

Metaphyseal locking compression plate (MLCP) revision for aseptic non-union of the femoral shaft performed using the compression technique, corticocancellous autograft.

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Abstract

Background: Non-union of the femur shaft is a burden to the patients and society. It implies extended periods of sickness, loss of previous abilities, a modified walking style, recurring surgeries and psychological suffering. Although our care for trauma injuries, surgical techniques and implants has improved, the issue remains.

Objective: To report results of revision fixation using a metaphyseal locking compression plate (MLCP) by compression fixation with autologous corticocancellous bone grafting for the treatment of aseptic non-union of the femoral shaft.

Case Summary: A 55-year-old woman was injured in a CNG auto-rickshaw (a high velocity road traffic accident) and had a closed mid-shaft fracture of the right femur that was initially stabilised with an interlocking intramedullary (ILIM) nail. Non-union was confirmed when she came back one year later. The nail was removed at the President Abdul Hamid Medical College Hospital and the femur was revised with MLCP and autologous corticocancellous graft.

Results: The functional result after 10 months was good due to failure of the previous fixation with non-union. Both the ASAMI bone and functional grades were Excellent.

Conclusion: In this patient, the combination of MLCP revision using compression with an autologous corticocancellous graft was an effective treatment for aseptic femoral shaft non-union.

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Keywords: Non-union, Femoral shaft fracture, Metaphyseal locking compression plate, MLCP, Bone graft, Compression technique.

Introduction

Fractures of the femur are among the commonest injuries seen in orthopedic trauma. Reported incidence is about 10 to 26.7 per 100,000 people each year, and most result from high-energy mechanisms such as motor vehicle collisions, falls from height and pedestrian accidents⁴. Non-union complicates roughly 1.9% to 11.3% of these fractures⁴. It is often traced to a misreading of the fracture pattern and an unsuitable treatment plan, which makes the cause iatrogenic⁵. Long-bone non-union severely reduces quality of life and carries a large economic cost⁶.

Multiple causes are typically in effect simultaneously. Mechanical factors involve improper stability and biological factors involve comminution, poor blood supply to the fragments, poor soft tissue

cover and local infection⁷. The fracture morphology, as well as patient history, also plays a role⁸. Nowadays, stable fixation and early mobilisation can be achieved in the majority of patients with modern implants and techniques. Despite this, non-union of the femoral diaphysis is a common problem⁹ and it is difficult to treat.

There are several options available for the treatment of non-union of diaphyseal long bones including nail dynamisation, exchange nailing, augmentation plating and bone transport over an external fixator⁸. Despite its mechanical and biological advantages, exchange nailing has been reported to be successful¹⁰ with some limitations¹¹. Compression plating has been reported as a successful method¹² and is rarely mentioned for

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the treatment of non-union of the femur or tibia¹³. Plating has also been suggested to have a poor performance in the presence of infection and bone loss¹⁴. Here we report a case of non-union in the femoral diaphysis that healed following compression plating using an MLCP. We would like to highlight the result, emphasize technical aspects of the compression of the end of the bones and discuss the role of compression plating in the treatment of non-union of the femur shaft.

Bone defects may be a result of resorption in atrophic non-union or due to removal of infected (sequestrum) or tumour tissue. Their size is determined by the extent of bone affected, and can vary from a few millimetres to several inches, with either a partial or complete loss of bone around the circumference of a segment. Up to more than half around may heal by itself, but may require additional treatment. After stabilisation, segmental defects > 2 cm will not heal. Factors such as age, chronic disease and smoking can all impair the healing of a defect¹⁵.

Case report

A 55 year old female occupant of a CNG Auto-Rickshaw sustained a road traffic accident at high speed, falling from the CNG and sustaining injury to her right thigh. A radiograph revealed a closed right femur midshaft fracture. She was taken to Khidmah Janata Hospital Ltd, Haybatnagar, Kishoreganj where she was resuscitated according to ATLS protocol and on the fifth day after the accident, she was operated with ORIF on an ILIM nail. She was followed up at 3, 6 and 12 weeks and radiographs were taken demonstrating nonunion at all follow-up appointments. Then she lost to follow up for the next 3 to 10 months and went back to the senior author. The examination and investigations showed that the right femoral shaft was not united and that there was a gap of more than 2.5 cm between the fragments and that the ILIM was still present. She was admitted to PAHMCH and revision surgery was planned, which included removal of the nail, fixation with an MLCP and corticocancellous bone graft.



