Case Report
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Revision with metaphyseal locking compression plate (MLCP) by compression technique for aseptic non-union of the shaft of femur combined with corticocancellous autogenus bone graft

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Abstract

Background: *Non-union of femoral shaft represents a significant socio-economic burden due to prolonged patient morbidity, inability to return to prior function, gait abnormality, re-operation and psycho-emotional impairment. Despite advances in trauma care, improved surgical techniques and latest implants, non-union still persists.*

Objective: *To evaluate the outcomes of revision with metaphyseal locking compression plate (MLCP) by compression technique combined with corticocancellous autogenous bone graft in the treatment of aseptic non-union of the shaft of femur.*

Case Summary: *A 55-year-old female patient had a history of trauma due to fall from a CNG auto-rickshaw (high velocity road traffic accident), sustaining a closed fracture of the mid-shaft of the right femur, previously treated by interlocking intramedullary (ILIM) nailing. She presented one year later with confirmed non-union. She was admitted to President Abdul Hamid Medical College Hospital and treated by revision with MLCP and corticocancellous autogenous bone graft.*

Results: *MLCP combined with autologous corticocancellous bone graft showed good functional results at the end of ten months postoperatively, following prior repetitive failure of implants due to non-union. ASAMI bone and functional scores were Excellent.*

Conclusion: *Revision with MLCP by compression technique combined with corticocancellous autogenous bone graft is an effective treatment for aseptic non-union of the femoral shaft.*

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

Introduction

Femoral fracture is one of the most common disease of the traumatic orthopaedics. The incidence rate is about 10-26.7 per 100000 persons per year and is often caused by high energy mechanism such as motor vehicles, high altitude fall injuries and padestrain accidents. Non-union is one of the most common complications (about 1.9%-11.3%)[4]. It is often related to surgeon's lack of understanding of different fracture types and inappropriate treatment plans that leads to differences in the etiology of iatrogenic bone non union[5]. Long bone non-unions have a devastating impact on patient's quality of life and cause a high socio-economic burden.[6]The occurrence of non-union is multifactorial and the mechanical and biological factors include inadequate immobilization, comminuation, bone defects, poor vascularity of the fracture fragments, poor soft tissue envelop and local infection [7]Fracture personalities and patient backgrounds also play important roles in the development of non-unions[8]. Now days, with rapid development of implants and surgical techniques, more fractures are being caused by surgeryy when reliable stability and early mobilization are achived. However, diaphyseal long bone non-union of femur still

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remain a common complications[9] and are difficult to treat currently, several techniques have been used to treat diaphyseal long bone non unions including but not limited to nail dynamization, exchange nailing, augmention plating, bone transportation with external fixation [8].Among these techniques, exchange nailing has been considered as a preferred choice with biological and mechanical advantage. However, there were conflicting reports on it's success[10] and its use also has limitations [11]. Although compression plating has been described as a successful treatment of non union [12] , it is rarely mentioned in the treatment of tibia or femur diaphyseal non union[13] . Plating was even believed to produce poor result in treating non union specially in this case with infection and bone loss[14] in current work we studied a femoral diaphyseal non-union, reunited by compression plating with metaphyseal locking compression plate . Our main purpose is to investigate the result of compression plating, emphasizing the essential techniques of compressing the bone gaps and highliting the advantage of this technique.We also aim to explore compression plating as an alternative method for treatment of diaphyseal non-union of the femur.

Bone resorption as an atropic non-union of excision for infection (sequestrum) or tumors can also result in bone defects. The extend of the defect can be considered in turns of the length of the bone involved. This defect can range from few milimeters to several inches. Also the defect can be partial or segmental circumferential loss. Those involving upto more than 50 % of the circumference can heal spontaneously but often required additional treatment to restore normal volumes straight segmental defects of greater than two cm are unlikely to heal spontaneously following skeletal stabilization alone. The age of the patient, the process of chronic diseases and tobacco users may alter the potential of bone defect to heal [15].

Case report:

A 55 years old female patient had a history of RTA due to fall from CNG auto rickshaw(high velocity RTA) . Sustaining injury over right thigh leading to closed fracture mid shaft of femur of same side . From X-ray of right thigh shows fracture mid shaft of right femur with a displaced fracture fragment .

