# Treatment of the fracture of femur in children at the age 6-12 yrs old review of literature

## Graduation Research

## College of Medicine

## Al- Nahrain University

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# Abstract

**Background**: Fractures of the femur are common problems among children as well as adults, our study aim for proper selection of modality of treatment for a femoral shaft fractures among children.

The management of femoral shaft fractures in children is largely directed by the age and built of the child. There is wide consensus on the non-operative treatment of children less than six years of age. Operative treatment is recommended for children more than 12 years of age, only the surgical options vary. The age group of 6-12 years remains a controversial area with multiple studies advocating different lines of treatment.

**Aim :** To study the method of Treatment of the fracture of femur in children at the age 6-12 yrs old

**Patients and methods:** All patient were diagnosed by orthopedic surgeon in hospital . Information collected from records of **30** patient randomly

**Conclusion :** The treatment modalities included early or immediate hip spica , traction alone, external fixator, plating (open/minimally invasive), intramedullary nailing- rigid/flexible and intramedullary Kirschner wire. The short listed articles were studied for rate and time of union, complications such as non-union and malunion, leg length discrepancy, infection, implant impingement, refracture and cost analysis. Operative treatment is usually the preferred treatment option in this age group, as it decreases hospitalization time, decreases morbidity and allows early return of child to school. Flexible intramedullary nailing is recommended for length stable fractures. Submuscular bridge plating (minimally invasive) is reserved for comminuted fractures. External fixator is reserved for open fractures and initial stabilization of femoral shaft fractures in polytrauma pediatric patients. Intramedullary K wire is a viable option in resource constrained centers where specialized implants and instrumentation is not available.

# -Chapter One –
# Inotrduction

**Aim :** To study the method of Treatment of the fracture of femur in children at the age 3-12 yrs old

Most paediatric femoral shaft fractures unite rapidly regardless of the fracture type, location and treatment given. However suboptimal outcomes in the form of malunion, delayed union, limb length discrepancy and growth disturbances are known [(1)]. Therefore the management of femoral shaft fractures in children is largely directed by the age, fracture pattern, associated injuries and social and economic situation of the child and family. As the treatment methods have evolved, the trend has been moving away from non operative methods such as traction and spica casting towards operative methods such as external fixation, open/minimally invasive plating, and flexible/rigid intramedullary nailing. Each method has its set of advantages and disadvantages [(2)].

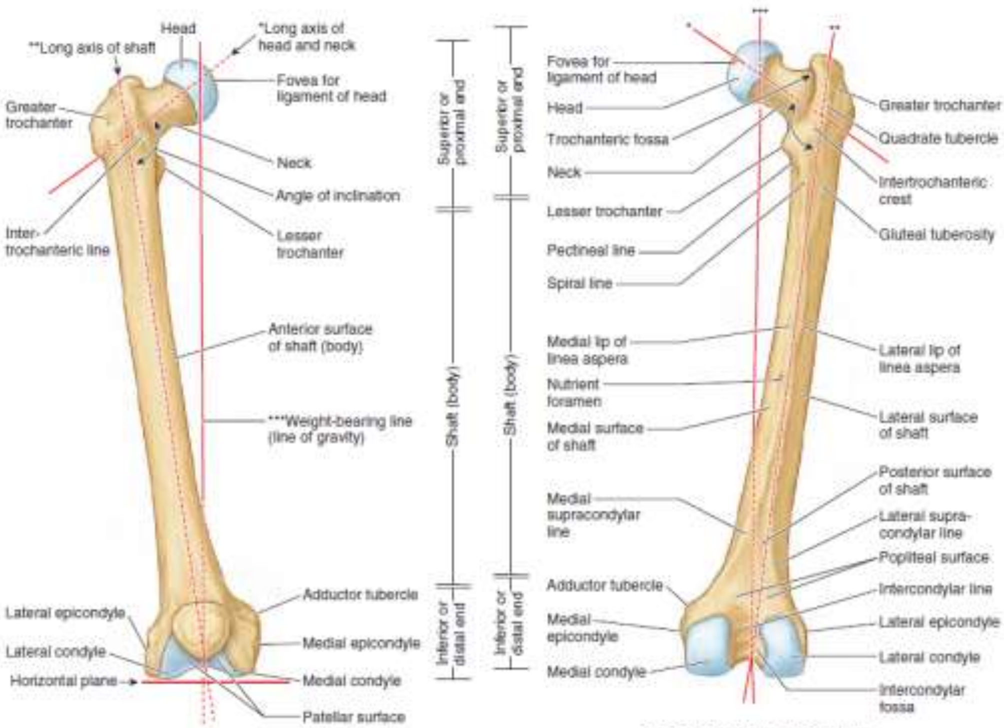
There is a broad consensus on the non operative treatment of paediatric femoral shaft fractures, in the form of spica casting with or without initial traction, in children less than six years of age. Operative treatment, usually in the form of rigid intramedullary nailing or plating is recommended for children more than 12 years of age. The age group of 3-12 years remains a controversial area with multiple studies advocating different lines of treatment ranging from immediate spica casting to rigid intramedullary nail fixation [(2)].

