Submuscular Plating vs Flexible Intramedullary Nailing in the Management of Paediatric Femoral Shaft Fractures

Inam Ul Haq[1], Asif Sultan[2], Shafat Rashid[3]

ABSTRACT

Introduction: The aim of this study was to compare the outcome in terms of patient characteristics, intraoperative blood loss, operative time, length of hospital stay and complications after insertion and removal of submuscular plates (SMPs) and flexible nails (FNs) for pediatric femoral shaft fractures.

Material and methods: 40 children between the age of 6 to 14 years of age who underwent treatment with SMPs (n=22) and FNs (n=18) from 2018 to 2020.

Results: insertion of FNs was associated with shorter operative time (mean= 61.2 minutes) and less blood loss (mean=92 ml) compared to SMPs. The FNs group had a shorter length of hospital stay (mean 4.9 days) compared with SMPs (mean=8.6 days). Removal of FNs was also associated with shorter operative time and less blood loss compared to SMPs. Two patients treated with SMPs and one patient treated with FNs developed surgical site infections. Two patients treated with SMPs and three treated with FNs developed implant irritation that resolved with removal. Two patients treated with SMPs and one treated with FNs developed knee stiffness requiring aggressive physiotherapy protocol. One patient treated with FNs developed burisitis at nail insertion site. No other complications occurred.

Conclusion: When compared with SMPs, FNs are associated with less operative time, decreased blood loss and less duration of hospital stay in patients with femur fractures.

Keywords: Children, Femur Fracture, Internal Fixation, Submuscular, Titanium, Union, Functional Outcome.

INTRODUCTION

Femoral shaft fractures account for <2% of all fractures in children.[1] The mechanism is typically high-energy trauma, such as a fall from a height or motor vehicle collision. The fractures are located in the diaphysis, and surgical intervention is typically necessary.[2] A variety of methods have been introduced to treat pediatric femur fractures, including spica casting, traction followed by spica casting, internal fixation with plate, intramedullary nailing, and external fixation. Little controversy exists in the immediate hip spica casting of femur fractures in patients under[3] years old, while no consensus has been reached in other age groups. Controversy exists regarding the most optimal surgical treatment for femoral shaft fractures in children.[3] The treatment should be decided based on age, fracture location and pattern, associated injuries, socioeconomic situation, as well as the preference of surgeons.[4]

The appropriate management of length-unstable femoral fractures is still a debatable issue. Skeletal traction followed by spica casting is a viable choice. However, this procedure has been largely abandoned because of excessive hospital stay and unfavorable qualify of life.[5] External fixation is a simple way to maintain anatomic alignment for a femur fracture, but complications are quite common, such as refracture, increased time to union, and pin tract infection.[6]

There are basically two types of FN techniques: the retrograde technique and the antegrade technique. The former involves one medial and one lateral incision just above the distal femoral physis. The entry points are created, medially and laterally, by drilling a hole in the distal metaphysis of the femur. The nails are then driven through the canal of the femur until the proximal metaphysis and the femoral neck. The nails are bent into a double C pattern. Most reported complications are problems with skin irritation due to the distal ends of the nails protruding. The antegrade technique involves a single incision around the level of the greater trochanter of the femur. This approach obviates the complications around the knee. The entry portals can be either through the greater trochanter apophysis or just inferior to the greater trochanter. The flexible nails are introduced downwards in the femoral canal until just proximal to the distal epiphysis. Nails are bent into C and S patterns. Plating techniques have been a popular alternative to ESIN and were primarily indicated in length-unstable fracture patterns or patients weighing over 49 kg. The benefits of plates include a lower incidence of malunion, stronger axial and torsional stability in loading, and the limited exposure of the submuscular technique.[7] In addition, plate osteosynthesis allows stable fixation with good results in the pediatric population.[8] Traditional plates require extensive exposure with soft tissue disruption. Minimally invasive plating and submuscular techniques have evolved to reduce soft tissue dissection.

MATERIAL AND METHODS

A consecutive series of patients aged 6 to 14 years with femur fractures were compared. We compared the treatment using FNs and SMPs. This study was carried out in Govt.

