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A prospective study of functional outcome in distal femoral fractures treated with locking compression plate by bridging plating method

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Abstract
Background and Objectives: Lower limb fractures are the most common injuries due to increased frequency of road traffic accidents in the world which is the major mode of trauma. With the better understanding of fracture healing, recent advances and development of newer fixation techniques shown promising results in the treatment of complex lower limb fractures. In our study we are using a unique plate fixation technique to treat the lower limb fractures called Biological plate fixation-Bridge plating. It uses the plate as an internal fixator to fix the two main fracture fragments. Length, alignment and rotation are restored without touching the complex fracture zone. Here fracture is healed by callus formation unlike conventional plating technique.
Titanium Locking plates are the most commonly used implant worldwide as bridging plate. The modulus of elasticity for titanium is low and it is comparable to that of bone. This helps in achieving relative stability which is necessary for the fracture union in comminuted fractures. This relative stability is achieved by leaving not less than half of the screw holes empty. But in developing country like India all patients cannot afford the titanium plates. Hence, we studied the bridging plate concept using cost-effective stainless-steel Locking Compression Plate to evaluate the outcome.
Material and Methods: We have studied 60 cases of distal femur fractures. All the cases were fixed using stainless steel locking compression plate by Bridging plate method. The study period was from July 2016 to Dec 2019.
Observation and Results: In our study of the 60 patients treated, 22 (36%) patients had excellent outcome, 30(50%) had good results, 08 (14%) had fair outcome & no poor result (Graph -03)
We had 14(23%) patients with the complications includes Superficial infection in 4(6%) patients, Joint stiffness in 6(10%) patients, Varus angulation knee of 10^0 in 2(3%) patient, deep infection in1(2%), screw loosening in 1 (2%). (Table-03). we followed up all the patients for a period ranging from 22 weeks to until the fracture unites. The average time for union of fractures was 20 weeks ranging from 16-28 weeks. (Graph -02)
The average knee flexion at the final follow-up was 106 degrees.76% of patients (46 of 60) had a flexion of >= 110 degrees. In the majority of cases, the range of knee flexion was 100-110 degrees. (Table-01)
Conclusion: we conclude that the stainless-steel locking compression plate system acts as a good biological fixation. Even though Stainless-steel plate has high modulus of elasticity, it is flexible enough to be used as bridge plate to achieve callus formation and fracture union in comminuted fractures of femur with a few acceptable complications which can be prevented by proper following of the principles of bridge plating.

Keywords: locking compression plate, bridge plate, comminuted fracture, distal femur fracture titanium locking plates

Introduction
The rapid industrialization and fast pace of life have increased the frequency of road traffic accidents in the world. A road traffic accident is a major mode of trauma in lower limb fractures which tends to make the patient disabled if not properly managed.
In the early 1960s, there was an unwillingness towards operative management of these types of fractures because of increasing incidence of infection, lack of proper instruments, non-union, malunion, inadequate fixation, and implant as well as antibiotics. Then, the traditional management of these displaced fractures was along with the principle of Watson Jones (3) & John Charnley [4]. These methods have problems like deformity, shortening, prolonged bed rest, stiffness of knee joint, an incongruity of joint, malunion, muscle wasting, knee instability, and post-traumatic osteoarthritis.
Later, these difficult fractures were started to be managed by open reduction and rigid internal fixation with a compression plate. A high rate of good to excellent results has been reported [5]. However, this technique has not produced consistent outcomes and still had an unacceptable rate of complications, including infection, poor wound healing, and nonunion [6].
Bridge plating is "biological plate osteosynthesis" which uses the

plate as an extramedullary splint fixed to the two main fragments [6]. The introduction of the locking compression plate was a revolution in the evolution of management of these fractures where prolonged bed rest is avoided and return to work early. The locking compression plate (LCP) improved stability in these situations with a minimum number of screws as compared with a conventional plate, lcp have a higher degree of stability and provides better protection against primary and secondary losses of reduction and minimization of bone contact [7, 8]

The locking compression plate (LCP) has the biomechanical properties of internal and external fixations, with better holding power because of fixed angular stability through the head of locking screws, independent of friction fit [9].

