ORIGINAL ARTICLE

Mid- and long-term outcomes of surgical treatment for distal tibial physeal fractures

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ABSTRACT

BACKGROUND: Distal tibial fractures are among the most common injuries in childhood. The treatment of distal tibial physeal fractures presents significant challenges for orthopedic surgeons, and potential complications are a major concern. The aim of this study is to evaluate the mid- and long-term outcomes of patients who underwent surgery for a distal tibial physeal fracture.

METHODS: This retrospective study included 46 patients who underwent surgery for a distal tibial physeal fracture between 2008 and 2022. Patients were evaluated based on the trauma that caused the fracture, the type of fracture (Salter-Harris classification), the type of reduction performed (open or closed), the type of implant used (K-wire or cannulated screw), the location of the fracture in the joint (intra-articular or extra-articular), and the presence of complications. The American Orthopaedic Foot and Ankle Society (AOFAS) score was used for clinical assessment.

RESULTS: The median age of the patients was 12 years (interquartile range [IQR] 10-14). The median follow-up time was 67 months (IQR 50.5-107). Postoperative anatomical reduction was achieved in 45 patients (97.8%), while 1 patient (2.2%) failed to achieve anatomical reduction. The median AOFAS score for all patients was 100 (IQR 90-100). Patients treated with K-wire fixation had a median score of 90 (IQR 86.5), while those treated with cannulated screws had a median score of 100 (IQR 92.5-100). Although the score for cannulated screws was statistically significantly higher (p=0.024), both groups demonstrated excellent clinical outcomes.

CONCLUSION: Distal tibial physeal fractures are one of the most common childhood fractures and can lead to severe complications. The mid- and long-term outcomes of surgical treatment of distal tibial physeal fractures are favorable. The method of reduction (open or closed), the choice of implant (K-wire or cannulated screw), and the location of the fracture (intra-articular or extra-articular) do not affect outcomes or complications in patients with these injuries. The crucial factor in the treatment of distal tibial physeal fractures is achieving anatomical reduction.

Keywords: Ankle; distal tibial physeal fracture; premature physeal closure.

INTRODUCTION

Distal tibial fractures are among the most common injuries in childhood. Following wrist fractures, they are the second most common type of fracture. The incidence of these fractures is higher in boys than in girls and is particularly prevalent in the 10-15 age group.[1,2] These fractures can result from various causes, including sports injuries, ankle sprains, low-energy falls, and road traffic accidents.

The first crucial distinction in the treatment of distal tibial fractures lies in the choice between conservative and surgical treatment. Surgical treatment is generally recommended for fractures with a displacement of 2 mm or more following re-

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duction.[3] The next decision for patients requiring surgery is whether to perform closed or open reduction. Additionally, the surgeon must choose the type of implant to be used, with K-wires or cannulated screws being the options for fracture fixation. As a result, the treatment of distal tibial physeal fractures is a complex process involving multiple dilemmas for orthopedic surgeons.

One of the most concerning aspects of distal tibial physeal fractures is the potential for complications. Complications may include non-union, wound infections, and pin tract infections. However, the most serious complication is the premature closure of the physis, which can lead to limb shortening and/or angular deformities.[3-5]

In this study, we aimed to evaluate the mid- and long-term outcomes of patients who underwent surgery for distal tibial physeal fractures.

MATERIALS AND METHODS

Patients

This retrospective study was conducted at Marmara University Hospital following approval by the Marmara University Faculty of Medicine Clinical Research Ethics Committee (Approval Number: 09.2021.862, Date: 02.07.2021). The study included 57 patients who underwent surgery for distal tibial physeal fractures between 2008 and 2022. Patients whose medical records could not be accessed, who did not attend regularly scheduled follow-up visits, or who did not consent to participate in the study were excluded. The final analysis was conducted with 46 patients. Patients were evaluated based on the trauma that caused the fracture, the type of fracture (classified using the Salter-Harris classification), the type of reduction performed (open or closed), the type of implant used (K-wire or cannulated screw), the location of the fracture in the joint (intra-articular or extra-articular), and the presence of complications.

