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ORIGINAL ARTICLE

Functional Outcome of Intramedullary Nailing of the Femoral Shaft Fracture

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Abstract: **Introduction:** Fractures of the shaft of the femur are among the most common fractures encountered in orthopaedic practice. Most of the fracture occurs in young adult due to high velocity injury. It can be life threating due to open wound, fat embolism, ARDS or multiple organ failure.
Objective: To assess the functional outcome of intramedullary nailing of the femoral shaft fracture.
Methods: The study was a prospective observational study with analytical design was conducted in National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Sher-E-Bangla Nagar, Dhaka, Bangladesh from July 2017 to June 2019. As the study was conducted over a limited period of time, the sample size was adjusted to 50. Patients with closed transverse fracture shaft femur (AO type 32-A3) attending the Emergency and Out Patient Department (OPD) of National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Sher-E-Bangla Nagar, Dhaka, within the defined period were the study population.
Results: The mean age of the patients was 32.50±11.81 years where minimum age was 18 years and maximum age was 60 years. Above figure shows that, most of the patients (92.0%, n=46) were male and the rests (8.0%, n=4) were female. Majority of the patients (64.0%, n=32) had injury on right femur and rests (36.0%, n=18) had on left femur. Above table shows that half of the patients, 50.0% (n=25) had duration of injury of 8-14 days and 46.0% (n=23) had duration of injury of 15-21 days. The mean duration of injury of the patients was 13.90±4.68 days where minimum duration of injury was 5 days and maximum duration of injury was 21 days. Most of the patients (95.5%, n=42) had no postoperative infection and rests (4.5%, n=2) had postoperative infection. Eight patients (18.2%) had internal rotation of knee and 15 patients (34.1%) had external rotation of knee. Majority of the patients (64.1%) who did not have any associated injury had excellent outcome whereas one fifth of the patients (20.0%) who had any associated injury had excellent outcome. Fisher Exact test showed that there was significant association between treatment result and associated injury as p=0.036.
Conclusion: Femoral shaft fracture occurs mostly in a male in the active part (young adults) of their life with RTA being the most common etiology. The findings with low complications rate, high incidence of union, shorter hospital stay, early mobility, the excellent functional outcome in terms of alignment and range of motion

in the majority of patients makes this technique more reliable and method of choice for femoral shaft fracture in adults.

Keywords: Functional Outcome, Intramedullary Nailing, Femoral Shaft Fracture.

