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Original Research Article

Outcome of Submuscular Plating for Diaphyseal Long Bone Fractures: An Observational Study

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Abstract

Aim: The aim of the present study was to evaluate the functional and radiological outcomes of paediatric femur diaphyseal fracture treated with locking compression plate.

Material & Methods: Clinical, radiographic, and functional effects of submuscular plating were assessed in 70 patients operated on for fracture shaft humerus, femur, and tibia within 2 years. One surgical team performed all procedures at Department of Orthopedics.

Results: The research group included 49 men and 21 women. Males predominated. The youngest patient was six and the oldest was 14. The mean age was 11.49 (2.08). Right side fractures 40 (57.14%) outnumbered left side fractures 30 (42.86%). 25 (35.71%) fractures were transverse, 18 (25.72%) comminuted, 21 (30%) oblique, and 6 (8.57%) spiral. Injury modes included road traffic accidents (60%), sports falls (15.71%), and height falls (8.57%). After evaluating functional results, 64 (91.42%) were outstanding, 5 (7.14%) were adequate, and 1 (1.42%) were bad.

Conclusion: When properly designed and implemented, submuscular plating for diaphyseal long bone fractures is a viable therapy. It is minimally invasive and permits early mobility with good radiological and functional results and few problems.

Keywords: Fracture, Shaft, Plate, Plating, Submuscular.

Introduction

Fractures of the distal femur make up 4-6% of all femoral fractures and supposedly make up less than 1% of all fractures. [1-3] Supracondylar femoral fractures are prevalent in two age groups: those who are young and have been in high-energy accidents (such as those involving motor vehicles, motorbikes, or sports injuries), and those who are older and, often, osteoporotic, and have had a low-energy fall. As a third prevalent group, Jahangir also noted an upsurge in periprosthetic femur fractures in patients who had undergone complete knee or hip arthroplasty in the past. [4] Improving results requires knowledge of distal femoral fracture features, therapeutic concepts and difficulties. [5] Conservative therapy with a U-shaped cast, velpau sling, thoracobrachial cast, or brachial orthosis may cure most of these fractures. On the other hand, complications such malunion, delayed union, nonunion, and limited elbow and shoulder mobility might develop in stages. [6-8] The surgical procedure may include plating or closed reduction and internal fixation with nailing, depending on the patient's preference. [7,9] While open reduction and internal fixation can help with anatomical reduction, they are more invasive and take more time during surgery. [10,11] They also increase the risk of nonunion, infection, and wound healing complications due to their large incisions, blood loss, and periosteal stripping. [12] Shaft fractures of the humerus account for 20% of all humerus fractures and have an incidence of 3-5% in adults. [13,14] There has been an uptick in the prevalence of diaphyseal femur fractures in children and adolescents as a result of traffic accidents. [15] It seems to manifest more often in men. [16] Young children, those under the age of five, show great promise as remodelers. As a result, traction and hip spica are appropriate conservative treatments for fractures in this age range. [17] In order to avoid problems such as a difference in

limb length, non-union, misalignment, and development abnormalities, surgical care is necessary for children older than five years who have displaced femur shaft fractures. [18,19]

The use of submuscular plating to treat diaphyseal long bone fractures in adults was first documented in the late 90s. [20] As the method became more widely used by orthopaedic surgeons, the same ideas were extended to treat pediatric fractures as well. The benefits include a safe and dependable healing process, early range of motion (ROM), and little invasiveness while conserving soft tissues. This research set intended to assess the radiographic and functional results of locking compression plate treatment for femur diaphyseal fractures in children.

Material & Methods

The clinical, radiological and functional results of Submuscular plating were evaluated in 70 patients operated in between the duration of 2 years for fracture shaft humerus, shaft of femur and shaft of tibia. All the surgeries were carried out by a single surgical team at Department of Orthopedics, Shree Narayan Medical Institute and Hospital, Saharsa, Bihar, India

Inclusion Criteria

1. Fracture shaft of humerus, shaft of femur, shaft of tibia;
2. Fractures without any neurological deficit;
3. Patients with minimum 2 year follow up.

Exclusion Criteria

1. Compound fractures
2. Fractures with non union or delayed union
3. Pathological fractures; Neurovascular insufficiency.

