Section: Orthopaedics

Original Research Article

ROLE OF THIRD FRAGMENT IN FEMUR SHAFT FRACTURE TREATED WITH IMIL – A COMPARATIVE STUDY

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Received : *05/01/2024*
Received in revised form : *03/02/2024*
Accepted : *29/02/2024*

Keywords:
Femur shaft fracture, Third fragment in femur shaft fracture, Closed Reduction, IMIL.

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DOI: 10.47009/jamp.2024.6.2.18

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2024; 6 (2); 89-94

Abstract

Background: Among the orthopaedic high-energy injuries, femur-shaft fractures are common in clinical fields. Intramedullary nails have been the treatment of choice for femur-shaft fractures in adults. The role of the third fragment size, fragment ratio and degree of displacement on the healing time of femoral shaft fractures was assessed. Care should be taken to avoid an excessive displacement of the third fragment during the intramedullary nail implantation in femur shaft fracture with third fragment. **Objectives:** The purpose of this study was to evaluate the radiologic outcomes after antegrade nailing in femur shaft fractures with and without third fragment. To study the impact of fragment size, ratio and displacement of third fragment on union time and rate. To assess the complications associated with third fragment in femur shaft fracture. **Materials and Methods:** Retrospective analyses were conducted for the 50 cases of the 112 femoral shaft fracture patients who underwent closed reduction and Intra Medullary nail fixation. 50 patients were divided in following groups – Group A - 16 patients had femur shaft fracture without third fragment, Group B.1 - 13 patients had femur shaft fracture with third fragment size less than 4cm, Group B.2 - 9 patients had femur shaft fracture with third fragment size 4cm to less than 8cm, Group B.3 - 12 patients had femur shaft fracture with third fragment size 8 or more than 8cm. Radiographic assessment was done during follow up at 3month, 6month, 9month and 1year. Assessment of third fragment size, fragment ratio and fragment displacement were done. Union assessment was done using modified Radiographic Union Score. Union time, union rate and complications were compared among the groups. **Result:** The mean patient age was 30.52years (range: 18–55 years), of which 6 patients were female and 44 were male. 33 patients had right-side fractures, and 17 patients had left-side fractures, majority of patients had femur shaft fracture following Road Traffic Accident. The mean fragment size of Group B.1, 10.84mm; Group B.2, 53.11mm; Group B.3, 92.33mm. Group A was scored at 7.93, 11.68, 15.62 and 16 at 3, 6,9 and 12 months, respectively; Group B.1 was scored at 7.08, 9.50,11.91 and 14.67 at 3,6, 9, and 12 months, respectively; Group B.2 was scored at 7, 9.5, 11.9 and 12.8 at 3, 6, 9 and 12 months, respectively and Group B.3 was scored at 4.83, 5, 6.58 and 9.75 at 3, 6, 9, and 12 months, respectively. Non-union developed significantly more frequently with fragments 8 cm or. **Conclusion:** Third fragment size and displacement of the third fragment significantly contributed to delayed union and non-union. The degree of fragment displacement has a greater effect on bone union than does fragment size.

INTRODUCTION

Among the orthopaedic high-energy injuries, femur-shaft fractures are common in clinical fields. Intramedullary nails have been the treatment of choice for acute femur-shaft fractures in adults. However, femur shaft fractures may have various characteristics that depend on the location of fracture, degree of bony comminution, and injured muscle envelopes.[1]

Along with the technological advancement of the implants and surgical techniques, the methods of IMN fixation have also developed, including antegrade and retrograde entry point, reamed and un-reamed nail, static and dynamic locked nail.[2]

Intramedullary nailing can be done by both open and closed method. Closed reduction with intramedullary nailing is currently the most used technique in the management of femoral shaft fractures, since it is associated to low non-union, delayed union, and infection rates and to a better functional outcome.[3]

According to the Winquist–Hansen classification: type 0: no third fragment between the fracture ends; type I: third fragment less than 25% of the femoral diameter; type II: third fragment greater than 25% and less than 50% of the femoral diameter; type III: third fragment greater than 50% of the femoral diameter; type IV: comminuted fracture between the femoral fracture ends.[4]

Femoral shaft fractures with third fragments, classified as 32-B fracture type according to the Arbeitsgemeinschaft für Osteosynthesefragen / Orthopaedic Trauma Association classification system (AO/OTA 32-B), account for 10–34% of all femoral shaft fractures. This injury pattern shows a high non-union rate which may reach 14%, since the presence of a third fragment makes the anatomical reduction of the fracture challenging, thus interfering with the bone healing.[5]

The role of the displacement degree on the healing time of femoral shaft fractures with third fragments was also observed thus, care should be taken to avoid an excessive displacement of the third fragment during the intramedullary nail implantation.[6]

The purpose of this study was to evaluate the radiologic outcomes after antegrade nailing in femur shaft fractures with or without third fragment. We hypothesized that third fragment in femur shaft fracture could not have an effect for the union of femur-shaft fractures.