Introduction

Fractures of the shaft of the femur are among the most common fractures encountered in orthopaedic practice [1]. Most of the fracture occurs in young adult due to high velocity injury. It can be life threating due to open wound, fat embolism, ARDS or multiple organ failure [2]. Femoral nailing with reaming remains the gold standard for the treatment of isolated femoral fractures [3, 4]. Treatment of long bone fractures had changed dramatically after introduction of Intramedullary nails by Kuntscher around 1939 [5]. Intramedullary nailing may be antegrade or retrograde and may be static or dynamic locking [6]. The average annual incidence of femoral fractures range from 0.1 to 3% (up to 37 per 100000 patient-years), with a peak incidence in young adult males [7-11]. Among different mechanisms of injury, road traffic incidents are the most common cause of femoral shaft fractures in low and middle-income countries. These fractures are nearly 10% of all nonfatal traffic-related injuries [12]. It is one of the main load-bearing bones in the lower extremity, femoral shaft fractures are associated with considerable mortality and morbidity whether they are caused by highor low-energy trauma [13]. The treatment of femoral shaft fractures has evolved from the historical non-operative methods to the most recent methods of intramedullary nail fixation. Interlocking nails have greatly widened the indications for closed intramedullary nailing of femoral fractures. Early mobilization following fractures of the femoral shaft has a significant advantage in both joint mobility and economic impact [13]. The intramedullary fixation with a thick intramedullary nail of diaphyseal fractures of the femur gives a fixation stable enough for the extremity for weight-bearing, at least partially, before healing of the fracture has taken place. The most important aim in the treatment of fractures is to restore the function of the injured extremity to the maximum. This aim is achieved by active exercise, during the healing process, of as many joints and muscle groups as the fixation methods allow [14]. The technique of interlocking of bone and nails was developed to overcome the rotational and longitudinal malalignment of long bone fractures as in comminuted fractures, very proximal and distal fractures, long spiral fractures, and fractures with bone loss. Reduced rates of infection, nonunion, and malunion, shorter hospital stay, and rehabilitation periods are advantages of intramedullary interlocking nails over the conventional non-locking intramedullary nails [15]. In comparison to plate intramedullary nail, can withstand bending and torsional loads better than plates and the locking mechanism provides less tensile and shear stress than plates. The intramedullary interlocking nail is a load-sharing device but less loaded than plates causing less cortical osteopenia of stress shielding, which is a feature of the load-bearing plates [13]. The bending moment on a nail is less than that on a plate because the force is applied over a shorter distance. The load shared over the mechanical and anatomic axis is stronger for a nail than for a plate as an intramedullary device [16]. Intramedullary nailing of the femur has a satisfactory union rate and other advantages under stable biomechanical circumstances. Nowadays, closed reduction and internal fixation with an interlocking nail for fracture of the femoral shaft is accepted as a standard treatment. Its use has been extended to nearly all shaft fractures from the proximal to the distal femur [17]. It requires a small incision and minimum dissection, which gives excellent healing of the fracture and rapid recovery. Interlocking provides rotational stability and maintains length which favors an early return to full weight-bearing and union of the fracture [18]. It has allowed reliable, reproducible rates of union and mechanical stability which allows early mobilization and improved function [17]. Moreover, intramedullary interlocking nailing is the method of choice in the treatment of most acute femoral shaft fractures in

adults [19]. Therefore, the study was designed to evaluate the functional outcome of intramedullary nailing of femoral shaft fracture.

Materials and Methods

Study design: The study was a prospective observational study with analytical design.

Study period: The study was conducted from July 2017 to June 2019.

Study place: The study was conducted in National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Sher-E-Bangla Nagar, Dhaka.

Study population: Patients with closed transverse fracture shaft femur (AO type 32-A3) attending the Emergency and Out Patient Department (OPD) of National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Sher-E-Bangla Nagar, Dhaka, within the defined period were the study population.

Inclusion criteria

1. Closed transverse fracture shaft femur (AO type 32-A3)
2. Duration of injury up to 3 weeks
3. Patient's age 18 years to 60 years
4. Patients of both sex

Exclusion criteria

1. Open fracture
2. Pathological fracture
3. Bilateral fracture
4. Fracture at the lower third or neck of the femur
5. Pregnant woman
6. Patients who did not agree to participate in this study

Sample size: Statistically the following formula was used to calculate the sample size:

$n=z^2pq/d^2$

So the calculated sample size n=384.16

As the study was conducted over a limited period of time, the sample size was adjusted to 50.

Preoperative evaluation

The following investigations were done preoperatively:

- Blood test: Complete blood count, Random Blood Sugar (RBS), Serum Creatinine, HBsAg and Anti-HCV
- X-ray pelvis including both hip joint and proximal femur (A/P view)
- X-ray affected thigh with knee and hip (A/P and lateral view)
- X-ray chest (P/A view)
- Investigations for General Anesthesia fitness according to patient condition

The intramedullary nail

The intramedullary nail or rod is commonly used for long-bone fracture fixation and has become the standard treatment of most long-bone diaphyseal and selected metaphyseal fractures. These implants are introduced into the bone remote to the fracture site and share compressive, bending, and torsional loads with the surrounding osseous structures. Intramedullary nails function as internal splints that allow for secondary fracture healing. Like other metallic fracture fixation implants, a nail is subject to fatigue and can eventually break if bone healing does not occur. Intrinsic characteristics that affect nail biomechanics include its material properties, cross-sectional shape, anterior bow, and diameter. Extrinsic factors, such as reaming of the medullary canal, fracture stability (comminution), and the use and location of locking bolts also affect fixation biomechanics. Although reaming and the insertion of intramedullary nails can have early deleterious effects on endosteal and cortical blood flow, canal reaming appears to have several positive effects on the fracture site, such as increasing extraosseous circulation, which is important for bone healing. Expanding canal diameter with IM reamers enable placement of large nails in closed diaphyseal long bone fractures. Reamed IM nails indications have been recently expanded to include treatment of both open fractures and distal metaphyseal fractures once thought to be unsuitable for IM nails [20].