Figure B1: Post operative after 3 days with ILIM nail .



Figure B2: Features of non-union .



Figure B3: Post operative X-Ray after 3 weeks with MLCP .



Figure B4: X-Ray of post operative bone graft .



Figure A: Fracture shaft of right femur

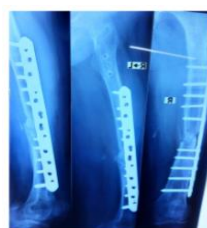


Figure C1: Sign of bridging callus .



Figure C2: Features of healing .

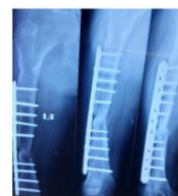


Figure C3: Features of union (consolidation phase)



Figure C4



Figure C5 :Patient after recovery (C4,C5)

Surgical procedure

Preoperative ESR and CRP were within normal limits, and it was unlikely to be an active infection. The surgery was under spinal anaesthetic. Patient was placed on his/her back, with the prepared, draped, and exposed ipsilateral iliac crest (in case of need for graft harvest). The femur was approached laterally reusing the previous skin incision as much as possible.

Debridement

The ILIM nail was removed and after exposure of the bone scarred fibrous tissue around the fracture site was removed and the fracture ends freshened. A biopsy of tissue was performed and sent for both microbiology and histology. The atrophic ends were osteotomised both proximally and distally and the medullary canal was reamed well with sequential reamers.

Plate fixation

The traditional method of treating non-union of the femur shaft was compression plating, prior to the use of reamed exchange nailing. The lateral plate is tension band, assists in correction of mal-alignment and allows the bone to support the axial compressive forces. Weber and Cech in their monograph on non-union recommended debridement, sequestrectomy, plating for mechanical rest and generous cancellous autograft. In this patient, the femoral shaft was treated with a 12 hole MLCP with 10 locking screws and 2 cortical screws. The whole procedure (nail removal, debridement and bridging ORIF with the MLCP) was done in a single stage.

Iliac crest graft

The anterior portion of the ipsilateral iliac crest was chosen as a donor site to minimize donor-site morbidity with corticocancellous graft from the anterior portion. Long pieces of the graft were placed in the defect at the non-union to optimize the healing biologic environment.

Postoperative care:

The wound was closed over a suction drain that was removed after 48 hours. The surgery was done with the use of axillary crutches and the patient was ambulating without weight bearing on the surgery leg. IV antibiotics were transitioned to oral antibiotics and she was discharged on postoperative day 6. The sutures were taken down at 2 weeks and the limb was immobilized in a plaster slab for 1 month. Review was conducted at 6 weeks, 12 weeks and monthly for 6 months (10 months in total). Only after the union was consolidated and full weight bearing and unrestricted use of the limb could be allowed. Radiographs and clinical photographs were taken at every visit and clinical details were recorded on a standard proforma.

In non-union atrophica tissue between the fragments is loose, avascular and biologically inactive. This tissue is first compressed, to stimulate an inflammatory reaction and new blood vessel formation that promotes bone formation¹⁸.

Clinical and radiological evaluation was done for healing and deformity. X-rays were taken each month from one to 10 months old. Union was considered to be present if bridging callus spanned the entire cross-section of fracture on orthogonal views and the diameter of the regenerated bone was equal to the width of the bone at the site of injury and the weight bearing did not cause pain. The ASAMI bone and functional criteria (Table I) [19,20] were used to grade outcome. There were also complication and deformity was assessed based on Paley's classification (Tables II and V).

Results:**Table I. ASAMI criteria 19,20**

Grade	Bone result
Excellent	Union, no infection, deformity < 7°, limb length discrepancy (LLD) < 2.5 cm
Good	Union plus any two of: no infection, deformity < 7°, LLD < 2.5 cm
Fair	Union plus only one of those three
Poor	Non-union, refracture, or union with infection, deformity > 7° and LLD > 2.5 cm

Grade	Functional result
Excellent	Active; no limp; minimal knee stiffness (loss < 15°); no reflex sympathetic dystrophy (RSD); insignificant pain
Good	Active, with one or two of: limp, stiffness, RSD, significant pain
Fair	Active, with three or all four of those problems
Poor	Inactive: unable to work or do daily activities because of the injury
Failure	Amputation

LLD: limb length discrepancy; RSD: reflex sympathetic dystrophy.

