Original Article

Radiographic Spectrums of Adults with Traumatic Femoral Shaft Fracture in the South-West, Nigeria

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Abstract

Background
Femoral shaft fracture injuries are common in our environment. The weight-bearing function of the femur makes its damage important in the young and adult population, as it leads to prolonged immobilization and hospitalization, which may result in pulmonary embolism and even death.

Objectives
To determine the relationship between the mechanism of injury and the patterns of fractures on the plain radiographs of adults with femoral shaft fractures.

Methods
A cross-sectional study of 390 adults with 402 femoral shaft fractures at three tertiary hospitals' Surgical Emergency and Orthopedics units was carried out over one year using plain radiographs. The demographics, fracture etiology, fracture site, and associated injuries were evaluated. Data were analyzed using the IBM SPSS Statistics for Windows version 23.0 (IBM Corp, Armonk, NY, USA)

Results
The mean age was 40.93 (SD=16.3) years. Road traffic accidents (82.8%) were the commonest etiology, while mid-shaft fracture (52.2%) and comminuted fractures (36.3%) were the most common fracture sites and fracture patterns, respectively. Soft tissue injuries were commonly associated.

Conclusion
Road traffic accident was the most common cause of femoral shaft fracture. The pattern of femoral fractures varied with age and the etiology of injury. Reducing road traffic accidents is key to decreasing femoral shaft fractures worldwide. The prompt assessment of femoral shaft fracture will enhance its effective management, reducing mortality and morbidity in affected individuals.

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Keywords: Adults, Femoral-shaft, Fracture, Plain radiograph, Trauma

Introduction

The femur is the strongest, longest, and heaviest bone, essential for ambulation. [1] It comprises the proximal and distal metaphysis and the shaft (diaphysis).[1] A femoral shaft fracture (FSF) is 5cm distal to the lesser trochanter and 5cm proximal to the adductor tubercle.[2,3] Reportedly, FSF is three times more common in males and has a bimodal age distribution.[2,4] Worldwide, the incidence of FSF ranges between 10 – 21/100,000/year, 2% of which are open fractures.[2,4-5] High-energy traumas following road traffic accidents (RTA) are more prevalent amongst the younger population, while low-energy concussions (ground-level falls) attributed to osteoporosis are common in the older age group.[2,4-5] A femoral fracture at the metaphyseal-diaphyseal junction, especially at an inconsistent traumatic level with the fracture pattern, should raise suspicion of a pathological fracture.[2,4]

The complications associated with FSF can be life-threatening.[6] They include neurovascular injury, bleeding, wound infection, fat embolism, compartmental syndrome, and adult respiratory distress syndrome.[6] It may also result in significant physical disabilities such as shortening, malalignment, or prolonged limb immobilization.[2-4] The considerable force required to cause FSF may result in another fracture in the body, such as the ipsilateral femoral neck, contralateral femur, patella, tibia, acetabulum, and pelvic ring.[7,8] Ligamentous and meniscal knee injuries may go undiagnosed.[7,8] Globally, the growing incidence of traumatic FSF with considerable morbidity and mortality may be attributed to bad roads, careless driving, poor vehicular maintenance, and a high vehicular production rate.[9] The economic burden of these injuries in resource-poor countries is enormous.

A plain radiograph of the femur is sufficient for diagnosing FSF and assessing associated injuries.[10.11] It is more affordable and accessible than Computed Tomography (CT) or Magnetic Resonance Imaging (MRI), especially in developing countries.[10,11] Therefore, this study aimed to determine the association between the causality of injury and patterns of FSF on plain radiographs, as well as the socio-demography and soft tissue involvement in patients with femoral fractures.

Methods

Study design and setting

A cross-sectional hospital-based study was conducted on 390 adults with FSF admitted to three public tertiary hospitals within one year.

Participant's eligibility

All consenting patients aged 18 years and older with FSF were recruited from the hospitals' orthopedics wards, accident and emergency units, and general out-patient units. Patients who declined consent with pathological fractures, previously treated FSF with known complications such as non-union, delayed union, mal-union, osteomyelitis, and those presentations lasting more than four weeks from the initial injuries and children were excluded from the study. All participants gave written informed consent.