# Femur Anatomy

The femur is the longest and heaviest bone in the body. Its composed an articular head which is a ball like structure that articulates with the acetabulum composing the hip joint ,the neck (which separate the head from the shaft ),two lateral structure in the cephalic end of the shaft that serve for muscular insertion which are the greater and lesser trochanters , the shaft , and medial and lateral condyles at the caudal part of the bone.

Like any longbone , the ends are composed of spongy (cancellous)

Bone and the shaft is composed of compact bone (3).



(A) Anterior view of right femur (B) Posterior view of right femur

Blood supply :-the femoral head is supplied by vessels in the ligament of the femoral head , capsular vessels (from the joint capsule) , and nutrient vessels from the femoral shaft .the shaft of femur is supplied by multiple branches of the femoral artery that penetrates the diaphyseal periosteum (periosteal arteries ) and the femoral condyles are supplied by branches of both the femoral and the popliteal arteries[4]

## Femoral Shaft Fractures

The femoral shaft is circumferentially padded with large muscles. This provides advantages and disadvantages:
reduction can be difficult as muscle contraction displaces the fracture; however, healing potential is improved by having this well-vascularized sleeve containing a source of mesenchymal stem cells, and openfractures often need no more than split thickness skin grafts to obtain satisfactory cover [5].

## Mechanism of injury

In children under 4 years thepossibility of physical abuse must be kept in mind. Fracture patterns are clues to the type of force that produced the break. A *spiral fracture* is usually caused by a fall in which the foot is anchored while a twisting force is transmitted to the femur [6].
*Transverse* and *oblique fractures* are more often due to angulation or direct violence and are therefore particularly common in road accidents. With severe violence (often a combination of direct and indirect forces) the fracture may be *comminuted*, or the bone may be broken in more than one place (*a* segmental fracture)
*Pathological fractures* are common in generalized disorders such as spina bifida and osteogenesis imperfecta, and with local bone lesions (e.g. a benign cyst or tumour).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# Pathological anatomy

Most fractures of the femoral shaft have some degree of comminution, although it is not always apparent on x-ray. Small bone fragments, or a single large 'butterfly' fragment, may separate at the fracture line but usually remain attached to the adjacent soft tissue and retain their blood supply. With more extensive comminution there is no point of firm contact between proximal and distal fragments and the fracture is completely unstable, This is the basis of a helpful classification (Winquist, Hansen et al. 1984). Fracture displacement often follows a predictable pattern dictated by the pull of muscles attached to each fragment [(7)].

• In *proximal shaft fractures* the proximal fragment is flexed, abducted and externally rotated because of gluteus medius and iliopsoas pull; the distal fragment is frequently adducted.

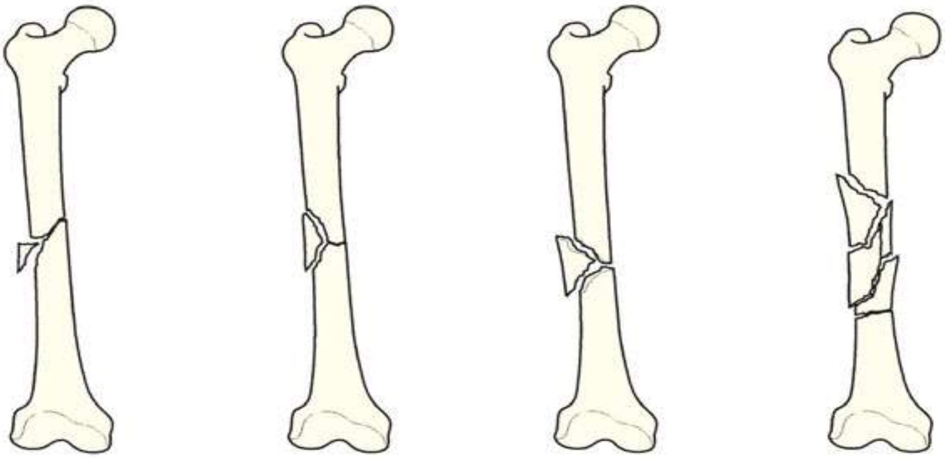
• In *mid-shaft fractures* the proximal fragment is again flexed and externally rotated but abduction is less marked.

