

A Review of Novel Perspectives on Proximal Femur Fractures in Children: Advances and Management Challenges

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ABSTRACT

Proximal femur fractures, though rare and constituting only 1% of all pediatric fractures, pose significant challenges in pediatric traumatology due to a high complication rate of 33%. This paper explores the epidemiological, pathophysiological, and treatment principles of these fractures in children, aiming to inform clinicians and guide families through the treatment process. It discusses surgical indications, implant options, and contemporary operative techniques, emphasizing the importance of anatomical reduction, stable fixation, and timely surgical intervention within 24 hours post-trauma. The review also addresses ongoing controversies, such as open versus closed reduction, the necessity of percutaneous capsulotomy, and managing complications like proximal femoral osteonecrosis and non-union. Proximal femur fractures in children typically result from high-energy trauma such as motor vehicle accidents or falls from significant heights. The unique anatomy and growth patterns in children add complexity to these injuries, particularly due to the proximity of the growth plate and the rich vascular supply of the femoral head. Given the complexity and high complication rates of these fractures, this comprehensive guide to evidence-based treatment strategies aims to optimize outcomes for pediatric patients. By examining current literature and practices, the paper seeks to offer a thorough understanding of the best approaches to manage these challenging injuries, ultimately striving to improve recovery and long-term functionality for affected children.

Keywords: Children; Delbet type; Osteonecrosis; Fracture; Femur

Introduction

Proximal femur fractures, while rare in pediatric populations, are of crucial importance in traumatology due to their high complication rates [1]. Understanding the epidemiological data, pathophysiological aspects, and treatment principles associated with these injuries is essential for selecting the appropriate management strategies. This knowledge not only informs clinicians in making evidence-based decisions but also helps guide families through the prognosis and recovery process, ensuring optimal outcomes and effective care [2-5]. Proximal femur fractures, though relatively uncommon in the pediatric population, are of significant concern in pediatric traumatology due to their propensity for severe complications [6]. These injuries,

while representing only a small fraction of all pediatric fractures, often lead to complex clinical scenarios that challenge even the most experienced clinicians [7]. Understanding the epidemiology, pathophysiology, and treatment principles associated with proximal femur fractures is essential for effective management and optimal outcomes for young patients. Proximal femur fractures in children are rare, accounting for a minimal percentage of all pediatric fractures [8]. Despite their infrequency, the impact of these injuries is profound due to the potential for serious complications. The rarity of these fractures means that less clinical experience and fewer established treatment protocols are available, which can contribute to higher complication rates compared to more common pediatric fractures.

The epidemiological data suggests that these injuries typically occur as a result of high-energy trauma, such as motor vehicle accidents or falls from significant heights, which are more likely to affect the femoral head and neck regions in children [9]. Studies indicate that the incidence of proximal femur fractures varies with age, with younger children often experiencing these injuries due to falls or accidents, while older children and adolescents may suffer from them due to more severe trauma or sports-related activities [10]. Additionally, there are variations in fracture types and associated complications based on the age of the child, which complicates the management and treatment approaches. Given the diversity of trauma mechanisms and the varying anatomical and physiological factors in pediatric patients, a comprehensive understanding of the epidemiological trends is crucial for developing targeted prevention and treatment strategies [11]. The pathophysiology of proximal femur fractures in children is closely related to their unique anatomical and physiological characteristics [12]. The proximal femur, which includes the femoral head, neck, and trochanters, is an area rich in vascular supply and growth plates [13]. This anatomical complexity contributes to the distinctive nature of these fractures and influences their healing processes [14]. In children, the presence of growth plates makes the management of these fractures particularly challenging, as improper alignment or fixation can disrupt normal bone growth and lead to long-term functional impairments [15].