Data collection

The data were collected using interviewer-administered questionnaires adapted to suit our setting from previous similar studies in China and Nigeria.[12-14] It was originally in English, translated into the indigenous language, and then translated back to English to ensure consistency. The research questionnaire sought information about the socio-demographics, date, cause, and injury site. A history of current medications, alcohol use, and smoking was obtained. Anthropometry and clinical history of the study participants were obtained. Information about the mechanism of injury, fracture type (close/open), classification, associated injury, number and side of limbs involved,

and soft tissue injury assessed by the consultant orthopedics surgeons managing these patients were extracted from the case notes. The radiographs of the affected femur, including the hip and knee joints, were obtained in the anteroposterior (AP) and lateral views. The gonads were protected, and sandbags were used to minimize patient discomfort. The affected limb was extended and medially rotated, with the patella parallel to the table for the AP projection. [15]

Figure 1. Anteroposterior and lateral radiograph of the right femur showing a mid-shaft transverse fracture

Figure 2. Anteroposterior and lateral radiograph of the femur showing a spiral fracture at its distal 1/3rd of the femur.

For the lateral view, the patient was turned to the side to be examined, the affected knee was flexed, and the contralateral knee was slightly extended with a soft pad placed under the ankle for an adequate superimposition of the femoral condyles.[15]

Two radiologists with at least five years of experience in musculoskeletal imaging concurrently reviewed the participants' radiographs, each blinded to the results of the other. There was a review of the fracture pattern and site, and the fracture pattern was classified as transverse, spiral, comminuted, oblique, and segmental. [Figures 1-3] Soft tissue involvements were also assessed and grouped as tissue disruption, the presence of subcutaneous gas, and bone chips within the soft tissue. A fracture is said to be closed when there is no physical contact between the fracture, the fracture hematoma, and the outside environment. In contrast, an open fracture communicates with the outside environment.

Figure 3. Anteroposterior radiograph of the right femur showing comminuted fracture of the mid-shaft of the right femur, soft tissue swelling with multiple bone fragments. An associated fracture of the right inferior pubic ramus was seen.

Data management and statistical analysis

The data were analyzed using the IBM SPSS Statistics for Windows version 23.0 (IBM Corp, Armonk, NY, USA). Descriptive statistics, which include proportions, frequencies (percentage), and the mean with standard deviation (SD), were used to summarize

the categorical and continuous variables. The chi-square assessed association, and $p<0.05$ was considered statistically significant.

Ethical consideration

Ethical approvals with reference numbers ADM/DCST/HREC/628, 011/90/C/IX, and LREC/10/06/641 were received for this study from the Health Research and Ethics Committees of Lagos University Teaching Hospital, National Orthopedic Hospital, Lagos and Lagos State University Teaching Hospital respectively. The participants were assured of their voluntary participation in the study and had the full right to withdraw at any time with no consequence. They were also told that their information would be safely kept. After the participants had read and understood the purpose and all explanations about the study's conduct, they were asked to sign the consent form without coercion. Precautions were set to ensure value, respect, and autonomy for participants in this study.

Results

This study involved 390 patients and 402 cases of FSF. The mean age was 40.93 (SD=16.3) years, with 31–45 years (43.6%) being the most commonly affected. The study comprised 218 (55.9%) males and 172 (44.1%) females, with a male-to-female ratio of 1.2:1. The socio-demographic parameters of the study participants are shown in Table 1.

Table 1. Socio-demographic characteristics of study participants

Variable	Frequency (n=390)	Percentage (%)
Age (years)		
18-30	110	28.2
31-45	170	43.6
46-60	53	13.6
>60	57	14.6
Education status		
None	34	8.7
Primary	66	16.9
Secondary	123	31.5
Tertiary	167	42.8
Occupation		
Students	57	14.6
Artisan/Self-employed	210	53.8
Professional/Civil servants	89	22.8
Retired/ Unemployed	34	8.7

Etiology of injury

The most typical mechanism of injury was the RTA, accounting for 82.8%, comprising motor vehicular accidents (MVA) and motorcycle accidents (MCA) in 48.7% and 34.1% of cases, respectively. Other causes of injury were accidental falls (15.4%), gunshots (1.3%), and industrial accidents (0.5%). Most of the RTA occurred during the day (72.8%) compared to 27.2% at night. Passengers in the MVA were more commonly affected (61.6%) than in the MCA (39.8%), FSF was higher among cyclists in the MCA (45.9%) than among drivers in the MVA (27.4%), and FSF among pedestrians was 14.3% and 11.1% in the MCA and MVA respectively. Of the participants, 75.6% reported to the tertiary centres within 12 hours of the injury, and 72.8% had minimal intervention before the presentation.

