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The Results of Retrograd Intramedullary Elastic Nailing in the Treatment of Pediatric Femoral Shaft Fractures

Çocuk Femur Cisim Kırıklarının Retrograd İntramedüller Elastik Çivileme ile Tedavi Sonuçları

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ABSTRACT

AIM: *The aim of this study was to evaluate the results of retrograd intramedullary nailing treatment in children with femoral shaft fracture.*

METHODS: *In this study, 20 patients, were included who applied to Mustafa Kemal University Research Hospital and were treated with retrograd intramedullary elastic nailing because of femoral shaft fracture.*

RESULTS: *The mean age of our patients was 14.5 months (9–24 months) and mean follow-up time was 8.3 years (4.5–14 years). The average length of stay in hospital were 3.4 days. The average reunion duration were detected as 7.8 weeks. There was no significant difference between reunion durations of open and closed fractures. Valgus alignment of 7 degrees was observed in one patient and 5 degrees in one other patient. But it did not result any functional or clinical restrictions. There were not any increase of anterior-posterior angle or any rotational deformities observed. Extremity length difference below 1cm was detected in 3 of the patients and length difference between 1–1.5 cm was detected in 2 patients. When patients were evaluated according to Flynn's criteria, the results were excellent in 14 patients (70%), good in 5 patients (25%) and poor in 1 patient (5%).*

CONCLUSION: *Elastic intramedullary nailing treatment of femoral shaft fractures in children between 5–14 years of age is a safe and effective treatment.*

Key words: *femoral fracture; elastic nail; osteosynthesis*

ÖZET

AMAÇ: *Retrograd elastik intramedüller çivileme yöntemi ile tedavi edilen femur cisim kırıklı çocukların sonuçları değerlendirildi.*

YÖNTEM: *Bu çalışmamıza, 2010–2014 yılları arasında Mustafa Kemal Ünviversitesi Araştırma hastanesine başvuran ve femur cisim kırığı tanısı nedeniyle retrograd intramedüller elastik çivileme ile tedavi ettiğimiz 20 (15 erkek, 5 kız) hasta dahil edildi.*

BULGULAR: *Hastalarımızın ortalama takip süresi 14,5 ay (9–24 ay), yaş ortalaması 8,3 (4.5–14 yıl) idi. Olgularımızın 16'sı (%90) kapalı, 4'ü (%10) açık kırık idi. Olgularımızın ortalama yatış süresi ise 3,4 gündür (2–10 gün). Hastalarımızda ortalama kaynama zamanı 7,8 hafta (6–12 hafta) olarak tespit edildi. Açık ve kapalı kırıkların kaynama süreleri açısından anlamlı bir fark saptanmadı. Olgularımızın birinde 5, diğerinde 7 derece valgus dizilimi gözlendi ancak hastalarımızda fonksiyonel ve klinik herhangi bir soruna yol açmadı. Olgularımızın hiç birinde anterior-posterior açılanma ve rotasyonel deformite gözlenmedi. Üç hastamızda 1 cm den az, 2 hastamızda 1–1,5 cm arası extremite uzunluk farkı tespit edildi. Ancak bu uzunluk farkı hastalarımızda klinik ya da fonksiyonel bir sorun yaratmadı. Hastalar klinik ve radyolojik olarak Flynn kriterlerine göre değerlendirildiğinde; 14 hastada (%70) mükemmel sonuç, 5 hastada (%25) iyi sonuç ve 1 hastada (%5) kötü sonuç elde edildi.*

SONUÇ: *Femur cisim kırıklı çocuklarda (5–14 yaş) elastik intramedüller çivi ile osteosentez, güvenilir ve etkin bir tedavidir.*

Anahtar kelimeler: *femur kırığı; elastik çivi; osteosentez*

Introduction

Femoral fractures are leading cause of hospitalization due to fractures in children and constitute 21.7% of total childhood fractures in United States[1]. Femoral fractures are more common in early childhood, when weak trabecular bone turns into hard lamellar bone structure, and also in adolescencents who can be frequently exposed to high-energy traumas[2]. The underlying reason for femoral fractures differ according to the age period. The most common reason before walking age is child abuse (80% of total)[3]. After walking age, child abuse seems to decrease and high-energy traumas are seen as the leading cause. High-energy traumas such as high falls and traffic accidents are responsible 90% of total femoral fractures in that period[4,5].

