ORIGINAL RESEARCH

Study to assess the functional and radiological results of sub muscular plating treatment for patients with long bone fractures attending tertiary care hospital, South India

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ABSTRACT
The aim of the present study is to evaluate the functional and radiological outcomes of paediatric femur diaphyseal fracture treated with locking compression plate.
Material & Methods: One hundred patients who had submuscular plating for humeral, femoral, or tibial shaft fractures over the course of 2 years had their clinical, radiological, and functional outcomes assessed. A single surgical team from the Department of Orthopaedics performed all of the procedures.
Results: The research group included 70 men and 30 women. Males were more predominant. The youngest patient was six and the oldest was 14. The mean age was 10.60 (2.08). Right side fractures 55 (55%) outnumbered left side fractures 45 (45%). Road traffic accidents caused 57% of injuries, sports falls 17%, and height falls 9%. About 35% of fractures were transverse, 25% were comminuted, 31% were oblique, and 9% were spiral. The average union time in group one was 10.5 weeks in our research. Early problems included 4 individuals with superficial infections. Late complications: 10 individuals had thigh soreness. Both knee stiffness and delayed union affected 6 individuals. Functional results were 92 (92%) excellent, 6 (6%) adequate, and 2 (2%) poor.
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.
Key words: Fracture, shaft, plate, plating, submuscular

INTRODUCTION

Diaphyseal femur fractures are often seen in children, mostly owing to the rising occurrence of road traffic accidents.[1] This phenomenon is more often seen in males.[2] Children under the age of five have a high potential for remodeling. Fractures in this age range may be treated non-surgically by using traction and applying a hip spica.[3] Surgical intervention is necessary for children older than five years with a displaced fracture of the femoral shaft in order to avoid consequences such as differences in limb length, failure of the bone to heal, misalignment, and disruptions in growth.[4,5] Operative care is the preferable approach in order to facilitate early ambulation and reduce the length of hospital stay. This helps to minimize the psychological and social consequences that are often linked with lengthy non-operative treatment approaches. There are several surgical options and procedures for fixing fractures, which are chosen depending on criteria such as the patient's age, the kind of fracture, any further injuries, and socio-economic circumstances.[5] There are several methods for treating fractures, including open reduction plate fixation with locking compression plate, dynamic compression plates and bridge plating, closed reduction/open reduction with intramedullary titanium elastic nailing system (TENS), stainless steel nailing, and locked intramedullary nailing. In children with open fractures of the femur shaft, external fixators are used.[3,5] TENS and plating are the common methods used for paediatric long bone fracture fixation. Transcutaneous electrical nerve stimulation (TENS) is advised for children aged five to 11 years.[4,5] TENS has advantages over plating as it reduces intraoperative blood loss, has shorter operative time, is comparatively less painful, and needs shorter hospital stay.[4] TENS in selected paediatric femur diaphyseal fractures is reasonably effective.[6] TENS is suitable for middle one-third femur shaft fracture and simple fractures.

Majority of these fractures can be treated by conservative management using U shaped cast, velpau sling, thoracobrachial cast, brachial orthosis.[7-10] However this can lead to nonunion, delayed union, malnuion, restricted elbow and shoulder movements.[8,11] The surgical treatment includes either open reduction and internal fixation with plating or closed reduction and internal fixation with nailing.[12,13] Open reduction and internal fixation helps to achieve anatomical reduction but this technique requires longer surgical duration, large incision, more soft tissue dissection, blood loss and periosteal stripping which can lead to increased chances of nonunion, infection and wound healing problems.[14]

Incidence of humerus shaft fracture in adult population is 3 to 5% approximately and it comprises 20% of all humerus fractures.[15,16] Diaphyseal femur fractures are commonly seen in the paediatric age group as there is an increase in incidence due to road traffic accidents.[15] It is more commonly seen in males.[17] Children of less than five years have good remodelling potential. So, fractures in this age group can be managed conservatively with traction and hip spica application.[18] Children of more than five years with displaced femur shaft fracture require operative management to prevent complications like limb length discrepancy, non-union, malalignment, and growth disturbances.[19,20] The purpose of this study was to evaluate the functional and radiological outcomes of paediatric femur diaphyseal fracture treated with locking compression plate.

