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Can Titanium Elastic Nails be the First Treatment Choice in Pediatric Femoral Shaft Fractures?

Çocuk Femur Cisim Kırıklarında Titanyum Elastik Çivi İlk Tedavi Seçeneği Olabilir mi?

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Absract

Introduction: To evaluate the clinical and radiological outcomes of school-age pediatric patients who underwent titanium elastic nailing (TEN) for femoral shaft fracture.

Materials and methods: The medical charts of 61 children aged 4–12 years who underwent titanium elastic nailing (TEN) in our clinic for diaphyseal femoral fracture between 2015 and 2019 were evaluated retrospectively. Functional outcomes were evaluated according to the Flynn criteria. A total of 61 patients who met the inclusion criteria, with a mean age of 7.18 (4–12) years, were followed up for 37.60 (13–72) months.

Results: On evaluation of the clinical and radiological outcomes of patients, we observed satisfactory results in 93.4% of patients, with 72.1% (n = 44) achieving excellent and 21.3% (n = 13) achieving good outcomes. Complete union was observed radiologically in all patients except 1 for a mean period of 8.45 ± 2.56 (5–14) weeks. When the duration of hospital stay for non-orthopedic reasons was excluded, we found that patients were discharged from the hospital after a mean hospitalization period of 2.32 (1–7) days. Ten patients (16.4%) had pain due to skin irritation at the nail insertion site, 8 had malunion with an angulation of >5°, whereas only 1 had an angulation of >10°.

Conclusion: TEN is an easily applicable, minimally invasive, fixation technique resulting in less scarring. TEN should be the first treatment choice in children aged 4–12 years with diaphyseal femoral fracture as it provides early union, short hospitalization, and successful radiological and functional outcomes.

Keywords: Child; titanium; fracture fixation; femoral fractures; hospitalization.

Özet

Amaç: Okul çağı çocuk femur cisim kırığı nedeniyle Titanyum Elastik Nail (TEN) uygulanan hastaların klinik ve radyolojik sonuçlarını değerlendirmek ve literatürdeki diğer çalışmalarla karşılaştırmaktır.

Gereç ve Yöntem: 2015-2019 yılları arasında femur cisim kırığı nedeniyle kliniğimizde TEN uygulanan, 4-12 yaş arası 61 çocuğun dosyası retrospektif olarak değerlendirildi. Fonksiyonel sonuçlar Flynn kriterlerine göre yapıldı. Dahil edilme kriterlerini karşılayan, yaş ortalaması 7.18 (4-12) yıl olan toplam 61 hasta, 37.60 (13-72) ay süreyle takip edildi.

Bulgular: Olguların klinik ve radyolojik sonuçları değerlendirildiğinde; %72.1 (n=44) mükemmel, %21.3 (n=13) iyi olmak üzere, %93.4 olguda tatminkar sonuç elde edildi. Bir olgu hariç tüm olgularda ortalama 8.45±2.56 (5-14) hafta için radyolojik olarak tam kaynama görüldü. Ortopedi dışı nedenlerle hastanede kalış süreleri çıkarıldığında, olguların ortalama 2.32 (1-7) gün sonra hastaneden taburcu edildikleri belirlendi. 10 (%16.4) olguda çivi giriş yerinde cilt irritasyonuna bağlı ağrı, 8 olguda 5° nin üzerinde malunion olmasına rağmen, sadece bir vakada 10° nin üzerinde açılanma tespit edildi.

Sonuç: TEN; kolay uygulanabilen, daha az skar bırakan, minimal invaziv bir tespit tekniğidir. 4-12 yaş çocuk femur cisim kırıklarında; hızlı kaynama, kısa hospitalizasyon, başarılı radyolojik ve fonksiyonel sonuçlar nedeniyle öncelikli olarak tercih edilmelidir.

