

Clinical and Radiological Outcomes of Distal Femur Physeal Fractures

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ABSTRACT

Objective: Fractures of the distal femoral physes usually occur after high energy trauma and they are serious injuries of pediatric population. This aim of this study is to examine distal femoral physeal fractures treated in a level I pediatric trauma center epidemiologically and to report the complications that occurred during follow-up.

Methods: Patients, <18 years of age, admitted to the emergency department with distal femoral physeal fractures were included in the study. Demographic data, medical history, preoperative findings, injury mechanisms, postoperative outcomes, complications during follow-up period of the patients were noted. Salter-Harris classification was used to categorize the fractures.

Results: In total, 21 patients, with a mean age of 12.3 years (range, 1-16 years), were included in the study. Male to female ratio was 2.5. 12 patients (57.2%) had Salter-Harris type 2 fractures and it was the most common type. 19 (90.5%) fractures were treated surgically with different fixation methods. Mean follow-up duration was 97 months (range, 72-133 months). Complications observed during follow-up were genu valgum (n=2, 9.5%), limb length discrepancy (n=2, 9.5%), reoperation (n=7, 33.3%) and joint stiffness (n=1, 4.8%).

Conclusion: Distal femoral physeal injuries are injuries with a high rate of complications and these complications, like growth disturbance, may cause serious problems in adulthood. Although this injury is relatively uncommon, patients should be treated appropriately and followed regularly until skeletal maturity for possible late complications.

INTRODUCTION

Fractures involving the distal femoral epiphyseal plate are relatively uncommon injuries, however, they are serious since their complication rates are known to be high.^[1] This injury, initially referred to as “cartwheel injury”, occurs when children’s feet get stuck and the knee becomes hyperextended.^[2] It is more common in adolescence period and as the incidence of high-energy trauma steadily increases, the frequency of distal femur fractures is also increasing accordingly.^[3,4]

The distal femoral epiphysis is the epiphyseal plate that contributes most to lower extremity growth.^[5,6] For this reason, there is a high probability of growth disturbance or angular deformities occurring with these injuries.^[7] As a result, repeated operations may be required to correct deformities.

This study aimed to examine pediatric distal femur fractures extending to the physeal plate in a level I pediatric trauma center epidemiologically and to report the compli-

cations that occurred during the follow-up and the treatment modalities according to the complications.

MATERIALS AND METHODS

The study was conducted at a tertiary center and was approved by the Ankara Etlik City Hospital Ethical Review Board in accordance with the Declaration of Helsinki (Date: 16/07/2025, No: AESH-BADEK1-2025-271). Informed consent was taken from all patients’ parents to use their data in the study.

Patients, <18 years of age, admitted to the emergency department with distal femur fractures between 2014 and 2019 were retrospectively analyzed. Patients with distal femur fractures which have epiphyseal involvement, follow-up longer than 24 months, good imaging quality, and sufficient clinical data were included in the study. Patients with distal femur fractures which do not have epiphyseal involvement, poor imaging quality, insufficient clinical data, and those who did not give consent to participate in the study and share data were excluded from the study. The

