

Primary hip spica with crossed retrograde intramedullary rush pins for the management of diaphyseal femur fractures in children: A prospective, randomized study

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ABSTRACT

Background: Femoral fractures are common in children aged between 2 and 12 years and 75% of the lesions affect the femoral shaft. Traction followed by a plaster cast is universally accepted as a conservative treatment. We compared primary hip spica or traction followed by hip spica with closed reduction and fixation with retrogradely passed crossed Rush pins for diaphyseal femur fracture in 25 children of the age group 3-12 years, randomly distributed in each group. **Materials and Methods:** Fifty children (age: 3-13 years, mean; 9 years) with femoral fractures were evaluated; 25 of them underwent the conservative treatment using immediate hip spica (group A) and 25 underwent treatment with crossed retrograde Rush pins (group B). **Results:** Mean duration of fracture union was within 15 weeks in group A and 12 weeks in group B. Mean duration of weight bearing was 14 weeks in group A and 7 weeks in group A. Mean hospital stay were 4 days in group A and 8 days in group B. The mean follow-up period was 16 months in group A and 17 months in group B. Complications like angulation, shortening and infection were compared. Bursitis and penetration of pins at the site of Rush pin insertion is a complication associated with this method of treatment. **Conclusion:** Closed reduction and internal fixation with crossed Rush pins was a superior treatment method in terms of early weight bearing and restoration of normal anatomy.

Key words: Femoral fractures, hip spica, rush pins

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INTRODUCTION

Femoral shaft fractures are one of the commonest fractures of lower extremities in children and the commonest complication requiring hospital admission. Few degrees of angular deformity and few centimetres of shortening are acceptable in children according to their age group, because children have tremendous re-modelling potential. A variety of methods are used for the treatment of paediatric diaphyseal femur fractures, including immediate spica casting, traction followed by spica casting, external fixators, osteosynthesis with plate and internal fixation with intramedullary rod or flexible intramedullary nail. Choice of treatments depends

upon the age of children, anatomical site, fracture pattern and preference of the surgeon. Traditionally, children below 6 years of age are treated with immediate hip spica and adolescent children are treated with operative methods.¹³

External fixators are associated with increased chances of pin tract infection and re-fracture. Plate osteosynthesis need extensive soft tissue strapping and re-surgery for removal. Intramedullary rods increase the chances of avascular necrosis of femoral head and damage to the physis. Flexible intramedullary nailing has become an increasingly popular method of paediatric femoral fracture fixation.^{4,5} Systemic reviews and various cohort studies have shown excellent clinical results with flexible intramedullary nails (Rush pins) for children, and few studies has extended its indication to preschool-going children. However, no randomized controlled trial has been reported comparing flexible intramedullary Rush nailing with other mode of management of paediatric diaphyseal femur fracture.

We present a randomized controlled trial comparing flexible intramedullary Rush pins with immediate spica casting for paediatric diaphyseal femur fracture.

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MATERIALS AND METHODS

A total of 50 children belonging to the age group 3 to 13 years presenting to Teaching Hospital of National Medical College (November 2010 to December 2012) with diaphyseal femur fracture were randomly allocated into group A (immediate hip spica casting) and group B (flexible intramedullary Rush pins) using random number generation technique.

In group A, the fracture was reduced on the same day or the next day of presentation to the hospital with fluoroscopy control under general anaesthesia and one and half spica casting was applied [Figure 1]. Criteria of acceptable reduction were based upon Kasser *et al.*, [Table 1].¹³ Children were admitted to the hospital until parents learned how to take care of spica. Follow-up was performed at the 2nd week for evaluation of reduction and spica-related complications. Radiological evaluation of bridging callus was performed at the 6th week for evaluation of radiological union. If bridging callus was seen at three cortices, the child was asked to bear weight with or without support, according to pain tolerance. If callus was not evident, long leg cast was applied for 4 more weeks.