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When chosing appropriate method for treatment of childhood femoral fractures, age, growing potential of the epiphysis, length of hospitalization and any other concomittant injuries play important role[6].

In children older than 5 years, closed reduction and pelvipedal casting provide satisfactory outcomes. This method is accepted as the most valuable treatment intervention in femoral fractures of this age group[7–9].

In older children (5–15 years), skeletal traction followed by pelvipedal casting has perfomed but in this age group, skeletal traction has been reported to cause malunions and lengthen the duration of hospitalization[8,10].

Surgical procedures include external fixation, osteosynthesis with plaque nailing and internal fixation with elastic nailing. Although all of these are generally reported to provide good results, while choosing the surgical method facts such as less morbidity, lower financial cost and psychological factors should be considered[11–13].

In this study, we aimed to evaluate and present the clinical and radiological results of patients with femoral shaft fractures between age of 5–15 and treated with intramedullary titanium elastic nailing.

Materials and Methods

20 children (15 male, 5 female) who applied to our clinic between years 2010–2014 and were treated with retrograd intramedullary titanium elastic nailing due to femoral shaft fractures, were included in this study. The mean age of our patients were 8.3 years (4.5–14).

Patients were first evaluated at the emergency room and hospitalized after long leg casting was applied (Fig.1). Time since last food intake and overall condition of the patient and material supplement was considered before admission to the operating room. Under general anestesia and at supin position, mini incisions were applied from median and lateral sides of femoral distal metaphysis, under scopy. After nail insertion points were opened with awl laterally and mediallly, 1 nail per each side were sent retrogradely to trochanteric region, paying attention that elastic nails filled at least 2/3 of the femoral medulla (Fig. 2). Fracture line was reducted with closed reduction. If closed reduction failed, osteosynthesis was provided by open reduction that was performed with a mini incision through lateral side of the fracture line. The nail was cautiously placed as proximal end contacting to the cortex in trochanteric region regarding 3-points- principal but also apophyseal injury of the trochantery was avoided carefully. Distal endings of the nails were cut in appropriate sizes in order to allow future removal. None of our patients needed atele or casting after the surgery. At postoperative first day, patients were allowed to do knee exercises and mobilize without weight-bearing through the operated extremity. After discharge, stiches were removed at day 11 and patients were scheduled for a follow-up visit within post-operative 4th week.

Patients were followed with anterior-posterior and lateral X-rays of both hip and knee.

Observation of callus at at least 3 of 4 cortexes in anterior-posterior and lateral X-rays was considered as radiological reunion and absence of pain and pathological movement was accepted as clinical reunion of the fracture (Fig. 3). Any complications during hospital stay and reunion period were noted. Also, the need for crunches in daily activites, pain during walking and at rest, gait pattern, range of motions of hip and knee were evaluted clinically. Additionally, lower extremity length inequalities and angular deformities were noted for each subject.

Figure 1. *Preoperative radiographs of the patient with elastic nailing we applied to the femoral shaft fracture due to falling.*

Figure 2. *Postoperative radiograph (1. day).*

Figure 3. *Postoperative radiograph (7. month).*

In order to determine functional outcomes, radiological and clinical results were evaluated using Flynn's criteria (Table 1).[14]

Results

Mean follow-up duration for our patients were 14.5 months (9–24 months). Eleven of fractures were at left (55%), and 9 were at the right side (45%). Etiologies of fractures were distrubuted as follows; 13 high-falls (65%), 5 traffic accidents (25%), 1 simple bone cycst (5%) and 1 gun-shot (5%).

16 (90%) of our cases had closed, 4 cases (10%) had open fractures. When closed fractures were graded according to AO classification; 5 patients (25%) were A1, 3 (15%) were A2 and 8 were A3. Open fractures were evaluated using Gustillo-Anderson classification; 2 patients (10%) were Type 1, 1 (5%) was Type 2 and 1 (5%) was Type 3.

