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Femur Fracture in Preschool Children. Experience with Flexible Intramedullary Nailing in 72 children

THESE

préparée sous la direction du Professeur titulaire Olivier Reinberg avec la collaboration du Docteur Nicolas Lutz, médecin associé, chirurgie pédiatrique, Hôpital de l'Enfance

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RESUME

Fractures du fémur chez les enfants d'âge préscolaire.
Expérience avec l'enclouage centromédullaire élastique stable chez 72 enfants

Introduction
L'immobilisation plâtrée est le traitement le plus fréquemment utilisé pour traiter les fractures du fémur chez les enfants d'âge préscolaire de moins de 6 ans. L'enclouage centromédullaire élastique stable (ECMES), qui a remplacé les immobilisations plâtrées chez les enfants d'âge scolaire, est une alternative qui n'a jamais été étudiée spécifiquement dans la tranche d'âge préscolaire.

Matériel et méthode
Nous avons réalisé une étude rétrospective de tous les cas de fractures du fémur chez l'enfant de moins de 6 ans traitées par ECMES dans le service de chirurgie pédiatrique du Centre Hospitalier Universitaire Vaudois et de l'Hôpital de l'Enfance de Lausanne sur une période de 15 ans.

Résultats
Parmi les 210 fractures du fémur traitées par ECMES entre le 1.1.1988 et le 31.12.2003, 74 fractures du fémur ont été identifiées chez 73 enfants âgés de 1.5 à 5.9 ans. Ces fractures étaient sous-trochantériennes (n=5), diaphysaires (n=64, dont 5 ouvertes), ou métaphysaires distales (n=4). Le type de fracture était transverse (n=35, dont 2 ouvertes), oblique (n=28, dont 3 ouvertes) ou spiroïde (n=11). Quatre fractures étaient comminutives. Le temps opératoire moyen était de 56,9 minutes (limites entre 20 et 155 min.) pour les enfants ne présentant pas d'autre pathologie chirurgicale. Le séjour hospitalier moyen était de 9.1 jours (limites entre 1 et 46 jours) pour tous les enfants n'ayant pas de pathologie associée. Chez les enfants sans lésion ou pathologie associée, la première mise en charge s'est effectuée en moyenne au 14,1^{ème} jour post-opératoire (limites entre 1 et 42ème jour) alors que la première mobilisation a eu lieu en moyenne dès le 2,7^{ème} jour post-opératoire (limites entre le 1 et le 14ème jour). 64 enfants ont été suivis à long terme avec un recul moyen de 36,8 mois (limites entre 4 et 124 mois). Nous avons relevés 6 enfants avec une inégalité de longueur de plus d'un centimètre, alors que nous n'avons jamais constaté de défaut de rotation. Durant le 11 premières années de l'étude, 9 enfants ont dû être réopérés pour raccourcissement secondaire de broches extériorisées ou douloureuses sous la peau. Aucun problème de broche n'a été observé après introduction d'une nouvelle pince à couper. 2 réductions de fracture se sont faites à foyer ouvert. Une infection localisée transitoire du point de ponction d'une broche a été notée, sans ostéite associée.

Discussion
L' ECMES chez le petit enfant est techniquement réalisable sans véritable limite inférieure d'âge. Il favorise la mobilisation et la charge précoces. Les complications sont avant tout en rapport avec la technique et peuvent être évitées. Les résultats sont au moins aussi bons et meilleurs sur certains points que ceux publiés en utilisant les immobilisations. En outre ce traitement évite une longue hospitalisation.

Conclusions
L'ECMES peut être appliqué aux enfants de moins de 6 ans avec les mêmes bénéfices que ceux observés pour les plus grands, sans en augmenter la morbidité. La limite inférieure d'âge reste à déterminer. Un suivi à long terme s'impose pour vérifier l'absence d'inégalité de longueur des membres inférieurs.

