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Comparison of Humeral shaft fractures treated with interlocking nailing versus plating

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Abstract

Introduction*:*
Plate osteosynthesis and interlocking humerus nailing are two commonly employed surgical techniques. Plate osteosynthesis offers stable fixation and is preferred for certain fracture patterns, while interlocking nailing provides rotational stability with minimal soft tissue disruption. This research aims to assess the outcomes of these surgical methods and their impact on functional recovery.

Materials and Methods:
This prospective research has been performed at Saveetha Medical College included 30 patients with closed humeral shaft fractures. Patients aged under 18 and those with compound grade III fractures were excluded. Treatment decisions were based on clinical and radiological assessments, with only operative cases included in the study. Plate osteosynthesis and interlocking humerus nailing were performed based on fracture characteristics and patient factors. Follow-up evaluations were conducted over a period of 3-9 months, assessing fracture union, functional outcomes, and complications.

Results*:*
Of the 30 patients included, the majority were in the 2nd and 3rd decades of life, with a male predominance (56%). Road traffic accidents were the leading cause of fractures (70%), with the right side being more commonly affected (53.33%). Plate osteosynthesis and interlocking nailing were performed in 15 patients each. Fractures predominantly occurred in the middle 1/3rd of the humeral shaft (73.33%).Union rates were high in both groups, with 80% achieving union in less than 16 weeks. However, in 20% of interlocking nailing cases, shoulder stiffness was noted, and in 6% of cases, the delayed union took place. Complications like radial nerve palsy and infection were more prevalent in the plating group, affecting 20% and 6% of cases, respectively.

Conclusion:
The selection of the implant depends on factors like indications, patient preference, and the surgeon's choice. In well-evaluated patients with clear indications, either plating or nailing for internal fixation of these fractures may be considered optimal management. Both methods have their advantages and disadvantages.

Keywords :*Interlocking nailing , plate osteosynthesis , shaft of humerus .*

INTRODUCTION :

Orthopaedic surgeons treat humeral shaft fractures often; they account for roughly 3percent of the fractures overall. Treatment approaches for these kind of the injuries continue to progress with advancements in both non-operative as well as operative management. [1]. Although it's generally acknowledged that non-surgical therapy is preferable for the most of humeral shaft fractures, there are various situations where primary or secondary operational treatment may be indicated. [2,3,4]. Conservative treatment, an option for some fractures, comes with drawbacks like immobilisation of prolonged limb, the requirement for consistent patient cooperation, and frequent hospital visits. Additionally, it's not suitable for all cases, particularly those with unstable fractures (such as spiral or long oblique fractures), comminuted fractures, open fractures, segmental fractures, pathological fractures, fractures with the delayed union & non-union, or fractures accompanied by radial nerve or vascular injuries.[5] In some cases, operative treatment is necessary. Operative treatment typically involves internal fixation and open reduction of the fracture using methods such as plate osteosynthesis, intramedullary implantation, or external fixation. These surgical approaches provide more stable fixation and are essential for addressing complex fractures or associated injuries.[6] Closed interlocking nailing offers advantages such as minimal surgical intervention, anatomical fixation, and rotational and torsional stability, leading to early mobilisation as well as anatomical reduction. This approach has become more widely available with the help of image intensifier control. Nevertheless, it might result in limited elbow mobility and rotator cuff impingement. At the same time, the plate provides higher rates of the fracture union with good compression and anatomical reduction across the fracture site. It avoids the elbow joint and damage to the rotator cuff but involves disadvantages such as excessive periosteal stripping, raised infection or nerve damage risks, extensive incision, and less secure fixation in osteopenic bone.[7]
A comparative study is made to determine the optimal surgical treatment for various kinds of closed fractures of the mid-shaft humerus along with their associated functional results.

Materials and methods :
This research was conducted at Saveetha Medical College, Thandalam. This research consists of 30 patients having humerus shaft fractures. Patients under 18 years of skeletally immature were excluded. Only compound grade I and grade II fractures (Gustilo and Anderson classification) were included.The radiological assessment involved lateral views as well as anteroposterior of the humerus, including the elbow joints and shoulder, classified using the AO system. Following up with clinical as well as radiological tests, an average of six months (with a range of three to nine months) were spent monitoring the patients.). Treatment decisions (operative vs. non-operative) were based on associated injuries, radiological findings, and clinical. Only operative cases have been included in the study.

