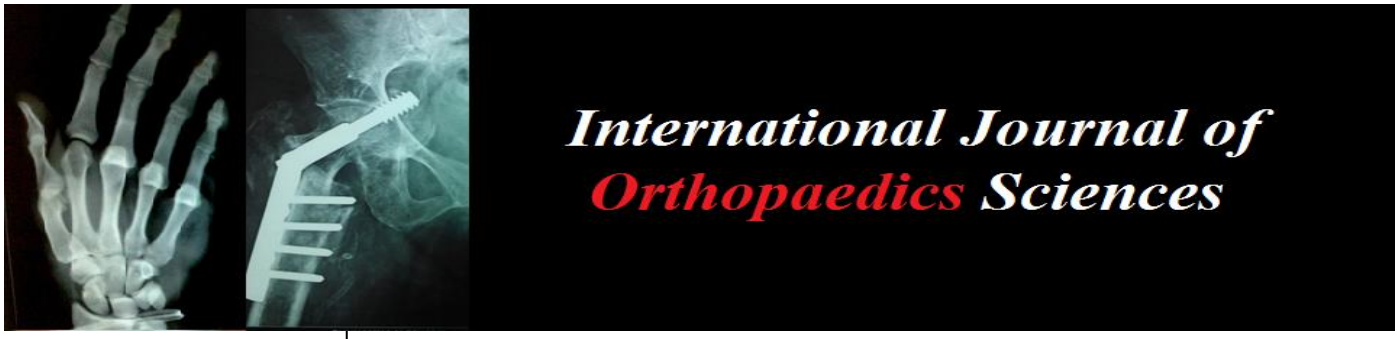

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Different management modalities in chronic osteomyelitis of long bones following open fractures: A case series

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Abstract
Chronic osteomyletis is one of the most dreaded complication of 0pen fractures and a surgeons nightmare. Eradication of COM requires aggressive surgical excision combined with effective antibiotic treatment and reconstructive procedures. The goal of therapy in such patients is to restore the functional anatomy of the limb. Depending on our experience and the type of infected nonunion we individualize a modality of management for the patient and the type of nonunion. The various modalities used were Corticotomy and lengthening using Ilizarov or LRS, Customized antibiotic rod implantation, Membrane osteosynthesis, Resection and endoprosthesis and Papineau technique. We followed up these patients till the radiological and clinical union occured and eradication of infection. The outcomes were based on bony union, functional outcome based on range of motion and occupational rehabilitation with eradication of infection at the last follow up. We publish our series of such cases and review of literature with representative cases.

Keywords: Chronic osteomyelitis, ilizarov, osteosynthesis, Masquelet, antibiotic cement

1. Introduction
Chronic osteomyletis is one of the most dreaded complication of 0pen fractures and a surgeons nightmare. The incidence of chronic osteomyletis has reduced drastically with the advent of newer antibiotics, better understanding of the incidence, prevelance and pathogenesis, and aggressive primary multidisciplinary management of open fractures and its early complications. Still the incidence of COM is high among patients with high velocity trauma and extensive soft tissue and bone loss with associated comorbid conditions.

Chronic osteomyelitis is difficult to eradicate completely, This is due to the fact that there are multiple foci of localized infection and sequestrae. The pathognomic feature of COM is infected dead bone with an envelope of granulation tissue with no systemic signs of inflammation. Acute intermittent exacerbations are a common feature and it may recur for years. The chronic indolent infection and inflammation leads to an envelope of scarred bone and muscle with poor soft tissue coverage. This island focii means systemic antibiotics are essentially ineffective. In addition poor local immunity with co morbid conditions leads to secondary infections and chronic sinus formation. It is not uncommon to isolate multiple organisms from the sinus tract and at times atypical organisms resistant to common antibiotics. Hence eradication of COM requires aggressive surgical excision combined with effective antibiotic treatment and reconstructive procedures. Reconstructive procedures like large free flaps may not be the best option in compromised patients. The goal of therapy in such patients is to restore the functional anatomy of the limb. Which is a herculean task considering the fact that after an aggressive local debridement there is a large area devoid of soft tissue and bone. Hence the course of treatment and definition of outcome must be individualized for each patient.

Our institute is a referral center and caters to a large population, We get patients after multiple interventions with deformity, bone loss and poor soft tissue condition. Depending on our experience and the type of infected nonunion we individualize a modality of management for the patient and the type of nonunion.