Operative technique for humerus

The surgery was carried out in a beach chair position with the arm abducted about 40^0 – 60^0 and supine under general anaesthesia. Indirect fracture reduction was achieved manually. With the help of C arm length of the plate, proximal and distal screw placement and skin incision was determined by keeping plate on the skin anteriorly 4-5 cm incision was made distally along lateral border of biceps approximately 5 cm proximal to flexion crease.

After this an interval was made between the biceps tendon and brachioradialis muscle to expose brachailis. By blunt dissection an interval was made in the fibers of brachialis till the anterior surface of humerus was seen. Then 4-5 cm incision was made proximally and an interval was made between lateal border of proximal biceps and medial border of deltoid. An epiperiosteal tunnel connecting the two incisions was made using a plate itself. From distal to proximal incision longest possible predermined 4.5mm narrow DCP or LCDCP was slide in the tunnel. Contouring of the plate was not essential as the implant was used to provide indirect relative stable fixation and minimal cortical contact preserving periosteal blood supply. [21] Under C arm control traction was applied to restore length and any angular or rotational deformity was corrected manually. Where reduction was difficult best possible reduction was accepted. After ensuring that plate is positioned centrally on anterior surface and reduction is satisfactory it was fixed with 2 screws on each side in most proximal and most distal holes of the plate. While putting screw reduction was held by assistant and repeatedly checked under C arm. The wound was closed in layers and sterile dressing applied. The operative time was recorded from incision to closure of wound. The arm was immobilized in a cuff and collar sling Post operatively adequate antibiotic cover was given. Active shoulder and elbow exercises within pain limits were started on 2nd post op day. Patients were discharged on 5th post op day. Patients were followed up periodically till radiological bony union occurred and half yearly thereafter. Radiological assessment was done on standard anteroposterior and lateral view. At every follow up, each patient was evaluated clinically, radiographically and functionally for the signs of union, nonunion, malunion, infection.

Operative Technique for Femur

While adhering to all aseptic protocols, the patient was positioned supine on the operating table and scrubbed, painted, and draped. Depending on fracture location, proximal incision (4-6 cm long) was generally done at the level of the vastus ridge on the greater trochanter. The plane between the muscle mass and the periosteum over the lateral cortex of the femur was developed distally using a long Cobb's elevator after the necessary dissection. LC-DCP plates, which are narrow and dynamic compression plates, were used. From the proximal to the distal end, the plate was moved in this plane while remaining epiperiosteal. Position of plate was temporarily anchored using a 1.5mm K-wire through the plate hole at one end, employing intraoperative imaging. The location of the opposite end of the plate was identified under fluoroscopy and incision was performed at that level. Distal incisions were created initially when fracture was in distal half of bone and plate was slide from distal to proximal in same epiperiosteal way. By manipulating and applying longitudinal traction, the fracture was lessened. Whenever needed, folded sterile sheets were utilized as an adjunct for reduction. If reduction was satisfactory reduction location of plate was modified to keep plate in excellent contact with bone and 2nd K-wire was placed through a hole at the other end of the

plate for temporary attachment. The two pieces were stabilized with three cortical screws after further assessment and any required adjustments. In rare situations soft tissue interposition rendered closed reduction problematic and an incision was made at fracture site to accomplish reduction using finger manipulation or a bone hook. During the time following surgery, splints were not utilized. Postoperatively patients were mobilized within 1-3 days as per their comfort, using a walker and with the advice to be partial weight bearing for 6 weeks.

Operative technique for tibia

The surgery was carried out in supine position with angle frame under spinal anaesthesia/general anaesthesia. All surgeries were carried out by single set of surgeons. Indirect reduction was achieved manually. With the help of C arm length of plate, proximal and distal screw placement and skin incision was determined by keeping plate on anterolateral aspect of proximal tibia. Anterolateral approach used for the exposure.4-5 cm Straight incision lateral to patella taken till tibial tuberosity. Deep fascia anterior to the IT band exposed, Proximal attachment of Tibialis anterior muscle released, anterior tunnel made in the submuscular plane, longest possible 4.5 mm LCDCP/DCP slide from proximal fragment to distal fragment. Reduction achieved with controlled traction under C arm guidance, An epiperiosteal tunnel connecting the two incisions was made, precontured plate was slide in the tunnel, three proximal and three distal screws are placed, the wound was closed in layers, sterile dressing done. Bed side knee, hip, ankle were started on 1 st post op day or as per patients comfort, patient was discharged on 5th post op day, patients was mobilized with walker with non-weight bearing for 6 weeks, partial weight bearing for next 6 weeks and full weight bearing after 12 weeks.