• In *lower third fractures* the proximal fragment is adducted and the distal fragment is tilted by gastrocnemius pull [(8)].

# Femoral shaft fractures –classification

Winquist's classification reflectsthe observation that the degrees of soft-tissuedamage and fracture instability increase withincreasing grades of comminution [9].

*Type 1* there is only a tiny cortical fragment.
*Type 2*the 'butterfly fragment' is larger but there isstill at least 50 per cent cortical contactbetween the main fragments.
*Type 3* thebutterfly fragment involves more than 50 percent of the bone width.
*Type 4* is essentially asegmental fracture.



# Clinical features

There is swelling and deformity of the limb, and any attempt to move the limb is painful. With the exception of a fracture through pathological bone, the large forces needed to break the femur usually produce accompanying injuries nearby and sometimes further afield. Careful clinical scrutiny is necessary to exclude neurovascular problems and other lower limb or pelvic fractures [(10)]. An ipsilateral femoral neck fracture occurs in

about 10 per cent of cases and, if present, there is a one in three chance of a significant knee injury as well. The combination of femoral shaft and tibial shaft fractures on the same side, producing a 'floating knee', signals a high risk of multi-system injury in the patient. The effects of blood loss and other injuries, some of which can be life-threatening, may dominate the clinical picture [(11, 12)].

# X-ray

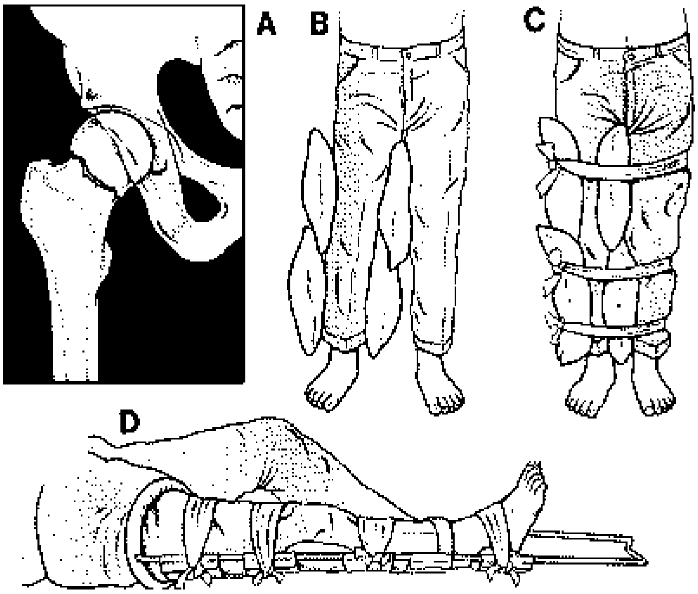
It may be difficult to obtain adequate views in the Accident and Emergency Room setting, especially views that provide reliable information on proximal or distal fracture extensions or joint involvement; these can be postponed until better facilities and easier patient positioning are possible. *But never forget to xraythe hip and knee as well* (Figure 29.21). A baseline chest x-ray is useful as there is a risk of adult respiratory distress syndrome (ARDS) in those with multiple injuries [(15)].
The fracture pattern should be noted; it will form a guide to treatment.

(a)

(b)

# Emergency treatment

Traction with a splint is first aid for a patient with afemoral shaft fracture. It is applied at the site of the accident, and before the patient is moved. A **Thomas'splint** is ideal: the leg is pulled straight and threaded through the ring of the splint; the shod foot is tied to the cross-piece so as to maintain traction and the limb and splint are firmly bandaged together. This temporary stabilization helps to control pain, reduces bleeding and makes transfer easier. Shock should be treated; blood volume is restored and maintained, anda definitive plan of action instituted as soon as the patient's condition has been fully assessed [13] .



# Definitive treatment

The choice of closed method depends largely on the age and weight of the child. As children get older (and larger), fractures take longer to heal and conservative treatment is more likely to result in problems associatedwith long hospitalization and a greater risk of malunion ,coupled tothis is the cost of protracted bed occupancy [14]. Consequently there has been a trend towards treating femoral shaft fractures in older children by operation,but the argument is flawed if this is based on cost

alone – many of these children will have to return for implant removal. Perhaps it is the risk of malunion, particularly in unstable fracture patterns, that renderssurgery a better option for older children and adolescents.