Methodology

This study was conducted at Department of Orthopaedics, RD Gardi Medical College ujjain between July 2016 to Dec 2019. The cases being selected were those who had comminuted fractures of metaphysis and diaphysis of femur, were operated with stainless steel bridging plate. Minimum of 1/3rd to half of the plate holes are left empty to achieve the relative stability and minimum of 3 screws or 6 cortices were fixed in each fracture fragment.

Inclusion criteria

Patients with complete clinical records. Patients with multifragmentary fracture of metaphysis and diaphysis of femur. Closed fractures or Compound fractures with Gustilo Anderson's Grade I or Grade II type. Age: - >18yrs.Patients treated primarily with stainless steel bridge plating. Patients followed up as outpatients for at least 24 weeks. Medically and surgically fit patients for surgery.

The following protocol was followed once patient was admitted and planned for surgery. after admission, a careful history was taken from the patient and/or attenders. Then patients were clinically examine to evaluate their general condition and the local injuryand systemic examination. Fractures at other sites were ruled out.

Management of closed fractures

Local examination of the injured extremity. Palpation revealed crepitus and abnormal mobility at the fracture site. Distal neurovascular status assessed by the dorsalis pedis and posterior tibial artery pulsations, capillary filling, local temperature, pallor, and paraesthesia.

Antero-posterior and lateral radiographs of the affected leg along with the joints both proximal and distal to the fracture site were taken and the fracture patterns were classified based on the AO/OTA classification of fractures.

Management of Open Fractures:

Patients with compound fractures were graded using the Gustilo Anderson classification for open fractures. Antibiotics were started immediately for all patients. Injection ceftriaxone 1-gram intravenous twice daily along with injection Amikacin 500mg intravenous twice daily were the antibiotics and a single dose of tetanus toxoid was given.

After obtaining the necessary radiographs, Type I and Type II open fractures were treated by cleaning the wound with a copious amount of normal saline followed by painting of the skin around the wound with Povidone-iodine and surgical spirit. Type III fractures were not included in this study.

Pre-operative Planning:

All the patients were counseled regarding the modes of treatment, advantages/disadvantages, and success rates of each. Appropriate and valid written consent was taken. The patients were taken for surgery after routine investigation and after obtaining fitness towards surgery. The investigations done were Hemoglobin percentage, Random blood sugar, Blood urea, Serum Creatinine, HIV (after taking patients consent for testing the same), HBsAg, Chest Xray, ECG, Xray of Leg (full length) with the joints adjacent to fracture site both AP and Lateral views. A dose of antibiotics preferably ceftriaxone 1 gm were given preoperatively just before the incision. The preparation of the part was done just before the surgery. Instruments were checked and sterilized before used.

Surgical Technique

Surgical Approach

Lateral Approach used for distal femur fractures

Post-operative care

After surgery, the patient's leg was elevated, with the leg placed on a pillow, Intravenous antibiotic regimen was continued for 5-7 days (12-14 days in compound fractures) after the surgery along with pain control medications. Another 5 days of oral antibiotics were advised. Suture removal was done at 12th-14th post-operative day.

Mobilization

Based on associated soft tissue injury, the decision regarding continuation of external splint with plaster of paris slab was made and patients were advised static quadriceps exercises. Fractures were mobilized after 48 hrs. Patients were encouraged for flexion to achieve full range of motion of knee and ankle joint. Limited weight bearing was started after 2-4 weeks and full weight bearing allowed after 12-14weeks.

Follow up

Patients follow up after 2, 6 and 12 weeks, and every 4 weeks thereafter until radiographic healing and function are established.

