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## Case Report

## Case report: Restoration of an open 12 cm femoral defect treated with the Masquelet technique in a 20-year-old polytrauma

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## ABSTRACT

Infected post-traumatic femoral defects are challenging to treat, and limited options exist. The case of a 20-year-old polytrauma male who sustained a segmental femur fracture involving the femoral neck, distal femur and an intermediate diaphyseal bone defect of 12 cm is presented. The patient declined a long-term frame in his femur. The 2-stage Masquelet procedure resulted in successful outcome with limb preservation.

## Introduction

Significant bone defects associated with infection pose a great challenge to the surgeon. Treatment consists of thorough irrigation and debridement, addressing the soft-tissue, stabilizing the bone and definitively reconstructing the defect when the infection has been eradicated [1]. The end-goal of management is to have an aseptic restoration of the defect associated with good functional outcomes. Several techniques have been described, however patients find difficult to tolerate long-standing treatment and rehabilitation [2].

The induced membrane (or Masquelet) technique, invented by Professor Masquelet in the 1980s [3], consists of an initial procedure whereby debridement of the bone and soft tissue takes place and the resultant defect is filled with a block of cement spacer and stabilized with either internal or external fixation. The cement acts as a spacer that induces an inflammatory “foreign body” reaction, preventing fibrous ingrowth into the defect and facilitating the formation of a pseudo—synovial membrane around it. This membrane, is extensively vascularized and produces several mediators including transforming growth factor beta (TGF- $\beta$ ), vascular endothelial growth factor (VEGF) as well as bone morphogenetic protein–2 (BMP-2) [4]. The final step, typically follows in 6–8 weeks and consists of carefully opening the induced membrane, disposing of the cement, filling the cavity with bone graft, closing the membrane and stabilizing the fracture [5].

The authors present herein the successful management of a difficult case of an acute traumatic 12 cm femoral defect in a 20-year-old polytrauma patient.

## Case report

An otherwise healthy 20-year-old male presented to our level 1 trauma Center after being involved in a high-speed motor vehicle