In group B, under general anaesthesia, two small skin incisions were made on either side of distal metaphysis and two holes are made obliquely facing towards medullary cavity with the help of 4-mm awl, an inch proximal to the growth plate. Two pre-contoured C-shaped Rush pins were passed retrogradely with fluoroscopy control until both the tips reached just distal to the fracture site. Fracture was reduced with manual traction and rush pins are pushed into medullary cavity of proximal fragment under fluoroscopy control [Figure 2]. Tips of the pins were targeted up to the level of the neck and base of the

greater trochanter. Care was taken to ensure that the bent distal part of Rush pin lied on the cortical surface of the supracondylar of femur without soft tissue impingement. Size of the Rush pins were measured as 40% of narrowest diameter of femur on AP and lateral view. In initial few cases, we applied posterior long leg plaster of Paris back slab, which we later discontinued and used only knee immobilizer post-operatively until the sutures were removed after 2 weeks. As soon as pain was tolerable, the hip and knee were mobilized and non-weight bearing ambulation was allowed. Weight bearing was permitted once bridging callus was evident on X-ray on three cortices. Follow-up was done at 6th, 12th week, 6th months, 1 year and 2 years for radiological and clinical evaluation [Figure 3]. Rush pins were routinely removed after 1 year of surgery. The treatment cost was calculated as the total amount paid to the hospital that covered admission, investigation, operation and hospital stay charges because many indirect costs are associated with total management, which could not be generalized.

Statistical analysis

Success of randomization was tested between two groups. Magnitude of difference between the two groups was measured between means in the both group by SPSS 11.5 software, and the significance of difference

Table 1: Acceptable Angulation and Shortening in Children with a Femoral Fracture*

Age	Varus – Valgus Angulation (degree)	Anterior – Posterior Angulation (degree)	Shortening (mm)
6-10 yr	10	15	15
11 yr to maturity	5	10	10

*Based on data from: Kasser JR, Beuty JH, Femoral shaft fractures. In: Beut JH, Kasser JR, editors. Rockwood and Wilkins' fractures in children, 5th ed. Philadelphia: Lippincott Williams and Wilkins; 2001. p. 948.

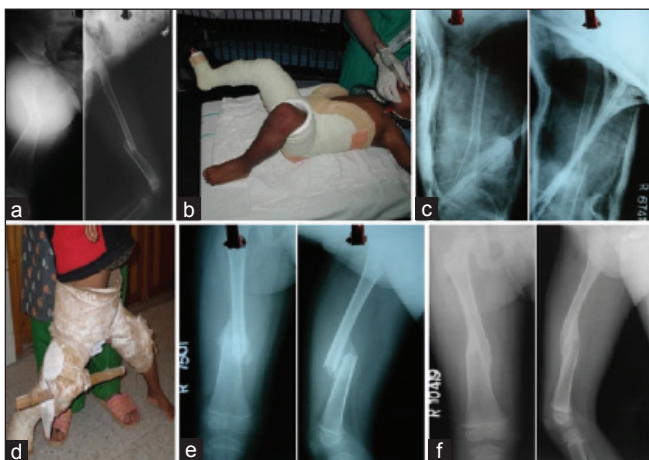


Figure 1: Children with femoral shaft fractures: Before hip spica X-ray, (a) in spica cast, (b) after the cast, (c) broken spica on 6-week follow-up, (d) X-ray on 6-week follow-up (e) and final X-ray at 4-month follow-up (f)

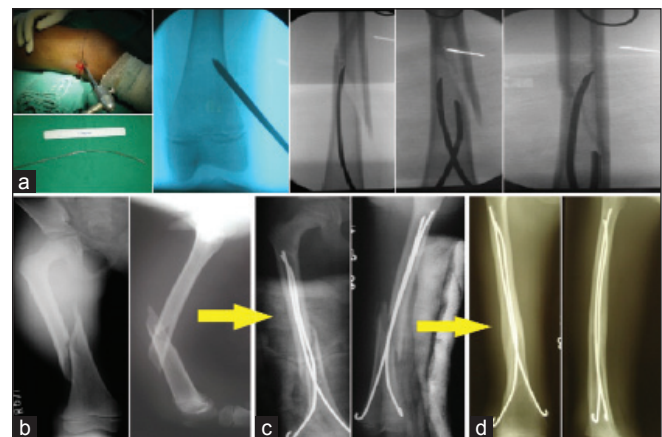


Figure 2: Fixation of flexible intramedullary Rush pins procedure in a child with femoral shaft fracture (a) and radiographs taken before operation, (b) immediately after operation (c) and at 14-month follow-up (d)