The pattern of injury

Type and fracture pattern: Among the participants, 83.1% and 16.9% had closed and open fractures, respectively. With the fracture pattern, comminuted fractures were the highest (36.3%), followed by transverse (32.3%), oblique (22.4%), spiral (5.5%), and segmental (3.5%) fractures in descending order.

Affected side

Most of the fractures were unilateral, seen in 97.2% and 96.5% of males and females, respectively. A higher right-sided distribution was observed in both sexes, higher among the females (55.2% vs. 49.5%). Twelve participants (3.1%) had bilateral fractures with equal distribution in the sexes and affected sides. The most typical cause of bilateral FSF was MCA (58.3%), followed by falls (25%) and MVA (16.7%). All the gunshot injuries were right-sided.

Anatomical femoral fracture site

Overall, the most typical site was the middle third of the shaft (52.2%), followed by the distal third (30.1%), and the least in the proximal third (17.7%). However, FSF due to falls were seen more in the distal third of the shaft (56.7%), followed by the middle third (40.0%) and the proximal third (3.3%).

Associated injuries

All participants had abrasions/lacerations. About 52.3% of the study participants had related injuries, including other limb fractures, head injuries, pelvic fractures, chest injuries, spinal injuries, and other extra-osseous injuries, as shown in Table 2. In 47.3% of the study population, there was no soft tissue involvement; however, bone fragments in soft tissue, soft tissue swelling, bone fragments in soft tissue and swelling, and disruption of muscle planes were distributed in 24.1%, 19.4%, 6.0%, and 3.2% of cases respectively.

Table 2. Associated injuries amongst the patients with femoral shaft fracture

Associated injuries	Frequency (%)
Fracture of another limb	71 (33.8%)
Head injury	53 (25.2%)
Chest injury	15 (7.1%)
Pelvic fracture	25 (11.9%)
Spinal cord injury	1 (0.5%)
Abdominal injury	23 (11.9%)
Bladder rupture	12 (5.7%)
Urethral injury	10 (4.8%)
Total	**210 (100%)**

The pattern of femoral shaft fracture and participants' socio-demographics

There were statistically significant differences between the prevalences of FSF and the participants' demography. In the modal age group, the comminuted fracture was the most common pattern of FSF (36.5%), as also noted in participants older than 60 (23.4%). Comminuted fracture (44.0%) was the most common in males, while transverse fracture was more common in females. The distribution of the FSF pattern amongst the participants' socio-demographics is shown in Table 3

Table 3.Distribution of patterns of FSF in participants' demographics

Variables	Comminuted n (%)	Oblique n (%)	Segmental n (%)	Spiral n (%)	Transverse n (%)	Total	P*
Age (years)							
18-30	53(46.9)	19(16.8)	0(0.0)	2(1.8)	39(34.5)	113	<0.001
31-45	62(36.5)	53(31.2)	4(2.4)	1(0.6)	50(29.4)	170	
46-60	16(29.1)	8(14.5)	2(3.6)	2(3.6)	27(49.2)	55	
>60	15(23.4)	10(15.6)	8(12.5)	17(26.6)	14(21.9)	64	
Gender							
Male	99(44.0)	47(20.9)	4(1.8)	8(3.6)	67(29.8)	225	
Female	47(26.6)	43(24.3)	10(5.6)	14(7.9)	63(35.6)	177	<0.001
Education							
None	12(33.3)	6(16.7)	3(8.3)	8(20.2)	7(19.4)	36	
Primary	25(36.8)	16(23.5)	2(3.9)	0(0.0)	25(36.8)	68	<0.001
Secondary	46(36.1)	27(21.3)	2(1.6)	2(1.6)	50(39.4)	127	
Tertiary	63(36.8)	41(24.0)	7(4.1)	12(7.0)	48(28.1)	171	
Occupation							
Students	22(36.7)	11(18.3)	0(0.0)	2(3.3)	25(41.7)	60	<0.001
Artisan	89(41.4)	55(25.6)	7(3.3)	4(1.9)	60(27.9)	215	
Professional	27(29.7)	18(18.8)	4(4.4)	6(6.6)	36(39.6)	91	
Unemployed	8(22.2)	6(16.7)	3(8.3)	10(27.8)	9(25.0)	36	

p* = level of significance at < 0.05

Distribution pattern of FSF and cause of injury, design, and anatomical site of fracture

