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FRACTURE REDUCTION AND INTERNAL FIXATION WITH ELASTIC STABLE INTRAMEDULLARY NAILS IN THE SKELETALLY IMMATURE PATIENT.

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Abstract: In this case study, we will analyze the reduction of a femoral fracture using elastic nails in a 12-year-old child. The choice of reduction technique and the osteosynthesis material used also present a challenge. We will also examine the post-fracture status and how the physical therapy recovery period should be managed. We will analyze the functional deficit and offer some recommendations regarding the development of an optimal rehabilitation program.

Introduction:

A femur fracture is a very serious and painful traumatic injury. The femur is one of the longest and strongest bones in the human body, and a crack or break in it is often caused by severe injury. Breaking the femur requires an extraordinary amount of force applied to the bone, and it will take several months to heal. A femur fracture requires emergency medical care. Femur fractures can also be classified based on: the location of the fracture; the site where the femur broke -distal, mid-shaft, or proximal; and the direction of the fracture - oblique, spiral, etc.

The most common types of femoral shaft fractures are:

- transverse fracture - the fracture is a straight horizontal line that runs across the femur;
- oblique fracture - the fracture has an angled line;
- spiral (spiroid) fracture - the fracture line encircles the bone's axis; this type of fracture is caused by a twisting force on the thigh;
- comminuted fracture - the bone breaks into three or more pieces;
- open fracture - bone fragments protrude through the skin or the wound extends to the broken bone; these also involve damage to the surrounding muscles, tendons, and ligaments.[15, 17]

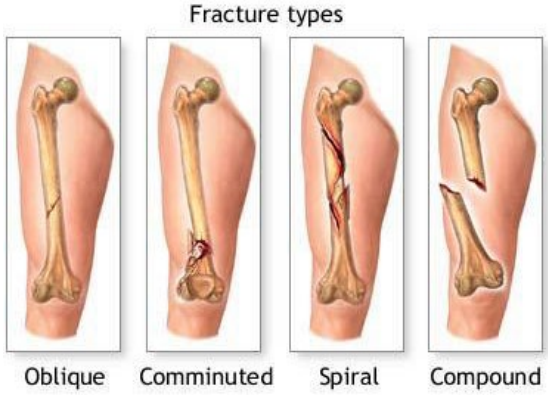

Fig.1 Types of Femoral Shaft Fractures [18]

The decision to treat a femoral shaft fracture using conservative or surgical methods is influenced by a wide range of factors, including the patient's age and weight, the type of fracture, associated injuries or multiple trauma, and the family's socio-economic status.[4]

External fixation is often used as a temporary treatment for femur fractures. Because they are easy to apply, external fixators are typically used when the patient has multiple injuries and is not ready for a more extensive surgical procedure to repair the fracture. An external fixator provides good temporary stability until the patient is stable and the final procedure can be performed. In some cases, the external fixator is left in place until the femur has fully healed, but these situations are quite rare.

Intramedullary nailing is the method of choice for treating femoral shaft fractures. In this procedure, a special metal rod is inserted into the medullary canal of the femur. The rod is inserted through a small incision at the hip or knee. It is then secured to both ends of the bone with screws. This method ensures that the rod and the bone remain in the correct position throughout the healing process.

The clinical practice guideline on pediatric diaphyseal femur fractures resulted in 14 specific recommendations in the following age groups: infants, children aged 6 months to 5 years, children aged 5 to 11 years, and children aged 11 years to skeletal maturity. The recommendations addressed treatments that include Pavlik harness, spica casts, flexible intramedullary nailing, rigid trochanteric entry nailing, submuscular plating, and pain management. [5]

Several methods have been used for the treatment of pediatric distal femoral fractures, such as elastic stable intramedullary nail (ESIN), external fixator (EF) and plate osteosynthesis, but there has been no consensus about the optimal method. [14]

Unlike when these fractures were managed with only splints, intramedullary nailing is the mainstay of treatment today. Pediatric patients are managed with flexible rods to allow for bone growth. [10]

The intramedullary nail or rod is commonly used for long-bone fracture fixation and has become the standard treatment of most long-bone diaphyseal and selected metaphyseal fractures. These implants are introduced into the bone remote to the fracture site and share compressive, bending, and torsional loads with the surrounding osseous structures. [1]

Elastic stable intramedullary nailing (ESIN) is a minimally invasive technique. According to this technique, two elastic nails are introduced through the metaphysis into the medullary canal, advanced through the fracture site and impacted into the opposite metaphysis. These nails are preformed in a C-shaped manner, which allows for their precise orientation and the creation of an elastic system that resists deformation. [13]

Fig.2 rgf. Elastic stable intramedullary nailing (ESIN) [16]

The insertion of 2 elastic stable intramedullary nails (ESINs) is a common treatment for pediatric femur fractures. However, the use of this technique in length-unstable or metadiaphyseal fractures has historically been associated with higher complication rates. [2]

The majority of complications are determined already preoperatively by the choice of treatment or implant. After exact analysis of the biomechanics and biological etiology, nonunion is dealt with by an imperative increase in mechanical stability. Additional procedures, i.e., bone graft or debridement, are incorporated into the therapeutic regime. Increasing mechanical stability should be attempted with a minimum of added trauma to avoid local biological impairment.[7]

Approximately one out of every eight distal fractures and one of every 16 shaft fractures requires re-operation. The most common cause of fixation failure is nonunion. Further research is needed to improve outcomes, particularly in distal femur fractures. [6]

Nonunion in femoral shaft facture following interlocking intramedullary nailing is related to fracture site, fracture reduction and nail diameter. The choice of reamed nails or unreamed nails depends on the fracture site and reduction degree.[8]