Results

Table 1: Demographic data

Gender	**N%**	**P Value**
Male	49 (70)	0.743
Female	21 (30)	
Mean (SD) age in years	11.49 (2.08)	0.068
Side affected		
Right	40 (57.14)	0.872
Left	30 (42.86)	

Among the study group, 49 were males, and 21 were females. There was a male preponderance. The youngest age among patients was six years old and the oldest age was 14 years old. The average age was 11.49 (2.08) years. Right side fractures 40 (57.14%) were more compared to left side fractures 30 (42.86%).

Table 2: Type of fracture and Mode of injury

Type of fracture	**N%**	**P Value**
Comminuted	18 (25.72)	0.848
Oblique	21 (30)	
Spiral	6 (8.57)	
Transverse	25 (35.71)	
Mode of injury		
RTA	42 (60)	0.642
Self-fall	11 (15.71)	
Fall from height	6 (8.57)	
Sports injury	11 (15.71)	
Assault	0	

For types of fractures, 25 (35.71%) fractures were transverse, 18 (25.72%) fractures were comminuted, 21 (30%) fractures were oblique, and 6 (8.57%) fractures were spiral. Considering the mode of injury, road traffic accident accounted for 60%, other injuries like fall during playing sports were seen in 15.71%, fall from height accounted for 8.57%.

Table 3: Fracture union and complications

Fracture union in weeks	**N%**	**P Value**
Less than 12 weeks	49 (70)	0.007
12 - 17 weeks	14 (20)	
More than 18 weeks	7 (10)	
Complications		
No complications	54 (77.14)	
Thigh pain	7 (10)	

Superficial Infection	3 (4.28)	0.210
Delayed union	4 (5.71)	
Knee stiffness	2 (2.85)	

In our study, the average union time in group one was 10.5 weeks. Early complications in the form of superficial infection were in 3 patients. Late complications in the form of thigh pain in 7 patients. Cases of knee stiffness were in 2 patients and delayed union were in 4 patients.

Table 4: Functional outcomes

Functional outcomes	**N%**
Excellent	64 (91.42)
Satisfactory	5 (7.14)
Poor	1 (1.42)
Total	70 (100)

The functional outcomes were evaluated and 64 (91.42%) were excellent, 5 (7.14%) were satisfactory and 1 (1.42%) were poor.

Discussion

Definitive treatment of distal femoral fractures involves preservation or restoration of distal femoral alignment to maintain the function of the extremity. [22] Additionally, early knee mobility is crucial to the therapy of distal femoral fracture. Knee stiffness and loss of range of motion (ROM) may occur with immobilization [23], and they frequently contribute to a poor prognosis. [24]

Among the study group, 49 were men, and 21 were females. A male majority was observed. The lowest age among patients was six years old and the oldest age was 14 years old. Ages ranged from 11.49 to 2.08 years on average. Right side fractures 40 (57.14%) were greater compared to left side fractures 30 (42.86%). Considering the form of injury, road traffic accident accounted for 58%, other injuries such fall whilst playing sports were found in 18%, fall from height accounted for 8%. The fracture fixation which permits the micro movements at the fracture site under physiological stress are referred as flexible fixations which assists in early union via callus development. The healing via bridging callus is quicker, effective and has higher strength as compared to main bone healing. [25] The initial bone healing without callus development is not very robust and has danger of refracture following removal of implant which occurs in the open procedure. [26] It protects blood flow, reduces periosteal stripping, soft tissue injury since the fracture site is not exposed and consequently prevents the devascularisation of bone fragments. It also protects the fracture haematoma environment while the fracture site is closed. [27-30] This method has benefit of tiny incision, needs short length, reduces blood loss, eliminates soft tissue dissection and periosteal stripping, thereby reducing issues such as non-union and infection. [28,29]