The various modalities used were Corticotomy and lengthening using Ilizarov or LRS, Customized antibiotic rod implantation, Membrane osteosynthesis, Resection and endoprosthesis and Papineau technique. We followed up these patients till the radiological and clinical union occured and eradication of infection. The outcomes were analyzed taking into consideration the clinicoradiological union of bone, functional improvement based on range of motion and occupational rehabilitation with eradication of infection at the last follow up. We publish our series of such cases and review of literature with representative cases.

Results and Discussion

The Papineau [1] technique is a very old procedure described in the original article published in French in 1973 [1]. Though it is out dated with the advent of new techniques and better reconstructive procedures, It may have to be used in rare circumstances when all other techniques have failed. We used a modification of the original technique of debridement of dead bone, bone grafting and vaccum assisted closure [2] (VAC). We have 2 patients in this series. The first representative patient was a 56year old male who was a chronic smoker and had undergone CABG (coronary bypass) 4 years back. He sustained an open fracture of the proximal tibia with internal fixation done elsewhere and presented with extensive soft tissue loss and COM. We did a through local debridement and soft tissue cover with local muscle flaps (Fig 1a) which failed to take up at 6 weeks follow up. Vascular evaluation of the limb showed severe artherosclerosis and poor flow. He was advised a crossed leg flap as free flap was likely to fail, which he refused and hence was advised amputation as a final resort by the reconstruction team. We did a modified papineau technique debridement of the dead bone and bone grafting with VAC application, in 4 months time the wound healed and patient was pain free and ambulant full weight bearing after 6months Fig (1b). At final follow up I year later the patient is symptom free and back to work with change of profession. He had active range movement of 100 degree of knee flexion.

Fig 1: A to E

Archdeacon MT [2] et report good result with the modification of original technique though the case series is small. Vasilios D [3] *et al* also reported 31 cases of draining COM or pseudarthrosis of foot and ankle secondary to trauma treated with papineau technique stabilized with ilizarov fixator. The mean time for bony union was 5 months and all patients were asymptomatic at 18 weeks follow up.

The Ilizarov [4] technique is one of the most common surgical techniques used to treat infected nonunion. The technique is the brain child of Prof. Gavriil Abramovich Ilizarov who was born on 15 June 1921 in Russia. In 1951 he developed this revolutionary technique and called it a ring fixator. It is a wonderful technique in cases associated with bony defect, deformity and infection. It is in most cases the “fall back”, procedure of choice when most other modalities failed or the reconstruction is very complex and lengthening more than 10 cm, with unifocal or bifocal corticotomy. We have 9 cases where 10cm or more lengthening was done for infected nonunion of tibia fractures in the last 3 years. The mean lengthening was 12.3 cm (range 10 – 16.5 cm).We had 4 cases where bifocal corticotomy was done. The distraction began 5 to 10 days after corticotomy at 1mm/day. The patients were allowed partial weight bearing during the immediate post op and full weight bearing after completion of distraction. The mean external fixation time was12.4 months (range 9.3 – 19 months) and mean external fixation index 1.43 months/cm (range 1.3-1.6). The results were evaluated according to ASAMI scoring system (table 2). We had 3 excellent results and 6 good results.

All patients had pin tract infection according to Moore and Dahl which was treated with systemic antibiotic and local pin care and one patient had ring sequestrum which was treated after implant removal with curettage. (Table 1).

The representative case was a 52 year male who sustained a Type 3B open comminuted proximal tibia fracture following a road traffic accident, was an alcoholic with compromised renal parameters. Was initially treated him with wound debridement and a knee spanning external fixator. He underwent a second look debridement and local flap cover followed by VAC application followed by skin grafting at 3 weeks. The external fixator was removed at 6 weeks and a long leg cast applied. Further evaluation at 3 and 4 months showed that the bone was avascular with evidence of COM. Hence we planned for debridement and Ilizarov fixator. After debridement there was a bone defect of 17.5 cm with soft tissue loss. A distal diaphseal corticotomy, proximal bone transport and sequential docking was done. A total of 16.5 cm lengthening done. After 4 months of consolidation of regenerate the fracture showed delayed union hence he underwent removal of frame, plating with bone grafting as patient could not tolerate the frame any longer. Six months later plate removal was done due to prominent implant. He had excellent outcome and patient returned back to his profession. But at 12 months follow up he had a fall from a bicycle and sustained fracture neck of femur for which he underwent cemented bipolar hemiarthroplasty. At last follow up at 22 months he is back to his profession as a barber. (fig 2).