More than 50% of the FSF was observed in the middle third of the femur, and the comminuted fracture was the most familiar (36.3%).A statistically significant difference was observed between the FSF pattern and the injury etiology (p<0.001).

Most participants with transverse fractures had soft tissue involvement, and 73.2% of the participants with comminuted fractures had bone fragments in the soft tissue. The distribution pattern of FSF with etiology, design, and anatomical site of fracture is shown in Table 4.

Table 4. Distribution of FSF with etiology, pattern, and soft tissue involvement

	Pattern of fracture						
Variables	**Comminuted**	**Oblique**	**Segmental**	**Spiral**	**Transverse**	**Total**	**P***
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**		
Etiology							
From height	12(27.9)	7(16.3)	3(7.0)	10(25.6)	11(25.6)	43	<0.001
Simple fall	3(17.6)	6(35.3)	0(0.0)	3(17.6)	5(29.4)	17	
Gunshot	5(100.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	5	
MCA	50(36.5)	21(15.3)	4(2.9)	4(2.9)	58(42.3)	137	
MVA	75(38.5)	56(28.7)	7(3.6)	3(1.5)	54(27.7)	195	
Industrial accidents	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(100.0)	2	
Location							
Proximal 1/3	31 (7.7)	19 (4.7)	2 (0.5)	0 (0)	18 (4.5)	70	0.004
Middle 1/3	76 (18.9)	35 (8.7)	7 (1.7)	10 (2.5)	83 (20.6)	211	
Distal 1/3	39 (9.7)	36 (9.0)	5 (1.2)	12 (3.0)	29 (7.2)	121	
Soft tissue involvement							
ST BF	71(73.2)	13(13.4)	2(2.1)	0(0.0)	11(11.3)	97	<0.001
STS	25(32.5)	12(15.6)	6(7.8)	6(7.8)	28(36.4)	77	
MPD	11(84.6)	0(0.0)	0(0.0)	0(0.0)	2(15.4)	13	
STS and BF	14(60.9)	2(8.7)	0(0.0)	0(0.0)	7(30.4)	23	
None	25(13.0)	63(32.8)	6(3.1)	16(8.3)	82(42.7)	192	

MCA – motorcycle accidents, MVA – motor vehicle accident, ST – soft tissue, BF – bone fragments, STS – soft tissue swelling, MPD – muscle plane disruption, P* = level of significance at < 0.05

Discussion

A femoral shaft fracture is not a rare surgical emergency. It usually results from high-energy trauma and can be life-threatening with associated polytrauma. It may cause abnormal limb shortening and deformities if not properly treated. The observed mean age and bimodal age distribution are comparable to previous reports.[13,14,16] The higher incidence of FSF in the male gender in this study was similarly reported in Nigeria,[14,18] and Iran , [16] which is not surprising as males are more adventurous and involved in dangerous activities than their female counterparts.[17] As seen in this study, the predominance of FSF in young, economically active males involved in their productive years may significantly negatively impact them, their families, and the country. Most of the FSF in our study resulted from RTA, as observed in Enugu, Nigeria.[14] The reported incidence in this study is lower than the expected estimated value in low-income countries , [19] although it is higher than reports in Eastern Africa and Nigeria.[4,14,20]

