Effect of reaming on intramedullary nailing of humeral shaft fractures

Abstract

Introduction: Humeral shaft fractures are highly prevalent. These fractures can lead to complications and significantly impact quality of life. Choosing the appropriate surgery type presents challenges of high cost, and economic burden. We are investigating and comparing the outcome of Intramedullary Nailing (IMN) surgery with reaming and nailing without reaming as a treatment method for humeral shaft fractures and its outcomes.

Materials & Methods: This study was a prospective cohort study that examined patients with humerus shaft fractures in 2023. The study was conducted on nailing humeral fractures in a teaching hospital. The patients were randomly divided into two groups: One group was treated with intramedullary nailing with reaming, and the other group without reaming. The patients were monitored for pain, delayed union, non-union, infection, radial nerve palsy, and healing status at intervals of two weeks, one, three, and six months after surgery.

Results & Discussion: Sixty-nine patients including 29 in non-reamed and 40 in the reamed cases were studied. Union was observed at 11.1±3.5 weeks in non-reamed and 8.2±1.9 in reamed group, delayed union was observed in 3 of non-reamed and 2 of reamed cases. One case of non-union was in non-reamed group. In the second week of the follow-up, the reamed group reported significantly higher pain levels; however, no significant difference was observed in the 4th and 12th weeks of follow-up. There was no significant difference between the two groups regarding complications.

Conclusion: Reamed IMN of humeral fracture can reduce the union time, and helps to lower the occurrence of delayed union and non-union. However, the patients would experience more pain in few first post-surgery weeks and reaming.

Keywords: Bone Fractures, Humerus, Intramedullary Nailing.

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Introduction

Humeral fractures can be classified into three types based on their location. These types include proximal fractures, shaft fractures, and distal fractures with the shaft being most common type. Shaft fractures are the second most common fracture in the general population. According to the latest reports, the prevalence of this fracture is estimated to be between 3-5% in 2023[(1)].

The symptoms of humerus bone fractures usually include pain, swelling, inability to move, and limb deformity[(1)]. Diagnosis of bone fractures is based on the loss of periosteum integrity and sometimes the apparent displacement of bones in radiographic images[(2)]. The treatment of this fracture is based on the type and location of the fracture and radiological criteria, which can take the form of non-surgical and surgical treatment[(3-5)]. Non-surgical treatment includes using a splint or arm sling, while surgical treatment includes external fixation, open reduction, internal fixation (ORIF), and intramedullary nailing (IMN)[(1)]. Complications associated with surgical treatment include fracture non-union, delayed union, and damage to the radial nerve, which can be seen in up to 18% of cases[(5)].

In cases of pathological unstable fractures, fragmented bone, osteoporotic, and high-energy fractures, physicians usually perform IMN[(1,6)]. This procedure can be done with or without reaming, which is the process of widening the medullary canal to allow for the passage of the nail[(7)].

Studies have shown that reaming and using larger nail sizes can help increase bone stability[8,9]. Moreover, reaming has been shown to speed up the bone union process. It does this by separating debris cells that could contain osteoblasts and stem cells, which are crucial in bone grafting and accelerating the bone union process[10,11]. Additionally, reaming increases the blood supply under the periosteum, which can reduce the time required for bone union[12]. Intramedullary nails, made of titanium, have been observed to accelerate callus formation, increase the rate of bone union, and reduce the time required for bone union[12].

Multiple studies have demonstrated higher union rates and lower rates of return to the operating room using reamed intramedullary nailing compared to un-reamed intramedullary nails[13-15]. Most of the studies have compared IMN with non-reamed and reamed methods in tibial and femoral fractures, and reaming has been associated with a reduction in the time required for bone union and an increase in the rate of bone union[16]. On the other hand, reaming can have complications such as bleeding, the need for blood transfusion, fat embolism syndrome, and heat-induced necrosis[12,17,18]. However, in a study by Achecar et al. 1997, it was observed that non-reamed IMN in humeral fractures was associated with a shorter time for radiological evidence of fracture improvement compared to reamed IMN[19].