## *Traction, bracing and spica casts*

The main indications for traction are (1) fractures in children; (2) contraindications to anaesthesia; and(3) lack of suitable skill or facilities for internal fixation [5].
For young children, *skin traction* without a splint is usually all that is needed. Infants less than 12 kg in weight are most easily managed by suspendingthe lower limbs from overhead pulleys *('gallows traction')*, 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'straction* or use of a *Thomas' splint*. Fracture union will have progressed sufficiently by 2–4 weeks (depending on the age of the child) to permit a *hip spica* to be applied and the child is then allowed up. Consolidation is usually complete by 6–12 weeks [7].

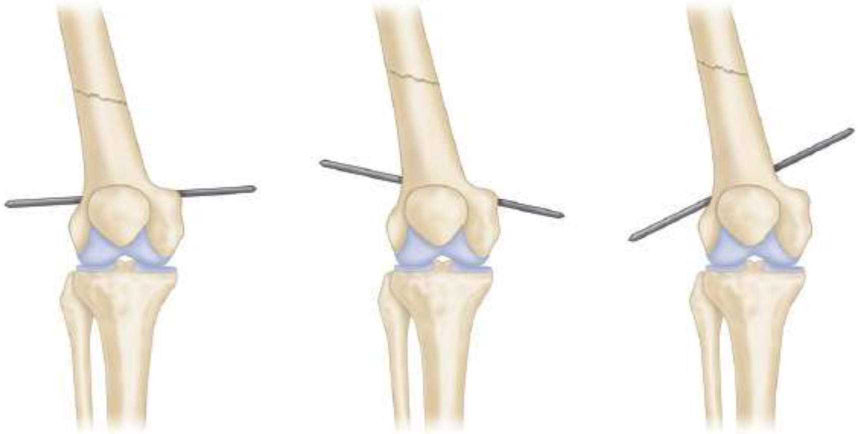


FIGURE 36-137 Position of pin in traction is either horizontal (optimal) or oblique. Oblique pins are either "to varus" or "to valgus," reflecting resultant pull of traction bow.

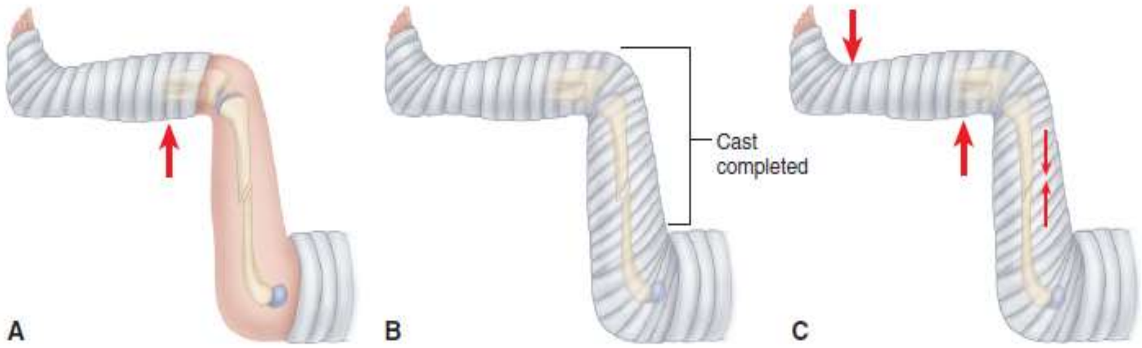



FIGURE 36-138 Pathogenic factors of traction, elevation, and pressure during the application of a short-leg cast used for traction can cause compartment syndrome. **A,** Below-knee cast is applied while patient is on spica frame. **B,** Traction is applied to the short-leg cast to produce distraction at the fracture site. The remainder of the cast is applied, fixing the relative distance between the leg and torso. **C,** After the child awakens from general anesthesia, there is shortening of the femur from muscular contraction, which causes the thigh and leg to slip somewhat back into the spica. This causes pressure at the corners of the cast *(arrows).*