Indications for operative treatment:
1. Patients with polytrauma should be mobilized as soon as possible.
2. unsuccessful conservative treatment.
3 Patients who could not be immobilized for an extended period of time insisted on returning to work early.
4. fractures that were comminuted, spiral fractures, or short oblique fractures that were not reducible using closed techniques.
5. fractures connected to damage to the brachial artery or radial nerve.
6. bilateral humeral fractures or floating elbow (associated with forearm fractures).
7. Both Grade 1 & Grade 2 compound fractures have been present.

Operative treatment includes:
Interlocking humerus - Antegrade technique
Plate osteosynthesis

Plateosteosynthesis, utilized for oblique fractures or closed transverse with minimal comminution, fractures related to vascular injury or radial nerve palsy, and closed and compound grade 1 fractures, involves the anterolateral or posterior approach. Fracture reduction and fixation are achieved using a narrow 4.5mm DCP ("Dynamic Compression Plate) with at least 7 cortices on each side. Depending on the stability of the fracture, an external splint in the form of a 'U' shaped slab" may be applied. Postoperatively, a follow-up visit is scheduled at the outpatient department (OPD).
Follow-up:

- First, follow up - 2 weeks post-surgery: Stitch removal is performed, and shoulder and elbow mobilisation is recommended. In situations where the patient's compliance is doubtful, a U-shaped slab may be extended for an extra four weeks.
- Second, follow up - 6 weeks post-surgery: Evaluation of elbow movements and shoulder is conducted. Tenderness at the site where the fracture occurred is observed, and a repeat X-ray is taken to assess fracture union. Full mobilisation is advised upon evidence of union.

Interlocking nailing :
This approach has been utilized "for: 1. Closed communited fracture of shaft humerus.
2. Early mobilization was necessary for every patient with polytrauma.
3. Non-unions following failed plate osteosynthesis.
4. Compound grade 1& 2 fractures.
5. Stress fractures at the ends" of plate.

Procedure :

The patient received either a general anaesthesia or scalene block and was positioned supine with the head turned contralaterally, allowing increased shoulder exposure.Proper surgical preparation and draping were performed, followed by a small incision over the acromion to access the greater tuberosity.The nail has been introduced directly into the humerus entry point and advanced to the fracture site. Manipulation ensured proper positioning, confirmed by an image intensifier. Distal locking was achieved with a parallel nail, while proximal locking was facilitated using a guide jig. The stability of fracture has been assessed by internal as well as "external rotation.In cases of radial nerve palsy, slight opening at the site" of fracture has been performed for nerve exploration.Following irrigation and closure, the patient was provided with a sling postoperatively and scheduled for follow-up visits.

Follow up:
First, follow up - 2 weeks post-surgery: Active shoulder and elbow movements were encouraged, and stitches were removed.
Second follow-up - 4 weeks later: To examine the union, X-ray of check was taken, and the movements of the shoulder and elbow were evaluated. The Constant-Murley Score and the American Shoulder and Elbow Surgeons (ASES) rating system have been utilized to evaluate functionality.

Continuous data collection is done using IBM SPSS version 22.0. Mean +/- SD is used to express variables, whereas percentages and numbers are used to express categorical variables. P values below 0.05 have been found as statistically significant.

Results :
In our series of 30 treated cases, the age range spanned from 18 to 60yrs, with the most common age group impacted being 21-30yrs. A predominance of males, constituting 56% of the cases, was observed in this study.

