International Journal of Research in Orthopaedics
Asaduzzaman M et al. Int J Res Orthop. 2025 Mar;11(2):355-360
http://www.ijoro.org

Original Research Article

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20250459

A study on submuscular bridge plating in paediatric femoral diaphyseal fracture

Mohammad Asaduzzaman[1]*, Quazi Shahid-Ul Alam[2], Mohammad Musa[1], Mohammad A. Rahman[3], Qaisur Rabbi[4], Syed A. Sobhan[5]

[1]Department of Orthopaedic Surgery, Sylhet MAG Osmani Medical College, Sylhet, Bangladesh
[2]Department of Pediatric Orthopedic, Sir Salimullah Medical College and Hospital, Dhaka, Bangladesh
[3]Department of Orthopaedics, National Institute of Burn and Plastic Surgery, Dhaka, Bangladesh
[4]Department of Pediatric Orthopedic Surgeon, Center for the Rehabilitation of the Paralyzed (CRP-Bangladesh), Dhaka, Bangladesh
[5]Department of Orthopaedics, Sylhet MAG Osmani Medical College, Sylhet, Bangladesh

Received: 24 January 2025
Accepted: 15 February 2025

***Correspondence:**
Dr. Mohammad Asaduzzaman,
E-mail: 786mazaman@gmail.com

ABSTRACT

Background: Pediatric femoral diaphyseal fractures represent a significant orthopedic challenge, often resulting from falls or motor vehicle accidents. Conservative treatments like traction and spica casting suit younger children, but surgery is preferred for older children to reduce hospitalization and immobility. This study aimed to assess the efficacy and safety of submuscular bridge plating (SBP) as a treatment modality for pediatric femoral diaphyseal fractures.
Methods: This prospective study was conducted at Sylhet MAG Osmani Medical College Hospital between February 2023 and February 2024, involving 40 patients aged 6–15 years. The study included closed fractures (AO 32A123) and excluded open fractures, pathological fractures, supracondylar extensions, and infections. A minimally invasive technique with dynamic compression plates was used, with follow-ups at 6 weeks and 3 months.
Results: The study cohort had an average age of 10.4 years, with a male predominance (75%). Injuries were primarily caused by falls (60%) and road traffic accidents (30%). Fracture patterns ranged from oblique (40%) to comminuted (15%), with most located in the middle third of the femoral shaft. Postoperative complications occurred in 25% of cases, including superficial wound infections (15%) and deep infections requiring intervention (10%). Callus formation was observed at an average of 7.2 weeks, with minimal limb length discrepancies (mean: 1.2 cm). Functional outcomes, assessed using the Flynn score, were excellent in 85% of cases.
Conclusions: Submuscular bridge plating demonstrates a reliable and effective solution for managing pediatric femoral diaphyseal fractures, offering excellent functional outcomes and low complication rates.

Keywords: Pediatric femoral fractures, Submuscular bridge plating, Minimally invasive surgery, Dynamic compression plates, Functional outcomes, Fracture healing

INTRODUCTION

Approximately 2% of pediatric fractures are triggered by a femur diaphyseal fracture.[1,2] The most common cause of fracture shaft femur is fall from height and motor vehicle accidents. Remarkably, a basic non-comminuted transverse fracture of the diaphysis is seen in over 50% of pediatric femur fracture cases.[3,4] The majority of fractures in children under six years old can be conservatively treated with traction and spica cast fixation. However, due to the high expense of hospitalization and extended immobility, nonoperative treatment modalities are no longer as popular with older children. Children's femur fractures have a high remodeling potential because of their open physis and thick periosteal layer. Nevertheless,

