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ORIGINAL ARTICLE

Which treatment option for paediatric femoral fractures in school-aged children: elastic nail or spica casting?

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Abstract
Objective Titanium elastic nails and immediate spica casts are treatment options for femoral fractures in school-aged children (6–12 years). This study aimed to compare the results of elastic nail and immediate spica cast methods for treating femoral fractures in school-aged children.
Materials and methods A retrospective evaluation was made of patients who underwent immediate spica cast (20 patients) or titanium elastic nail (22 patients) for femoral fracture. Groups were compared in terms of clinical and radiographic union, duration of hospitalisation, range of knee motion, walking independently and complications. The mean age was 9.8 ± 1.3 years for the elastic nail group and 6.4 ± 1 for the cast group. The mean follow-up period was 12.6 ± 5.2 months for the elastic nail group and 14.3 ± 6 months for the cast group.
Results All fractures in both group were healed. Duration of hospitalisation was shorter (2.2/7.1) and range of knee motion was better (132°/129°) in the cast group. The duration for independent walking was shorter (49.2/79.8) in the nail group. These differences were significant ($p < 0.001$). Two superficial infections and two malalignment were detected in the nail group. Three superficial infections and four malalignment were detected in the cast group.
Conclusion We detected that both treatment options were similar with regard to complications and results. Although the complications are similar in two treatment methods, complications of elastic nail are more challenging and may require new surgical procedure. If the elastic nail is selected, surgical complications should not be underestimated.

Keywords Child · School age · Femur fracture · Immediate spica cast · Elastic nail

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Introduction

Following forearm and tibial fractures, femoral fractures are the most frequently seen fractures in childhood [1]. In children, fractures heal rapidly with generally good results, so the classic treatment would be a non-surgical approach. With the increase in fixation techniques and advances in surgical techniques, there is an increasing trend towards surgical fixation [2]. In making the choice of conservative or surgical treatment, the age and weight of the child, surgical experience, injury and type of fracture, existence of associated injuries and social factors of family are important. For children under 5 years of age, closed reduction and spica cast are suitable treatment for femoral fractures [3]. Treatment choices for children between the ages of 6 and 12 years are debatable [4]. Treatment choices for this age group are early reduction and spica cast [5], skeletal traction followed by spica cast [6], plate fixation [7] and external fixation [8]. In addition to these, elastic intramedullary nailing has become a frequently used technique among surgical treatment choices in recent years [9–11].

This study aimed to evaluate and compare the results of treatment by early reduction and spica cast with those of

elastic nailing fixation in school-aged children (6–12 years) diagnosed with femoral fracture.

Materials and methods

A retrospective evaluation was made of patients diagnosed with femoral fracture at the age of between 6 and 12 years who were treated at our clinic between November 2010 and November 2012. Patients to whom external fixator or plate and screw fixation were applied were excluded from the study. Children with metabolic bone disease or pathological fracture or neuromuscular disease were not included in the study.

In the cast group, firstly, under operating theatre conditions, a Steinmann pin was inserted from the proximal of the distal femoral physeal line. Closed reduction was achieved under fluoroscopy. Keeping the reduced position, the spica cast was applied up to the thigh. The cast was placed with the child's hips flexed approximately 60°–90° (the more proximal the fracture, the more the hip was flexed), with 30° of abduction. The knees were flexed to 90° in the injured limb. The cast was not applied to allow movement in the other knee of the sound limb. Fluoroscopic and radiological checks were made after the cast application. The patients had weekly follow-ups at the polyclinic. Depending on the patient's age and clinical and radiological recovery status, the cast and pin were removed and supported mobilisation was started.

