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Research Article

TENS in Femoral Shaft Fractures of Children

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Abstract

Background: Pediatric femoral shaft fractures are one of the common fractures that we encounter in the orthopedics outpatient department. These fractures have various treatment options ranging from traction and early hip spica casting to elastic titanium intramedullary nails [titanium elastic nailing system (TENS)] and reamed intramedullary nails. In this study, we are evaluating the functional outcome and results following the use of flexible intramedullary nails and conservative management for femoral shaft fractures in children.
Methods: This was a prospective observational study which was carried out in a tertiary care hospital from October 2015 to May 2017 for two groups of children who sustained traumatic femoral shaft fractures. A total of 40 patients were taken into consideration with 20 patients each in two groups.
Results: The male-to-female ratio was 2.6:1 in our study population. The overall post-operative complication rate was more in the TENS group. Besides, we found that the TENS group of patients had a less limb length discrepancy (LLD) (P = 0.004) and a lower degree of angular deformity (P = 0.36).
Conclusion: TENS demonstrated advantages including sufficient axial stability, early mobilization, and more rapid return to function than spica cast treatment; however, it had the drawback of possible infection and pin site irritation. Overall, TENS offers a minimally invasive method for treatment of the femoral shaft fractures in children which stands superior to traditional spica casting.

Keywords: Titanium; Nail; Cast; Pediatrics; Femoral Fractures

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Background

Femoral shaft fractures constitute up to 1.6 percent of all bone injuries in children. With an annual incidence of up to 1 in 5000, they are among the most common lower extremity fractures in children (1). In addition, the most common significant pediatric orthopedic injury that most orthopedists would treat consistently are femoral shaft fractures (2-4). These fractures are more common in boys (2.6:1) and have a unique bimodal distribution, peaking during the toddler years (typically from simple falls) and then peaking again in early adolescence (generally from higher-energy injury) (5-8).

Current treatment options include early spica casting, traction, external fixation, open reduction and external fixation (ORIF) with plating, elastic stable intramedullary nails (ESIN) and reamed intramedullary nails as well as more recently submuscular plating (9). Whatever the method of treatment, the goals should be to stabilize the fracture, control length and alignment, promote bone healing, and minimize morbidity and complications for the child and his/her family (10).

In the last two decades, the treatment of pediatric femoral shaft fractures has increasingly developed toward a more surgical approach. This is due to patients' faster recovery and reintegration, as well as an awareness that prolonged immobilization might be harmful to children (11). Lower incidence of malunion, shorter hospital stays, lower surgical costs, superior nursing care, and early ambulation are also among the advantages of surgical treatment (12). Fractures of the femoral shaft in children are frequently treated with various types of traction for approximately 3 weeks, followed by immobilization in a plaster cast. The two significant disadvantages of this treatment are prolonged bed rest, which isolates the youngster from normal activities, and the cost of the treatment during the hospital stay (13).

Shortening, angulation, and malrotation are not always effectively rectified (14). Plaster sores and stiffness are some issues that arise. To avoid excessive shortening and angulation, cast wedging or a cast change may be required.

Intramedullary rods (rigid or semi-rigid) and ESIN or simply titanium elastic nailing system (TENS) have been utilized with great effectiveness in children under the age of 12 (15, 16). Transverse and/or short oblique fractures react better to intramedullary nails than long oblique or compound fractures, which respond better to external fixation or traction followed by a cast (2). The flexible nailing approach provides adequate support, and enough stress at the fracture site to promote callus formation, and is reasonably simple to insert and remove. The implants are affordable, and the procedure is simple to learn. However, the lack of rigid attachment is the fundamental drawback of flexible nailing. Besides, in older and heavier youngsters, length-unstable fractures can shorten and angulate (17).

The use of intramedullary fixation in the treatment of long bone fractures in children has escalated in recent years. This is partly owing to a more interventional mindset among pediatric orthopedic surgeons, but it is also due to technological advances, particularly the ESIN. This study aims to evaluate the functional outcomes and results following the use of flexible intramedullary nails and conservative management for femoral shaft fractures in children.

Methods

This study was carried out in VIMSAR, Burla, India, from October 2015 to May 2017, for two groups of children, aged between 5-14 years, sustaining traumatic femoral shaft fractures. The study was a prospective observational study wherein the sample was calculated by the statistician. It was approved by the Institutional Research and Ethics Committee (Registration No. 2014/P-I-RP/14M-O-ORT-044/008).

Inclusion Criteria: Patients with non-comminuted diaphyseal fractures of the femur were taken into the study. Finally, we included a total of 40 patients. Patients were then randomized into two groups: A and B with 20 patients in each. Group A patients included those children who were treated with conservative management (hip spica), whereas group B included patients who were treated with elastic intramedullary nailing.