The patient admitted in KHIDMAH JANATA HOSPITAL LTD , HAYBATNAGAR , KISHOREGANJ for better treatment . After resuscitation, According to ATLS protocol. She was treated on fifth day after RTA by ORIF with ILIM nail in her right femur. She attended post operatively on 3 , 6 and 12 weeks post-operative follow up but no sign of union was seen on radiograph . Suddenly she had no follow up on the next 3 months to 10 months. After that, she suddenly attended to me. We thoroughly examined the patient and necessary investigation were done and diagnosed as a case of non-union of fracture shaft of right femur with ILIM nail in situ and a fracture gap >2.5 cm in mid shaft of her right femur . Then she admitted to PAHMCH for better treatment. We planned revision surgery by removing of ILIM nail and fixation with MLCP with corticocanceleous 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 .

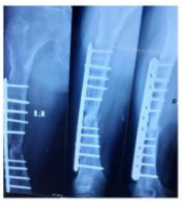

Figure C3: Features of union (consolidation phase)

Figure C4

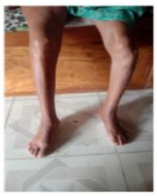

Figure C5 :Patient after recovery (C4,C5)

SURGICAL PROCEDURES:

After ensuring normal inflammatory marker's preoperatively (ESR and CRP) to exclude the possibility of active infection , she was operated upon under spinal anaestheisa . The position of the patient on the operative table was dicteted according to the bone graft donor site in a usual situation , the patient should be positioned supine and ipsilateral iliac crest should be prepared and included within the surgical drape for the posibility of harvesting bone graft , thorough a direct lateral approach to the femur engaging , the previous skin incisions whenever possible , the following steps are followed :

Debridement:

After ILIM nail was removed, proper exposure was done . We exciesd the scarred fibrous tissues from surrounding fractured site of femur , perform refreshment of fractured site,tissue samples were sent for histological and microbiological examination . We did excise the atrophic segment , however instead , after we osteotomised the atrophic segment proximally and distally , the marrow cavity was thoroughly reamed with several reamer of the femoral bone.

Plate Fixation:

Before the introduction of reamed exchange nailing, the use of compression plating for femoral shaft non unions was gold standard. The plate functions as a tension band on the lateral side. As such, it will also help with correction of mal-alignment . The bone itself absorbs the axial compression forces. In their book on non-unions , weber and Cech advocated debridement , sequestrectomy ,use of plates for "mechanical rest" and "massive cancelleous autograft". Fracture end of the femoral shaft fixed with 12 holed MLCP

with 10 locking screws and 2 cortical screws is done . The patient was treated in a single stage by removal of ILIM nail , debridement , ORIF by bridging with MLCP .

Harvesting of iliac bone graft:

Which was then impacted at the fractured non union area to enhance the biological environment for healing . From iliac crest corticocancellous bone graft was harvested preferably from ipsilateral anterior aspect of the iliac bone to reduce morbidity. The gap was filled with long chips (silvers) of autogenous iliac crest bone graft.

The surgical wound was closed by a negative suction drain which was removed after 48 hours post operatively. The patient was allowed non weight bearing walking with the help of axillary crutches. After drain tube removal, patient was discharged on sixth post-operative day after conversion of intravenous antibiotics to oral antibiotics. Stitches were removed at 2 weeks post operatively. The operative right lower limb was supported by a plaster stab for 1 month. Further follow up was done at 6 weeks and 12 weeks post operatively and monthly for 6 months to total follow up period was 10 months. Full weight bearing without supports or unrestricted use of lower limb depending upon the operated part was permitted only after fracture union was consolidated. Radiographs and clinical photographs were taken at each follow up along with clinical details as per proforma decided.

RESULTS:

In atrophic non-union; loose fibrous tissue is present at the non-union site which is avascular and biologically inactive, in that case compression done 1st to crush the tissue to invite inflammation and coming neo-vascularization, that is conducive for Neo-osteogenesis [18]

Clinical and radiological assessment was done for notice healing and bone deformity during treatment peroid. Radiological assessment was done at monthly interval, starting at the end of 1 month to 10 months. Cross sectional diameter of regenerated bone is equal to the width of bone at injury site. Union was established, if there was bridging callous across fracture site in entire cross section of orthogonal views. Union confirmed clinically by the absence of pain on weight bearing. The outcome of treatment was assessed according to ASAMI bone and functional result criteria, also complications (Deformity was evaluated as per Paley's classification (Table, 1. 2)

Table I : ASAMI scoring :19,20

Type (Score)	Criteria
Bone result using ASAMI scoring system:	
Excellent	Union , no infection , deformity <7 LLD < 2.5 cm
Good deformity <7. LLD < 2.5 cm	Union with any 2 of the following : absence of infection
Fair <7 LLD <2.5 cm.	Union with any of the following , absence of infection ,
Poor >7 and LLD >2.5cm	non union / refracture / union with infection , with deformity

