CASE REPORT

Modified Masquelet Technique and Primary Tibial Metaphyseal Shortening for the Management of Proximal Tibial-infected Non-union in a Patient with Alcohol-induced Neuropathy: A Case Study

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Abstract

Aim: To highlight the role of the Masquelet technique as a limb salvage procedure for a neuropathic patient presenting with infected non-union of proximal tibia.

Background: The management of an infected non-union in neuropathic patients is most challenging; with various treatment options available, the prognosis is often guarded.

Case description: A 37-year-old male with chronic polyneuropathy, also possessing a contralateral midfoot Charcot arthropathy secondary to a history of alcohol abuse, developed infection after a proximal tibial osteotomy for a preceding mal-non-union of a proximal tibia fracture. The management included hardware removal, excision of necrotic bone, interim insertion of antibiotic-loaded bone cement followed by an acute shortening and revision of the internal fixation utilising a second surgical incision. Successful bone union and eradication of infection was achieved and maintained after 13 months follow-up.

Conclusion: A successful outcome was achieved for an infected non-union of a long bone in a neuropathic patient using the Masquelet technique which was then followed with a second-stage removal of the spacer and shortening. By performing the revision ORIF surgery utilising a different skin incision in the setting of complicated previous surgical scars proved to be a viable technique towards reducing risk of recurrence of infection and a good outcome.

Clinical significance: Utilisation of the Masquelet technique and limb shortening in a staged manner for the management of long bone infections in neuropathic patients has not been reported before and may be valuable in such demanding clinical situations.

Keywords: Alcohol, Infected non-union, Masquelet, Neuropathy, Tibia.

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Background

Alcohol-induced polyneuropathy is the most common complication of excessive alcohol intake.[1,2] With symptoms ranging from paraesthesia, dysaesthesias, pain, weakness, and sensory loss due to axonal degeneration, alcohol neuropathy affects the distal extremities mostly leading to decreased ability to ambulate, muscle atrophy, pressure ulcers, and Charcot arthropathy.[1–4] In the event if there is an accompanying bone or soft tissue injury, the presence of a neuropathy further compromises tissue healing of the skin, muscles, tendons, and bone.[5–8] Performing surgery in neuropathic patients necessitates careful planning with realistic expectations expressed to the patient and their family in order to achieve reasonable outcomes.[9]

An infected non-union of the tibia is a challenging problem for many reasons. Bone resorption, the presence of bony gaps, a lack of soft tissue coverage, stiffness of joints, the limited bone available for reconstruction as well as the psychological and economic impact of the length of reconstruction process, can make the outcomes unfavourable.[10–14] This is made more difficult when the problem is present in periarticular regions of the limb. When the comorbidities are amplified by complications consequent to long-standing alcohol-related neuropathy, the management becomes even more

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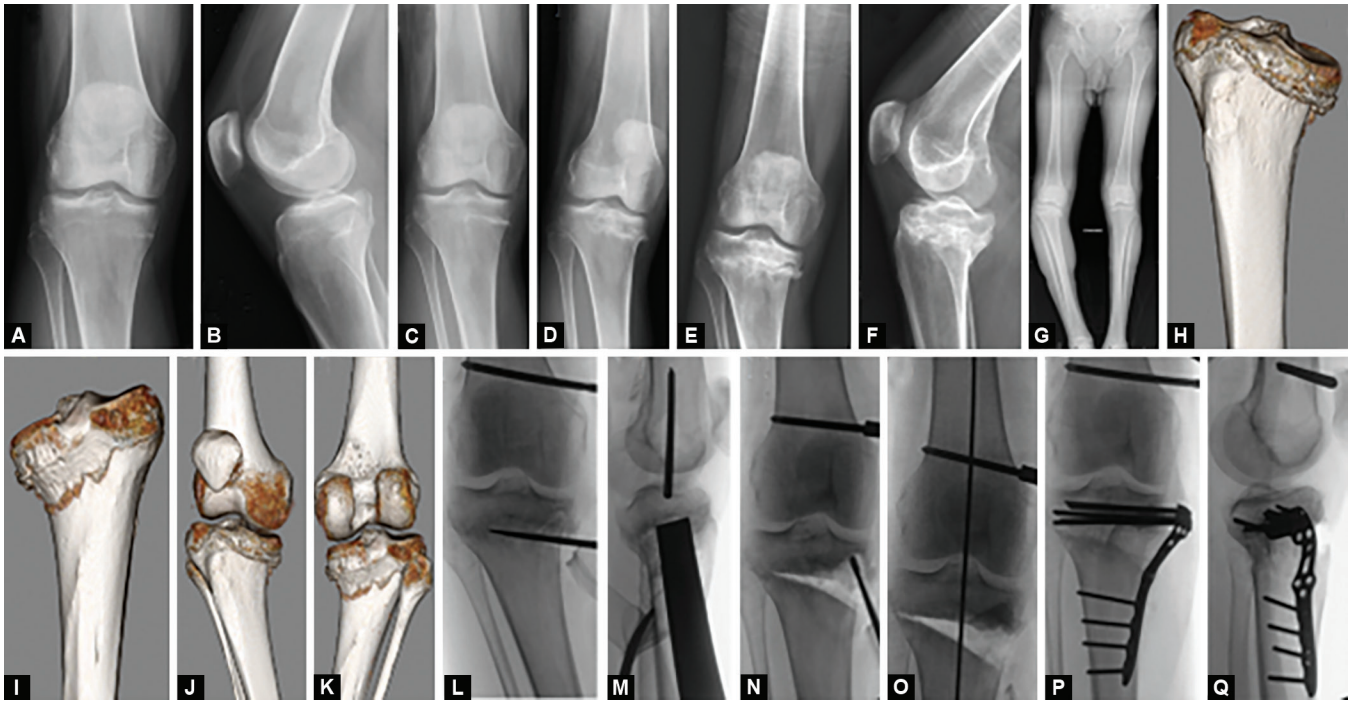