Fractures were located at upper 1/3 of femur in 5 subjects (25%), at lower 1/3 of femur in 2 subjects (%10) and at middle 1/3 of femur in 13 (65%) subjects.

Patients were operated within average 0.9 days (0–8 days) after admission to the hospital.

The mean length of hospitalization was 3.4 days (2–10 days). Some of our patients had additional injuries inconjunction with the femoral fracture. These injuries

Table 1. *FLYNN criteria*

	Perfect result	Good result	Bad result
Limb length discrepancy	<1.0 cm	1–2 cm	>2.0 cm
Angular deformity	<5°	5–10°	>10°
Pain	No	No	Yes
Complication	No	Minor –transitory	Major –permanent

are the major factors that alter duration of hospitalization and prolong the surgical admission period. Two of our patients who had head trauma, were operated after they were followed by neurosurgery department for 1 week. One patient with elevated liver enzymes were followed and treated by paediatrices department and could be operated at day 8 of hospitalization. One patient had ipsilateral, one other patient had contralateral femoral neck fracture. In both cases, femoral neck fractures were stabilized using cannula nails. There was a fracture of mandible in one patient, whom had been followed conservatively by concerning department. One of our patients had ipsilateral humerus fracture which was stabilized with 2 kirschner wires during the same operation session.

Mean union time in our patients was recorded as 7.8 weeks (6–12 weeks). There was no significant difference between open and closed fractures concerning union timing.

There were complete reunion in all of our patients except for one case. In a case of pathologic fracture with underlying simple bony cyst, due to migration of endings from trochanteric area towards posterior region, elastic nails were removed and replaced with plaque nail stabilization.

There was a valgus alignment of 5 degrees in one case, 7 degrees in an other case but neither caused any functional and clinical problems. No anterior-posterior anglings or rotational deformities were noted in any of our cases. There was an extremity length difference less than 1 cm in 3 patients and 1–2.5 cm in 2 patients. However, this length difference did not result any clinical or functional problems. Extreme loss in knee extention was determined in one patient's first follow-up visit. Patient was immediately included in rehabilitation programme and nails were removed after reunion. Loss in knee extention was noted as 5–10 degrees in this case. In 5 patients, there were local tenderness and mild swelling at distal nail endings, that fully recovered after removal of nails. Neither of our patients had superficial or deep infections of any kind. Mean removal time of nails for our patients were approximately 6 months. No recurrent fractures occured following nail removals. There were no abnormal gait, inability to walk without crunches or pain during activity or rest in any of our patients.

When patients were evaluated according to Flynn's criteria[14], 14 patients (70%) had excellent results, 5 patients (25%) had good results and 1 patient (5%) had fair results.

Discussion

Femoral shaft fractures are one of the most common type of injuries in paediatric orthopaedic patient group[15]. It is more frequent during early childhood and adolescence. Also, it is almost 2.5 times common in girls than boys[16,17]. In our study, similar results were found. 15 of our patients were boys and 5 of them were girls and mean age of the patients were 8.3 years.

Femoral shaft fractures are type of fractures that usually happen due to trauma, can be together with other injuries and may result permanent functional damages[18]. They generally occur after high-energy traumas, such as high falls and motor vehicle accidents[16]. In our study, the cause was falls and traffic accidents in 95% of the cases.

In all cases with a femoral fracture, physicians should perform a complete physical examination of the child and bear in mind a type of multiple injury named as the "waddel triad", which consists of traumas of abdomen, thorax and head in addition to the femoral trauma[15]. In our study, 2 patients of total 20 patients had head trauma, 1 patient had humeral fracture, 1 had mandible fracture, 2 head femoral neck fracture and 1 had elevated enzymes due to liver laceration, together with the femoral fracture.

There are various methods for treatment of childhood femoral shaft fractures. When selecting the most appropiate treatment plan, many factors such as age, mechanism of the injury, fracture type, accompanying injuries, social status of the family and treatment costs are considered[15]. In one study, it is reported that surgeons are tend to choose conservative methods before the age of 6, when they are more likely to prefer surgical methods after the age of 6[11].