Anahtar Kelimeler: Çocuk; titanium kırık fiksasyonu; femur kırığı; hospitalizasyon,

Introduction

Pediatric femoral fractures are the most common orthopedic injuries that require hospitalization in children. Femoral fractures account for 1.6% of all bone fractures seen in childhood, and 70% of these fractures occur in the femoral shaft (1, 2). Conservative therapies still remain popular due to their affordable cost and effectiveness in preschool children. However, there is lack of information on when to switch from conservative to surgical therapy. Additionally, there is no consensus among researchers on location, at what age, and how many degrees of angulation must be considered for surgical therapy. In the last 30 years, there has been an increasing interest in surgical treatment, especially in school-age and adolescent children with femoral fractures. As a result of facilitated patient care as well as early joint range of motion exercises, mobilization, and

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return-to-school, surgical therapy has gain importance considering the expected positive effects on the child and family (3, 4). Ligier et al. described the indirect reduction of fractures with the insertion of two flexible nails in the 1980s. Although the fracture was less stable in this method, fracture healing was faster (5). Today, there are two different flexible intramedullary nails: Ender nails made of stainless steel and titanium elastic nails (TEN), which are more flexible. The aim of this study is to evaluate the clinical and radiological outcomes of school-age pediatric patients who underwent TEN for the management of femoral shaft fractures and compare them with other treatment options in literature.

Materials and Methods

The medical charts of children aged 4–12 years who underwent TEN due to femoral shaft fracture between January 2015 and December 2019 were retrospectively reviewed. This study was approved by Kahramanmaraş Sütçü İmam University Medical Faculty of Medicine Clinical Research Ethics Committee (Session: 2021/01, Date: 27.01.2021, Decision No: 07). Standard demographic data were collected from the medical charts.

Figure 1a, b. Anteroposterior and lateral x-ray images after femoral shaft fracture

The exclusion criteria were as follows: children aged <4 years and >12 years, metaphyseal fracture or shaft fracture extending to metaphysis, Gustilo–Anderson type 2 or 3 open fracture, pathological fracture, metabolic bone disease, neuromuscular disease, body weight ≥50 Kg Standard elastic intramedullary nailing was performed in all patients after reduction (closed or mini open) (Figure 1a, b). After the patients were immobilized in a long leg splint for 3 weeks, the splint was removed and range of motion exercises were initiated. Partial weight bearing was allowed when radiological union was observed, and full weight bearing was allowed at the end of the 12th week (Figure 2a, b).

Figure 2a, b. Anteroposterior and lateral x-ray images of the patient who underwent titanium elastic nail after femoral shaft fracture, 3 months after the operation

The examination findings (pain and lower limb length discrepancy), postoperative x-rays, time to union, presence or absence of varus-valgus deformity, and the extent of anteroposterior angulation were retrieved from the medical charts of the eligible patients. An angulation of >5° was termed malunion, and a difference of >10 mm between the lengths of the lower limbs was called limb length discrepancy. According to the scale for grading callus formation described by Anthony et al., radiological union was defined as the presence of cortical continuity on three or four sides as defined by Dr. Keybek (6).

Table 1: TEN outcome score

Parameters	Excellent	Satisfactory	Poor
Leg lenght inequality (cm)	<1	1-2	>2
Malalignment (degree)	<5	5-10	>10
Pain	None	None	Present
Complication	None	Minor and resolved	Major complication and/or lasting morbidity

Table 2: Demographics of the patients and fractures

Age (years)	7.18±2.63 (4-12)
Gender	
Male	44 (% 72.1)
Female	17 (% 27.9)
Side	
Right	33 (% 54.1)
Left	28 (% 45.9)
Etiology	
Motor vehicle accidents	30 (% 49.2)
Domestic fall	11 (% 18.0)
Falling from high	4 (% 6.6)
Falling off the ladder	4 (% 6.6)
Sports injuries	6 (% 9.8)
Playground injuries	6 (% 9.8)
Morphology	
Transverse	27 (% 44.3)
Oblique	27 (% 44.3)
Spiral	7 (% 11.5)
Follow-up (mounth)	37.60±19.06 (13-72)

Table 3: Outcomes

Mean time for radiological union (week)	8.45±2.56 (5-14)
Length of hospitalization (day)	2.32±1.33 (1-7)
Flynn's criteria results	
Excellent	44 (% 72.1)
Satisfactory	13 (% 21.3)
Poor	4 (% 6.6)
Complications	
Superficial wound infection	2 (%3.3)
Malunion	8 (%13.1)
Re-operation	3 (%4.9)
Pain at the site of nail insertion	10 (%16.4)
Leg length inequality	1 (%1.6)

Clinical and radiological evaluations of the patients were made according to the criteria defined by Flynn et al. as shown in Table 1 (7).