Humeral shaft fractures are highly prevalent among young and working populations, as well as elderly and disabled individuals. These fractures can lead to complications and significantly impact quality of life. Choosing the appropriate surgery type presents challenges, high costs, and an economic burden, and more studies in this area need to be conducted. To address this issue, we investigated the outcome of IMN surgery with and without reaming as a treatment method for humeral shaft fractures.

Materials & Methods

Study Design

This study was a prospective cohort study that examined patients with humerus shaft fractures in 2023. The study was conducted in Kashani and Al-Zahra hospitals in Isfahan, Iran, and was approved by the Ethics Committee of Isfahan University of Medical Sciences (Code:IR.MUI.MED.REC.1402.300).

Inclusion Criteria

To be included in the study, patients had to suffer from humerus shaft fractures, be between the ages of 20 and 60, have no history of musculoskeletal disease, not be taking any drugs that interfere with the bone union, and participate in all follow-up courses. They also had to meet other criteria, such as having no previous fractures, no current open fractures, and no vascular or nerve damage with the current fracture.

Treatment Groups

The patients were randomly divided into two groups: one group was treated with intramedullary nailing with reaming, and the other group received humerus shaft fixation with intramedullary nailing without reaming.

Surgical Procedure

The surgical approach for the anterolateral shoulder begins with a 3-4cm incision along the anterolateral border of the acromion. Tenotomy is performed to develop a soft tissue plane, followed by cautery through subcutaneous tissue. Sharp dissection is carried out through fascia, bursa, and rotator interval. The surgeon marks out the acromion's anterior, lateral, and posterior borders before making the incision and dissecting along the anterolateral border of the acromion down to the rotator cuff interval.

For guidewire insertion, the start point is between the greater tuberosity and the sulcus in the center of the humeral head. The aim is to have a 50% bare area, with the guidewire malleted into place and checked on fluoroscopy. The rotator interval is divided, and the guidewire is driven down the canal on power. AP and lateral fluoroscopy views ensure the guidewire is centered in the canal. A lateral entry awl or reamer (approximately 8mm) with a soft tissue protector is used to ream until it hits the stop plate.

Fracture reduction is achieved by applying manual traction, varus/valgus, and rotational force. Once reduced, a long ball-tip guidewire is manually pushed past the fracture site using a T-handle with a slight bend at the tip. The guidewire is malleted to the distal aspect of the humerus (olecranon fossa) and checked on AP/lateral fluoroscopy. A radiolucent ruler is used to measure the appropriate nail length on AP fluoroscopy of the shoulder. Rechecking the fracture site is essential to ensure no gapping for accurate

length measurement. If segmental comminution exists, the contralateral side can be measured to determine the intact humerus length.

For nail insertion, the nail is assembled on the back table, ensuring the targeting guide aligns with the holes in the nail and checking sleeves for each interlock hole. The top locking screw is tightened with a pumpkin screwdriver to lock the assembly together. The nail is inserted over the guidewire, following its 6° lateral bend, and malleted with a strike plate. The targeting jig should be 30° anterior to the bed for proper alignment. The nail is held by the handle, not the targeting guide, and advanced manually or with a mallet to the fracture site, checking on AP/lateral fluoroscopy. Manual advancement past the fracture site is preferred to avoid iatrogenic comminution or new fracture lines. The nail is inserted entirely and seated fully, with seating in the humeral head checked. It is essential to bury the nail 7-10mm to decrease the incidence of shoulder pain. Finally, the long balltip guidewire is removed. For the non-reamed group, the reaming process is omitted. The nail is fixed, specifically the Biotech brand (Figure 1 to 3).

Outcome Measures

Shoulder mobility restriction was considered 50-60% one month post-intervention, 20-30% at three months, and 5% at six months. Patients' Demographic information, including age and sex, was recorded in the checklist. The patients were monitored for pain, complications such as delayed union, non-union, superficial infection, deep infection, radial nerve palsy, comminution at the fracture site, and welding condition by X-ray at intervals of two weeks, one month, three months, and six months after surgery. In our study, a delayed union was considered if it took more than three months for the union, and a non-union was considered if the union was not achieved after six months.

Statistical Analysis

Data analysis was done using IBM SPSS 28. After using the Kolmogorov-Smirnov test, the mean±SD was used to describe continuous variables, and the number (%) was used to describe categorical variables. Independent t-student, Chi-square test, and one-way ANOVA were performed to compare the effect of the intervention. A p-value less than 0.05 was considered statistically significant (two-sided).

