Original Research Article

Prospective Study of Submuscular Plating For Diaphyseal Long Bone Fractures in Paediatric Age

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Abstract

Aim: To evaluate long term results of submuscular plating in closed paediatric femur fractures.

Methods: This prospective study was carried out in the department of Orthopaedics at Shri Krishna Medical College and Hospital Muzaffarpur, Bihar, India from july 2019 to jan 2020. Total 70 cases with closed femoral shaft fractures with age between 8 years to 16 years were included in the study.

Results: Total 70 patients with 40 boys and 30 girls were included in the study. The average age of the patients was 13 years (range=8-16 years). 42 patients were with right femur fracture and 28 with left femur fracture. All the patients had unilateral femur fracture. 46 patients were having isolated femur fracture and 24 were cases of polytrauma. 61 out of 70 patients regularly followed up during the full duration of the study. The average follow up duration was 20-24 months. 26 fractures were comminuted, 19 were spiral, 15 were oblique and 10 were transverse.

Conclusion: Submuscular plating is a surgical method with a learning curve and is a very effective method of fixation for paediatric femur fractures. It has definitive advantages over other surgical methods and is associated with minimal complications.

Keywords: fracture, femur, submuscular plating.

Introduction

Femoral shaft fractures constitute only 1.6% of all paediatric fractures but at the same time they are the most common fractures which require hospitalization in children.[1]Etiology varies from child abuse and trivial trauma in smaller children to high energy trauma in adolescents.[2-5]

Children younger than 6 years of age can be managed conservatively by traction and spica cast application.[6] Increased cost of hospitalization, probability of malalignment and prolonged immobilization due to conservative method has led to shift towards operative intervention in older children.

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Different modalities described are intramedullary nailing by flexible or rigid nails, external fixation, traditional open reduction and plate fixation and sub muscular bridge plating. Goals of any operative treatment modality are to preserve femoral blood supply, avoid damage to the physis and achieve adequate fracture stability. External fixation may lead to refracture, malunion, delayed union, pin tract infections and unsightly scars.[7-10] Rigid intramedullary nails with piriformis fossa as the entry site raise possibility of damaging the vascular supply to the femoral head, resulting in avascular necrosis. Utilizing nails with greater trochanter entry points also does not completely obviate this problem. Fractures in proximal 1/3rd and distal 1/3rd may not gain adequate stability with intramedullary nails due to smaller length of nail-bone contact.[11-14] Traditional open reduction and application of compression plate requires long incisions and more soft tissue dissection. Therefore it has a higher risk of infection and delayed healing with a reported reoperation rate of 10%. [15]

However, controversy continues to exit in literature about the ideal treatment method above 6 years till skeletal maturity though. In the last decade surgical

stabilization is preferred over conservative management for paediatric femoral shaft fractures.[16,17] Many fixation methods are used for paediatric femoral fractures depending on age, fracture pattern, weight and surgeon preference. Various studies have proven submuscular plating as an excellent method for femoral shaft fractures with distinct advantages of this method over other surgical methods.[18]Submuscular plating can be effectively used for proximal and distal femur fractures where other surgical methods are not feasible. In this study we have evaluated the results of submuscular plating in diaphyseal long bone femur fractures.

Material and methods

This prospective study was carried out in the department of Orthopaedics at Shri Krishna Medical College and Hospital Muzaffarpur, Bihar, India from July 2019 to Jan 2020, after taking the approval of the protocol review committee and institutional ethics committee. After taking informed consent detailed history was taken from the patient or the relatives if the patient was not in good condition. Total 70 cases with closed femoral shaft fractures with age between 8 years to 16 years were included in the study. Patients with open, associated neurovascular injuries, age below 7 years and above 16 years were excluded from the study.

Complete information about patient demography, fracture characteristics, intraoperative and postoperative findings, radiological findings, Intraoperative or post complication, infection, hardware related problems, fracture union, implant breakage, refracture in the follow up and limb length discrepancy was maintained. All the cases were done on fracture tables using in line traction under fluoroscopic guidance. Preoperative anteroposterior and lateral view x ray of femur were taken to see the type of fracture. In the post-operative period patients were regularly followed up in the OPD and sequential X rays were taken on the first postoperative day and 4 weeks, 8 weeks, 12 weeks and around 10-12 months. After that patients were called yearly for the follow up. Post operatively toe touch weight bearing was allowed from one month and full weight bearing was allowed as per status of fracture union on radiological assessment. Implant removal was done between 7 to 27 months depending on the patient's request.