debate over the best course of treatment beyond the age of six until skeletal maturity persists in the literature. For pediatric femoral shaft fractures, surgical stabilization has been the preferred treatment for the past ten years.[5,6] The location and kind of the fracture, the patient's age and weight, the degree of shortness and angulation, and other variables all affect how the femoral shaft is fixed.[7] A variety of techniques are employed to fix pediatric femur fractures. Among the operational treatment modalities are submuscular bridging plating, external fixation, conventional open reduction and plate fixation, intramedullary nailing with flexible or rigid nails, and others. Regarding pediatric diaphyseal femur fractures, the American Academy of Orthopaedic Surgeons (AAOS) Clinical Practice Guidelines state that there is inadequate evidence to support any particular surgical treatment approach.[8] Adults frequently use rigid intramedullary devices, but when piriformis fossa or even greater trochanter entry sites are used in children, there is a significant risk of vascular damage to the femoral head, leading to avascular necrosis of the femoral head and growth disturbance of proximal femur.[9-12] Pin tract infections, refracture, delayed union, malunion, and unsightly scars can all complicated by external fixator application. Children can typically be mobilized quickly following an injury thanks to nailing, which also has a low overall risk of physeal injury. In cases of comminuted or long oblique fracture patterns, as well as distal or proximal diaphyseal fractures, using nails becomes more difficult. According to data from our center, using titanium elastic nails to stabilize long oblique length unstable fractures that were comminuted resulted in a higher rate of complications.[13] In recent years, there has been an increase in the use of plate fixation for pediatric diaphyseal femur fractures, partly due to the limitations of elastic and rigid nailing becoming more widely recognized.[14] With a longer incision and more soft tissue damage, traditional compression plating has a 10% reported reoperation rate and is associated with a higher risk of infection and delayed healing. Advances in minimally invasive plating techniques have made it possible to tunnel submuscular plates extraperiosteally beneath the thigh musculature with tiny incisions. When a "bridge plating" screw construct is used, this technique often makes use of the concept of "relative stability," which leaves the biological milieu of the fracture site largely intact and permits more abundant callous formation. Early reports on the treatment of pediatric diaphyseal femur fractures with submuscular plating have indicated that the procedure is safe and can produce positive outcomes at an early follow-up.[15]

METHODS

This was a prospective study carried out in Sylhet MAG Osmani Medical College Hospital from February 2023 to February 2024. Total 40 patients were selected through purposive sampling according to inclusion and exclusion criteria. Inclusion criteria age group between 6 to 15 years, AO 32A123, closed fracture. Exclusion criteria are open fracture, pathological fracture, fracture shaft femur with supracondylar extension, active infection of the surgical site. All of the patients were evaluated by through history, clinical examination and investigations. All the patients were undergoing submuscular plating by senior surgeon. All data were collected from pre-tested structured questionnaire. Intraoperative, post-operative follow up findings and complications were documented.

Operative procedure

4.5 mm long narrow dynamic compression plate were used. All patients were in supine position on a fracture table and image intensifier was used. Plate length was measured by placing the plate over thigh during using fluoroscopy. A long plate was used for bridging purpose. Contouring the plate at proximal and distal portion with a plate bender. Two small, lateral, longitudinal incision (2 to 3 cm) were made at proximal and distal part of the femur and iliotibial band. Vastus lateralis was elevated by using Cobb elevator. The plate was passed through distal incision and advanced proximally maintaining contact between the plate and the femur. During advancement of the plate traction was used to maintain fracture length. Contact between plate and femur maintained. C-arm used to assist fracture reduction and plate advancement. Kirschner wires are placed temporarily to secure plate position. Insertion of first screw through distal incision under direct visualization and rest of the screws were inserted percutaneously. Postoperative X-ray was taken on 2nd day. Full weight bearing was allowed after clinical and radiological evaluation. Follow up of the patient was done at 6 weeks and 3 months.

Figure 1: Pre-operative.

Data were analyzed using statistical package for the social sciences (SPSS) version 25. Descriptive statistics were utilized to summarize the demographic data, fracture characteristics, and clinical outcomes of the study. Continuous variables, such as age, time to callus formation, and limb length discrepancies, were presented as averages to highlight overall trends. Categorical variables, including fracture types, locations, and complications, were expressed as frequencies to provide a comprehensive overview of the patient population and outcomes. Functional outcomes were evaluated using the

Flynn scoring system, categorized into excellent, satisfactory, or poor, to assess the effectiveness of the treatment. Postoperative complications were systematically documented and analyzed to evaluate the safety and efficacy of submuscular bridge plating as a treatment modality.

Figure 2 (A and B): Post-operative.