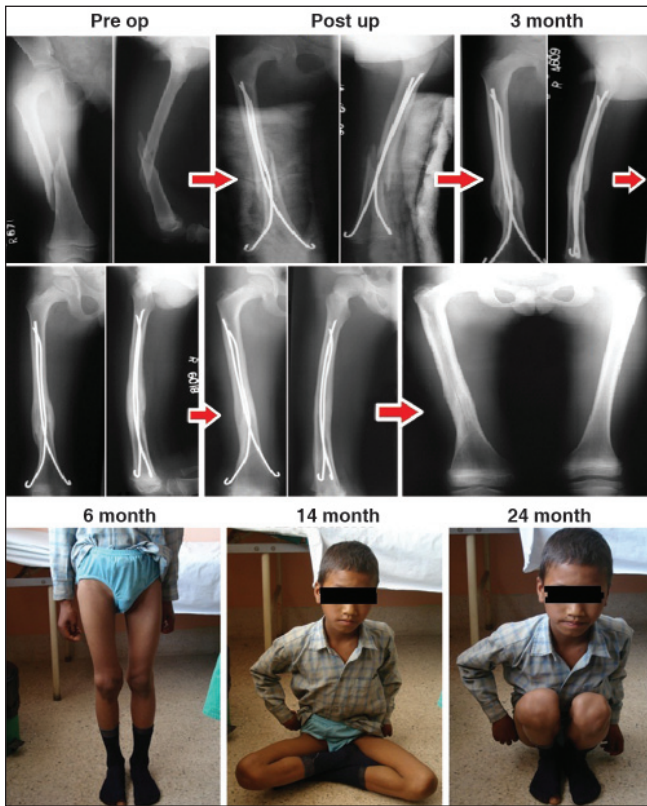


Figure 3: Radiological and clinical evaluation of the outcome of Rush pin fixation

was measured by determining p value using Chi-square test for qualitative variables and independent t test or Man-Whitney U test for quantitative variable, depending upon whether p value obtained from Kolmogorov-Smirnov Z test for homogeneity of variance was below or above 0.05. P value < 0.05 was considered statistically significant.

RESULTS

Table 2 compares the success of randomization between the two groups in terms of age, sex, weight, side, fracture pattern, stability, mode of injury and the anatomical site.

Age in both the groups ranged from 3 to 13 years with a mean age of 6.4 ± 3.46 years. Male to female ratio was 2.5:1 and 4:1 in group A and B, respectively. Fracture pattern was classified according to AO classification, which showed type 32A1 as the most common pattern of injury. Spiral or long oblique fractures or fracture with comminution more than two-third of the diameter of the bone were considered unstable. Fall related injury either from hill slope, tree, cliff or wall was commonest mode of injury, which comprised of 88% of injury in both group A and B. Anatomically, femoral diaphysis was the most common site of femur fracture in this study.

Table 2: Success of randomization between groups A and B

Variables	Group A (Hip spica) (N = 25)	Group B (Rush pin) (N = 25)	P values
Age (Yrs±SD)	5.6±3.61	6.92±3.57	0.20
Sex			
Male	18	20	0.5
Female	7	5	
Weight (Kgs±SD)	17.44±7.68	20.4±8.29	0.19
Side			
Right	14	18	0.24
Left	11	7	
Classification			
32A1	9	13	
32A2	4	3	
32A3	9	4	0.43
32B1	1	3	
32B2	2	2	
Stability			
Unstable	16	20	0.33
Stable	9	5	
Mode of injury			
Height	14	11	
Tree	4	6	
RTA	2	1	
Play ground	1	2	0.61
Staircase	1	3	
Wall	3	1	
Cliff	0	1	
Fracture site			
Proximal	5	4	
Middle	18	20	0.76
Distal	2	1	

The mean follow-up period was 16.1 months (range: 6-26 months) in group A and 17 months (range: 6-28 months) in group B. One patient in group A could not be followed up at all after discharging from the hospital and hence excluded from the analysis.

