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Effect of Ultrasound-Guided Lumbar Plexus Block on Perioperative Analgesia in Children Undergoing Proximal Fracture Femur Surgeries

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ABSTRACT

Children's proximal femur fractures are uncommon, representing below one percent of all children's fractures, and are commonly because of high-energy trauma. These injuries pose significant diagnostic and therapeutic challenges due to their anatomical complexity and the possibility of complications like avascular necrosis. Prompt diagnosis, appropriate classification—most commonly via the Delbet system—and early anatomical reduction are crucial for optimal outcomes. Fixation strategies vary by age, fracture type, and displacement, often involving smooth pins, cannulated screws, or pediatric sliding hip screws. Effective perioperative pain management is essential in these patients to improve recovery, minimize opioid use, and reduce hospital stay. The lumbar plexus block (LPB), although traditionally underused in children due to anatomical depth and technical complexity, has gained attention with the advent of ultrasound-guided techniques. The lumbar plexus, positioned deep within the psoas muscle, innervates the hip, thigh, and knee via its major branches. Ultrasound-guided LPB, especially with the "Shamrock method," enhances needle placement accuracy and decreases the possibility of complications like vascular puncture or nerve injury. When combined with general anesthesia or other regional techniques, LPB provides superior analgesia and improved patient satisfaction in pediatric proximal femur surgery. This review outlines the current understanding of pediatric proximal femoral fractures, their management, and the evolving role of ultrasound-guided LPB in enhancing perioperative care.

Keywords: *Pediatric femur fracture, lumbar plexus block, ultrasound-guided anesthesia, avascular necrosis.*

1. INTRODUCTION

Proximal fractures of the femur in the children's case are uncommon, representing below 1% of all pediatric fractures. Unlike the elderly case having osteoporotic bone who sustains a fracture of the hip from a slight fall, the pediatric case with great bone mineral density needs significant trauma to fracture (Dial & Lark, 2018). (Mosallam et al., 2025)

Pain control before the operation is crucial after pediatric proximal femur fractures. Insufficient analgesia may lead to dissatisfaction of the case and their parents, extended recovery times, and prolonged hospitalization. (Salem et al., 2025)

Numerous investigations have examined the association among results following operation and anesthesia type. The efficacy of spinal anesthesia in cases had fractures of the femur in comparison with that of general anesthesia has long been controversial (Lee et al., 2020); however, spinal anesthesia was the favored anesthetic method with benefits regarding 1-month death and deep vein thrombosis, and spinal anesthesia has been primarily used in elderly cases (Curtis et al., 2021). (Shoura et al., 2025)

Lumbar plexus block, neuraxial methods (epidural or caudal), and combined fascia iliaca blockade and femoral nerve were demonstrated in numerous children's research to show opioid-sparing impacts and reduced pain scores following operation in cases with proximal femur fractures (Steinhaus et al., 2018).

The lumbar plexus (LP) is a web of nerve roots situated inside the psoas muscle and forms portion of the larger lumbosacral plexus. Block of this plexus (lumbar plexus block) might be conducted to give analgesia during operation and following operation for proximal femur, hip, as well as anterior thigh operation. (Steinhaus et al., 2018).

The LPB is frequently used as analgesia for adult hip operations and has a positive impact, nevertheless because of the requirement of utilizing a neurostimulator, it has been infrequently utilized in pediatrics before (Ahamed & Sreejit, 2019).

Ultrasound technology has gained prominence in children for LPB, as ultrasound guidance may give direct visualization of the lumbar plexus to confirm both the efficiency and safety of LPB (Zhang et al., 2019).

2. Anatomy of Femur

Introduction

Of all the bones in the human body, the femur is the one that is the heaviest, longest, and most robust. It is the pyramid-shaped neck that connects the spherical head at the apex to the cylindrical shaft at the base, which is located at the proximal end. Additionally, there are 2 noticeable bony projections, known as lesser and greater trochanters. These projections attach to muscles that are responsible for facilitating mobility in the knee and hip. In the average adult, the angle that exists among the shaft and the neck, which is also referred to as the inclination angle, is approximately 128 degrees. On the other hand, the angle of inclination diminishes with increasing age. The tubercle of the adductor, which is responsible for the attachment of the linea aspera, and the posterior part of the adductor magnus are two additional distinguishing characteristics (Boese et al., 2016).

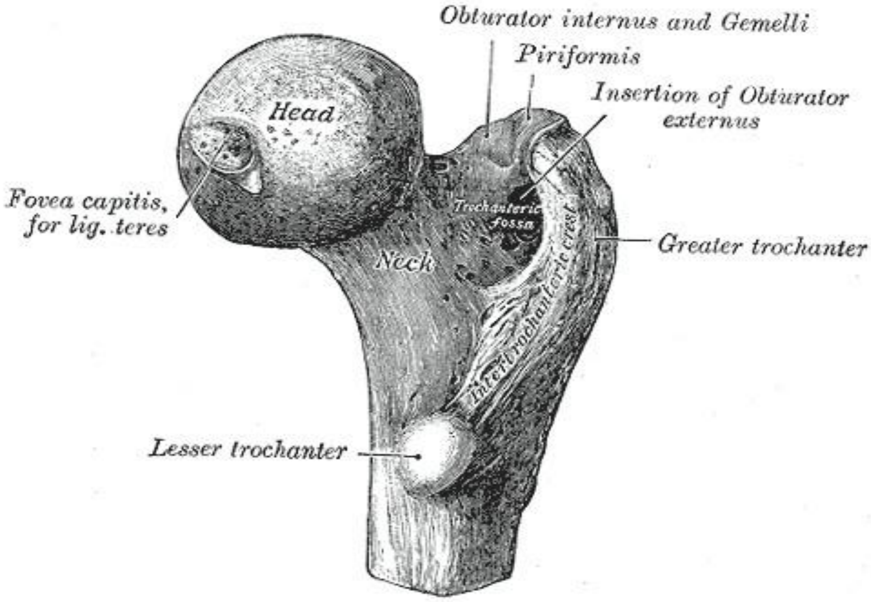

Fig. 1: This is the anatomy of the right proximal femur. The fovea capitis, the femoral head, the neck of the femur, the ligamentum teres, the trochanter, the trochanteric fossa, the greater trochanter, the intertrochanteric crest, the lesser trochanter, and the insertions for the obturator externus, obturator internus, piriformis, and gemelli are all illustrated in this image (Clar & Bordoni, 2019).

