



ORIGINAL PAPERS

Elastic nailing vs. external fixation as methods to address pediatric femoral fractures: a review of 40 cases

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KEYWORDS

Femur fracture;
Elastic intramedullary
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External xator

Abstract

Purpose: To analyze the outcomes of pediatric femoral shaft fractures in our hospital, comparing the results obtained with elastic intramedullary nailing with those of external fixation.

Materials and methods: We retrospectively studied 40 patients with femoral fractures operated in our hospital between May 1995 and January 2006. 20 patients were treated by means of elastic nailing and 20 with an external xator. Mean follow-up was 20.6 months (range: 3-59). Initial and subsequent radiographic results were analyzed, as well as their relationship with hospitalization time, time to healing, number of follow-up visits and incidence of complications and reoperations.

Results: OR time, mean hospital stay and complications related to the surgical wound were lower in the elastic nailing group. Time to fracture union, the rate of long-term complications and the number of reoperations were also lower in this group. Radiological findings also showed less angulation, displacement and nal leg length discrepancy in children treated with elastic nails.

Conclusions: This study confirms the notion that elastic nailing, given the simplicity of the procedure and its lower degree of invasiveness, the reduced need to protect the child, its better clinical-radiological results and the lower rate of complications and reoperations, is a better option for treating these fractures.

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PALABRAS CLAVE

Fractura de fémur;
Enclavado intramedular
elástico;
Fijador externo

Estudio comparativo del tratamiento con enclavado elástico y fijador externo en las fracturas de fémur del niño: a propósito de 40 casos

Resumen

Objetivo: analizar los resultados de las fracturas de diáfisis femoral del niño tratadas en nuestro centro mediante enclavado intramedular elástico y su comparación con los resultados del tratamiento con fijador externo.

Material y método: se estudió retrospectivamente a 40 pacientes con fracturas de fémur intervenidos en nuestro centro entre mayo de 1995 y enero de 2006. Veinte pacientes se trataron mediante enclavado elástico y 20 mediante fijador externo. La media de tiempo de seguimiento fue 20,6 (intervalo, 3-59) meses. Se analizaron los resultados radiográficos iniciales y evolutivos, y su relación con el tiempo de ingreso, tiempo de consolidación, número de consultas de revisión e incidencia de complicaciones y reintervenciones.

Resultados: la duración de la cirugía, la estancia media hospitalaria y las complicaciones de la herida quirúrgica son menores en el grupo de enclavado elástico. El tiempo de consolidación de la fractura, así como las complicaciones a largo plazo, y el número de reintervenciones fueron también menores en este grupo. Los hallazgos radiológicos demostraron también menores angulación, desplazamiento y discrepancia de longitudinal de las extremidades en los niños tratados con clavos elásticos.

Conclusiones: en este trabajo se refuerza la idea de que el enclavado elástico, por la sencillez del proceso, menores agresión y necesidad de cuidados para el niño, los mejores resultados clínico-radiológicos y la menor tasa de complicaciones y reintervenciones, es una mejor opción en el tratamiento de estas fracturas.

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Introduction

For many years the classical treatment for femur fracture in children has been traction and traction with rigid bandaging, with relatively good results. The disadvantages of these treatments are the need for keeping the child in bed or in a wheel chair, pain during movements, skin problems and the need for multiple X-ray studies to control secondary displacements.¹ They have also meant long periods of absence from work for the parents and absence from school for the children.

During the last decade there has been a trend to treat these fractures surgically, especially in children over 5 years of age.^{1,2} The surgical techniques most frequently used are those that are less invasive and aggressive to growth zones and vascular bone areas such as external fixation (EF) and elastic intramedullary nailing (EIN).

When different treatments are compared, differences are seen between traction and other surgical techniques in comparison with EIN and EF, separately;³⁻⁵ but when comparing EIN and EF the good results seen are evidence of the limitations of the studies published to date since it is impossible to decide which is preferable. In this sense the study carried out by Bar-on et al⁶ is one of the few randomized studies that compares both techniques.

In this study we present the results of EIN in shaft fractures of the femur in children since this technique was first used in our center, and we compare these results with those obtained using EF in the same type of fractures.

