








# Short-term Results of the Treatment of Hip Fractures in Children

## *Resultados a corto plazo del tratamiento de fracturas de cadera en población infantil*

Felipe Hodgson Ovalle<sup>1</sup>  Francesca Moller<sup>1</sup>  Manuela Angulo<sup>1</sup>  Maria-Jesus Figueroa<sup>1</sup>   
Alejandro Gündel<sup>1</sup> Ismael Cañete<sup>1</sup> 

<sup>1</sup>Department of Orthopedics and Traumatology, Escuela de Medicina, Pontificia Universidad Católica de Chile, Santiago, Chile

Rev Chil Ortop Traumatol 2022;63(3):e164–e170.

Address for correspondence Ismael Cañete Campos, MD, Departamento de Ortopedia y Traumatología, Escuela de Medicina, Pontificia Universidad Católica de Chile, Diagonal Paraguay n° 362, 3er piso, Santiago, Chile (e-mail: icanete1@uc.cl).

### Abstract

**Introduction** Pediatric hip fractures are infrequent, associated with high-energy trauma, and present devastating complications. Most cases are treated surgically using different types of fixation. The objective of the present study is to report the results of a series of cases of surgical patients in two reference hospitals in Chile.

**Materials and Methods** A case series which included pediatric patients diagnosed with hip fractures and treated surgically between 2004 and 2008. We performed descriptive statistics for the demographic variables, the energy of the accident, the Delbet classification, the type of treatment, the osteosynthesis technique, of complications, and the clinico-radiological evaluation according to evaluation.

**Results** A total of 17 cases were evaluated, 76.5% of which were secondary to high-energy accidents. The median age of the sample was of 7 years, and it was composed of 58.8% of girls. There were 3 cases of Delbet type II, 9 of type III, and 5 of type IV. As fixation method, we used cannulated screws (9 cases), locking compression plates (LCPs; 5 cases), dynamic hip screws (DHSs; 2 cases), and dynamic compression plates (DCPs; 1 case). The median follow-up was of 2.3 years (range: 0.5 to 12.8 years). Complications were observed: coxa vara in one case, and discrepancy in the length of the lower extremities in another case, and there were no cases of osteonecrosis. Osteosynthesis removal was performed in seven patients. Good results were obtained in all patients according to Ratliff criteria.

**Conclusions** Most fractures were associated with high energy trauma, with the most frequent being type III on the Delbet classification. All the patients were treated surgically, with good results, with no cases of osteonecrosis.

Level of evidence: 4.

### Keywords

- ▶ hip fractures
- ▶ osteosynthesis
- ▶ children

received  
June 9, 2021  
accepted  
January 10, 2022

DOI <https://doi.org/10.1055/s-0042-1744266>.  
ISSN 0716-4548.

© 2022. Sociedad Chilena de Ortopedia y Traumatología. All rights reserved.

This is an open access article published by Thieme under the terms of the Creative Commons Attribution-NonDerivative-NonCommercial-License, permitting copying and reproduction so long as the original work is given appropriate credit. Contents may not be used for commercial purposes, or adapted, remixed, transformed or built upon. (<https://creativecommons.org/licenses/by-nc-nd/4.0/>)

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

## Resumen

**Introducción** Las fracturas del fémur proximal pediátricas son infrecuentes, se asocian a traumas de alta energía, y presentan complicaciones devastadoras. La mayoría de los casos se tratan en forma quirúrgica utilizando diversos tipos de fijación. El objetivo de este estudio es reportar los resultados de una serie de casos de pacientes quirúrgicos en dos hospitales de referencia en Chile.

**Materiales y métodos** Serie de casos tratados entre el 2004y el 2018, en la que se incluyeron pacientes pediátricos con diagnóstico de fractura de fémur proximal que fueron operados. Se realizó estadística descriptiva de las variables demográficas, la energía del accidente, la clasificación según Delbet, el tipo de tratamiento, la técnica de osteosíntesis, la aparición de complicaciones, y la evaluación clínico-radiológica según los criterios de Ratliff.