Structure and Function

Both gait stability and weight bearing are the primary functions that the femur is responsible for. The two femoral heads are responsible for supporting the upper body's weight. The proximal femur and the acetabulum periosteum are both components of the capsular ligament, which is a robust and thick sheath which wraps around both. To preserve the head of the femur in place within the acetabulum of the pelvis, this ligament is responsible. Although it permits external rotation, the capsular ligament limits internal rotation that can occur (van Arkel et al., 2015).

The knee is a hinge joint among the proximal tibia and distal femur. The lateral and medial meniscus stabilize and cushion the tibiofemoral articulation. The lateral and medial ligaments avoid varus or valgus deformities. The posterior and anterior cruciate ligaments within the knee joint permit certain rotational mobility of the knee whereas avoiding posterior or anterior dislocation of the tibia. The patellofemoral joint is utilized in extension of the knee (Ehlinger et al., 2013).

Embryology

In the beginning, the cells of the lateral plate mesoderm are responsible for the development of the limb buds of the lower limb and the femur. The limb bud is formed by these cells, which become active during the fourth week of human development. A little time after the bud of the upper limb, the lower limb begins to form (Elshazzly et al., 2018).

In the limb bud, the apical ectodermal ridge is responsible for stimulating the formation and growth of the limbs. The femur is created by the lateral plate somatic mesoderm of the lower limb bud. This femur is formed through endochondral ossification, which is a process in which bone substitutes hyaline cartilage models. The formation of epiphyseal plates and articular cartilages occurs by a process known as intramembranous ossification, which doesn't involve the use of a cartilage model (Chang et al., 2023).

Blood Supply and Lymphatics

One of the key blood vessels that supplies blood to the lower limb is the femoral artery. Following its passage through the ilioinguinal ligament, this artery is the major branch of the external iliac artery. 2 branches of the femoral artery are known as the lateral circumflex artery and the medial circumflex artery. These vessels, in addition to the obturator artery, that is a branch of the internal iliac artery, are responsible for providing the femoral head with innervation through significant anastomotic connections. Although it is not the principal blood supply to the head of the femur, the foveal artery, that is a branch of the obturator artery that crosses the ligamentum teres femoris, provides the head of the femur with a supporting blood supply (Lazaro et al., 2015).

Nerves

The lumbosacral plexus is the origin of the nerves that are responsible for innervating the thigh. The following are the nerves that are involved (Kendir et al., 2018):

From the roots of the L2 and L3 vertebrae, the lateral femoral cutaneous nerve originates and penetrates deep into the thigh, reaching the inguinal ligament. The anterolateral thigh is the source of sensation that is transmitted by this nerve (Swezey & Bordoni, 2018). The obturator nerve originates from the L2 to L4 nerves. All of the muscles that are located in the medial thigh compartment are supplied by the obturator nerve, as well as its posterior and anterior branches. The femoral condylar regions and the medial thigh are also associated with this nerve, which is responsible for transmitting sensory information (Üçeyler et al., 2018). The L2 to L4 rami are the origin of the femoral nerve. This thick nerve penetrates deep into the inguinal ligament and reaches the thigh, providing access to the femoral vessels on the lateral side. The anterior thigh is the location where the femoral nerve separates into a number of branches that are cutaneous and muscular in nature. Innervation of the muscles which are positioned in the anterior compartment of the thigh is provided via the muscular branches. Sensory information that is transmitted from the anterior thigh to the spinal cord is carried by the cutaneous branches. The anterior femoral cutaneous nerve is a branch of the femoral nerve, which facilitates transmitting sensation from the anteromedial surface of the thigh (Clar & Bordoni, 2019). Although the saphenous nerve originates from the femoral nerve that is located inferior to the femoral triangle, it receives contributions from the L2 to L4 roots because of its origin. The femoral vein and artery are followed by the saphenous nerve as it travels via the adductor canal, which is positioned deep to the sartorius muscle (Migirov & Vilella, 2024). The sciatic nerve originates from the L4 to S3 nerves. The sciatic nerve is the greatest nerve in the human body. Those muscles that are located in the posterior compartment of the thigh are supplied through this nerve. The tibial nerve and the fibular nerve are the branches of this nerve that arise from the popliteal fossa and are responsible for providing innervation to the leg (Giuffre et al., 2023). As a result of the contributions that it receives from the S1 to S3 roots, the posterior femoral cutaneous nerve is commonly referred to as the "posterior cutaneous nerve of the thigh." From the posterior thigh, this nerve is responsible for transmitting sensation (Saba, 2022).

3. Muscles

Femoral muscles facilitate movement of the knee and hip joints. There are three distinct compartments contained inside these muscles: the anterior, the medial, and the posterior muscles. Muscles that are located in the same compartment usually exhibit movement in the same direction and are innervated through the same neurovascular structures (Clar & Bordoni, 2019).