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Bone and Joint Hospital, Barzulla, Srinagr from September 2018 to December 2020. Informed consent was obtained. We reviewed operative notes, clinical records and radiographs to determine skeletal immaturity, comorbidities, fracture type, mechanism of injury and treatment method. Children with pathological fractures or comorbidities with major musculoskeletal manifestations such as osteogenesis imfercta, skeletal dysplasia, spina bifida and cerebral palsy were excluded.

Patient characteristics, such as sex and age, were obtained from clinical records. Mechanism of injury was categorized as recreational (e.g. falling from climbing bars, being tackled during football), motor vehicle accident (e.g. pedestrian struck by automobile, passenger in motor vehicle crash) or other (e.g. tripping and falling at home, crush injury from furniture). Patients were categorized as having isolated injuries or polytrauma (defined as having injuries with Abbreviated Injury Score ≥ 2 in two or more regions of the body.[9,10] The primary outcomes were EBL and operative time for the initial implant insertion and removal procedures. Data on EBL during implant insertion and removal were obtained from operative notes; estimates were made by the surgeon and anaesthesia team members through intraoperative assessment of volume in the suction device and number of sponges saturated. Operative time was calculated as the number of minutes between 'incision time' and 'surgery stop' in the operating room nursing documentation. Discharge summaries, hospital records and follow-up clinic notes were reviewed to determine the length of postoperative hospital stay and incidence of the following complications: surgical site infection, implant irritation, leg-length discrepancy > 2 cm, mal-union and non-union. Radiographic records were also reviewed for evidence of abnormal healing, including mal-union and non-union. Clinical documentation by the surgeon regarding the radiographs, as well as radiologists' assessments for each image were reviewed; evidence of healed or healing fractures, anatomic alignment, complications and abnormal healing were noted.

The radiographic data included AP view of pelvis, AP and lateral views of femur, preoperatively and postoperatively. Fracture patterns were classified as length stable or unstable. Transverse and short oblique fractures were included as length stable fractures whereas comminited and long oblique fractures, where the length of fracture was at least twice the diameter of the femoral shaft at that level. Radiographic union was defined as bridging callus across at least three of the four cortices at the fracture site seen both on AP and lateral radiographs of the femur.

The final functional outcome was evaluated using Flynn scoring system[11] and were classified into excellent, satisfactory or poor based on residual leg length inequality, fracture malalignment, pain, complications and unplanned surgery for the treatment of complications.

RESULTS

In all, 22 patients treated with SMPs and 18 treated with FNs met the inclusion criteria. The mean ages were similar between groups. The sex distribution and fracture laterality were also similar. The mean length of clinical and radiographic follow-up was 8.16 weeks.

There were 12 comminuted, 15 transverse, 6 oblique and 7

Variables		SMP Group (n=22)		FN Group (n=18)		Total (n=40)	
		Mean age (9.8)		Mean age (8.6)		Mean age (9.2)	
		Number	%age	Number	%age	Number	%age
Sex	Male	16	73.73	11	61.11	27	67.5
	Female	6	27.27	7	38.89	13	32.5
Mechanism of injury	Road accidents	8	36.36	4	22.22	12	30.0
	Recreational	9	40.91	11	61.11	20	50.0
	Others	5	22.73	3	16.67	8	20.0
Side	Right	9	40.91	10	55.56	19	47.5
	Left	13	59.09	8	44.44	21	52.5
Type of injury	Isolated	19	86.36	16	88.89	35	87.5
	Poly-traumatized	3	13.64	2	11.11	5	12.5
Fracture type	Comminuted	9	40.91	3	16.67	12	30.0
	Oblique	3	13.64	3	16.67	6	15.0
	Spiral	3	13.64	4	22.22	7	17.5
	Transverse	7	31.81	8	44.44	15	37.5

Table-1: Demography of patients

Grading	SMP Group (n=22)		FN Group (n=18)		Total (n=40)	
	Number	%age	Number	%age	Number	%age
Excellent	17	77.27	10	55.56	27	67.5
Good	5	22.73	7	38.89	12	30.0
Fair	0	0	1	5.55	1	2.5
Poor	0	0	0	0	0	0