Femur Fracture in Preschool Children

Experience with Flexible Intramedullary Nailing in 72 children

Lea Bopst, MD, Olivier Reinberg, MD, and Nicolas Lutz, MD

Abstract: Spica cast immobilization is the preferred treatment for closed femur fracture in preschool children. Flexible intramedullary nailing (FIN) is an alternative treatment but has never been specifically evaluated in this age group. A retrospective analysis of 72 children (mean age, 4.1 years; age range, 1.5–5.9 years) with 73 femur fractures treated by means of FIN was performed. The mean length of stay in hospital was 9.1 days (range, 1–46); weight bearing was started at a mean of 16.4 days (range, 1–60 days) after surgery. Follow-up was available in 62 children (mean, 36.7 months; range, 4–124 months). Complications included early distal nail exteriorization in 9 children (12.3%) during the first 10 years of the study. More than 1 cm of femur overgrowth was noted in 6 children (8.2%). Preschool children with femur fracture treated by means of FIN benefited from short hospital stay, early mobilization and weight bearing. Technique-related complications could be avoided. Long-term follow-up is mandatory in these children.

Key Words: femur fracture, flexible intramedullary nailing, pediatric trauma, preschool children

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Femur fracture is one of the most common major pediatric fractures encountered. In school-aged children, flexible intramedullary nailing (FIN) is widely performed and has been extensively studied.[1–4] External fixation plating or interlocking nail fixation have also been used in selected cases with good results.[5–8] Most surgical techniques allow for early mobilization, weight bearing, and short hospital stay with minimal morbidity.[9,10] These treatment modalities are widely used in school-aged children but have been used only occasionally in preschool children,[4,8] for whom spica cast immobilization or traction remain the most frequently used treatment.[3,7] Although these conservative treatments give excellent results in this age group, complications have been described, such as skin breakdown or even compartment syndrome.[11,12] Furthermore, secondary displacement justifying spica cast replacement, significant femur shortening, and angular or rotational deformities have also been reported.[13–15] The choice between conservative and surgical treatment is based on many criteria, including the surgeon's personal experience, the child's age, the child's body size, and the child's social situation. The fracture characteristics and associated injuries will also greatly influence the choice of treatment. In our institution, FIN has been the treatment of choice for femur fracture in walking children since Metaizeau's first publication, although we did not follow his suggestion to avoid using FIN in children younger than 6 years.[2,16]

Some studies have mentioned the feasibility of surgical treatment of femur fractures in preschool children,[4,8,15,17] but none have assessed them specifically.

The aims of this study were to assess FIN in preschool children with femur fractures and to evaluate both the benefits and the outcome in this age group. Comparison with FIN in school-aged children was performed using the literature.

METHODS

Approved by the local ethics committee, a retrospective analysis of all femur fractures treated in the department of pediatric surgery of a university hospital during a 15-year period was performed. The data from the other pediatric hospital in the same urban setting was included for the last 5 years of the study after the merger of the 2 institutions. The surgical procedure was performed on a regular surgical operating table by 7 certified pediatric surgeons with varying experience in trauma. Fluoroscopic control was available for each case; nail introduction and positioning were performed following the original technique described by Metaizeau,[3] although distal nail bending was rarely performed. One significant technical modification was introduced in 2000 after the marketing of a new nail cutting device (TEN Cutter 359.217; Synthes, Oberdorf, Switzerland). For the last 4 years of the study, this cutter was used in every case. A long-term follow-up trauma clinic was available for every child with a long bone fracture. Each eligible child was automatically given an appointment and reassessed at regular intervals for a minimum of 2 years after surgery.

The children's medical records were reviewed to assess the individual demographics and the fracture characteristics. The duration of the surgical procedure, the size of nails used, and the date of removal were recorded. Any intraoperative complication and any other fracture, organ injury, or underlying medical illness were noted. The length of stay in hospital and the time to first mobilization and weight bearing were also calculated. Postoperative complications, such as secondary fracture displacement, infection, and pin exteriorization were also recorded. Follow-up assessment with clinical evaluation of the child's gait and skeleton was noted. The potential leg length discrepancy was always measured and considered significant when clinically greater than 1 cm.

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RESULTS

Between January 1, 1988 and December 31, 2003, 242 femur fractures were treated in the 2 institutions. Of these, 105 were in children younger than 6 years. Thirty-two were treated by means of spica cast application, traction, or a combination of both. One child with a bone cyst sustained a pathological fracture and was excluded from the study because he represented an entirely different topic. The remaining 72 were treated by means of FIN. They formed the basis of the remainder of the analyses. There were 21 girls and 51 boys (ratio, 1:2.4) aged 1.5 to 5.9 years (mean, 4.1 years). On admission, associated injuries were diagnosed in 17 children (23.6%), which included a fracture to another limb in 6, pelvic fracture in 2, thoracic trauma in 5, abdominal trauma in 4, and head injury in 6. Three children (0.4%) had other medical illnesses; 1 child had West syndrome, 1 had Klippel-Treunaunay syndrome, and 1 had homocystinuria.