Figure 1: Cannulated intramedullary nail.

Operative technique (Open reduction)

Anaesthesia: Patient give spinal anaesthesia.

Positioning of patient: The patient was placed in lateral position on the fluorescent operating table.

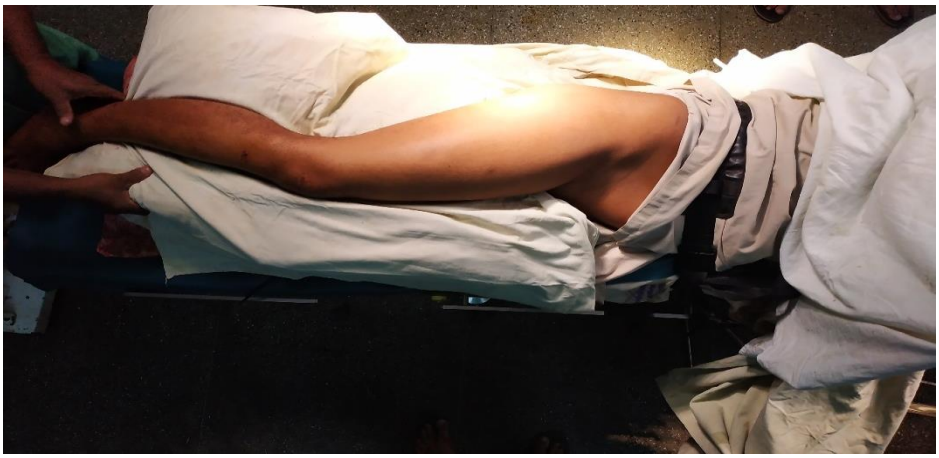

Figure 2: Positioning of patient.

Approach: Standard lateral approach to femur was used. Longitudinal lateral skin incision was given around the fracture site, tensor fascia lata was cut, vastus lateralis was split and the fracture site was exposed.

Figure 3: Longitudinal lateral skin incision.

Reaming: Fracture hematoma evacuated. 8mm manual reamer passed across the proximal fragment and then guide wire was passed and extracted through the gluteal region. Reaming of the proximal fragment was done over the guide wire with 1 mm increments. Followed by the reaming of the distal fragment.

Figure 4: Reaming.

Entry portal make: The entry portal for the nail was made in a retrograde fashion with a sharp reamer inserted from distal to proximal direction with the hip in flexion and adduction and incision given at the site of exit of the reamer proximal to the greater trochanter.

Figure 5: Incision at the site of exit of the reamer proximal to the greater trochanter.

Reduction of fracture: A guidewire was inserted from the entry portal upto just proximal to the fracture site. Both the fracture ends were held with bone holding clamps and approximated with angulation. Maintaining this position, reduction was done gradually allowing the soft tissues to stretch and guide wire was inserted into the distal fragment.

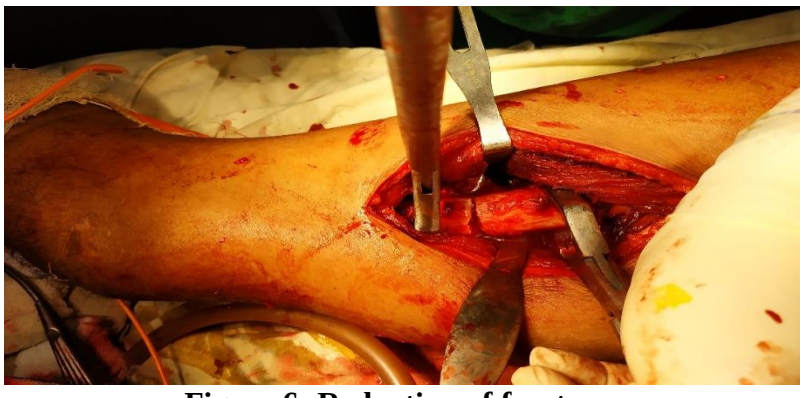

Figure 6: Reduction of fracture.