Figs 1A to Q: (A and B) Plain radiographs of a 37-year-old male patient with alcohol-induced chronic polyneuropathy who presented with a non-displaced fracture of the medial proximal tibia after a fall; (C to G) Plain radiographs and long film showing progressive deformity and malunion leading to varus collapse of the proximal tibia and overall significant varus malalignment of the right lower limb after a period of 10 weeks of conservative management; (H to K) Three month follow-up 3D CT scan images showing extension of the fracture line and varus non-union; (L to Q) Intraoperative C-arm images of the first surgery, open wedge valgus high tibial osteotomy, autologous bone grafting and fixation with proximal tibial locking plate performed 4 months after the fracture

difficult. The published literature specifically about the management of infected non-union of long bones in neuropathic patients is sparse. We describe a strategy for resolving such a problem.

Case Description

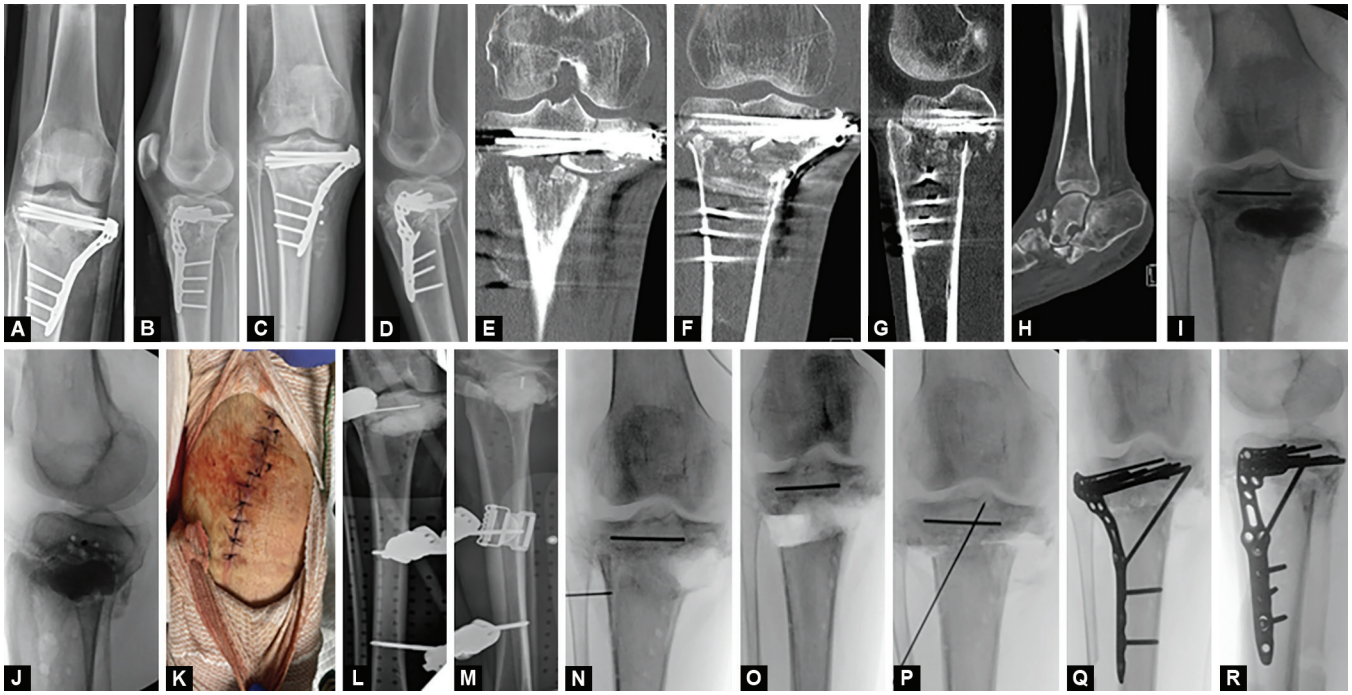
A 37-year-old male with a previous history of alcohol abuse and chronic polyneuropathy presented with right knee pain and limitation of weight-bearing after a fall when walking. The examination showed mild tenderness and swelling over the medial proximal tibia. There was diminished sensation over both legs and feet. The past medical history included rheumatoid arthritis treated with long-term oral corticosteroids and a midfoot Charcot arthropathy that had been managed conservatively. The plain radiographs revealed a non-displaced fracture of the proximal medial tibial metaphysis (Figs 1A and B). Conservative management was chosen in the form of a knee immobiliser and instructions to remain non-weight-bearing, with a follow-up every 2 weeks.

