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Conservative Management of Femoral Shaft Fractures in Children
Presenting to Khartoum Teaching Hospital

By

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Dedication

To my Father ... My Mother...

To My Wife ... My Daughter... "Nour"

To My Brothers and sisters...

To All the teachers I met during my study life.

To All colleagues and friends...

With My Best Wishes...

Omer
Acknowledgement

I would like to express my sincere thanks to Mr. Ali Eltayeb Elamin for his supervision and for his valuable contributions to my study. Really, I am much indebted to his kind help and precious advises, despite his valuable time.

I would like to thanks all those who helped me during this study. I am glad to thank Mr. Mubarak Fadul who provided me with his knowledge and experiences. I am also grateful to my colleagues in orthopaedics, who worked with me in particular Dr. Osman Idris and Dr. Ahmed El Bushera.

Above all, I have to thank my God "Allah" the most merciful, for giving me health and power to complete this study.
Abstract

This is a prospective study of 104 children under the age of 14 years who had femoral shaft fractures and were treated at Khartoum Teaching Hospital by conservative methods. The study was from 1st of March 2003 to 1st of March 2004. Only 60 patients of these were available for final assessment.

The data was collected after completing a questionnaire containing a comprehensive history, proper physical examination and radiographs in anteroposterior and lateral planes. The study was carried out to construct scientific bases for clinical presentation, radiological appearances, the outcome of conservative management of these patients and to recommend a treatment approach.

Of 60 patients, 40 were males 66.7% and 20 were females 33.3%. Male to female ratio was 2:1. The two limbs were affected equally. Two patients had bilateral femoral shaft fractures.

The most common area of fracture location was the mid-diaphyseal region, 32 patients (53.3%) and the most common type of fracture seen was closed transverse, 21 patients (35.0%). The most common cause of injury was a fall from a height or road traffic accident 19 patients (31.7%) for each. The fracture was an isolated injury in 78.3% and the most common associated injury was head injury, 9 patients (15.0%).

The majority of patients, 57 children (95.0%), had displaced fractures and were treated by skin traction. Only in four children, spica cast was used following a period of traction. Three infant's patients had non-displaced fractures were treated by immediate
spica casting. 88.1% of the patients had an outcome with excellent to satisfactory results.
خلاصة الأطروحة

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Introduction and Literature review:

Femur fractures are the most common major injury in children. Males affected more than females with bimodal distribution\(^{(1)}\). The first peak occurs typically in early childhood, when weak woven bone is changing to the lamellar bone, the second during adolescence, when children are subjected to high-energy trauma from sport and motor vehicle accidents\(^{(1, 2)}\).

Although femoral shaft fractures are dramatic and disabling injuries, both to the patient and the family, the vast majority heal rapidly without significant complication or sequelae regardless of treatment method. Treatment of femoral shaft fractures is considered one of the major pediatric orthopedic problems; it remains controversial\(^{(3)}\). Spica cast, or traction followed by spica casting, has been used with great success, largely because children have tremendous ability to remodel the deformities\(^{(2)}\). In the past, operative treatment has been reserved primarily for children with significant associated injuries, such as thoracic or head injuries, or ipsilateral tibial fracture and in children with metabolic bone disease\(^{(2, 3)}\). There is a virtual consensus of different modalities of treatment\(^{(4)}\). There is a trend by pediatric orthopedic surgeons to surgically treat femur fracture of older children and conservatively treat younger children.
There is no local study to evaluate and document our own experience so as to
determine which method among these options is suitable to our situation. This
research attempts to create a baseline study to make out our records in the
different methods we use.

1.1. Anatomical considerations:

The femur is the largest and strongest bone. It consists of a head
which is two-thirds of sphere and faces upwards, medially and forwards. It is
covered with cartilage except for its central fovea where the ligamentum
teres is attached \(^5,6\). The head connected to the shaft by the neck, which is set
at angle of 125\(^0\) to the shaft. In the female and children, the angle is smaller
\(^7\). The junction between the neck and the shaft marked anteriorly by the
trochanteric line, laterally by the greater trochanter, medially and somewhat
posterior by the lesser trochanter.

The femoral shaft is circular in section at the middle but it is flattened
posteriorly at each extremity. Posteriorly also it is marked by a strong crest, the
linea aspera. Inferiorly this crest splits into the medial and lateral supracondylar
lines leaving a flat popliteal surface between them. The medial supracondylar
line ends distally in the adductor tubercle. The lower end of the femur bears the
prominent condyles which are separated by a deep intercondylar notch posterior
but blend anteriorly to form an articular surface for the patella \(^6,7,8\).
1.2. Pathological anatomy:

The femoral shaft is well padded with powerful muscles, which give it protection. Moreover, fractures often severely displaced by muscles pull, hence, making reduction difficult. Displacement determined by the pull of muscles; in the proximal shaft fracture, the proximal fragment flexes, abducts and externally rotates because of gluteus medius and iliopsoas. In mid-shaft fractures, the proximal fragment abducts less but flexion and external rotation by iliopsoas persists. The distal fragment is frequently adducted. In lower third fractures; the proximal fragment adducts and the distal fragment is in position of hyperextension because of the over pull of gastrocnemius (9, 10 and 11).

1.3. Mechanism of injury:

The etiology of femoral fractures in children varies with the age of the child. In children younger than walking age, the commonest cause is child abuse. In older children, it is unlikely to be caused by abuse, because their bone is sufficiently strong to tolerate forceful blows. It is most likely to be caused by high-energy injuries, such as motor vehicle accidents or a fall from a height. Pathological femoral fractures are relatively rare in children, but they may occur because of generalized disorders such as osteogenesis imperfecta and
spina bifida, and with local bone lesions such as nonossifying fibroma, aneurismal bone cyst, unicameral cyst, or essinophilic granuloma. Pathologic femoral fractures rarely occur in patients with osteosarcoma or Ewing's sarcoma \(^{(1,9)}\). Stress fractures may occur in adolescents involved in sport activity \(^{(1)}\).

1.4. Diagnosis:

Having Clinical examination, this is usually sufficient for diagnosis of a femoral fracture. Most patients are unable to walk and are in extreme pain. There are often swelling, deformity, tenderness, repentance, instability and any attempt to move the limb is painful \(^{(1,9)}\). Hypotension from blood loss in an isolated femoral fracture rarely occurs. When it does, usually result from associated injuries "Waddell's triad" of femoral fracture, intra-abdominal or intrathoracic injury, and head injury \(^{(1,12)}\)

Plain x-rays generally are sufficient for confirming the diagnosis. It should include the entire femur and the hip and knee, to detect the common associated injury of adjacent joints \(^{(1,9)}\). Hip fractures and dislocation often occur with proximal femoral shaft fractures while distal fractures are often associated with physical injury about the knee, knee ligament injury, menisci tear and tibia fractures \(^{(1)}\). The fracture pattern should be carefully noted as it forms a guide to
treatment (9).

1.5. Classification:

There are various systems of classification, which have been used to grade injury severity but there is no universally agreed classification (13). Femoral fractures are classified as transverse, spiral, or oblique; comminuted or non-comminuted; and open or closed. Open fractures are classified according to Gustilo's system. The most common type (over 50%) is a simple transverse, closed, non-comminuted fracture (1). Inquest et al classification, in 1984, reflects the observation that the degrees of soft tissue damage and fracture instability increase with increasing grades of comminution (9).

1.5.1. Type 1 (there is only a tiny cortical fragment).

1.5.2. Type 2 (the butterfly fragment is larger but there is still at least 50% cortical contact between the main fragments).

1.5.3. Type 3 (the butterfly fragment involves more than 50% of the bone width).

1.5.4. Type 4 (is essentially a segmental fracture).

1.6. A. O classification:

In the AO classification system the femoral shaft is defined as in effect stretching between the inferior margin of the lesser trochanter and the upper
border of a square containing the distal end of the femur. For descriptive purposes, the shaft (or diaphyseal segment) may in turn be divided into proximal, middle, and distal thirds. The proximal third is sometimes referred to as the subtrochanteric zone.