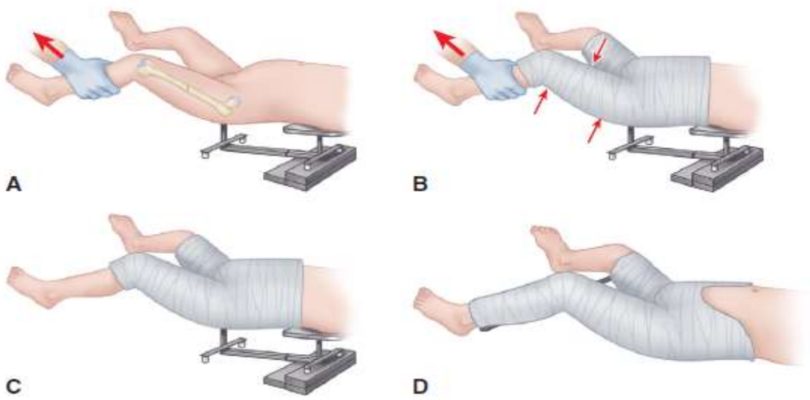
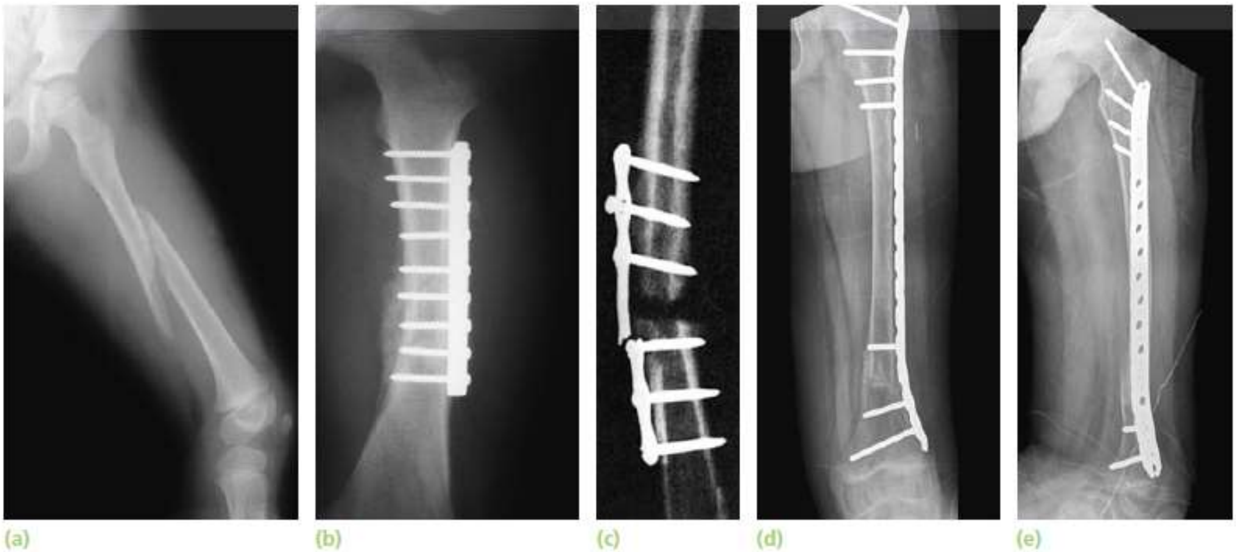



FIGURE 36-139 Technique of spica cast application. **A,** The patient is placed on a child's fracture spica table. The leg is held in about 45 degrees of flexion at the hip and knee, with traction applied to the proximal calf. **B,** The one and one-half spica cast is applied down to the proximal calf. Molding of the thigh is done during this phase. **C,** Radiographs of the femur are obtained, and any necessary wedging of the cast can be done at this time. **D,** The leg portion of the cast and the cross-bar are applied. The belly portion of the spica cast is trimmed to the umbilicus.

***Plate and screw fixation*** Plating is a comparatively easy way of obtaining accurate reduction and firm fixation. The method was popular at one time but went out of favour because of a high complication rate. This occurred when plates were applied through a wide open exposure of the fracture site and perfect anatomical reduction of all bone pieces. Such extensive surgery damaged the healing potential and led to tardy union and implant failure [9]. However, plates have encountered resurgence: today, they are inserted through short incisions and placed in a submuscular plane, rather than deep to periosteum; an indirect (closed) reduction of the fracture is done; fewer screws are used, and usually placed at the ends of the plate, leading to a less rigid hold on the fracture. This technique of *minimally invasive plate osteosynthesis(MIPO)* has led to better union rates. However, postoperative weightbearing will need to be modified as the implant is not as strong as an intramedullary nail. **The main indications for plates are**[10] (1) fractures at either end of the femoral shaft, especially those with extensions into the supracondylar or pertrochanteric areas, (2) a shaft fracture in a growing child, and (3) a fracture with a vascular injury which requires repair




29.24 Plate fixation – past and present (a,b) Plate fixation was popular in the past, but it fell out of favour because of the high complication rate (c). Modern techniques of minimally invasive plate osteosynthesis (d,e) have shown that it still has place in the treatment of certain types of femoral shaft fracture.