Fig 2: A to G

Table 1: Classification of pin tract infection by Moore and Dahl

Grade	Appearance
0	Normal
1	Inflamed
2	Serous Discharge
3	Purulent Discharge
4	Osteolysis
5	Ring Sequestrum

Table 2: The results were assessed based on ASAMI scoring system

Excellent	Union, no infection, deformity < 7°, limb length discrepancy (LLD) < 2.5 cm
Good	Union plus any two of the following : absence of infection, deformity < 7°, LLD < 2.5 cm.
Fair	Union plus any one of the following absence of infection, deformity < 7°, LLD < 2.5 cm.
Poor	Nonunion/refracture/union plus infection plus deformity > 7° plus LLD > 2.5 cm

Cattagni *et al.* [5] used the circular external fixation using the ilizarov apparatus combined with internal bone transport or compression-distraction techniques were used to treat 28 patients with infected nonunions or segmental bone loss of the tibia. Functional results were good to excellent in 21, fair in six, and poor in one. The application of Ilizarov techniques to diaphyseal infected nonunions and segmental defects is very encouraging. He suggested that the technique may prove to be an excellent technique for future management of resistant diaphyseal infections of bone.

Lakhani Bone [6] reported a case series of 20 patients with chronic osteomyelitis and bone loss following open fractures. 10 patients had open fractures and 10 patients gap nonunion following debridement for infected nonunion, They studied problems related to heavy apparatus, persistent pain, deformity of joints and discomfort caused by an Ilizarov ring fixator and concluded that fixator was well tolerated with good functional results and gap reconstruction. Easy application of rail fixator and comfortable distraction procedure suggest rail fixator a good alternative for gap reconstruction of limbs. The average bone gap reconstructed was 7.72 cm and normal range of movement was achieved in 80% cases and had excellent results in 85% cases according to ASAMI score.

Another attractive alternative method of treating chronic osteomyelitis is the use of local antibiotic impregnated (AII) biodegradable or nonbiodegradable implant. The implant delivers high tissue levels of antibiotics, obliterates dead space, aids bone repair and provides temporary mechanical support till bone heals. This technique of antibiotic impregnate cement rod was introduced by Paley [8] and Herzenberg in 2002 as an alternative to antibiotics beads which offered minimal or no mechanical support. Though antibiotic beads deliver local antibiotic, it does not give mechanical support hence it needs removal before 2 week, after which removal becomes difficult and augments a second insertion or a definitive fixation if infection is controlled. They custom made antibiotic rods on table with different size chest tubes with beaded wire within cement.

We modified the above technique in our patients with infected nonunion without bone loss. After pus culture and sensitivity and iv antibiotic for 2 weeks the patients were taken up for surgery. The medullary cavity was reamed upto 12 /13 mm with a reamer and a custom made antibiotic cement rod using 7 size K nail cut to appropriate size and shaped to have a heroz bent was coated with antibiotic cement (4 gm vancomycin in 60gm plain cement). The nail was introduced to press fit. Intravenous antibiotics was continued for 2 weeks followed by oral antibiotics for another 2 weeks. The patients were allowed full weight bearing with functional cast 2 weeks after surgery and full weight bearing without brace after 6 to 8 weeks. The patients were followed up on a routinely both clinically and radiologically till union. The average time to union was 16 weeks (range 11- 20weeks). We have 4 cases treated by this method all of them underwent multiple surgeries for open fracture (Type 2 & 3A) and presented with infected nonunion without bone loss.

The representative patient is a follow up case of infected non union after type 3A Open fracture operated multiple times. He had wound debridement, local flap cover for wound closure, intramedullary nail insertion, fibulectomy, broken implant and bone grafting done before he presented to us with chronic sinus, pain and hypertrophic nonunion. The culture sensitivity yielded staph aureus and was started on linezolid, followed by implant removal and the medullary cavity reamed to size 12 and insertion of rod to press fit. Fig 3A-D. At last follow up at 20 months he is symptom free and perusing his profession as a sales personal.

Fig 3: A to D

Bhatia [9] *et al* published the results of 20 cases following antibiotic intramedullary nailing using a Knail in tibial fractures with less than 2cm bone loss and achieved union in 12 cases (60%) with a single surgery. Other 8 cases needed secondary procedures. He concluded that antibiotic cement nail is a simple, cheap, single stage treatment in infected tibial non union. Pradhan *et al*. [11] published a case series of 21 patients of infected non union in diaphyseal shaft fractures with gap less than 4 cm after debridement and achieved union in 16 cases with antibiotic K nail insertion, 5 others needed secondary procedures. Brebach [10] in his paper published his early clinical experience with custom-made calcium sulfate antibiotic impregnated implants with biodegradable implants which fills void aids bone healing and deliveries high local antibiotic but it does not provide adequate mechanical support hence there are chances of fractures.