**Resultados** Se evaluaron 17 casos, de los cuales un 76,5% fueron secundarios a accidentes de alta energía. La mediana de edad de la muestra fue de 7 años, y había un 58,8% de niñas. Hubo 3 casos de tipo II en la clasificación de Delbet, 9 de tipo III, y 5 de tipo IV. Como método de fijación, se utilizaron tornillos canulados (9 casos), placa de compresión de bloqueo (*locking compression plate*, LCP, en inglés; 5 casos), tornillo dinámico de cadera (*dynamic hip screw*, DHS, en inglés; 2 casos), y placa de compresión dinámica (*dynamic compression plate*, DCP, en inglés; 1 caso). La mediana de seguimiento fue de 2,3 años (rango: 0,5 a 12,8 años). Se presentaron complicaciones: *coxa vara* en un caso, y discrepancia de longitud de extremidades inferiores en otro caso, y no hubo osteonecrosis. Se realizó retiro de osteosíntesis en siete pacientes. Se obtuvieron buenos resultados en todos los pacientes según los criterios de Ratliff.

**Conclusiones** La mayoría de las fracturas se asociaron a traumas de alta energía, siendo el tipo más frecuente el III de Delbet. Todos los pacientes fueron tratados en forma quirúrgica, con buenos resultados, sin observar osteonecrosis.

Nivel de evidencia: 4.

## Palabras clave

- ▶ fractura de cadera
- ▶ osteosíntesis
- ▶ niños

## Introduction

Pediatric proximal femur fractures are rare injuries; however, they can lead to severe complications and potential long-term disability.<sup>1</sup> Due to the features of the immature skeleton, a high-energy mechanism is required in order for the femoral neck to undergo a fracture.<sup>2</sup> Thus, most of these fractures result from high-energy trauma, especially motor vehicle accidents (53–57%) and falls from height (36–43%).<sup>3,4</sup> Associated injuries occur in 61% to 86% of the patients, including head, chest, abdomen, pelvic ring lesions, acetabular fractures, hip dislocations, and ipsilateral femur fractures.<sup>3,4</sup>

Although the incidence of pediatric proximal femur fractures is low, the literature about it consists mainly of case series<sup>3,4,8–10,13</sup> in which advances have been observed, especially regarding treatment. In the past, conservative treatment involving months of traction and plaster casts, with a high level of complications, was chosen in most cases. The current trend is to try to achieve anatomical reduction and stable fixation; therefore, the rate of surgical indication has increased.<sup>5</sup>

The most frequent complication is avascular necrosis, with an incidence ranging from 0 to 47%, depending on the series. The increased risk compared to that of proximal femur

fractures in adults is due to differences in the irrigation of the femoral head. In adults, intraosseous vessels irrigate the femoral head, but, in children, these vessels do not cross the physis, and the contribution from the artery of the ligamentum teres is greater.<sup>6,7</sup> Other complications include malunion with *coxa vara*/*valga* (14–21%), premature physeal closure (7–61%), nonunion (0–8%), septic arthritis (0–8%), and iatrogenic femoral head perforation by screws (0–3%).<sup>4,8–13</sup>

Although pediatric proximal femur fractures are uncommon, they are relevant because complications can be devastating. Hence, it is critical to understand their diagnosis, proper treatment, and complication management to optimize the outcomes in this population. The present study describes the management of these fractures through a retrospective review of cases from two Chilean reference centers, along with a critical analysis of the treatment and complications.

## Materials and Methods

The present is a descriptive series of cases treated from 2004 to 2018 at 2 high-complexity centers. The ethics committee from both participating centers approved the study.

**Table 1** Ratliff<sup>15</sup> criteria

	Good	Regular	Poor
Pain	No pain	Occasional	Debilitating pain
Mobility	Complete	> 50%	< 50%
Activity	Normal mobility	Avoids playing	Restricted mobility
Radiological assessment	Normal	Severe deformity	Avascular necrosis, arthritis, arthrodesis

A diagnosis database query revealed patients up to 15 years old with proximal femur fracture who underwent surgical treatment at both centers between 2004 and 2018. The excluded subjects presented pathological bone fractures, closed physis at diagnosis, or incomplete records.

The recorded data included the following: age, gender, fracture mechanism, associated injuries, time until surgery, type of reduction (open or closed), osteosynthesis material, the reduction achieved with osteosynthesis, and the duration of the follow-up. Preoperative images were analyzed retrospectively, and the injuries were classified according to the Delbet criteria adapted by Colonna<sup>14</sup> as type I (transepiphyseal), type II (transcervical), type III (basicervical), and type IV (intertrochanteric). To assess the follow-up, we used the Ratliff criteria,<sup>15</sup> shown in ►Table 1, according to the most recently-available data and images. In addition, complications during the follow-up period were recorded.