Anterior Thigh Muscles

The primary knee extensors and hip flexors are located in the muscles of the anterior thigh. This compartment has a large number of muscles, which are supplied by the femoral nerve (L2-L4), which will be discussed below. Although it is partially located in this area, the tensor fascia lata is generally regarded as the gluteal muscle. (A. Khan & Arain, 2023).

It is the superior pubic ramus that gives rise to the pectineus, which then attaches itself distally to the region that is inferior to the lesser trochanter. The pectineus is responsible for flexing, adducting, and medially rotating the hip joint. In certain people, this muscle obtains motor innervation from the obturator nerve in addition to the femoral nerve. (Kim & Nam, 2021)

The iliacus, the psoas minor, and the psoas major are the components that make up the iliopsoas. In addition to passing through the iliac fossa, the iliac crest, the sacroiliac ligaments, and the superior sacrum, the proximal attachment of the iliacus is wide. The lateral borders and intervertebral discs of the T12 to L5 vertebrae, as well as the transverse processes of the L1 to L5 vertebrae, are the areas from which the psoas major arises. The lateral borders and intervertebral discs of the vertebrae that range from T12 to L1 are the areas from which the psoas minor arises. A common insertion point can be seen in the area of the lesser trochanter for both the iliacus and the psoas major. Additionally, the pectineal line of the femur is the point at which the psoas minor muscle terminates proximal to this zone. As a group, these muscles are responsible for stabilizing and flexing the hip joint. The femoral nerve and the ventral rami of the L1 to L3 vertebrae are the nerves that supply the iliopsoas muscles (Clar & Bordoni, 2019).

The sartorius, also referred to as the "tailor's muscle," is a muscle that is elongated and slender. It extends inferomedially from the anterior superior iliac spine to insert on the superomedial tibia. The actions of this muscle include abduction, flexion of the knee, flexion of the hip, as well as lateral rotation. The sartorius is a muscle that has influence over the hip and knee joints. Although it is able to move in a variety of directions, the muscle is not very strong because of the fact that it has a limited cross-sectional region and is verylong. The sartorius muscle receives its supply from the femoral nerve (Walters & Varacallo, 2018).

There are four heads that make up the quadriceps femoris, which is the anterior muscle group of the femur. The quadriceps femoris serves as a potent extensor of the knee. Although they originate from various areas of the proximal lower limb, the element muscles attach themselves to the patellar base by a common tendinous structure known as the quadriceps tendon. A connection between the quadriceps tendon and the tibial tuberosity, which is located on the proximal anterior tibia, is made by the patellar ligament. The following muscles are located within the quadriceps femoris, and the femoral nerve is responsible for their innervation (Clar & Bordoni, 2019):

The rectus femoris is a bipennate muscle that arises from the anterior inferior iliac spine and an area that is located superior to the acetabulum. In addition to being a potent knee flexor, this muscle is the only component of the quadriceps that flexes, crosses, and stabilizes the hip joint. Both the linea aspera as well as the greater trochanter of the femur are the initial points of the formation of the vastus lateralis. The vastus intermedius is a muscle that arises from the lateral and anterior margins of the femoral shaft. It is situated among the two additional vastus muscles and is located deep to the rectus femoris. Between the intertrochanteric line and the linea aspera of the femur is where the vastus medialis muscle originates. It is the vastus muscle that is placed the most medially. The articularis genu is a muscle that, in certain people, might have originated from the vastus intermedius. It is the fifth head of the quadriceps femoris. Occasionally, this muscle is referred to as the "tensor of the vastus intermedius" or the "articular muscle of the knee."

Medial Thigh Muscles

The adductors of the thigh are the muscles that are called the medial compartment muscles of the femur. These muscles are responsible for internal rotation and flexion of the hip. This compartment receives its supply from the obturator nerve (L2-L4) in addition to its branches (Launico et al., 2024).

The gracilis is an extended muscle which expands inferiorly from the inferior side of the pubis to the superomedial tibia. The thigh is adducted by this muscle, which also is responsible for medial rotation and flexion of the knee (I. A. Khan et al., 2023).

The inferior pubis is the point of origin for the adductor brevis, which subsequently descends inferolaterally and inserts on the linea aspera as well as the pectineal line of the femur. In addition to facilitating adduction of the hip, the adductor brevis contributes to weak knee flexion (Kumar & Kalyan, 2013).

Subsequently, the adductor longus descends inferolaterally prior to inserting on the linea aspera.

It is a muscle that originates from the pubis.

The "hamstring" and "adductor" portions of the adductor magnus are both included in this muscle. The adductor portion of the adductor muscle originates from the inferior edge of the ischiopubic ramus and inserts on the posterior femur. This particular muscle segment receives its supply from the obturator nerve’s posterior division. The adductor portion of the adductor magnus is responsible for facilitating adduction of the thigh as well as flexion of the hip. Furthermore, the hamstring portion of the muscle originates from the ischial tuberosity and descends inferiorly, ultimately inserting on the adductor tubercle located on the posteromedial femur. This muscle segment obtains it’s supply from the sciatic nerve’s tibial division, that also helps to facilitate the extension of the hip (Jeno et al., 2018).

In addition to inserting on the femoral trochanteric fossa, the obturator externus arises from the margin of the obturator membrane in addition to the obturator foramen. Lateral rotation and hip stabilization are both functions that are performed by this muscle (Glenister & Sharma, 2022).

There is a cavity in the adductor magnus tendon that is located proximal to the medial supracondylar edge. This gap is recognized as the adductor hiatus. To reach the popliteal region, the femoral neurovascular structures must first traverse the adductor hiatus (Kale et al., 2012).