Table 1. Demographic and clinical data of patients

Case number	Age (years)	Sex	Mechanism of injury	Salter-Harris classification	Additional injury	Treatment	Follow-up duration (months)	ROM (12th month)	Complications
1	1	M	Fall from height	2	N/A	Long leg cast	119	133	N/A
2	2	M	Fall from height	4	N/A	Long leg cast	120	130	N/A
3	9	M	MVA	2	Ipsilateral tibia shaft (Floating knee)	CRPF (K-wire + cannulated screw)	99	132	Reoperation (implant removal)
4	11	F	MVA	4	Contralateral femur shaft	ORIF (Plate)	108	135	Reoperation (implant removal)
5	12	M	Sport-related	2	N/A	CRPF (Cannulated screw)	91	132	N/A
6	12	F	Sport-related	2	N/A	CRPF (Cannulated screw)	90	136	N/A
7	13	M	Sport-related	2	N/A	CRPF (K-wire)	81	140	N/A
8	13	M	MVA	4	N/A	ORIF (External fixator + plate)	133	130	Reoperation (implant removal)
9	13	M	MVA	3	N/A	ORIF (Plate)	94	135	N/A
10	14	F	MVA	2	Bilateral tibia shaft (Floating knee) + Contralateral medial malleol	CRPF (K-wire)	89	95	Valgus (20°) and flexion (10°) angulation+LLD (3cm)+ Reoperation (Corrective osteotomy)+Stiffness
11	14	M	MVA	4	Ipsilateral tibial plateau	ORIF (Cannulated screws)	72	133	Reoperation (implant removal)
12	14	M	Fall from height	2	N/A	ORIF (Cannulated screws)	92	134	N/A
13	14	F	MVA	3	N/A	ORIF (Cannulated screws)	91	138	N/A
14	14	M	MVA	4	Ipsilateral tibia shaft (Floating knee)	ORIF (Cannulated screws)	92	132	N/A
15	14	M	Sport-related	2	N/A	CRPF (Cannulated screws)	113	136	Reoperation (implant removal)
16	14	M	MVA	2	Contralateral tibia shaft	CRPF (Cannulated screws)	112	137	N/A
17	15	F	Sport-related	2	N/A	CRPF (Cannulated screws)	76	134	Valgus angulation (16°)+LLD (3cm)
18	15	M	MVA	2	N/A	ORIF (Plate)	72	136	N/A
19	15	F	MVA	4	N/A	ORIF (Cannulated screws)	123	138	N/A
20	15	M	Fall from height	4	N/A	ORIF (Cannulated screws)	88	133	Reoperation (implant removal)
21	16	M	MVA	2	N/A	ORIF (Plate)	82	132	N/A

M: Male; F: Female; MVA: Motor vehicle accident; N/A: Not applicable; ORIF: Open reduction-internal fixation; CRPF: Closed reduction-percutaneous fixation; K-wire: Kirschner wire; ROM: Range of motion; LLD: Limb length discrepancy.

patients' treatments were decided by the senior orthopedic surgeon on duty on the day they came to the emergency room.

Demographic data, medical history, preoperative findings, injury mechanisms, postoperative outcomes, complications during the follow-up period of the patients were noted. Fractures were classified according to the Salter-Harris classification.^[8] Anteroposterior and lateral orthoroentgenograms and knee radiographs were examined for possible radiographic complications. For functional evaluation, knee joint range of motion measurements at every follow-up examination were made with a goniometer.

RESULTS

There were 48 patients <18 years of age who were treated for distal femur fractures in our center between 2014 and 2019. 21 patients were included in the study because 27 of these fractures did not extend to the distal femoral epiphysis. Thus, during the same period, 43.8% of distal femur fractures had epiphyseal extension.

There were 15 male (71.4%) and 6 female (28.6%) patients and the male to female ratio was 2.5. Mean age of the patients was 12.3 years (range, 1-16 years). According to the Salter-Harris classification, the fractures of 12 patients (57.2%) were type 2, 2 patients (9.5%) were type 3, and 7 patients (33.3%) were type 4. 4 fractures (19%) occurred due to falls, 5 (23.8%) occurred due to sport-related injuries and 12 (57.2%) occurred due to motor vehicle accidents. 6 patients (28.6%) had additional injuries along with the distal femur fracture. 3 patients (14.3%) had floating knee injury. Additional injuries are detailed in the Table 1. 2 (9.5%) of the fractures were treated conservatively with a long leg cast held for 6 weeks, while the remaining 19 (90.5%) fractures were treated surgically. Open reduction and internal fixation was performed in 11 (57.9%) patients, while closed reduction and percutaneous fixation was performed in 8 (42.1%) patients. Details about fixation methods were given in the Table 1.

Mean follow-up duration was 97 months (range, 72-133 months). Fracture union was complete in all patients after 6 months. Complications observed during the follow-up were genu valgum (n=2, 9.5%), limb length discrepancy (LLD, n=2, 9.5%), and reoperation (n=7, 33.3%).

The patients' average knee joint range of motion at 12 months was 132.4° (range, 95-140°). Only 1 (4.8%) patient had decreased knee range of motion (95°) and no improvement was observed in subsequent follow-up. Detailed clinical and demographic data of the patients were given in the Table 1.