### Statistical Analysis

The descriptive statistical analysis included demographic variables, fracture mechanism, time until surgery, the Delbet classification, the type of treatment, the osteosynthesis technique, complications, and a clinico-radiological evaluation per the Ratliff criteria. Absolute and relative frequencies were used to describe the categorical variables. For the quantitative variables, the Shapiro-Wilks test determined data normality; given its non-parametric distribution, median values and minimum-maximum ranges were calculated. The Stata (StataCorp LLC, College Station, TX, US) software, version 16, was used for the statistical calculations.

### Results

We evaluated 17 patients with proximal femur fractures, and ►Table 2 summarizes the main features of each case. The median age was of 7 years (range: 3 to 14 years), and 58.8% ( $n = 10$ ) of the patients were female. A total of 76.5% ( $n = 13$ ) of the cases were secondary to high-energy accidents, and the most common associated injuries were head trauma ( $n = 3$ ; 17.6%), and long-bone fractures: femur ( $n = 1$ ; 5.9%) and tibia ( $n = 1$ ; 5.9%).

As for fracture type, there were 3 (17.6%) cases of type II, 9 (52.9%) of type III, and 5 (29.4%) of type IV. All patients underwent reduction and osteosynthesis, and 12 surgeries (70.6%) occurred within 24 hours. The patients treated after presented injuries classified as type I ( $n = 1$ ; 5.9%), type III ( $n = 3$ ; 17.6%), and type IV ( $n = 1$ ; 5.9%) on the Delbet

classification; the main reason for later treatment was clinical instability.

►Table 3 describes the implants used in the present study. All type-II fractures underwent closed reduction and osteosynthesis with screws. Among the type-III fractures, 6 (67%) were treated with closed reduction and cannulated screws, an example is shown in ►Figure 1. The other 3 cases (33%) required open reduction, as the case shown in ►Figure 2. Closed reduction was not achieved in one patient and not attempted in a second subject with a concomitant pelvic fracture; these two cases underwent fixation with a locking compression plate (LCP). The third case presented a basicervical fracture; fixation was performed using a dynamic hip screw (DHS), with no attempt to perform closed reduction. All Delbet IV fractures underwent open reduction and fixation with LCP ( $n = 3$ ; 60%), dynamic compression plate (DCP;  $n = 1$ ; 20%) and DHS ( $n = 1$ ; 20%). An example of a Delbet IV fracture fixed with an LCP is shown in ►Figure 3.

The median follow up was 2.3 years (range: 0.5 to 12.8 years). All patients presented good clinical and radiological outcomes according to the Ratliff criteria at the end of the period. Complications occurred in two (11.8%) cases, including coxa vara ( $n = 1$ ; 5.9%) and lower limb discrepancy ( $n = 1$ ; 5.9%). No cases of osteonecrosis were observed in our series. Removal of the osteosynthesis material was performed in 7 (41.2%) cases; all procedures were elective due to implant-related symptoms.

### Discussion

The present study described a series of cases of proximal femur fractures in the pediatric population operated in two high-complexity centers in Chile. Our study shows that a high percentage of these cases were due to high-energy trauma; in addition, 70.6% (12 cases) of surgeries were performed within the first 24 hours. Although the complication rate was of 12% (2 cases), no cases of vascular necrosis were observed.

In our study, 76.5% ( $n = 13$ ) of the fractures were associated with high-energy trauma, which is consistent with the literature.<sup>5</sup> Although infrequent, these fracture are associated with motor vehicle accidents in 53% to 57% of the cases, depending on the series.<sup>3,4</sup> In Chile, the number of motor vehicle accidents has increased from 57,087 to 89,311 between 2008 and 2018.<sup>16</sup> Even though there are no Chilean data regarding pediatric proximal femur fracture, we can assume that these injuries will remain a concern given their association with traffic accidents.