The fracture characteristics are summarized in Figures 1 and 2. The fracture site was the shaft in 64 (including 5 open), the subtrochanter in 5, the trochanter in 1, and the distal metaphysis in 3. The fracture type was transverse in 34 (2 open), oblique in 28 (3 open and 4 comminuted), and spiroid in 11.

When considering children not requiring any other surgical procedure (n = 60), the mean duration of FIN was 56.9 minutes (range, 20–155). Open reduction was required for 1 distal metaphysis and for 1 midshaft fracture in 1992 and 1993, respectively. Distal metaphysis fractures (n = 3) were treated by means of descending FIN in all but one case. All other patients were treated using the ascending technique as illustrated in Figures 3 and 4. A third nail was required to improve stability for 1 distal metaphysis transverse fracture. Nail sizes 2, 2.5, and 3 were used in 11%, 67.1%, and 21.9% of cases, respectively.

Overall, the mean hospital length of stay was 9.1 days (range, 1–46). When excluding patients with associated injuries or underlying medical illness, the mean hospital stay decreased to 6.4 days (range, 1–24). In these children,

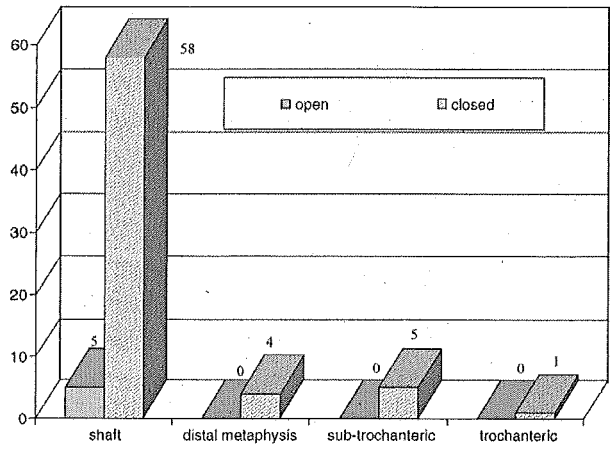

FIGURE 1. Distribution of open and closed femur fractures in 72 preschool children according to type.

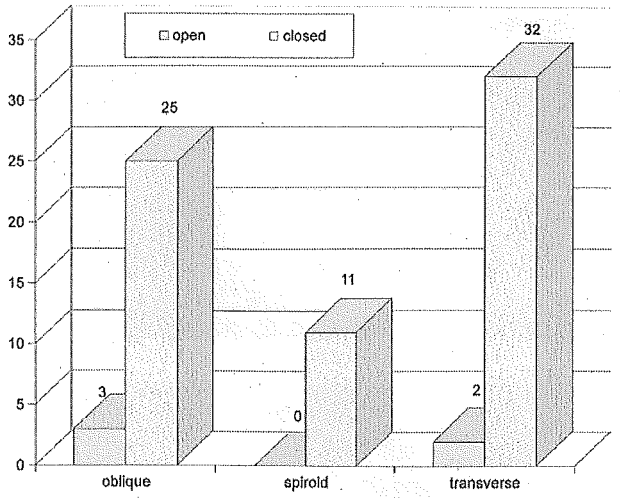

FIGURE 2. Distribution of open and closed femur fractures in 72 preschool children according to location.

mobilization and weight bearing after FIN were started on an average of 2.7 days (range, 1–14) and 14.1 days (range, 1–42), respectively. Nail removal was performed at a mean of 103 days (range, 50–241) after surgery. No death occurred.

Follow-up was available in 62 children after a mean period of 36.7 months (range, 4–124). Early postoperative complications included distal nail exteriorization in 9 children (12.3%). Nail exteriorization occurred between 5 and 18 days (mean, 10.8 days) after surgery and was treated by means of nail shortening in all cases except for one, where nail repositioning was sufficient. This was always performed under general anesthesia. In 5 children, pin shortening was performed on an outpatient basis between 3 and 12 days (mean, 7.6 days) after discharge from the hospital. Every nail exteriorization occurred in children operated on before the use of the new nail cutter. From 2000 onward, 22 FINs were performed and none of the children had skin irritation or nail exteriorization. Local skin infection after nail repositioning was diagnosed in 1 child (1.4%). He was treated successfully with intravenous antibiotics and healed without further complication.