Posterior Thigh Muscles

The muscles located in the posterior thigh are part of the hamstring muscle group. The 1ry function of these muscles is to flex the knee and extend the hip. Abduction of the hip, external rotation, and internal rotation are all tasks that are performed by the posterior femoral muscles in addition to their other functions. These muscle groups are supplied by the branches of the sciatic nerve (Yamauchi et al., 2019).

The semitendinosus is a muscle that attaches distally to the superomedial surface of the tibia. It develops from the ischial tuberosity, which is also the location of the semimembranosus.

The semimembranosus arises from the ischial tuberosity alongside the semitendinosus and inserts on the posteromedial condyle of the tibia. This muscle additionally contributes to the oblique popliteal ligament.

There are both short and long heads that make up the biceps femoris. Conversely, the short head originates from the posteroinferior femur and the linea aspera, whereas the long head originates from the ischial tuberosity along with the additional hamstrings. The long head is supplied via the tibial division of the sciatic nerve. Furthermore, the short head is supplied via the common fibular nerve. The fibular head is the point at which both heads of the biceps femoris muscle insert. The fibular collateral ligament is the ligament that divides the tendon of the muscle at this particular location.

4. Pediatric Proximal Femur Fractures

Introduction:

Pediatric proximal fractures of the femur are uncommon, representing below 1% of all children's fractures. Unlike elderly patients, these injuries in kids are usually because of high-energy trauma, as significant falls or motor vehicle accidents. Low-energy fractures warrant evaluation for metabolic bone disease, pathologic lesions, or child abuse. Historically associated with poor outcomes, treatment has improved through better understanding and standardized approaches (Lark et al., 2020).

Anatomy and Ossification:

The proximal femoral ossification centers develop progressively, with the primary center appearing between 4–7 months of age and secondary centers (greater and lesser trochanters) developing later. The physis contributes significantly to femoral and limb length, and fusion occurs between ages 14 and 18. Vascular disruption in this region can cause avascular necrosis (AVN) or growth arrest, particularly in younger children (Wang et al., 2019).

Vascular Supply:

In early life, the head of the femur receives blood from the medial as well as lateral femoral circumflex arteries and the ligamentum teres artery. Post-ossification, the superior in addition to inferior retinacular branches of the MFCA become the main supply. After skeletal maturity, an extracapsular anastomosis provides robust circulation, reducing AVN risk in adults (Dial & Lark, 2018).

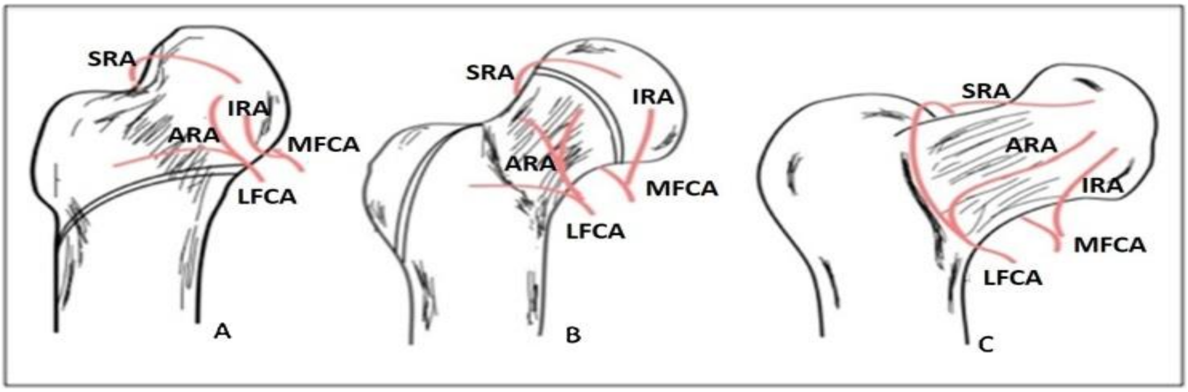

Fig. 2: Vascular anatomy of the children's proximal femur. The figure additionally illustrates the gradual reduction of the femoral neck-shaft angle from 150° in the babies to 130° in the skeletally mature individuals. A, Phase one with the supply from tri-vessel. B. Phase two: The anterior retinacular artery ceases to supply the head of the femur because of the physis. C. Phase three: the skeletally mature vascular supply. IRA—inferior retinacular artery, ARA—anterior retinacular artery, SRA—superior retinacular artery, MFCA—medial femoral circumflex artery, LFCA—lateral femoral circumflex artery (Dial & Lark, 2018).

Classification:

The Delbet classification (I–IV) is most commonly used, with type II (transcervical) fractures being most frequent. Type I fractures are subdivided into IA (without dislocation) and IB (with dislocation). Additional classifications include type V (subtrochanteric), Pauwels (angle-based stability), and further zonal subclassifications to guide fixation strategy (Pinto & Aroojis, 2021).

Etiology and Epidemiology:

High-energy trauma is the leading etiology of these fractures in older kids and adolescents, while pathologic fractures are more prevalent in kids under 4 years old. The peak incidence is between 11–13 years with a male predominance (Kenawey et al., 2019).

Mechanism of Injury:

Most injuries result from direct trauma, axial loading, or torsional forces. Low-energy mechanisms suggest underlying pathology. Stress fractures, though rare, may occur in athletic adolescents. Advanced imaging (MRI or CT) is recommended for diagnostic clarification (Haram et al., 2022).

Pathophysiology:

The vascular supply to the proximal femur is uniquely vulnerable during childhood, especially due to the dependency on lateral epiphyseal vessels between ages 4–7, which are prone to injury. As the physis closes in adolescence, vascular anastomosis improves, reducing AVN risk (Seeley et al., 2016).

Healing and Fracture Characteristics:

Despite being intra-articular, pediatric femoral neck fractures often heal with callus due to the rich periosteal layer. These fractures are highly unstable, with smooth, uniplanar lines and high susceptibility to shear forces, making them prone to displacement (Shen et al., 2016).