The AO classification based on the level and pattern of the fracture (14):

1.6.1. Type A (fractures are simple).
   1.6.1.1. Type A1 = (Spiral fracture). When subtrochanteric it is (A1,1), when it is in the mid-shaft (A1, 2) and when in the distal zone (A1, 3).
   1.6.1.2. Type A2 = (Oblique fracture 30 degree or more). When subtrochanteric it is (A2, 1), when it is in the mid-shaft (A2, 2) and when in the distal zone (A2, 3).
   1.6.1.3. Type A3 = (Transverse fractures). When subtrochanteric it is (A3, 1), when it is in the mid-shaft (A3, 2) and when in the distal zone (A3, 3)

1.6.2. Type B (fractures are wedge fractures).
   1.6.2.1. B1= Spiral wedge fractures; .1 subtrochanteric; .2 midshaft; .3 distal zone.
   1.6.2.2. B2= Bending wedge fractures; 1. subtrochanteric; 2. midshaft, 3. distal segment.
   1.6.2.3. B3= Fragmented wedge fractures; 1. subtrochanteric; 2. midshaft; .3 distal segment.
1.6.3. Type C fractures are complex:

1.6.3.1. C1= Spiral fractures; one with two intermediate fragments; 2 with three intermediate segments; 3 with more than three intermediate segments.

1.6.3.2. C2= Segmental fractures; one with one intermediate segment; two with one intermediate segment and additional wedge fracture; three with two intermediates segments.

1.6.3.3. C3= Irregular fractures; 1 with two or three intermediate fragments; 2 with shattering limited to less than 5 cm length of the bone; 3 with shattering over 5cm or more of the bone.

1.7. Emergency treatment:

Shock, if present, should be treated (9). Children with isolated femoral fractures rarely lose sufficient amounts of blood to necessitate blood transfusion. The majority may be managed by observation alone. Multiple trauma and underlying disorders are indications for careful monitoring. Haematocrit determination, and cross match for blood. Older children, present with a haematocrit less than 30%, or who have multiple traumatic injuries have a relatively greater risk of needing a transfusion (12). The fracture should be splinted either tied to other limb or using Thomas' splint. This will control pain, reduces bleeding and makes transfer easier (9).

1.8. Definitive treatment:
The vast majority of femur fractures in children, heal without any long term sequalae regardless of treatment method (2). Femoral shaft fractures in children have been treated with various methods. The fact that the fracture is surrounded by richly nourished muscle ensures rapid solid union (usually within 6 weeks). Rapid remodeling of the bone makes perfect reduction (15,16). If alignment and length are maintained, mild malrotation usually corrects with growth. Wallace and Hoffman reported an average 85% correction in 28 children who had angular deformities of 10 to 26 degrees after unilateral fractures of the middle third of the femoral shaft. Most of the correction (74%) occurred at the physes; (26%) occurred at the fracture (10).

Treatment of femoral shaft fractures in children still remains controversial (3). It is age dependent, with considerable overlap between age groups. The child size and bone age also must be considered, as well as the cause of the injury or part of poly-trauma, associated medical condition, open wounds and some social factors primarily influences treatment choices (1, 3, 4, 10 and 17).

In adolescents, the psychological implications of treatment should be considered. Prolonged hospitalization alters the adolescent's self-image and interrupts social and educational development (1, 2). Especially in older children, the disadvantages of non-operative treatment – time in traction or a cast,
economic and social impact on the family – must carefully weighed against the potential complications of a surgical procedure: infection, refracture after removal of fixation, neurological injury, limb shortening or overgrowth and avascular necrosis of the femoral head. Certainly cost is a major factor, but it should not be the overriding consideration in discussions of treatment options with the family.¹

1.8.1. Conservative Treatment:

Is variable and is often best described according to age.¹ ¹ ¹

1.8.1.1. In infants, newborn to 6 months of age, femoral fractures usually are stable because of the thick periosteum. For stable proximal or mid-shaft femoral fractures, simple or a Pavlic harness is all that is required.¹ ¹ ¹ ¹ The advantages of using it are ease of application without anesthesia, minimal hospitalization easy reduction, ability to adjust the harness, minimal costs, ease in diaper changing, nursing and bonding.

Infants younger than 6 months provide a unique treatment population for a number of reasons. They achieve clinical and radiographic union of their fractures in only 6-8 weeks, they have outstanding remodeling potential at the fracture site, and their natural position is one of the substantial flexion at the hips as result of their position in the uterus. The increased movement allowed in the harness does not appear to have adverse effects in term of non-unions or
mal-unions. The position required for wearing the Pavlic harness is the natural position of infants in this age range, and it is the position necessary to obtain and maintain a reduction of proximal femur fractures \(^{(18)}\). Motion at the fracture site may result in pain until callus starts to form. For the very ill child, cloth bolsters and careful handling may be sufficient treatment. Residual deformity or leg-length discrepancy is unusual \(^{(17)}\). For femoral fractures with excessive shortening (more than 1 to 2 cm) or angulations (more than 30 degrees), spica casting is required \(^{(1, 4 \text{ and } 10)}\).

Immediate spica casting is available alternative to traction and delayed casting. It is indicated for isolated, stable femoral shaft fractures in children younger than 6 years of age unless shortening of more than 2 to 3 cm is present, massive swelling of the thigh is noted or associated injuries are present \(^{(1)}\). It is easier for preschool children than for those with school-age children. General anesthesia is used to relieve discomfort, to ensure that a well-formed cast is applied and to allow performance of telescope test \(^{(19)}\). Advantages of immediate casting include, shorter hospitalization time, less cost, no complication from traction, and less radiographic examination \(^{(1, 4)}\). There is no discernible difference in leg-length discrepancy, rotational alignment, or function on follow-up of children with femoral shaft fractures treated by this non-operative method \(^{(4)}\). Although shortening and angulations may occur in
spica cast, its risk may be lessened by flexing the knee sufficiently at the time of cast application. Careful follow-up radiograph during the first week and second week after cast application is necessary to detect excessive deformity. Minimal shortening is acceptable but should not exceed 2cm. This is best measured on a lateral x-ray. If follow up radiographs reveal significant varus (common) or anterior angulations (more than 10 degree), timely wedging of the cast to within 5 to 10 degree or manipulation is needed to realign the fractured femur. It has been reported that wedging of 90/90 spica cast can cause peroneal nerve palsies especially during correction of valgus angulations. For more angular correction, the fracture can be manipulated and a new cast applied, or the cast removed and the patient placed in traction to regain or maintain length. Angular deformity up to 15 degree in the coronal plane and up to 30 degree in the sagittal plane may be acceptable.

The position of the hips and knees in the spica cast is controversial.

Spica cast application with hip and knee extended and the bottom of the foot cut out to prevent excessive shortening has been described. The variation in the amounts of hip and knee flexion in the spica cast based on the position of the fracture. The more proximal the fracture, the more flexed the hip should be.

An alternative to extended hip and knee cast, the 90/90 degree spica cast is the sitting spica cast with hips and knees set in 90 degree of flexion, is easiest
and perhaps the most effective cast for femoral fractures in preschool-aged children, unless the fracture can not be maintained in this position. The child is placed in a sitting position with the legs abducted about 30 degree on either side; no bar is required between the legs. This will allow the child to be carried on parent's hip and aids in toiletry needs, and the child can sit upright during the day and can even attend school in a wheel chair \(^{(1, 10)}\). Guttmann and Simon described a modified pantaloon-walking cast for middle and proximal femoral shaft fractures \(^{(10, 20)}\). It is hypothesized that spica cast failure, is related to the amount of soft tissue injury and preinstall stripping at the site of fracture. To identify this telescope test, a new clinical test; which allows the identification of patient at high risk of poor spica cast outcome. It consist of gentle compression force applied manually a cross the fracture site. Radiographs then are made at 101.6 cm on standard cassettes with the x-ray beam perpendicular to the fracture site to document maximum overriding of the fracture fragments. Repeat films were taken with distraction force applied to the distal femoral fragment. If fracture fragment overlap was greater than 2.5 cm at any time during follow up, the patient was considered to have had a failed spica cast treatment \(^{(18)}\).

Generally, the spica is worn for 4 to 8 weeks, depending on the age of the child and the severity of the soft tissue damage \(^{(1, 4, 9, 10, 14 \text{ and } 18)}\). After the
cast has been removed management should include skin care in young children, crutch-assisted or walker-assisted ambulation in older children. Stiff knees and weak hamstrings and quadriceps should be noted and physiotherapy should be started. Kisser, Richards, and Millis found persistent deficits in strength of the quadriceps muscle as measured by Cyber II testing. The only etiological factor that correlated with this weakness was the amount of initial displacement of the fracture. Despite this weakness, no patient had clinical problems at follow up\(^{(10, 21)}\).