Figure 1: Before surgery

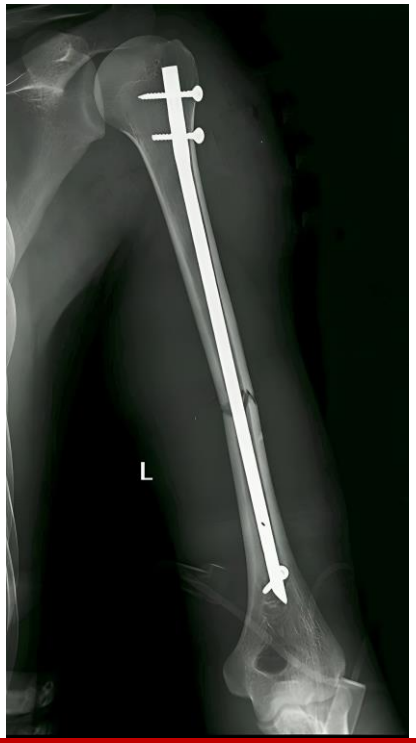

Figure 2: Three months after reaming surgery

Figure 3: Six months after reaming surgery

Results

Sixty-nine individuals were included in this study, with a mean±SD age of 35.3±10.2 years. Out of them, 35 (50.7%) were male. The participants were divided into two groups: non-reamed (29 individuals) and reamed (40 individuals), as shown in Table 1. Table 1 shows no significant age or sex differences between groups.

Participants were assessed based on the study's outcomes; the results are presented in Table 2. According to the outcome comparison, the union duration was significantly less in the Ream group than in the non-reamed group (P<0.001). The reamed group also had fewer delayed unions, although this difference was not statistically significant. Only one case of non-union was observed in the study, which was in the non-reamed group. Regarding pain scores, it was found that during the second week of the follow-up period, the Ream group reported significantly higher pain levels (P<0.001). However, no significant differences were observed in the 4th and 12th weeks of the follow-up.

The study also investigated the complications of fracture and intervention in patients, and the results are presented in Table 3. As shown, there was no significant difference between the two groups regarding complications.

Discussion

Fracture of the humerus is a common orthopedic problem often associated with several complications. The availability of various treatment methods makes it challenging to select the appropriate type of treatment for the humerus fractures. Reaming and non-reaming IMN are two procedures used to treat humerus fractures. In this study, we investigated the efficiency of these two procedures.

Table 1: Demographics variables

	non- Ream (n=29)	Ream (n=40)	P-value
Age (year), mean±SD [1]	37.5±12.3	33.8±8.2	0.14
Sex (male), No (%)[2]	17 (58.6)	18 (45.0)	0.26

[1]Indipendent t-test; [2]Chi-squar; SD= standard deviation

Table 2: Comparison of outcomes

	non- Ream (n=29)	Ream (n=40)	P-value
Weeks to union, mean±SD [1]	11.1±3.5	8.2±1.9	0.001
Delayed union, No (%)[2]	3 (10.3)	2 (5.0)	0.64
Non-union, No (%)[2]	1 (3.4)	0 (0)	0.42
Pain score at week 2, mean±SD [1]	3.2±0.7	3.8±0.6	0.001
Pain score at week 4, mean±SD [1]	2.0±0.7	1.9±0.6	0.50
Pain score at week 12, mean±SD [1]	0.5±0.5	0.4±0.5	0.95
ROM at week 2, mean±SD [1]	31.2±6.3	49.3±7.1	0.001
ROM at week 4, mean±SD [1]	15.6±4.2	18.4±5.3	0.021
ROM at week 12, mean±SD [1]	6.1±2.2	4.2±1.8	0.001

[1]Indipendent t-test; [2]Chi-squar; SD= standard deviation, ROM= Range of motion

Table 3: Comparison of complications

	non-Ream (n=29)	Ream (n=40)	P-value
Superficial infection, No (%)[1]	1 (3.4)	2 (5.0)	1.00
Deep infection, No (%)[1]	0 (0)	0 (0)	-
Radial nerve palsy, No (%)[1]	0 (0)	0 (0)	-
Comminution at fracture site, No (%)[1]	0 (0)	0 (0)	-

[1]Chi-squar; SD= standard deviation

Non-union and delayed union are significant complications of humerus fractures, which may occur in both surgical and non-surgical cases[20-23]. The incidence of these complications has been reported to range from 2% to 10% in surgical treatments, which is consistent with the findings of our study[23,24]. We observed that 5% of patients in the Ream IMN group and 10% in the Non-Ream IMN group experienced delayed union.