Radiological Evaluation

The Salter-Harris classification was used to categorize the fractures.[6] X-rays (anteroposterior [AP] and lateral [LAT] views) and computed tomography (CT) images obtained at the time of the patients' initial presentation were used for classification. Immediate postoperative radiographs were reviewed to assess the quality of reduction achieved during surgery, with reductions of less than 1 mm considered anatomical.[7] Current ankle X-rays were obtained during the patients' final outpatient clinic visits. The presence of deformity and osteoarthritis in the joint was assessed using the patients' most recent X-rays. A change of 5° in the coronal plane or 10° in the sagittal plane was considered a deformity.[8]

Clinical Evaluation

Patients were clinically evaluated during their last outpatient clinic visit. The American Orthopaedic Foot and Ankle Society (AOFAS) score was used to assess clinical outcomes.[9] The AOFAS ankle-hindfoot score is categorized as follows: scores of 90 to 100 points indicate an "excellent" outcome, 80 to 89 points represent a "good" outcome, 60 to 79 points signify a "fair" outcome, and scores below 60 points indicate a "poor" outcome.[10]

Statistical Analysis

Statistical analyses were performed using SPSS 22.0 software (IBM SPSS Corp., Armonk, NY, USA). Study data were evaluated using descriptive statistical methods, including median, interquartile range, frequency, and ratio. The Shapiro-Wilk test and graphical assessments were used to determine whether the quantitative variables were normally distributed. The Mann- Whitney U test was used to compare non-normally distributed quantitative variables between the two groups. Pearson's Chi-square test and Fisher's Exact test were employed to compare qualitative variables. A p-value <0.05 was considered statistically significant.

RESULTS

Of the patients included in the study, 29 (63%) were male and 17 (37%) were female. The median age of the patients was 12 years (interquartile range [IQR] 10-14). The median follow-up time was 67 months (IQR 50.5-107). The specifics of the fractures and surgical details are presented in Table 1.

Table 1. Fracture characteristics and surgical details

	n (%)
Trauma	
Fall	25 (54.3)
Sprain	12 (26.1)
Non-Vehicle Traffic Accident	9 (16.6)
Side	
Right	22 (47.8)
Left	24 (52.2)
Type (Salter-Harris)	
Type II	19 (41.3)
Type III	10 (21.7)
Type IV	17 (37)
Fracture	
Open	1 (2)
Closed	45 (98)
Reduction	
Open	21 (45.7)
Closed	25 (54.3)
Implant	
K-Wire	22 (47.8)
Cannulated Screw	24 (52.2)

Postoperative anatomical reduction was achieved in 45 patients (97.8%), while 1 patient (2.2%) did not achieve anatomical reduction. The median AOFAS score for all patients was 100 (IQR 90-100). The median lateral tibial distal angle (LTDA) was 90° (IQR 88-91.25) and the anterior tibial distal angle (ATDA) was 82.5° (IQR 80-84).

Statistical analysis of outcomes based on the type of reduction revealed no statistically significant difference in AOFAS scores between patients who underwent open or closed reduction procedures (p=0.94). Regarding the type of implant, the median AOFAS score for patients whose fractures were fixed with K-wires was 90 (IQR 86.5), while the median AOFAS score for patients whose fractures were fixed with cannulated screws was 100 (IQR 92.5-100). Although the AOFAS scores for patients treated with cannulated screws were statistically significantly higher than for those treated with K-wires (p=0.024), the clinical outcomes in both groups were excellent. Postoperative joint alignment and its relationship to implant type were evaluated. A comparison was made between the use of K-wires and cannulated screws, and no significant difference was observed between the implants in terms of postoperative alignment (p=1.0). X-rays of a patient who underwent closed reduction and internal fixation with cannulated screws are shown in Figure 1. When the clinical outcomes of extra-articular fractures (Salter-Harris [SH] type II) were compared with intra-articular fractures (SH type III and SH type IV), no statistically significant difference was found between the AOFAS scores of the groups (p=0.459).

A total of seven complications were identified, including wound problems in three patients, varus deformity in two patients (caused by premature physeal closure), valgus deformity in one patient (caused by malreduction), and implant irritation in one patient. Analysis of the relationship between the type of reduction and complications revealed no statistically significant difference between open and closed reduction (p=1.0). The relationship between implant type and the incidence of complications was also analyzed. There was no statistically significant difference in the incidence of complications between the use of cannulated screws and K-wires (p=0.234). Based on fracture location, six patients with intra-articular fractures and one patient with an extra-articular fracture experienced complications, but the difference between the two groups was not statistically significant (p=0.213). The median AOFAS score was 85 (IQR 80-90.3) in patients with complications and 100 (IQR 90-100) in patients without complications. Patients with complications had statistically significantly lower AOFAS scores than those without complications (p<0.001).

DISCUSSION

The results of this study indicate that excellent clinical outcomes can be achieved in patients with anatomical reduction in the treatment of distal tibial physeal fractures. The type of reduction, choice of implant, and intra-articular or extra-articular location of the fracture do not significantly affect clinical outcomes or complication rates.