DISCUSSION

The distal femoral physeal plate is responsible for 70% of femoral growth and 40% of lower extremity growth. It is the fastest growing physes and has an average growth

of 1 cm per year.^[9-11] Therefore, in case of distal femoral injury, it may lead to devastating complications like growth arrest, varus-valgus angulation and LLD and because of that, repeated operations to correct deformities become inevitable.^[7,12] In this study, growth arrest occurred in 2 (9.5%) of the patients, followed by valgus angulation and LLD of 3cm. One of them underwent corrective distal femoral osteotomy for valgus angulation. In a meta-analysis conducted by Basener et al.,^[7] although the definition of growth disturbance has not been made clearly, the rate of overall growth disturbance after distal femur physeal fracture was reported as high as 52% and the rate of LLD>1.5cm was reported as 22%.

Risk factors for growth disturbance have been investigated many times in the literature. Many studies have been conducted to predict the outcome of distal femoral physeal fractures and some risk factors were determined. Salter-Harris classification, presence of displacement, degree and direction of displacement were found to be significant risk factors, while injury mechanism and age were not found to have an effect on growth disturbance.^[7,11,13-15]

In this study, 43.8% of distal femur fractures occurred during the same period of time were found to be physeal fractures. Similar results were found in previous epidemiological studies.^[4,16,17]

Salter-Harris classification is a valuable classification as it gives an idea about prognosis of physeal fractures.^[7,8,11,12,18] The most common fracture type in the study was Salter-Harris type 2 fractures and this confirms the literature.^[4,16-18] The highest complication rate was seen in Salter-Harris type 4 fractures, similar to the literature.^[11,12,17]

Various fixation methods are used in the surgical treatment of distal femur physeal fractures.^[3,19,20] The main purpose of treatment should be to prevent further damage to the physeal plate that has already been damaged because of the fracture. In this study, fracture fixation was performed with cannulated screws in more than half of the patients. Although the aim is to preserve the physeal plate, stable fixation of the fracture is also important. Fixation with smooth pins has been reported to cause less growth disturbances.^[21,22]

Most of the patients included in the study had been exposed to high-energy trauma. For this reason, approximately 30% of patients had additional injuries along with the distal femur fracture. Ipsilateral tibial shaft fracture, called as floating knee, was observed in 3 patients. This injury is rarely seen in the pediatric population and associated with higher complication rates, but there is no consensus in the literature regarding its management.^[23,24] Although it is a rare injury, floating knee should be kept in mind in the event of high-energy trauma and action should be taken accordingly.

None of the children included in the study had either neurological or vascular injuries pre or postoperatively. However, distal femoral physeal fractures may also be associated with vascular injuries especially in Salter-Harris

type I injuries when the epiphysis fragment is displaced posteriorly.^[12] Posteriorly displaced fracture fragments may cause compression or direct injury to the popliteal vessels. A proper vascular assessment is mandatory in the emergency department when the patient first presents and after closed reduction. If vascular injury is suspected, this is a medical emergency and immediate intervention is required.^[25] Because, if a vascular injury is missed or not treated properly as soon as possible, devastating consequences may occur. Since it is a rare condition, there are few cases of distal femur physeal fracture with vascular compromise reported in the literature.^[25-27]

Although it was a study conducted in a Level I trauma center and had long follow-up durations, the study has some limitations. First of all, the study is designed retrospectively and the sample size is small because it is a relatively rare injury. In addition, only available data for functional evaluation of the patients was knee joint range of motion measurements. Using functional scores instead of just measuring range of motion could provide a more accurate functional assessment.

Conclusion

Distal femoral physeal injuries are uncommon injuries, however the incidence of these injuries is increasing every day because of the increased motor vehicle accidents. Since the complication rates of these injuries are high, they are serious injuries that require proper treatment. Growth disturbance is a common complication of these injuries. For this reason, following-up patients until they reach skeletal maturity is strongly recommended.

Ethics Committee Approval

The study was approved by the Ankara Etlik City Hospital Ethical Review Board in accordance with the Declaration of Helsinki (Date: 16.07.2025, Decision No: AESH-BADEKI-2025-271).

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: A.B.G., A.A., Ö.T., H.B.Ç.; Design: A.B.G., A.A., H.B.Ç.; Supervision: E.D., H.A., O.Y.A., H.B.Ç.; Data collection &/or processing: A.B.G., A.A., Ö.T., E.D., H.B.Ç., H.A., O.Y.A.; Analysis and/or interpretation: A.B.G., H.B.Ç., E.D., H.A.; Literature search: A.B.G., H.B.Ç.; Writing: A.B.G.; Critical review: A.B.G., A.A., Ö.T., E.D., H.A., O.Y.A., H.B.Ç.

