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Case Report

Application of Masquelet technique across bone regions - A case series

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ABSTRACT

Managing large bone defects in the setting of acute open fractures remains a challenging problem. We present a retrospective case series of acute lower limb open fractures with bone loss in the diaphysis, metaphysis and epiphysis addressed using the Masquelet technique. All cases present had at least 1 year follow-up with evidence of bony union and good functional outcome. Masquelet technique is both versatile and effective in managing acute open fracture with bone loss across bone regions.

Introduction

Managing large bone defects in the setting of acute open fractures remains a challenging problem. A vast range of surgical options for limb salvage ranging from acute shortening and limb lengthening, internal bone transport, vascularized bone grafting and the Masquelet technique amongst others that have been described to address this problem [1].

In the 1980s, Masquelet treated patients with infected non-unions in two stages. At the 1st stage, radical debridement of the affected bone and soft tissue followed by soft tissue repair and the use of a methyacrylate cement spacer placed into the bone defect to preserve limb length and soft tissue tension was performed [2]. At the 2nd stage, when there were no signs of infection, removal of cement spacer, bone grafting and definitive fixation was performed. The key to success of the Masquelet technique was the preservation of an induced membrane that formed around the cement spacer [2].

Today, the Masquelet technique is indicated for the treatment of traumatic bone defects or surgical debridement in the setting of infection, nonunion, joint fusion, tumour or congenital pseudoarthrosis. We present a case series using the Masquelet technique in the setting of acute open lower limb fractures with bone loss in the diaphysis, metaphysis and epiphysis.

Case 1

A 33 year old electrician was involved in a road traffic accident where he was a motorcyclist hit by a lorry at high speed and flung 1 m. He sustained a comminuted open right Gustilo-Anderson 3B tibia/fibila shaft (Fig. 1).

The patient underwent wound debridement with removal of devitalized bone. Post debridement, an 80% circumferential loss of bone over the anterolateral tibia diaphysis was noted and measured 7 cm long as well as a 15 × 8 cm soft tissue defect over the fracture site (Fig. 2). Post debridement, the patient was placed in a temporary external fixator and negative pressure therapy over the soft tissue

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Fig. 1. Radiographs showing a comminuted right diaphyseal fracture of the tibia and fibula.

defect.

One week later the patient underwent intramedullary nailing of his tibia fracture with 1 cm of bone shortening performed to approximate perfused bone ends on the postero-lateral tibia followed by the insertion of a cement spacer and coverage of the soft tissue defect with an anterolateral thigh free flap (Figs. 3 & 4).

Four weeks later, the 2nd stage Masquelet technique was performed. The anterolateral thigh flap was elevated, induced membrane was incised and preserved, cement spacer removed and autologous iliac crest bone grafting was performed (Fig. 5).

Four months post injury, the patient returned to work and was ambulating without aids. At 1 year follow-up, radiographs showed bony union, no pain and good lower limb range of motion (Figs. 6 & 7).

Case 2

A 73 gentleman was involved in a road traffic accident where he self-skidded at 60 km/h and hit a lorry, sustaining an open left distal femur fracture (Fig. 8). Initial examination revealed a 3 cm laceration superior to the patella.

He underwent debridement and application of a spanning external fixator within 24 h. Devitalised bone fragments measuring up to 6 cm were removed (Fig. 9).

Five days after the initial debridement and temporary stabilization, the patient underwent definitive fixation of the AO-C3 distal femur fracture using a dual plate construct. The Metaphyseal bone defect was filled with bone cement (Fig. 10). Dual plate construct was chosen in view of metaphyseal comminution and allowed for weight bearing physiotherapy immediately post-operatively [3].

Two months after Stage one, the patient was brought back to the operating theatre for stage two. The induced membrane was protected and elevated, cement spacer removed and bone defect packed with bone graft (Fig. 11).

The patient was followed up for one year post injury. Serial radiographs revealed fracture union. He remained pain free and returned to ambulating with a walking stick (Figs. 12 & 13). His knee range of motion at 1 year was 5° to 130°.