MATERIAL & METHODS

Hospital based multi-centric interventional study. An assessment was conducted on the clinical, radiological, and functional outcomes of Submuscular plating in a cohort of 100 patients who had surgery for fractures of the humerus shaft, femur shaft, and tibia shaft over a period of 2 years. The procedures were performed exclusively by a single surgical team from the Department of Orthopaedics.

INCLUSION CRITERIA

1. Fractures of the humerus, femur, and tibia shafts.
2. Fractures that do not cause any neurological impairment.
3. Patients who have been followed up for a minimum of six months.

EXCLUSION CRITERIA

1. Fractures that include the breaking of a bone into many pieces.
2. Fractures exhibiting nonunion or delayed union.
3. Fractures caused by disease or abnormal conditions; Inadequate blood supply to the nerves and blood vessels.

OPERATIVE TECHNIQUE FOR HUMERUS

The procedure was performed in a beach chair posture, with the arm abducted at an angle of around 400-600, and the patient lying on their back under general anesthesia. Manual manipulation was used to accomplish indirect fracture reduction. The C-arm was used to identify the length of the plate, as well as the positioning of the proximal and distal screws and the location of the skin incision. The plate was positioned anteriorly on the skin to assist with this determination. A 4-5-centimeter cut was done on the outside edge of the biceps, about 5 cm above the bending line.

Subsequently, a separation was created between the biceps tendon and brachioradialis muscle to reveal the brachialis. An gap was created with blunt dissection in the brachialis fibers until the anterior surface of the humerus became visible. A 4-5 cm incision was made at the origin, and a gap was created between the outer edge of the upper arm muscle and the inner edge of the shoulder muscle. A tunnel was created between the two incisions by employing the plate itself, positioned on top of the periosteum. A 4.5mm thin DCP or LCDCP was inserted into the tunnel, starting from the farthest point and moving towards the closest incision. The contouring of the plate was unnecessary as the implant was employed to provide indirect and somewhat stable fixation, while also minimizing contact with the cortical bone in order to preserve the blood supply from the periosteum.[21] Traction was administered under C-arm control to restore the length of the affected area, while any angular or rotational distortion was manually rectified. Acceptance was granted for the best feasible reduction in cases where reduction proved to be challenging. Once the plate was confirmed to be centrally positioned on the front surface and the reduction was deemed appropriate, it was secured with two screws on each side, using the most proximal and most distal holes of the plate. During the procedure, an assistance securely maintained the screw reduction and continuously verified its position using C-arm imaging. The incision was sutured in many layers and a sterile dressing was placed. The duration of the surgical procedure was measured from the first incision to the final closure of the wound. The arm was rendered immobile with a cuff and collar sling. After the operation, the patient received sufficient antibiotic treatment. On the second day after the operation, the patient began doing shoulder and elbow activities that were within their pain tolerance. Patients were released from the hospital on the fifth day after their surgery. Patients were monitored at regular intervals until radiographic bone fusion occurred, and then every six months afterward. A radiological evaluation was performed using typical anteroposterior and lateral views. During each subsequent examination, every patient had clinical, radiological, and functional assessments to determine the presence of union, nonunion, malunion, or infection.