Materials and Methods

The clinical histories of 40 children with femur shaft fractures treated in our center were analyzed retrospectively. These were: 20 treated between May 1995 and January 2000 with EF and 20 treated between January 2000 and January 2006 with EIN. In both groups the fracture patterns were similar; the transverse, non-comminuted and closed fracture pattern was the most frequent.

The mean follow-up time in these patients was 20.6 (interval 3-59) months.

Of the 20 patients treated by means of EIN, 13 were boys and 7 girls, with a mean age and weight of 10.4 (4-15) years and 36.3 (16-59) kg and of the 20 treated with EF, 11 were boys and 9 were girls, with an average of 10.3 (6-15) years of age and 38.5 (26-63) kg.

Only 3 of the patients treated with EIN presented concomitant lesions at time of admittance, in comparison with 8 in the group treated with EF.

Of the 20 cases treated with EIN titanium nails were used, 18 were retrograde nail placements and 2 were antegrade. In the 20 fractures treated using EF a lateral monotube system was used. The surgical technique was performed in a standardized manner in both procedures.

In the postoperative study of the 40 patients, evolution of the surgical wounds, type and time of immobilization, time of initial weightbearing, need for blood transfusion and number of days in hospital for initial surgery were included.

Anteroposterior (AP) and lateral X-rays of the fractures were taken: during the pre-operative stage, the immediate post-operative stage, at the time of union, considered as the time at which sufficient callous was present in 3 out of 4 cortical bones over the AP and L projections, and during the last follow-up visit of the patient before final discharge. Angulation and the percentage of contact in AP and LAT X-rays, femur shortening and if there was a length discrepancy in the lower limbs measured by tele-X-ray during the patient's last consultation were all taken into account. Based on the X-rays taken after union, we describe the lack of alignment as the distance between the mid-points of the longitudinal axis of the proximal and distal femur fragments.

Patient data was collected until discharge of treatment for femur fracture, and included the moment of extraction of the osteosynthesis device, any complications, the need for re-operation due to treatment of the femur fracture, alterations of limb rotation or leg length discrepancy, as well as the number of follow-up consultations carried out.

Results

Surgery was carried out at 1.3 (0-4) days in the EIN group and at 3.8 (0-28) days in the EF group (table 1). The boy that was operated after 28 days was referred from another center where he had been treated by nailing with a Kirschner wire that was not sufficient. In the EIN group 10 children received no previous treatment; 9 had skeletal traction, and 1 soft-tissue traction; in the EF group, 4 received no prior treatment, 12 skeletal traction and 3 soft-tissue traction. Time of operation was 71 (30-150) minutes in EIN and 89 (20-180) minutes in EF. In only one case of both series was open reduction necessary. There were no complications during surgery in any of the 40 cases.

In the EIN group 6 (30%) children used some type of immobilization during the post-operative period (table 1); 5, used a whole leg cast for an average period of 43.6 (21-79) days and 1, used a fixed brace with the knee in extension for 2 days. The child that used the whole leg cast for 79 days had an ipsilateral tibia fracture that was treated

Table 1 Pre-operative, union and extraction material data

	Elastic Nailing	External Fixation
Mean (interval) time to surgery (days)	1,3 (0-4)	3,8 (0-28)
Previous treatment	None, 10 Skeletal traction, 9 Skin traction, 1	None, 4 Skeletal traction, 12 Skin traction, 3
Mean (interval) operation time (min)	71 (30-150)	89 (20-180)
Complications during surgery	None	None
Immobilization	None, 14 (70%) Whole leg cast, 5 (25%) Knee brace, 1	None, 19 (95%) Knee brace, 1
Weightbearing	Immediate, 5 (25%) Off weightbearing, 15 (75%) 33.2 (6-80) days	Immediate, 3 (15%) Off weightbearing, 17 (85%) 17.2 (4-50) days
Wound complications	None, 17 (85%) 3 (15%): Hematoma at the fracture focus, joint effusion, subcutaneous intolerance	None, 8 (40%) Suppuration through fixation points, 12 (60%)
Transfusion	Boys, 0	Boys, 2 (10%)
Hospital discharge (days), mean (interval)	8 (2-16)	24.5 (9-90)
Union (days), mean (interval)	76 (48-281)	94.1 (60-149)
Extraction of osteosynthesis material (days), mean (interval)	168 (6-460)	112.7 (85-161)
Weightbearing after extraction of osteosynthesis material	Immediate weightbearing 17 (85%) Off weightbearing, 3 (15%), 21.6 (6-44) days	Immediate weightbearing 20 (100%)
Immobilization after extraction of osteosynthesis material	Not immobilized, 19 Brace, 1 (5%)	Not immobilized, 20 (100%)
Complications after extraction of osteosynthesis material	0	7 (35%) 5 wound granulomas, 1 re-fracture, 1 breakage at fixation point