Table-2: Results according to Flynn criteria

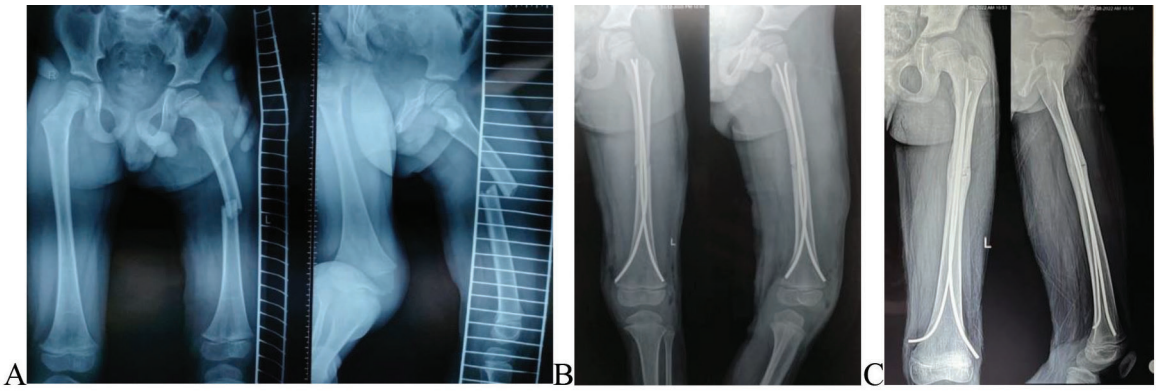

Figure-1: A 8 year old boy with transverse fracture managed with flexible intramedullary nailing: A (Pre-operative radiograph), B (Post-operative radiograph) and C (Radiograph at the follow-up of 6 months)

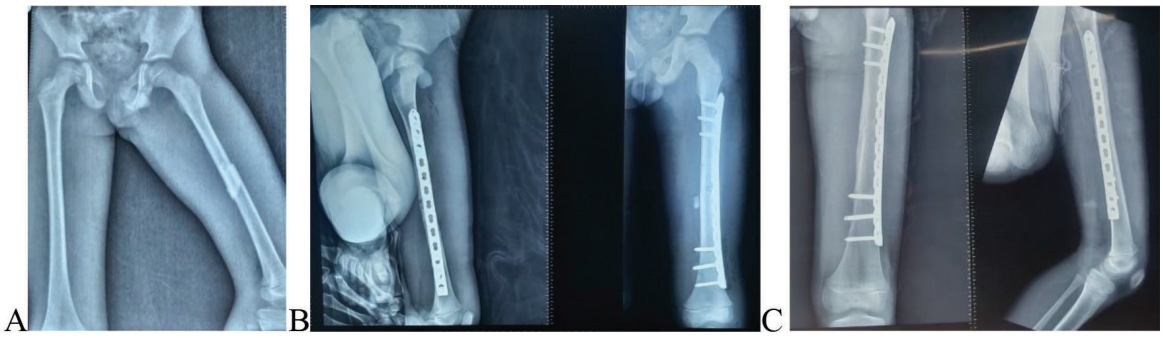

Figure-2: A 10 year old boy with transverse fracture managed with submuscular plating: A (Pre-operative radiograph), B (Post-operative radiograph) and C (Radiograph at the follow-up of 6 months)

spiral fractures. Comminuted fractures represented the largest proportion of fractures treated with SMPs, and transverse fractures represented the largest proportion of fractures treated with FNs. There was a significant association between fracture type and treatment method. However, the fracture was not directly exposed with either implant; therefore, we felt that the fracture characteristics were not the primary determinants of our study variables. Mechanisms of injury included 20 recreational injuries, 12 motor vehicle accidents and 8 other injuries. In all, 35 patients experienced isolated injuries and 5 experienced polytrauma.

Treatment with FNs significantly predicted lower EBL during insertion, shorter operative time during insertion and shorter operative time during removal. Treatment with FNs also predicted a shorter LOS after implant insertion as compared to SMPs.