Statistical analysis: The data obtained in the study were analysed statistically using SPSS for Windows vn 25.0 (IBM Corporation, Armonk, NY, USA). Numerical variables were stated as mean ± standard deviation (SD) values and categorical variables as number (n) and percentage (%). A value of $p < 0.05$ was accepted as statistically significant. total of 61 patients who met the inclusion criteria, with a mean age of 7.18 (4–12) years, have been followed up for 37.60 (13–72) months. It was observed that 44 patients

were male and 33 had right-sided fractures. The demographic data of the patients are shown in Table 2. When the clinical and radiological outcomes of the patients were evaluated, the outcomes were satisfactory in 93.4% of patients, with 44 (72.1%) achieving excellent and 13 (21.3%) achieving good outcomes. Poor outcomes were achieved in only 4 (6.6%) patients. When the patients were examined, we observed that the most common etiological cause was motor vehicle accidents (49.2%, n = 30). Domestic fall was the second most common cause (18%, n = 11). The examination of the fracture pattern revealed that 27 (44.3%) had transverse, 27 (44.3%) had oblique, and 7 (11.5%) had spiral fractures. The mean time to union was 8.45 ± 2.56 (5–14) weeks (Figure 3a, b), while nonunion was observed in only 1 patient till 18 weeks. The patient later underwent revision surgery with plate-screw osteosynthesis after open reduction. The mean duration of hospital stay was 2.32 (1–7) days after exclusion of 3 multiple trauma patients with prolonged hospitalization due to non-orthopedic reasons (intensive care). When the complications noted in the patients were evaluated, the most common complication was pain due to skin irritation at the nail insertion site observed in 10 (16.4%) patients. Although 8 patients had malunion with an angulation of >5°, only 1 patient with an angulation of >10° underwent revision surgery using thicker TEN. Superficial skin infection was observed in 2 (3.3%) patients that resolved with oral antibiotics and did not require additional intervention. One patient who underwent TEN for comminuted fracture had a leg length discrepancy of 13 mm. The outcomes of the patients are shown in Table 3. Revision surgery was required due to nonunion in 1 patient, malunion in 1 patient, and re-fracture 14 months after the initial fracture and 3 months after implant removal in one patient.

Discussion

In the treatment of pediatric femoral shaft fractures, there is a need for a simple internal splint that shares the load. This internal splint should maintain alignment until callus formation occurs in the fracture line, accelerate the union by allowing minimal movement in the fracture line, and allow early mobilization by keeping the fracture line stable. Additionally, placement of such an implant should be possible without damaging the physis, and the implant should be easily removable. Under these circumstances,

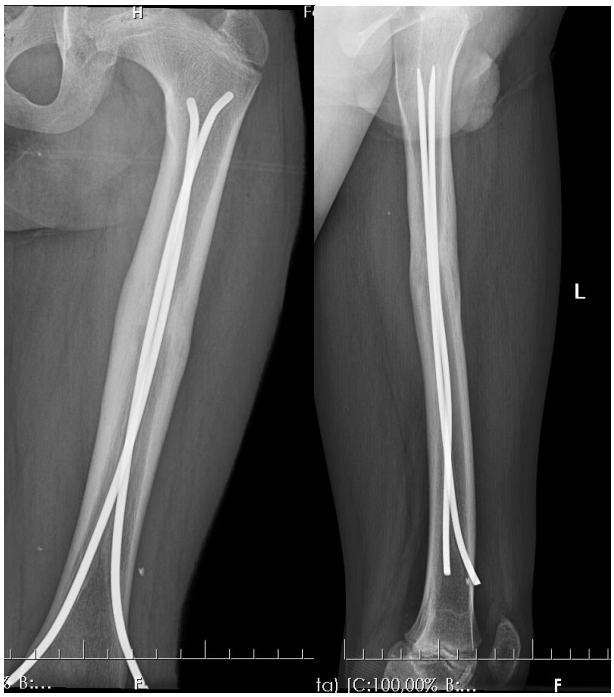

Figure 3a, b. Anteroposterior and lateral x-ray images of the patient who underwent titanium elastic nail after femoral shaft fracture, 1 year after the operation.