Distal tibial physeal fractures remain a significant problem for orthopedic surgeons due to the high number of variables involved in the treatment decision-making process and the potential for serious complications. Seel et al.[11] emphasised that the most crucial factor in the successful treatment of physeal fractures is achieving complete anatomical reduction. In their study, Cottalorda et al.[12] recommended that absolute anatomical reduction of the fracture is essential and that surgery should not be avoided for fractures that cannot be reduced anatomically. Karlikowski et al.[13] reported that periosteal interposition may interfere with closed reduction and recommended open reduction for fractures that could not be reduced using a closed approach. In our study, open reduction was performed in 21 patients (45.7%), while closed reduction was carried out in 25 patients (54.3%). Anatomical reduction was achieved in 45 patients (97.8%). The median AOFAS score for all patients was 100 (IQR 90-100). There was no difference in clinical function between patients who under-

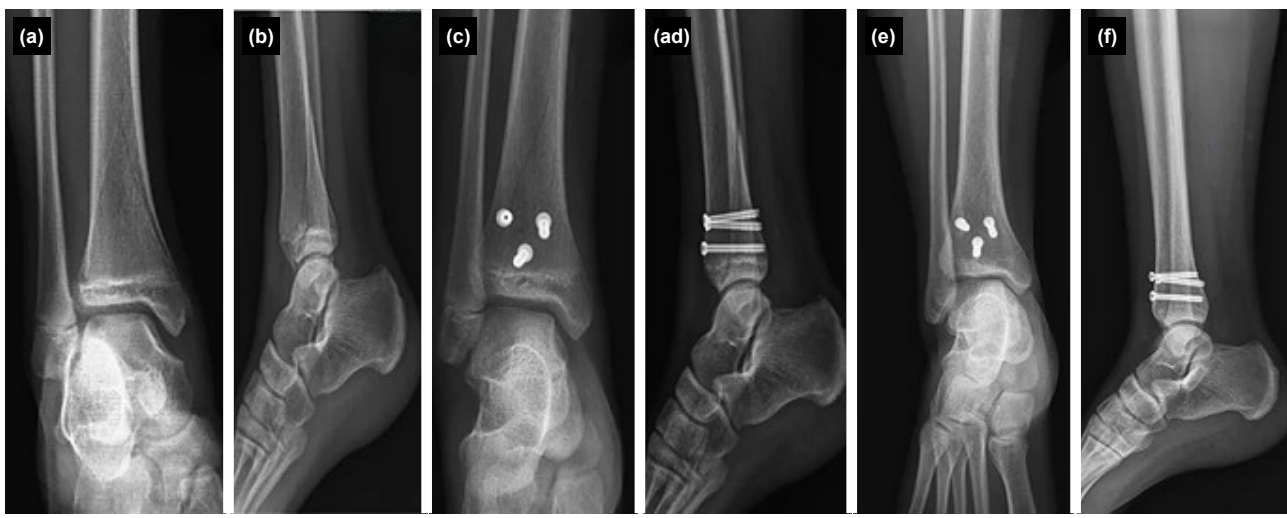

Figure 1. (a, b) Preoperative X-rays of an 11-year-old girl. **(c, d)** Immediate postoperative X-rays. **(e, f)** X-rays at 88 months postoperatively.

went open and closed reduction of their fractures (p=0.94). Mid- and long-term results demonstrate that achieving anatomical reduction in distal tibial physeal fractures is critical for excellent clinical outcomes. Therefore, anatomical reduction should always be the primary goal in the treatment of these fractures.

In the treatment of physeal fractures, maintaining the reduction is just as important as achieving it. De Sanctis et al.[14] reported that inadequate surgical fixation may lead to growth-related complications. Cannulated screws and K-wires are widely used implants in orthopedic practice.[15] The primary objective of these implants, which each have advantages and disadvantages, is to provide adequate fixation without damaging the physis. Çiçekli et al.[15] reported that the smooth surface of K-wires reduces damage to the physis but does not allow for compression. Cottalorda et al.[12] stated that the risk of physeal damage with cannulated screws is not as high as expected and that these screws can be used safely. Jiang et al.[16] reported satisfactory outcomes with both implants in ankle fractures treated with either cannulated screws or K-wires. In our study, patients treated with cannulated screws and those treated with K-wires both achieved excellent clinical outcomes.

Intra-articular fractures of the ankle may predispose patients to future ankle disorders.[8] It has been reported that the involvement of the proliferative layer of the physis in type III and IV fractures may affect growth.[14] Therefore, it has been emphasised that achieving anatomical reduction is particularly important in type III and IV intra-articular fractures. In our study, a comparative analysis was conducted to evaluate the clinical outcomes of intra-articular (SH type III and IV) and extra-articular (SH type II) fractures. Our findings revealed no statistically significant difference between the two groups (p=0.459). We believe that this result is attributable to the high rate of anatomical reduction achieved in both groups.