conservatively; 15 (75%) of the children underwent a nonweightbearing period of the operated limb for an average of 33.2 (6-80) days. Only 3 (15%) of the 20 children had complications related to the surgical wound: a hematoma in the wound at the site of the fracture focus, a joint effusion related to the nail entry points and early subcutaneous intolerance to one of the nails because it was too long at the entry point. The children with EIN were discharged from hospital at 8 (2-16) days; none required a blood transfusion.

In the EF group only 1 (5%) child was immobilized by means of a knee-support for 19 days and 17 (85%) children

were kept off weightbearing for 17.2 (4-50) days; 12 of those with fixation were able to move normally after an average of 50.3 (27-85) days. Of the children with EF, 60% (12 cases) had as an early complication suppuration at the points of nail fixation. Hospital discharge was at 24.5 (9-90) days; 2 of the 20 children required blood transfusion.

Fracture union took place 76 (48-281) days after EIN (table 1) and 94 (60-149) days after EF. It must be highlighted that one patient that took 281 days for fracture union to take place suffered new trauma and re-fracture 105 days after surgery when there had not yet been bone union. The elastic nails were withdrawn at 168 (6-460) days; 3 (15%) of

Table 2 Complications and re-operations

	Elastic intramedullary nailing (EIN)	External fixator (EF)
Complications	1 re-fracture, 1 22° valgus, 4 subcutaneous intolerance to nails	5 maintained suppuration, 2 unsightly scars, 2 unions with internal rotation, 1 chronic osteomyelitis, 1 focus re-fracture, 1 clamp breakage in an EF
Re-operations	1 change to a rigid nail, 1 early EXTRACTION OF OSTEOSYNTHESIS MATERIAL nails	7 fixator adjustments, 2 unsightly scar surgeries, 1 change of a patella due to breakage, 1 change of an extraosseous nail, 1 third fragment reduction, 1 rigid nail due to refracture, 1 extraction of a sequestration, 1 corrective osteotomy, 1 epiphysiodesis

Table 3 X-ray Findings (mean values)

	Preoperative X-ray					Post-operative X-rays				
	Angulation		%of Contact		Shortening	Angulation		%of Contact		Shortening
	AP	LAT	AP	LAT		AP	LAT	AP	LAT	
EIN	7.8° (0-22)	4.8° (0-23)	60.7% (0-90)	43.3% (0-100)	8.8 mm (0-33)	2.8° (0-25)	1.8° (0-15)	90.8% (28-100)	75.7% (44-100)	1.4 mm (0-10)
FE	10.6° (0-40)	8.2° (0-36)	65.3% (9-100)	21.7% (0-79)	14.4 mm (0-75)	4.3° (0-25)	6.3° (0-20)	61.9% (0-100)	56.3% (0-100)	5.8 mm (0-14)

EIN: Elastic Intramedullary Nailing; EF External Fixation.

Table 4 X-ray Findings (mean values)

	Union X-ray					Last follow-up X-ray					
	Angulation		Lack of alignment		Shortening	Angulation		Lack of alignment		Shortening	Di-symmetry
	AP	LAT	AP	LAT		AP	LAT	AP	LAT		
EIN	2.5° (0-15)	2.1° (0-15)	1.3 mm (0-13)	2.6 mm (0-9)	2 mm (0-13)	1.8° (0-14)	1.8° (0-15)	0.9 mm (0-9)	1.3 mm (0-10)	1.6 mm (0-14)	2 mm (0-15)
EF	5° (0-12)	4.1° (0-14)	6.7 mm (0-16)	8.6 mm (0-25)	6.2 mm (0-30)	3.1° (0-18)	2.1° (0-12)	3.7 mm (0-10)	4.4 mm (0-15)	6.8 mm (-10-35)	10 mm (5-40)

EIN: Elastic Intramedullary Nailing; EF External Fixation.



Figure 1 Examples of union with elastic nailing.