Our study revealed that patients who underwent Non-Ream IMN surgery took longer to achieve union than those in the Ream IMN group. The mean time reported for the Non-Ream IMN group was 11.1 weeks, while the Ream IMN group took 8.2 weeks to achieve union. Similarly, in the study of COURT-BROWN et al., which was conducted on 50 patients, it was seen that in patients who were reamed IMN, the time required for the union was shorter, and in 20% of non-reamed patients, the need to replace the nail was reported due to delay in the union[25].

In Larsen et al.'s study, which involved 45 patients with tibial fractures, it was observed that those who underwent reamed nailing had a lower incidence of delayed union and non-union[16]. A 2016 meta-analysis of 1078 patients found femoral fractures treated with reamed intramedullary nailing union were faster than those treated with non-reamed nailing[12]. The shorter union time in the reamed group may be due to the reaming process itself, which increases blood supply six-fold by putting pressure on the vessels under the periosteum, thereby reducing the time required for a union[12]. Furthermore, some studies have shown that the debris cells separated during reaming may contain osteoblasts and stem cells, which act as bone grafts and facilitate bone union[11,18].

In our study, only one case of non-union was seen in the non-reamed group. However, there was no significant relationship between the type of operation (reamed IMN or non-reamed IMN) and non-union occurrence. This finding is in line with the study of Enes Ocalan et al., and it has been seen that smoking and underlying diseases such as diabetes, heart, and kidney disease are risk factors for not eating well in these patients[26]. It has also been seen in previous studies that old age, various medical co-morbidities, sex, smoking, use of non-steroidal anti-inflammatory drugs, various genetic disorders, metabolic disease, malnutrition, and use of steroids and fracture pattern, location and displacement, the severity of soft tissue damage, the degree of bone loss, the quality of surgical treatment, and the presence or absence of infection are also involved in non-union[24,27,28]. Patients who have these conditions were excluded from the study.

One of the most common complications after surgery is postoperative pain, which is debilitating and negatively affects the patient's quality of life in the long term[29]. In our study, the mean pain score in the second week after the operation for the reamed group was higher than the non-reamed group, but no clear difference was seen in the pain of the two groups in the 4th and 12th weeks. Pain experienced during the first few weeks after surgery may be caused by various factors, such as cytokines, prostaglandins, histamine, and bradykinin, which are produced due to the bone healing process[30]. The pain may also result from the reaming process and the type of surgical procedure that involves introducing nails into the bone marrow, which may affect the nearby nerves[30]. On the other hand, activities such as weight bearing and walking before successful and complete healing and re-modeling can affect the patient's pain, although this issue has not been investigated explicitly in these people[31].

Overall, our study had some limitations. It was done in a single center with a limited sample size, which may affect the generalizability of our findings, so multicenter studies with a larger sample size are recommended to improve the results and increase accuracy. In addition, the variables that may affect the union process should be investigated as confounding variables in future studies, and their role in the amount of union delay should be investigated. It is also recommended that some significant life-limiting complications of reaming, including bleeding and the need for blood transfusion, fat embolism, and necrosis caused by heat, should also be investigated in the follow-up of patients. The strength of the present study includes the prospective design and follow-up of patients and the examination of some of the most common and essential complications, which have yet to be extensively investigated in the center where our study was conducted.

Conclusion

The reamed IMN procedure can reduce the time it takes for a humerus fracture to heal. It can also lower the occurrence of delayed union and non-union. However, the only significant downside of using this

method is the pain that patients may experience in the first few weeks after surgery. This pain gradually subsides, and no other side effects have been observed. It is recommended that some significant life-limiting complications of the reaming, including bleeding and the need for blood transfusion, fat embolism, and necrosis caused by heat, be investigated in the follow-up of patients.

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