One of the most critical issues in distal tibial physeal fractures is the severity of potential complications. In their study, Çiçekli et al.[15] reported early and late complication rates of 20.8%. In this study, complications were observed in a total of seven patients (15%). The most severe complication of distal tibial fractures is premature physeal closure,[4] which can lead to serious complications for patients, including deformity and significant discrepancies in limb length.[17] Premature closure of the distal tibial physis has been reported in the literature at rates as high as 27.2%.[3,15,18] In this study, two patients (4%) experienced early closure of the physis due to the fracture, resulting in varus deformity. One patient (2%) experienced malreduction, which led to the development of valgus deformity. Wound problems were observed in three patients (6.5%). One of these patients had an open fracture caused by a farm injury and developed osteomyelitis despite undergoing repeated debridement procedures. In the other two patients (4%) with wound problems, pin tract infections were observed, which resolved after the removal of the pins. In one patient (2%) who underwent closed reduction and fixation with a cannulated screw, implant-related irritation was observed during the postoperative period. The implant was removed, and no further issues were encountered during follow-up. The findings of this study indicate that the type of reduction, implant type, and whether the fracture was intra-articular or extra-articular had no significant impact on the incidence of complications.

This study has some limitations. One limitation is its retrospective design. Another limitation is that only surgically treated patients were included. It should be considered that different results may emerge in studies that also include patients treated conservatively.

CONCLUSION

Distal tibial physeal fractures are one of the most common childhood fractures and can lead to severe complications. The mid- and long-term outcomes of surgical treatment for distal tibial physeal fractures are favorable. The method of reduction (open or closed), the choice of implant (K-wire or cannulated screw), and the placement of the fracture (intra-articular or extra-articular) do not affect outcomes or complication rates in patients with these injuries. The critical factor in the treatment of distal tibial physeal fractures is achieving anatomical reduction.

Ethics Committee Approval: Ethics committee approval was obtained from Marmara University Faculty of Medicine Clinical Research Ethics Committee (Approval Number: 09.2021.862, Date: 02.07.2021).

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ORİJİNAL ÇALIŞMA - ÖZ

Distal tibia fiz kırıklarının cerrahi tedavisinin orta ve uzun dönem sonuçları

AMAÇ: Distal tibia kırıkları çocukluk çağında en sık görülen yaralanmalar arasındadır. Distal tibia kemik kırıklarının tedavisi ortopedik cerrahlar için ikilemlerle dolu zorlu bir süreçtir. Potansiyel komplikasyonlar da fizis kırıkları ile ilgili ciddi bir endişe kaynağıdır. Bu çalışmanın amacı distal tibia fizis kırığı nedeniyle ameliyat edilen hastaların orta ve uzun dönem sonuçlarını değerlendirmektir.

GEREÇ VE YÖNTEM: Çalışmamız 2008 ile 2022 yılları arasında distal tibial fizis kırığı nedeniyle ameliyat edilen 46 hasta ile retrospektif olarak gerçekleştirildi. Hastalar kırığa neden olan travmaları, kırık tipi (Salter-Harris), redüksiyon tipi (açık/kapalı), kullanılan implant tipi (K-teli/kanüle vida), kırığın eklem içindeki yeri (eklem içi veya dışı) ve komplikasyon varlığı açısından değerlendirildi. Hastaların klinik değerlendirmesinde AOFAS skoru kullanıldı.

BULGULAR: Çalışmaya dahil edilen hastaların medyan yaşı 12 yıldı (IQR 10-14). Medyan takip süresi 67 aydı (IQR 50.5-107). Ameliyat sonrası 45 (%97.8) hastada anatomik redüksiyon sağlanırken, 1 (%2.2) hastada anatomik redüksiyon sağlanamadı. Tüm hastalar için medyan AOFAS skoru 100 (IQR 90-100) idi. K-teli fiksasyonu yapılan hastaların medyan AOFAS skoru 90 (IQR 86.5) iken, kanüllü vida kullanılan hastaların medyan AOFAS skoru 100 (IQR 92.5-100) idi. Kanüle vida kullanılan hastaların AOFAS skoru istatistiksel olarak anlamlı derecede daha yüksek olmasına rağmen (p=0,024), her iki grupta da mükemmel klinik sonuçlar elde edilmiştir.

SONUÇ: Distal tibia fizis kırıkları, ciddi komplikasyonlara neden olabilen yaygın çocukluk çağı kırıklarından biridir. Distal tibia fizis kırıklarının cerrahi tedavisinin orta ve uzun dönem sonuçları iyidir. Redüksiyon yöntemi (açık veya kapalı), implant seçimi (K-teli veya kanüllü vida) ve kırığın yerleşimi (eklem içi veya eklem dışı) bu yaralanmalara sahip hastalarda sonuçlar ve komplikasyonlar üzerinde etkili değildir. Distal tibial fizis kırıklarının tedavisinde en önemli faktör anatomik redüksiyonun sağlanmasıdır.

Anahtar sözcükler: Ayak bileği; Distal tibia fiz kırığı; Erken fiz kapanması.

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