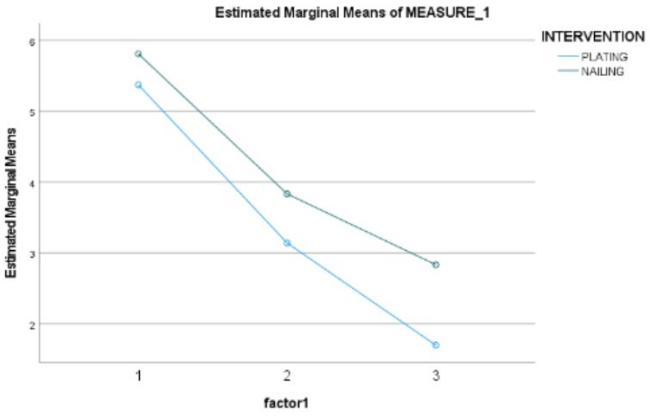

Figure-3. Comparison of the time trend of the VAS score in the two study groups

Table-4. Determining and comparing of the mean Constant-Murley Score and Mayo Elbow Performance Index in 3 months and 6 months after surgery in two groups

Variable		Plating (Mean ± SD)	Nailing (Mean ± SD)	P-value**
Constant-Murley Score	3 months	82.2±7.16	75.69±7.1	0.001
	6 months	91.33±5.1	80.9±5.5	0.001
	P value*	0.001	0.001	
Mayo Elbow Performance Index	3 months	77.42±5.4	80.9±5.7	0.005
	6 months	80.4±6.3	90.8±5.8	0.001
	P value*	0.001	0.001	

*Paired t-test was used to compare the data in two groups. The significance level is less than 0.05, **Independent t-test was used to compare the data in two groups. The significance level is less than 0.05

Table-5. Determination and comparison of the VAS score on 1, 3 and 6 months after surgery in two study groups

Variable		**Plating** (Mean ± SD)	**Nailing** (Mean ± SD)	P-value*	P-value**
VAS score	1 month	5.37±1.6	5.81±1.9	0.001	0.03
	3 months	3.14±2.07	3.8±2.1		
	6 months	1.7±1.5	2.8±2.3		

The repeated measures analysis test was used to compare the data. ** Between-Subjects Effects* within- Subjects Effects. The significance level is less than 0.05.

Discussion

Based on the findings of the present study, there was no significant difference between the mean age and frequency of gender in the two study groups. There was no significant difference between type, nonunion, need for reoperation in the two groups. The mean of duration of surgery and average union time in the plating group was significantly higher than the nailing group. A significant difference was observed 3 months and 6 months after surgery in both groups in comparison between Constant-Murley Score and Mayo Elbow Performance Index in 3 months and 6 months after surgery. Moreover, the results showed that the mean of Constant-Murley Score at 3 months and 6 months after the surgery in the nailing group were significantly lower than the plating group. Over time, the mean VAS score has decreased significantly and based on the results, the mean VAS score in the plating group was significantly lower than the nailing group.

According to a study, Wang et al. reported significantly shorter operative time in IMN (intramedullary nailing) group and lower VAS scores in the IMN group after surgery in the first and third months but not at the sixth month.[24] In contrast, in our study in both nailing and plating groups, VAS scores showed a significantly decreasing course over six months but not over the first third and sixth months separately. Similar to our study, we had a shorter duration of surgery in the nailing group.

The complication rate was found to be relatively higher in the plating group when compared to the IMN group.[25] This report is similar but not significant in our study.

According to a study, the shoulder stiffness function was worse and more painful in the nailing group than in the plating group and the elbow function was worse in the plating group.[8] Similarly, in our study also the patients in the nailing group significantly had more impingement and pain. According to another study on 44 patients, which compared plating and nailing methods, the plating was introduced as the method of choice, and nailing was associated with more complications and shoulder stiffness.[10] Changulani et al., observed more complications in patients treated with plating and recommended nailing.[7] Due to the present study, patients in the plating group had significantly more nonunion, nerve damage and superficial infection, but patients in the nailing group just had more impingement after the operation. According to another study, three patients in the plating group suffered iatrogenic radial nerve injury and recovered four to six months later similar to our study. No implant failures occurred in either group,[26] but in our study, we had nerve damage mostly in the plating group.

In comparison between open plate fixation and nailing for humeral shaft fractures in the meta-analysis, they had similar reports with us, which reported that nailing carries a lower risk of infection, postoperative radial nerve palsy, has a shorter operation duration, and possibly a shorter time to union.

According to a study, exactly similar to our study, IMN may be superior to plate in postoperative infections for the treatment of humeral shaft fracture. However, in contrast to our study, the plating group was superior to the IMN group in nonunion.[27,30]

In a comparison of results between plating and interlocking nails for the management of humeral shaft fractures, Chandan et al. reported union was more present in the nailing group [18 (90%)] than in plating [17 (85%)] patients. The average union time was 7.83±1.54 weeks in the nailing group and 8.64±1.96 weeks in the plating group. In contrast in our study average union time in the plating group was longer (18.32±1.97) than the nailing (14.90±2.13).[29]

Conclusions

Taken together, our study demonstrated a comparison between plating and nailing in the approach of humeral shaft fracture with displacement. It seems that intramedullary nailing had significantly more impingement and less average union time and duration of surgery. Approach with plating had a longer average union time, nerve damage and infection rate. In this study, we found that the results of both methods are acceptable, but given that the healing time in the nailing group is less in comparison with plating, we recommend that nailing is a better method in patients with a high risk of nonunion, like smokers. Further in-depth prospective studies are greatly needed to verify our conclusion. Our limitation in this study is the small sample size and the short follow-up period. It is recommended to conduct studies with a larger sample size and longer follow-up periods.

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Competing interests

The authors declare that they have no competing interests.

Abbreviations

Open Reduction and Internal Fixation: ORIF; Intramedullary Nailing: IMN; Visual Analogue Scale: VAS; Mayo Elbow Performance Index: MEPI; Close Reduction and Internal Fixation: CRIF; Dynamic Compression Plate: DCP; Constant-Murley Score: CMS; Mayo Elbow Performance Score: MEPS.

Authors' contributions

MT, MAT: Study conception and Writing; MI: Writing; SSL: Data analysis and Interpretation; MME: Drafting; SYA: Drafting, Project management. All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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Role of the funding source

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Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

Approved by the Isfahan University of Medical Sciences Ethics Committee (IR.MUI.MED.REC.1399.210). Written informed consent obtained.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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