Exclusion Criteria: Patients with pathological fractures, segmental fractures, open injuries, metabolic disorders, and patients without consent were excluded from the study.

Follow-up period of patients was done both clinically and radiologically for one and a half years. All patients were admitted to the emergency department after a complete history and physical examination. After admission, patients were assessed with hematological and radiological investigations. Patients satisfying the criteria were taken up for study. Informed consent was obtained from parents before the procedure, though some parents understood the right of voluntary participation and withdrawal from the trial. Moreover, ethical approval was obtained. General anesthesia was used for both types of treatments.

Spica Casting Technique: Under general anesthesia, the patient was positioned on the fracture table and the leg was held in approximately 45 degrees of flexion at the hip and knee, 30 degrees of abduction at the hip, and 15 degrees of external rotation of the leg, with traction applied proximally to the calf (Figures 1, 2, and 3).

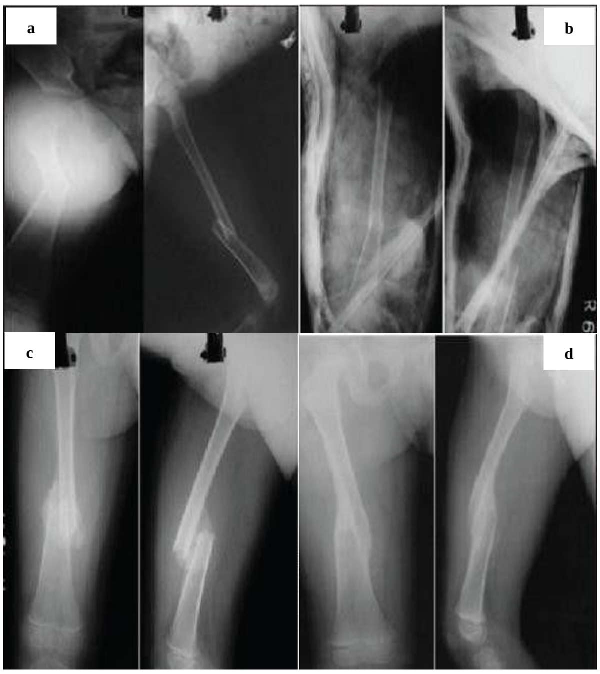

Figure 1. Pre-cast (a) and post-cast [immediate (b), 3 months (c), 6 months (d)] radiographic images

Figure 2. Pre-reduction (a) and post-reduction (b) spica application images of the patient

The reduction of the fracture was obtained by monitoring with C-arm. The one-and-one-half spica cast was applied. Molding of the thigh was done during this phase and any necessary wedging of the cast could be done at this time under C-arm. The belly portion of the spica cast was trimmed to the umbilicus. Padding of the bony prominences and the genitalia were made to avoid maceration and sores.

Figure 3. Clinical images of the patient pre-reduction, traction application, and post spica application

Surgical Technique for TENS: Under general anesthesia, the patient was placed on the fracture table. Parts were draped and the surgeon had access to both the lateral and medial aspects of the distal femur. Using Flynn's formula [diameter of nail = width of the narrowest point of the medullary canal on anteroposterior (AP) and lateral view × 0.4 mm], appropriately sized nails were chosen. The fracture was reduced under C-arm guidance and the nails were driven through a retrograde approach around 2.5-3.5 cm above the physis. The nails were pre-bent sufficiently, so that the apex of the bowed nails rested at the same level on the fracture site to ensure a good equal recoil force. The rotational alignment was obtained by aligning the iliac crest, patella, and the first web space of the foot in comparison with the opposite leg. Intravenous antibiotics were continued for 5 days. Physical therapy with touchdown weight-bearing was given as soon as the patient was comfortable. In addition, gentle knee exercises and quadriceps strengthening exercises were done.

Follow-up: Patient follow-up was done every week for 2 weeks and then was followed every two weeks till weeks 8-12.

Figure 4. Radiographic images prior to operation (a), and at 6-month follow-up (b)

Patients were then regularly evaluated clinically and radiologically at 6 months, 12 months, and 18 months to assess union status, malalignment, etc. (Figures 4 and 5).

Figure 5. Clinical picture of the patient at 6th month of follow-up following titanium elastic nailing system (TENS) surgical procedure

Results

Of the 40 included patients, 29 (15 in group A and 14 in group B) were boys and the remaining 11 (5 in group A and 6 in group B) were girls. The male to female ratio was 2.6:1. Moreover, the age of included patients ranged from 5 to 14 years, which were non-uniformly distributed among treatment groups (Table 1). The mode of injury was uniformly distributed in both groups, and road traffic accident (RTA) was the cause in 55% of patients.