The high vascularity of the femoral head plays a critical role in both the initial injury and the healing process [16]. Fractures in this region can compromise the blood supply to the femoral head, leading to complications such as avascular necrosis (osteonecrosis) and delayed union or non-union [17]. The proximity of the growth plates also means that there is a risk of premature closure or growth disturbances if the fractures are not managed appropriately [15]. Therefore, understanding the pathophysiological implications of these fractures is essential for selecting the right treatment approach and mitigating the risk of long-term complications. Effective management of proximal femur fractures in children requires a thorough understanding of several key treatment principles [18]. Immediate and appropriate FE analysis is critical to achieving optimal outcomes [19-21]. Surgical intervention is often necessary to ensure anatomical reduction and stable fixation of the fracture. The choice of surgical technique and implant depends on the type and severity of the fracture, the age of the patient, and other individual factors [22]. In addition to clinical management, guiding families through the prognosis and recovery process is a critical aspect of treating pediatric proximal femur fractures [1,23]. Parents and caregivers need clear, comprehensive information about the nature of the injury, the proposed treatment plan, and the expected outcomes [24]. Effective communication helps in setting realistic expectations and preparing families for the potential challenges and complications that may arise.

Families should be informed about the importance of follow-up care, including regular monitoring of the healing process and early detection of any complications [25]. Rehabilitation and physical

therapy play a vital role in the recovery process, helping to restore function and strength to the affected limb [26]. Support and education for families can also aid in managing any psychological impacts of the injury and ensuring that the child receives appropriate care and support throughout their recovery [27]. In summary, proximal femur fractures in children, though rare, are of fundamental importance in pediatric traumatology due to their high complication rates and the complexity of their management. A thorough understanding of the epidemiological data, pathophysiological aspects, and treatment principles is essential for effective management and optimal outcomes. Clinicians must be well-versed in these areas to provide the best care for young patients and guide families through the prognosis and recovery process. By addressing these factors comprehensively, we can improve treatment strategies and enhance the overall quality of care for children with proximal femur fractures.

Methods

The literature review was conducted using the PubMed database, employing the search terms “proximal femur fractures in children,” “pediatric hip fractures,” and “pediatric neck fracture.” These specific terms were chosen to address the research question, which aimed to explore the epidemiological data, pathophysiological aspects, and treatment principles related to pediatric proximal femur fractures. The search included all relevant publications from the earliest available date up to 2022. Following the initial search, the articles underwent a screening process to determine their relevance to the research question. Non-relevant articles were excluded from the review. The remaining articles were then meticulously evaluated for their quality and pertinence. Ultimately, only those articles that provided significant insights into the management of proximal femur fractures in children were included in the study. This process ensured a thorough and comprehensive review of the existing literature on the topic.

Discussion

Epidemiology and Injury Mechanisms in Pediatric Fractures

The incidence of proximal femur fractures in children is low, accounting for less than 1% of all fractures in the pediatric age group [28,29]. Even in reference centers, it is estimated that only one to two cases are treated annually. These fractures are more prevalent in male patients, particularly those aged 10 to 13 years [30,31]. Despite their rarity, proximal femur fractures in children have a high complication rate, with approximately 33% of cases developing some form of complication. The primary complications include osteonecrosis, non-union or pseudoarthrosis, coxa vara, septic arthritis, premature physal closure, femoral neck overgrowth, and posttraumatic epiphysiolysis [32-37] (Table 1). Nearly all pediatric proximal femur fractures result from high-energy trauma, such as falls from heights, sports injuries, or automobile accidents [3-5]. The most common mechanisms of injury include direct or torsional trauma, axial loads, and hyperabduction. Patients often present with multiple trauma injuries [4,38],

necessitating a thorough search for additional systemic injuries. Consultation with other specialists should be sought as needed (Figure 1). A comprehensive orthopedic physical examination is essential for all cases. In instances where the mechanism of injury involves low-energy trauma, an atypical cause should be considered. Such cases are often linked to underlying conditions like bone cysts, metabolic bone diseases, malignant tumors, fibrous dysplasia, or osteomyelitis. Conversely, if no trauma is reported, the possibility of a stress fracture must be evaluated. Stress fractures are more common in adolescent girls engaged in impact sports [1,3,39,40]. If radiographic findings are inconclusive, additional imaging tests, such as Magnetic Resonance Imaging (MRI) or Computed Tomography (CT), should be employed to clarify the diagnosis [1].