No intraoperative or perioperative complications occurred in either group. Radiographic assessments, at a mean of 5.34 months after insertion, showed evidence of healed or healing fracture and anatomic alignment or near anatomic alignment in all cases. Prophylactic implant removal was recommended to all 40 patients to prevent stress risers, but the decision to undergo removal depended on patients' and their families' preferences. In all, 14 patients in the SMP group and 10 in the FN group chose to undergo removal. Of these patients, two in the SMP group and seven in the FN group waited until experiencing soft-tissue irritation before agreeing to removal. In the SMP group, irritation was caused by the size of the plate and by the plate serving as a stress riser. In the FN group, irritation was caused by nail prominence at the entry points or distal ends. Irritation resolved after implant removal in all cases. Mean indwelling time was 276 days and surgical site infection developed in two patients in the SMP group and one patient in the FN group. No evidence of avascular necrosis, heterotopic ossification, leg-length discrepancy > 2 cm, malunion or nonunion was identified.

DISCUSSION

The purpose of this study was to evaluate operative parameters, postoperative outcomes, and the length of hospital stay of SMPs in comparison with FNs techniques. The data from our study showed shorter operative time, lower blood loss during operation, and lower hospital stay with FN technique and similar results for postoperative outcome. For length-stable fracture patterns, FNs are widely accepted to have high rates of union, short time before ambulation, limited surgical dissection, and shorter hospitalization as compared with other operative techniques.[12] Nevertheless, the use of FN for length-unstable fracture patterns is still controversial. In addition, FNs are limited by higher reported complication rates, LLD, and malunion, especially for patients heavier than 49 kg.[13,14] Plating techniques are an important alternative to FN, indicated in length-unstable fracture patterns or patients weighing >49 kg. The submuscular plate technique has gained popularity for limited exposure.[15,16] Operation time and blood loss were obviously lower for FN than plates, which is consistent with the literature. No difference in any other clinical or radiological parameters between the two

groups was identified. Reported ranges of 54 min for FN[17] and 114 minutes for open plating[18] have been documented. Our results were 61.2 mins for FNs and 88.3 min for plates in comminuted pattern, in consistent with the literature. FNs performed better in regard to blood loss. The blood loss for FNs averaged 92 mL as compared with plating at 187 mL in the current study. In some cases, open reduction was not necessary and this minimized blood loss dramatically.

Saikia et al.[19] have examined twenty-two children. The evaluation of results was performed with the help of Flynn's criteria. Fracture union, which was observed radiologically, was attained at the mean of 8.7 weeks. Our study findings are consistent with the above-reported studies. The capacity to bear complete weight was achieved at a mean time of 8.8 weeks. The mean days for hospitalization period were 9.8. The results were categorized as excellent, successful, and poor in 13(59%), 06(27.2%), and 3(13.6%) children, respectively. All of these children were back at school soon enough. The study concludes that an efficient treatment method through titanium elastic nailing (TEN) for intramedullary fixation incautiously chosen children from 6 to 16 years of age.[20] In the current study, 02 (3.9%) children in the nailing group had delayed union. Moreover, Bekir Yavuz et al.[21] reported all of the TEN group's fractures united without the need for a second procedure, before three months with no delayed or nonunions in the study. Eidelman et al.[22] m analyzed the results of 11 children having a union on radiographs that were visible after 6 to 10 weeks, and the solid union was observed after 12 weeks in all the children. Hardware-related complications were not observed in any case. Easy removal of plates in 5 children was conducted having no fracture afterwards. The author has concluded that the submuscular locking plate in the shaft of femur fractures managed with already contoured plates in adolescents was found to be a more beneficial and safe technique. Our study results are similar to Eidelman et al.[22] Sink et al.[23] studied 27 children gone through submuscular locking plate to children with the shaft of femur fractures, which were not stable, having some contraindications to fixation with titanium elastic nailing despite the fact that both options are indicated procedure. Reduction and implant failure were not observed in any case. Initial bone formation was observed by 6-8 weeks and firm bony-union up to 12 weeks in all children. The submuscular locking plate is quite an adequate surgical stability procedure of comminuted and unstable shaft of femoral fractures in children.[6] These findings regarding callus formation are in favour of the submuscular plating.

CONCLUSION

Treatment with FNs was associated with significantly shorter operative time, less blood loss and shorter postoperative hospitals stays compared with treatment with SMPs in skeletally immature patients with diaphyseal femur fractures. however with SMPs being less invasive, no need for splint cast posoperatively,low infection, a better outcome with early range of motion,quick callus formation and low rate of implant failure.

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