Insertion of nail: Interlocking nail of appropriate size was selected and inserted in antegrade direction with the help of zig. Alignment, rotation and axial stability were checked. Proximal locking was done with the help of zig and distal locking was done free hand with the help of image intensifier.

Figure 7: Insertion of nail.

Closure of the wound: Manipulation of the knee was done to obtain the range of motion. Haemostasis was achieved. Thorough lavage of the wound was done. Suction drain was kept in place and wound was closed back in layers. Antiseptic dressing was done and the patient was shifted out of the operation theatre.

Figure 8: Closure of the wound.

Close reduction: Patient Positioning: Supine poisoning to allow unencumbered access to the entire patient by the anesthesiologists, general surgeons, neurosurgeons, and other physicians involved with ongoing resuscitation and treatment. Rotational and angular deformities was also minimized with supine positioning.

Figure 9: Patient Positioning.

Reduction of fracture: Obtaining and maintaining a reduction of the femoral shaft could be difficult and was required during several key stages of femoral nailing. Large reduction levers were applied externally to assist with reduction of the femur. In addition, if needed a cannulated nail was used and placed it into the proximal segment after it has been prepared with an awl or reamers, thus allowing control of the proximal segment. This technique allows correction of both angular and rotational deformities simultaneously. Then accurate assessment of the length was easily obtained from fluoroscopic clues.

Entry point: Current nail designs allow for placement of antegrade intramedullary implants in the region of the greater trochanter. A trochanteric entry might be easier to identify given the improved access to the greater trochanter. With a trochanteric tip entry location, the medial femoral circumflex vessel and the hip joint capsule were not injured.

Incision: Incision was made proximal to the greater trochanter that allows placement of guide pin at the greater trochanter.

Figure 10: Identification of entry point and incision.

Postoperative follow up

All the patients were checked 6 hours after operation and following parameters were noted:

- Pulse
- Blood pressure
- Temperature
- Respiratory rate
- Condition of the dressing- dry or soaked

Outcome measure: Clinical and radiological outcome of the fracture fixation were assessed by assessing malalignment like varus/ valgus, rotation, antecurvatum/ recurvatum, shortening, pain and swelling.

Data analysis: The data collected from the patients were analyzed. After completion of data collection, the data were checked and edited manually and verified before tabulation. Data were coded, entered and analyzed in a computer. The statistical analysis was conducted using SPSS (statistical package for social science) version 25 statistical software. The findings of the study were presented by frequency, percentage in tables and graphs. Means and standard deviations for continuous variables and frequency distributions for categorical variables were used to describe the characteristics of the total sample. Associations of data were assessed using Fisher's Exact test. Here, $p<0.05$ was considered significant. Here, all p-values were two sided.

Results

Table 1: demographic characteristics of this patients (n=50)

Age (in years)	Frequency (n)	Percentage (%)
18-27	20	40.0
28-37	13	26.0
38-47	11	22.0

≥48	6	12.0
Mean ± SD	32.50±11.81	
Range (min-max)	18-60	
sex		
Male	46	92.0
Female	4	8.0
Comorbidity		
Absent	47	94.0
Diabetes mellitus	2	4.0
Hypertension	1	2.0
side involvement		
Right	32	64.0
Left	18	36.0
Duration (in days)		
Up to 7	2	4.0
8-14	25	50.0
15-21	23	46.0
Mean ± SD	13.90±4.68	
Range(min-max)	5-21	
Mechanism of injury		
RTA	39	78.0
Fall from height	11	22.0