Table 1: Most frequent issues arising from proximal femur fractures in children [32-37].

Complication	Incidence
Avascular necrosis	45-55%
Malunion	40-50%
Premature physeal closure	35-40%
Nonunion	<5%
Infection	<5%
Heterotopic ossification	<5%

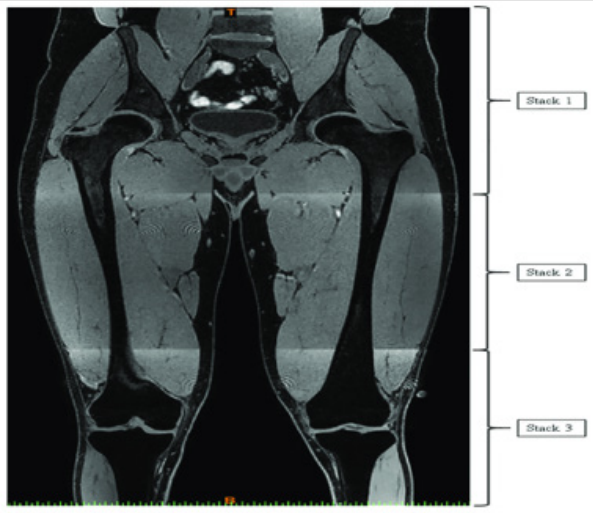


Figure 1: Radiography of Both Femurs and Pelvis.

Signs, Symptoms, and Diagnosis

Given that most proximal femur fractures in children result from high-energy trauma, orthopedic surgeons must conduct a thorough physical examination to identify other potential orthopedic and non-orthopedic injuries. It is often necessary to involve pediatric surgeons and pediatricians to ensure comprehensive care and appropriate support for the patient. Injuries to the cranial, thoracic, abdominal, and facial regions, as well as additional orthopedic injuries, must be accurately diagnosed and managed [1,4]. The clinical presentation of these fractures in children is akin to that in adults. Patients typically exhibit hip pain upon mobilization, and in cases of dislocated fractures, the affected limb may appear shortened and externally rotated. Knee pain, referred from the hip, is also a common symptom. Conversely, in pathological and stress fractures, there may be a history of prior hip pain without a significant traumatic event [39,40]. These cases often present with milder, more insidious symptoms, making the clinical condition less pronounced. To accurately diagnose

proximal femur fractures, several specific radiographs are essential. These include an antero-posterior (AP) view of the pelvis, an AP view of the hip with internal rotation, and a lateral view of the hip [1,3]. The AP view of the hip with internal rotation is particularly crucial for evaluating dislocated fractures. The internal rotation minimizes the overlap caused by the external rotation of the diaphysis, thus providing a clearer view of the fracture pattern. Frog-leg radiographs should be avoided in these cases due to the risk of causing severe pain [41]. If pathological or stress fractures are suspected, additional imaging studies should be conducted. Magnetic Resonance Imaging (MRI) is the preferred modality in these situations, offering detailed insights into bone and soft tissue conditions. If MRI is unavailable, a Computed Tomography (CT) scan can be used as an alternative [1]. For confirmed stress fractures, a comprehensive endocrine-metabolic assessment is recommended, ideally carried out by a pediatrician, to identify any underlying metabolic or hormonal issues contributing to the fracture.

Classification

The Delbet classification, popularized by Colonna, is the most widely used system for categorizing proximal femur fractures in chil-

dren [3,4,42]. This classification is particularly valuable because it not only predicts the prognosis but also informs management decisions (Figure 2). It is important to note that insufficiency fractures and stress fractures are considered separately from this classification.