Table II. Paley classification of deformity

Type	Description
Type 1	Intact femur with mobile hip and knee: (a) normal ossification of the proximal femur; (b) delayed ossification
Type 1-0	Ready for surgery; no factor to correct before lengthening
Type 1-1	One factor to correct before lengthening
Type 1-2	Two factors to correct before lengthening
Type 1-3	Three factors to correct before lengthening
Type 2	Mobile pseudarthrosis with mobile knee: (a) femoral head mobile in the acetabulum; (b) femoral head absent or stiff in the acetabulum
Type 3	Diaphyseal deficiency of the femur: (a) knee motion $> 45^\circ$; (b) knee motion $< 45^\circ$

Factors needing correction before lengthening: neck-shaft angle $< 90^\circ$, delayed ossification of the proximal femur, CE angle $< 20^\circ$, subluxing patella and/or dislocating knee.

Results

A follow-up examination and imaging confirmed bony union and the plate was left in place once the regenerate healed and consolidated. Physiotherapy programme was given to the patient for knee and hip movements. At that time, knee range of motion was $0-100^\circ$ with a normal hip range of motion, and at last follow-up knee flexion was 135° without loss of extension. Three times CRP and ESR were measured in the week following surgery and remained in normal range and no increase was

noted. Intraoperative cultures were obtained to evaluate for deep infection, and were negative.

Radiological evidence of callus bridging was seen approximately 6 weeks after surgery and completed bone remodeling with full consolidation and range of motion was seen at the end of 10 months (Table III). There was still mild stiffness of the right knee. Patient is now able to ambulate without walking aid or crutches. She was able to move her knee and hip freely at 12 months post-surgery and walked without any problems.

Table III. Bone healing

Item	Finding
Fibrous tissue present	6 months
Consolidation time	8 months
Union time	10 months

Consolidation index	30 days/cm
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Table IV. Bone defect status

Item	Finding
Femoral defect at presentation	> 2.5 cm gap at the non-union site
Bone resection	Nil
Angulation after fixation	10°
Lengthening	Nil
Final shortening	0.5 cm
Follow-up	10 months

Table V. Final grading

Item	Finding
ASAMI bone	Excellent
ASAMI function	Excellent
Knee flexion	135° (full)
Knee extension loss	None
Paley type 1	Intact femur with normal knee and hip movement
Paley types 2 and 3	None
Union	Achieved, no infection, LLD 0.5 cm
Clinical status	Active, no limp, no RSD, no pain

Discussion

The first description of the use of the compression principle using plates in the treatment of femoral non-union was by Müller ¹⁵. Plate osteosynthesis has shown to be effective, but it results in increased blood loss and infection risk as compared to ex-

change nailing, and higher rate of non-union. For all these reasons we had tended to avoid the plating at all. However in this patient, non-union with implant failure had already happened and we took the decision to go for MLCP with bone graft together.

Bone graft is done in conjunction with other methods, primarily plating. The source of autograft is normally the iliac crest or reamings. The intramedullary nail technique has been associated with autograft and has consistently demonstrated its superiority to other types of grafts or bone substitutes. Cancellous bone has more surface area and more living cells per unit volume than cortical graft and thus has more potential to form new bone^{16,17}. Osteoinduction involves the recruitment of mesenchymal precursor cells that differentiate into pre-osteoblasts or chondroblasts and consequently cartilage and bone formation^{16,17}. Osteoconduction is the supply of a scaffold which allows capillaries and osteoprogenitor cells from the recipient site to grow¹⁵⁻¹⁷. Cortical graft acts as a scaffold and as a mechanical support during replacement. It also takes longer than cancellous graft to heal, obeying the same sequence and is thought to be slower due to the limited porosity and slower revascularisation. Due to non-union, fixation with autogenous cortical and cancellous graft and MLCP was done which gave a good functional result.