Statistical Analysis

The recorded data was compiled and entered in a spreadsheet computer program (Microsoft Excel 2010) and then exported to the data editor page of SPSS version 19 (SPSS Inc., Chicago, Illinois, USA). Descriptive statistics included computation of percentages.

Results

Table 1: Patient morphology and fracture data

Parameters	Values
Average duration of hospital stays (in days)	14.5
Blood loss (in ml)	81 (range=67-190)
Fluoroscopy time (minutes) per surgery	60 (range=37-109)
Radiological findings	
Average time of Callous formation (in weeks)	3.4 (range=2.8-4.7)
Average time of Fracture union (in weeks)	8.1 (range=6.4-16)
Number of patients with complications	
Superficial infection	8
Deep infection	1
Insignificant limb length discrepancy	6
Significant Limb length discrepancy	2
Implant breakage	5
Patients with varus/valgus of <10 degrees	6
Functionally disabling malunion	0
Delayed union	5
Non-union	0
Refracture	0

Table 2: Intra-op, post-op and long term follow up observations

Variables	**N**
Boys	40
Girls	30
Laterality	
Right	42
Left	28
Bilateral	0
Patient age (years)	13 (8-16)
Average Follow up duration (months)	20-24 months
No of patients with complete follow up	61
No of patients lost in the follow up	9
Isolated femur fractures	46
Polytrauma cases	24
Mechanism of injury	
RTA	44
Fall from height	20
Other	6
Fracture pattern	
Transverse	10
Oblique	15
Spiral	19
Comminuted	26

Discussion

Historically treatment of femoral shaft fractures in the paediatric age group varies from conservative methods like pavlik harness and hip spica for children below 6 years to various operative methods in the adolescent age group. In the last decade the trend is shifting more towards surgical intervention because of advantages like quick recovery, early mobility, and lesser time for hospitalization but controversy continues to exist in literature about best method in paediatric age group.[19]

Various surgical methods used in paediatric femoral fractures include open or submuscular plating, retrograde elastic nailing, antegrade rigid nailing or external fixation.

Antegrade rigid nailing through Trochanteric tip is considered to be very good method for femoral fractures for late adolescent age group.[20, 21] However, complications like damage to Trochanteric physis and avascular necrosis have been reported with this method, besides this method is not feasible for fractures involving proximal and distal ends of femur fractures.[22,23] Retrograde elastic nailing is another method used for fixation of femoral shaft fractures. However, the indications of this method are limited to mid shaft length stable fractures and patients with weight less than 45 kg.[24,25]

Many studies have shown higher incidence of complications like malunion and implant irritation with this method more in patients with unstable fractures and obesity .External fixation is another method used for femoral shaft fractures mostly in open fractures and polytrauma patients.[26,27]

Higher chances of refracture, scar formation and pin site infection make this method less acceptable.[28] Plate osteosynthesis remains a viable option for most of the femoral shaft fractures in paediatric age group.[29,30] Open plating allows anatomical reduction however higher incidence of complications like excessive bleeding, ugly scar, infection and non-union makes this method less popular.[31]

Submuscular bridge plating is increasingly being used for paediatric femoral fractures with advantages of preserving fracture biology, less blood loss, smaller scar and lesser chances of infection compared to open plating.[32] The advantages of plating over other surgical methods is that it can be used for both stable and unstable fractures, pathological fractures, fractures of proximal and distal end of femur and patients with narrow medullary canal and deformed femur where

intramedullary nailing is not possible.[33] A number of studies have shown excellent results with submuscular plating in paediatric femur shaft fractures with minimal complications.[34]Stuphen et al. in their comparative study between retrograde elastic nailing, rigid antegrade nailing and submuscular bridge plating showed maximum complications with elastic nailing and best results with respect to early callus formation, early mobility and least implant related complications with submuscular plating.[35]

The average time of callous formation in our study was 3.4 (range=2.8-4.7) Weeks and radiological fracture union at an average of 8.1 (range=6.4-16)weeks. 6 patients in our study had varus/valgus mal union of less than 10 degrees however they didn't have any functional disability. Samora et al. in their study observed similar findings in their study on submuscular plating.[36]

Many studies have shown the plate length to be the predictor for successful outcome as longer plates makes the construct less stressful by distribution the stress over a larger surface area.[37]

We observed implant breakage in 5 patients where an implant of proper size was not used. all the 5 cases were done in the beginning of the study but with better understanding of the principles of the technique we did not observe such complication subsequently. Abott et al. in their comparative study between open and submuscular plating showed more complications implant breakage and need of unplanned revision surgeries more in open plating than submuscular plating.[38]

One of the complications attributed to the submuscular plating is limb length discrepancy.