***Intramedullary nailing*** Intramedullary nailing is the method of choice for most femoral shaft fractures. However, it should not be attempted unless the appropriate facilities and expertise are available [11]. The basic implant system consists of an

intramedullary nail (in a range of sizes) which is perforated near each end so that locking screws can be inserted transversely at the proximal and distal ends; this controls rotation and length, and ensures stability even for subtrochanteric and distal third fractures

***Open medullary nailing*** is a feasible alternative where facilities for closed nailing are lacking. A limited lateral exposure of the femur is made; the fracture is reduced and a guidewire is passed between the main proximal and distal fragments. A small exposure toachieve reduction does not significantly affect the risk of complications or fracture healing as compared to 'closed' nailing [22].


29.25 Intramedullary nailing Nowadays this is the commonest way of treating femoral shaft fractures. Ideally a range of designs to suit different types of fracture should be available. (a,b) Antegrade nailing with insertion of the nail through the pyriform fossa and transverse locking screws proximally and distally. (c) Retrograde nailing with insertion of the nail through the intercondylar notch at the knee – useful for obese patients and those with bilateral femoral fractures. (d,e) Proximal locking can be achieved in other ways e.g. by using parallel screws or a sliding hip screw

***External fixation*** The main indications for external fixation are (1) treatment of severe open injuries; (2) management of patients with multiple injuries where there is a need to reduce operating time and prevent the ‘second hit’; and (3) the need to deal with severe bone loss by the technique of bone transport. External fixation is also useful for (4) treating femoral fracturesin adolescents [16]

Like closed intramedullary nailing, it has the advantage of not exposing the fracture site and small amounts of axial movement can be applied to the bone by allowing a telescoping action in the fixator body (with some designs of external fixator). As the callus increases in volume and quality, the fixator canbe adjusted to increase stress transfer to the fracture site, thus promoting quicker consolidation. However, there are still problems with pin-site infection, pin loosening and (if the half-pins are applied close tojoints) limitation of movement due to interference with sliding structures [17].

The patient is allowed up as soon as he or she is comfortable and knee movement exercises are encouraged to prevent tethering by the half pins. Partial weightbearing is usually possible immediately but this will depend on the x-ray appearance of callus –this may take some time (more than 6 weeks) if the fixator is a rigid device. Most femoral shaft fractures will unite in under 5 months but some take longer if the fracture is badly comminuted or contact between fracture ends is poor [19].


29.26 External fixation for femoral shaft fractures in older children (a–c) External fixation is an option for treating femoral shaft fractures in adolescents. Elastic stable intramedullary nails shown in Fig 29.31 may not be strong enough for this heavier group of teenagers.

*Traction and casts Infants* need no more than a few days in balanced traction, followed by a spica cast for another 3–4 weeks. Angulation of up to 30 degreescan be accepted, as the bone remodels quite remarkably with growth. Immediate spica casting has also found favour and this approach does not appear to increase the risk of complications [4, 5].

*Children between 2 and 10 years of age* can be treated either with balanced traction for 2–3 weeks followed by a spica cast for another 4 weeks, or by
early reduction and a spica cast from the outset. Shortening of 1–2 cm and angulation of up to 30 degrees are acceptable [7].

*Teenagers* require somewhat longer (4–6 weeks) in balanced traction, and those aged over 15 (or even younger adolescents if they are large and muscular) may need skeletal traction [23]. Once the fracture feels firm, traction is exchanged for either a spica cast (in the case of upper third and mid-shaft fractures) or a cast-brace (for lower third fractures), which is retained for a further 6 weeks. The position should be checked every few weeks; the limit of acceptable angulation in this age group is 15 degrees in the anteroposterior x-ray and 25 degrees in the lateral [4].

If a satisfactory reduction cannot be achieved by traction, internal (plates or flexible intramedullary nails) or external fixation is justified. This applies to older children and those with multiple injuries [24, 25 ,26].

*Operative treatment* This is growing in popularity as there is: (1) a shorter in-patient stay (and for the child, a quick return home); (2) a lower incidence of malunion [27,28] .