Femoral shaft fractures can be caused by high-energy trauma (e.g. road trauma) and low-energy trauma (e.g. elderly patient with osteoporosis). Occur at the rate of approximately 10-21 per 100,000 people annually. This patient had a closed comminuted fracture of the middle third of the right femur that occurred in a motor vehicle accident.

There are a number of options available for femoral shaft fractures and there are no clear guidelines

for what is best. The options include plate ORIF, intramedullary nailing and external fixation – depending on the surgeon's experience and knowledge, as well as available implants. Plating is an option for comminuted fractures of the shaft, and the use of minimally invasive plate osteosynthesis (MIPO) preserves blood supply and soft tissue, promoting healing. Post op X-rays here revealed an in situ graft and plate, well aligned with a small gap between the fragments.

Infection and associated complications

Infection and non-union are the main complications of femoral fractures. Infection has a higher incidence after open injuries, and may also occur after open superficial surgical site infection (SSI). Reported infection rates are: 1–3% in closed fractures, approximately 5% (Gustilo I), 10% (Gustilo II) and 15% (Gustilo III) in open fractures. The rates for femur are 4-7% in open fracture, 1-2% in closed fracture and 3.6-4.8% after surgical intervention for femur fracture. Fracture complexity and soft-tissue damage are the main risk factors. It is hard to diagnose infection after long-bone surgery, and requires careful clinical assessment and investigations. Blood count, ESR, CRP and imaging provide useful information and culture of infected tissue is definitive. The post-implant infection is classified according to the Romano classification (Table VI). Table VI. Post-implant infection can be classified into the following categories: 1. Latent infection 2. Local infection 3. Hematogenous infection.

Table VI. Romano classification of post-implant infection

	Stage 1	Stage 2	Stage 3
Time after surgery	2 to 6 weeks	2 to 9 months	> 2 months
Tissue involved	Soft tissue	Bone (not intramedullary)	Bone (intramedullary)
Implant removal	Not needed	Not needed	Needed

Stage 1 is managed by debridement and intravenous antibiotics guided by culture and sensitivity, without implant removal. Stage 2 is treated with antibiotics, with or without implant removal. In stage 3 the implant

is removed and an external fixator used. Infection slows union or may cause non-union by reducing blood flow and damaging tissue.

Table VII. Clinical signs recorded in this patient

Sign	Present
Serous or bloody discharge	No
Swelling, redness, raised local temperature	Yes
Purulent or yellow-green discharge	No
Hardened or fluctuant area	No
Reduced sensation, vomiting	No
Local pain	Yes

Later the wound healed and the infection subsided. According to the Romano classification, by the time of the picture, it was stage 1: infection identified within 2 weeks of first operation, with no involvement of bone. Plate was stable and retained.

Another type of complication is refracture, typically following additional trauma to an implant failure with poor callus. There are reported refracture rates ranging from 6.5 to 14.2%. The incidence of non-union varies from 5 to 12% for all fractures and about 20% of diaphyseal fractures. Delayed union is found in approximately 3% and non-union in femoral fractures is reported between 1.1 and 14%. The estimated rate of long-bone non-unions in Europe is 150,000 per year.

The patient presented 4 months post surgery with a slight complaint of pain in the right thigh upon walking, following a fall. On examination it was found to be mildly tender with no abnormal mobility at the site of fracture and no signs of infection. There were only slight restrictions of movement in the knee and hip joints due to pain. Radiographs showed bridging callus with no angulation or other deformity. During the subsequent follow-up examinations, approximately 3 cm of callus was seen and the function of the limb was good except for slight stiffness.

Consent

Appropriate written consent has been obtained by the authors. The patient consented to publication of her photographs, radiographs and clinical information in print and electronic form, knows that her name and initials will not be published and that reasonable measures will be taken to preserve her identity.

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Author contributions

Mustofa MG: study conception, surgery, writing the manuscript. Bhadra A: clinical management, manuscript revision. Saha S: Data collection, follow up, manuscript revision. All authors read and approved the final manuscript.

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Data availability

Data for this case report can be made available by the corresponding author on reasonable request.

AI disclosure

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Conflicts of interest

The authors have no conflict of interest to declare.

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