Figure 2 Examples of union with external fixation.

the children underwent a period of nonweightbearing for an average of 21.6 days after extraction; 1 of them remained immobilized with a brace for 23 days and there were no complications after extraction in the whole EIN group. The girl who had elastic nails removed 6 days after surgery had an unacceptable result and it was decided to change the elastic nails for a rigid nail, therefore this case with a long term clinical and X-ray assessment was removed from the group. The external fixators were removed at 112.7 (85-161) days and none of the children were kept off weightbearing or immobilized; complications after extraction were seen in 7 (35%) children, 5 with granulomas in some of the nail wounds, 1 that suffered a breakage of one of the nails that remained in the bone and 1 with a re-fracture of the fracture focus at 10 days.

The patients treated with EIN required 8 (4-14) revision consultations in comparison with 13 (8-21) of those treated with EF.

Results of X-ray measurements are detailed in tables 3 and 4. At the time of union the angle parameters did not differ very much from the values obtained after surgery, both in magnitude and in deformity.

It must be pointed out that the percentage of contact area between the fragments became at that moment a lack of alignment between the femur axes. Of the patients treated with EIN 90% had no AP lack of alignment at the time of union, whereas 30% of those treated by EF did (figs. 1 and 2).

The last follow-up revision of the patients, carried out at an average of 20.6 months, shows a remodeling process of growing bone evidenced by all variables, except for shortening, in a similar proportion in both groups, but without the EF group achieving the same values as the EIN group, that had half the angular deformity and less than a third of the lack of alignment and shortening.

The difference in overall length of lower limbs became manifest at the end of follow-up, when it was seen that 75% of the boys in the EF group presented a discrepancy, in comparison with 16% of the boys in the EIN group. The difference in mean length in the EF group was 10 (5-40) mm (13 shortenings and 2 lengthenings) and 2 (0-15) mm in the EIN (2 shortenings and 1 lengthening).

In the follow-up of the EIN group there were 6 complications in 5 patients (table 2). One girl had a re-

fracture at the fracture focus site due to an accidental fall before union was achieved. This re-fracture caused a valgus deformity at the focus of up to 18° with lack of alignment of 22° of the mechanical axis of the extremity that caused pain in the knee. During follow-up the deformity decreased up to 8° in valgus and correction surgery was considered unnecessary; 4 patients presented subcutaneous intolerance to nail entry, which made it necessary to remove the nails early (62 days) in one of them.

Only 2 patients in all the EIN series required re-operation due to the femur fracture itself; early withdrawal of nails due to intolerance and a change to a rigid nail 6 days after surgery due to a 25° varus in the post-operative AP X-ray.

Twelve evolutionary complications appeared in the EF group in 8 boys; 5 cases of persistent suppuration with positive culture at the fixation points of the extensor that required prolonged antibiotic treatment, 1 of them turned into chronic osteomyelitis and another 2 resulted in unsightly scars. In 2 boys there was union with internal rotation of the limb, in one this was asymptomatic and in the other it caused pain and limping, a computerized tomograph was performed that showed a 35° internal rotation of the femur and that, after follow-up, was considered not to require surgery. In 1 case there was a re-fracture at the fracture focus 10 days after removing the extensor and in 1 case one of the EF clamps broke.

In the EF group 9 (45%) of the children required re-intervention; 16 operations were performed (table 2). In 7 (35%) children it was necessary to re-position the extensor in the operating theatre, with a new fracture reduction, due to unacceptable post-operative results. Two operations were performed to resolve unsightly scars on the thigh over wounds caused by nails, 1 operation to change the clamp of a extensor, 1 to change the threaded nail because it remained outside the bone, 1 to reduce a third fracture fragment, 1 for rigid nailing due to re-fracture, 1 for elimination of a sequestration and stulectomy over chronic osteomyelitis, 1 a lengthening osteotomy to correct an 18° varus and 40 mm of femur shortening and 1 a contralateral femoro-tibial epiphysodesis to correct the 40 mm discrepancy in the length of the limbs.