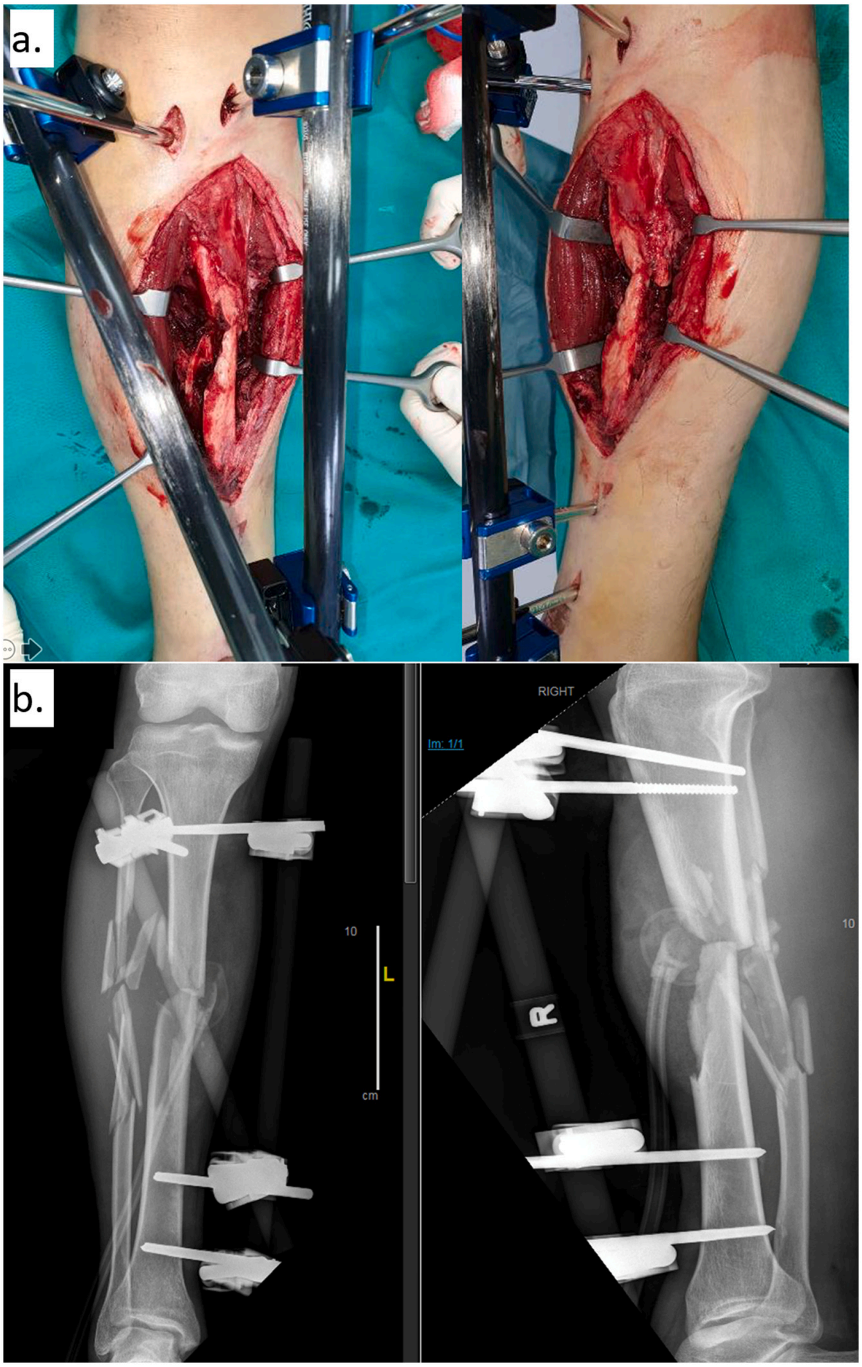

Fig. 2. a: Intraoperative clinical photos showing post-debridement anterolateral bone loss of 7 cm. b: Post-operative radiographs showing anterolateral bone loss with interval application of a temporary external fixator.

