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# Chinese Journal of Traumatology

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## Original article

# Pediatric femoral shaft fractures treated by flexible intramedullary nailing

K.C. Kapil Mani\*, R.C. Dirgha Raj, Acharya Parimal

Department of Orthopaedics, Civil Service Hospital, Kathmandu, Nepal

## ARTICLE INFO

### Article history:

Received 19 October 2014

Received in revised form

18 May 2015

Accepted 29 May 2015

Available online 30 October 2015

### Keywords:

Flexible intramedullary nail

Femoral shaft fracture

Fracture union

Stainless steel

## ABSTRACT

**Background:** Nowadays pediatric femoral fractures are more commonly managed with operative treatment rather than conservative treatment because of more rapid recovery and avoidance of prolonged immobilization. Children between the ages of 5–13 years are treated either by traction plus hip spica and flexible/elastic stable retrograde intramedullary nail, or external fixators in the case of open fractures. The aim of this study is to evaluate the outcome of pediatric femoral shaft fractures treated by stainless steel flexible intramedullary nail in children between 5 and 13 years of age.

**Methods:** There were 32 cases of femoral shaft fractures which were all fixed with stainless steel flexible intramedullary nail under fluoroscopy. Long leg cast was applied at the time of fixation. Partial weight bearing was started 2 weeks after surgery. Patients were evaluated in follow-up study to observe the alignment of fracture, infection, delayed union, nonunion, limb length discrepancy, motion of knee joint, and time to unite the fracture.

**Results:** We were able to follow up 28 out of 32 patients. The patients were 8.14 years of age on average. The mean hospital stay after operation was 4 days and fracture union time was 9.57 weeks. There were 3 cases of varus angulation, 2 cases of anterior angulation, and 4 cases of limb lengthening.

**Conclusion:** Patients aged between 5 and 13 years treated with flexible intramedullary nail for closed femoral shaft fracture have rapid union and recovery, short rehabilitation period, less immobilization and psychological impact, and cost-effective.

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## 1. Introduction

Over the past few decades, pediatric femoral fractures have been more appropriately managed with operative treatment rather than conservative treatment because the former has more rapid recovery and shorter immobilization.<sup>1</sup> Small children less than five years old are treated with early reduction and hip spica while young adolescents more than 15 years old are treated with intramedullary interlocking nail. Children between the age of 5–13 years are treated with either traction, hip spica, flexible/elastic stable retrograde intramedullary nail, or external fixators in cases of open fractures.<sup>2</sup> Operative treatments are appropriate to avoid physical, social and psychological complications as well as prolonged immobilization, which include external fixators,<sup>3</sup>

plates and screw fixation,<sup>4</sup> antegrade intramedullary nailing,<sup>5</sup> and flexible or elastic stable retrograde intramedullary nailing. Antegrade intramedullary nailing may cause osteonecrosis of the femoral head while external fixators may lead to infection of the pin tract and re-fracture of bone. So retrograde flexible or elastic stable intramedullary nailing has become widespread for the management of pediatric diaphyseal femoral shaft fractures. Early good results using flexible (Ender) or elastic stable (Nancy) intramedullary rods have been reported by several European and American researchers.<sup>6–10</sup>

Considering the widespread use of either flexible or elastic stable intramedullary nailing, we conducted a prospective study to evaluate the outcome of pediatric femoral shaft fractures treated with flexible stainless steel nail in children between 5 and 13 years old. Stainless steel nail rather than titanium nail is used because it is more economical and it can fulfill the same purpose and results. We focused specifically on the first year post injury—the period when the treatment method should have the greatest impact.

\* Corresponding author. Tel.: +977 9841244502.

E-mail address: [drkapil2007@yahoo.com](mailto:drkapil2007@yahoo.com) (K.C. Kapil Mani).

Peer review under responsibility of Daping Hospital and the Research Institute of Surgery of the Third Military Medical University.

## 2. Materials and methods

This study was conducted in Civil Service Hospital, Kathmandu, Nepal from July 2011 to June 2014. All the patients between 5 and 13 years with closed diaphyseal femoral fractures were enrolled into the study. Patients were excluded if 1) age more than 13 years or less than 5 years, 2) weight more than 70 kg, 3) with sclerotic and narrow femoral canal, compound fractures, or fractures extending to the proximal or distal ends. Fractures were fixed with two flexible stainless nails of appropriate length and diameter through a small incision that is 2.5–3 cm proximal to the distal femoral growth plate under fluoroscopy. One nail was driven towards the femoral neck approximately 2 cm distal to the capital physis and the other towards the greater trochanter, 1 cm distal to its physis.<sup>11</sup> Because of its flexible nature, pre-bending of the nail was not required in comparison to the Nancy nail which was pre-bent before insertion. Long leg cast was applied at the time of fixation. Both plaster and stitches were removed 2 weeks after surgery. Partial weight bearing was started 2 weeks after surgery in cases of midshaft transverse fractures and delayed to 4 weeks in cases of oblique and comminuted fractures.