We observed 6 cases of limb length discrepancy, however only 2 cases had significant LLD of more than 2 cm. May et al. in their study 1% case of limb lengthening of more than 3 cm for which epiphysiodesis was done.[31] Implant removal was done between 7 to 27 months after surgery. 1n 6 cases we had to prolong incision to take out the implant because of excessive bone growth around the plate. In four patents screw breakage occurred during implant removal. No complications occurred in any of such patients in the follow up. The bone growth around the plate and difficulty in removing the plate was not related to the timing of implant removal. Pate et al. in their study also observed that bone growth around the plate and difficulty in removing the plate was independent of the time of implant removal.[39]Most of the studies on submuscular plating have shorter follow up. We believe our study is the first study on submuscular plating with long follow up till skeletal maturity which makes our observations about complications like limb lengthening, non-union and implant related complications more reliable.

Conclusion

Sub-muscular plating is a surgical method with a learning curve and is a very effective method of fixation for paediatric shaft femur fractures. It has definitive advantages over other surgical methods and is associated with minimal complications.

References

1. Hinton R.Y., Lincoln A., Crockett M.M., et al.: Fractures of the femoral shaft in children. Incidence, mechanisms, and sociodemographic risk factors. J Bone Joint Surg Am. 1999;81:500-509.
2. Loder R.T., ODonnell P.W., Feinberg J.R.: Epidemiology and mechanisms of femur fractures in children. J PediatrOrthop. 2006;26:561-566.
3. Beals R.K., Tufts E.: Fractured femur in infancy: the role of child abuse. J PediatrOrthop. 1983;3:583-586.
4. Rewers A., Hedegaard H., Lezotte D., et al.: Childhood femur fractures, associated injuries, and sociodemographic risk factors: a population-based study. Pediatrics. 2005;115:e543-e552.
5. Hedlund R., Lindgren U.: The incidence of femoral shaft fractures in children and adolescents. J PediatrOrthop. 1986;6:47-50.
6. Heyworth BE, Galano GJ, Vitale MA, Vitale MG. Management of closed femoral shaft fractures in children,ages 6 to 10: national practice patterns and emerging trends. J PediatrOrthop. 2004;24:455– 9.
7. Anglen JO, Choi L. Treatment Options in Pediatric Femoral Shaft Fractures. J Orthop Trauma. 2005;19(10):724–33.
8. Miner T, Carroll KL. Outcomes of External Fixation of Pediatric Femoral Shaft Fractures. PediatrOrthop. 2000;20(3):405–10.
9. Poolman RW, Kocher MS, Bhandari M. Pediatric femoral fractures: a systematic review of 2422 cases. J Orthop Trauma. 2006;20:648–54.
10. Skaggs DL, Leet AI, Money MD, Shaw BA, Hale JM, Tolo VT. Secondary Fractures Associated with External Fixation in Pediatric Femur Fractures. J PediatrOrthop. 1999;19(5):582–6.