elastic intramedullary nails can be regarded as ideal implants for this purpose. The closed, flexible intramedullary nailing technique in pediatric fractures was first described by Ligier et al. in 1983. Fracture healing was faster after the indirect reduction of fractures with the insertion of two flexible nails in this technique, although the fracture was less stable (8). Despite the lack of definitive clinical evidence, titanium elastic nails have replaced the stainless steel ones used in the original technique in recent years, as titanium elastic nails are hypoallergenic, magnetic resonance imaging compatible, and have higher elastic modulus and superior osteointegration properties (9). In many studies, TEN has been reported to help achieve early functional gains by providing stable internal fixation and having an acceptable complication rate along with well-established effectiveness in stable femoral fractures in childhood. More than 90% satisfactory (excellent and good) outcomes have been reported in these studies (1, 3, 10–15). It has been shown that TEN can be used safely and effectively in unstable femoral fractures as well as stable fractures of childhood (16). Kawalkar et al. and Guzel et al. reported that all patients who underwent TEN for femoral fractures achieved union in an average of 9 weeks (12, 17). Another study evaluating 48 patients between the ages of 6 and 16 years showed that all patients achieved

complete union in 9–12 weeks (18). In most patients, TEN can be easily applied after closed reduction and allows micro movements in the fracture line. Therefore, it does not damage the fracture biology and allows rapid healing. In their study, Govindasamy et al. reported a mean duration of hospital stay of 7.3 days, although patients with head trauma and other related injuries had a longer hospital stay (18). In a similar study, the mean duration of hospital stay was reported as 6 days (12). Considering that it often occurs after high-energy trauma, hospital stays are within reasonable limits. TEN ensures that the social life of the patient and family is not interrupted due to early return home. The most common complication reported in previous studies was pain due to skin irritation at the nail insertion site (12–18). In some studies, a frequency of up to 60% has been reported (18). Superficial skin infection, another important complication, has been reported at a rate of 2%–8% (17, 18). Problems associated with an angulation of >5° have been reported in up to 9% of patients (12, 18). When pediatric patients with femoral fractures treated with conservative methods were compared with those treated with TEN, we observed that excellent outcomes were reported for those treated with TEN (19, 20). External fixation appears to be disadvantageous due to the risk of re-fracture and infection (21, 22). One study that compared external fixation with TEN stated that TEN application in pediatric diaphyseal femoral fractures was superior to external fixation due to rapid union and recovery, early return to school, and better tolerance by the child and family, although similar results were obtained in the long term (23). Additionally, TEN was found to be superior to plate-screw osteosynthesis considering the operation time and duration of hospital stay, although comparable clinical outcomes have been observed in the comparison of TEN and plate application (24). When the results of our study were evaluated, the time to union, functional outcomes, and complication rates seem to be consistent with those in literature. The duration of hospital stay is remarkably shorter compared to that observed in literature. This result is due to the fact that patients who have to stay in the hospital for a long time due to head or chest trauma were not considered in our analysis. In addition to the small number of patients, retrospective study design, and the performance of operations by three different surgeons are regarded as the limitations of the present study. TEN is a successful implant that can be applied easily, because it is applied with mini incisions, it does not interrupt the social life of the child and family due to the short hospital stay, improves the range of motion by allowing early movement, and allows rapid recovery as it does not disturb the fracture biology. It is safe due to its acceptable complication rate.

In conclusion, Elastic Intramedullary Nailing is a successful method in the treatment of pediatric femoral shaft fractures in the 4-12 age group. Early mobilization, short hospitalization and rapid recovery will benefit children and their families in many ways. In addition, it is a cosmetic treatment as it is applied with simple, mini incisions.It should be the preferred method because of its low complication rate and successful radiological and functional results.

Ethical Approval: This study was approved by Kahramanmaraş Sütçü İmam University Medical Faculty of Medicine Clinical Research Ethics Committee. (Session: 2021/01, Date: 27.01.2021, Decision No: 07)

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References

1. Flynn JM, Hresko T, Reynolds RA, Blasier RD, Davidson R, Kasser J. Titanium elastic nails for pediatric femur fractures: a multicenter study of early results with analysis of complications. J Pediatr Orthop 2001;21:4-8.
2. Yandow SM, Archibeck MJ, Stevens PM, Shultz R. Femoral-shaft fractures in