We did not include the patients managed with conservative treatment in this study. Patients who did not want to receive surgery were managed by skin traction for 2–3 weeks followed by hip spica application. Total cost for conservative treatment was calculated including the cost for hospital stay in order to compare with the total cost for operative treatment. The number of patients treated with conservative treatment was 20 and their characteristics were the same as those for operative treatment. Patients were evaluated at two weeks, six weeks, three months, six months and one year after surgery to observe the alignment of fracture, any infection, delayed union, nonunion, limb length discrepancy, motion of knee joint, and fracture union time. Orthopedic registrars as well as consultants in outpatient department measured all these parameters.

Final limb length discrepancy, fracture alignment and range of movement were calculated at the time of fracture union. Alignment of fracture was assessed by drawing lines on X-ray films and measured with a goniometer. Limb length discrepancy was assessed by measuring both limbs from anterior superior iliac spine to medial malleolus in supine position. Any difference of length in the fractured limb as compared to the normal one was taken as limb length discrepancy. Range of movement of knee joint was assessed by passive extension and flexion of knee joint and the angle was measured with a goniometer. Delayed union and nonunion were assessed on the basis of clinical and radiological union. Radiological union is defined as the appearance of a mature callus at least on 3 out of 4 planes and clinical union as no pain on movement of the fracture ends.<sup>12</sup>

## 3. Results

Altogether we had operations on 32 patients with flexible stainless steel nails, out of which only 28 patients were available for follow-up study. In the end we included only 28 patients in this study. Even though we had operations on more than 60 cases of femoral shaft fractures with intramedullary flexible nails, we excluded those fixed by titanium nails. The average age of patients was 8.14 years with a minimum age of 5 years and maximum age of 13 years. Detailed general data were listed in Table 1.

Six (21.42%) patients sustained injuries on other parts of the body but resolved spontaneously. The mean hospital stay after surgery was 4 days and that for the non-operative treatment was 26 days. There were 3 cases of varus angulation (5°, 8°, and 7°) and 2 cases of anterior angulation (8° and 6°). Out of these 5 malunion

**Table 1**  
Characteristics of patients (n = 28).

Parameters	No. of cases (percentage, %)
Gender	
Male	16 (57.14)
Female	12 (42.85)
Involved femoral side	
Right	16 (57.14)
Left	12 (42.85)
Involved region (femoral shaft)	
Middle third	14 (50)
Proximal third	8 (28.57)
Distal third	6 (21.42)
Cause of injury	
Fall from the height	16 (57.14)
Road traffic accident	8 (28.57)
Direct hit	2 (7.14)
Sports injury	2 (7.14)
Fracture type	
Transverse fracture	13 (46.42)
Oblique fracture	8 (28.57)
Spiral fracture	4 (14.3)
Comminuted fracture	3 (10.71)

cases, fractures were present in the distal third of femur in 3 cases and proximal third in 2 cases. Moreover, 2 were older children with their weight more than 50 kg. We also found limb lengthening of 6 mm in 2 cases and 8 mm in another 2 cases. In those cases, fractures were in the distal third of femur in 3 cases and middle third of femur in 1 case. The average time to unite the fracture was 9.57 weeks (6–14 weeks). Knee motion recovered to pre-injury level in all cases. There was no case of infection, breakage of nail, delayed union or nonunion. However there was formation of bursa over the site of nail entry in 6 cases because of friction between the tip of the nail and the skin.

## 4. Discussion

The ideal treatment for pediatric femoral shaft fractures depends upon the age of child, location and type of fracture, availability of facilities, knowledge of surgeon, and financial conditions to some extent.<sup>13</sup> Over the past few decades, management of pediatric femoral fractures has shifted more towards operative intervention because of quicker recovery, shorter rehabilitation period, less immobilization, and less psychological impact to the children.<sup>2</sup> Flexible intramedullary nails can be easily applied, require no exposure of fracture site, and cause few complications. During insertion of nails, reaming is not done, and nutrient vessels are preserved, so there is a theoretical advantage of early healing of fractures.<sup>14</sup> Presence of parents in the hospital reduces their working hours and increases the economic burden of the family. Reeves<sup>15</sup> et al performed a large comparative study between the conservative and operative treatment and showed a much longer mean hospital stay in the conservative group (26 days vs. 9 days) and more complications too. They concluded that intramedullary nailing has a shorter hospitalization, and has psychological, social, educational, and some economical advantages over traction and hip spica. Similarly Sink<sup>16</sup> et al treated unstable pediatric femoral fractures in 27 patients with sub-muscular bridging plates. They found all the fractures united within 12 weeks without any complications. However fractures treated with intramedullary nails have better stability than those treated with sub-muscular bridging plates even though the hospital stay is comparable to both techniques.

In our study the mean hospital stay was 4 days. There were only 3 cases of varus angulation and 2 cases of anterior angulation. In all

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