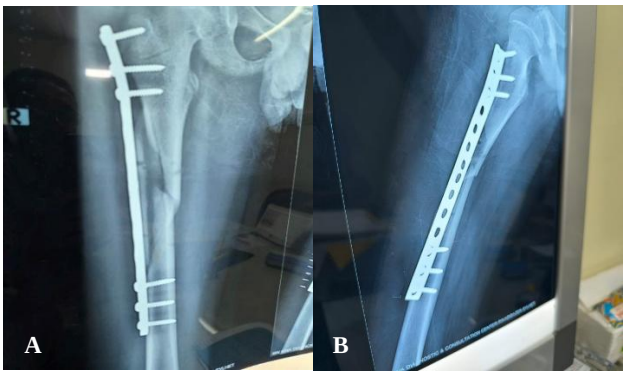

Figure 3 (A and B): 6 weeks post-operation.

Figure 4 (A and B): 3 months of operation.

RESULTS

Total 40 patients were included in the study. The average age was 10.4 years, ranged from 6 to 15 years.

Most of them were male 30 (75%) and 10 (25%) were female (Figure 5).

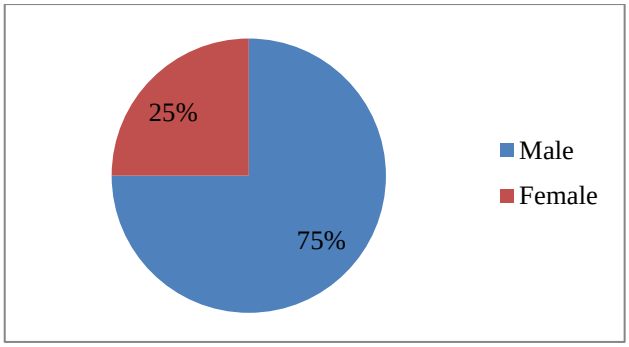

Figure 5: Sex distribution of our study participants (n=40).

Fall from height were majorities of the injury 24 (60%), following by road traffic accident 12 (30%) and history of physical assault in 4 (10%) cases (Table 1).

Table 1: Mode of injury (n=40).

Cause of Injury	Number of cases	Percentage
Fall from height	24	60
Road traffic accident	12	30
History of physical assault	4	10

Among 40 patients 16 were oblique, 10 were spiral, 8 were transverse and 6 were comminuted in nature (Table 2).

Table 2: Fracture configuration (n=40).

Fracture type	Number of cases	Percentage
Oblique	16	40
Spiral	10	25
Transverse	8	20
Comminuted	6	15

According to position of fracture majority were involved in middle 1/3 30 (75%), upper 1/3 6 (15%) and lower 1/3 4 (10%) (Figure 6).

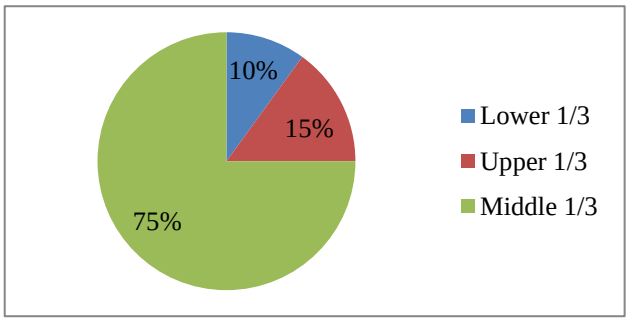

Figure 6: Position of fracture.

Postoperative wound complication occurred in 10 (25%) patients, with superficial wound infection 6 (15%) and 4

(10%) patients has deep infection requiring irrigation and debridement (Table 3).

Table 3: Postoperative complications (n=40).

Postoperative wound complications	Number of cases	Percentage
Superficial wound infection	6	15
Deep infection requiring irrigation and debridement	4	10
Total complications	10	25

The average period of callus formation in our study at 7.2 weeks and four patients have limb length discrepancy about 1.2 cm. According to Flynn score functional outcome was excellent (Table 4).

Table 4: Flynn score (n=40).

Parameter	Excellent results	Satisfactory results
Limb-length inequality	34 (85%)	6 (15%)
Malalignment		
Pain		
Complication		

DISCUSSION

Pediatric femoral shaft fractures are common injuries requiring timely and effective management to prevent complications and ensure optimal functional recovery. Despite advances in treatment techniques, the management of these fractures remains debatable, particularly in children over six years of age. The American Academy of Orthopaedic Surgeons (AAOS) Clinical Practice Guidelines suggest that there is insufficient evidence to support one specific treatment modality for pediatric femoral shaft fractures. Consequently, the choice of treatment often depends on factors such as the patient's age, fracture pattern, and surgeon preference.