Table 1. Age and sex-wise distribution of the patients and the allocated treatments

Age group (year)	Spica		TENS	
	No. of patients [n (%)]	Sex wise distribution (M:F)	No. of patients [n (%)]	Sex wise distribution (M:F)
5-8	13 (65)	10:3	3 (15)	2:1
8-11	6 (30)	4:2	9 (45)	7:2
11-14	1 (5)	1	8 (40)	5:3
Total	20 (100)	15:5	20 (100)	14:6

TENS: Titanium elastic nailing system

We found that 28 patients had right side femur fracture and 12 had left side femur fracture, while the ratio of right to left was 2.3:1. The most common site of femur shaft fracture in both groups was the middle third, comprising 62.5% of total cases.

Transverse pattern of fracture was most common in both groups, comprising 60% of total fractures. The mean duration of traction was 19.20 ± 3.52 days for the spica group, and 3.95 ± 1.50 days for the TENS group (P ≤ 0.0001). The mean duration of hospitalization was 21.70 ± 3.74 days for the spica group and 6.45 ± 1.57 days for the TENS group (P ≤≤0.0001).

We found four cases of nail tip irritation and two cases of infection in the TENS group, while two cases of plaster sores were found in the spica group. The overall post-operative complication rate was higher in the TENS group.

The mean shortening for the spica and the TENS group were 1.23 ± 0.42 cm and 0.56 ± 0.07 cm, respectively (P = 0.0472), and the mean lengthening for the spica and the TENS group were 1.37 ± 0.15 cm and 0.83 ± 0.27 cm, respectively (P = 0.016).

In the spica group, 65% of the patients had shortening, 15% had lengthening, and 20% demonstrated no limb length discrepancy (LLD), whereas in the TENS group, shortening was found in 10%, lengthening in 30%, and no LLD in 60%. We found that TENS group had less LLD (P = 0.004). Further, a lower degree of angular deformity was present in the TENS group compared to the spica group (P = 0.36) (Table 2), indicating statistically non-significant difference.

Table 2. Patients with limb length discrepancy (LLD) following both procedures

LLD	Spica	TENS
	No. of patients [n (%)]	No. of patients [n (%)]
Shortening	12 (65)	2 (10)
Lengthening	3 (15)	6 (30)
No LLD	5 (20)	12 (60)

TENS: Titanium elastic nailing system; LLD: Limb length discrepancy

The mean time of radiological union was 10.30 ± 2.45 weeks in the spica group, and 8.00 ± 1.26 weeks in the TENS group. We found that the time of radiological union was shorter in the TENS group (P ≤≤0.0006). The mean time to return to daily activities in the spica group was 11.35 ± 2.46 weeks and in the TENS group was 5.15 ± 1.09 weeks. TENS group of patients could return to daily activities earlier than the spica group (P ≤ 0.0001) (Table 3).

Table 3. Union time following both procedures

Time of union (week)	Spica	TENS
	No. of patients [n (%)]	No. of patients [n (%)]
6-8	5 (25)	12 (60)
8-10	7 (35)	8 (40)
> 10	8 (40)	0 (0)
Total	20 (100)	20 (100)

TENS: Titanium elastic nailing system

The functional outcome in the spica group was excellent in 35% of patients, satisfactory in 55%, and poor in 20%. Whereas in the TENS group, it was excellent in 70%, satisfactory in 15%, and poor in 15%. Overall, we noticed better functional outcomes in the TENS group (P = 0.029) (Table 4).

Table 4. Functional outcome using Flynn's score in both groups

Functional outcome	Spica	TENS
	No. of patients [n (%)]	No. of patients [n (%)]
Excellent	7 (35)	14 (70)
Satisfactory	11 (55)	3 (15)
Poor	2 (10)	3 (15)
Total	20 (100)	20 (100)

TENS: Titanium elastic nailing system

Discussion

In the current study, we compared the functional and adverse outcomes of spica cast treatment and TENS in children with femoral shaft fractures. Overall, our results favor the use of TENS in this population. Further, our results were backed by the findings of other studies that found elastic nails to be more effective and beneficial than spica therapy for treating femoral shaft fractures in children aged 5 to 14 years.

In the present study, mean ages in the treatment groups were 7.95 years and 10.8 years in spica and TENS, respectively. Similarly, participants in the study of Nascimento et al. had a mean age of 8 years in the spica group and 9.6 years in the TENS group (17).

There were 29 (72.5%) boys and 11 (27.5%) girls in our study population. The sex incidence is comparable to other studies in the literature. For instance, the proportions of sex groups in the study of Mazda et al. with 32 total patients was 75% for boys and 25% for girls (18). Boys are more active and therefore more prone to accidents and falls, which explains the male majority.