**1.8.1.2.** In children between the ages of 6 months 6 years, immediate or early spica casting is the treatment of choice for femoral fracture with less than 2cm of initial shortening\(^{(1, 10 \text{ and } 17)}\). Femoral fractures with more than 2 cm of initial shortening or marked instability that can be telescoped > 3 cm and fractures that can not be reduced with immediate spica casting require 3 to 10 days of balanced skin traction or skeletal traction followed by spica cast for another 4 weeks. Shortening of 1-2 cm is accepted in anticipation of a similar amount of overgrowth and angulations of up to 20 degree in the coronal plane, 30 degree in the sagittal plane, and 20 degree of rotation will generally assure a good result\(^{(1, 9 \text{ and } 17)}\). Traction followed by spica casting is still considered one of the best treatment methods. This especially true for the treatment of closed, isolated, femoral shaft fractures\(^{(19)}\).
Skin traction without a splint is usually all that is needed. Infant's under 12 kg in weight is most easily managed by gallows or modified Bryant traction for treatment of the femoral shaft in children of up to 3 years old. The cords are attached to an overhead beam. The buttocks, are suspended just clear of the mattress, so that the weight of the lower part of the trunk and pelvis exerts continuous traction on the limbs. The knees should be held slightly flexed by the simple plastic splint but no more than 2 kg weight should be used and the feet must be checked frequently for circulatory problems. Older children are better suited to Russell's traction (1, 9, 10 and 22). Skin complications, such as skin slough and blistering, usually occur when more than 5 pounds of traction applied and when this is required, skeletal traction may be used.

The distal femur is the location for a traction pin, tibia traction not frequently used because it causes growth arrest in the proximal tibia and subsequent recurvatum deformity. If a tibial pin is used, it should be placed distal to the tibial tubercle and the proximal tibial physis to minimize the risk of growth disturbances (1, 10). Skeletal traction is applied in a 90/90 degrees position (the hip and knee flexed 90 degree) (1). Aronson, Singer, and Higgins reported excellent results in femoral fractures treated with 90/90 skeletal traction and spica casting. Peroneal nerve palsy is a rare complication of skin or skeletal traction and casting (10).
1.8.1.3. Treatment of femoral fractures in children between 6 and 11 years of age is controversial (1, 3). Casting with or without preliminary traction is the standard treatment for the majority of stable, isolated, closed injuries with a negative telescope test (1, 4, 9, 10 and 17). Surgical treatment, such as external fixation or flexible intramedullary fixation, is gaining popularity. Incorporating a traction pin in a spica cast may control shortening and enable a short hospital admission but will not enable ambulatory treatment. Cast bracing will allow ambulatory treatment but may not provide good control of fracture alignment (17). However, in large children with unstable comminuted fractures, traction followed by application of a cast bracing or spica casting may be necessary (1, 9 and 10).

1.8.1.4. Treatment for a child older than 12 years of age to maturity, casting becomes less practical because of prolonged immobility. Internal fixation with a locked intramedullary nail has been advocated for isolated femoral fracture in this age group, but recent reports of osteonecrosis of the proximal femoral epiphysis and growth abnormalities of the proximal femur have tempered enthusiasm (1, 10 and 17).

1.8.2. Surgical treatment:

In the past, operative treatment has been reserved primarily for children with significant associated injuries or an associated ipsilateral tibia fracture and
in children with metabolic bone disease (e.g. osteogenesis imperfecta) \(^{(1, 2 \text{ and } 10)}\). Recently, increasing attention has been focused on the difficulty of caring for an older child or adolescent in a body cast for 2-3 months. Such prolonged immobilization stresses the child and the family with missed school, lost work, and deleterious psychosocial effects. Social changes over the last three decades have made standard cast treatment particularly challenging \(^{(1, 2)}\).

The management of pediatric femoral shaft fractures gradually has evolved toward an operative approach in the past decade. This is because of a desire for more rapid recovery and reintegration of the patients, and recognition that prolonged immobilization can have negative effects even in children. Economic pressures also favor a treatment that does not require as prolonged a hospitalization as that required with the traditional traction method \(^{(23)}\).

Enthusiasm has been increasing for methods of internal or external fixation that obviate the need for lengthy traction and casting. External fixation, flexible or rigid interamedullary nails, and plating are used to maximize early mobility, and to minimize the length of hospital stay. Each method has particular indications, and complications that must be considered in choosing the optimal treatment for a particular child and his or her fracture \(^{(2)}\).

The aim of treatment is to restore length and alignment and to encourage union and early rehabilitation \(^{(16)}\).
1.8.2.1. External fixation:

It provides a relatively safe method of femoral fracture treatment in children from age 5 to 11 years\textsuperscript{1}. It has been increasingly popular way to rapidly stabilize the fracture and mobilize the patient while correcting malalignment and shortening. It is indicated for children with multiple injuries, especially head injuries or severe extensive soft tissue or vascular injuries, open fractures that are not appropriate for casting and failed conservative management \textsuperscript{1, 2, 10, 24, 25, 26 and 27}. Unfortunately, the external fixater may stress-shield the fracture leading to delayed union, minimal callus response, and risk of fracture after the fixator is removed. Prolonged rigid or static fixation appears to be detrimental to sufficient callus formation and healing. In addition, pin track infections are common \textsuperscript{2, 10, 28 and 29}.

Evanoff, Strong, and Maclntosh reported the use of external fixation until fracture consolidation in 25 femoral fractures and 21 tibial fractures in skeletally immature patients, most of whom had multiple fractures or head injuries. All fractures consolidated with the fixators in place, and most patients regained preoperative motion. Eighty-four percent of fractures lost no position in the fixator; the remaining 16% lost fewer than 5 degrees. These authors recommended external fixation of all femoral fractures in children between the ages of 3 and 13 years \textsuperscript{10}.
Aronson and Tursky used primary external fixation with early weight-bearing for 44 femoral fractures in children. The fixators were left in place an average of 70 days. Thirty-eight percent of patients had femoral overgrowth, ranging from 2 to 10 mm and averaging 5.8 mm. Aronson and Tursky recommended external fixation as an alternative to casting for the treatment of isolated femoral fractures in children ages 4 to 12 years. Probe et al. reported re-fractures after frame removal in two adolescent patients treated with external fixation. Aronson and Tursky recommended the use of a monolateral fixator with four half pins that were predrilled and hand-screwed laterally into the bone. Occasionally, in a young child with poly-trauma, open fracture, or severe head injury, a small fragment external fixator with 4-mm pins can be used\(^{(10)}\).

External fixation is contraindicated in very proximal or distal fractures, which may preclude proper pin placement. A relative contraindication is a family or social environment that cannot support compliance with pin care, precaution, and follow up\(^{(2)}\).

1.8.2.2. Intramedullary Fixation:

Intramedullary rod fixation has long been considered the treatment of choice for adult femoral fractures. Over the past 15 years, the age at which antegradreamed intramedullary rodding is accepted as the procedure of choice has steadily decreased to about the age of 12 years\(^{(1, 10 \text{ and } 30)}\).
When surgical treatment of pediatric femur is indicated, intramedullary fixation is preferred (either reamed or non-reamed) depending on age, fracture pattern (level and degree of comminution) and size of femoral canal. Experience and careful surgical judgment are required to appropriately individualize treatment for these patients (31).

1.8.2.2.1. Flexible intramedullary rod fixation:

Flexible intramedullary nails have been used for pediatric femur fractures for many years. No other form of operative management for diaphysial femur fractures in children as universal or produces better result than it (2). Antegrade or retrograde, flexible intramedullary roding using a smaller Rush pin through the greater trochanter is the technique used in younger children, retrograde rod insertion is used in most patients to avoid the risk of growth disturbance and alteration of femoral blood supply caused by antegrade nailing in children (1, 2 and 32). Antegrade insertion may be required for fractures with distal supracondylar malalignment.

It combines the advantages of external fixation; rapid fracture stabilization, immediate patient mobilization, and anatomic fracture union- without major disadvantages- stress shielding and pin tract infection. The disadvantages are the lack of rotational control, the necessity of a general
anesthetic to implant and remove the nails, and soft tissue irritation that develop
distally at the insertion site\(^{(2)}\).