OPERATIVE TECHNIQUE FOR FEMUR

The patient is lying on the operating table in a supine position, and all necessary measures have been taken to maintain a sterile environment, including washing, painting, and draping. An incision, typically about 4-6 centimeters in length, was made at the level of the vastus ridge on the greater trochanter, depending on the location of the fracture. The dissection was performed to determine the boundary between the muscle mass and periosteum on the outer surface of the femur's lateral cortex. This boundary was then extended farther down using a long Cobb's elevator. The surgical procedure included the use of 4.5mm narrow low contact dynamic compression plates (LC-DCP). The plate was moved in a proximal to distal direction along the surface of the bone, remaining close to the outer layer of the bone. The plate was temporarily anchored in position using a 1.5mm K-wire inserted through one of the plate holes, with the assistance of intraoperative imaging. The location of the other end of the plate was ascertained using fluoroscopy, and an incision was performed at that specific level. When the fracture was located in the distal half of the bone, the initial incisions were created in the distal area. The plate was then moved from the distal to the proximal end of the bone using a similar epiperiosteal technique. The fracture was realigned using manipulation and longitudinal traction. When needed, folded sterile sheets were employed as an additional aid for reduction. If the reduction was deemed satisfactory, the location of the plate was modified to ensure proper contact with the bone. Additionally, a second K-wire was inserted through a hole at the opposite end of the plate for temporary attachment. Following further assessment and required modifications, three cortical screws were put into each of the pieces. In certain instances, the presence of soft tissue interposition posed a challenge to achieving closed reduction. To overcome this, a surgical incision was created at the fracture site, allowing for reduction using finger manipulation or the use of a bone hook. There was an absence of splints throughout the postoperative phase. After the surgery, patients were encouraged to start moving within 1-3 days, according on their own comfort level. They were provided with a walker and advised to put just a portion of their body weight on the operated limb for a period of 6 weeks.

OPERATIVE TECHNIQUE FOR TIBIA

The procedure was performed with the patient lying on their back, using an angle frame, while under either spinal or general anesthesia. The procedures were performed exclusively by a single team of surgeons. Manual indirect reduction was performed. The C-arm was used to establish the length of the plate, as well as the positioning of the proximal and distal screws and the location of the skin incision. The plate was positioned on the anterolateral aspect of the proximal tibia. The anterolateral technique was used for the purpose of exposure.A straight incision of 4-5 cm is made on the side of the patella, extending to the tibial tuberosity. The deep fascia located in front of the iliotibial band is shown. The proximal connection of the Tibialis anterior muscle was detached, and an anterior tunnel was created in the sub-muscular plane. The longest available 4.5 mm LCDCP/DCP slide was used to connect the proximal segment to the distal piece. Reduction accomplished with the use of controlled traction under the supervision of a C-arm. A tunnel was created on the outside surface of the periosteum to link the two incisions. A pre-contoured plate was inserted into the tunnel, and three screws were installed at the proximal and distal ends. The wound was then closed in layers and covered with a sterile covering. Bedside mobilization of the knee, hip, and ankle was started on the first day following the operation or according to the patient's comfort. The patient was released on the fifth day after the operation. The patient was encouraged to walk with a walker without putting weight on the operated limb for six weeks, followed by partial weight bearing for the next six weeks, and finally complete weight bearing after twelve weeks.

RESULTS

Table 1: Demographic data of the study participants

Gender	N%	P Value
Male	70 (70)	0.734
Female	30 (30)	
Mean (SD) age in years	10.60 (2.08)	0.068

Side affected		
Right	55 (55)	0.812
Left	45 (45)	

Among the study group, 70 were males, and 30 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 10.60 (2.08) years. Right side fractures 55 (55%) were more compared to left side fractures 45 (45%).

Table 2: Type of fracture and Mode of injury in the study group

Type of fracture	N%	P Value
Comminuted	25 (25)	0.844
Oblique	31 (31)	
Spiral	9 (9)	
Transverse	35 (35)	
Mode of injury		
RTA	57 (57)	0.694
Self-fall	17 (17)	
Fall from height	9 (9)	
Sports injury	17 (17)	
Assault	0	

Considering the mode of injury, road traffic accident accounted for 57%, other injuries like fall during playing sports were seen in 17%, fall from height accounted for 9%. For types of fractures, 35 (35%) fractures were transverse, 25 (25%) fractures were comminuted, 31 (31%) fractures were oblique, and 9 (9%) fractures were spiral.

Table 3: Fracture union and complications among the study participants

Fracture union in weeks	N%	P Value
Less than 12 weeks	70 (70)	0.007
12-17 weeks	20 (20)	
More than 18 weeks	10 (10)	
Complications		
No complications	74 (74)	0.228
Thigh pain	10 (10)	
Superficial Infection	4 (4)	
Delayed union	6 (6)	
Knee stiffness	6 (6)	

In our study, the average union time in group one was 10.5 weeks. Early complications in the form of superficial infection were in 4 patients. Late complications in the form of thigh pain in 10 patients. Cases of knee stiffness and delayed union were in 6 patients each.