Our experience with K nail is comparable to the published literature and very effective particularly in hypertrophic nonunion with infection and a cheap alternate to expensive readymade antibiotic nail in market. The key to good results is the proper selection of patients with isolation of organism, appropriate antibiotic therapy, over reaming, press fit nail and early weight bearing.

Masquelet [12] and Begue reported in 2010, the concept of membrane induced osteosynthesis, which was a relatively new technique in the management of infected defect nonunion. It is a 2 stage procedure in which stage one involves radical debridement and cement spacer and second stage at around 6 weeks meticulous exposure of the induced membrane removal of cement spacer and autologous graft from iliac crest and or allograft not exceeding 30% of total graft. Wang [13] *et al* studied a total of 32 cases of post traumatic osteomyelitis between August 2011 and October 2012. This retrospective study included 22 men and ten women, with a mean age of 40 years (19 to 70). Within this group there were 20 tibias and 12 femurs with a mean defect of 5 cm (1.5 to 12.5). Antibiotic loaded PMMA cement was inserted into the defects after radical debridement. After approximately eight weeks, the defects were implanted with bone graft. They found that radiographic bone union occurred at six months for 26 cases (81%) and clinical healing occurred in 29 cases (90%) at ten months. A total of six cases had a second debridement before bone grafting because of recurrence of infection and one patient required a third debridement. No cases of osteomyelitis had recurred at the time of the last follow-up visit. Kim *et al.* [7] in their long term study on membrane osteosynthesis on 20 patient concluded that the Masquelet technique is a viable option for treatment of long bone osteomyelitis. Primary advantages of this technique include its length independence, induction of a periosteal membrane that protects against graft resorption, and eradication of infection with an antibiotic impregnated cement spacer that preserves dead space volume for delayed reconstruction. Radical debridement should extend to viable bone margins (as indicated by the paprika sign). Use of an osteotome to perform corticotomy helps prevent damage to healthy surrounding tissue. Following thorough debridement, an antibiotic-impregnated PMMA cement spacer is placed. Irrigation with cold saline during preparation of the antibiotic-cement mixture will help prevent skin burns. Stabilization during the first stage can be achieved with an external fixator, plate or IM nail. The cement spacer must be left in place for 6-8 weeks. Complete eradication of infection, confirmed by culture and pathology, is a prerequisite to the second stage of the procedure reconstruction of the osseous defect.

Our representative patient was a 34 male who sustained a type 3B Open comminuted Supracondylar fracture of the right femur which was initially treated with wound debrided and internal fixation. He developed post op infection 2 months later and presented to us. After debridement there was a loss of 18 cm with only posterior thin cortex intact and 5cm of distal fragment of femoral condyle. We planned Ilizarov fixator for the patient, but after second debridement realized that the proximal bone below lesser trochanter was short and devoid of periosteum Hence we planned cement spacer and stabilization with ring frame (Masquelet technique), followed by fibular strut graft, autologous iliac crest graft plus bone substitute and shortening of 2 cm as the knee was stiff. The bone achieved stiff hypertrophic nonunion after 9 months on frame and the frame was removed. The patient refused any further intervention and returned to running a shop, but he had a fall 8 months after removal of frame and sustained ipsilateral trochanteric fracture. He was operated with DHS for trochanteric fracture and in the same sitting with a minimally invasive locking plate for the hypertrophic nonunion. Both sites healed uneventfully after 4 months, and he is self-employed and independent at last follow up.

Fig 4: A-F

In the rarest of cases the infected bone had to be resected and replaced with a endoprosthesis. The representative patient had COM of the right distal radius and distal ulna, with completed destruction of articular surface after type2 open fracture and fixation, he refused autologous fibular reconstruction and centralization of ulna was not a option due to COM of distal ulna and underwent 2 stage procedure. Resection of distal radius and ulna and spacer followed by titanium custom prosthesis. At 3 year follow up there is no evidence of infection and he has returned to work as bank employee.

Fig 5: A-D xray, MRI shows complete destruction of distal radius and ulna, followed by endoprosthesis

Limitation of study

Single institution study. As the treatment is individualized for a particular case there can be surgical bias based on surgeons experience and skill.

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