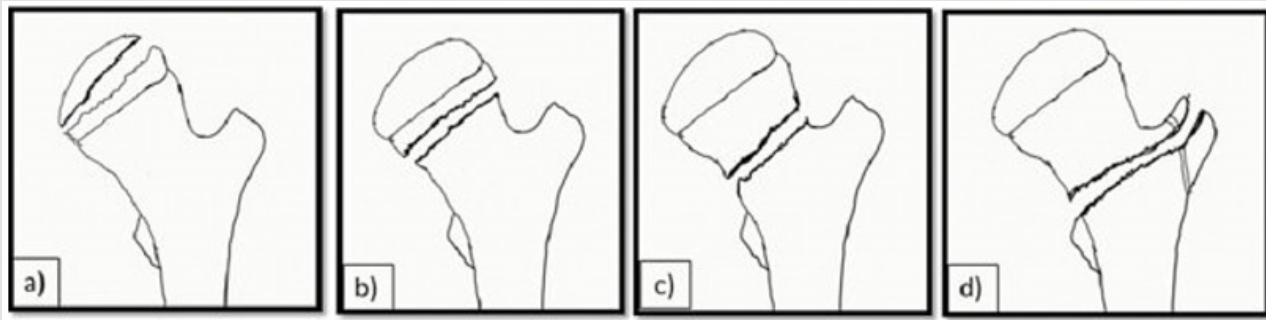


Figure 2: The Delbet Classification of Pediatric Proximal Femur Fractures:

- a) Type I: transepiphyseal fracture,
- b) Type II: transcervical fracture,
- c) Type III: basicervical fracture,
- d) Type IV: intertrochanteric fracture.

Delbet Type (I- IV)

Type I fractures, known as transphyseal fractures, are subdivided into IA and IB. Type IA fractures occur without dislocation of the proximal fragment, while Type IB fractures involve dislocation of the proximal fragment. These fractures have the highest risk of developing osteonecrosis, with an overall incidence of approximately 38% [2,31,37,43-45]. Notably, Type IB fractures are particularly prone to this complication, with up to 100% of cases developing osteonecrosis regardless of the treatment approach. Additionally, Type IB fractures carry a significant risk of premature physeal closure [1]. Type II frac-

tures, also known as transcervical fractures (Figure 1), are the most common type of proximal femoral fractures in children, accounting for 45-50% of cases [46]. The likelihood of progression to osteonecrosis in these fractures is approximately 28%, with a higher risk observed in dislocated fractures [3,43]. Another frequent complication associated with Type II fractures is coxa vara [1]. Type III fractures, known as basocervical fractures (Figure 3), are the second most common type of proximal femur fractures in children, comprising 34% of cases [3,46]. The incidence of osteonecrosis in these fractures is around 18%, with a higher likelihood when the fracture is dislocated. Additionally, there is a 14% risk of developing coxa vara.



Figure 3: Delbet type III fracture anatomically aligned and secured with a fixed-angle locking plate [3].

Stress Fractures: Causes and Diagnosis

Stress fractures of the femoral neck are not included in the Delbet classification and are addressed separately in this review. Although some classification systems for these fractures have been proposed, none are specifically tailored to the pediatric population [47-49]. Among the existing classifications, the Fullerton and Snowdy system is considered the most useful due to its decision-making utility [47]. This system categorizes stress fractures into three types: compression, tension, and displaced.

Evidence-Based Treatment for Pediatric Fractures

General Principles and Reduction Types for Acute Fractures:

Unlike many other pediatric fractures, proximal femur fractures frequently necessitate surgical intervention [29,44,50]. Historical accounts of conservative treatments indicate a high rate of complications associated with non-surgical approaches [51]. In contrast, recent literature shows that surgical treatment leads to better prognoses [1,4,5,18,52-54]. Despite advancements in surgical techniques, there remain significant debates regarding the optimal approaches, particularly concerning open versus closed reduction, the necessity of capsulotomy, and the timing of surgery. The consensus is that ideal treatment should adhere to three key principles: anatomical reduction, stable fixation, and performing surgery within 24 hours of injury [1]. There are differing opinions on the best reduction technique for pediatric proximal femur fractures. Some studies suggest better outcomes with open reduction in cases of displaced fractures [32,55], while others indicate higher complication rates with this method. However, this might be influenced by the severity of fractures typically treated with open reduction [36,56]. Recent meta-analyses have produced conflicting results regarding complication rates between open and closed reductions. One comprehensive review found no significant difference in complication rates between the two methods [44,54]. For less displaced fractures, it is recommended to attempt a closed reduction initially, using either a traction table or a standard radiolucent table. If this approach fails, an open reduction is advised. In cases of significantly displaced fractures, open reduction via anterior (Smith-Petersen), anterolateral (Watson-Jones), or lateral (Hardinge) incisions is recommended [1]. Regardless of the reduction technique, achieving anatomical reduction is paramount for optimal outcomes.