Conservative methods in treatment include pelvic bandage, pelvipedal casting following traction and immediate pelvipedal casting. In surgical methods, there are options like conventional or biological plaque stabilization, rigid or elastic intramedullay stabilitation and external stabilization[15].

Titanium elastic intramedullary nailing has increasingly become a popular treatment method for childhood femoral fractures in many centers in Europe and Northern America[19].

They are preferred because of early mobilization and early return to daily activities and short-term hospitalization. Also, titanium intramedullary nailing has additional advantages such as being less traumatic, using smaller size nails, absence of drilling, usually being performed with retrograde surgical technique and avoiding epiphyseal damage[20].

There are many studies that compares elastic intramedullay nailing to other alternative treatment methods. In Song et al.'s study that compares the results of retrograd intramedullary elastic nailing to pelvipedal casting following traction, it is reported that there was not any problems such as angular malalignment or inequality of the extremities in elastic naling group, unlike the pelvipedal casting group[21].

Baron et al. compared elastic nailing to external fixation and reported better functional healing and early re-gain of range of motion and early return to school with elastic nailing[22].

Moreover, there were some complications reported with external fixation, such as recurrent fractures, rotational aligment problems and infections of the naling area.

It is reported that duration of hospital stay and related to that, treatment costs decrease with usage of elastic nailing method[14]. In Heybeli et al.'s study[23], they performed retrograde elastic titanium nailing in 34 patients with femoral diaphysis fracture and reported mean duration of hospitalization as 5.5 days.

Mean time of hospital stay was found as 4.2 days by Şükür et al.[24] and as 6 days in another study with 31 patients[25]. Nascimento et al.[26] compared outcomes of intramedullary elastic nailing to pelvipedal casting followed by traction and reported mean time of hospitalization as 9 days in intramedullary nailing group and as 20 days in casting group.

In our study, similar to previous studies in the literature, mean hospitalization time of our patients was 3.4 days (2–10 days).

When mean reunion time for femoral shaft fractures were analyzed, there were different results in different studies. The mean time of reunion was 6.8 weeks in Şükür et al.'s study[24], 7 weeks in Houshian et al.'s study[25] and 7.4 weeks in Heybeli et al.'s study[23].

Mishra et al.[27] reported a mean time of reunion as 9.5 weeks in their study with 30 patients, when a mean time of 6.86 weeks is reported in Jalan et al. 's series[28] and 7.6 ± 1.5 weeks in Assaghir's series[29]. In Nascimento et al.'s[26] study that compared results of titanium elastic nailing to pelvipedal casting following traction, mean reunion time was 7.7 weeks in surgery group and 9.3 weeks in conservative treatment group.

In our study, mean reunion time was detected as 7.8 weeks. There was no significant difference in reunion times between open and closed fractures. Our results were compatible with other studies in the literature.

The most common complication of childhood femoral fractures is inequality of two extremities[23]. Houshian et al.[25] reported an extremity inequality above 1 cm in 6 of 31 children in their study. In Şükür et al.'s study[24], it is found that there was a leg inequality below 1 cm in 5 cases out of 22 patients in total. There were 7 patients with an extremity inequality out of 34 patients in Heybeli et al.'s series[23], 4 out of 30 patients in Jalan et al.'s series[28] and 7 in 59 patients in Assaghir's series[29].

In Nascimento et al.'s study[26] that compared titanium elastic intramedullary nailing to pelvipedal casting follllowing traction, they detected lenghtening in 60% of patients (mean 0.66 cm) and shortening in 6.7% of patients (mean 0.25 cm) in the surgery group. However, in the casting group, they reported shortening in 63.3% of patients (mean 1.14 cm) and shortening in 13.3% of patients (mean 1.06 cm). In our study, out of total 30 patients, we have observed an extremity inequality below 1 cm in 3 patients and 1–1.5 cm in 2 patients. But these inqualities did not cause any clinical or functional problems in none of the cases.