The chief cause of fractures, accounting for 70% of cases, was road traffic accidents, followed by falls from a height of 20%. Fractures were more prevalent on the right side, representing 53.33% of cases. Among the fractures, the majority (73.33%) fractures in the upper 3rd (16.66%) of the humeral shaft occurred after those that happened in the middle 1/3 of the shaft. Patients in odd numbers underwent plating and even numbers underwent interlocking nailing procedures respectively. (Table 1)
The total number of patients who underwent the interlocking nailing procedure - 15 patients.
The majority of patients, comprising 80%, achieved union in less than 16 weeks, with 53% of patients experiencing union in under 10 weeks. On average, the time taken for union was 10.5 weeks. Among those patients who achieved union after 16 weeks, three cases had experienced failed plating with subsequent implant back out. These cases underwent revision surgery involving reamed antegrade interlocking nailing accompanied by bone grafting. One patient achieved union at 18 weeks (a 51-year-old female), while the second patient achieved union at 20 weeks (a 31-year-old male). (Table 2). Total number of patients who underwent the Plating procedure - 15 patients.
Most patients, constituting 70%, attained union within a timeframe of less than 20 weeks, with 46% achieving union in less than 10 weeks. On average, the time for union among all patients was 14 weeks. (Table 3)
From the data provided, it's evident that in cases treated with interlocking nailing, around 66% of patients achieved excellent upper limb functional status at the treatment end, as indicated by ASES scores ranging from 47 to 52. Only 6% had ASES scores between 36 and 41, suggesting fair functional status of the upper limbs.
In contrast, for patients treated with plating, 86% attained ASES scores between 47 and 52, signifying excellent upper limb function. Only 13% had ASES scores ranging from 42 to 46, still indicating good functional status of the upper limbs. This 13% primarily consisted of patients with comminuted fractures who were managed with an external splint and cases of nonunion previously treated with a functional cast until radiological evidence of union was observed. (Table 4)
Based on the observations, it's apparent that intramedullary nailing presents certain notable complications. In 20% of instances, there was evidence of stiff shoulders, while delayed union occurred in 6%. Notably, no instances of non-union were reported. Despite the utilization of intramedullary nailing in grade 2 compound fractures, no cases of deep-seated infection were noted. Additionally, no occurrences of iatrogenic radial nerve palsy were recorded.
In contrast, plating exhibited infection as the most significant complication, affecting 20% of cases. Delayed union and nonunion followed closely, each observed in 6% of cases. Additionally, 6% of cases experienced iatrogenic radial nerve palsy. Follow up period at first is 2 weeks post-surgery: Stitch removal is performed, and shoulder and elbow mobilisation is recommended. Second, follow up at 6 weeks post-surgery. Further all the follow up was carried on every month basis and assessed with radiological and functional results upto 1 year.

Discussion:

The primary objective of our research is to measure the outcomes of interlocking nailing and plating in treating closed fractures of the humeral shaft. In our discussion, we compare the union rates, final functional recovery, early return to pre-fracture status, as well as complications associated with each method.
Plate osteosynthesis has been employed for treating oblique fractures and closed transverse of the humeral shaft, particularly those with minimal comminution. For closed comminuted fractures of the humeral shaft, pathological fractures, or the cases of nonunion following plate osteosynthesis, we utilized the Russell Taylor humeral interlocking nail.

The Netherlands' Crolla and De Vries [8] reported in 1993 on 46 patients treated “with interlocking humeral nails; of them, 27 had acute fractures and the remaining cases had nonunions. In 16 weeks, every case recovered, and 93% of them had outstanding to good functional outcomes, with 7% showing satisfactory results. Among the nonunion cases, three required subsequent bone grafting, while the remainder united with the intramedullary nailing”.

Similarly, in 1993, UCLA, USA's R.S. Watanbe [9] reported that of 22 patients, 91% had satisfactory to outstanding outcomes with the application of interlocking humerus nails. Watanbe [6] advocated for antegrade interlocking nailing over the routine usage of compression plates as well as screws due to surgical time and

minimal incision, as well as the avoidance of exposing the fracture site unless there was radial nerve involvement. He highlighted internal fixation and closed reduction as the ideal treatment for fractures of humeral shaft.

Three instances of humeral shaft fractures arising at the tip of previously placed interlocking nails for acute fractures were described by McKee et al [10] from the University of Toronto in 1996. These fractures happened via the distal interlocking screw following the application of rotational force to the arm.

A cadaveric study was carried out in 1996 by Rupf and Chrissos [11] of Ohio Medical College in the United States to assess the neurovascular injury risk associated with distal locking screws in humeral locking nails. They observed that lateral-to-medial screw placement posed a risk to the radial nerve, while over-penetration of medial cortex posed risks to the ulnar nerve, median nerve, and brachial artery. Anterior-posterior screw placement was found to pose a risk to the musculocutaneous nerve

In May 1998, Romans et al [12]. revealed a study on 48 fractures that were given retrograde interlocking nailing treatment. They documented three occurrences of iatrogenic comminution at the fracture site and one incidence of iatrogenic radial nerve palsy. An average of 13.7 weeks were needed for fracture consolidation, and in 87% of cases, elbow and shoulder function was excellent.