The patient returned after 1 month, bearing weight over his limb without a brace, complaining of increased pain over the proximal right tibia. Plain radiographs showed sclerosis of the fracture site with a mild varus collapse of the proximal right tibia (Figs 1C and D). The patient was reminded to follow the touchdown and bracing instructions precisely. Two months later, he presented with marked knee pain and an inability to bear weight. The examination now revealed varus collapse and non-union of the proximal tibial fracture with loss of axial limb alignment (Figs 1E to K). Various treatment options were discussed with the patient and the decision then made to proceed with an open wedge high tibial osteotomy and bone grafting. Surgery in the form of an open wedge medial proximal tibial osteotomy was carried out with fresh-frozen structural cancellous allograft (femoral head), iliac crest bone marrow aspiration and stem cell concentration, and calcium phosphate bone cement used to fill the subchondral bone defect (Figs 1L to Q). The patient's limb was placed in a hinged knee brace and was instructed to touchdown weight-bear with crutches.

The patient presented at 6 weeks post-op fully weight-bearing without an assistive device but with maintenance of limb axial alignment (Figs 2A and B). Restriction instructions were again presented clearly to the patient, but at the 4th month visit, the patient then presented with wound swelling and pain. Plain radiographs revealed resorption of the osteotomy site and loosening of one of the proximal screws along with shearing of one of the screw heads. A CT scan revealed resorption of the bone graft along with the presence of sequestrated bone fragments (Figs 2C to H).

Serum investigations denoted elevated inflammatory markers. The decision made was to proceed promptly with hardware removal, an extensive debridement with tissue (bone and soft tissue) biopsies and the insertion of gentamicin and vancomycin-loaded bone cement (PALACOS® fast R+G) along with the application of a uniplanar external fixator (Figs 2I to M). The results from the tissue cultures and implant sonication revealed a non-methicillin resistant *Staphylococcus aureus* infection which was sensitive to vancomycin, clindamycin, tetracycline, and cotrimoxazole. Clindamycin was prescribed orally and the patient was discharged with a 2-week follow-up.

Three weeks later, the patient presented with wound inflammation and purulence and was admitted for re-debridement and replacement of cement spacer (PALACOS® fast R+G with additional