11. Hosalkar HS, Pandya NK, Cho RH, Glaser DA, Moor MA, Herman MJ. Intramedullary Nailing of Pediatric Femoral Shaft Fracture. J Am AcadOrthop Surg. 2011;19(8):472–81.
12. 17. MacNeil JAM, Francis A, El-Hawary R. A Systematic Review of Rigid, Locked, Intramedullary Nail Insertion Sites and Avascular Necrosis of the Femoral Head in the Skeletally Immature. J PediatrOrthop. 2011;31(4):377–80.
13. Gordon JE, Khanna N, Luhmann SJ, Dobbs MB, Ortman MR, Schoenecker PL. Intramedullary Nailing of Femoral Fractures in Children Through the Lateral Aspect of the Greater Trochanter Using a Modified Rigid Humeral Intramedullary Nail. J Orthop Trauma. 2004;18(7):416–22.
14. Kanlic E, Cruz M. Current Concepts in Pediatric Femur Fracture Treatment. Orthop. 2007;30(12):1015–9.
15. Caird MS, Mueller KA, Puryear A, Farley FA. Compression Plating of Pediatric Femoral Shaft Fractures. J PediatrOrthop. 2003;23(4):448– 52.
16. Madhuri V., Dutt V., Gahukamble A.D., et al.: Interventions for treating femoral shaft fractures in children and adolescents. 2014.
17. Kocher M.S., Sink E.L., Blasier R.D., et al. American Academy of Orthopaedic Surgeons American Academy of Orthopaedic Surgeons clinical practice guideline on treatment of pediatricdiaphyseal femur fracture. J Bone Joint Surg Am. 2010;92:1790-1792.
18. Li Y., Hedequist D.J.: Submuscular plating of pediatric femur fracture. J Am AcadOrthop Surg. 2012;20:596-603.
19. Rakesh J., Siddhartha S., Gopinathan N.R., et al.: Current Concepts in Paediatric Femoral Shaft Fractures. Open Orthop J. 2017;11:353-68.
20. Reynolds R.A., Legakis J.E., Thomas R., et al.: Intramedullary nails for pediatricdiaphyseal femur fractures in older, heavier children: early results. J Child Orthop. 2012;6:181-88.
21. Townsend D.R., Hoffinger S.: Intramedullary nailing of femoral shaft fractures in children via the trochanter tip. ClinOrthopRelat Res. 2000;376:113-18.
22. Beaty J.H., Austin S.M., Warner W.C., et al.: Interlocking intramedullary nailing of femoral-shaft fractures in adolescents: preliminary results and complications. J PediatrOrthop. 1994;14:178-83.
23. GonzÃ¡lez-Herranz P., Burgos-Flores J., Rapariz J.M., et al.: Intramedullary nailing of the femur in children. Effects on its proximal end. J Bone Joint Surg Br. 1995;77:262-66.
24. Ligier J.N., Metaizeau J.P., Prevot J., et al.: Elastic stable intramedullary nailing of femoral shaft fractures in children. J Bone Joint Surg Br. 1988;70:74-77.
25. Saikia K., Bhuyan S., Bhattacharya T., et al.: Titanium elastic nailing in femoral diaphyseal fractures of children in 616 years of age. Indian J Orthop. 2007;41:381-85.
26. Moroz L.A., Launay F., Kocher M.S., et al.: Titanium elastic nailing of fractures of the femur in children. Predictors of complications and poor outcome. J Bone Joint Surg Br. 2006;88:1361-1366.
27. Sink E.L., Gralla J., Repine M.: Complications of pediatric femur fractures treated with titanium elastic nails: a comparison of fracture types. J PediatrOrthop. 2005;25:577-80.
28. Skaggs D.L., Leet A.I., Money M.D., et al.: Secondary fractures associated with external fixation in pediatric femur fractures. J PediatrOrthop. 1999;19:582-86.
29. Caird M.S., Mueller K.A., Puryear A., et al.: Compression plating of pediatric femoral shaft fractures. J PediatrOrthop. 2003;23:448-52.
30. Fyodorov I., Sturm P.F., Robertson W.W., et al.: Compression-plate fixation of femoral shaft fractures in children aged 8 to 12 years. J PediatrOrthop. 1999;19:578-81.
31. Collin May., Yi-Meng Yen., Adam Y.: et al. Complications of plate fixation of femoral shaft fractures in children and adolescents. J Child Orthop. 2013;7:235-43.
32. Hedequist D.J., Sink E.: Technical aspects of bridge plating for pediatric femur fractures. J Orthop Trauma. 2005;19:276-79.
33. Kanlic E.M., Anglen J.O., Smith D.G., et al.: Advantages of submuscular bridge plating for complex pediatric femur fractures. ClinOrthopRelat Res. 2004;426:244-51.
34. Hammad A.: Locking plate construct for femoral shaft fractures in skeletally immature patients. ActaOrthop Belg. 2008;74:630-35.
35. Sean A.S., Juan D.M., Andre C.M., et al. Paediatric diaphyseal femur fractures: submuscular plating compared with intramedullary nailing Orthopedics. 2016;39:353-58.
36. Walter P.S., Micheal G., Leisel W., et al.: Submuscular bridge plating for length unstable paediatric femur fractures. J PediaterOrthop. 2013;33:797-802.

37. Sink E.L., Hedequist D., Morgan S.J., et al.: Results and technique of unstable pediatric femoral fractures treated with submuscular bridge plating. J PediatrOrthop. 2006;26:177-81.
38. Mathew D.A., Randal T.L., Jeffery O.A.: Comparison of sunmuscular and open plating of pediatric femur fractures: A retrospective Study. J PediatrOrthop. 2013;33:519-23.
39. Pate O., Hedequist D., Leong N., et al.:1 Implant removal after submuscular plating for pediatric femur fractures. J PediatrOrthop. 2009; 29(7) :709-12.

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