In the elastic nailing group, titanium elastic nails were applied in the standard manner as described in the literature [9–11]. At the level of the distal femoral metaphysis, the femur was reached with medial and lateral incisions. To avoid residual angulation, the nails were introduced at the same level. The medullar canal was reached through the first opening. The tip of the commercial nail was ready to bend with an angle of 45°. The implant diameter was selected to be one-third or 40 % of the narrowest diameter of the femoral diaphysis. The titanium elastic nails were bent with a similar gentle curvature, so as to have contact at three points. Following closed reduction under fluoroscopy, the medial and lateral nails were advanced to the proximal (Fig. 1). To avoid soft-tissue irritation, only a small part of nail is left outside. Open reduction was not necessary for any case. Cefazolin sodium was administered as 24-h antibiotic prophylaxis. Postoperative fixation was achieved with a splint until the sutures were removed. Knee, hip and ankle exercises were started after suture removal and supported mobilisation was achieved.

At patient follow-up, knee movement was measured, lower extremity rotation and shortness were measured clinically, and wound and skin status were examined. Times of walking with and without support were recorded. Acceptable alignment was determined according to the values defined in the literature [12] (Table 1).

Fig. 1 Preoperative and postoperative radiographs of a patient treated with titanium elastic nails

Table 1 Acceptable angulation and shortening values in paediatric femoral fractures [12]

Age	Varus–valgus angulation (°)	Anterior–posterior angulation (°)	Shortening (mm)
0–2 years	30	30	15
2–5 years	15	20	20
6–10 years	10	15	15
11 years to maturity	5	10	10

The mean age was 9.8 ± 1.3 years for the elastic nail group and 6.4 ± 1 for the cast group. The mean follow-up period was 12.6 ± 5.2 months for the elastic nail group and 14.3 ± 6 months for the cast group.

Data were analysed using SPSS Windows version 16.0. Mean values between groups were evaluated using Fisher's exact, Mann–Whitney, Chi-square and independent sample t tests. A value of $p < 0.05$ was accepted as statistically significant.

Results

A total of 50 patients diagnosed with and treated for femoral fracture were evaluated throughout this study. Three patients with external fixation applied for a diagnosis of open fracture, and five patients who had plate and screw fixation were excluded from the study. Of the remaining 42 patients, 22 were treated with elastic nail fixation and 20 with early reduction and spica cast. All the fractures were closed fractures. Full union was achieved in all cases.

The mechanism of the injury, fracture location and fracture types of groups are listed in Table 2. No statistically significant difference was determined when the groups were compared according to these parameters.

When the groups were compared, the spica cast group was found to have a shorter duration of hospital stay

Table 2 Patient demographics, injury mechanism and features of fracture

	Titanium elastic nail $n = 22$	Spica cast $n = 20$	p value
Age	9.8 ± 1.3	6.4 ± 1	<0.001*
Male/female	13 (59.1 %)/ 9 (40.9 %)	12 (60 %)/ 8 (40 %)	1**
Mechanism of the injury			0.795***
Falling down	7	9	
Motor vehicle accident	10	7	
Bicycle accident	5	4	
Fracture location			0.792***
Proximal	2	3	
Middle	14	11	
Distal	6	6	
Fracture type			0.153***
Transverse	10	5	
Oblique-spiral	12	12	
Comminuted		3	

* Mann–Whitney test

** Fisher's exact test

*** Chi-square test

(2.2 ± 0.8) compared with elastic nail group (5.1 ± 2.1) ($p < 0.001$). The knee range of motion of the spica cast group (132° ± 4) was found to be better compared with the elastic nailing group (129° ± 5.2) ($p < 0.001$). The elastic nailing group was found to have started walking earlier both with and without support ($p < 0.001$) (Table 3).

Malalignment was detected in two (9 %) patients as complication in elastic nail group. In postoperative week eight, a 10-year-old male in the elastic nailing group was found to have 15° valgus and 15° posterior angulation. In this patient, the fracture was located between distal and middle part of the femur, the elastic nails were removed and osteoclasis performed, and then K-wires were passed from the fracture line distal and proximal and incorporated into the cast (Fig. 2). At the final follow-up, no shortness, malrotation or angulation was determined (Fig. 3). Another patient with 8 years of age was found to have 13° valgus angulation. In this patient, fracture line was oblique and located distally. The clinical measurement of patients' limb length discrepancy was within the acceptable limits (<1.5 cm, Table 1) in this group. Malrotation was not detected in any of the patients. Two superficial infections with implant irritation developed on the incision site in two patients. The implants were removed in these two patients.