Against this is the added risk of surgery, taking into account that many such fractures have good results when treated non-operatively. The tendency to adopt this approach in older children and adolescents may be justified. Surgical options include fixation with flexible intramedullary nails or trochanteric entry-point rigid nails with interlocking screws (neither of which damages the physes), plates inserted and external fixation [29 ,30] .

# Complications of femoral shaft fractures

## Early [18]

—

— **1-** ***Shock*** ***One or two litres of blood can be lost even*** **with a closed fracture, and if the injury is bilateral**

— **shock may be severe. Prevention is better than cure;**

— **most patients will require a transfusion [18].**

— **2-** ***Fat embolism and ARDS***

—

— ***Fracture through a large marrow*****-filled cavity almost inevitably results in small showers of fat emboli being**

— **swept to the lungs [31]. This**

— **can usually be accommodated without serious consequences,**

— **but in some cases (and especially in those with multiple injuries and severe shock, or in patients with associated chest injuries) it results in progressive respiratory distress and multi-organ failure (adult respiratory distress syndromeas shortness of breath, restlessness or a rise in temperature or pulse rate should prompt a search for petechial haemorrhages over the upper body, axillae and conjunctivae [32,33,34].**

— **Treatment is supportive, with the emphasis on preventing hypoxia and maintaining blood volume.**

— **3-** ***Thromboembolism Prolonged traction in bed predisposes***

— **to thrombosis. Movement and exercise are important in preventing this, but high-risk patients should be given prophylactic anticoagulants as well [35].**

—

— **4- infection**

— **In open injuries, and following internal fixation,**

— **there is always a risk of infection.**

# Late complications

— 1- Delayed union and non-union The time-scale for declaring a delayed or non-union can vary with the type of injury and the method of treatment. If there is
— failure to progress by 6 months, as judged by serial
— x-rays, then intervention may be needed[36]

2- Malunion Fractures treated by traction and bracing
— often develop some deformity; no more than 15 degrees of angulation should be accepted [37].

— 3- *Joint stiffness The knee is often affected after a*
— femoral shaft fracture. The joint may be injured at the
— same time, or it stiffens due to soft-tissue adhesions
— during treatment; hence the importance of repeated
— evaluation and early physiotherapy [38].

— 4- *Refracture and implant failure Fractures which heal*
— with abundant callus are unlikely to recur. By contrast,
— in those treated by internal fixation, callus formation
— is often slow .

# -Chapter Two–

## Patients and methods

This study was done in al-kadhemiya hospital in orthopedic ward in the period between **November** 2018- **March** 2019.

All patient were diagnosed by orthopedic surgeon in hospital . Information collected from records of **30** patient randomly depend on data according to following :

1-Age .

2-Gender .

3-Side of fracture .

4- Type of treatment (conservative or operative ) .

5-type of operation (internal or external fixation ) .

6-Incidence of knee joint stiffness .

# -Chapter THREE-

# Result

**30 patients had femoral shaft fracture :**

1-According to age the high percent about 60 % in age between 9-12 years old .
The second percent in group between 6-9 years old (40%) .

2- The incidence of femoral shaft fracture according to gender was higher in male than female about (70%) male while in female (30%).

3- According to side of injury showing right side more than the left about 63.33% while in the left side 36.67%

4- About the type of treatment show that : operative treatment has a higher incidence than conservative treatment 70 % .

5- About the type of operation show that internal fixation has a higher incidence than external fixation 76.2%

6- About the knee joint stiffness show that : the incidence of knee joint stiffness is higher in conservative treatment than operative 22.2 %

**Table (1): age distribution in femoral shaft fracture**

| **Age** | **No. of cases** | **Percentage %** |
|---|---|---|
| **6-9** | 12 | 40% |
| **9-12** | 18 | 60% |

**Table 2: sex percentage in femoral shaft fracture**

| **Gender** | **No. of cases** | **Percentage %** |
|---|---|---|
| **Male** | 21 | 70% |
| **Female** | 9 | 30% |

**Table 3: side of fracture**

| Side of fracture | N. o of cases | Percentage % |
|---|---|---|
| Right side fracture | **19** | **63.3%** |
| Left side fracture | **11** | **36.7%** |

**Table 4 : type of treatment**

| Type of treatment | N.o of cases | Percentage % |
|---|---|---|
| Conservative | **9** | **30 %** |
| Operative | **21** | **70 %** |

**Table 5 : type of operation**

| Type of operation | N.o of cases | Percentage |
| --- | --- | --- |
| Internal fixation | **16** | **76.2%** |
| External fixation | **5** | **23.8%** |

**Table 6: incidence of knee joint stiffness**

| Type of treatment | N.o of total cases | N.o of cases that develop stiffness | Stiffness % |
| --- | --- | --- | --- |
| Conservative | **9** | **2** | **22.2%** |
| Operative | **21** | **2** | **9.5%** |

# -Chapter FOUR-

## Discussion

Although femoral shaft fractures constitute less than 2% of all pediatric fractures, the choice of treatment remains a constant challenge to orthopedic surgeons. Various methods of treatment can be used successfully depending upon the age of the children and the type of fracture.