Functional results using ASAMI criteria	
Excellent	Active , no limp , minimum knee stiffness (loss of <15 degree dorsiflexion) No RSD , insignificant pain .
Good	Active , with 1 or 2 of the following : limp , stiffness , RSD , significant pain .
Fair	Active , with 3 or all of the following : limp , stiffness , RSD , significant pain .
poor	Inactive (unemployment or inability to perform daily activities because of injury).
Failures	Amputation

LLD – limb length discrepancy , RSD – Reflex sympathetic dystrophy

Table II: Paley classification of bone deformity

Paley Type	Deformities
Type 1	Intact femur with mobile hip and knee a. normal ossification proximal femur . b. delayed ossification proximal femur .
Type 1-0	Ready for surgery , no factors to correct before lengthening .
Type 1-1	One factor to correct before lengthening
Type1-2	Two factor to correct before lengthening
Type1-3	Three factors to correct before lengthening.
Type 2	Mobile pseudoarthrosis with mobile knee a. femoral head mobile in acetabulam b. femoral head absent or stiff in acetabulam
Type 3	Diaphyseal deficiency of femur a. Knee motion >45 degrees b. Knee motion <45 degrees

Factors requiring correction prior to lengthening of femur : NSA < 90 degree +/- delayed ossification proximal femur , CE angle < 20 degrees sublaxing patella and/or dislocating knee .

In the subsequent follow up we found after clinical and radiogical assessment confirmed bony union. After complete healing and consolidation of regenerated bone , substantiated by radiological evidence without removing of plate . She was instructed to incur physiotherapy to recuperate range of motion (ROM) at the knee and hip joint. ROM of the knee was 0-100° and normal hip motion. C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) were done. 3 consecutive tests in a week of surgery, the values were in normal range and did not increase . Intraoperative bacteriological culture was done to see deep seated infection. There was no evidence of infection.

Table III: Bone healing status of the patient:

Criteria	Patient presesnt
internal fibrous tissue (months)	6 months
Consolidation time (months)	8 months
Union time (months)	10 months
Consolidation index	30 day / cm

Table IV: Bone defect status of the patient:

Criteria	Patient Profile
Femoral defect at first (cm)	nil
Bone ressection (cm)	nil
Angulation after fixation	10 degree
Amount of elongation (cm)	nil
Shortening at the end (cm)	0.5 cm
Follow up (month)	10 months

Table V: ASAMI criteria, bone and functional status also complication, classification of the patient:

Criteria	patient present
ASAMI bone	Excellent
ASAMI function	Excellent
Knee flexion	135 degree full flexion
Knee extension loss	0 degree (no loss)
Paley 1	intact femur with normal range of movement of knee and hip joint
Paley 2	none
Paley 3	none

-Bone union , no infection , angulation , LLD-0.5 cm
Active , no limp , full ROM knee (flexion 135 degree , extention 0 degree) , No RSD , no pain .
-After 12 months or one year of ORIF with MLCP , now the patient's full free movement of knee and hip joint . She had no question during walking.
The patient followed up regularly, bridging callous was seen around 6 weeks radiologically and union around 8 months with remodelling of bone. Patient achieved Complete range of motion and complete union with at the end of 10 months of surgery but mild stiffness RT. Knee joint . At present patient walk without the help of walking aid or crutches .

Discussion:
Muller and Rosen first described the utilization of the plate compression principle in the treatment of femoral non unions. Despite the disadvantages of upper blood loss, higher rate of infection and better non union rate than with exchange nailing plate osteosynthesis has been proven effective. Since there's high risk of infection and non-union with plating we have avoided to do it . In our case since non union with implant failure already occurred we decided to do MLCP with bone grafting.

Bone grafting techniques are used as adjuncts Combined with some surgical techniques usually plating Autologus bone graft are often obtained either from the iliac crest or from the reaming products.. In case of Intramedullary nailing autogenous bone has repeatedly been shown to be superior to all other types of bone grafts or bone substitute .

Cancellous bone features a large surface area and more cells a survive per unit volume of graft than in cortical bone grafts. Therefore autogenous cancellous bone features a greater potential to form new bone than autogenous contical bone. Osteoinduction is the process of recruitment mesenchymal precursor cell to differentiate into pre osteoblast on chondroblast leading to cartilage and bone production (16,17) . Osteoconduction occur through provision of matrix for the ingrowth of recipient site capillaries in vascular tissue and osteoprogenitor cell necessary for bone formation (15-16,17) .

