A prospective observational study examining the radiological and functional results of locking compression plate treatment for femur diaphyseal fractures in children

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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 and Methods: Seventy patients who underwent submuscular plating for humeral, femoral, or tibial shaft fractures over the course of three years had their clinical, radiological, and functional outcomes assessed. A single surgical team from the Department of Orthopaedics, Shri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun performed all of the procedures.

Results: Of the people who participated in the study, 49 were men and 21 were women. The majority of the participants were men. From the youngest patient to the oldest, the range of ages was six to fourteen years. With a standard deviation of 2.08, the average age was 11.49 years. There were 40 fractures on the right side (57.14%) more than 30 fractures on the left (42.86%). Regarding the types of fractures, there were 25 fractures (35.71%), 18 fractures (25.72%), 21 fractures (30%), 6 fractures (8.57%) that were spiral. Falling while performing sports was reported in 15.71% of injuries, while falls from heights accounted for 8.57%. Road traffic accidents accounted for 60% of all injuries. After looking at the functional results, 64 (91.42%) were good, 5 (7.14%) were fair, and 1 (1.42%) were bad.

Conclusion: Submuscular plating is a dependable treatment option for diaphyseal long bone fractures when it is well-planned and carried out. Early mobilisation is possible with a good radiological and functional outcome with this minimally invasive method, and problems are minor.

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]. There are two main groups of people who are more likely to sustain supracondylar femoral fractures: younger patients who have been in high-energy accidents (such as those involving motor vehicles, motorcycles, or sports injuries), and elderly patients who have had low-energy fall fractures and are more likely to be osteoporotic. 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 principles and difficulties [5].

Conservative therapy using a U-shaped cast, velpau sling, thoracobrachial cast, or brachial orthosis can treat most of these fractures [6-8]. The risk of nonunion, delayed union, malunion, and limited motion in the elbows and shoulders increases in such a situation. Both open and closed reduction and internal fixation with plating or nailing are part of the surgical treatment options [7, 9]. Femur shaft fractures in children are managed with external fixators for open fractures [10, 11]. Surgical treatment options include open reduction plate fixation with locking compression plate, dynamic compression plates and bridge plating, stainless steel nailing, locked intramedullary nailing, and closed reduction/open reduction with intramedullary titanium elastic nailing system (TENS) [12,13].
Paediatric long bone fracture repair typically involves transcutaneous electrical nerve stimulation (TENS) and plating. In children aged five to eleven, transcutaneous electrical nerve stimulation (TENS) is advised. Reduced intraoperative blood loss, shorter operation time, reduced pain, and shorter hospital stay are some of the benefits of transcutaneous electrical nerve stimulation (TENS) compared to plating\[^{13,14}\]. TENS is reasonably successful in treating certain types of juvenile femur diaphyseal fractures\[^{15}\].

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The purpose of this study was to evaluate the functional and radiological outcomes of paediatric femur diaphyseal fracture treated with locking compression plate.

### Materials and Methods

Seventy patients who underwent submuscular plating for humeral, femoral, or tibial shaft fractures over the course of three years had their clinical, radiological, and functional outcomes assessed. A single surgical team from the Department of Orthopaedics, Shri Guru Ram Rai Institute of Medical and Health Sciences, Dehradun performed all of the procedures. Prior approval from the relevant institutional ethics committee was obtained for the scientific investigation.

#### 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

Under general anaesthesia, the patient was positioned supine on the operating table and scrubbed, painted, and draped. The level of the vastus ridge on the greater trochanter was the traditional location for a proximal incision, which was four to six centimetres long and determined by the fracture site. 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. The plate was temporarily fastened in place using intraoperative imaging and a 1.5 mm K-wire threaded through the plate hole on one end. Under fluoroscopy, the location of the opposite end of the plate was identified, and an incision was created at that level. When the break was at the farthest part of the bone, the first incision was made at the farthest point, and the plate was slid from farthest to nearest the bone using the same epiperiosteal technique. Through manipulation and longitudinal traction, the fracture was minimised. When needed, folded sterile sheets were utilised as an auxiliary for reduction. The reduction position of the plate was modified to provide good contact with the bone, and a second K-wire was inserted through a hole at the opposite end of the plate for provisional attachment if the reduction was deemed satisfactory. Three cortical screws were put into each piece after further evaluation and any required adjustments. In some instances, the presence of soft tissues rendered closed reduction challenging, necessitating the creation of an incision at the site of the fracture. This allowed for the use
of a bone hook or finger manipulation to accomplish reduction. During the time following surgery, splints were not utilised. Patients were encouraged to walk or use other forms of mobility aid within one to three days following surgery, according to their comfort level, and were advised to avoid full weight bearing for six weeks.

Surgical procedure for the tibia
The patient was placed in a supine position while the surgeon, using spinal or general anaesthesia, performed the procedure. A same group of surgeons performed all of the operations. Reduced indirectly through manual means. By positioning the plate on the anterolateral aspect of the proximal tibia, we were able to calculate the skin incision, proximal and distal screw placement, and C arm length. For the exposure, anterolateral approach was utilised. A straight incision is made four to five centimetres laterally to the patella and continues all the way to the tuberosity of the tibia. A large tunnel is created in the submuscular plane, the proximal attachment of the Tibialis anterior muscle is freed, and the deep fascia anterior to the IT band is revealed. LDCP/DCP slide measuring 4.5 mm from the proximal to distal fragments. Loss alleviated by use of controlled traction guided by the C-arm. The procedure involved creating an epiperiosteal tunnel that connected the two incisions, sliding a precontured plate into the tunnel, positioning three screws, one at the proximal end and three at the distal end, closing the wound in layers, and applying a sterile dressing. Starting on the first post-operative day or as the patient felt comfortable, bedside knee, hip, and ankle immobilisation was gradually increased over the following six weeks, with full weight bearing allowed after twelve weeks. The patient was discharged on the fifth post-operative day.