Capsulotomy: To Perform or Not to Perform and the Ideal Timing for Surgery: The decision to perform a capsulotomy or aspirate the intracapsular hematoma during closed reduction remains controversial in the literature. There is no consensus on whether these interventions reduce the risk of osteonecrosis, with some case series showing no benefits and other studies indicating positive outcomes from these techniques [3,4,36,55,57,58]. Despite the lack of statistical significance in demonstrating better results, more consistent evidence suggests that performing a capsulotomy may be beneficial in cases of Epiphysiolysis [59]. These procedures can be performed percutaneously with minimal morbidity, making them recommended for closed

reduction cases where patients undergo some form of fixation. There is no definitive evidence favoring one decompression technique over another, whether it be aspiration, percutaneous capsulotomy, or open capsulotomy [4,5,58]. However, percutaneous capsulotomy, as popularized by Schrader et al., is suggested due to its minimally invasive nature and potential benefits [59]. Controversy also surrounds the optimal timing for performing capsulotomy. A meta-analysis indicated lower complication rates in patients who had surgery within the first 24 hours post-trauma [36]. Conversely, another study reported higher complication rates in patients operated on within the first 12 hours [33]. Despite these conflicting findings, it is generally agreed that reduction should not be delayed beyond 24 hours to minimize the risk of complications [3,28,32,50,57].

Prompt treatment of proximal femur fractures in children is crucial to avoid delays that could lead to adverse outcomes. In conclusion, while there is no clear consensus on the best approach to capsulotomy or the ideal timing for surgery, evidence suggests a potential benefit from percutaneous capsulotomy in specific cases. Moreover, timely intervention, ideally within 24 hours, is crucial in managing proximal femur fractures to reduce the risk of complications.

Guidelines for Implant Selection and Immobilization Techniques: The literature offers limited evidence on the optimal types of implants for individual patients, but experts agree on several fundamental principles to guide the selection of fixation methods. It is crucial to prioritize stability, even if it requires crossing the physis with the implants [28,29]. For fractures requiring immobilization without fixation, a hip spica cast is recommended. The fractured limb should be positioned in abduction and neutral rotation to prevent varus deviation. When opting for Kirschner wires, it is advised to use two or three 2.0 mm diameter, non-threaded KWs. These wires should be buried under the skin to prevent intra-articular migration and reduce the risk of infection. After the procedure, a hip spica cast should be applied for at least six weeks. Kirschner wires should be removed in the operating room under anesthesia once the fracture has consolidated or if complications arise, such as pin migration, pain, or skin injuries [1,50]. For screw fixation, it is recommended to use two or three partially threaded cannulated screws with washers, if possible. The largest diameter screws suitable for the patient should be utilized: 4.0 mm to 4.5 mm for children under eight years old, and 6.5 mm, 7.0 mm, or 7.3 mm for those older than eight years [50]. All guide wires should be positioned before the first screw to prevent loss of reduction due to rotation of the proximal fragment during screw insertion. When crossing the physis, it is advised not to drill through it.

The drill should be introduced only immediately before the physis, and then tapped through it before inserting the screw. This approach aims to prevent premature physeal closure [50]. Screws should be inserted at least 5 mm away from the joint surface to avoid iatrogenic joint damage. The anterolateral quadrant of the epiphyses should be avoided to prevent osteonecrosis. For primary fixation with

plates, a fixed-angle plate is recommended, particularly for Delbet type IV fractures. There is no consensus on the use of plates for Delbet type I, II, or III fractures as primary treatment. Due to the risk of varus deviation following screw fixation, primary fixation with a fixed-angle plate, such as sliding screw fixation, blade plate, proximal humerus locking plates, or locked proximal femoral nail, is advised for fractures with significant instability or comminution [1,60]. A screw or KW should be placed before inserting the sliding screws to avoid loss of reduction [1].