During follow-up

- The course of fracture healing was documented radiologically with a minimum of 6 weeks interval.
- The moment of complete healing was defined as radiologically complete bone regeneration at fracture site by bone bridging across at least 3 cortices in AP and lateral x-ray views.
- Evaluation of any possible loss of reduction was done.
- Any complication was assessment and analysed during the follow up.
- The duration of patients followed up ranged from 22 weeks to until the fracture unites.

Observation & Results

The present study consisted of 60 cases of distal femur fractures. All the cases were fixed using stainless steel locking compression plate by Bridging plate method. The study period was from 2016

to DEC 2019.

1. Range of Motion at Knee

Table 1: ROM at Knee (Flexion in Degrees)

Range of Knee Flexion (in Degrees)	No. Of Patients	Percentage
<90	4	07
90-109	10	17
110 & more	46	76
Total	60	100

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2. Associated Orthopaedic Injuries

Table 2: Associated Injuries

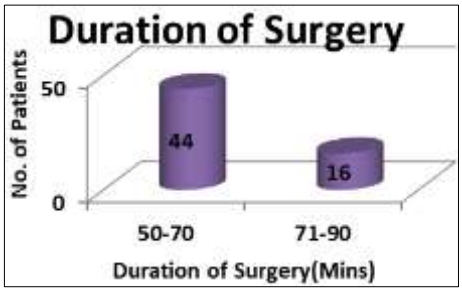
Associated Injuries	No. Of Patients	Percentage
Fracture of Tibia/Fibula	2	3
Fracture Distal End Radius	4	7
Fracture Metatarsals	2	3
Fracture Metacarpals	2	3
Fracture humerus	1	2
Total	11	18

3. Complications

Table 3: Complications

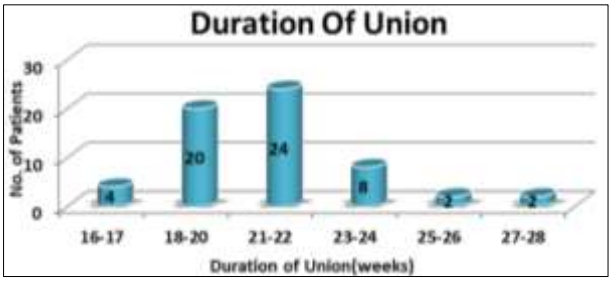
Complication	Number of Patient	Percentage (%)
Superficial Skin Infection	4	7
Joint Stiffness	6	10
Varur Angulation knee (10^0)	2	3
Deep Infection	1	2
Screw loosening	1	2

4. Duration of Surgery



Graph 1

5. Duration of Fracture Union



Graph 2

6. Results

Graph 3

Clinical Photographs

Radiographic and Clinical Slides- Cases

Discussion

Fractures around the Knee joint are among the most difficult fractures to treat effectively. The status of the soft tissues, the degree of comminution sustained at the time of injury affect the long-term clinical results. The goal of operative treatment is to obtain anatomic realignment of the joint surface while providing enough stability to allow early motion. This should be accomplished using techniques that minimize osseous and soft tissue devascularization in the hopes of reducing the complications resulting from treatment. The present study was undertaken to determine the role of the stainless-steel locking compression plates in the treatment of the comminuted metaphyseal and diaphyseal fractures of the femur using the Bridging plate technique. We evaluated our results and compared

them with various other studies. Our analysis is as follows:

1. **Age/Sex/side**: In our study of 60 patients with comminuted distal femur fractures the mean age of the patients was 41 years and there were 50 males (83%) and 10 females (17%). There were 44 (74%) patients with right-sided fractures 16 (26%) patients with left-sided fractures.