Muscle Forces and Displacement:

Muscle contractions cause characteristic deformities, including external rotation of the shaft and medial and proximal translation. The proximal fragment, lacking direct attachments of the muscle, is passively displaced (Pinto & Aroojis, 2021).

Clinical Presentation:

Children have pain, limb deformity (shortening and external rotation), and sometimes referred knee pain. A thorough systemic and orthopedic examination is critical due to the high trauma involved. Kid abuse must be suspected if the reported mechanism is inconsistent with the injury (Mehmet et al., 2014).

Diagnosis and Imaging:

Diagnosis typically relies on anteroposterior and cross-table lateral radiographs. Advanced imaging (CT/MRI) is indicated for complex, pathological, or occult fractures. MRI is particularly useful for detecting early or stress-related injuries (Kenawey et al., 2019).

5. Management of Pediatric Hip Fractures

Initial Assessment and Stabilization:

Pediatric proximal fractures of the femur are commonly because of high-energy trauma, as falls from heights or motor vehicle accidents. A comprehensive trauma evaluation is essential, including a detailed history to assess for prior bone disorders, previous fractures, or non-accidental injury. A neurovascular examination and a full musculoskeletal survey should be performed. Limb positioning with slight flexion and external rotation using a pillow may help maintain capsular volume and potentially preserve femoral head perfusion. Traction is discouraged due to lack of pain relief and potential reduction in capsular volume (Emmerson et al., 2023).

Timing and Technique of Reduction:

Timely anatomic reduction is critical to reducing the possibility of avascular necrosis (AVN). Early reduction may “unkink” compromised vessels and restore femoral head perfusion. Closed reduction is attempted first, except in Delbet type IB fractures, where open reduction is often required. Reduction maneuvers vary by fracture type, with specific protocols for IA versus types II–IV. Surgical approach depends on fracture location, with anterior approaches used for Delbet I/II and anterolateral or posterior approaches for more distal or dislocated injuries (Napora et al., 2021).

Capsular Decompression:

Capsular hematoma may contribute to AVN by increasing intracapsular pressure. Though evidence is mixed, decompression—via capsulotomy or needle aspiration—is generally recommended within 24 hours’ post-injury due to its low risk and potential benefit in reducing AVN incidence (Bukva et al., 2015).

Fixation Methods:

Anatomic fixation is preferred over casting due to the higher risk of non-union and deformity with non-operative management. Fixation options include smooth pins, cannulated screws, and pediatric sliding hip screws (SHS), with the choice depending on age, fracture type, and surgeon experience. Biomechanical principles from SCFE management may offer insights, favoring compression screws over pins for stability while cautioning against excessive hardware to avoid physeal or vascular damage (Ma et al., 2018).

General fixation guidelines include using two or three fixation points to prevent rotation. Avoid crossing the physis unless necessary; use smooth pins if required. SHS is recommended for Delbet types III and IV. Post-operative spica casting may be needed for up to six weeks (Chandankere & Shah, 2021).

Type-Specific Fixation Considerations:

Delbet Type I: Non-displaced fractures in children <4 years may be casted. Displaced fractures in older children require fixation with smooth pins or screws across the physis. Hardware removal is recommended to prevent growth disturbances

(Tisherman et al., 2018).

Delbet Types II/III: These unstable fractures require internal fixation. For proximal type II, transphyseal fixation is often unavoidable. Fixation should avoid the physis in type III. Post-op care includes non-weight bearing and bracing or casting for six weeks (Panigrahi et al., 2015).