Conflict of Interest

None declared.

REFERENCES

1. Czitrom AA, Salter RB, Willis RB. Fractures Involving the distal epiphyseal plate of the femur. *Int Orthop* 1981;4:269–77. [\[CrossRef\]](#)

[Ref\]](#)

2. Hutchinson J. Lectures on injuries to the epiphyses and their results: Delivered at the Royal College of Surgeons. *Br Med J* 1894;1:669–73. [\[CrossRef\]](#)
3. Sepúlveda M, Téllez C, Villablanca V, Birrer E. Distal femoral fractures in children. *EFORT Open Rev* 2022;7:264–73. [\[CrossRef\]](#)
4. Engström Z, Wolf O, Hailer YD. Epidemiology of pediatric femur fractures in children: The Swedish Fracture Register. *BMC Musculoskelet Disord* 2020;21:796. [\[CrossRef\]](#)
5. Ladenhauf HN, Jones KJ, Potter HG, Nguyen JT, Green DW. Understanding the undulating pattern of the distal femoral growth plate: Implications for surgical procedures involving the pediatric knee: A descriptive MRI study. *Knee* 2020;27:315–23. [\[CrossRef\]](#)
6. Liu RW, Armstrong DG, Levine AD, Gilmore A, Thompson GH, Cooperman DR. An anatomic study of the distal femoral epiphysis. *J Pediatr Orthop* 2013;33:743–9. [\[CrossRef\]](#)
7. Basener CJ, Mehlman CT, DiPasquale TG. Growth disturbance after distal femoral growth plate fractures in children: A meta-analysis. *J Orthop Trauma* 2009;23:663–7. [\[CrossRef\]](#)
8. Salter RB, Harris WR. Injuries involving the epiphyseal plate. *JBJS* 1963;45:587–622. [\[CrossRef\]](#)
9. Pritchett JW. Longitudinal growth and growth-plate activity in the lower extremity. *Clin Orthop Relat Res* 1992;274–9. [\[CrossRef\]](#)
10. Edwards PH Jr, Grana WA. Physeal fractures about the knee. *J Am Acad Orthop Surg* 1995;3:63–9. [\[CrossRef\]](#)
11. Arkader A, Warner WC Jr, Horn BD, Shaw RN, Wells L. Predicting the outcome of physeal fractures of the distal femur. *J Pediatr Orthop* 2007;27:703–8. [\[CrossRef\]](#)
12. Young EY, Stans AA. Distal femoral physeal fractures. *J Knee Surg* 2018;31:486–9. [\[CrossRef\]](#)
13. Hooper N, Johnson L, Banting N, Pathy R, Schaeffer EK, Bone JN, et al. Risk factor analysis for growth arrest in paediatric physeal fractures-A prospective study. *J Clin Med* 2024;13:2946. [\[CrossRef\]](#)
14. Bellamy JT, Ward LA, Fletcher ND. Evaluation of pediatric distal femoral physeal fractures and the factors impacting poor outcome requiring further corrective surgery. *J Pediatr Orthop B* 2021;30:6–12. [\[CrossRef\]](#)
15. Hulbert MA, Chun L, Bryan TP, Souder CD, Pennock AT. Factors associated with premature physeal closure after distal femur physeal fracture. *J Pediatr Orthop* 2025;45:e413–e7. [\[CrossRef\]](#)
16. Mann DC, Rajmaira S. Distribution of physeal and nonphyseal fractures in 2,650 long-bone fractures in children aged 0-16 years. *J Pediatr Orthop* 1990;10:713–6. [\[CrossRef\]](#)
17. Yamamura MK, Carry PM, Gibly RF, Holmes K, Ogilvie B, Phillips A, et al. Epidemiology of physeal fractures and clinically significant growth disturbances affecting the distal tibia, proximal tibia, and distal femur: A retrospective cohort study. *J Am Acad Orthop Surg* 2023;31:e507–e15. [\[CrossRef\]](#)
18. Cepela DJ, Tartaglione JP, Dooley TP, Patel PN. Classifications in brief: Salter-Harris classification of pediatric physeal fractures. *Clin Orthop Relat Res* 2016;474:2531–7. [\[CrossRef\]](#)
19. Korobeinikov A, Popkov D. Use of external fixation for juxta-articular fractures in children. *Injury* 2019;50:s87–s94. [\[CrossRef\]](#)
20. Abdelgawad AA, Kanlic EM. Pediatric distal femur fixation by proximal humeral plate. *J Knee Surg* 2013;26:S45–9. [\[CrossRef\]](#)
21. Dahl WJ, Silva S, Vanderhave KL. Distal femoral physeal fixation: Are smooth pins really safe? *J Pediatr Orthop* 2014;34:134–8. [\[CrossRef\]](#)
22. Garrett BR, Hoffman EB, Carrara H. The effect of percutaneous pin fixation in the treatment of distal femoral physeal fractures. *J Bone Joint Surg Br* 2011;93:689–94. [\[CrossRef\]](#)

