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Original Research Article

Effectiveness of Locking Compression Plates for Treating Diaphyseal Fractures of Children's Femurs: An Observational Study

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Conflict of interest: Nil

Abstract

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

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 orthopaedics, Jawahar Lal Nehru Medical College and Hospital, Bhagalpur, Bihar, India

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

Conclusion: The submuscular plating technique for diaphyseal long bone fractures is considered a dependable treatment option when well-planned and implemented.

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

Introduction

Reportedly, fewer than one percent of all fractures are distal femoral fractures, which make up between four and six percent of all femur fractures. [1-3] Young patients in high-energy accidents (including motor vehicle and motorcycle accidents and sports trauma) and elderly patients, typically osteoporotic, suffering low-energy fall fractures, are the most likely to get supracondylar femoral fractures. Jahangir also mentioned a third prevalent demographic seeing a rise in periprosthetic fractures of the distal femur after total knee or hip arthroplasty. [4] Optimizing results requires familiarity with the features of distal femoral fractures, as well as the concepts and difficulties of care. [5]

The majority of these fractures may be effectively managed using conservative treatment methods, such as the use of U-shaped casts, Velpau slings, thoracobrachial casts, and brachial orthoses. [6-8] However, these outcomes may include nonunion, delayed union, malunion, and limited motions of the elbow and shoulder. [7-9] The surgical intervention encompasses two primary approaches: open reduction and internal fixation using plating, or closed reduction and internal fixation utilising nailing. [10,11] Open reduction and internal fixation (ORIF) is a surgical procedure that aims to accomplish anatomical alignment of fractured bones. However, it is important to note that this approach is associated with several drawbacks. These include a lengthier surgical time, the need for a larger incision, more soft tissue dissection, higher blood loss, and periosteal stripping. These factors might potentially contribute to a higher risk of nonunion, infection, and complications related to wound healing. [12]

The prevalence of humerus shaft fracture in the adult population is estimated to be between 3 to

5%, accounting for roughly 20% of all humerus fractures.[13,14] Diaphyseal fractures of the femur are often seen in the paediatric population, mostly attributable to a rise in occurrence resulting from road traffic accidents. [15] The prevalence of this condition is higher among men. [16] Children under the age of five have considerable potential for effective remodelling. Fractures occurring within this particular age range may be effectively treated by conservative management techniques, such as the use of traction and the installation of a hip spica. [17] Children of more than five years with displaced femur shaft fracture need operational care to avoid problems such limb length disparity, non-union, malalignment, and growth abnormalities. [18,19]

Sub-muscular plating for diaphyseal long bone fractures was initially documented for adult patients in the late 1990s.The number 20. As the approach started to acquire favour among Orthopaedic surgeons' similar ideas were employed for treatment of fractures in the pediatric population as well. The benefits include a minimally invasive technique that preserves soft tissue, providing a relative stability that enables early range of motion and dependable recovery. The goal of this research was to examine the functional results of paediatric femur diaphyseal fracture treated with locking compression plate.

Material & Methods

The clinical, radiological and functional results of Submuscular plating were evaluated in 70 patients operated in between the duration of 2 years (Nov 2017 to Oct 2019) 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 Orthopaedics, Jawahar Lal Nehru Medical College and Hospital, Bhagalpur, 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

Patient supine on operation table, under all aseptic precautions scrubbing, painting and draping done. Depending on fracture site, proximal incision (4-6 centimeters long) was usually made at the level of the vastus ridge on the greater trochanter. Dissection was done to identify plane between muscle mass and periosteum over lateral cortex of femur and this plane was developed distally using a long Cobb's elevator. 4.5mm narrow low contact dynamic compression plate (LC-DCP) plates were utilized. The plate was slide in this plane from proximal to distal staying epiperiosteal. Position of plate was provisionally secured with a 1.5mm K-wire through the plate hole at one end, utilizing intraoperative imaging. The position of the other