MATERIALS AND METHODS

Patient Characteristics

Retrospective analyses were conducted for the 50 cases of the 112 femoral shaft fracture patients who underwent surgery. 15 cases of femur shaft fracture without third fragment (AO-32-A) and 35 cases of femur shaft fracture with third fragment (AO-32-B) were included. A femoral shaft fracture was defined as a fracture in the area beginning 5 cm distal to the lesser trochanter and ranging to 5 cm proximal to the adductor tubercle. Inclusion criteria were (1) radiographic examination confirmed a femoral shaft fracture with or without third fragment with clear surgical indications; (2) the time from injury to operation was less than 3 weeks; (3) closed femur injury, excluding vascular and neurological injuries; (4) no obvious surgical contraindications such as cardiorespiratory dysfunction; (5) no preoperative cognitive impairment that could affect postoperative follow-up. Exclusion criteria were (1) complicated with femoral neck or condyle fracture of the ipsilateral limb; (2) polytrauma and head injury; (3) patients with incomplete follow-up data or uncooperative treatment; (4) pathological fracture;

Surgical Technique

The surgery was done usually under spinal or general anaesthesia. Later patient was put on traction table in supine position.

Reduction of the fracture under C-arm guidance, this is achieved after giving traction to affected limb in line with the body. In few cases reduction couldn't be achieved even after giving traction, in these cases manual reduction was done under C-arm guidance. The skin incisions run in line with the femoral shaft. The correct point of entry is the most important feature of the operative procedure. Entry point was made in piriform fossa. After locating the entry point, it is checked under C-arm in both AP and lateral views. curved bone awl was used to make the entry point followed by insertion of guide wire. The bend in the reaming guide wire is essential for closed reduction. Then closed reduction with the help of assistant surgeon was done. The wire was pushed into the distal fragment. The tip should be in the center, otherwise it may cause varus or valgus deformity. Sequential reaming was done. The femur was progressively reamed to more than 1 mm of the selected nail. Exchange the reaming rod with guide rod by using Teflon sleeve. During nail insertion extra care was taken while crossing the fracture site to prevent communition. Nail should be placed in the center. Locking of the nail was done with specially designed interlocking bolts. Proximal locking was done with the help of targeting device that attaches firmly to the proximal tip of the nail and distal locking was done with free hand technique with the help of C-arm. Wound wash, closure and sterile dressing was done and patient shifted to post-op ward.

Post-Operative follows up: ROM was initiated immediately after the surgery. Partial weight bearing training was conducted a week for six weeks after callus formation was observed upon completion of the non-weight-bearing ambulation exercise using crutches. Some patients underwent additional procedures like dynamization, bone marrow injection based on the progression of union. Radiographic assessment was done during follow up at 1.5month, 3month, 6month, 9month and 1year. Assessment was done using modified Radiographic Union Score (mRUS).

Statistical Analysis: Statistical analysis was performed by IBM SPSS 25.0 version software. Before applying parametric methods, the data was checked for normality. If there was significant deviation from normality or the data was ordinal, then non-parametric tests were used. The student's t-test was used for normally distributed data and the Mann-Whitney U test for ordinal data. The chi-squared test or Fisher's exact test were used for nominal data. All tests were two-sided. p-value of <0.05 was considered as statistically significant after assuming all the rules of statistical tests.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Assessment and Parameters: The fragment size was determined by measuring the length of its long axis using the larger measurement shown on anteroposterior or lateral view of plain radiographic images. The fragment ratio was defined as the ratio of the width of the fragment to the diameter of the femoral shaft at the point nearest to the fracture surface. Postoperative fragment displacement was determined, Dpro refers to the distance from the proximal end of the fragment to intact cortex; Ddis represents the distance of the distal end of the fragment to intact cortex; and Ds indicates the diameter of the femoral shaft at the point nearest the fracture site.[9]