Specific Treatment Strategies Based on Delbet's (I-IV) Classification: For pediatric femur fractures, the treatment approach varies based on age and fracture type. For children under two years old with minimally displaced fractures, closed reduction followed by a hip spica cast without capsulotomy is recommended [1, 50]. For those over two years old with minimally displaced fractures, closed reduction and fixation with implants are advised. In patients under 10 years old, fixation with Kirschner wires (KW) is preferred to prevent premature physeal closure, while in those older than 10 years, cannulated screws are recommended due to their greater stability and lower risk of physeal damage [1]. In type IA fractures with significant displacement and type IB fractures, open reduction and internal fixation should be performed regardless of age, as closed reduction may not achieve anatomical alignment and could prolong surgery unnecessarily. Types II and III fractures are prone to reduction loss if not stabilized with implants; hence, they should always be managed with fixation methods ensuring high stability [51,61]. For minimally displaced fractures, closed reduction, percutaneous capsulotomy, and implant fixation are options, whereas significantly deviated fractures require open reduction and fixation to ensure anatomical alignment [1,4]. For type III fractures, cannulated screws or a fixed-angle plate should be used without crossing the physis [1,50]. In type II fractures, implant choice and whether to cross the physis should be individualized, with KW fixation across the physis and additional hip spica cast immobilization recommended for children under five [1].

For those aged five to nine, careful consideration of implants and physeal integrity is crucial, often requiring cannulated screws or a fixed-angle plate with blocked cervical screws crossing the physis to ensure stable fixation [3,29]. For patients aged 10 years and older, fixation with cannulated screws or a fixed-angle plate crossing the physis is advised, with postoperative use of an abduction pad if necessary. For patients aged five years or younger with minimally displaced fractures, closed reduction and immobilization with a hip spica cast are typically sufficient [1]. Since all type IV fractures are extra-articular, capsulotomy is not required. If reduction and stability cannot be achieved with a hip spica cast alone, fixed-angle plates should be used, usually without crossing the physis. For patients older than five years, closed or open reduction with fixation using a fixed-angle plate is recommended. When open reduction is necessary, a lateral incision provides excellent exposure [4,50]. In adolescent patients, crossing the physis with implants may be considered for enhanced stability,

although in general, stable fixation can often be achieved without crossing the physis [1].

Treatment of Stress Fractures

Management of Compression-Sided and Tension-Sided Displaced Fractures: Compression-sided fractures can often be managed conservatively, with a treatment regimen including non-weight-bearing and the use of crutches, walkers, or wheelchairs for six to eight weeks, followed by a period of partial weight-bearing for an additional four to six weeks [62]. For patients who are less compliant with non-weight-bearing instructions, immobilization with a hip spica cast for the initial six weeks is recommended. On the other hand, tension-sided fractures or those with significant displacement are best addressed with internal fixation [47,48,63]. While some literature suggests that conservative management might be effective in mature patients, surgical intervention is generally preferred to ensure proper stabilization and alignment. The selection of implant and the decision to cross the physis should adhere to established guidelines for managing acute fractures [63].

Follow-Up, Rehabilitation, and Management of Complications: Patients who are treated with a hip spica cast or Kirschner wires (KW) should maintain their immobilization until fracture consolidation, which typically takes between six to twelve weeks. For cases requiring stable fixation but not a hip spica cast, non-weightbearing is advised for six to eight weeks. Physical therapy, including active and passive non-weightbearing exercises, should commence around the second week post-operation. Partial weight-bearing can begin after the fourth week, with a gradual increase to full weight-bearing. If the patient has fully rehabilitated, a return to sports may be considered after approximately four months. Proximal femoral fractures in children are associated with a high complication rate, approximately 33% [3,37,56]. Osteonecrosis is the most prevalent complication, affecting up to 50% of cases [1,3,37,45]. Other common issues include coxa vara, non-union, and early physeal closure [3,4,36,64], while post-traumatic epiphysiolysis, septic arthritis, and femoral neck overgrowth are less common but should still be monitored during follow-up [1,35,64].