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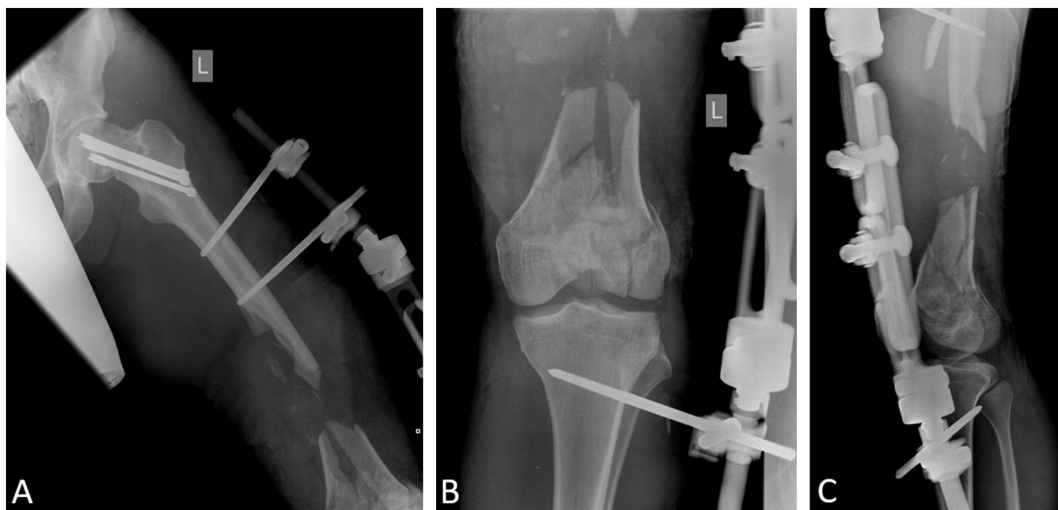
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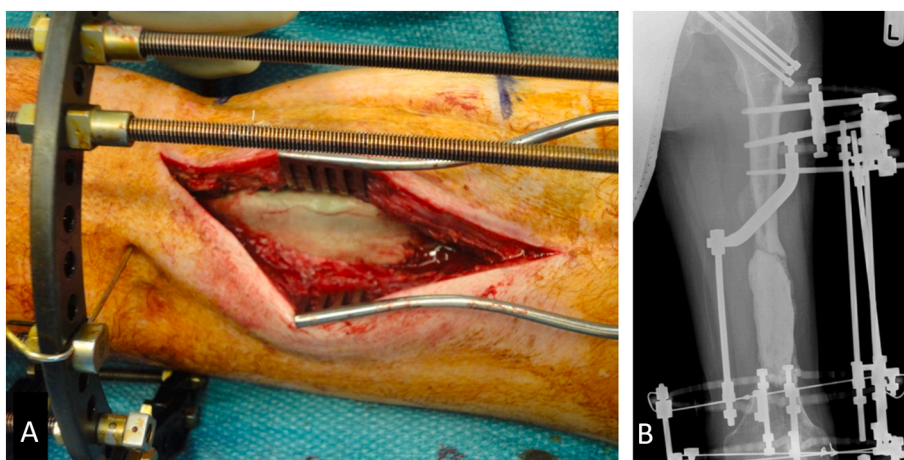
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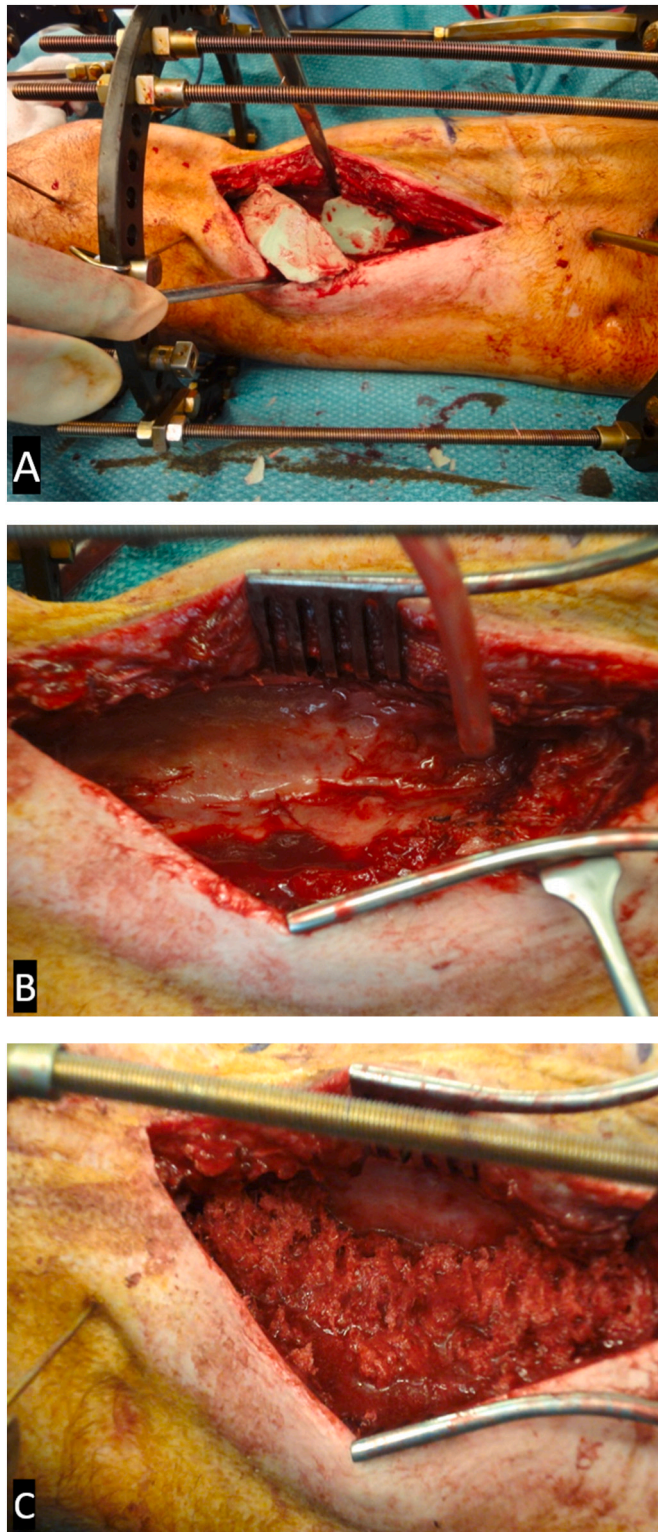
**Fig. 1.** A-C: Radiographs showing spanning of the femoral defect with cannulated screw fixation of the femoral neck fracture and significant comminution of the distal femur.