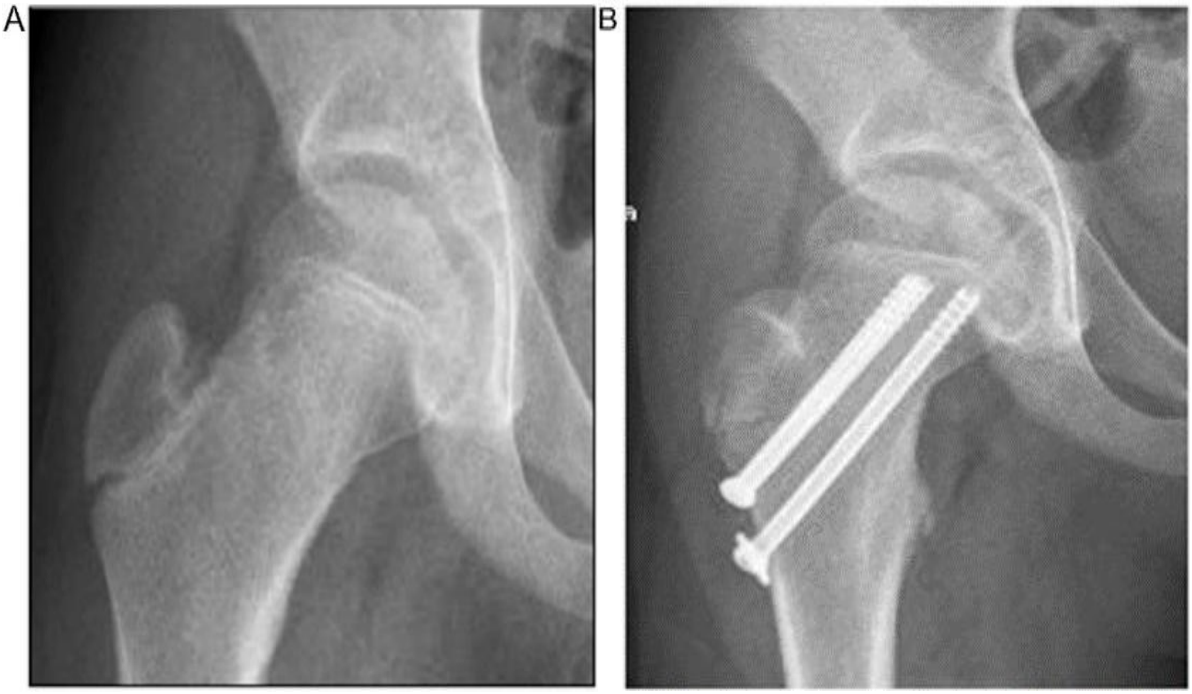

Fig. 6: A) A boy twelve years old has a non- dislocated transcervical fracture (Delbet II). B) Three 6.5-millimeter partially threaded screws have been inserted in an inverted triangle configuration. The screws don't pass the physis, and a washer has been utilized for additional stability with the inferior screw (Dial & Lark, 2018).

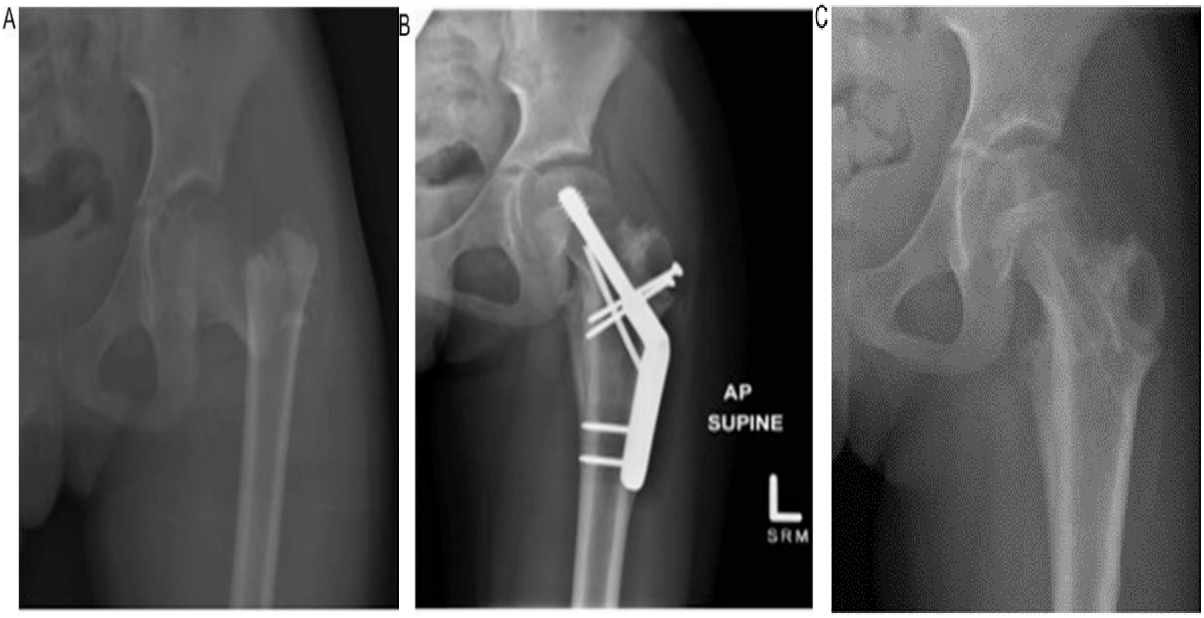

Fig. 7: A) Basicervical fracture (Delbet III) accompanied by a fracture of the greater trochanter in a girl seven years old after a motor vehicle collision. B) A pediatric sliding hip screw (SHS) has been utilized for main stability, and an additional screw has been utilized to regulate rotation. Furthermore, 2 screws have been utilized to stabilize the fracture of the greater trochanter. C) After healing of the fracture, the hardware has been eliminated to avoid physeal arrest (Dial & Lark, 2018).

Delbet Type IV: Typically, stable with lower AVN risk. Children <8 years may be managed with spica casting; older children usually require SHS fixation. Patients treated with SHS may bear weight postoperatively. Weekly radiographs are advised until callus forms (Лемос et al., 2018).