Early good result using flexible (Ender) intramedullary rods or several
European authors have reported titanium equivalent. Ligier et al reported the
use of elastic stable intramedullary nails (ESIN) in 123 fractures of the femoral
shaft in patients ranging from 5 to 16 years of age; all fractures united and no
patient complained of disability or had gait abnormalities at follow up\(^{(2,10)}\).
Most reports recommend this technique for children ages 6 to 10 years in
whom traction is not feasible because of head injury or multiple trauma and in
whom both the proximal and distal femoral physis need to be avoided\(^{(10,31)}\).
Flexible intramedullary nailing may be indicated in children who cannot be
treated with immediate spica casting and have not yet reached skeletal maturity
\(^{(33)}\). They are ideal for transverse fractures with excessive shortening or
instability in children who would benefit from rapid mobilization. They can be
used as salvage after refracture when an external fixator or cast was used for the
primary fracture treatment. They can also be used in children with metabolic
bone disease such as osteogenesis imperfecta\(^{(1,2)}\). It is contraindicated in very
distal or very proximal fractures that preclude nail insertion. Relative
contraindications include unstable long spiral or comminuted fractures\(^{(1,2)}\).

1.8.2.2.2. Rigid intramedullary rod fixation:
Rigid intramedullary fixation of femoral fractures in adolescent has been reported to result in high rates of union with short hospital stays and brief periods of immobilization \(^{(10)}\). Interlocking proximally and distally to maintain length and rotational alignment in unstable fractures appears to be of benefit to adolescents. Reamed antegrade nailing in children younger than 12 years of age is not routinely recommended unless the child is near skeletal maturity because of proximal femoral growth abnormalities, avascular necrosis of the femoral head, size of the proximal femur, and the relative success of the other treatment methods \(^{(1, 2)}\). There is a high incidence of abnormality at the proximal end of the femur, including coxa valga, arrest of growth of the greater trochanter and thinning of the neck of the femur, because of damage to the trochanterocervical growth plate \(^{(2, 34)}\). In addition, it may be associated with much higher neurologic complication rates than previously reported. Fortunately, most of the palsies in this series resolved spontaneously and quickly. The risk of neurologic complications may be reduced by using adequate preoperative skeletal traction, with radiographic documentation, in patients not rodded within 48 h of admission, and by avoiding the use of intraoperative boot traction \(^{(35)}\).

Open fractures can be effectively treated with intramedullary rodding, either as delayed or primary treatment, including those caused by gunshot
wounds and high-velocity injuries \(^{(1)}\).

**1.8.2.3. Open reduction and internal fixation with plate and screws:**

Ward and associates have recommended this form of treatment in selected femoral fractures, only for children younger than 11 years of age with closed-head injuries or multiple traumas. Pathologic fractures, especially in the distal femoral metaphysis, create larger areas of bone loss that may be treated with plate fixation and immediate bone grafting to avoid protracted periods of traction and immobilization. With so many other options available, only very unusual situations justify plate fixation as the treatment of choice for pediatric femur fractures. One such clinical scenario is femoral shaft fixation associated with vascular repair in the thigh \(^{(1,2)}\).

Plate fixation offers the advantages of anatomical reduction, ease of reduction, ease of insertion, simplified nursing care, rapid mobilization without casting, and applicability to any size femoral shaft \(^{(1)}\).

Disadvantages of plate fixation include the long incision necessary and the risk of plate breakage and stress fracture after plate removal, extensive dissection and periosteal stripping during plate application may lead to overgrowth \(^{(1)}\). Overgrowth was not a significant problem in Kregor and coworkers'. Ward and associates reported several patients with considerable overgrowth and Hansen reported overgrowth of an inch in a 12-year-old boy,
suggesting that overgrowth is possible in children older than age 10 years. It has not been prove that femoral overgrowth occurs more with plate fixation than with other treatment methods. More data are necessary on this issue to make a definitive statement (1, 2 and 36). Overgrowth is caused by activation of growth plate in someway. The risk of infection after plate fixation has been one of the main reasons for the technique's lack of popularity in adults; recent reports documented no infection with plate fixation. Many different techniques could be effective in the management. Both interfragmentary compression and dynamic compression techniques must be used to achieve stability through fixation and anatomical alignment (1, 36).

Minimally invasive internal fixation is closely linked to what is called biologic internal fixation. Biological internal fixation cannot eliminate the mobility at the fracture site, but it provides an optimum stabilization and helps to keep the bone fragments vital (3).

1.9. Special fractures of the femoral shaft:

1.9.1. Metaphyseal (subtrochanteric and supracondylar) fractures:

Subtrochanteric fractures can be treated in traction, followed by either a cast brace or single spica cast with satisfactory results. Internal fixation with plate and screw devices can also produce satisfactory results. Antegrade intramedullary nail systems that place significant holes in the upper femoral
neck and posterior insertion sites in the piriformis fossa should be avoided. Unlike subtrochanteric fractures in adults, nonunion are rare in children with any treatment method \(^{(1)}\).

Supracondylar fractures are considered rare. Difficulties in management of displaced supracondylar fractures have been identified by several authors because the gastrocnemius muscle insert just above the femoral condyles and pulls the distal fragment into a position of extension \(^{(9, 10, 11 \text{ and } 37)}\). The principal variables affecting treatment and outcome are fracture displacement and pathologic bone. Displacement makes the fracture unstable and management can be extremely difficult such that operative intervention is more likely. The traditional methods of casting and single pin traction may be satisfactory or combined epiphyseal-metaphyseal traction may be used. Traction treatment for displaced fractures had a high failure rate. If alignment cannot be achieved with these, however, open reduction and internal fixation either with compression plates and with fully threaded cancellous screws if there is sufficient metaphyseal length to allow this or with crossed smooth kirschner wires transfixing the fracture from the epiphysis to the metaphysis are used. Pathologic bone may limit the purchase of internal fixation \(^{(1, 37)}\).

1.9.2. Open femoral fractures:
Open femoral fractures are uncommon in children because of the large soft-tissue compartment around the femur. Proper wound care, debridement, stabilization, and antibiotic therapy are required to reduce the chance of infection. External fixation of open femoral shaft fractures simplifies wound care and allows early mobilization. Plate fixation is an invasive technique with the potential risk of infection and additional injury to the already traumatized soft tissues. In emergencies, plate fixation can be used for Gustilo-Anderson fractures type II and I; type III fractures in older adolescents are better suited for external fixation or intramedullary nailing (1).

In older adolescents, intramedullary nailing is especially useful. Closed nailing after irrigation and drainage of the fracture allows early mobilization and easy wound care, especially in patients with Gustilo-Anderson type I, II, IIIA, and IIIB injuries (1).

1.9.3. Femoral fractures in patients with metabolic or neuromuscular disorders:

For patients with osteogenesis imperfecta who have potential for ambulation, surgical treatment with Rush pin or Bailey-Dubow rod is recommended for repeated fractures or angular deformity. Cast immobilization is usually avoided in patients with myelomeningocele or cerebral palsy because of the frequency of osteoporosis and refracture in these patients. In
nonambulatory patients, a simple pillow splint is used \(^{(1)}\).

2. Complications:

2.1. Leg-length discrepancy:

The most common sequel after femoral shaft fractures in children is leg-length discrepancy. The fractured femur may be initially short from overriding of the fragments at union; growth acceleration occurs to "make up" the difference, but often this acceleration continues and "overgrowth" occurs in particularly in children between the ages of 2 and 10 years especially if traction has been used while in patients older than 10 years of age, shortening is more likely. The exact cause of this phenomenon is still unknown \(^{(1, 10 \text{ and } 17)}\).

2.2. Shortening:

Because the average overgrowth after femoral fracture is approximately 1.5 cm, shortening of 2 to 3 cm in the cast is the maximum acceptable amount. The maximum acceptable shortening depends on the age of the child \(^{(1, 15, 16 \text{ and } 17)}\).

2.3. Angular deformity:

Some degree of angular deformity is frequent after femoral shaft fractures in children, but usually remodels with growth. Angular remodeling occurs best in the direction of motion at the adjacent joint. Thus the anterior and posterior remodeling occurs rapidly and with little residual deformity. In
contrast, remodeling of a varus or valgus deformity occurs more slowly \(^{(1, 9 \text{ and } 10)}\).