Above table shows that among the patients, 40.0% (n=20) were from 18-27 years age group, 26.0% (n=13) were from 28-37 years age group, 22.0% (n=11) were from 38-47 years age group and 12.0% (n=6) were from ≥48 years age group. The mean age of the patients was 32.50±11.81 years where minimum age was 18 years and maximum age was 60 years. Above figure shows that, most of the patients (92.0%, n=46) were male and the rests (8.0%, n=4) were female. Above table shows that most of the patients (94.0%, n=47) did not have any co-morbidity. Few had Diabetes mellitus (4.0%, n=2) and Hypertension (2.0%, n=1). Majority of the patients (64.0%, n=32) had injury on right femur and rests (36.0%, n=18) had on left femur. Above table shows that half of the patients, 50.0% (n=25) had duration of injury of 8-14 days and 46.0% (n=23) had duration of injury of 15-21 days. The mean duration of injury of the patients was 13.90±4.68 days where minimum duration of injury was 5 days and maximum duration of injury was 21 days. Above table shows that 78.0% (n=39) patients had RTA and 22.0% (n=11) had a fall from height.

Table 2: Distribution of patients by associated injury (n=50)

Associated injury	Frequency (n)	Percentage (%)
Absent	44	88.0
Ipsilateral jones fracture	1	2.0
Contralateral dislocation of elbow	1	2.0
Ipsilateral fracture base of 4th metatarsal	1	2.0
Ipsilateral fracture patella	1	2.0
Contralateral open Fracture of 2^{nd}, 3^{rd} and 4^{th} metatarsal	1	2.0
Ipsilateral open Monteggia fracture dislocation	1	2.0

Above table shows that most of the patients (88.0%, n=44) had no associated injury. Others had ipsilateral jones fracture (2.0%, n=1), contralateral dislocation of elbow (2.0%, n=1), ipsilateral fracture base of 4th metatarsal (2.0%, n=1), ipsilateral fracture patella (2.0%, n=1), contralateral open

Fracture of 2nd, 3rd and 4th metatarsal (2.0%, n=1), and ipsilateral open Monteggia fracture dislocation (2.0%, n=1).

Table 3: Distribution of patients by type of reduction (n=50)

Type of reduction	Frequency (n)	Percentage (%)
Open	37	74.0
Closed	13	26.0

Above table shows that 74.0% (n=37) patients had open reduction and 26.0% (n=13) had a closed reduction.

Table 4: Distribution of patients by postoperative infection (n=44)

Postoperative infection	Frequency (n)	Percentage (%)
Absent	42	95.5
Present	2	4.5

Above table shows that, most of the patients (95.5%, n=42) had no postoperative infection and rests (4.5%, n=2) had postoperative infection.

Table 5: Distribution of patients by rotation of knee (n=44)

Rotation of knee	Frequency (n)	Percentage (%)
No rotation	21	47.7
Internal rotation		
Excellent (0^0 to 5^0)	6	13.6
Good (10^0)	1	2.3
Moderate (15^0)	1	2.3
Poor ($<15^0$)	0	0.0
External rotation		
Excellent (0^0 to 5^0)	9	20.4
Good (10^0)	3	6.8
Moderate (15^0)	2	4.5
Poor ($>15^0$)	1	2.3

Above table shows that, 47.7% (n=21) patients had no rotation. Eight patients (18.2%) had internal rotation of knee and 15 patients (34.1%) had external rotation of knee.

Table 6: Association between *treatment result* and associated injury (n=44)

Associated injury	Treatment results according to the Thoresen criteria				P value
	Excellent	Good	Moderate	Poor	
Absent	25(64.1%)	8 (20.5%)	6 (15.4%)	0 (0.0%)	0.036
Present	1(20.0%)	2 (40.0%)	1 (20.0%)	1 (20.0%)	

Above table reveals that majority of the patients (64.1%) who did not have any associated injury had excellent outcome whereas one fifth of the patients (20.0%) who had any associated injury had excellent outcome. Fisher Exact test showed that there was significant association between *treatment result* and associated injury as p=0.036.