A total of 16 children in group B who could be trained for ambulation with walking aids started walking much earlier than 14 children in group A with significant mean difference (13.38 ± 2.3 days in group B vs. 52.33 ± 4.5 days in group A, $P = 0.000$). Similarly, children in group B started walking without aid with a mean duration of 6.6 ± 1.29 weeks as compared to 10.67 ± 4.32 weeks in group A ($P = 0.002$). Also, 17 children in group B and 13 in group A were school-going children pre-operatively. The mean duration of return to school was 8.82 ± 0.17 weeks in group B and 15.6 ± 2.98 weeks in group A ($P = 0.000$). In group A, clinico-radiological union was achieved within 12 weeks duration in 10 cases, within 16 weeks in 12 cases and within 17 weeks in 2 cases with a mean union time of 13.25 ± 2.43 weeks, whereas all the fractures united within 12 weeks in group B with a mean duration of 10.76 ± 0.72 weeks ($P = 0.000$). Children returned to full activities at a mean time of 8.76 ± 2.27

weeks in group B and 12.08 ± 4.51 weeks in group A ($P = 0.027$) [Table 3].

Children in group B were discharged from the hospital with an average duration of 6.56 ± 2.75 days as compared to 3.32 ± 1.4 days in group A ($P = 0.000$). The hospital cost was more for children with fracture managed with Rush pins in group B (US\$ 50.68 ± 11.70) than in group A (US\$ 31.04 ± 12.16 ; $P = 0.000$) [Table 3]. Increased hospital cost in group B can be attributed to longer hospital stay that ranges from 3 to 14 days, as many patients in our teaching hospital come from far and remote distance from where it is not only expensive but also difficult for coming to hospital for the removal of sutures. Therefore, they preferred longer hospital stay until the sutures were removed.

Final outcome at the end of follow-up was evaluated according to Flynn's grading.¹ Table 4 shows that individually and overall group B had superior outcome as compared to group A; 19/25 (76%) children had excellent, 5/25 (20%) had satisfactory and 1/25 (4%) had poor result in group B as compared to 4/24 (17%) with excellent, 11/24 (49%) with satisfactory and 9/24 (44%) with poor outcomes in group A ($P = 0.000$).

In group A, 3 patients had plaster sores at the perineal area, which recovered with dressing and antibiotics; 1 child had broken and loosened hip spica on the 2nd week [Figure 1d] and needed re-application of spica; 4 children had increased angular deformity or overlapping, but within acceptable range on the 2nd weeks of follow-up.

Table 3: Outcome variables comparing two groups A and B

Variables	Group A (Hip spica) N = 24	Group B (Rush pin) N = 25	P values
Hospital Stay (days)	3.32±1.4	6.56±2.75	0.0001
Walking with aids (days)	52.33±1.55	7.38±0.68	0.0001
Walking without aids (Wks)	10.6±0.88	6.6±0.25	0.0001
Weight bearing (Wks)	12.5±0.41	5.6±0.22	0.0001
Return to full activity (Wks)	15.6±0.82	8.8±0.41	0.0001
Return to school (Wks)	11.5±1.03	8.7±0.45	0.019
Union time (Wks)	12.4±0.51	10.7±0.14	0.0001
Treatment cost (US dollar)	31.04±12.16	50.68±11.70	0.0001

Table 4: Flynn's Grading (2001, JPO)

Flynn's Grading	Excellent	Satisfactory	Poor
Limb length discrepancy	<1 cm 11(45%)/22(88%)	>1 cm 6(25%)/3(12%)	>2 cm 7(30%)/0
Misalignment	<5° 5(20%)/22(88%)	<10° 9(38%)/2(8%)	>10° 10(42%)/1(4%)
Complications	None 20(83%)/23(92%)	Minor and resolved 4(17%)/2(8%)	Major and lasting 0/0
Over all result	4(17%)/19(76%)	11(49%)/5(20%)	9(44%)/1(4%)

In group B, 2 children had complications related with long protruded Rush pin at entry site. One child presented with pin tract infection on the 7th day of surgery, which recovered after trimming of the protruded part; another child presented with bursitis after 1 year, which recovered after removal of Rush pins. One patient had lost antero-posterior alignment on the 6th week of follow-up. In 1 child, penetration of posterior cortex of base of the neck was identified in subsequent follow-up. Rush pin was removed on 6th month and did not show any changes of avascular necrosis till 1 and half years of follow-up. Another patient had penetration of greater trochanter but no limb length discrepancy.