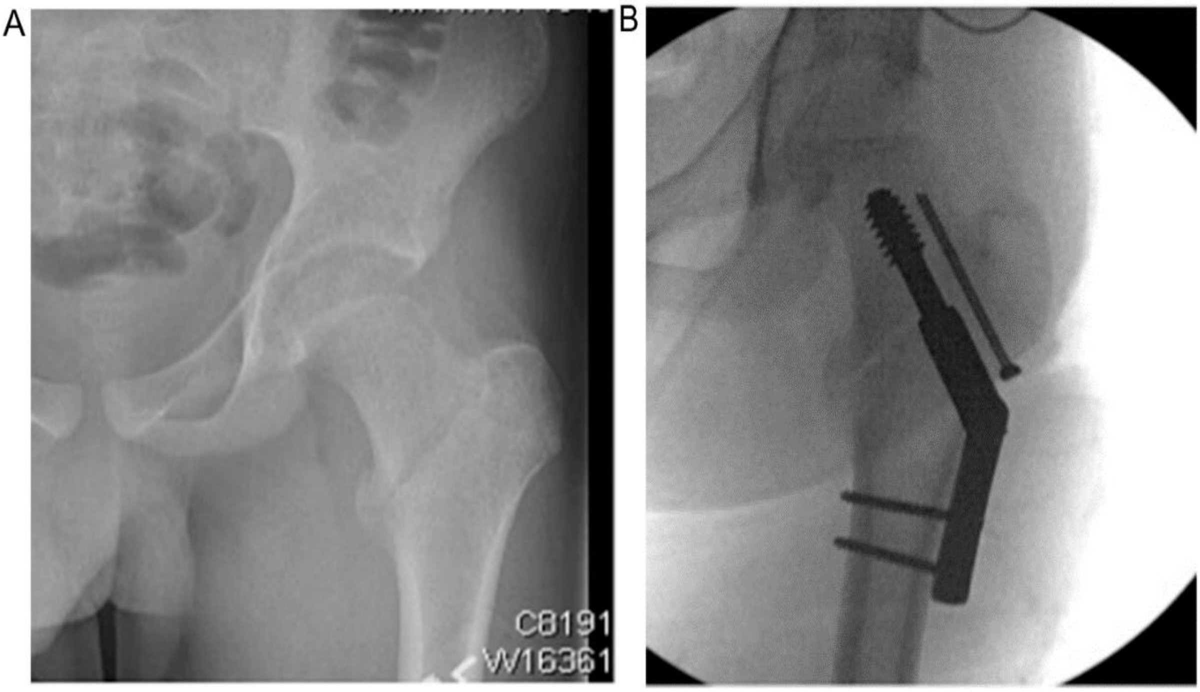

Fig. 8: A) A fracture inside trochanter (Delbet IV) in a case nearing skeletal maturity. B) Fluoroscopy during operation exhibiting a standard hip screw has been utilized for main stability, and a partially threaded screw has been inserted across the fracture location to avoid rotation (Dial & Lark, 2018).

Complications:

Pediatric proximal femoral fractures are related to great complication rates, up to thirty-three percent. The most serious is osteonecrosis (up to 50%), followed by non-union, coxa vara, and premature physeal closure. Less common but significant complications include septic arthritis, femoral neck overgrowth, and epiphysiolysis (Chinoy et al., 2020).

Outcomes

Prolonged results of pediatric femoral neck fractures are most frequently defined based on the Ratliff classification (Table 3). In a systematic review, out of 608 cases documented in nineteen investigations, results were good in 59.7 percent, poor in 20.7 percent, and fair in 19.6 percent (Lark et al., 2020).

Table 3: Classification of Ratliff for assessing results of children's femoral neck fractures (Lark et al., 2020).

	Good	**Fair**	**Poor**
Pain	None or 'ignores'	Infrequent	'Disabling'
Mobility	Full or terminal limitation	Above fifty percent	Below fifty percent
Activity	Usual or prevents games	Usual or prevents games	Limited
Radiographic appearance	Usual or certain femoral neck deformity	Severe femoral neck deformity 'Mild' avascular necrosis	Severe avascular necrosis Arthrodesis Degenerative arthritis

6. Lumbar Plexus Block (LPB)

Introduction:

The lumbar plexus, part of the lumbosacral plexus, is positioned within the psoas major muscle and comprises the anterior rami of T12 to L4 spinal nerves. Lumbar plexus block (LPB), a deep peripheral nerve block, is used for anesthesia and analgesia following operations in hip, femoral, as well as anterior thigh surgeries, often in combination with sciatic nerve block for more extensive lower limb procedures. Traditional landmark- and nerve stimulator-guided techniques posed risks such as vascular or renal injury. Ultrasound guidance has improved safety and precision, although deep nerve visualization remains a challenge. Therefore, a combined ultrasound and nerve stimulator approach is often recommended. (Hetta et al., 2025)

Anatomy:

The LP generates the genitofemoral, iliohypogastric, lateral femoral cutaneous, ilioinguinal, femoral, and obturator nerves. It lies deep in the posterior 3rd of the psoas muscle, making ultrasound identification difficult (Chan et al., 2022).

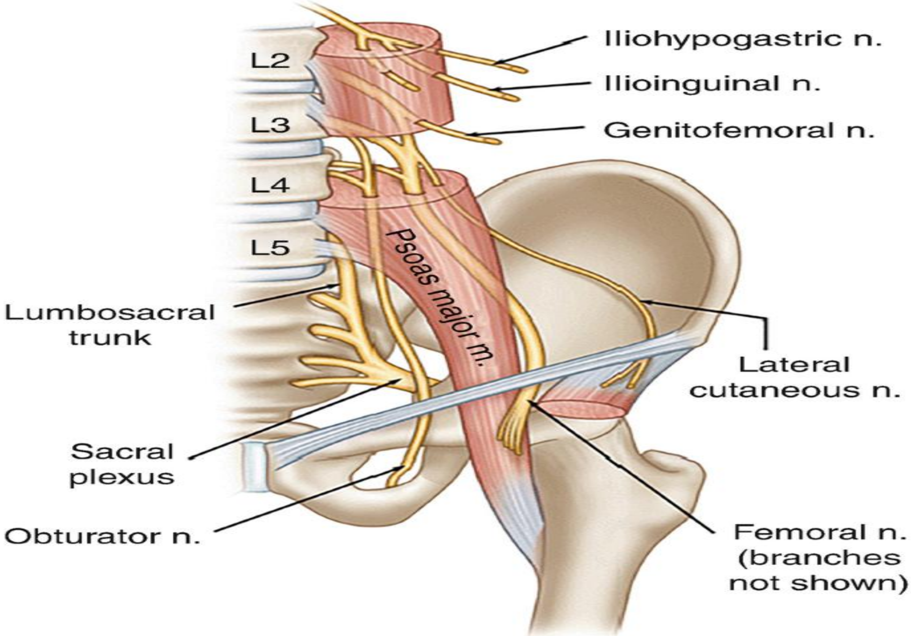

Fig. 9: Lumbar plexus anatomy (de Angeli et al., 2023).