Malalignment was detected in four (20 %) patients as complication in spica cast group. Shortness of 2 cm was detected in a patient who had a comminuted fracture. Varus angulation of 16° and valgus angulation of 14° were detected in another two patients. In the rest of the group, the clinical measurement of patients' limb length discrepancy was within the acceptable limits (<1.5 cm, Table 1). Malrotation was not detected in any of the patients. Pin tract infection was detected in three patients. The infection was resolved after the pins were removed.

Table 3 Patient outcomes

	Titanium elastic nail $n = 22$	Spica cast $n = 20$	p value
Hospital stay (days)	5.1 ± 2.1	2.2 ± 0.8	<0.001*
Malalignment	2 (9 %)	4 (20 %)	0.4**
Infection	2 (9 %)	3 (15 %)	0.656**
Knee range of motion (°)	129 ± 5.2	132 ± 4	<0.001***
Walking with aids (days)	24.5 ± 5.8	59 ± 7.7	<0.001***
Walking independently (days)	49.2 ± 12	79.8 ± 9.9	<0.001***

* Mann–Whitney test

** Fisher's exact test

*** Independent samples test

In the elastic nailing group, five patients had a concomitant injury. Forearm fractures in three patients, clavicle fracture and head trauma in one patient, and tibia fracture in another patient were accompanying. There was no concomitant injury in the spica cast group.

Discussion

The treatment for femoral fractures varies according to factors such as the age of the patient, the fracture type, localisation and surgical experience. Despite the increase in surgical treatment choices, with the increase in fixation techniques and improved imaging methods, the basic rules described for the treatment for paediatric femoral fractures remain valid today. These basic rules as described by Dameron and Thompson [13] are:

1. The simplest treatment is best.
2. The initial treatment should be permanent where possible.
3. Perfect anatomic reduction is not essential for perfect function.
4. Restoration of alignment is more important than fragment position.
5. Overtreatment is usually worse than undertreatment.
6. Immobilise/splint the injured limb before definitive treatment.

In the treatment for paediatric femoral fractures, conservative methods are generally preferred up to the age of six. Early spica casting for this age group gives good clinical results and a low rate of complications, so it is in

widespread use [14]. Angulation and shortening may be seen with spica cast treatment. These complications can be avoided by passing the pin from the femoral distal metaphysis and enclosing with the spica cast [15–17]. The spica cast may be applied under emergency conditions or in the operating theatre. If there are not concomitant injury, spica cast may be applied under emergency conditions [18]. Results of spica casting have been reported to be the same from emergency application or from operating theatre application with cheaper costs associated with emergency application [19].

In the treatment for femoral fractures for 6-year-olds to adolescents, a spica cast is used immediately or following skeletal traction depending on the child's weight [5, 6]. It has been reported that there is no difference in results between early spica casting and following traction [5, 20]. The disadvantages of spica casting for this age group are skin care, hygiene, and educational and social isolation. In the current study, reduction and spica casting were applied in the operating theatre within the first 24 h for the patients of the spica casting group. The application of spica casting following skeletal traction requires a longer stay in hospital and entails higher costs [21].

Although the application of spica cast in the treatment for paediatric femoral fractures is a reliable, safe and biological treatment, when there are concomitant multiple injuries with femoral fracture, in cases of head trauma and spasticity, surgical treatment is more appropriate. In our study, five patients had a concomitant injury in the elastic nailing group. There was no concomitant injury in the spica cast group. Of the surgical treatment options, intramedullary elastic nailing spreads the load, provides mobilisation until sufficient callus tissue is created, and preserves alignment. With the application of elastic nailing, there is a lower risk of impaired blood flow in the physis or femoral head. Ender nails made of stainless steel have been used in femoral fracture treatment, and successful results have been reported [22]. Titanium elastic nails have a lower modulus of elasticity, and by providing stable fixation, callus formation is increased [9].