DISCUSSION

Staheli *et al.*,⁶ defined the ideal treatment of femoral shaft fractures in children as one that controls alignment and length, does not compress or elevate the extremity excessively, is comfortable for the child and convenient for the family and causes the least negative psychological impact possible. Immediate spica casting or skeletal traction and application of a cast is common method for the treatment of diaphyseal femoral fractures in children and young adolescents and surgical intervention is indicated in open fractures, multi-trauma, concomitant head injuries, burns and neuromuscular wounding. However, psychosocial and economic effects of spica cast immobilization on children and their families have been reported by Hughes *et al.*,⁷ and many studies advocate early fixation of femur fracture because complications inherent in conservative treatment, such as malunion and shortening, cast intolerance, financial factors and increased hospitalization can be decreased by surgery. Among other operative methods, flexible intramedullary nail has been used increasingly due to its simplicity and characteristics of load-sharing internal splint that maintains the length and alignment of the limb until bridging callus is formed and spares the risk of damaging the physis or the blood supply to the capital femoral epiphysis with a proper surgical technique.

Torsional stability depends upon divergence of the rods in the proximal metaphysis and resistance to sagittal and coronal bending results from spreading of the prebent rods through the diaphysis, size of the rod and material properties of the rod. Micro-motion confirmed by elasticity of fixation promotes early callus formation. There are no clinical study comparing efficacy of titanium elastic nail with stainless steel nail like Enders nail and Rush pins. The Young modulus of stainless steel is nearly double the size of titanium (approximately 200 GPa versus approximately 110 GPa), making it a much stiffer material with less elastic properties. Lee *et al.*,⁸ demonstrated that Ender nail fixation of simulated femur fractures maintained fracture length and rotational control with weight bearing of up to 40% of body weight, even in the presence of comminution, whereas Mahar *et al.*,⁹ reported that the titanium implants provided greater stability in resisting

torsional loading and axial compression in both transverse and comminuted fractures in biomechanical comparative study with stainless steel nails. Besides elastic property, retrogradely passed adequate size crossed Rush pins offer all the advantages of closed reduction technique and internal fixation with flexible intramedullary nails. Excellent clinical results using stainless steel flexible nails have been reported for both stable and unstable femur fracture in children. Rathjen *et al.*,¹⁰ assumed that the stiffer properties of a stainless steel implant should confer greater fracture stability, especially in the setting of an unstable fracture pattern.

Cramer *et al.*,¹¹ reported 10 prospectively evaluated 57 femoral shaft fractures in children treated with Ender rods, 21 of which were either spiral fractures or comminuted. Although the results were not stratified according to fracture stability, the authors noted no clinically significant leg length discrepancy or malunion. Four patients did demonstrate radiographic angular deformities of <15° deviation at final follow-up. Another advantage of stainless steel nail is ready availability and lesser cost.

Simanovsky *et al.*,¹² defined that the flexible intramedullary nails can be an attractive and safe treatment options in children aged 3-5 years for femoral shaft fracture and should be brought up and discussed with parents.

This study had a prospective design and used a convenience sample, which were its limitations. The different characteristics of the two groups of patients were also a limitation. Nonetheless, this study points towards the important that femoral shaft fractures in children can be better treated with surgery. This is a proper scenario within which a randomized controlled trial can be developed to obtain reliable answers without bias.

CONCLUSION

Intramedullary crossed Rush pins are effective method of management of paediatric diaphyseal femur fracture as compared to primary hip spica in terms of early ambulation and return to normal activities and school earlier. The former gives a predictable clinical pathway and reduces the periods of traction and occupancy of hospital beds.

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