The complications that required unplanned surgery for either prominent nails or loss of reduction occurred more commonly in unstable non-transverse fracture patterns. The authors conclude that in patients with "length-unstable" femur fractures, consideration should be given to methods of treatment other than titanium flexible intramedullary nails. [12]

Failure of bone healing after intramedullary nailing of a diaphyseal long bone fracture is a severe complication that requires an effective management to ensure the best chances for successful bone-union and termination of a long period of incapacity and morbidity for the sufferers. Traditional procedures require removal of the existing nail and re-fixation with wider nail, plate or external fixation constructs. [3]

Complications following a femur fracture depend not only on the severity of the injury and the treatment approach, but also on the patient's age and the circumstances surrounding the fracture:

- leg length discrepancy - due to improper surgical alignment of the bone, in addition to causing disability, this increases the risk of chronic hip or knee pain;peripheral damage - the bone injury also affects the muscles, tendons, nerves, and ligaments near the injured area;
- surgical complications - risk of bleeding and bacterial infections;
- osteonecrosis of the femoral head - in cases of severe trauma, there is a risk of interrupted blood flow to the femoral head, which is considered non-viable bone tissue;
- complications due to immobilization - in patients requiring long-term immobilization who cannot undergo surgery, infections, pressure ulcers, and muscle wasting may occur, along with a risk of pneumonia or venous thrombosis.[15]

The length unstable diaphyseal femoral fracture is problematic in children ages 5–11 due to the long recovery time, skeletal immaturity, heightened risk of post-operative complications, and a lack of consensus as to the proper fixation modality. [11]

Elastic stable intramedullary nailing is a commonly used modality for the surgical stabilization of long-bone fractures in children, with routine implant removal recommended within 6–12 months. Delayed removal beyond this timeframe is uncommon and presents unique surgical challenges. [9]

Aim and objectives of the study:

Aim of the work: analyze the post-immobilization status in patients with a femoral fracture reduced using an elastic stable intramedullary nailing, with skeletal immaturity.

Research objectives:

- analysis of the specialized literature regarding of the femoral fracture reduced using an elastic stable intramedullary nailing;
- identifying and understanding the femoral fracture reduced using an elastic stable intramedullary nailing post-immobilization status;
- the realization of a therapeutic pathway in the femoral fracture reduced using an elastic stable intramedullary nailing.

Materials and methods: We present a case study of a 12-year-old male patient who sustained a fracture of the distal third of the right femur following an accidental fall.

On November 20, 2025, open reduction with osteosynthesis using two elastic titanium rods was performed; walking with a walker was recommended, and the postoperative course was favorable.

On December 9, 2025, a refracture occurred; clinical examination revealed callus formation but with angulation at the fracture site. Osteotomy, orthopedic reduction, and immobilization of the right lower limb in a Pelvipedioas plaster splint were performed. Figure 3 shows the patient's X-ray taken 4 weeks after surgery.

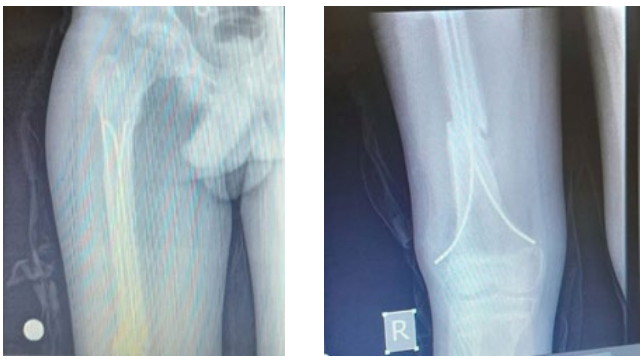

Fig.3 rgf. Elastic stable intramedullary nailing (ESIN) rgf patient

The patient stops using the orthosis due to complications involving the skin. At the same time, the patient is referred to a physical therapist. An assessment of the patient's condition following immobilization reveals the following:

- marked muscle hypotonia in the affected limb;
- a locked knee joint, with edematous, hyperalgesic tissue;
- walking with the aid of a walker;
- severe pain in the hip and thoracolumbar joints;
- visible asymmetries are noted in the pelvic and scapulohumeral regions.

Fig.4 scoliosis

The affected lower limb is found to be approximately 1 cm shorter due to vicious callus formation.

A physical therapy program is initiated with the aim of promoting neurovasculotrophic mechanisms and maintaining/increasing muscle tone, segmental joint mobility, postural reeducation, and gait recovery.

At the follow-up examination conducted 6 months after the injury, in May 2026, figures 4 and 5 show the pattern of callus formation and the dynamics of the osteosynthesis material. Due to accelerated growth in height (during the prepubertal period), the patient was able to compensate for and balance his postural status, though this was accompanied by the development of scoliosis.

Fig.5 rgf. Elastic stable intramedullary nailing (ESIN) rgf patient after 6 months

Results and discussions: Therefore, based on the findings of the functional and clinical evaluations, the following can be summarized: The post-immobilization treatment strategy was not properly managed, specifically due to the lack of additional measures to protect the site of the injury. The fact that the refracture occurred during the provisional callus phase confirms the findings reported above.

Abnormal callus formation, combined with the dynamics of growth during the prepubertal period, contributed to the development of scoliosis. A timely exercise program can promote the callus formation process and maintain optimal health status during the convalescence period.

Conclusions:

- reduction of a femoral fracture in prepubertal children using elastic rods may lead to complications;
- a kinesiotherapy program and mandatory medical care are required;
- medical follow-up through an X-ray examination is mandatory;
- however, each fracture must be reduced and immobilized based on all the variable factors contributing to the pathophysiological process.

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