2.4. **Rotational deformity:**

Tortional deformity is usually expressed as increased femoral anteversion on the fractured side. Rotational remodeling in childhood femoral fractures is another controversy. Certainly, in older adolescents, no significant rotational remodeling will occur \(^{(1)}\).

2.5. **Delayed union:**

Delayed union of femoral shaft fractures is uncommon in children. The time to fracture union in most children is rapid and age dependent \(^{(1)}\).

2.6. **Neurovascular injury:**

Nerve and vascular injuries are uncommon with femoral fractures in children. Vascular injury occurs most frequently with displaced Salter-Harris physeal fractures of the distal femur \(^{(1, 35)}\).

2.7. **Compartment syndrome:**

Compartment syndromes of the thigh are rare, but it has been reported \(^{(1, 38)}\).

2.8. **Nonunion:**

Nonunions of pediatric femoral fractures are rare. They tend to occur in adolescents, in infected fractures, or in fractures with segmental bone loss or
severe soft-tissue loss \(^{(1)}\).

2.9. **Muscle weakness:**

Weakness after femoral fractures has been described in hip abductor musculature, the quadriceps, and the hamstrings, but persistent weakness in some or all of these muscle groups seldom causes a clinical problem \(^{(1,21)}\).

2.10. **Infection:**

Infection may rarely complicate a closed femoral shaft fracture, with hematogenous seeding of the hematoma and subsequent osteomyelitis \(^{(1)}\).
Objectives

1. To describe the pattern of clinical presentation of femoral shaft fracture in children.
2. To describe the radiological features.
3. To evaluate the outcome of conservative treatment.
4. To report on difficulties encountered with treatment.
5. To recommend a protocol for treatment.
2. Patients and methods.

2.1. Nature of the study:

Hospital based prospective study.

2.2. Study area:

The study was carried in Orthopedics Department Khartoum Teaching hospital (K.T.H).

2.3. Study population:

Children with femoral shaft fracture attending the causality in the period between the 1st of March 2003 to 1st of March 2004.

2.4. Duration of the study:

The period between the 1st of March 2003 and 1st of March 2004.

2.5. Case definition:

Children with fracture femoral shaft stretching between the inferior margin of the lesser trochanter and the upper border of square containing the distal end of the femur. All patients were diagnosed on the clinical and radiological bases including anteroposterior and lateral radiographs.

2.6. Inclusion criteria:

All children from birth to 14 years old presented with femoral shaft fractures treated with conservative treatment.
2.7. Exclusion criteria:

Patients above 14 years or children below this age with femoral shaft fracture treated surgically.

2.8. Study sample:

The whole sample size was 104 patients. Twenty-six were lost to follow up in the referred clinic. Additional 18 patients were treated surgically. Both groups were excluded from the study.

2.9. Number of cases available for final assessment:

Only the remaining 60 patients who were followed up to the end of the period of weight bearing were included in the final assessment.

2.10. The protocol of management:

All patients were initially seen in the casualty by the registrars and the diagnosis was confirm by plain radiograph; anteroposterior and lateral views. The fracture site, type and the amount of displacement were identified and the degree of angulations was measured.

All patients were admitted to the ward. The registrar or house officers under supervision did traction; often skin traction in the form of gallows or balanced traction in almost all patients. The duration of traction ranges between 3 to 6 weeks during which patients were followed up with assessment of the circulation and nerve injury, limbs measurement and
frequent radiograph while the patient in traction especially in the first week. Then the alignment of the fractured limb will be achieved either by manipulation of the position or by increasing or decreasing the traction weight until acceptable position was attained.

In a few patients, traction followed by spica cast and this is usually after 3 weeks when fracture became sticky. In a minority of patients, immediate spica cast was used for undisplaced fractures or after reduction of a displaced fracture. Usually done under general anesthesia or sedation with the patients placed in spica table. A short leg cast is applied with the foot in neutral extra padding are placed in the area of the popliteal fossa. The cast then extended to a long-leg cast, and then the remainder of the cast completed up to the level of the nipple. The child is seen within a week of spica cast application to check maintenance of length and alignment this was done especially in case of immediate casting not preceded by traction. Generally, the spica cast is worn for 4 to 8 weeks, depending on the age of the child and the severity of soft tissue damage accompanying the fracture or whether it was preceded by traction or not.
2.10.1. Evaluation:

2.10.1.1. Radiographic evaluation:

By using the following measures:

1. **Angulations in lateral view radiograph (i.e. anterior and posterior angulations):** The range of acceptable anterior and posterior angulations varies from 30 to 40 degrees in children up to 2 years, 10 degrees in older children and adolescents.

2. **Angulations in anteroposterior view (varus and valgus angulations):** The range of acceptable varus and valgus angulations also becomes smaller with age. Varus angulations in infants and children should be between 10 to 15 degrees, although greater degrees of angulations may have a satisfactory outcome. The acceptable valgus angulationsis 20 to 30 degrees in infants, 15 to 20 degrees in children up to age 5 years, and 10 degrees in older children and adolescents.

3. **Rotational deformity:** The accuracy of measurements from plain x-rays has been disputed, and the use of computed tomographic (CT) scanning is of greater accuracy, but unfortunately it is very expensive and most of the patients cannot afford. Instead of we depend on the clinical assessment based on alignment of the proximal and distal femur
radiologically, interpretation of skin and soft tissue envelope alignment,
and correct positioning within a cast, based on the muscle pull on the
proximal fragment.

2.10.1.2. Shortening:

Because the average overgrowth after femoral fracture is approximately
1.5 cm, shortening of 2 to 3 cm is the maximum acceptable amount. This is
for children between the age of 2 and 10 years, whereas only 1 to 2 cm
accepted for those approaching skeletal maturity.

2.10.2. Follow up at the referred clinic:

The children had seen in the referred clinic to re-assess the
adequacy of reduction, immobilization and the degree of healing.
Radiographs were taken to ensure that no displacement has occurred and
the position is still acceptable, also the rate of healing is assess by
grading of callous formation and accordingly the traction or spica can be
removed and weight bearing is allowed. The following is the
radiographic grading of callous in femoral shaft fractures:
Grade 0: no identifiable fracture healing.
Grade 1: primary bone healing with little or no periosteal new bone
formation.
Grade 2: perioteal new bone formation on two sides of the femur.
Grade 3: periosteal new bone formation on three or four sides.

Partial and full weight bearing can only be allowed after seeing radiographic new bone formation on two sides and three or four sides of femur, respectively.

Final assessment been made when the child started full weight bearing with regard to non-union, shortening, angulations and rotational deformity. Stiff knees and weak hamstrings and quadriceps should be identified after the child begins to walk and physical therapy program was started.

2.10.3. Consent: Verbal consent was taken from the child's parents who were informed about the aim of this study and that the patient will be excluded from the study if he went into surgical treatment.

2.10.4. Questionnaire: (see appendix).

2.10.5. Data analysis:

The data was collected in questionnaire; and entered into Microsoft access tables. The data was subjected to statistical analysis in Scientific Package for Social and Scientific Studies (SPSS). Frequencies, percentages and cross tabulation were sent to Microsoft excel where charts were computed. The interpretation of the results was done with help of Microsoft excel and access and again sent to SPSS for statistical analysis.
3. Results

3.1. Demographic characteristics of people in the study:

3.1.1. Sex characteristic of the sample:

Forty patients (66.7%) were males; the remaining 20 patients (33.3%) were females (Fig. 1).

3.1.2. Age characteristics of the sample:

2 patients (3.3%) in the age group < 6 months. 23 patients (38.3%) in the age group 6 months to 6 years. 27 patients (45%) in the age group 6 years to 11 years. 8 patients (13.3%) in the age group >12 years (Table 1).

3.2. Initial assessment at the causality:

3.2.1. Mechanism of injury:

The mechanism of injury was fall from a height in 19 patients (31.7%) and the same number and percentage for road traffic accident. In 12 patients (20.0%), the fracture was the result of direct blow, eight patients (13.3%) had sport injury and two patients (3.3%) slipped while they were running (Fig. 2).