The primary outcomes were union time and union rate. "Union" was defined as a modified Radiographic Union Scale (mRUST) score > =13 within 24 months postoperatively. Union time was defined as the period between surgery completion and the last outpatient clinic visit in which radiographic union was noted. Union rate was defined as the percentage of patients in a group achieving union of fracture during follow-up. Union of fracture was defined as achieving bone continuity in more than or equal to three of four cortexes in the anterior–posterior and lateral views of plain radiographic images.[7]

In contrast, "non-union" was defined as an mRUST score < 13, or the need for any revision procedure, including nail exchange, plate augmentation, or bone grafting within 24 months postoperatively or no evidence of radiographic union at the last follow-up.[8]

RESULTS

Demographics and fracture classification

A total of 50 patients were included in the study, of which 6 patients were female and 44 were male. The mean patient age was 30.52years (range: 18–55 years). Of the 50 patients, 33 patients had right-side fractures, and 17 patients had left-side fractures. 50 patients were divided in following groups – Group A - 16 patients had femur shaft fracture without third fragment, Group B.1 - 13 patients had femur shaft fracture with third fragment size <4cm, Group B.2 - 9 patients had femur shaft fracture with third fragment size >4cm - < 8cm, Group B.3 - 12 patients had femur shaft fracture with third fragment size > 8cm. Majority of patients had femur shaft fracture following Road Traffic Accident. There were no significant differences in age, gender, fracture side and mechanism of injury between the groups.

Union rate according to fracture fragment size

Fractures were distributed by size into different groups as follows: Group A – 16 fractures, Group B.1-13 fractures; Group B.2, 9 fractures; Group B.3, 12 fractures. The mean fragment size of Group B.1, 10.84mm; Group B.2, 53.11mm; Group B.3, 92.33mm. The mean displacement in the proximal fracture area in Group B.1 was 5.16 ± 2.65 mm; Group B.2, 5.80 ± 3.19 mm; Group B.3, 5.72 ± 3.43 mm. The mean displacement in the distal fracture area in Group B.1 was 4.91 ± 2.77 mm; Group B.2, 5.50 ± 3.51 mm; Group B.3, 6.08 ± 3.87 mm.

Figure 1: Group A (femur shaft fracture without third fragment)

Figure 2: Group B.1(third fragment size <4cm)

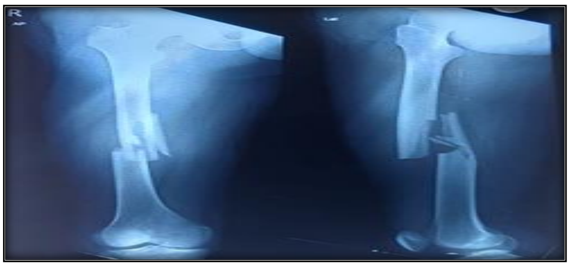

Figure 3: Group B.2 (third fragment size 4-8cm)

Figure 4: Group B.3 (third fragment size >8cm)

Figure 5: Post operative x-ray of Group B.1

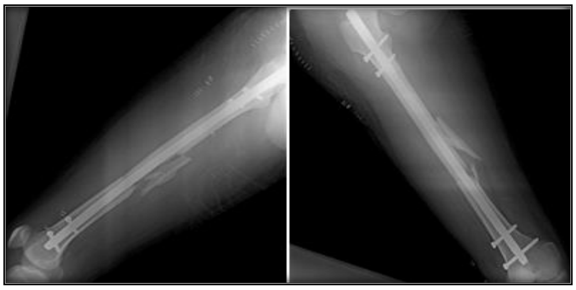

Figure 6: Post operative x-ray of Group B.2

Figure 7: Post operative x-ray of Group B.3

Figure 8: mRUSF score 12

mRUST scoring system and union rate

Group A was scored at 7.93, 11.68, 15.62 and 16 at 3, 6,9 and 12 months, respectively; Group B.1 was scored at 7.08, 9.50,11.91 and 14.67 at 3,6, 9, and 12 months, respectively; Group B.2 was scored at 7, 9.5, 11.9 and 12.8 at 3, 6, 9 and 12 months, respectively and Group B.3 was scored at 4.83, 5, 6.58 and 9.75 at 3, 6, 9, and 12 months, respectively. The final fracture union rates post-surgery for Group A, B.1, B.2, B.3 was 100%, 100%, 88.8%, and 83.33 %, respectively, with a mean union time in Group A, B.1, B.2 and B.3 is 7.31 ± 1.54 months, 9.75 ± 1.35 months, 11.67 ± 1.00 months, 13.70 ± 1.34 months respectively.