Osteonecrosis

Osteonecrosis is the most prevalent complication following femoral neck fractures (Figure 4). Key risk factors include Delbet I and II fractures, displaced fractures, and patients older than 10 years of age [1,32,37,45,56,57]. Current evidence does not conclusively show that open reduction and capsulotomy, nor the timing of surgery, significantly reduce the incidence of osteonecrosis [1,37,45]. Nevertheless, some studies suggest that these techniques may lower the risk of osteonecrosis [3,32,36,54,55]. Despite ongoing debates, an early approach—whether through open or closed anatomical reduction combined with capsulotomy and stable fixation—might reduce the overall complication rate. Osteonecrosis typically develops around seven months after the trauma but can take up to two and a half years

to fully manifest [4,44,57]. The classification system by Ratliff [65] is commonly used to assess post-traumatic osteonecrosis (Figure 5) [66]. Type I generally has a poorer prognosis, and there is debate on whether type III represents a response from the metaphyseal bone rather than true osteonecrosis [1]. Children over 10 years old generally face a worse prognosis [50]. Early-stage osteonecrosis may be managed conservatively with symptomatic treatments, including physiotherapy and non-weight-bearing with crutches or wheelchairs [1,4]. Severe cases with significant femoral head deformities require

individualized treatment strategies. Another complication, coxa vara, is characterized by a cervical-diaphyseal angle of less than 120° due to issues in fracture reduction, fixation, or consolidation [4,5]. Symptoms may include pain, femoroacetabular impingement, early arthritis, and Trendelenburg gait [1]. While younger children may experience valgus remodeling without intervention, severe cases or those with additional complications are often treated with a valgus osteotomy [61,67,68] (Figures 6-8).



Figure 4: Pelvis AP View.



Figure 5: A young man broke his left hip half a year ago and had the metal implants removed a week before the X-ray was taken. The first X-ray shows that the broken hip bone had not healed properly. A second X-ray, taken four months later, shows that the bone is healing after surgery to repair the nonunion and correct the hip's alignment [66].



Figure 6: The frog leg lateral view.

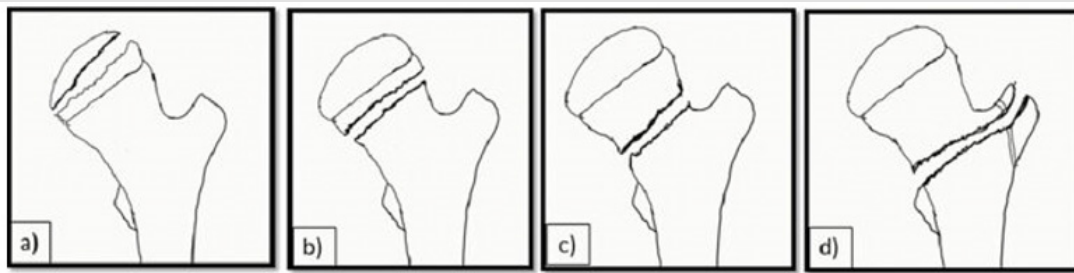


Figure 7: Ratliff Classification of Avascular Necrosis Following Femur Neck Fracture:

- A. A: entire head affected,
- B. B: partial head affected,
- C. C & D: Necrosis area extends from the fracture line to the physis in the femoral neck [67].