This study noted low-energy traumas among the aging population, likely due to osteoporosis. Fractures from osteoporosis are usually secondary to falls with known risk factors such as increasing age, female gender, early menopause, and sedentary lifestyle.[21] However, high-energy trauma from MVA accounted for the majority cause of RTA, seen in the younger age group. The increasing use of motorcycles and motorcycle accidents (MCA) are gaining momentum in our metropolis. They transport faster than vehicles and easily access remote areas, albeit with increased use of untrained riders for commercial transportation as a means of livelihood in the face of a high unemployment rate.[22] Interestingly, MCA was the commonest etiology of RTA-FSF in Brazil and Tanzania [2, 23], buttressing that the available mode of transportation in a region largely determines FSF etiology. In developing countries, RTA is still a neglected epidemic with a combination of factors that include but are not limited to rapid motorization, poorly maintained roads, ignorance and negligence of road safety rules, and destructive road user behaviors. [24]

Many of the FSFs had closed fractures, as reported in other studies.[13,22,25] Unilateral fractures were commoner with a higher preponderance on the right, a finding comparable to another study.[14] All the gunshot injury fractures in this study were observed on the right side, a finding indifferent to a previous survey explaining that most shootings during crime were usually not to kill but to frighten and demobilize the victims.[26] Similarly, the high occurrence of FSF in this study's middle third of the femur was reported.[22-25] The midshaft of the femur is the narrowest and conceivably the weakest point of the femoral shaft.[27] This extensive part of the bone also receives the highest traumatic impact, either from a high- or low-energy trauma, making it highly susceptible to fracture. [24,27]However, FSF in the proximal one-third and distal one-third of the femoral shaft have also been reported.[2,14]

In this study, most of the FSF was comminuted, followed by transverse fractures, as previously reported.[22,28] The combined action of an axial force and a bending moment of the femur during motion may induce a femoral fracture. [29] In addition, a hyperextended femur in a 3-point bending nature may result in a transverse fracture pattern. In contrast, a spiral fracture pattern may often be caused by rotational injury, as seen among the older study population.[30]

The femur is the strongest bone in the body and is highly vascularized.[31] It usually makes a high-energy impact with a fracture, resulting in significant bleeding into the thigh and injuries in other parts of the body. [25] In this study, bruises, lacerations, and soft tissue injuries were the most commonly associated injuries with statistical significance ($p < 0.001$). A high incidence of organ damage and other bone fractures was similarly reported.[25] They observed that most of the FSF resulting from RTAs, especially VMAs, were high-energy injuries with fractures of the limbs and other bones, joint dislocations, intrabdominal injuries, and other associated injuries.[25] Therefore, the significance of thoroughly examining a patient with FSF to rule out injuries in different body regions must be considered.

Limitations of the study

The actual number of FSF sustained during the study period may need to be more adequately reflected as only tertiary hospitals were involved. Many patients with FSF may end up in private or general hospitals, especially those far from the tertiary centres. Furthermore, people with FSF still visit traditional bone setters in our environment, believing their non-surgical bone healing process involves using spiritual powers. In addition, armed robbers with FSF from gunshot cases may not report to these centres for fear of being apprehended by the police.

Conclusion

Road traffic accidents and falls from osteoporosis were the most common causal agents of FSF in the younger and older generations, respectively, with a higher incidence in males. It is usually unilateral and right-sided, with the majority in the middle one-third of the femoral shaft. A good knowledge of the etiology, pattern, magnitude, and nature of FSF with its associated injuries will guide the attending orthopedic surgeons in its management and post-surgical therapies.

The government should implement and enforce regulations about road usage and road safety policies for all users. The availability of appropriate preventive measures on the roads and for road users should be heightened, as this will restrict the unnecessary menace of RTA, ensure the safety of motorists and other road users, and ultimately reduce the incidence of RTA-related FSF. Finally, efforts to educate, screen, and treat osteoporosis among the older generation should be intensified. Adequate and appropriate dietary intake boosting bone strengthening with exercise should be encouraged in all populations.

Authors contribution

OOO: conception, study design, literature search, data analysis, manuscript review
AOA: conception, study design, literature search, data analysis, manuscript writing, and review.
MAJ: study design, literature search, manuscript writing, and review.
RAA: study design, data analysis, and manuscript review.
BOB: study design, data analysis, and manuscript review.
All the authors approved the publication of the final version. They will be accountable for all aspects of the work and ensure that questions related to the accuracy or integrity of any part are appropriately investigated and resolved.

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Conflict of interest

The authors declare no conflict of interest about this research and authorship of this article.

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