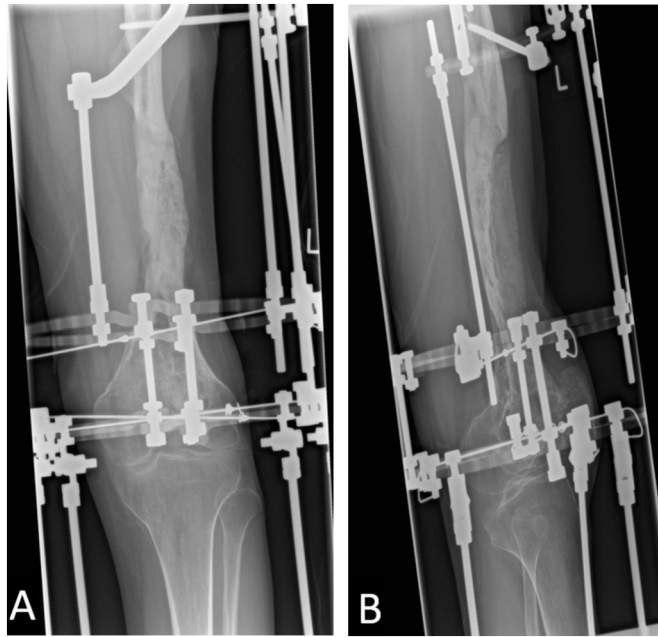
**Fig. 2.** Clinical images (A, B) and corresponding radiograph (C) of management of the defect using a hybrid frame for bone transport.



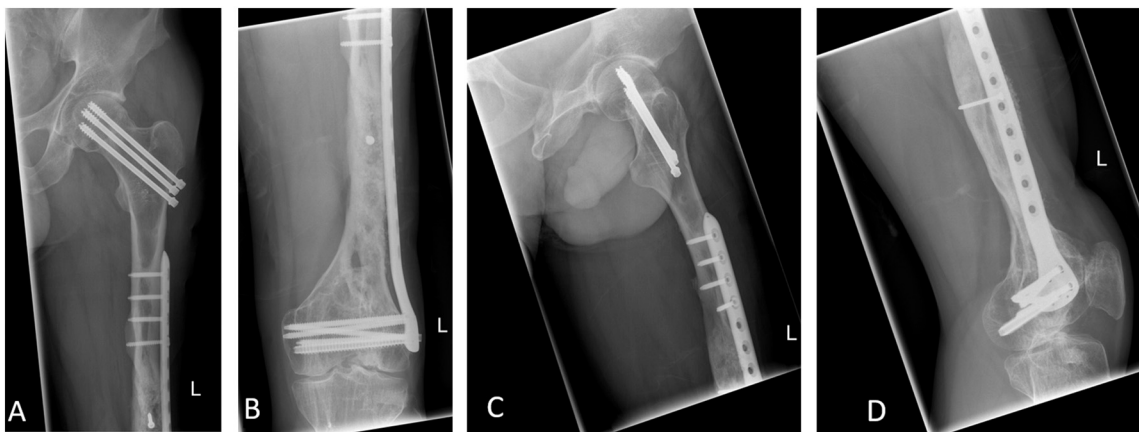
**Fig. 3.** First stage Masquelet procedure. Clinical image with insertion of the cement and preservation of the frame in situ (A) with corresponding radiograph (B).



**Fig. 4.** Second stage Masquelet procedure. Clinical Images showing extraction of the cement (A), formation of the induced membrane (B), and implantation of the RIA graft containing stem cells (C).



**Fig. 5.** Radiographs (A, B) showing good incorporation of the graft at 7 months status post second stage Masquelet procedure



**Fig. 6.** Latest 13-year follow-up radiographs showing healing of all fractures and restoration of the bone defect (A-D).