This is a reflection of the mechanism of the injury which was high energy trauma in 70% of our patients of which most of whom were younger. The reason being that, in male patients, there were more outdoor activities, so they were more prone to vehicular accidents and the majority of females being housewives were less exposed to road traffic accidents. Yeap and Deepak [10], conducted a retrospective review of 11 patients who were fixed with the Titanium Distal femur locking compression plate and reported a higher incidence in males compared to females and the mean age was 44 years. Mongkon Luechoowong [12] analyzed retrospectively medical records of 19 patients who underwent LCP plating for complex distal femoral fractures and reported a higher incidence in males than females and the mean age in the study was 41.6 years

2. **Mode of Injury:** In our study, 46 (77%) of 60 patients sustained an injury following road traffic accidents, and 12 (20%) patients sustained an injury following fall, and 2(4%) patients sustained a firearm injury. This shows a Road traffic accident is the major mode of injury.

Yeap and Deepak [10], reported a higher incidence of RTA (7 patients) than Falls (3 patients).

3. **Fracture pattern** Out of the 60 cases, 46 (77%) cases were closed fractures and 14 (23%) cases were open fractures. Classification of open fractures was based on Gustillo Anderson's classification of open fractures. 4 patients were typed I open fractures and 10 were Type II fractures. Type III fractures were not included in the study.
4. **Duration Of Surgery**: Out Of the 60 cases treated with Stainless steel locking compression plates 44 (73%) took 50-70 minutes and 16(27%) took 71-90 minutes. The average time duration was 69 minutes. Sah S *et al.* [11] Duration of surgery was average 85 (range 60-150) minutes.
5. **Tourniquet Time:** All the surgeries were done under the Electric Pneumatic tourniquet application and no surgery took more than 90 mins of tourniquet time.
6. **Time of Union:** All the fractures united with an average of 20 weeks ranging from 16 to 28 weeks. Radiological union of the fracture i.e. characterized by cortex to cortex healing and bridging callus of the fracture in both AP and lateral views of follow up x-rays was considered as a satisfactory union.

Time to union increased with an increase in the age of the patient. Time to a union in Type C fractures generally was found to be longer compared to Type A fractures. Yeap and Deepak (10), reported average time to a union to be 18 weeks with a range from 6 weeks to 36 weeks excluding one patient. Mongkon Luechoowong [12] average time to a union as 17 weeks with a range of 12 – 38 weeks.

7. **Range of Motion:** The average knee flexion at the final follow-up was 106 degrees.76% of patients (46 of 60) had a flexion of >= 110 degrees. In the majority of cases, the range of knee flexion was 100-110 degrees Yeap and Deepak (10), reported Mean extension was 1° (range 0° to 5°), with mean flexion 107.7° (range 40° to 140°). The mean range of motion was from 1° to 107.7°.
8. **Complications:** We had 14(23%) patients with the complications includes Superficial infection in 4(6%) patients, Joint stiffness in 6(10%) patients, Varus angulation knee of 100 in 2(3%) patient, deep infection in1(2%), screw loosening in 1 (2%)

In our study, we had two cases of varus malalignment for the distal femur. Which has a firearm injury that belonged to AO – A3 type. Varus malalignment occurred as a result of some factors like improper reduction, comminution, usage of inadequate locking plate length or early weight-bearing, superficial and deep infection subsided after debridement, dressing, and course of IV antibiotics., screw loosening improves by revision surgery. Joint stiffness improves by physiotherapy.

9. **The Knee Society Score And Results:** Evaluation according to the Knee Society Score showed a mean Knee society score of 78.36 with a range of 60 to 94. In our study of the 60 patients treated, 22 (36%) patients had excellent outcomes, 30(50%) had good results, 08 (14%) had fair outcome & no poor result. Kiran Kumar G.N. *et al.* [13] reviewed 46 distal femoral fractures treated with distal femoral locking compression plates, out of which 38 patients (86%) had good/excellent outcomes.

Conclusion

we conclude that the stainless-steel locking compression plate system acts as a good biological fixation. Even though Stainless-steel plate has high modulus of elasticity, it is flexible enough to be used as bridge plate to achieve callus formation and fracture union in comminuted fractures of femur with a few acceptable complications which can be prevented by proper following of the principles of bridge plating.

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