**Table 2** Summary of the patients included in the study subjects

Patient number	Age (years)	Gender	Injury mechanism	Delbet classification	Type of reduction	Type of fixation	Anatomical reduction	Removal of osteosynthesis material	Complications	Duration of the follow-up (years)
1	11	Female	Traffic accident	Type IV	Open	DHS	No	No	Coxa vara	8.5
2	14	Male	Fall from height	Type III	Closed	DHS	Yes	No	No	3.6
3	3	Female	Fall from height	Type III	Closed	Cannulated screws	Yes	No	No	12.8
4	7	Male	Fall from height	Type II	Closed	Cannulated screws	Yes	No	No	10.9
5	8	Female	Fall from height	Type IV	Open	3.5-mm LCP	Yes	No	Discrepancy in the length of the lower limbs	1.8
6	4	Female	Polytrauma	Type III	Closed	Cannulated screws	Yes	Yes	No	4.0
7	4	Male	Gate fell over the patient	Type IV	Open	3.5-mm LCP	Yes	No	No	1.3
8	13	Male	Not reported	Type II	Closed	Cannulated screws	Yes	No	No	1.8
9	5	Female	Fall from height	Type III	Closed	Cannulated screws	Yes	No	No	3.1
10	6	Male	The patient was run over	Type IV	Open	3.5-mm DCP	No	Yes	No	2.3
11	4	Male	Fall from stairs	Type III	Open	3.5-mm LCP	Yes	Yes	No	1.4
12	12	Female	Fall from same level	Type II	Closed	Cannulated screws	No	No	No	3.0
13	12	Female	Fall from same level	Type III	Open	Cannulated screws	Yes	Yes	No	1.7
14	14	Male	Fall from height	Type IV	Open	3.5-mm LCP	Yes	Yes	No	0.5
15	7	Female	Fall from height	Type III	Closed	Cannulated screws	No	Yes	No	1.8
16	14	Female	Traffic accident	Type III	Open	4.5-mm LCP	Yes	No	No	2.8
17	7	Female	Traffic accident	Type III	Closed	Cannulated screws	Yes	Yes	No	1.9

Abbreviations: DCP, dynamic compression plate; DHS, dynamic hip screw; LCP, locking compression plate.

**Table 3** Implants used

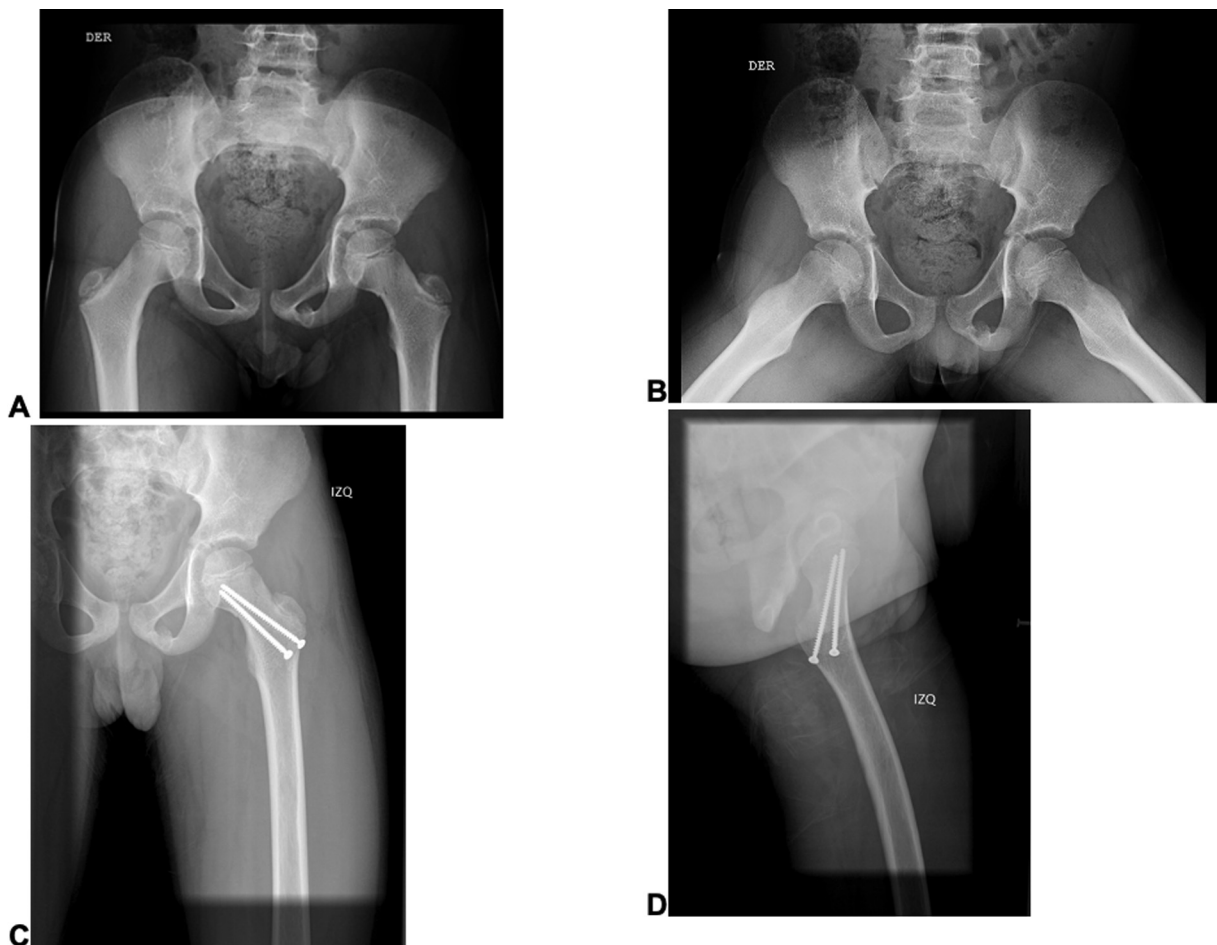
Type of osteosynthesis	N
Cannulated screws	9
Locking compression plate (LCP)	5
Dynamic hip screw (DHS)	2
Dynamic compression plate (DCP)	1