Figs 2A to R: (A to D) Follow-up plain radiographs showing non-union of the osteotomy, graft resorption and hardware breakage at 4 months postoperatively; (E to G) Four months follow-up CT scan images showing non-union of the osteotomy, the presence of sequestrated bone and hardware loosening; (H) CT scan of the contralateral ankle and foot showing Charcot arthropathy of the midfoot with bone resorption and fragmentation; (I and J) Intraoperative C-arm images showing hardware removal and insertion of antibiotic-loaded bone cement which was performed at the 4th month; (K) Clinical photo 3 weeks after debridement showing wound inflammation, swelling and purulence; (L and M) Postoperative radiographs after a second debridement and exchange of the cement spacer performed after 3 weeks. The patient underwent another surgery at the 6th month stage with repeat debridement, replacement of the antibiotic-loaded spacer and with secondary wound closure after an initial period using a negative pressure dressing; (M to P) Intraoperative C-arm images of the definitive surgery, performed at the 7th month, involving removal of external fixator and cement spacer, excision of a defined bone segment, fibular osteotomy, acute shortening and fixation with an anterolateral tibial locking plate from a separate lateral incision

3 grams of vancomycin and 2 grams of tobramycin). The wound was loosely approximated with the additional placement of a negative pressure system over the incision. The patient was discharged on a 6-week regimen of oral clindamycin and cotrimoxazole, and for weekly follow-up with inflammatory marker monitoring which were decreasing. After 1 month, with normalisation of serum CRP to 0.5 mg/dL and formation of healthy wound granulation tissue, the patient was readmitted for secondary wound closure along with an exchange of the antibiotic delivery system. At this stage, neither purulence nor bone necrosis was observed, and the bone defect was clean with obvious punctate bleeding. A well-formed healthy membrane was noticed along the medial, posterior, and anterior portions of the defect. Multiple swabs were taken for culture and sensitivity which later revealed no growth. The subsequent surgery was planned for at 8 weeks after ensuring full wound healing and maintenance of normal serum inflammatory markers.

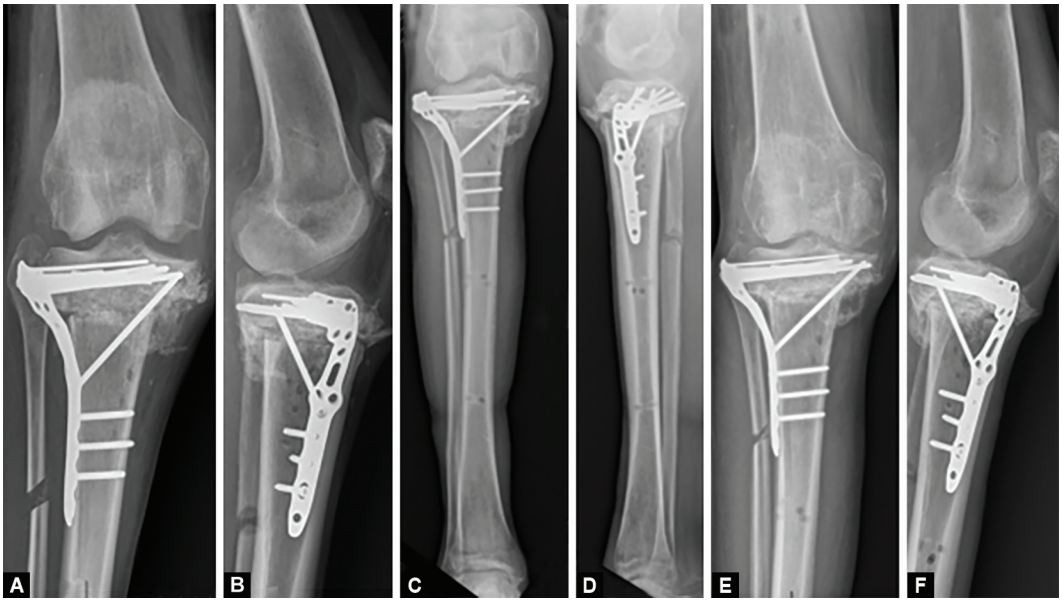
The definitive reconstructive surgery was performed through the removal of external fixator, an anterolateral incision, removal of antibiotic cement, an oblique osteotomy with bone excision to create oblique bony surfaces that coapted well, impaction of autologous iliac bone graft along the osteotomy to the medial side, acute shortening with compression and fixation with an anterolateral locking tibial plate (Figs 2N to R). A formal fibular resection was performed to allow acute shortening of the tibia of 1.5 cm.

Post-operatively, a knee immobiliser was applied to the limb and weight-bearing was slowly advanced over 6 weeks until the patient was fully weight-bearing at 12–14 weeks. Regular follow-up visits showed progressive consolidation of the osteotomy site and ossification along the well-formed pseudomembrane along the medial aspect of the osteotomy (Fig. 3). At 12 months, the clinical and radiographic follow-up showed the osteotomy site to be consolidated with bridging callus and the patient ambulating independently with a 1 cm shoe lift. The patient has approximately 2 cm of shortening in this limb with knee range of motion of 0–100°.