RTA was the most common method of injury in the current study, accounting for 22 (55%) cases, followed by falls from height (30%) and sports injuries (6%). Femoral shaft fractures were studied by Bar-On et al., who showed that in 15 (75%) cases, a motor vehicle accident was the cause of injury (19).

The mean duration of traction in the spica group was 19.2 days, while it was 3.95 days in the TENS group. Similarly, Nascimento et al. depicted 18.7 days for the spica group, and 5.3 days for patients treated with titanium elastic nails (17). In addition, the average duration of hospital stay in the present study was 21.7 days for patients treated with spica cast, while it was 6.45 days for the surgical group. Greisberg et al. compared flexible intramedullary nailing to hip spica casting in their study. In line with our findings, the flexible intramedullary nail group had an average hospital stay of 6 days compared to 29 days in the hip spica casting group (20).

The average time of union in our study was 8 weeks in TENS and 11.35 weeks in spica. Verma et al. reported that the average duration was 4.5 weeks for bridging callus and 10 weeks for union in spica treatment. While bridging callus and union time was 3.8 and 8.2 weeks in surgical treatment, respectively (21). In addition, the average time for the return to daily activities in this study was 11.35 weeks for the spica group and 5.15 weeks for the TENS group. Shemshaki et al. reported that the mean time to return to school was 31.5 days for the TENS group and 64.3 days for the spica group (22), which is in agreement with our results. All of these findings favor the use of TENS and indicate an earlier recovery in TENS than spica.

Nail site irritation was the most common complication in TENS. Nail impingement was seen in 4 (16.66%) patients in the TENS group. Khaffaf and Altaweel reported 4 cases (13.3%) of nail tip irritation (23). Further, Flynn et al. indicated that irritation at the nail insertion site (18% of the cases) was the most common complication (24). In the present study, 4 cases (25%) encountered superficial wound infection in the TENS group and none in the spica group. Similarly, Verma et al. reported 5 (10%) cases of superficial wound infection in TENS and none in spica (21).

Furthermore, there were 2 (10%) cases of plaster sores in our study, which is roughly similar to the results of Khaffaf and Altaweel (23) who reported 8 (26.7%) cases, and Verma et al. (21) who reported 4 (8.8%) cases. Moreover, we found only one case of knee pain in the TENS group and none in the spica group. Besides, due to good rehabilitation, no occurrence of stiffness in either group was noticed.

Czertak and Hennrikus considered that up to 2.5 cm of LLD was acceptable (25), while Staheli considered a maximum LLD of 1.5 cm acceptable (26). Mean shortening was 1.14 cm in spica and 0.25 cm in TENS, while mean lengthening was 1.06 cm in spica and 0.66 cm in TENS. Although both treatment options demonstrated an acceptable LLD, TENS outperformed spica by both preventing LLD in more patients and leading to a slighter LLD.

We excluded rotational malalignment because it was difficult to get a proper image. In the present study, < 5° of angular deformity was found in 11 patients (55%) in the spica group and 15 patients (75%) in the TENS group. Only 1 patient (5%) in the TENS group showed > 10° of angular deformity as compared to 3 patients (15%) in the spica group.

All patients had a complete range of hip motion; however, two (10%) patients in the spica group had 10 degrees of knee flexion limitation, which was followed by intense physiotherapy. In the research by Herscovici et al., 14 (53.84%) individuals lost knee mobility (27). Moreover, Flynn and Schwend reported one case of knee stiffness in patients treated with spica casting that necessitated anesthetic manipulation (2). Hence, the functional outcomes are also in favor of TENS treatment.

The number of the participants included in the study was low; different age distribution in treatment groups and irregular follow-ups were some of the limitations in our study.

Conclusion

The management of femur shaft fractures in the age group of 5 to 14 years is still controversial with proponents of both conservative and surgical methods. The optimal therapy for a femoral shaft fracture in a child maintains alignment and length, is pleasant for the child and convenient for the family, and has the least potential psychological impact.

In the modern era of fashion and comfort, titanium elastic nail treatment stands far better than spica cast for the treatment of diaphyseal femoral fractures. TENS offers a minimally invasive method of treatment for femur shaft fractures in children. The advantages include sufficient axial stability, early mobilization and more rapid return to function, taking less time for union, and minimal LLD and malalignment compared to spica cast treatment. However, these advantages come with the drawback of possible infection and pin site irritation. Overall, our results indicate TENS as a superior treatment option for diaphyseal femoral fractures than traditional spica cast.

Conflict of Interest

The authors declare no conflict of interest in this study.

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We thank the patients for their consent to participate in this study. Separate consent was taken from the patient and the attenders for preoperative and postoperative pictures.

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