Avascular necrosis is the most feared complication from these fractures. It relates to the type of fracture, and it is more frequent in type-I and -II fractures due to the disruption of the epiphyseal irrigation.<sup>17</sup> In addition, the risk is greater in patients operated on, after 24 hours.<sup>5</sup> Regarding other published series, the oldest ones report a higher incidence of necrosis, such as those by Canale and Bourland<sup>9</sup> (43%) and Davison and Weinstein<sup>8</sup> (47%), in contrast to more recent series, such as those by Cheng and Tang<sup>12</sup> (0), Song et al.<sup>11</sup> (0), Flynn et al.<sup>10</sup> (6%), Shrader et al.<sup>13</sup> (10%), and Bali et al.<sup>4</sup> (19%).

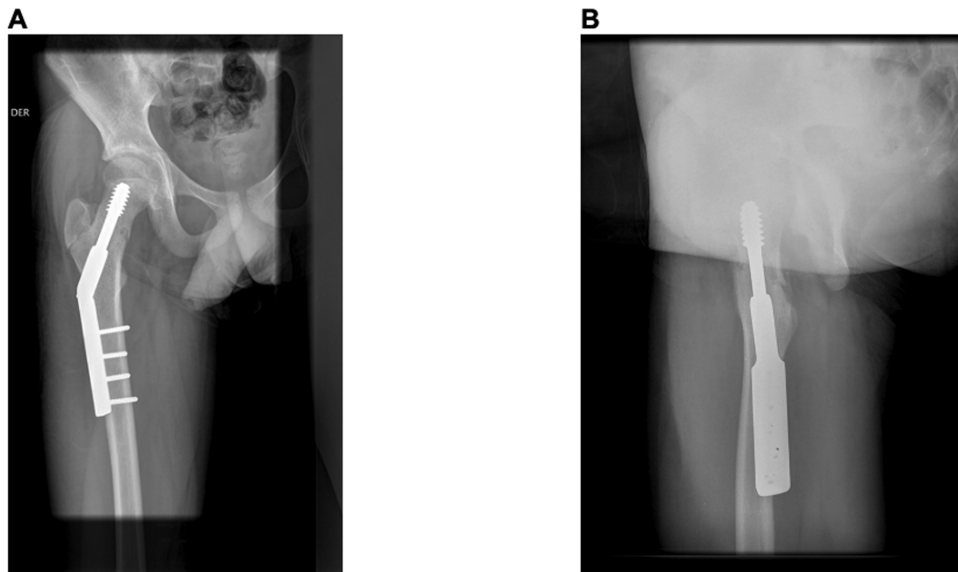
It is believed that these differences relate to early treatment and the achievement of an anatomical reduction.<sup>5,12</sup> In the present series, the rate of complications was of 12% ( $n=2$ ), with no cases of osteonecrosis, maybe due to the low incidence of type-I and -II fractures (3 patients - 17.6%) and the fact that most of our patients (12; 70.6%) underwent surgery within the first 24 hours.