3.2.2. The presence of previous medical diseases:

54 patients, (90%) have no previous medical disease and only one patient (1.7) for each of the following; benign cyst, poliomyelitis, fibrous
dysplasia, Marbel bone disease, fracture of the other limb and nephrectomy (Table 2).

3.2.3. Time lapse between injury and presentation:

Forty-nine patients (81.7%) presented within the first 24-hours. Eight patients (13.3%) within the first week and three patients (5%) after the first week (Table 3).

3.2.4. Affected limb:

The right and left limb were affected equally 29 patients (48.3%) for each limb while in two patients (3.3%) both limbs were affected (Fig. 3).

3.2.5. Closed or open fracture:

In 56 patients, (93.3%) it was a closed fracture and in 4 patients (6.7%) the fracture was open.

3.2.7. Neurovascular injury:

There was no neurovascular injury detected in all patients.

3.2.6. Initial deformity:

In 53 patients, (88.3%) there was obvious deformity. In seven patients (11.7%), no deformity was detected (Fig. 4).

3.2.8. Associated injuries:

In 47 patients (78.3%), the fracture was not associated with other injuries. In nine patients (15%) associated with head injury and in two patients
(3.3%) there were tibial fractures on the same side. In one patient (1.7%), there was abdominal injury and another one with vaginal tear (Fig. 5).

### 3.3. The radiological appearance:

#### 3.3.1. Fracture site:

In 32 patients (53.3%), the fracture was in the middle third and in 24 patients (40%) in the proximal third. 4 patients (6.7%) with fracture in the distal third (Table 4).

#### 3.3.2. Pattern of fracture:

The fracture was transverse in 21 patients (35.0%), oblique in 19 patients (31.7%), spiral in 16 patients (26.7%) and comminuted in four patients (6.7%) (Fig. 6).

#### 3.3.3. Shift:

In 41 patients (78.3%), the displacement was sideways while in 17 patients (28.3%) it was backwards or forwards and only in two patients (3.3%) there was no shift (Table 5).

#### 3.3.4. Altered length:

In 56 patients (93.3%) there was overlap and in 4 patients (6.7%) no change in length.
3.4. Management and follow up:

3.4.1. Necessity of traction:

Traction was done in 57 patients (95.0%) and immediate spica casting in 3 patients (5.0%).

3.4.2. Type of traction:

In 54 patients (90.0%) it was balanced skin traction while gallows traction was done in five patients (8.3%) (Table 6).

3.4.3. Duration of traction:

Seven patients (11.7%) were put on traction for 3 weeks, 18 patients (30.0%) for 4 weeks, 17 patients (28.3%) for 5 weeks, 12 patients (20.0%) for 6 weeks while one patient (1.7%) for < 1 week, 2 weeks and 8 week. 3 patients needed no traction (Table 7).

3.4.4. Complications of traction:

In 21 patients (35.0%), no complication was detected. Skin blisters and joints stiffness occur in 12 patients (20.0%), joints stiffness alone occurred in 10 patients (16.7%), skin blisters and ulcerations occurred in seven patients (11.7%). Constipation joints stiffness in three patients (5.0%) and pneumonia in addition to the previous complications in four patients (6.7%). Pneumonia alone in two patients (3.3%) (Table 8).
3.4.5. Use of spica cast: Spica cast support the fracture only in four patients (6.7%).

3.4.6. Duration of spica cast: In one patient spica was left for 3 weeks and in three patients >3 weeks.

3.5. Assessment after treatment:

3.5.1. Clinical signs of union after treatment: In 56 patients (93.3%) signs of union were good and in three patients (5.0%) were poor.

3.5.2. Signs of union; grading of callous formation after treatment:

In 34 patients, (56.7%) it was grade 2, in 21 patients (35.0%) grade 3, in 3 patients (5.0%) grade 1 and in 1 patient (1.7%) it was grade 0, (Fig. 7).

3.5.3. Degree of coronal angulations after treatment: In 6 patients (10.0%) it was < 5 degrees, 5 to 10 degrees in 17 patients (28.3%), 10 to 15 degrees in 17 patients (28.3%), 15 to 20 degrees in 13 patients (21.7%), 20 to 25 degrees in 4 patients and 25 to 30 degrees in 3 patients (5.0%) (Table 9).

3.5.4. Degree of sagittal angulations after treatment: It was < 5 degrees in three patients (5.0%), 5 to 10 degrees in 11 patients (18.3%), 10 to 15 degrees in 22 patients (36.7%), 15 to 20 degrees in 12 patients (20.0%), 20 to 25 degrees in 10 patients (16.7%) and 25 to 30 degrees in 2 patients (3.3%) (Fig. 8).
3.5.5. **Limb length difference after treatment:** It was < 1 cm in three patients (5.0%), 1 to 2 cm in 32 patients (53.3%), 2 to 3 cm in 19 patients (31.7%) and > 3 cm in one patient (1.7%) (Table 10).

3.5.6. **Partial weight bearing:**

Fifteen patients (25.0%) started partial weight bearing at 4 to 6 weeks, 30 patients (50.0%) at 6 to 8 weeks, 10 patients (16.7%) at 8 to 10 weeks and 3 infant (5.0%) younger than the walking age (Fig. 9).

3.5.7. **Full weight bearing:** Three patients started full weight bearing at 4 to 6 weeks, 12 patients (20.0%) at 6 to 8 weeks, 24 patients (40%) at 8 to 10 weeks and 18 patients (30%) at 10 to 12 weeks (Table 11).

3.6. **Complications after final assessment:**

In 17 patients (28.3%), no complication was detected. Shortening occurred in seven patients (11.7%), angulations in 2 patients (3.3%) limping in three patients (5.0%), rotational deformity in one patient (1.7%), shortening and limping in 18 patients (30.0%). In three patients, (5.0%) there were shortening, angulations, limping and rotation. Shortening, limping and rotation in two patients (3.3%). Shortening, limping and angulations in six patients (10.0%). Shortening and angulations in one patient (1.7%) (Table 12).
Table 1: Age group in years

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<thead>
<tr>
<th>Age</th>
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<td>&lt;6 months</td>
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<tr>
<td>6 months to 6 years</td>
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<td>38.3</td>
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<tr>
<td>6 -11 years</td>
<td>27</td>
<td>45.0</td>
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<tr>
<td>&gt; 12 years</td>
<td>8</td>
<td>13.3</td>
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<td>Total</td>
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Table 2: Previous medical diseases

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<tr>
<td>Condition</td>
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<td>Percentage</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------</td>
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<tr>
<td>no previous medical history</td>
<td>54</td>
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<tr>
<td>Marbel Bones disease</td>
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<td><strong>Total</strong></td>
<td><strong>60</strong></td>
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Table 3: Time lapse between injury and presentation

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<th>Frequency</th>
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<tr>
<td>Within the first 24 hours.</td>
<td>49</td>
<td>81.5</td>
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<tr>
<td>Within the first week.</td>
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<tr>
<td>After the first week</td>
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<td>Total</td>
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Table 4: Level of the Fracture

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<tr>
<td>proximal third</td>
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<td>middle third</td>
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<td>distal third</td>
<td>4</td>
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Table 5: Type of displacement

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<td>backward or forward</td>
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<td>3.3</td>
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<td>100.0</td>
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<tr>
<td>Type of traction</td>
<td>Frequency</td>
<td>Percentage</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------</td>
<td>------------</td>
</tr>
<tr>
<td>gallows</td>
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<tr>
<td>balanced skin traction</td>
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<tr>
<td>Total</td>
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Table 6: Types of traction
Table 7: The duration of traction

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<th>Duration</th>
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<td>21.0</td>
</tr>
<tr>
<td>8 weeks</td>
<td>1</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Table 8: Complications of traction

<table>
<thead>
<tr>
<th>Complication</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>21</td>
<td>36.3</td>
</tr>
<tr>
<td>pneumonia</td>
<td>2</td>
<td>3.6</td>
</tr>
<tr>
<td>skin ulceration</td>
<td>7</td>
<td>12.2</td>
</tr>
<tr>
<td>joint stiffness</td>
<td>10</td>
<td>18.0</td>
</tr>
<tr>
<td>constipation and joint stiffness</td>
<td>3</td>
<td>5.3</td>
</tr>
<tr>
<td>skin ulceration and stiffness</td>
<td>12</td>
<td>21.0</td>
</tr>
<tr>
<td>constipation, bronchopneumonia and joint stiffness</td>
<td>2</td>
<td>3.6</td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Table 9: The degree of coronal angulations after treatment