A rotational abnormality of 5-degree angle was clinically measured in 1 child. No delayed union or neurovascular injury was recorded.

Femur overgrowth occurred in 27 children and was more than 1 cm in 6 (8.2%). Their demographics and fracture characteristics are summarized in Table 1. Their age ranged from 2.8 to 5.9 years; all but one child had transverse fractures. Three had associated injuries and 1 had an open fracture. The duration of FIN ranged from 23 to 240 minutes. Significant femur overgrowth was recorded as late as 124 months after surgery, as shown in Figure 5.

DISCUSSION

Femur fractures in preschool children heal quickly and have a tremendous potential for remodeling. Treatment

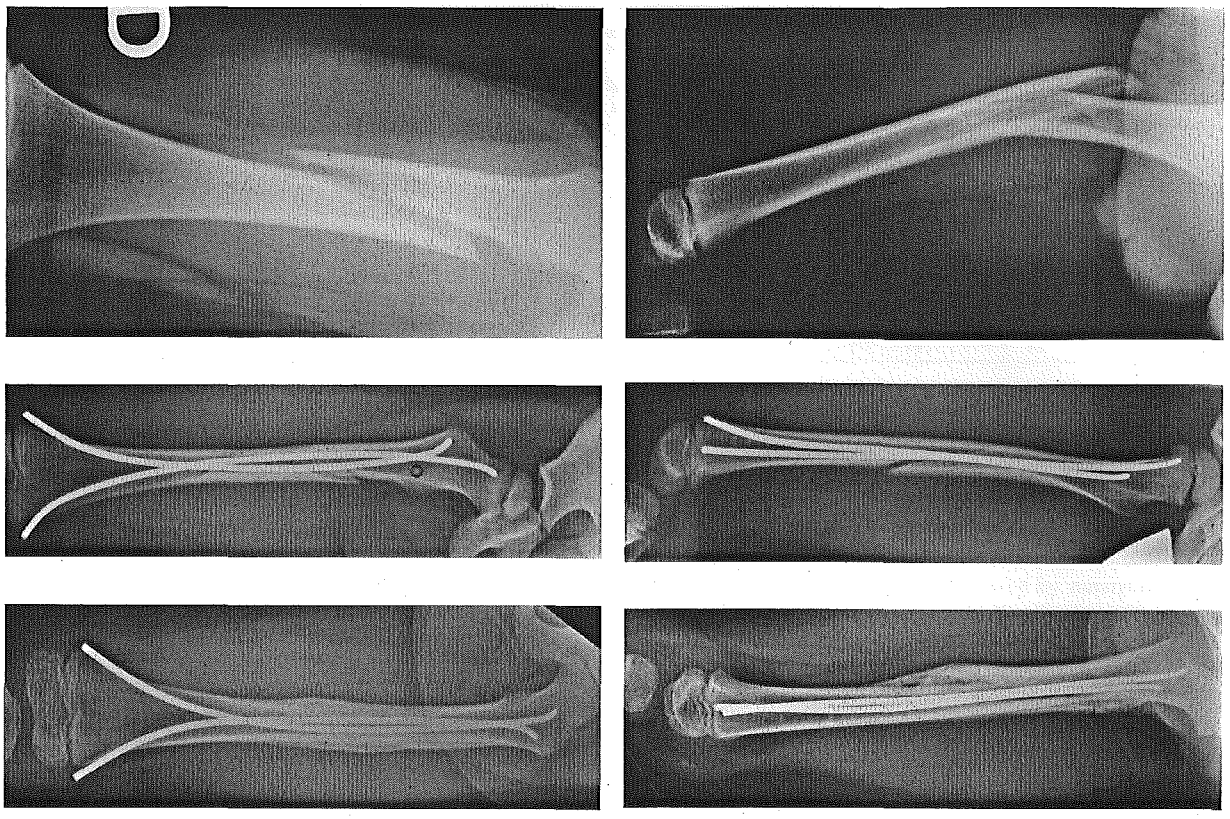

FIGURE 3. Anteroposterior and lateral radiographs of a long, oblique shaft femur fracture in a 4.3-year-old boy at 0, 3 (postoperative), and 60 days, respectively.