23. Anari JB, Neuwirth AL, Horn BD, Baldwin KD. Ipsilateral femur and tibia fractures in pediatric patients: A systematic review. *World Journal of Orthopedics* 2017;8:638. [CrossRef]
24. Baldwin K, Anari J, Shore B, Denning JR, Li Y, Spence D, et al. The pediatric "floating knee" injury: A state-of-the-art multicenter study. *JBJS* 2019;101:1761–7. [CrossRef]
25. McKenna SM, Hamilton SW, Barker SL. Salter Harris fractures of the distal femur: Learning points from two cases compared. *J Investig Med High Impact Case Rep* 2013;1:2324709613500238. [Cross-Ref]
26. Ambulgekar RK, Chhabda GK. A rare case of distal femur physeal fracture dislocation with positional vascular compromise in an adolescent male. *J Orthop Case Rep* 2022;12:101–6. [CrossRef]
27. Houass E, Elgalio MR, Riache H, Boufettal M, Allah Bassir R. Open distal femur physeal fracture with positional vascular compromise and ipsilateral open tibia fracture: A rare case report. *Vis J Emerg Med* 2024;36:101970. [CrossRef]

Distal Femur Fizyel Kırıklarının Klinik ve Radyolojik Sonuçları

Amaç: Distal femoral fizyel yaralanmaları genellikle yüksek enerjili travmalardan sonra oluşur ve pediatrik popülasyonda görülen ciddi yaralanmalardır. Bu çalışmanın amacı, birinci seviye pediatrik travma merkezinde tedavi edilen distal femoral fizyel yaralanmaları epidemiyolojik olarak incelemek ve takip sırasında oluşan komplikasyonları bildirmektir.

Gereç ve Yöntem: Çalışmaya, acil servise distal femoral fizyel yaralanma ile başvuran, 18 yaş altı hastalar dahil edildi. Hastaların demografik verileri, tıbbi öyküleri, ameliyat öncesi bulguları, yaralanma mekanizmaları, ameliyat sonrası sonuçları, takip süresince gelişen komplikasyonlar kaydedildi. Kırıkları kategorize etmek için Salter-Harris sınıflaması kullanıldı.

Bulgular: Çalışmaya toplam 21 hasta alındı ve yaş ortalaması 12.3 yıl (dağılım, 1-16 yıl) idi. Erkek/kadın oranı 2.5 idi. 12 hastada (%57.2) Salter-Harris tip 2 kırık vardı ve bu en sık görülen tipti. 19 (%90.5) kırık farklı fiksasyon yöntemleri kullanılarak cerrahi olarak tedavi edildi. Ortalama takip süresi 97 ay (dağılım, 72-133 ay) idi. Takip sırasında gözlenen komplikasyonlar genu valgum (n=2, %9.5), ekstremité uzunluk farkı (n=2, %9.5), reoperasyon (n=7, %33.3) ve hareket kısıtlılığı (n=1, %4.8) idi.

Sonuç: Distal femoral fizyel yaralanmalar yüksek komplikasyon oranına sahip yaralanmalardır ve bu komplikasyonlar, büyüme duraklaması gibi, yetişkinlikte ciddi sorunlara yol açabilir. Bu yaralanmalar nispeten nadir görülse de, hastalar uygun şekilde tedavi edilmeli ve olası geç komplikasyonlar için iskelet maturitesine kadar düzenli olarak takip edilmelidir.

Anahtar Sözcükler: Büyüme duraklaması; ekstremité uzunluk eşitsizliği; fizyel yaralanma; genu valgum; pediatrik kırık.