In this study, the mean age of patients was 10.4 years, with a male predominance of 75%. This finding aligns with the study by Kanlic et al., where the mean age of patients treated with submuscular bridge plating was 10 years.[16] The predominance of males in pediatric fractures is likely attributable to higher activity levels and increased exposure to trauma-related incidents, such as falls and road traffic accidents. The primary mechanisms of injury in our study were falls from height (60%) and road traffic accidents (30%), consistent with similar studies highlighting these as the leading causes of pediatric fractures.

Submuscular bridge plating has gained attention in recent years as a minimally invasive surgical technique that preserves the biological environment of the fracture site while providing stable fixation. In our study, postoperative complications were observed in 25% of cases, including superficial wound infections in 15% and deep infections requiring irrigation and debridement in 10%. These findings are comparable to Sink et al, who reported a 12% complication rate with submuscular plating, including issues such as hardware prominence and malrotation.[17] Hedequist et al reported even lower complication rates, with only one patient out of 32 experiencing valgus deformity following submuscular locked bridge plating.[14] This highlights the relative safety of this technique, though the variability in complication rates across studies may reflect differences in surgical expertise, patient selection, or follow-up protocols.

The average time for callus formation in our study was 7.2 weeks, with radiological union observed by 8–10 weeks in most cases. Limb length discrepancies were minimal, with only four patients experiencing discrepancies of approximately 1.3 cm. These results align with the findings of Caglar et al, who compared minimally invasive plating with titanium elastic nails (TENS) in pediatric femoral fractures.[18] Their study found no significant differences in healing times between the two groups, with 33.3% of fractures achieving union by 6 weeks and an average radiological healing time of 8.5 weeks. However, TENS has limitations in addressing long oblique, comminuted, or proximal/distal fractures, making submuscular plating a more versatile option in such cases.

Functional outcomes in our study, assessed using the Flynn scoring system, were excellent in 85% of cases and satisfactory in 15%. These results underscore the reliability of submuscular bridge plating in providing stable fixation, promoting fracture healing, and minimizing complications. Submuscular plating has the advantage of maintaining fracture biology by avoiding extensive periosteal disruption, which is crucial for robust callus formation.[19] Furthermore, the minimally invasive nature of the technique reduces soft tissue damage and the risk of infection compared to traditional open reduction and internal fixation.

Traditional plating techniques, though effective in achieving fracture stability, are associated with higher rates of soft tissue complications, infection, and delayed healing due to larger surgical incisions and more extensive periosteal stripping.[20] In contrast, submuscular plating involves tunneling the plate beneath the vastus lateralis, preserving soft tissue integrity. This technique also employs the concept of relative stability through "bridge plating," allowing for micromotion at the fracture site and enhancing callus formation.[21,22]

A notable limitation of submuscular plating, as reported in the literature, is the potential for hardware-related complications, such as prominence or irritation. However, with proper preoperative planning and plate contouring, these risks can be minimized. The findings of our study,

along with previous research by Hedequist et al, Kanlic et al, and Caglar et al, support the use of submuscular bridge plating as a safe and effective option for managing pediatric femoral shaft fractures.[14,16,18]

Limitations

While the results of our study are encouraging, certain limitations should be acknowledged. The sample size was relatively small, and the follow-up period was limited to 3 months. Longer follow-up studies with larger cohorts are needed to assess long-term outcomes, including growth disturbances and functional impairments. Additionally, comparative studies evaluating submuscular plating against other techniques, such as TENS or external fixation, would provide further insight into the relative advantages and disadvantages of each method.