Discussion

This is a case study of an infected non-united proximal tibial osteotomy in a young neuropathic patient. Successful management has been achieved utilising the Masquelet technique and sequentially then performing an acute bone shortening and revision of internal fixation. Acute shortening, without later limb length restoration, was accepted in this case to avoid further surgery with possible potential complications. The modifications on the classic Masquelet technique in this case were the multiple renewals of the antibiotic delivery system and the addition of acute shortening as a staged procedure.

Infected non-union of tibia is often difficult to manage. The lack of soft tissue covering along with bone defects before or after surgical intervention call for multidisciplinary and complex reconstruction techniques, and may involve bone transport, deformity correction, and soft tissue coverage.[11] Several surgical



Figs 3A to F: (A and B) Six-week postoperative follow-up radiographs showing early union of the osteotomy site and ossification of the soft tissue membrane around the fracture site; (C and D) Long film radiographs 6 months postoperatively showing fracture healing and restoration of the limb alignment; (E and F) 12 month follow-up radiographs showing bony consolidation

steps are crucial; firstly, the meticulous, and frequently, multiple surgical debridement which removes all necrotic bone and soft tissues as well as the removal of loose or broken implants.[12] This should aim to establish bone surfaces that allow for wide surface area of contact upon compressing the bone ends. Sustained compression can improve bony and soft tissue vascularity, reduce sclerosis, and help to achieve bony union.[11–13] Secondly, there is an application of a local antibiotic delivery system, whether non-absorbable as with polymethyl methacrylate (PMMA) or absorbable calcium sulphate for smaller defects.[11] Antibiotic delivery systems allow for elution of high concentrations of antibiotics, well above the minimum inhibitory doses for microorganisms and promote eradication of infection.[14–16] Fracture stability is also required in facilitating healing and in the periarticular regions, where lack of bone stock can cause fixation issues, there can be greater difficulties in control and eradication of infection. Often the construct will require external fixation as an adjuvant step to help stabilise the antibiotic cement complex. Thirdly, the need for reconstruction of the bone defect which can be done using either bone transport,[17–20] Masquelet technique,[21–24] or using vascularised or non-vascularised bone graft and substitutes.[25–28]

The induced membrane technique, known as the Masquelet technique[21–24] classically involves two-stage surgery using PMMA to induce the formation of a pseudomembrane subsequent to the foreign body reaction. This membrane can hold bone graft, boost blood flow to the graft and induce bone healing.[29] The Masquelet technique has proved successful in the management of infected non-union,[29–31] reconstruction of large bone defects,[32,33] reconstruction after excision of bone tumours, congenital pseudoarthrosis or as a step in arthrodeses of joints[33] with excellent results even in the long term.[29]

The management of an infected non-union in the presence of established chronic neuropathy is, as was described here, even more challenging. The lack of neuropeptides and neurotrophic factors in neuropathic patients decreases soft tissue healing.[5–8] Chronic alcoholism too negatively impacts soft tissue healing and bone remodelling, osseointegration, bone formation, and fracture repair.[34–36] Additionally, the psychological and mental health-related complications that are associated with alcohol abuse[1] may affect patients' compliance with surgical instructions. The expectations regarding the prognosis should be reasonably presented. As there are no published guidance about the management of fracture non-union in association with chronic alcohol abuse, this case study may present stimulus for further research as the impact of chronic alcoholism worldwide is well documented.[37]

The Masquelet technique for the management of orthopaedic conditions in neuropathic patients has been reported in one case previously where the authors describe successful management of ulcerative midfoot osteomyelitis in a patient with Charcot diabetic neuropathy.[38] This case report further illustrates the potential of the induced membrane technique as a viable option for the management of bone infections in the presence of chronic neuropathy.

Conclusion

The management of infected non-union in patients with alcohol-induced neuropathy is a challenging condition. Masquelet technique with acute shortening appears to be a viable option in the management of such cases. Changing the surgical incision site should be utilised whenever possible in cases with previous wound infections to allow reconstruction through more healthy tissues.

Clinical Significance

The combination of repeat episodes of surgical debridement and antibiotic spacer renewal followed after with acute shortening, stable internal fixation and bone grafting has been shown to be a successful strategy for managing an infected non-union in an individual with chronic polyneuropathy.

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