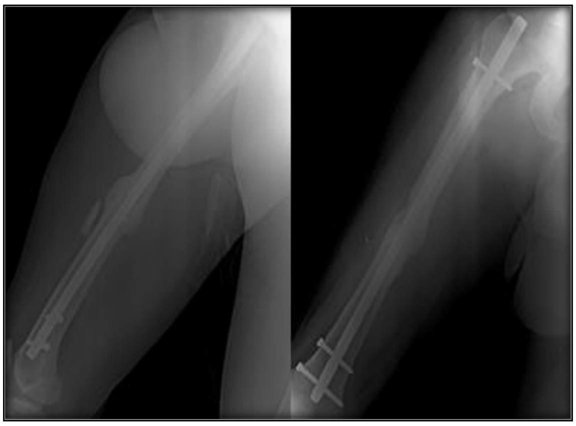

Figure 9: mRUSF score 14

Figure 10: mRUSF score 16

Table 1: Comparison of demographical profiles with grades fragment length

Variables	Categories	Grades of fragment length				P-value and Significance
		A (N=16)	B1 (N=13)	B2 (N=9)	B3 (N=12)	
Age	Mean ± SD	30.18 ± 9.71	33.25 ± 10.8	31.70 ± 7.31	27.25 ± 5.51	P = 0.393, NS
Gender	Males- N (%)	14 (87.5%)	11 (84.6%)	9 (100.0%)	10 (83.3%)	P = 0.655, NS
	Females- N (%)	2 (12.5%)	2 (15.4%)	0 (0.0%)	2 (16.7%)	
Side	Right – N (%)	12 (75.0%)	7 (53.8%)	6 (66.7%)	8 (66.7%)	P = 0.697, NS
	Left - N (%)	4 (25.0%)	6 (46.2%)	3 (33.3%)	4 (33.3%)	
Cause of injury	RTA -N (%)	12 (75.0%)	11 (84.6%)	8 (88.9%)	10 (83.2%)	P = 0.428, NS
	Fall- N (%)	4 (25.0%)	2 (15.4%)	0 (0.0%)	1 (8.4%)	
	Others – N (%)	0 (0.0%)	0 (0.0%)	1 (11.1%)	1 (8.4%)	

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 2: Comparison of variables with grades of fragment length				
Variables	**Grades fragment length**			
	A (N=16)	**B1 (N=13)**	**B2 (N=9)**	**B3 (N=12)**
Fragment ratio	0.00 ± 0.00	0.19 ± 0.13	0.31 ± 0.23	0.38 ± 0.15
Proximal fragment displacement (mm)	0.00 ± 0.00	5.16 ± 2.65	5.80 ± 3.19	5.72 ± 3.43
Distal fragment displacement (mm)	0.00 ± 0.00	4.91 ± 2.77	5.50 ± 3.51	6.08 ± 3.87
Union Time	7.31 ± 1.54	9.75 ± 1.35	11.67 ± 1.00	13.70 ± 1.34

Table 3: Comparison of m RUST with grades of fragment length

m RUST	**Grades of fragment length**				**ANOVA test P-value and Significance**
	A (N=16)	**B1 (N=13)**	**B2 (N=9)**	**B3 (N=12)**	
m RUST 1 (3 month) (Mean ± SD)	7.93 ± 0.93	7.08 ± 1.08	5.70 ± 1.05	4.83 ± 0.58	F = 29.721 P <0.05, S
m RUST 2 (6 month) (Mean ± SD)	11.68 ± 1.25	9.50 ± 1.31	7.00 ± 1.69	5.00 ± 0.03	F = 76.925 P < 0.05, S
m RUST 3 (9 month) (Mean ± SD)	15.62 ± 1.50	11.91 ± 1.44	9.60 ± 2.06	6.58 ± 0.51	F = 93.821 P < 0.05, S
m RUST 4 (12 month) (Mean ± SD)	15.81 ± 0.75	14.67 ± 0.88	12.80 ± 1.68	9.75 ± 0.86	F = 82.912 P < 0.05, S

Table 4: Comparison of m RUST with Winquist and Hansen's classification

m RUST	**Winquist and Hansen's classification**			
	0	**1**	**2**	**3**
m RUST 1 (3 month)	7.93 ± 0.93	6.90 ± 1.28	5.60 ± 1.24	5.22 ± 0.83
m RUST 2 (6 month)	11.68 ± 1.25	9.10 ± 1.72	6.73 ± 2.28	5.78 ± 1.09
m RUST 3 (9 month)	15.62 ± 1.50	11.70 ± 1.94	8.80 ± 2.59	7.67 ± 1.65
m RUST 4 (12 month)	15.81 ± 0.75	14.60 ± 1.26	12.00 ± 2.20	10.56 ± 1.81