Discussion

The present study showed that 40.0% patients were from 18-27 years age group, 26.0% were from 28-37 years age group, 22.0% were from 38-47 years age group and 12.0% (n=6) were from ≥48 years age group. The mean age of the patients was 32.50±11.81 years and most of the patients (92.0%) were male in the present study. There tends to be an

age- and gender-related bimodal distribution of fractures with injuries occurring most frequently in young males after high-energy trauma and in elderly females after falls from standing [22]. Other studies also found that younger patients were more affected than older ones and there were predominance of male patients Khalid et al; Jan et al; Demiroglu et al. [22,23,24]. Most of the patients (94.0%) did not have any comorbidity. Few had diabetes mellitus (4.0%) and hypertension (2.0%). Majority of the patients (64.0%) had injury on right femur and the mean duration of injury of the patients was 13.90±4.68 days. The mechanisms in young patients tend to be motor vehicle crashes, motorcycle crashes, pedestrians struck by vehicles, or falls from height [22]. Majority of the patients (78.0%) of the current study had RTA and 22.0% had a fall from height. This result was consistent with other studies Khalid et al; Jan et al and Demiroglu et al. [22,23,24]. Numerous associated injuries occured in conjunction with fractures of the femoral shaft and were more commonly observed in young patients after high-energy traumatic injuries [22]. Majority of the patients (88.0%) had no associated injury. Others had ipsilateral jones fracture (2.0%, n=1), contralateral dislocation of elbow (2.0%, n=1), ipsilateral fracture base of 4^{th} metatarsal (2.0%, n=1), ipsilateral fracture patella (2.0%, n=1), contralateral open Fracture of 2^{nd}, 3^{rd} and 4^{th} metatarsal (2.0%, n=1), and ipsilateral open Monteggia fracture dislocation (2.0%, n=1). Dynamization results in increased contact area at the fracture site, improved osteogenesis, and improved transmission of weight-bearing forces Gelalis et al. [25]. Within 6 months, most of the patients (86.4%) had radiographic union in ≥ 3 cortices. Six patients (13.6%) failed to progress to union by six months. In the current study, functional outcome was categorized as excellent, good, moderate and poor outcome. Patient was considered as having excellent outcome if patient had no to minimal mal-alignment (0^0-5^0), < 1 cm femoral shortness, no to minimal extension lag (0^0-5^0) and no pain. Patient was considered as having good outcome if patient had >5^0 -10^0 mal-alignment, 1.1-2 cm femoral shortness, extension lag >5^0-10^0 with mild pain. Patient was considered as having moderate outcome if patient had 15^0 -20^0 mal-alignment, 2.1-3 cm femoral shortness, extension lag 10^0 -15^0 with moderate pain. If patient had >20^0 mal-alignment, >3 cm femoral shortness, extension lag >15^0 with severe pain, it was considered as poor outcome Thoresen et al [26]. Majority of the patients (59.1%) had excellent outcome and near about one fifth of the patients (22.7%) had good outcome. However, 15.9% patients had moderate outcome and only one patient (2.3%) had poor outcome (had associated fracture patella). Significant association was found between *treatment result* and associated injury (p=0.036). Majority of the patients (64.1%) who did not have any associated injury had excellent outcome whereas one fifth of the patients (20.0%) who had any associated injury had excellent outcome. In the present study, no significant statistical difference was found between open reduction and closed reduction regarding functional outcome which was consistent with other studies Seetharamaiah et al; Kumar et al. [27, 28]. Closed interlocking nailing was an accepted modality of treatment for femoral shaft fractures. Open nailing was given up as high rates of infection and extensive surgery were noticed. But recently with the development of potent antibiotics, surgical asepsis and meticulous dissection, these fallacies could be overcome [27].

Conclusion

Femoral shaft fracture occurs mostly in a male in the active part (young adults) of their life with RTA being the most common etiology. The findings with low complications rate, high incidence of union, shorter hospital stay, early mobility, the excellent functional outcome in terms of alignment and range of motion in the majority of patients makes this technique more reliable and method of choice for femoral shaft fracture in adults. Additionally, load sharing property, internal splinting, and rotational stability are the main advantages of IMIL in femoral shaft fracture.

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