<table>
<thead>
<tr>
<th>Angulations</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 5 degree</td>
<td>6</td>
<td>10.0</td>
</tr>
<tr>
<td>Angle Range</td>
<td>Frequency</td>
<td>Percentage</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
<td>------------</td>
</tr>
<tr>
<td>6 to 10 degree</td>
<td>17</td>
<td>28.3</td>
</tr>
<tr>
<td>11 to 15 degree shortening</td>
<td>17</td>
<td>28.3</td>
</tr>
<tr>
<td>16 to 20 degree</td>
<td>3</td>
<td>5.0</td>
</tr>
<tr>
<td>21 to 25 degree</td>
<td>4</td>
<td>6.7</td>
</tr>
<tr>
<td>26 to 30 degree</td>
<td>3</td>
<td>5.0</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 10: Limb length differences after treatment
<table>
<thead>
<tr>
<th>Size</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 1.9cm</td>
<td>32</td>
<td>53.3%</td>
</tr>
<tr>
<td>2 to 3cm</td>
<td>19</td>
<td>31.7%</td>
</tr>
<tr>
<td>&gt;3cm</td>
<td>1</td>
<td>1.7%</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
<td>8.3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>60</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>
Table 11: Time at which the patients start Full weight bearing.

<table>
<thead>
<tr>
<th>Weight bearing</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 to 6 weeks</td>
<td>3</td>
<td>5.4</td>
</tr>
<tr>
<td>6 to 8 weeks</td>
<td>12</td>
<td>21.3</td>
</tr>
<tr>
<td>8 to 10 weeks</td>
<td>24</td>
<td>42.1</td>
</tr>
<tr>
<td>10 to 12 weeks</td>
<td>18</td>
<td>31.2</td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 12: Complications at final assessment

<table>
<thead>
<tr>
<th>Complication</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>17</td>
<td>28.3</td>
</tr>
<tr>
<td>shortening</td>
<td>7</td>
<td>11.7</td>
</tr>
<tr>
<td>angulation</td>
<td>2</td>
<td>3.3</td>
</tr>
<tr>
<td>limping</td>
<td>3</td>
<td>5.0</td>
</tr>
<tr>
<td>rotational deformity (tortion)</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>Condition</td>
<td>Count</td>
<td>Percentage</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-------</td>
<td>------------</td>
</tr>
<tr>
<td>shortening and limping</td>
<td>18</td>
<td>30.0</td>
</tr>
<tr>
<td>shortening, angulation, limping and rotation</td>
<td>3</td>
<td>5.0</td>
</tr>
<tr>
<td>shortening, limping and rotation</td>
<td>2</td>
<td>3.3</td>
</tr>
<tr>
<td>shortening, limping and angulation</td>
<td>6</td>
<td>10.0</td>
</tr>
<tr>
<td>shortening and angulation</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>60</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>
Figure 1: Sex distribution for the patients with femoral shaft fractures

- Male: 67%
- Female: 33%
Figure 2: Mechanism of injury for the children with femoral shaft fractures

- Fall from a height: 31.7%
- Direct blow: 20%
- Involve in sport injury: 13.3%
- Involve in R.T.A: 31.7%
- Slipped: 3.3%
Figure 3: Affected limb in children with femoral shaft fractures

- Right: 48.3%
- Left: 48.3%
- Both: 3.3%
Figure 4: Initial deformity

- Yes; 53
- No; 7
Figure 5: Associated injuries

- No other injuries: 78%
- Head injury: 15%
- Tibial fracture on the same side: 3%
- Abdominal injury: 2%
- Perineal and vaginal tear: 2%

Diagram: Pie chart showing the distribution of associated injuries.
Figure 6: Pattern of fractures

- Transverse: 35%
- Spiral: 31.7%
- Spiral: 26.7%
- Spiral: 6.7%
Figure 7: Grading of callus formation after removal of traction

- No traction was used
- Grade 0
- Grade 1
- Grade 2
- Grade 3

Percentages are indicated by the height of the bars.
Figure 8: Degree of sagittal angulations after treatment
Figure (9): Partial weight bearing
Discussion

Clinical presentation

It becomes obvious from this study that femoral shaft fractures in children are relatively common. The clinical presentation is comparable to that mentioned in the literature. The male to female ratio of femoral fracture is 2.6:1 with bimodal distribution. The first peak occurs in early childhood, the second in mid-adolescence. This study showed that the gender distribution of the patients was 40 boys and 20 girls with male to female ratio 2:1. The greater numbers of boys was thought to be explained by the fact that they indulge into higher risk activities. The highest incidence was in the age group between 6 to 11 years (45%) which is typical for the second peak of the incidence and this is the group best managed by conservative method. We get infrequent fractures in the age group < 6 months i.e. younger than the walking age, which is supposed to be the first peak. This is probably because most of the fractures in this age group are due to child abuse and this phenomena is rare in our community.

Most of the injury was equally the result of road traffic accident and a fall from a height (31.7%) for each. These mechanisms of injury indicate the significant trauma required to fracture the femur.
Most patients presented immediately within the first 24 hours 81.7%, the other present within the first week and rare after that. This is because children needed special care and urgent management and these were well appreciated by most parents probably due to improvement of the level of health education and general awareness. Those who presented after the first week; were usually from distant areas or referred from other hospital.

The study showed that children with femoral shaft fractures are usually free from previous illness; 90% had no history of any medical disease. The rest of the patients had benign cyst, poliomyelitis, fibrous dysplasia, and Marbel bones disease, fracture other limb or nephrectomy. This is in accordance with the literature, which prove that pathological femoral fractures are relatively rare in children\(^{(1)}\).

The fractures were closed in the majority of patients 93.3% and open fractures only in 6.7%. This is may be related to the mechanism of injury, open fractures usually resulted from direct blow injury.

In most patients, there was initial deformity (88.3%), only minority (11.7%) had no obvious deformity perhaps they were subjected to low energy trauma and those were the children who got the fractures during sport injury.

The fractures were not associated with neurovascular injury, this could be because the femoral shaft well padded with muscles and most of the injuries
were closed fractures. Most of the fractures (78.3%) were isolated injuries. They were associated with head injury in (15%) and this happened when the mechanism of injury was due to road traffic accident.

**Radiological Appearance**

Radiographic evaluations include the entire femur and the hip and knee in two views antero-posterior and lateral plane were done in all patients. The study showed that the most common femoral fractures in children is a simple transeverse, closed diaphyseal, noncommminuted fracture which is the typical radiological appearance to those mentioned in the literature and similar to the result in a study done in Abha and Asir hospital in a Saudi Arabian population by (Tarek Mirdad)\(^9\). In 53.3%, it was in the middle third and transeverse in 35.0%, followed by oblique fractures 31.7%, spiral in 26.7% and commonuted in 6.7%.

**Management and follow up**

In the majority of patients, the fractures were displaced 96.6%; and only two patients had no shift. This makes traction necessary in 57 patients 95.0%. Immediate spica casting was done in three patients 5.0%; the 2 undisplaced fractures plus a minimally displaced fracture and their age was younger than 6 years. Skin traction was used in all patients who needed traction. It was supported by spica cast in four patients 6.7%. It appeared from this study that
spica cast was infrequently used because it is poorly tolerated especially we have a hot weather during most of the year. So a great number of patients completed the whole period of treatment in traction.

Two problems were noted during follow up of these patients in the wards; the first was the maintenance of traction in the proper position. This was very difficult and required careful monitoring. The second was the lack of a portable X-ray machine. We had to send the patients to the radiology department in traction.

**Outcome of Conservative Management**

Most reports in the literature concentrate on three main clinical measures of outcome: the speed of healing, complication rate and incidence of joints stiffness and deformity. These primarily affected by the age of the child and the degree of displacement in the form of angulations and shortening. Most patients 93.3% had clinical and radiological union after removal of traction or spica; 56.7% grade two callous formations usually in the fifth or sixth week. The outcome of children treated by immediate spica cast is excellent and this was expected because they were in the age best managed by this method, their fractures were not displaced i.e. telescope test <30 mm (negative) which is prognostic test. The fractures healed very rapidly without residual deformity. Twenty-five millimeters was used as the upper limit of acceptable overlap of
fracture fragments. This was derived from the expectation of approximately 11 mm of overgrowth and 2.5 mm or 10% magnification error from the radiograph subtracted from 25 mm leaving a final leg length discrepancy of approximately 12 mm. It is generally accepted that a leg length discrepancy greater than 10 to 15 mm places the patient at risk of having limp, back pain, and or osteoarthritis of the hip\(^{19}\).