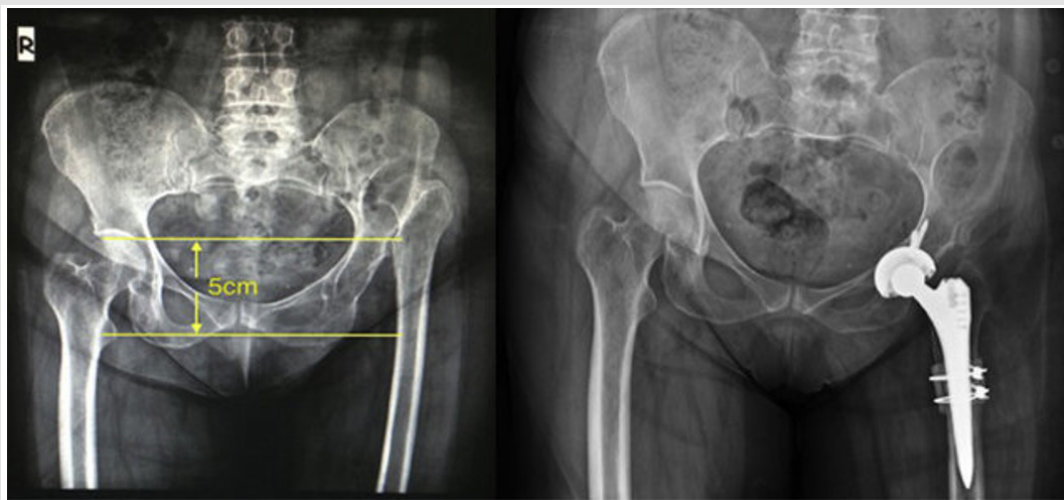


Figure 8: Comparison of Leg Length Before and After Surgery: The images show a difference in leg length as measured on X-rays of the pelvis. One X-ray was taken before surgery and the other after. The measurement used was the distance between the lesser trochanters (bony protrusions on the thigh bone) [68].

Approaches to Non-Union and Premature Physeal Closure

Non-union is a frequent complication of proximal femur fractures in children, particularly in Delbet II fractures [3-5,36,69]. This issue typically arises from non-anatomic reduction and inadequate fixation. To address non-union, a valgus osteotomy is often recommended, as it converts shear forces into compression forces, facilitating fracture consolidation [1,61] (Figures 6-8). Additionally, applying an autologous bone graft from the iliac crest to the non-union site is advisable. The incidence of non-union can be as high as 62% in certain case series, potentially due to trauma, vascular issues, or complications related to the fixation implants [1,3,29]. Non-union is most commonly observed in Delbet II and III fractures [50]. Complications such as varus and valgus displacement and limb length discrepancy may occur, but surgical interventions to correct limb length are rarely necessary, except in very young children (typically under eight years of age) [5,50]. Regular monitoring through physical examinations and panoramic radiography (scanogram) is crucial until skeletal maturity is reached. It is important to note that, despite the risks of premature physeal closure, achieving stable fixation may require crossing the physis [1,50].

Conclusion

In conclusion, proximal femoral fractures in children, though rare, present significant management challenges and are associated with a high rate of complications. These fractures predominantly affect children aged 10 to 13 years, with up to 33% developing complications, most commonly osteonecrosis, which occurs in up to 50% of cases. Key risk factors include Delbet I and II fractures, displacement, and patient age over 10 years. High-energy trauma is the primary cause, necessitating thorough assessment for associated injuries, while low-energy trauma warrants investigation for underlying metabolic disorders and bone tumors. Effective treatment requires anatomical reduction, stable fixation, and surgical intervention within the first 24 hours post-trauma. Closed reduction is appropriate for non-displaced fractures, but displaced fractures necessitate open reduction. Additionally, open or percutaneous capsulotomy should be considered to manage intracapsular pressure in closed reduction cases. Regular follow-up every two weeks for the initial two months is essential, and a return to sports may be permitted after four months if rehabilitation is successfully completed.

Credit Authorship Contribution Statement

Pourya Bazayr: Conceptualization, Writing – original draft. Ehsan Sheidaee: Methodology, Visualization, Writing – review & editing. Elham Ghazi Zadeh: Visualization, Writing – review & editing.

Declaration of Competing Interest

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Data Availability

No data was used for the research described in the article.

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