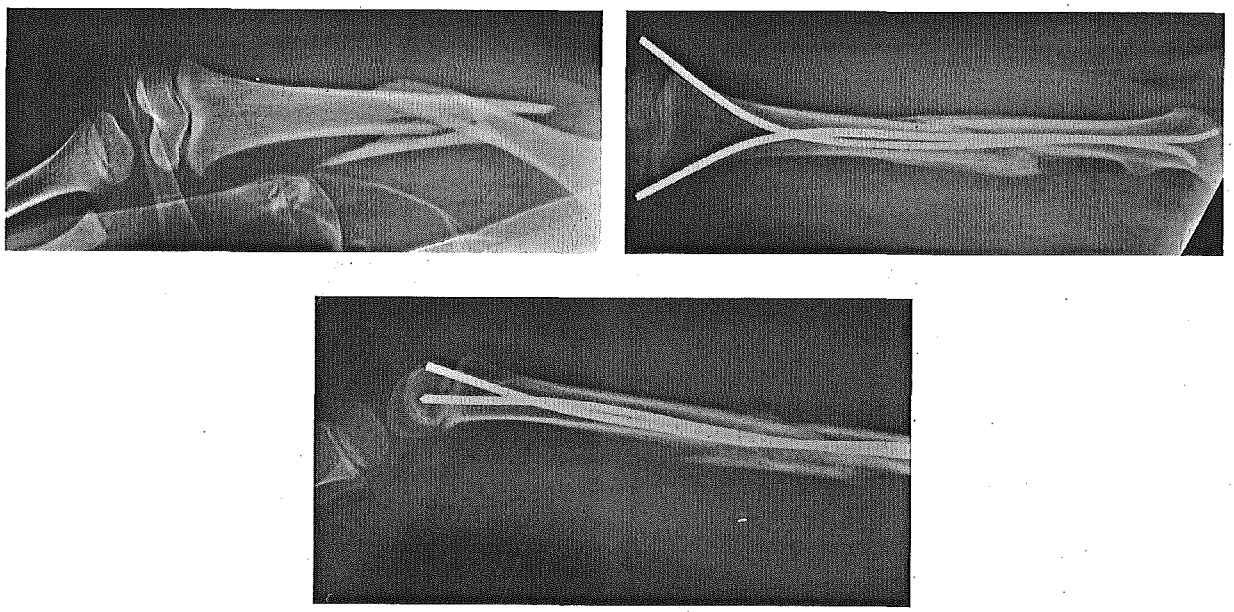

FIGURE 4. Radiographs of an oblique comminuted shaft femur fracture in a 3.3-year-old boy at 0 (anteroposterior) and 60 (anteroposterior and lateral views) days, respectively.

TABLE 1. Child Demographics and Fracture Characteristics in Cases with Significant Leg Length Discrepancies

Child	Age (y)	Fracture Type	Associated Injuries	Duration of Procedure (min)	Size of Nail	First Weight Bearing (d)	Fractured Femur Overgrowth at Follow-up			
							Minimum (mm)	Follow-up (mo)	Maximum (mm)	Follow-up (mo)
1	2,8	T*	Pelvic,‡ lower extremity degloving injury	240	2.5	40	0	7	12	66
2	3,0	T	Pulmonary contusion rib and clavicle‡	23	2.5	2	5	5	20	39
3	3,1	T	No	40	2.5	3	0	6	25	124
4	3,5	T†	No	140	2.5	3	10	12	13	93
5	4,7	T	No	50	2.5	25	5	1	21	52
6	5,9	T	Sacroiliac‡	50	2.5	49	10	78	12	96

*Open fracture.
†Nail exteriorization.
‡Fracture.

modalities therefore require immobilization without total anatomical reconstruction. Significant shortening and angulation can be tolerated, especially in the very young child. Although the fracture has a limited impact on the child's social activities, it keeps him immobilized for a minimum of 3 to 4 weeks. Spica cast immobilization has been the preferred treatment for many years and is still applied widely. It has disadvantages and is not free of complications. General anesthesia is necessary for fracture reduction and cast application. The cast may have to be adjusted or replaced, and serial radiological examinations are necessary to confirm the position of the fractured bone. Skin irritation may be significant and extensive. Compartment syndrome has even been reported.[7] On the other hand, FIN has gained international approval for the treatment of the same fracture in children aged 6 to 10 years. The lower age limit has never been well identified. Our study showed the feasibility of FIN in preschool children, even in very young children. The mean duration of FIN was within an hour, and only 2 fractures had to be opened for reduction.