There are a wide variety of surgical and non-surgical treatment options are available as early spica casting; traction followed by cas-ting; external fixation; plate fixation; intramedullary inter-locking nails and flexible intramedullary nails with no clear consensus as to the preferred treatment.

With the potential for rapid union and remodeling in children's bones excellent results are expected after conservative treatment for pediatric femoral shaft fracture.

Conservative treatment includes traction and subsequent immobilization in an uncomfortable spica casting. This safe form of treatment has some draw backs : limb length discrepancy, angulations, loss of reduction, prolonged bed rest separates the child from his normal environment, difficulty in transporting child and high cost of bed for hospital for long period which might be able to serve other patients.

Initially surgical treatment was limited to open fractures or for patients with head injury or multiple injuries. However to avoid prolonged immobilization, loss of school days and for better nursing care the operative approach has been gaining popularity for last two decades.

Reeves et al reported that cost of non-operative treatment is 40% higher than operative treatment.

# Discussion

Our experience is that **spica casting** is an effective and reliable method for treating femoral shaft fractures in children. It had a union rate of 100%, with a 92.7% rate of normal leg length and an 85.4% complication-free rate.  the good outcome achieved with spica casting compared to the other treatment options we examined, especially those appropriate for children above 4 years of age, spica casting had more side effects (mainly contact dermatitis) and more complications (mainly more cases of re-manipulation due to loss of reduction). It also had more LLDs (>2 cm shortening or <1 cm lengthening). Nevertheless, we believe that these differences are still not convincing enough to rule out the use of spica casting, even in children above the age of 4 years, although they should be borne in mind and explained to the parents. The advantages of conservative treatment, such as the avoidance of general anesthesia on two occasions and the obviating of surgery, altogether make a compelling argument in its favor. On the other hand, the use of spica casting includes some disadvantages, such as a long period of immobilization, untoward side effects, the need for re-manipulation, and a higher risk for LLD.

## Titanium ElasticNail **(TEN technique)** :

A child whose femoral fracture is treated with the TEN technique achieves recovery milestones significantly faster than a child treated with traction and a spica cast,

and the complication rate associated with nailing compares favorably with that associated with traction and application of a spica cast

The TEN approach has some disadvantages that should be noted. One of them is that the child is expected to undergo two separate operations under general anesthesia.

other side effect of the TEN treatments was soft tissue irritation at the insertion site in one patient. The literature, however, more fully describes complications associated with TEN, such as re-fractures, delayed unions, varus or valgus malalignments, malrotation, nail tip irritations, broken interlocking screws, and proximal nail migration .

## external fixation

Our experience with external fixation shows it to be an appropriate modality for pediatric femoral fractures, especially when dealing with an open fracture and a multitrauma-injured child. There is no need to convert to internal fixation. Surgical treatment for these fractures using various fixation devices (flexible nails, plating, or antegrade trochanteric nail) yielded highly satisfactory results with few complications in children who were 8 years and older, similar to others

# -Chapter Five-

# Conclusion and Recommendations

The ideal device for the treatment of most femoral fractures in children should be a simple, load sharing internal splint that allows mobilization and maintenance of alignment and limb length until bridging callus forms. The implant should neither endanger the physis nor the blood supply to the femoral head. It should promote, rapid healing and should provide for ability to remodel.

The literature recommends flexible intramedullary nailing in this age group for length stable fractures. Submuscular bridge plating (minimally invasive) is reserved for comminuted fractures. External fixator is reserved for open fractures and initial stabilization of femoral shaft fractures in polytrauma pediatric patients. Intramedullary K wire is a viable option in resource contrainedcentres where specialized implants and instrumentation is not available. Nonoperative treatment is now a less preferred option owing to increased morbidity and higher costs involved if the entire treatment is supervised in hospital. Reamed nailing is reserved for patients older than 12 years and nearing skeletal maturity. However, the indication of type of implant to be used in this age group (6-12 years) depends upon an individual surgeon’s experience and availability of resources.

# -Chapter Six-

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