accident. His major injury was a grade IIIB left femur segmental open fracture, involving the femoral neck, femoral shaft with a 12 cm defect and distal femur comminuted intra-articular fracture (AO type C) with significant fragmentation of the lateral surface. Associated polytrauma injuries were all ipsilateral and included a closed olecranon, forearm and metatarsal fractures. He was appropriately resuscitated and emergently underwent irrigation and debridement of his open femoral fracture, with cannulated screw fixation of his proximal femoral neck fracture, and temporary spanning of his femoral defect with a knee external fixator (Fig. 1). A vac pack was applied to the femoral wound after debridement. Four days later, the vac pack was removed, and the femoral wound was approximated, and the soft tissue defect was reconstructed with a split skin graft. Ten days later, the external fixator was revised to an ilizarov frame as a decision was taken to manage the defect with bone transport, and at the same time the distal femoral articular fracture was reconstructed using the Olive wires of the Ilizarov frame (Fig. 2). Bone transport was delayed until enough healing would have taken place for the distal femoral and proximal neck of femur fracture. However, 14 weeks after the injury, and prior to bone transport initiated, the patient subsequently declined to undergo distraction osteogenesis as he felt that he could not tolerate a frame in his femur for a long period of time and therefore he sought treatment from our team. Therefore, a first stage Masquelet procedure was performed with implantation of a cement spacer in the defect. At that point, the frame remained to provide temporary stability (Fig. 3). Twelve weeks later, the cement spacer was removed and the defect was filled with Reamer-Irrigator-Aspirator (RIA) graft from the contralateral femur, loaded with bone marrow aspirate (BMA) for increased osteogenicity and bone morphogenetic protein 7 (Fig. 4). Tissue and bone biopsies taken during the second stage were unremarkable. The graft was incorporating well at 7 months (Fig. 5) and at this

point, the frame was removed and exchanged with a distal femur locking plate. At his latest follow-up, 13 years after the original injury, the femoral neck fracture, the defect and the distal femur fracture show complete healing (Fig. 6). Clinically, the patient does not have any hip or knee pain, but walks with a limp secondary to a limited 40 degree of flexion of his left knee. He is quite happy for the moment and in the future he will be a candidate either for a total knee arthroplasty or a knee fusion.

## Discussion

The management of the posttraumatic segmental bone defects associated without or with infections is very challenging both to the patient and surgeon. In infected post-traumatic bone defects, irrigation and debridement, soft-tissue reconstruction and establishing an aseptic environment with subsequent application of regenerative techniques to restore the bone that is missing remain the mainstay of treatment [1]. Regenerative techniques that can be applied include bone transport [6], vascularized bone transfer [6], titanium cages and allograft [7]. The Masquelet technique however, has the advantages of local antibiotic delivery, healing time independent of the defect length and avoidance of lengthy use of a cumbersome external frame, especially in less compliant patients [8]. Bone defects with mean length of 6.32 cm (range 2.0–25.0 cm) [9] treated with the Masquelet technique have been reported in the literature with a success rate of about 86–89% [5,9]. The majority of those defects involve the tibia, followed by the femur, but several other anatomical sites have also been reported [5,9]. The most common overall complication of treatment with the Masquelet technique is deep infection (8%) however, after additional management including debridements, fixation revisions, more bone grafting and in some cases casting, the success rate increases to 92% [9]. In order to minimise the risk of developing infection an adequate debridement must take place during the first stage, whereas during the second stage, if there is any concern about the state of the bone, additional debridement must be carried out. Tissues must be sent also to microbiology and if there is a positive result then pathogen specific antibiotic treatment must be prescribed for a period of 6–8 weeks. Other complications including refractures, implant failures, amputations and malalignments may occur, but are rare [9]. In our case, the clinical course was uncomplicated with a favourable outcome.

In general, the complication rate in the femur is lower than the tibia since the soft-tissue coverage is better [9], however, mechanical instability is an important issue, as the mechanical and anatomical axes diverge and therefore insufficient fixation stability may result in failure [10]. Although intramedullary nailing of the femur may result in faster union and better overall outcomes [11], when the distal femur is involved as in this case, a plate fixation is required. We did not encounter any healing problems, and this can be attributed to the properties of the graft material implanted being inductive (addition of BMP-7), osteogenic (addition of progenitor cells) and conductive (RIA graft). As a general rule, it is important for the surgeon to remember the “diamond concept” of bone healing [12] which supports the presence of five prerequisites for a successful bone healing outcome: the presence of osteogenic stem cells, osteoconductive scaffold, growth factors, good vascularity and adequate mechanical stability. Application of the Masquelet technique along with these principles is essential for optimal outcomes.

The patient described herein was in favor of limb salvage but at the same time was not tolerating a cumbersome frame and its lengthy rehabilitation. He achieved union of the defect in a timely fashion, with satisfactory quality of life and function, and residual knee joint mobility related problems secondary to his initial intra-articular injury. Despite the variability in reporting and the outcomes from different anatomical sites not being reported individually, the technique has an overall excellent outcome in the management of segmental bone defects as illustrated in the case reported herein.

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No funding has been received and the authors declare no conflict of interest regarding the present manuscript.

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