end of the plate was determined under fluoroscopy and incision was made at that level. Distal incisions were made first when fracture was in distal half of bone and plate was slide from distal to proximal in similar epiperiosteal manner. Fracture was reduced with manipulation and longitudinal traction. Folded sterile sheets were used as adjunct for reduction whenever necessary. If reduction was acceptable reduction position of plate was adjusted to maintain plate in good contact with bone and 2nd K-wire was introduced through a hole at the other end of the plate for provisional fixation. After additional evaluation and necessary adjustments were made, 3 cortical screws were inserted in either fragments. In few cases soft tissue interposition made closed reduction difficult and an incision was made at fracture site to achieve reduction with finger manipulation or a bone hook. Splints were not used in postoperative period. Postoperatively patients were mobilized within 1-3 days as per their comfort, using a walker and with the recommendation 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)	0.210
Thigh pain	7 (10)	
Superficial Infection	3 (4.28)	
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

The preservation or restoration of distal femoral alignment is crucial in ensuring the optimal function of the extremities while treating distal femoral fractures. [22] Furthermore, the prompt initiation of knee motion plays a pivotal role in the effective treatment of distal femoral fractures. Knee stiffness and a decrease in range of motion (ROM) may occur as a result of immobilisation, and these factors often lead to an unfavourable outcome. [23,24]

Within the cohort under investigation, there were 49 individuals identified as male and 21 individuals identified as female. A predominance of males was observed. The age range of the patients in the study ranged from six to 14 years old, with the youngest participant being six years old and the oldest participant being 14 years old. The mean age of the participants was 11.49 years, with a standard deviation of 2.08. The incidence of fractures on the right side (57.14%) was higher than that on the left side (42.86%). In terms of the mode of injury, it was found that road traffic accidents constituted the majority at 58%, while other types of injuries, such as falls during sports activities, were observed in 18% of cases. Additionally, falls from heights were responsible for 8% of the reported injuries. Flexible fixations, also known as fracture fixation systems that permit micro movements at the fracture site in response to physiological stress, contribute to the promotion of early union by callus development. The process of healing via bridge callus formation exhibits superior speed, efficacy, and strength in comparison to main bone healing. [25] The process of primary bone healing, which does not involve the formation of callus, is characterised by relatively low strength and carries a risk of refracture following the removal of an implant, particularly in cases where an open technique is employed. [26,27]

The preservation of blood supply is maintained, periosteal stripping is prevented, soft tissue damage is minimised as the fracture site remains closed, thereby reducing the risk of devascularization of bony fragments. Additionally, the closure of the fracture site helps to maintain the integrity of the fracture hematoma environment. The range of values is between 27 and 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]

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 form of injury, road traffic accident accounted for 60%, other injuries such fall whilst playing sports were found in 15.71%, fall from height accounted for 8.57%. The research findings revealed that the mean duration of union in group one was 10.5 weeks. Three individuals had early problems in the form of superficial infection. Seven patients experienced postoperative thigh pain as a manifestation of delayed complications. Two individuals had cases of knee stiffness, while delayed union was seen in four patients. It has a more extended learning curve. It requires competent assistance to aid in the operation. In

every close reduction operation, some axial or rotational malalignment may occur. In humerus such modest residual malalignment is tolerable. Submuscular plating cannot be done in pathological fracture. Also, nonunion and delayed union patients are contraindicated since they necessitate refreshing of bone ends and bone grafting. [30] Hedequist and Sink observed 8 of their 39 patients (21%) had unexpected procedures and found 10 of the 15 patients (66%) in the unstable fracture group had either fracture shortening or angulation. The outcomes using sub muscle bridge plating were not impacted by patient age, weight or location of fracture. It can be conducted even in younger children independent of the size of their medullary canals which might be a limiting issue for intramedullary nail fixation. With intramedullary nails, stability may be poor owing to shorter bone nail contact. The employment of sub-muscular plating consistently ensures sufficient stability. The study assessed the functional results, revealing that 91.42% of the cases were classified as outstanding, 7.14% as good, and 1.42% as bad. [31]

Conclusion

The submuscular plating technique for diaphyseal long bone fractures is considered a dependable treatment option when well-planned and implemented. The procedure is considered minimally invasive, enabling early mobilisation and resulting in good radiological and functional outcomes while minimising problems.

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