Table 5: Comparison of fragment ratio with union and non-union cases

Variables	**Number of cases**	**Fragment Ratio**	**t-test value and P-value**
	No (%)	**Mean ± SD**	
Union	47 (94.0%)	0.18 ± 0.20	t = 2.063, P =0.045 S
Non-Union	3 (6.0%)	0.43 ± 0.06	
Total	50 (100.0%)	0.20 ± 0.21	-----

DISCUSSION

The management of fracture shaft femur continues to pose vexing problems for orthopaedic surgeons even in the 21st century. Fracture shaft femur is at an increased incidence the present, due to high-speed transportation and rapid industrial development. In the past 25 years, internal fixation of femoral shaft fractures has gained widespread acceptance as the surgical techniques and implants have steadily improved.

We conducted retrospective analyses of 50 patients who underwent IMN of femoral shaft fractures with and without third fragments. Fractures with fragments 8 cm or longer in length and fractures with fragments with 10 mm or greater displacement may have more negative outcomes when intramedullary nailing is performed without additional fixation for displaced or/and larger fragments. The presence of fracture fragments may yield conditions unfavourable to bone union due to diastasis of large fracture fragments, trapped soft tissues, and insufficient axial load. Moreover, the increased space between fracture fragments means that movements among the fracture fragments also increase after intramedullary fixation, due to the small degree of cortical contact. These movements inhibit callus formation and eventually increase the risk of non-union. For these same reasons, the incidence of non-union is increased when fracture fragments are inverted or perpendicularly crossed.

The precise conditions under which additional procedures, such as intramedullary nailing with bone graft, circumferential wiring, and nailing are required to decrease the non-union incidence in fractures with fragments have not yet been clearly defined. Moreover, these additional procedures carry an extra risk of open reduction. According to this study, the group with the longest femoral shaft fracture fragments showed higher time required for union. Thus, the incidence of non-union was higher when fragments were longer and had needed revision surgeries.

The average age in the present series was found to be 30.52 years. In the study, most of the patients were males; male to female ratio was 7.5:1 the higher percentage of males than females reflect the fact that under Indian circumstances males were more exposed to trauma. In the study, the involvement of the right side was more than the left side in the order of 70 percent, which is in well accordance with Donald Wiss series.[10]

The commonest mode of injury in our series is that by road traffic accident (82%) followed by fall from heights (14%) and others (4%). This series is well in accordance with Johnson series.[11]

In a study by Yuan-Hsin Tsai, MD et.al,[6] the non-union rate was 5.6% (2/36) in patients with a

ISSN (O): 2687-5365; ISSN (P): 2753-6556

fragment size ≤5.4 cm, compared with 37.5% (9/24) in patients with a fragment size >5.4 cm. The non-union rate was significantly higher in patients with a fragment size >5.4 cm (p = 0.004). These findings were similar to our study Group B.2 and B.3 had 11.2% and 16.67% respectively.

Lee et. Al,[12] reported that non-union developed significantly more frequently with fragments 8 cm or longer or when the displacement was 20 mm or more in the proximal area and 10 mm or more in the distal area. We agreed with their perception that the degree of displacement has more influence on the union rate than the third fragment size. It was suggested that reduction of the third fragment is important.

According to Shuo Yang et.al,[13] as per Winquist and Hansen's classification grade I displacement was scored at 9.0, 11.1, and 12.7 at 6, 9, and 12 months, respectively; grade II displacement was scored at 6.8, 8.3, and 9.4 at 6, 9, and 12 months, respectively; grade III displacement was scored at 4.8, 6.1, and 8.9 at 6, 9, and 12 months, respectively. Results were comparable to our study.

CONCLUSION

We retrospectively evaluated the clinical outcomes of IMN of femoral shaft fractures with third fragments and analysed the risk factors for delayed union. Third fragment size and displacement of the third fragment significantly contributed to delayed union and non-union. The degree of fragment displacement has a greater effect on bone union than does fragment size. In these cases, active treatment methods such as open reduction and internal fixation with a plate or wiring may be required during the initial surgery.

Limitations

This is a retrospective study and the relatively small case number for the under individual groups.

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ISSN (O): 2687-5365; ISSN (P): 2753-6556