Other common problems related to childhood femoral fractures are malunions and angular deformities[23]. In Şükür et al.'s series[24] including 22 patients, they observed an outer rotation deformity of 10 degrees in one patient and a coronal or sagittal deformity of 5–10 degrees, which does not cause any clinical problems, in 5 of total 22 patients. In a series of Houshian et al.[24], they found an inner rotational deformity of 10 degrees in one of 31 children and no angular deformities. In Heybeli et al.'s study[23] including 34 patients, less than 10 degrees of varus/valgus or anterior/posterior angling were observed in 4 children. In Assaghir's series[29], 5–9 degrees frontal angling has been detected in 6 subjects (10.2%), sagital angling in 7 subjects (11.9%) and 10 degrees rotational deformity in 2 subjects (3.4%). Jalan et al.[28] reported more than 10 degrees rotational deformities in 6 out of 30 patients in their series. In our study, at the last follow-up visits of the 20 patients, we

have detected 5 degree valgus alignment in 1 patient, as well as 7 degree valgus alignment in 1 other patient. Thus, this angling did not lead to any clinical problems. Neither of our patients had anterior/posterior angling or rotational deformities.

Further problems related to elastic intramedullary nailing are pain and skin irritation at nail insertion points, infection and implant failure[15]. In Jalan et al.'s study[28] with 30 patients, they found soft tissue irritation at nail insertion points in 6 patients, superficial infection in 2 patients and skin ulceration in 2 patients. In Assaghir's[29] series with 59 patients, pain in the nail insertion points was reported in 5 patients and superficial infection was reported in 2 patients. In Mishra et al.'s series with 30 patients[27], it is reported that there were 3 irritations but no infections at nail insertion points. Şükür et al.[24] indicated that in 2 of their 22 patients, nails migrated posteriorly and resulted subcutaneous irritation.

In Flynn et al.'s[14] study, only one implant failure was observed and only this one patient out of 234 children who had underewent titanium elastic nailing needed revision. In our study, in 5 of our patients we noted edema and tenderness around nail insertion points, which immediately resolved following nail removal. Also, there were no deep or superficial infections noted. In one patient, who had fracture with an underlying cycst, we had to remove elastic nails due to migration and failure of the implant and then replace it with plaque nailing stabilization. Therefore, we concluded that plaque nailing stabilization is a more convenient option for treatment of femur fractures that developed with an underlying cycst in children.

Different timings for nail removal after titanium elastic nailing has been claimed. Mean time for nail removal is reported as 22 weeks in Houshian et al.'s study[25], 9 months in Şükür et al.'s study[24], 12 months in Heybeli et al.'s study[23] and 20.3±10.2 weeks in Assaghir's study[29]. In our study, we removed the nails approximately at the 6th month. No recurrent fractures have been observed following nail removal. We assume that various numbers have been reported because timing for removals are usually adjusted according to the school breaks of the children.

Today, Flynn's criteria[14] is commonly used to evaluate treatment outcomes of elastic intramedullary nailing. Heybeli et al. reported 71.4% excellent, 25.7% good and %2.9 fair results according to this criteria. Also Jalan et al.[28] reported 66.7% excellent, 33.3% good results as well as Mishra et al.[27] reported 80% excellent, 20% good results. However, Şükür et al.[27] found 68% excellent, 32% good results in their study with 22 patients. In our study, our results were 70% excellent, 25% good and 5% fair, according to Flynn's criteria.

We concluded that our results were similar to previous studies in the literature. Short follow-up time and limited number of patients are the major weaknesses to this sudy. However we believe that this study is a contrubution to the current literature.

Conclusion

In conclusion, in the treatment of femoral shaft fractures, osteosynthesis with elastic intramedullary nailing has many advantages such as less soft tissue and periost damage, less bleeding during surgical procedure, smaller size of scarring, shorter duration of hospitalization, early weight-bearing and early return to school and faster bone healing without damaging the blood flowing of the growing plates.

On the other hand, this method has some disadavateges like causing rotational and angular deformities and resulting extremity inequalities. Despite such disadvantages, osteosynthesis with elastic intramedullary nailing is a safe and affective treatment of children with femoral shaft fracture between the age of 5–14 and it is the first choice treatment method with appropriate indications.

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