Indications and Uses:

LPB is used for perioperative and surgical anesthesia in femoral fractures, hip replacement, acetabular fractures, and knee procedures. It may also benefit chronic pain conditions, including herpes zoster and postoperative neuralgia. Complete anesthesia for hip replacement typically requires adjunctive sciatic nerve block due to sacral plexus innervation of the posteromedial hip capsule (Gutierrez & Ben-David, 2023). (Abdel Azeem et al., 2023)

Contraindications:

Absolute contraindications include case refusal, allergy to local anesthetics, local infection, and significant coagulopathy (INR > 1.5). Relative contraindications include prior spinal surgery, deformities, or implanted spinal devices (Gutierrez & Ben-David, 2023).

Advantages Over Neuraxial Blocks:

Compared to central neuraxial anesthesia, LPB offers unilateral blockade, preserving contralateral motor function, reduced urinary retention, and improved hemodynamic stability. It also provides longer-lasting analgesia with reduced opioid needs (Omar et al., 2011).

Techniques:

***Landmark Technique*:** The insertion site is at the junction of the medial 2/3 and lateral 3rd of a line from the posterior superior iliac spine (PSIS) to the spinal processes, one centimeter cephalad to the intercristal line. Quadriceps contraction with a current of 0.3 to 0.5 milliampere confirms femoral nerve proximity. Following negative aspiration, twenty ml of LA is injected incrementally (Lim et al., 2022).

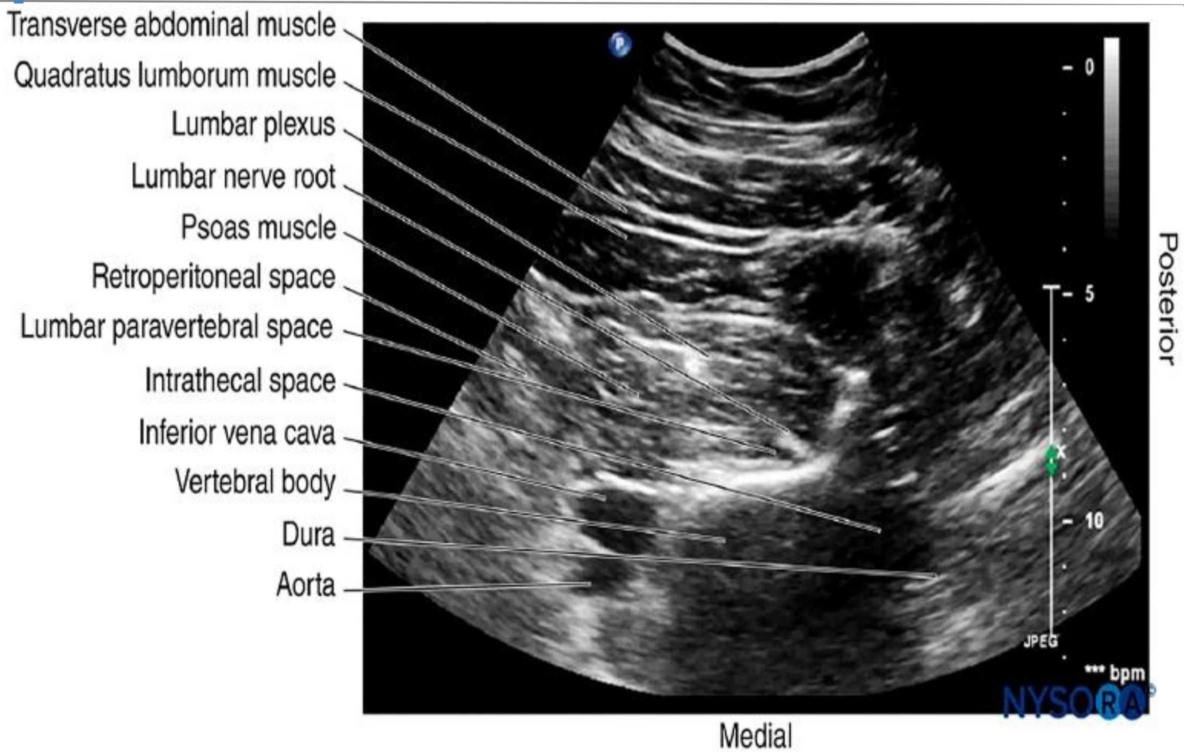

Fig. 10: Transverse sonogram of the lumbar paravertebral area throughout the Shamrock technique (Haram et al., 2022).

Ultrasound-Guided Techniques:

Shamrock Method: The transducer is positioned transversely above the iliac crest. The lumbar plexus is targeted by the L4–L5 intertransverse space, and a block needle is advanced in-plane under ultrasound guidance with nerve stimulation confirmation. About twenty milliliters of LA is injected around the nerve (Karmakar, 2023).

Longitudinal Approach: Insert the needle 1.5 to 2 centimeters lateral to the midline at L3–L4 using a high-frequency transducer. The LP lies posterior in the psoas, typically 1 to 1.5 centimeters below the transverse process. Injection is guided by ultrasound and nerve stimulation. A maximum of 20 mL of ropivacaine (0.2%) is used at 1 mL/s. Block adequacy is confirmed via hemodynamic response and real-time needle and drug spread visualization (Sato et al., 2018).

7. Intraoperative Monitoring:

Anesthesia is sustained with sevoflurane and nitrous oxide. Adjustments to anesthetic depth are made in response to alterations in respiratory rate, heart rate, and blood pressure. Increases of >twenty-five percent may warrant additional opioids, and such cases are labeled as LPB failures (Ohashi et al., 2016).

8. Complications:

Despite its benefits, LPB carries potential risks, including epidural or intrathecal spread (1–10%), renal capsule puncture, intravascular injection, hematoma, nerve damage, and lumbar root injury (Chan et al., 2022).

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