Flinkkil et al.[13] from Finland's Oulu University Hospital conducted research on 43 patients who received Russell Taylor nail treatment. They decided that antegrade nailing carries a high risk of shoulder function impairment and nonunion. Therefore, they suggested it as the main course of treatment only in cases when non-operative treatment is expected to be ineffective.

In our study conducted at Saveetha Medical College, involving Thirty instances (four lost to follow-up visits) of humeral shaft fractures were treated; fifteen patients received stabilization with DCP plates, and fifteen patients had stabilization with Russell Taylor's interlocking nail. This study's results are analyzed here.

In this study, the majority of patients fell within the 2nd and 3rd decades of life, making it the most commonly affected age group. The age range spanned from 18 to 60 years. This demographic profile is comparable to that of Lal et al., whose series also showed a majority (55%) of patients in the 20 to 40-year age range, with a mean age of 39.6yrs.
The significance of this group of age lies in the fact that it represents the prime earning period in an individual's life. Early mobilisation of these patients allows them to regain full motion range quickly, minimizing loss of productivity.

The male predominance of 56% observed in this series may be elucidated by the fact that the majority of traumas resulted from motor vehicular accidents and falls from heights, activities in which males are more frequently involved. Additionally, it was noted that the right side 3.33% of the humerus was more commonly affected, a finding consistent with the study by Lin [14]. This right-sided involvement could be accidental or the result of right-sided dominance.
As far as the etiology of fractures goes, the majority (70%) have been caused by the traffic accidents, with falls from a height coming in second (20%), in line with findings from previously published studies.
Of the cases in the series by Flinkkila et al. [15], 4% needed further investigation and 8% had primary radial nerve palsy. Four cases (21%) with preoperative radial nerve palsy were reported by Lin; all but one of the cases resolved within one to nine months following fixation, and the one that remained revealed a laceration upon investigation. Ingmanns' series reported preoperative nerve palsy in 15% of cases.
3 patients (6.25%) in our series had radial nerve palsy at initial presentation; two of those cases resolved in less than four months, while one case persisted.
As a outcomes, the incidence of radial nerve palsy found in this research is similar to that found in other studies. According to Holstein and Levis (1996), radial nerve palsy results from oblique fractures of the distal part of the humerus caused by a distal bone fragment displaced spike. They noted that “the nerve is least mobile in this

location where it pierces the lateral intermuscular septum. In order to minimize further damage to the nerve, they therefore strongly advised against manipulation in this fracture pattern as well as favor of internal fixation in conjunction with nerve exploration.
In this series, the majority of fractures (80%) achieved union in less than 16 weeks, with an average time to union of 10.5weeks. Notably, no cases of non-union were observed. These results are consistent with those reported by LMPH Crolla et al. and Lal et al. In Lal et al.'s study, 100% union was observed at 16 weeks. In the interlocked series, it was observed in three patients (5%). This resulted from a related dislocation and stiffness of the shoulder that was closed off. Shoulder stiffness has been reported in 20% of cases, though delayed union occurred in 6%. In the current series, only one patient (6%) had iatrogenic radial nerve palsy in the plating group; there were no" occurrences of iatrogenic radial nerve palsy at interlocking nailing group. [16-20]

When interlocking intramedullary nailing humeral shaft fractures, appropriate precautions must be taken to prevent problems such as damage to the axillary nerve. The optimal position for the nail is 5 mm below the entry point, according to the Wheeless Online Textbook of Orthopaedics. If the nail is countersunk more than 1cm below the articular surface, the proximal interlocking screw may reach the axillary nerve level, posing a risk of nerve injury. Therefore, it is essential to ensure that the proximal locking screw remains above the surgical neck of the humerus to prevent this type of complication.[21-23]

It's noteworthy that this complication has not been observed in the plating series, as plating typically involves a different surgical approach and technique compared to interlocking intramedullary nailing.