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. There were 40 fractures on the right side (57.14%) more than 30 fractures on the left side (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%.

Table 3: Fracture union and complications

<table>
<thead>
<tr>
<th>Fracture union in weeks</th>
<th>N%</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 12 weeks</td>
<td>49 (70)</td>
<td></td>
</tr>
<tr>
<td>12 - 17 weeks</td>
<td>14 (20)</td>
<td>0.007</td>
</tr>
<tr>
<td>More than 18 weeks</td>
<td>7 (10)</td>
<td></td>
</tr>
</tbody>
</table>

Complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>N%</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No complications</td>
<td>54 (77.14)</td>
<td></td>
</tr>
<tr>
<td>Thigh pain</td>
<td>7 (10)</td>
<td></td>
</tr>
<tr>
<td>Superficial Infection</td>
<td>3 (4.28)</td>
<td>0.210</td>
</tr>
<tr>
<td>Delayed union</td>
<td>4 (5.71)</td>
<td></td>
</tr>
<tr>
<td>Knee stiffness</td>
<td>2 (2.85)</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Functional outcomes</th>
<th>N%</th>
</tr>
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<tbody>
<tr>
<td>Excellent</td>
<td>64 (91.42)</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>5 (7.14)</td>
</tr>
<tr>
<td>Poor</td>
<td>1 (1.42)</td>
</tr>
<tr>
<td>Total</td>
<td>70 (100)</td>
</tr>
</tbody>
</table>

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

Discussion
Fractures of the distal femur make up 4-6% of all femoral fractures and supposedly make up less than 1% of all fractures [25, 27]. There are two main groups of people who are more likely to sustain supracondylar femoral fractures: younger patients who have been in high-energy accidents (such as those involving motor vehicles, motorcycles, or sports injuries), and elderly patients who have had low-energy fall fractures and are more likely to be osteoporotic. As a third prevalent group, Jahangir also noted an upsurge in sports injuries, and elderly patients who have had low-energy fall fractures and are more likely to be osteoporotic.

Of the people who participated in the study, 49 were men and 21 were women. The majority of the participants were men. From the youngest patient to the oldest, the range of ages was six to fourteen years. With a standard deviation of 2.08, the average age was 11.49 years. There were 40 fractures on the right side (57.14%) more than 30 fractures on the left (42.86%). Falling while performing sports was reported in 15.71% of injuries, while falls from heights accounted for 8.57%. Road traffic accidents accounted for...
60% of all injuries. Fixations for fractures that permit micro movements at the fracture site when subjected to physiological stress are known as flexible fixations. These fixations facilitate early union through the production of calluses. Bridge callus healing outperforms primary bone healing in terms of speed, effectiveness, and strength [30]. Without callus development, initial bone healing is weak and prone to refracture following implant removal (an issue with the open approach) [31]. Because the fracture site is not opened, it prevents the devascularization of bone fragments, protects blood supply, and avoids periosteal stripping and soft tissue damage. Additionally, by sealing off the fracture site, it maintains the fracture haematoma environment [32, 33]. Complications like infection and non-union can be avoided with this procedure because of its small incision, short length, and lack of blood loss, as well as its avoidance of soft tissue dissection and periosteal stripping [33, 34]. Regarding the types of fractures, there were 25 fractures (35.71%), 18 fractures (25.72%), 21 fractures (30%), 6 fractures (8.57%) that were spiral. The first group in our study had an average union duration of 10.5 weeks. Two individuals experienced early problems in the form of superficial infections. Thigh discomfort was reported by six patients as a late consequence. Three patients experienced delayed union and one patient experienced knee stiffness. The learning curve is longer for this one. The process requires the assistance of knowledgeable helpers. There is always the chance of axial or rotational misalignment in close reduction procedures. The humerus can tolerate a little amount of residual misalignment. Pathological fractures do not permit submuscular plating. Patients requiring bone grafting or freshening of bone ends, such as those with nonunion or delayed union, are also not candidates. In a study conducted by Hedequist DJ and Sink E et al [36]. It was observed that out of 39 patients, 8 (or 21% of the total) needed unanticipated surgical procedures. Additionally, out of 15 patients in the unstable fracture group, 10 (or 66% of the total) experienced fracture shortening or angulation. Age, weight, and fracture site had little effect on submuscular bridge plating outcomes. No matter how narrow a child's medullary canals are, which can be an issue for intramedullary nail fixation, the procedure can still be done. Due to the reduced bone nail contact, stability may be inadequate with intramedullary nails. Consistently, submuscular plating offers sufficient stability. After looking at the functional results, 64 (91.42%) were great, 5 (7.14%) were good, and 1 (1.42%) were bad.

Conclusion
Submuscular plating is a dependable treatment option for diaphyseal long bone fractures when it is well-planned and carried out. Early mobilisation is possible with a good radiological and functional outcome with this minimally invasive method, and problems are minor.

References


30. Shetty MS, Kumar MA. Minimally invasive plate osteosynthesis for humerus diaphyseal fractures. Indian J Orthop; c2011, 45(6).