Table 4: Functional outcomes among the study participants

Functional outcomes	N%
Excellent	92 (92)
Satisfactory	6 (6)
Poor	2 (2)
Total	100 (100)

The functional outcomes were evaluated and 92 (92%) were excellent, 6 (6%) were satisfactory and 2 (2%) were poor.

DISCUSSION

Distal femoral fractures are estimated to make up fewer than 1% of all fractures and represent around 4%-6% of all femoral fractures.[22-24] Supracondylar femoral fractures are often seen in two specific groups: youthful patients who have high-energy accidents such as motor vehicle and motorcycle accidents, as well as sports-related trauma; and elderly patients, who are typically osteoporotic, and suffer low-energy fractures from falls. Jahangir also reported that periprosthetic fractures of the distal femur are more likely in patients who have previously had total knee arthroplasty or total hip arthroplasty in the distal region. This group of patients is the third most frequent population affected by these fractures.[25] Gaining knowledge about the features of distal femoral fractures, as well as the concepts and problems involved in their therapy, is crucial for maximizing positive results.[26]

Out of the study group, there were 70 men and 30 females. There was a predominance of males. The age range of the patients varied from six to 14 years old. The mean age was 10.60 (2.08) years. The incidence of right-side fractures was 55%, which was higher than the incidence of left side fractures at 45%. When looking at the kind of injury, road traffic accidents made up 58% of the cases, while other injuries such as falls while sports accounted for 18%, and falls from heights accounted for 8%. Flexible fixations refer to fracture fixation methods that permit micro movements at the fracture site under physiological stress. These fixations facilitate early union by promoting callus production. Bridging callus healing is superior than main bone healing in terms of speed, effectiveness, and strength.[27] The process of primary bone healing, without the creation of callus, is relatively weak and carries the danger of refracture following the removal of the implant, as shown in the open approach.[28] It maintains the blood flow, avoids removing the periosteum, minimizes soft tissue injury by not opening the fracture site, and so prevents the loss of blood supply to the bone fragments. Additionally, it maintains the fracture haematoma environment by sealing the fracture site.[29-32]This procedure offers the benefit of a tiny incision, a short duration, less blood loss, and eliminates the need for extensive cutting of soft tissue and stripping of the periosteum. As a result, it helps reduce problems like non-union and infection.[31,31]

When examining the kind of injury, it was found that road traffic accidents made up 57% of the cases, while other injuries such as falls during sports activities accounted for 17%, and falls from heights accounted for 9%. The distribution of fracture types was as follows: 35 (35%) fractures were transverse, 25 (25%) fractures were comminuted, 31 (31%) fractures were oblique, and 9 (9%) fractures were spiral. The mean duration of union in group one was 10.5 weeks, as seen in our research. Four individuals had early problems in the form of superficial infection. Thigh discomfort was seen as a late consequence in 10 subjects. There were 6 individuals who had knee stiffness and delayed union. It has a steeper learning curve. Experienced assistance are required to aid in the operation. During any close reduction technique, it is possible for there to be axial or rotational malalignment. Minimal residual malalignment in the humerus is considered acceptable. Pathological fractures are not amenable to submuscular plating. Additionally, patients who are nonunion and delayed union are not recommended for this procedure, as they need the refreshing of bone ends and bone grafting. Hedequist DJ et al. [33] observed that 21% of their 39 patients needed unexpected procedures. Additionally, they discovered that 66% of the 15 patients in the unstable fracture group had either fracture shortening or angulation. Patient age, weight, and location of fracture did not have an impact on the outcomes of sub muscle bridge plating. It can be done in young children, regardless of the size of their medullary canals, which might sometimes restrict the use of intramedullary nail fixation. Intramedullary nails may not provide sufficient stability owing to limited bone-nail contact. Sub-muscular plating consistently offers sufficient stability. The functional outcomes were assessed, and 92 (92%) were deemed good, 6 (6%) were considered adequate, and 2 (2%) were classified as bad.

CONCLUSION

The submuscular plating technique, when carefully planned and accurately performed, is a dependable treatment method for diaphyseal long bone fractures. This procedure is minimally invasive, enabling early deployment and resulting in good radiological and functional outcomes with minimum problems.

CONFLICT OF INTEREST: None to be declared.

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