With regard to the types of fractures, 25 fractures (35.71%) were transverse, 18 fractures (25.72%) were comminuted, 21 fractures (30%) were oblique, and 6 fractures (8.57%) were spiral. When looking at the manner of injury, 60% were caused by road traffic accidents, 15.71% by other causes, such as falls while performing sports, and 8.57% by falls from great heights. The first group in our research had an average union duration of 10.5 weeks. Three individuals had early problems, namely a superficial infection. Pain in the thighs manifested as a late consequence in seven cases. A total of four patients had delayed union, and two individuals reported knee stiffness. The learning curve is longer for this one. The process requires the assistance of knowledgeable helpers. Some degree of axial or rotational misalignment is inevitable in every close reduction operation. The humerus may tolerate a little amount of residual misalignment. In cases of pathological fracture, submuscular plating is not an option. Patients requiring bone grafting or freshening of bone ends, such as those with nonunion or delayed union, are also not candidates. In their study, Sink et al. [31] discovered that angulation or fracture shortening occurred in 10 out of 15 patients (66%) in the unstable fracture group, and that 8 out of 39 patients (21%) needed unexpected procedures. Submuscular bridge plating yielded consistent outcomes regardless of patient age, weight, or fracture location. No matter how narrow a child's medullary canals are, which might be an issue for intramedullary nail fixation, the procedure can still be done. Stability may be compromised with intramedullary nails because of the shorter bone-to-nail contact. Stability is adequately provided by sub-muscular plating. There were 64 outstanding (91.42%), 5 good (7.14%), and 1 poor (1.42%) functional results.

Conclusion

Submuscular plating is one of the treatment modalities that is considered to be reliable for diaphyseal long bone fractures, provided that it is well planned and carried out appropriately. It is a procedure that is minimally invasive and allows for early mobility, with a favorable radiological and functional result, and with little consequences.