CONCLUSION

In conclusion, submuscular bridge plating offers a reliable solution for pediatric femoral diaphyseal fractures, demonstrating excellent functional outcomes and a low complication rate. Its minimally invasive nature, coupled with the preservation of fracture biology, makes it a preferred option for managing fractures in children aged 6–15 years. Future studies should aim to standardize protocols and explore the long-term benefits of this technique to further establish its role in pediatric orthopedic trauma care.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Sahlin Y. Occurrence of fractures in a defined population: a 1-year study. Injury. 1990;21(3):158-60.
2. McCartney D, Hinton A, Heinrich SD. Operative stabilization of pediatric femur fractures. Orthop Clin North Am. 1994;25(4):635-50.
3. Galano GJ, Vitale MA, Kessler MW, Hyman JE, Vitale MG. The most frequent traumatic orthopaedic injuries from a national pediatric inpatient population. J Pediatr Orthop. 2005;25(1):39-44.
4. Baldwin K, Pandya NK, Wolfgruber H, Drummond DS, Hosalkar HS. Femur fractures in the pediatric population: abuse or accidental trauma? Clin Orthop Relat Res. 2011;469(3):798-804.
5. Madhuri V, Dutt V, Gahukamble AD, Tharyan P. Interventions for treating femoral shaft fractures in children and adolescents. Evidence-Based Child Health: Cochrane Rev J. 2014;9(4):753-826.
6. Kocher MS, Sink EL, Blasier RD, Luhmann SJ, Mehlman CT, Scher DM, et al. Treatment of Pediatric Diaphyseal Femur Fracture. J Bone Joint Surg Am. 2010;92:1790-2.
7. Jones CB, Walker JB. Diagnosis and management of ipsilateral femoral neck and shaft fractures. J Am Acad Orthop Surg. 2018;26(21):e448-54.
8. Kocher MS, Sink EL, Blasier DR, Luhmann SJ, Mehlman CT, Scher DM, et al. Treatment of pediatric diaphyseal femur fractures. J Am Acad Orthop Surg. 2009;17(11):718-25.
9. Heyworth BE, Suppan CA, Kramer DE, Yen YM. Management of pediatric diaphyseal femur fractures. Curr Rev Musculoskelet Med. 2012;5:120-5.
10. Hosalkar HS, Pandya NK, Cho RH, Glaser DA, Moor MA, Herman MJ. Intramedullary nailing of pediatric femoral shaft fracture. J Am Acad Orthop Surg. 2011;19(8):472-81.
11. O'Malley DE, Mazur JM, Cummings RJ. Femoral head avascular necrosis associated with intramedullary nailing in an adolescent. J Pediatr Orthop. 1995;15(1):21-3.
12. Gonzalez-Herranz P, Burgos-Flores J, Rapariz JM, Lopez-Mondejar JA, Ocete JG, Amaya S. Intramedullary nailing of the femur in children. Effects on its proximal end. J Bone Joint Surg Br. 1995;77(2):262-6.
13. Sink EL, Gralla J, Repine M. Complications of pediatric femur fractures treated with titanium elastic nails: a comparison of fracture types. J Pediatr Orthop. 2005;25(5):577-80.
14. Hedequist D, Bishop J, Hresko T. Locking plate fixation for pediatric femur fractures. J Pediatr Orthop. 2008;28(1):6-9.
15. Sink EL, Faro F, Polousky J, Flynn K, Gralla J. Decreased complications of pediatric femur fractures with a change in management. J Pediatr Orthop. 2010;30(7):633-7.
16. Kanlic EM, Anglen JO, Smith DG, Morgan SJ, Pesántez RF. Advantages of submuscular bridge plating for complex pediatric femur fractures. Clin Orthop Relat Res. 2004;426:244-51.
17. Sink EL. Submuscular bridge plating for pediatric femur fractures. Oper Tech Orthop. 2005;15(4):350-4.
18. Caglar O, Aksoy MC, Yazc M, Surat A. Comparison of compression plate and flexible intramedullary nail fixation in pediatric femoral shaft fractures. J Pediatr Orthop. 2006;15(3):210-4.
19. Abdelgawad AA, Sieg RN, Laughlin MD, Shunia J, Kanlic EM. Submuscular bridge plating for complex pediatric femur fractures is reliable. Clin Orthop Relat Res. 2013;471:2797-807.
20. Abbott MD, Loder RT, Anglen JO. Comparison of submuscular and open plating of pediatric femur fractures: a retrospective review. J Pediatr Orthop. 2013;33(5):519-23.
21. Sutphen SA, Mendoza JD, Mundy AC, Yang JG, Beebe AC, Samora III WP, et al. Pediatric diaphyseal femur fractures: submuscular plating compared with intramedullary nailing. Orthopedics. 2016;39(6):353-8.

22. Pawar G, Darawade N, Gaikwad YR. Sub muscular bridge plating for pediatric femur fractures—review of 12 patients. Indian J Orthop. 2018;4(3):240-4.

Cite this article as: Asaduzzaman M, Alam QS, Musa M, Rahman MA, Rabbi Q, Sobhan SA. A study on submuscular bridge plating in paediatric femoral diaphyseal fracture. Int J Res Orthop 2025;11:355-60.