The present study has some limitations. Since it is a retrospective analysis, there may have been biases in recording information; in addition, the period studied to obtain a sufficient number of patients was long, patients treated orthopedically were not considered, and different surgeons performed the procedures. The small number of patients limits the ability to draw conclusions; however, this limitation occurs because these fractures are rare.

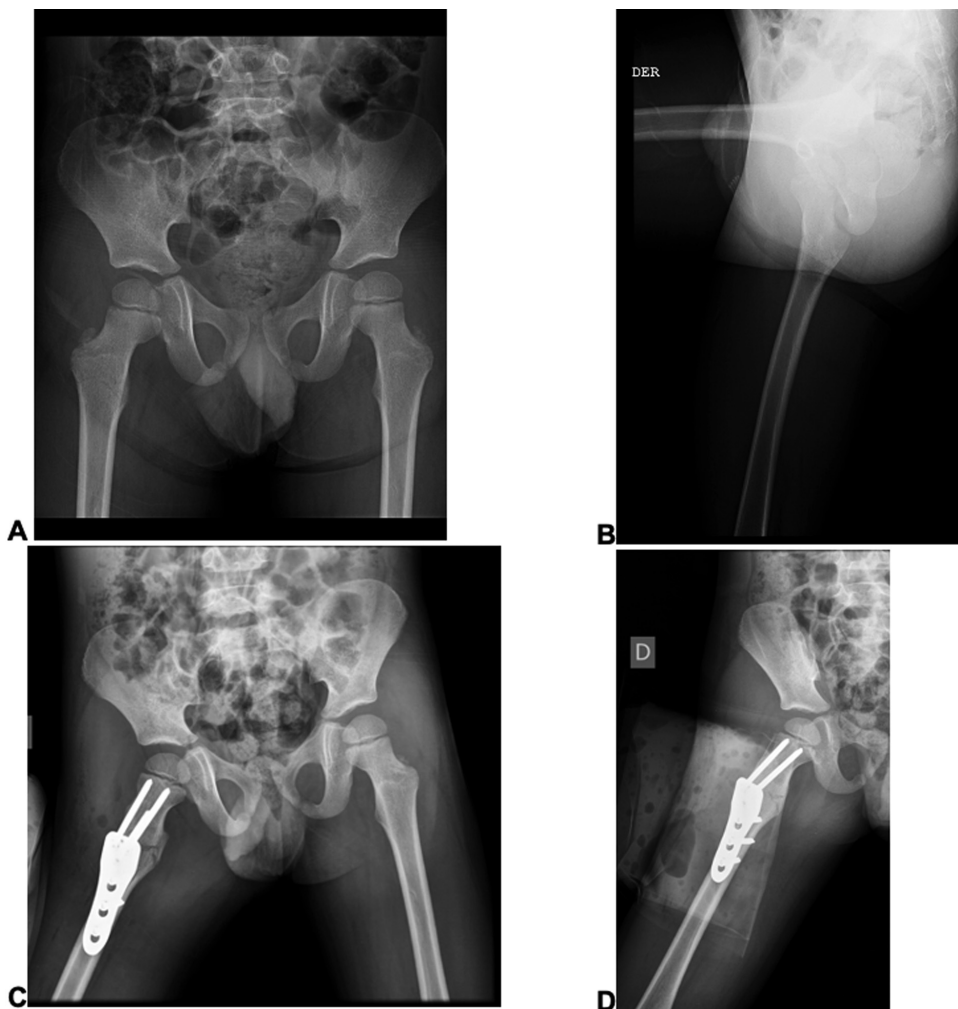
It is worth mentioning that the literature on this subject is scarce<sup>4,5,8-12</sup> and that, to date, there are no Chilean case series, so the present is the first publication on the subject. Furthermore, although our series is small, an aggressive surgical management had led to acceptable outcomes in our patients, without increasing the risk of avascular



**Fig. 1** A 7-year-old male patient with a Delbet type-II fracture of the proximal femur. The treatment consisted of closed reduction and osteosynthesis with cannulated screws. (A,B) Preoperative radiographs showing a non-displaced fracture of the femoral neck. (C,D) Postoperative radiographs showing anatomical reduction and osteosynthesis with cannulated screws.