References

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. Injury. 2006 Aug 1;3 7(8):691-7.
2. Martinet O, Cordey J, Harder Y, Maier A, Bühler M, Barraud GE. The epidemiology of fractures of the distal femur. Injury. 2000 Sep 1; 31:62-94.
3. Wähnert D, Hoffmeier K, Fröber R, Hofmann GO, Mückley T. Distal femur fractures of the elderly—different treatment options in a biomechanical comparison. Injury. 2011 Jul 1;42 (7):655-9.
4. Jahangir AA, Cross WW, Schmidt AH: Current management of distal femoral fractures. Current Orthopaedic Practice 2010,21:193–19 7.
5. Marsh JL, Slongo TF, Agel J, Broderick JS, Creevey W, DeCoster TA, Prokuski L, Sirkin MS, Ziran B, Henley B, Audigé L. Fracture and dislocation classification compendium-2007: Orthopaedic Trauma Association classification, database and outcomes committee. Journal of orthopaedic trauma. 2007 Nov 1;21 (10):S1-6.
6. Sarmiento A. Functional bracing of fractures of the shaft of the humerus. Orthopedic Trauma Directions. 2008 Jan;6(01):33-7.
7. Taha MM. The outcome of conservative treatment of closed fracture shaft humerus in adult patients. Am Med J. 2011;2(1):32-9.
8. Superti MJ, Martynetz F, Falavinha RS, Fávaro RC, Villas Boas LF, Mussi Filho S, Martynetz J, Ribas B. Evaluation of patients undergoing fixation of diaphyseal humeral fractures using the minimally invasive bridge-plate technique. Revista Brasileira de Ortopedia. 2012; 47:310-7.
9. Walker M, Palumbo B, Badman B, Brooks J, Van Gelderen J, Mighell M. Humeral shaft fractures: a review. Journal of shoulder and elbow surgery. 2011 Jul 1;20(5):833-44.
10. Strohm PC, Reising K, Hammer T, Sudkamp NP, Jaeger M, Schmal H. Humerus shaft fractures-where are we today. Acta Chir Orthop Traumatol Cech. 2011 Jan 1;78(3):185-9.
11. Bhandari M, Devereaux PJ, D Mckee M, H Schemitsch E. Compression plating versus intramedullary nailing of humeral shaft fractures—a meta-analysis. Acta orthopaedica. 20 06 Jan 1;77(2):279-84.
12. Anglen JO, Choi L. Treatment Options in Pediatric Femoral Shaft Fractures. J Orthop Trauma. 2005;19(10):724–33.
13. Mahabier KC, Vogels LM, Punt BJ, Roukema GR, Patka P, Van Lieshout EM. Humeral shaft fractures: retrospective results of non-operative and operative treatment of 186 patients. Injury. 2013 Apr 1;44(4):427-30.
14. Schemitsch EH, Bhandari M. Fractures of the humeral shaft. In: rauma S, editor. Basic Science, Management and Reconstruction vol. 2. Philadelphia: Saunders; 2008. p. 1593–4.
15. Engström Z, Wolf O, Hailer YD. Epidemiology of pediatric femur fractures in children: the Swedish Fracture Register. BMC musculoskeletal disorders. 2020 Dec; 21:1-8.
16. Hedlund R, Lindgren U. The incidence of femoral shaft fractures in children and adolescents. Journal of Pediatric Orthopaedics. 1986 Jan 1;6(1):47-56.
17. Hunter JB. Femoral shaft fractures in children. Injury. 2005 Feb 1;36:A86-93.
18. Allen JD, Murr K, Albitar F, Jacobs C, Moghadamian ES, Muchow R. Titanium elastic nailing has superior value to plate fixation of midshaft femur fractures in children 5 to 11 years. Journal of Pediatric Orthopaedics. 2018 Mar 1;38(3):e111-7.
19. JH B. Beaty JH. Operative Treatment of Femoral Shaft Fractures in childrem and Asolescents. Clin Orthop Relat Res. 2005; 434:114-22.
20. Chrisovitsinos JP, Xenakis T, Papakostides KG, Skaltsoyannis N, Grestas A, Soucacos PN. Bridge plating osteosynthesis of 20 comminuted fractures of the femur. Acta Orthopaedica Scandinavica. 1997 Jan 1;68(sup275): 72-6.
21. Imarisio D, Trecci A, Sabatini L, Scagnelli R. Treatment for proximal humeral fractures with percutaneous plating: our first results. Musculoskeletal surgery. 2013 Jun; 97:85-91.
22. Gwathmey WF, Jones-Quaidoo SM, Kahler D, Hurwitz S, Cui Q. Distal femoral fractures: current concepts. JAAOS-Journal of the American Academy of Orthopaedic Surgeons. 2010 Oct 1;18(10):597-607.
23. Nasr AM, Mc Leod I, Sabboubeh A, Maffulli N. Conservative or surgical management of distal femoral fractures. A retrospective study with a minimum five year follow-up. Acta orthopaedica belgica. 2000 Dec 1;66(5):477-83.
24. Bolhofner BR, Carmen B, Clifford P: The results of open reduction and internal fixation of distal femur fractures using a biologic (indirect) reduction technique. J Orthop Trauma 19 96, 10:372–377.
25. Shetty MS, Kumar MA. Minimally invasive plate osteosynthesis for humerus diaphyseal fractures. Indian J Orthop. 2011;45(6).
26. Breedervad RS, Patka P, Maurik JCV. Refracture of the femoral shaft. Neth J Surg. 1985;37 :114.
27. Lau TW, Leung F, Chan CF, Chow SP. Wound complication of minimally invasive plate osteosynthesis in distal tibia fractures. Int Orthop. 2008;32(5):697–703.

28. Gupta RK, Rohilla RK, Sangwan K, Singh V, Walia S. Locking plate fixation in distal metaphyseal tibial fractures: series of 79 patients. Int Orthop. 2010; 34:1285–90.
29. Ronga M, Longo UG, Maffulli N. Minimally Invasive Locked Plating of Distal Tibia Fractures is Safe and Effective. Clin Orthop Relat Res. 2010;468(4):975–82.
30. Farouk O, Krettek C, Miclau T, Schandelmaier P, Guy P, Tscherne H. Minimally Invasive Plate Osteosynthesis: Does Percutaneous Plating Disrupt Femoral Blood Supply Less Than the Traditional Technique? J Orthop Trauma. 1999;13(6):401–6.
31. Hedequist DJ, Sink E. Technical aspects of bridge plating for pediatric femur fractures. Journal of orthopaedic trauma. 2005 Apr 1;19 (4):276-9.