Discussion

Both the group of 20 children treated with EIN as the 20 children treated with EF presented similar epidemiological distribution in as far as sex, age, weight and history. Both were similar population samples, but at different time periods, since for the same type of fracture treatment was changed after the introduction of EIN. In our series of EIN there is one 4 year old girl, and although there is controversy as to surgery before 5 years of age, there are studies that recommend it in certain situations and when chosen as the form of treatment by the family surgeon.⁷

The greater number of lesions associated with initial trauma in the EF group may influence hospital stay and ambulatory follow-up. Although it is true that in the majority of cases severe associated lesions were not an exclusive determinant of the increase of hospitalization time, and

only revision consultations due to femur fracture were considered.

The time to surgery, significantly less in the EIN group (1.3 days) than in the EF group (3.8 days) can be attributed to the standardization of treatment by means of EIN and the early decision making process, in comparison with the EF. This means that half the patients treated by EIN did not receive prior treatment. As to choice of skin or skeletal traction, in long term studies the literature does not show differences as to patient comfort, functional result or subsequent fracture status,¹¹ which would lead to choosing a non-invasive treatment.

The data on the post-operative treatment of these fractures show variable results. EIN allows early weight-bearing in a greater number of girls (25% in comparison with 15% for EF); however, those kept off weight-bearing required more days before initial weight-bearing (33.2 days in comparison with 17.2 days for EF) and some of them even required associated immobilization (30% in comparison with 4% for EF). In four of the five EIN series revised in this study a period of nonweight-bearing of 3 weeks^{9,12-14} was preferred with a patient immobilization rate of 70 to 100% and only one study supports mobilization and early loading.¹⁰

Assessing the incidence of early complications over surgical wounds, in our EIN study we found 15% (3 children) and these were slight and transient, whereas with EF there were 60% (12 children), with suppuration at the site of the nail entries, which was higher than the incidence described in the literature,^{6,8,15,16} which seems to be one of the main causes of the longer hospital stay (24.5 days in comparison with 8 days).

Time to union, in our opinion the appearance of sufficient callus to consider removal of the EF and allow complete weight-bearing in EIN, is slightly greater than what has been seen in the literature (between 30 and 40 days for EIN and 60 for EF),^{8,10,12} although there is a similar proportion with significantly less time for EIN (76 days in comparison with 94.1 days).

In most revised studies^{3,5,6,8-10,12,13,17,18} no mal-unions were seen with an angulation greater than 10°, except for isolated cases. In our series the greatest deformities were seen in EF, with 8 (40%) cases with an angulation $\geq 10^\circ$ in some planes. Angular values for EIN were less than half those for EF throughout fracture evolution and only 4 (21%) cases presented deformities $\geq 10^\circ$. Furthermore, from the moment of union to the last follow-up consultation, the remodeling capacity of the children's bones decreased the value of the deformities. Only 15% in each of the series had an angular deformity $> 10^\circ$ at the end of follow-up.

One of the classical problems with traction is the discrepancy in the length of the limbs due to overgrowing of the fracture focus.^{3,11,18} On considering surgical treatment of these fractures, there was an initial tendency to reduce them with shortening to compensate for the overgrowth.¹⁹ Subsequently, it was seen that this phenomenon was not so frequent and that the best option was anatomical reduction of the fractures. This study shows similar results, since post-operative alterations of femur length are barely modified during follow-up and the healing of the fracture.

As to discrepancy in the length of the limbs, 75% of those treated with EF have much higher values than those seen in

the literature, whereas for EIN the values are similar to those published.^{12,13,18}

Complications show marked differences, 6 in the EIN group and 12 in the EF group. Much the same as in our study, the literature shows subcutaneous intolerance to elastic nails as the most frequent complication of EIN, from 7 to 40%^{2,20-23} of cases, this was 21% in our series. In spite of the fact that nail migration in the bone during growth or perforation of the cortical with the tip of the nail appears in revisions as a complication to be feared, in this series no case was found.

In conclusion, although both external fixation and elastic intramedullary nailing have shown good results in the treatment of simple femur shaft fractures, this study has served to strengthen the concept that the simplicity of the EIN process, the fact that it is less aggressive, and less care of the child is needed, the better clinical and X-ray results, and its lower rate of complications and re-interventions make it a better option for the treatment of these fractures.

Conflict of interests

The authors have not received any financial support in the preparation of this article. Nor have they signed any agreement entitling them to receive benefits or fees from any commercial entity. Furthermore, no commercial entity has paid or will pay any sum to any foundation, educational institution or other non-profit-making organization to which they may be affiliated.

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