The cortical graft functions as a scaffold and mechanically structure during bone replacement. Cortical bone graft heal for more slowly than cancellous bone grafts but follow the identical sequential process . Those delay is said to slowed revascularization in cortical graft secondary to the limited porosity of cortical bone . After failure of fixation due to non union twice attempted autologous cortical and cancellous bone graft with metaphyseal locking compression plating yielded good functional result .
Femoral shaft fractures are frequently occuring injury due to high energy trauma such as road traffic accident and also low energy trauma , like fracture in elderly caused by osteoporosis . Femoral shaft fractures are 10-21 % per 100000 per year . In this case , Gustilo type I , comminutedfracture , middle segment shaft of the right femur by motor vehicle accident ..
There are many treatment options in fracture shaft of femur but deficiency of standard guidelines the treatment options are open reduction and internal fixation (ORIF) by plate , intramedullary nail by external fixation . The more diversity of treatment options reflect more challenges of femoral shaft fractures: Depending upon the surgeons, treatment option may choose on their experience, knowledge and availability of tools and implants. Plate fixation is suitable in comminuted fracture shaft of femur and Minimally invasive plate Osteosynthesis (MIPO) procedure preserve vascularity and soft tissue which facilated bone healing.

The patient's fracture was fixed by Metaphyseal locking compression plate (MLCP) for Non-union. Post operative radiographs ensured bony fragments (graft) and plate was in position, maintaining well alignment with minimal fracture gap between fragments.

Infection and non union are the morbid complications of femoral fractures. Infections are more common in open tracture and also caused by superficial surgical site Infection (SSTI). The incidence of infection in closed bone fracture 1-3%, and it is higher in open fracture that is 5 % in Gustilo Type I, 10% in Gustilo Type-II 15% Gustilo type III. In femoral fracture infection rate is 4-7% in open, 1-2% in closed cases and surgical site infection (SSI) in femur fracture are 3.6% to 4.8%. The fracture complexity and soft tissue demage are the critical factors that influence the risk of infection. Thorough clinical evalution, proper investigations and a specific treatment strategy , are the troublesome factors to diagnosis infection after long bone fracture surgery. Complete blood counts (CBC), ESR, CRP with radiological image studies can be give accurate information if underlying infection. Infected tissue Culture provides the final and specific diagnosis post implant classification is done according to Roman CL. Et. Al.

Stage-1: wound debridement and surgical toileting intravenous antibiotic given as per culture and sensitivity test (C/S). No need for implant removal.

Stage: 2: Treated with antibiotic with or without implant removal.

Stage 3: Implant removed and sucessfully treated by external fixator. Infection causes delay union or may lead non union of fracture due to decrease blood flow and tissue damage.

Table VI. Romano cl. Et.al. classification of post implant infections

	stage 1	stage 2	stage 3
Post op. period	2-6 week	2-9 months	>2 monthas
Involvement of tissue	soft tissue	bone (non intra medullary)	Bone (intra medullary)
Removal of implant	not required	not required	required

Table VII : clinical signs observed in the patient with SSI in femur fracture

Clinical signs	patient present
serous or bloody exudates	no
edema , hypermia and local temparature increases	yes
purulent or yellowish or greenish exudate	no
hardened or floating area in place	no
sensory lowering and vomiting	no
local pain	yes

During subsequent follow up wound was healed and infection subsided. According to Romano classification (Table-VI) the fracture was in stage 1. Post implant infection, as infection was diagnosed within 2 weeks of initial surgery and not spread to bone. The plate provides sufficient stability. That is why of initial surgery it kept in position.

Refractures are another complication by further trauma where implant failure in the region of improper callus formation. The incidence of refracture is 6.5 to 14.2%. Approximately 5-12% non-unions occur in all fracture and it is around 20% for diaphyseal fracture. Delayed union (3%) and non unions are more common in femur fracture (1.1 % - 14%).On average 200 cases of long bone non unions occur per population, estimating of 150,000 cases in Europe each years.

The patient came after 4 months of her operation with complaints of mild pain in

Right thigh during walking following trauma by fall. During physical examination we found mild tenderness without any abnormal mobility at fracture site. There were no sign of infection. Knee and hip joints movement mildly restricted due to pain. In radiograph, There was bridging callus formation was seen with no angulation and other deformities. There were 3 cm callous formed subsequent next several follow up and limb functions are excellent movement except mild stiffness .

Consent:
We are certify that we have taken all appropriate patient's consent form. In the forms , the patient given her consent for use of her images (both photographic and radiological) and clinical information to be published both in electronic and print form. The patient understand that her name, and initials will not be published and due efforts will be made to hide his identity.

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Author Contribution
Mustofa MG - study conception, surgical procedure, manuscript writing; 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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Conflicts of interest.
There is no conflict of interest.

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