Technique-related complications were similar to those reported in the literature assessing older children.[1,2,4,6,7,9,10,15,17–19] Skin irritation or pin exteriorization occurred in 12.3% of our patients. This was in accordance with the literature, which reported similar complications in 3.7% to 18% of cases, all ages considered.[1,17,19] Both the avoidance of distal pin bending and an ability to cut pins short-eliminated these complications in our patients during the last 4 years of the study. The use of a new nail cutter was a substantial technical improvement. Open reduction was required in 2 children possibly because of muscle interposition. Open reduction was not required during the last 10 years of the study probably because of the growing technical experience of the surgeons.

Preschool children with femur fracture treated by means of FIN benefited from early mobilization and weight bearing. For those with a single femur fracture without comorbidity, the mobilization could be started at a mean of 2.7 days after surgery. Their mean length of stay in hospital was 6.4 days. The mobilization at home allowed for regular hygiene and skin care. No secondary fracture displacement was observed. Flexible intramedullary nailing allowed for early weight bearing, which was started at a mean of 14.1 days after surgery. These figures are similar to the ones reported in school-aged children treated by means of FIN[1,2,5,10,17] and confirm that the known advantages of early mobilization and weight bearing after FIN in school-aged children are also achievable in younger children.

In our institution, after these observations, we have always cut the nails as short as possible, never added a spica cast, nor kept the leg in a splint. Children are allowed to mobilize as tolerated in bed and are discharged home when their parents are at ease and can carry them pain-free. Weight bearing is tolerated according to the fracture characteristics: as soon as possible for transverse fractures and after 3 weeks for long oblique, spiroid, or multifragmental fractures.

Leg length discrepancy and other orthopaedic complications of femur fracture have been described using both conservative and surgical treatments.[1,2,4,8–10,13–15,17–20] Pediatric femur overgrowth after fracture has been described in all age groups. Corry and Nicol[13] recorded clinical overgrowth of an average of 9.2 mm in 88% of children treated conservatively, being possibly more significant in the 4- to 7-year-old age group. Ligier et al[2] reported radiological overgrowth of more than 1 cm in 5% of school-aged children treated by means of FIN at an average of 22 months after surgery. Mazda et al[20] treated 34 femur fractures with FIN and recorded 3 children (8%) with more than 1 cm of overgrowth.

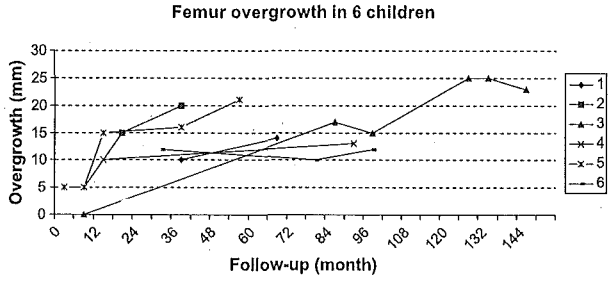

FIGURE 5. Evolution over time of significant femur overgrowth in 6 children.

Nordin et al[14] reported overgrowth of more than 1 cm after traction treatment in 21% of their patients. They suggested that proximal femur fracture had a higher potential for overgrowth.

In our study, although 27 children were noted to have a small leg length discrepancy at some stage during follow-up, this was only significant in 6 cases (8.2%). In 21 children, it was less than 1 cm and was stable or disappearing overtime, never becoming clinically significant. The age of the child, the size of the pin, the duration of the procedure, or the fracture characteristics did not significantly influence overgrowth, which was first noted in 6 children at an average of 18.1 months after trauma. The evolution of overgrowth over time, as illustrated in Figure 5, revealed that overgrowth could continue even up to 24 months after trauma. One 3.1-year-old child showed continuing femur overgrowth for 125 months, which then stabilized at 25 mm. These findings emphasize the need for long-term follow-up in preschool children with femur fracture for a minimum of 24 months and at least until the overgrowth has stabilized for 24 months.

In conclusion, preschool children with femur fracture treated by means of FIN benefited from the same advantages as older children. No increase in morbidity was encountered in this age group. Flexible intramedullary nailing is a safe and effective mode of treatment for femur fracture in walking children, regardless of their age. Long-term follow-up is mandatory in preschool children with femur fracture treated by means of FIN because of the potential for overgrowth, which should always be looked for and treated accordingly.

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