The majority of patients were treated by skin traction 57 patients 95.0%, following traction four of the fractures immobilized in a plaster spica. The outcome of both were more or less the same apart from short hospital stay when using spica. Satisfactory outcome was achieved in 53 patients (88.1%) and 3 patients (11.9%) had unacceptable outcome by the definition of more than 3 cm overlap of fracture fragments and angulations < 20 degree in the coronal plane and up to 25 degree in the sagittal plane in the established literature. According to the study done by Wallace and Hoffman, an average 85% correction in 28 children who had angular deformities of 10 to 26 degrees after unilateral fractures of the middle third of the femoral shaft. Most correction (74%) occurred at the physis; 26% occurred at the fracture. These authers concluded that in children younger than 13 years of age, malunion of as much as 25 degree in any plane would remodel enough to give normal alignment of the joint surfaces. Another study which supports this is the one done by Rosemary A.
Davies, Mathias J. C. Stanislas and H. P. John Walsh (1998)⁴⁰, the Tobruk splint was described as being a traditionally applied Thomas Splint with a plaster of Plaster cast applied over the bandaging to give additional support. It was this system of management that seen by the orthopaedic surgeons in Liverpool to be a way in which children with fractured femurs could be nursed at home. The evidence from this review suggests that any loss of position corrects itself in the remodeling process with no long-term disadvantage to the patient. This evidence has increased the confidence of consultants in this method of management, and led to a reduction in the number of patients returning for check X-rays and a further reduction in the length of in-patient stay.

The commonest complication of skin traction was joints stiffness mainly the knee joint that occurred in 20% of patients. Skin problems occurred in 11.7%, usually result from adhesive plaster used in traction.

Healing time of femur shaft fractures that have been treated by conservative methods seems to be related to the age of the child. In older children, mean healing time was reported to be 9 and 11 weeks in two different studies. In younger children, mean healing time was reported as 6 weeks (³). In this study, a significant amount of callus was seen after a period of 6 to 8 weeks, and the mean radiographic complete healing time was 10 weeks in older
children and 6 weeks for younger children. This is comparable with a study done by Haluk Agus, Onder Kalenderer, Gurkan Eryanilmaz and Hakan Omeroglu (2003)\(^3\). After ensuring clinical and radiological union, the traction or spica were removed. In addition, the child often started partial weight bearing after grade two callus formations. Fifteen patients 25.0% started partial weight bearing at 4 to 6 weeks. Thirty patients 50.0% began to walk with support at 6 to 8 weeks. Ten patients (16.7%) became able at eight to 10 weeks. Three infants (5.0%) were younger than the walking age.

Full weight bearing usually allowed after grade three callus formations. Another factor that should be considered here is the pattern of fracture. Children with stable fractures; transverse and short oblique fractures started to walk earlier than those having unstable fractures; spiral and comminuted fractures. Few patients 5.0% started to walk earlier. Twenty-four patients 40% started full weight bearing at 8 to 10 weeks. Eighteen patients 30% began at 10 to 12 weeks. The remainders were able to walk between 10 to 12 weeks. Limping was a common complication observed, when the child with femoral fracture resume walking. It is considered common in the first month because the hip girdle musculature regains its strength only slowly. No physical therapy was required, however, because normal walking permits spontaneous recovery and long-term results of pediatric femur fractures are excellent.
Conclusion

1 The main goal of this study was to evaluate the outcome of conservative treatment of femoral shaft fractures in children and establish a record for clinical presentation, radiological features.

2 Males were affected more than females with the ratio 2:1. The highest incidence in the age group 6 to 11 years. It equally resulted from road traffic accident and a fall from heights.

3 The fracture was commonly an isolated, simple, transverse, closed diaphyseal injury.

4 The majority of patients were treated by skin traction. In four of them the fracture was supported by spica. Three children with undisplaced fractures were treated by immediate spica casting.

5 Clinical review of children confirms that skin traction is an effective method of management and there were no major complications. The outcome of conservative treatment for these patients had excellent to satisfactory results in most patients (88.1%).
Recommendations

6 Conservative methods should be tried first especially in children below 10 years unless there is clear indication for surgery.

7 Young infants have outstanding remodeling potential at the fracture site, which makes perfect reduction unnecessary, and their natural position is one of substantial flexion at the hips because of their position in utero. For this age group introduction of new method like Pavlik harness is recommended.

8 Skin traction is an effective conservative method, which is suitable for our hot weather but careful monitoring especially in the first weeks by portable x-rays.

9 Immediate spica casting gives excellent result in young children with non-displaced fractures.

10 To shorten child hospital stay operative treatment by flexible nail, external fixater or plate and screws should be encouraged in our children femur fractures treatment.
REFERENCES


University of Khartoum

Postgraduate Medical Studies Board

Orthopaedic Department

Femoral shaft fractures in Sudanese Children: Presentation, Radiographic appearance and Outcome of Conservative Management

K.T.H.


1. Name:______________________________________

2. Serial number:___________________ Date of trauma:_____________

3. Age:___________________________

4. Sex:___________________________

5. Address:________________________ Telephone:________________

6. Previous medical disease?

   a. Spina bifida.

   b. Osteogenesis imperfecta.

   c. Benign bone cyst.

   d. Tumour.

   e. Others ( _______________________________ ).
7. Mechanism of injury?
   a. Fall from a height.
   b. Direct blow.
   c. Involved in sport injury.
   d. Involved in R.T.A.
   e. Others (______________________________).

8. Time lapse between injury and presentation?
   a. Within the first 24 hours.
   b. Within the first week.
   c. After the first week.

9. Affected limb?
   a. Right.
   b. Left.
   c. Both.

10. Closed or open fracture?
    a. Closed.
    b. Open.

12. Initial deformity?
    a. Yes.
    b. No.
13. Associated vascular injury?
   a. Yes.
   b. No.

14. Presence of other injuries?
   a. Pelvic fracture.
   b. Tibial fracture on the same side.
   c. Head injury.
   d. Multiple injuries.
   e. Others (_________________________).

15. Comment on presentation.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Radiological Assessment

16. Fracture site:
   a. Proximal third.
   b. Middle third.
   c. Distal third.

17. Fracture type:
a. Transverse.
b. Oblique.
c. Spial.
d. Comminuted.

18. Shift:
   a. Sidways.
   b. Backward or forward.

19. Altered length:
   a. Ovelap.
   b. Impaction.

20. Rotation:
   a. Yes.
   b. No.

21. Coronal angulations after treatment (__________). 
22. Sagittal angulations after treatment (__________). 
23. Limb length differences after treatment (__________). 

24. Comment on radiological features.

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
Causality Management

25. Was traction necessary?
   a. Yes.
   b. No.

26. Type of traction?
   a. Gallows.
   b. Balanced skin traction.
   c. Skeletal traction.

27. Duration of traction?
   a. < 1 week.
   b. Two weeks.
   c. Three weeks.
   d. > three weeks.

28. Complication of traction:
   a. None.
   b. Pneumonia.
   c. Skin ulceration.
   d. U.T.I.
   e. Constipation.

29. Was the fracture supported by hip spica?
a. Yes.

b. No.

30. If yes, for how long?

  a. Two weeks.
  
  b. Three weeks.
  
  c. > three weeks.

**Final Assessment**

31. Signs of union; clinically after treatment?

  a. Good.
  
  b. Poor.

32. Signs of union; radiologically after treatment, grading of callus formation

  a. G0.
  
  b. G1.
  
  c. G2.
  
  d. G3.

33. Hip joint stiffness?

  a. Yes.
  
  b. No.

34. Knee joint stiffness?
a. Yes.

b. No.

35. Weight bearing. When?

   a. Partial (_________).

   b. Full (_________).

36. Complication at final assessment:

   a. None.

   b. Shortening.

   c. Angulation.

   d. Limping.

   e. Rotational deformity (tortion).
Treatment approach to paediatric femoral fractures