Conclusion :
Internal fixation using various fixation devices enables early mobilization and facilitates good functional outcomes. Surgical treatment outcomes with dynamic compression plates and interlocking nails were largely comparable, although each approach had its own drawbacks such as varying union time, distraction, nerve injury, shoulder Stiffness, and infection. The selection of the implant relies on factors like indications, patient preference, and the surgeon's choice. In well-evaluated patients with clear indications, either plating or nailing for internal fixation of these fractures could be considered optimal management. Both methods have their advantages and disadvantages.

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Table 1 :

S.NO	Age	Sex	Side	Mode of injury	ANATOMICAL LEVEL	Plating	Nailing
1	37	M	RIGHT	RTA	Middle 1/3rd	+	
2	44	F	LEFT	RTA	Middle 1/3rd		+
3	28	M	LEFT	FALL FROM HEIGHT	Middle 1/3rd	+	
4	41	F	RIGHT	RTA	upper 1/3rd		+
5	59	M	LEFT	RTA	Middle 1/3rd	+	
6	41	M	LEFT	FALL FROM HEIGHT	Middle 1/3rd		+
7	55	F	RIGHT	ASSAULT	upper 1/3rd	+	
8	26	M	RIGHT	RTA	Middle 1/3rd		+
9	31	F	RIGHT	RTA	Middle 1/3rd	+	

S.NO	Age	Sex	Side	Mode of injury	ANATOMICAL LEVEL	Plating	Nailing
10	18	M	LEFT	FALL FROM HEIGHT	Middle 1/3rd		+
11	29	F	RIGHT	RTA	mid 1/3 low 1/3	+	
12	29	M	LEFT	RTA	Middle 1/3rd		+
13	28	M	LEFT	RTA	Middle 1/3rd	+	
14	31	M	RIGHT	RTA	Middle 1/3rd		+
15	38	F	RIGHT	RTA	Middle 1/3rd	+	
16	22	M	LEFT	RTA	mid 1/3 low 1/3		+
17	44	F	RIGHT	RTA	Middle 1/3rd	+	
18	48	M	LEFT	FALL FROM HEIGHT	Middle 1/3rd		+
19	60	M	RIGHT	RTA	Middle 1/3rd	+	
20	28	F	RIGHT	RTA	upper 1/3rd		+
21	49	F	LEFT	ASSAULT	Middle 1/3rd	+	
22	44	M	RIGHT	RTA	Middle 1/3rd		+
23	55	M	LEFT	RTA	mid 1/3 low 1/3	+	
24	33	F	LEFT	FALL FROM HEIGHT	Middle 1/3rd		+
25	58	M	RIGHT	RTA	Middle 1/3rd	+	
26	34	F	RIGHT	RTA	upper 1/3rd		+

S.NO	Age	Sex	Side	Mode of injury	ANATOMICAL LEVEL	Plating	Nailing
27	59	M	LEFT	FALL FROM HEIGHT	Middle 1/3rd	+	
28	51	F	RIGHT	RTA	Middle 1/3rd		+
29	42	M	LEFT	RTA	upper 1/3rd	+	
30	49	F	RIGHT	RTA	Middle 1/3rd		+

Table 2 : Time Taken for union in interlocking nailing

Time in weeks	No.of patients	Percentage
<10 weeks	8	53%
10- 16 weeks	4	26%
16-24 weeks	3	20%
24-30 weeks	-	
30-36 weeks	-	

Table 3 :Time Taken for union in Plating

Time in weeks	No.of patients	Percentage
<10 weeks	7	46%
10- 16 weeks	4	26%
16-24 weeks	3	20%
24-30 weeks	1	6%
30-36 weeks	-	

Table 4 : Functional assessment of whole upper limbs function

ASES score	No.of Interlocking nail Patients	Percentage	No.of Plating patients	Percentage
42-52	10	66%	13	86%

ASES score	No.of Interlocking nail Patients	Percentage	No.of Plating patients	Percentage
42-46	4	26%	2	13%
36-41	1	6%	-	
31-35	-	-	-	
>30	-	-	-	

Table 5 : Complications

Complications encountered	Interlocking nail (%)	Plating (%)
1. Infection	0 (0%)	3 (20%)
2. Delayed union	1 (6%)	1 (6%)
3. Non-union	0 (0%)	1 (6%)
4. Iatrogenic Radial nerve	0 (0%)	1 (6%)
5. Shoulder stiffness	3 (20%)	1 (6%)