children: a comparison of immediate casting and traction. J Pediatr Orthop 1999;19:55-59.
3. Aktuğlu K, Önçağ H. Elastic intramedullary nailing in pediatric femoral shaft fractures. Acta Orthop Traumatol Turc 1993;27:47-50.
4. Alonso J, Geissler W, Hughes JL. External fixation of femoral fractures. Indications and limitations. Clin Orthop Relat Res 1989;241:83-88.
5. Ligier JN, Metaizeau JP, Prévot J, Lascombes P. Elastic stable intramedullary nailing of femoral shaft fractures in children. J Bone Joint Surg Br 1988;70:74-77.
6. Stans AA, Morrissy RT, Renwick SE. Femoral shaft fracture treatment in patients age 6 to 16 years. J Pediatr Orthop 1999;19:222-228.
7. MacEwen GD, Kasser JR, Heinrich SD. Pediatric fractures, Baltimore: Williams & Wilkins 1993:281.
8. Ligier JN, Metaizeau JP, Prévot J. Closed flexible medullary nailing in pediatric traumatology. Chir Pediatr 1983;24:383-385.
9. Uhthoff HK, Bardos DI, Liskova-Kiar M. The advantages of titanium alloy over stainless steel plates for the internal fixation of fractures. An experimental study in dogs. J Bone Joint Surg Br 1981;63-B:427-434.
10. Khan JA, Singh GP, Pandey A. Outcome of Titanium Elastic Intramedullary Nail in the Treatment of Shaft of Femur Fracture in Children. Kathmandu Univ Med J (KUMJ) 2015;13:195-199.
11. Sinha SK, Kumar V, Singh A. Outcomes of fracture shaft femur in pediatric population managed at emergency. J Clin Orthop Trauma 2017;8:313-319.
12. Kawalkar A, Badole CM. Percutaneous titanium elastic nail for femoral shaft fracture in patient between 5 and 15 years. J Orthop 2018;15:695-700.
13. Moroz LA, Launay F, Kocher MS, Newton PO, Frick SL, Sponseller PD. Titanium elastic nailing of fractures of the femur in children. Predictors of complications and poor outcome. J Bone Joint Surg Br 2006;88:1361-1366.
14. Sink EL, Gralla J, Repine M. Complications of pediatric femur fractures treated with titanium elastic nails: a comparison of fracture types. J Pediatr Orthop 2005;25:577-580.
15. Song HR, Oh CW, Shin HD, Kim SJ, Kyung HS, Baek SH, et al. Treatment of femoral shaft fractures in young children: comparison between conservative treatment and retrograde flexible nailing. J Pediatr Orthop B 2004;13:275-280.
16. Siddiqui AA, Abousamra O, Compton E, Meisel E, Illingworth KD. Titanium Elastic Nails Are a Safe and Effective Treatment for Length Unstable Pediatric Femur Fractures. J Pediatr Orthop 2020;40:e560-565.
17. Guzel Y, Guvenç K, Bilge O, Toker S, Yel M. Management of Femoral Shaft Fractures with Elastic Titanium Nails in Pediatric Patients. Dicle Medical Journal. 2016;43(2):224-228.
18. Govindasamy R, Gnanasundaram R, Kasirajan S, Ibrahim S, Melepuram JJ. Elastic Stable Intramedullary Nailing of Femoral Shaft Fracture-Experience in 48 Children. Arch Bone Jt Surg. 2018;6:39-46.
19. Sarkar S, Bandyopadhyay R, Mukherjee A. Titanium elastic nail - Complications in the treatment of pediatric diaphyseal fracture of femur [corrected]. Open Orthop J 2013;7:12-17.
20. Belhan O, Gürger M. Çocuk Femur Cisim Kırıklarının İntramedüller Kirschner Teli ile Tespit Sonuçları. Fırat Tıp Dergisi 2012;17(4):233-237.
21. Rahman MM, Kabir SJ, Islam NA, Saha MK, Islam MS, Islam MA, et al. Outcome of Closed Reduction and Internal Fixation by Titanium Elastic Nailing for Fracture Shaft of Femur in Children. Mymensingh Med J 2020;29:823-288.
22. Miner T, Carrolo KL. Outcomes of external fixation of pediatric femoral shaft fractures. J Pediatr Orthop 2000;20:405-410.
23. Rollo G, Guida P, Bisaccia M, Pichierri P, Filipponi M, Lanzetti RM, et al. TEN versus external fixator in the management of pediatric diaphyseal femoral fractures: evaluation of the outcomes. Eur J Orthop Surg Traumatol 2018;28:1421-1428.
24. Bajelidze G, Kanashvili B, Cholokava N, Bajelidze M, Zimlitski M. Treatment of pediatric femoral shaft fractures - titanium elastic intramedullary nails vs plate. Georgian Med News 2020;298:36-41.