**Fig. 2** A 14-year-old male patient with a Delbet type-III fracture of the proximal femur. The treatment consisted of closed reduction and osteosynthesis with a dynamic hip screw (DHS). (A,B) Postoperative radiographs showing anatomical reduction and osteosynthesis with a DHS.



**Fig. 3** A 4-year-old male patient with a Delbet type-IV fracture of the proximal femur. The treatment consisted of open reduction and osteosynthesis with a 3.5-mm locking compression plate (LCP). (A,B) Preoperative radiographs showing an intertrochanteric fracture. (C,D) Postoperative radiographs showing anatomical reduction and osteosynthesis with an LCP.



necrosis. Lack of studies does not enable us to establish the best fixation method and clarify the factors influencing avascular necrosis and other complications.

#### Conflict of Interests

The authors have no conflict of interests to declare.

#### References

- 1 Hajdu S, Oberleitner G, Schwendenwein E, Ringl H, Vécsei V. Fractures of the head and neck of the femur in children: an outcome study. *Int Orthop* 2011;35(06):883–888
- 2 Green NE, Swiontkowski MF. *Skeletal Trauma in Children E-Book*. Elsevier Health Sciences; 2008
- 3 Mirdad T. Fractures of the neck of femur in children: an experience at the Aseer Central Hospital, Abha, Saudi Arabia. *Injury* 2002;33(09):823–827
- 4 Bali K, Sudesh P, Patel S, Kumar V, Saini U, Dhillon MS. Pediatric femoral neck fractures: our 10 years of experience. *Clin Orthop Surg* 2011;3(04):302–308
- 5 Yeranorian M, Horneff JG, Baldwin K, Hosalkar HS. Factors affecting the outcome of fractures of the femoral neck in children and adolescents: a systematic review. *Bone Joint J* 2013;95-B(01):135–142
- 6 Ogden JA. Changing patterns of proximal femoral vascularity. *J Bone Joint Surg Am* 1974;56(05):941–950
- 7 Trueta J. The normal vascular anatomy of the human femoral head during growth. *J Bone Joint Surg Br* 1957;39-B(02):358–394
- 8 Davison BL, Weinstein SL. Hip fractures in children: a long-term follow-up study. *J Pediatr Orthop* 1992;12(03):355–358
- 9 Canale ST, Bourland WL. Fracture of the neck and intertrochanteric region of the femur in children. *J Bone Joint Surg Am* 1977;59(04):431–443
- 10 Flynn JM, Wong KL, Yeh GL, Meyer JS, Davidson RS. Displaced fractures of the hip in children. Management by early operation and immobilisation in a hip spica cast. *J Bone Joint Surg Br* 2002;84(01):108–112
- 11 Song KS, Kim YS, Sohn SW, Ogden JA. Arthrotomy and open reduction of the displaced fracture of the femoral neck in children. *J Pediatr Orthop B* 2001;10(03):205–210
- 12 Cheng JC, Tang N. Decompression and stable internal fixation of femoral neck fractures in children can affect the outcome. *J Pediatr Orthop* 1999;19(03):338–343
- 13 Shrader MW, Jacofsky DJ, Stans AA, Shaughnessy WJ, Haidukewych CJ. Femoral neck fractures in pediatric patients: 30 years experience at a level 1 trauma center. *Clin Orthop Relat Res* 2007;454(454):169–173
- 14 Colonna P. Fractures of the neck of the femur in children. *Am J Surg* 1929;6:793–797
- 15 Ratliff AH. Fractures of the neck of the femur in children. *Orthop Clin North Am* 1974;5(04):903–924
- 16 Observatorio de Seguridad Vial [Internet]. Comisión Nacional de Seguridad de Tránsito.; 2020. Disponible en: <https://www.conaset.cl/programa/observatorio-datos-estadistica/>
- 17 Gautier E, Ganz K, Krügel N, Gill T, Ganz R. Anatomy of the medial femoral circumflex artery and its surgical implications. *J Bone Joint Surg Br* 2000;82(05):679–683