The complications of elastic nailing can be listed as malalignment, infection and soft-tissue irritation at the nail site [11, 23]. Exposure to radiation is another disadvantage [24]. Most of these complications can be avoided by following the strict recommendations of the promoters of the method. Malalignment can be prevented by using titanium nails rather than stainless steel. Another important step to avoid malalignment is to choose correct nail diameter. Metaizeau [10] suggested that if the titanium nails are used, their diameter must be greater than that of steel nails. The diameter of nail suggested one-third of the medullary canal as measured on radiographs [10] or 40 % of the narrowest diaphyseal diameter [11]. Preparation of the nail is another important step: the tip of the nail is bent more sharply over a length of 1 cm, at an angle of 30°–45° to the main portion of the nail and both nails bent with a similar gentle curvature [9–11]. Nowadays, most tips of the commercial nail are ready to bend with an angle of 45°. Fracture location is another important point. In a study of 58 patients, Flynn et al. [11] reported five of the six fractures with more than 5° of angulation were in the proximal one-third of the femur. Metaizeau [10] suggested in the distal metaphyseal fractures, nails must therefore be inserted from proximal to distal and diverge in the distal fragment. So, in case of a

Fig. 2 **a**, **b** A 10-year-old male patient treated with titanium elastic nails. 15° valgus and 15° posterior angulation were seen in radiographs at the postoperative eighth week. **c**, **d** Incorporated cast with K-wires was applied to the same patient after the elastic nails were removed and osteoclasis performed

Fig. 3 Clinical appearance and radiographs of the same patient in Fig. 2 at the postoperative tenth month

distal femur fracture, an anterograde nailing can be preferred to the classical retrograde method, by introducing both nails under the lateral trochanter. This method provides a better stability in distal fractures. In the current study, in the elastic nailing group, there were complications of two patients with infection and irritation and two patients with malalignment. The fracture located distally and classical retrograde elastic nailing method was chosen in these two patients (Figs. 2, 3).

In the current study, the patients in the elastic nailing group walked with and without support earlier than the spica cast group, which conforms with the literature [23, 25]. Allowing early movement by providing sufficient fixation is a primary advantage of elastic nailing. When knee range of motion was examined, the spica cast group was found to be better. But the difference in both groups was only 3°, which is of no clinical significance despite being statistically significant. The goniometer was used to measure range of motion. This minimal difference between groups could be explained by measurement error.

When the groups were examined with respect to malalignment, two patients (9 %) in the elastic nailing group and four patients (20 %) in the spica cast group were found to have malalignment. In studies comparing elastic nailing and traction and spica cast groups, malalignment was seen to be greater in the cast group, as it was in the current study [25, 26]. To avoid malalignment in the cast group of the current study, a Steinmann pin was passed from the femoral metaphysis and incorporated into the spica cast.

The duration of hospital stay was found to be shorter for the spica cast group in the current study. In similar studies, the duration of hospitalisation was seen to be longer for patients to whom spica cast had been applied [21, 23, 25]. A longer stay in hospital is known to be a factor which increases costs [21]. The difference in the current study was due to the early reduction applied to the patients who then had a spica cast. The cost of the treatment was not

calculated in this study. The short duration of hospital stay of the spica cast group is seen as a factor, which reduces costs.

Limitations of the current study are the lack of long-term follow-up, and the cost of the treatment was not calculated.

In conclusion, the application of titanium elastic nailing and spica cast in this study were found to be similar in terms of complications and results. Although the complications are similar in two treatment methods, complications of elastic nail are more challenging and may require new surgical procedure. If the elastic nail is selected, surgical complications should not be underestimated. However, there is a need for further clinical, randomised, prospective studies to clarify the results.

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Conflict of interest None.

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