Case 3

A 26 year old motorcyclist was involved in a road traffic accident with a petrol tanker at high speed and sustained and open left distal femur fracture (Fig. 14), pelvic and acetabular fractures, a closed right ankle fracture, multiple rib fractures with pneumothorax and a vascular injury to the left renal artery. He was treated by a multidisciplinary team and treated with the principles of damage control orthopaedics for his multiple fractures.

With regards to his open left distal femur fracture, he underwent debridement of his knee wound on the day of admission as well as application of a spanning external fixator One week later, he underwent open reduction and internal fixation and the distal femur bone

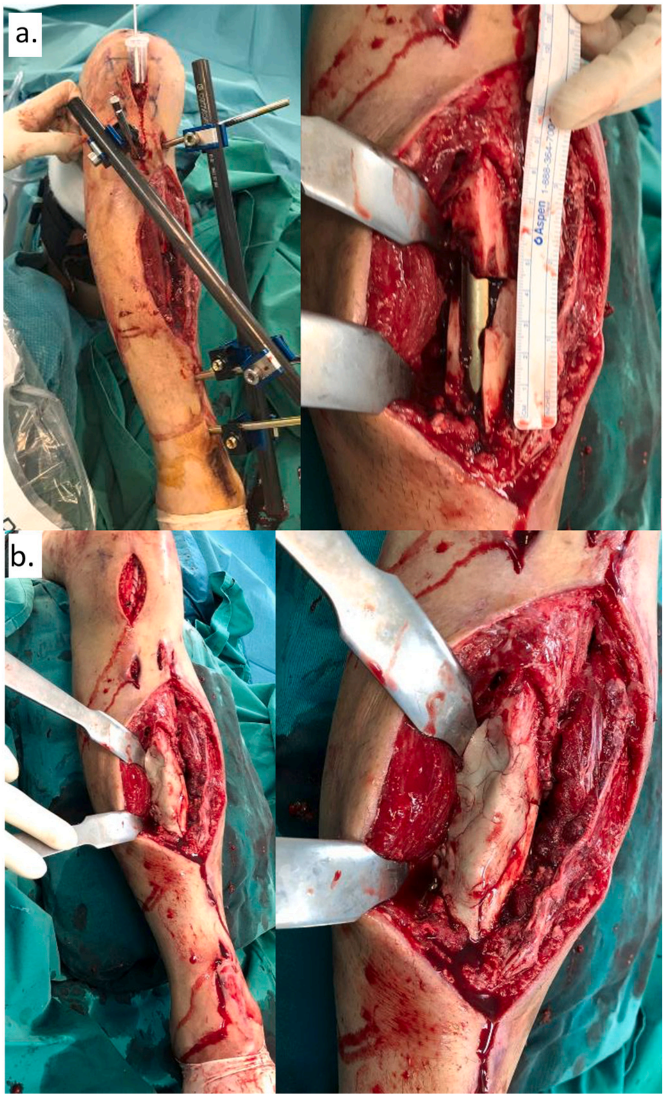

Fig. 3. a: Fixator assisted intra-medullary fixation of fracture with residual bone defect over tibial diaphysis. b: Cement spacer inserted into area of bone defect.

defect was filled with cement (Figs. 15 & 16).

Three months later, he underwent 2nd stage Masquelet due to delays from his other injuries. The pseudomembrane was elevated, cement spacer removed and cavity packed with bone graft (Fig. 17).

At 1 year post injury, the patient achieved bony union (Fig. 18). However, his knee range of motion was limited to 0–5°. He underwent removal of implants, arthrolysis and quadricepsplasty (Fig. 19). However, there was an inadvertent patella tendon avulsion during manipulation of his knee for which he underwent patella tendon repair and achieved a post-operative range of motion of 0–45 degrees.

6 months after, the patient was still troubled by his limited knee range of motion from 0 to 45° and underwent a patella tendon lengthening with allograft augmentation procedure (Fig. 20). Post operatively, he started range of motion exercises and was able to achieve 0–100° (Fig. 21). He has a 10 degree extensor lag which has been steadily improving with post-operative quadraceps strengthening exercises.

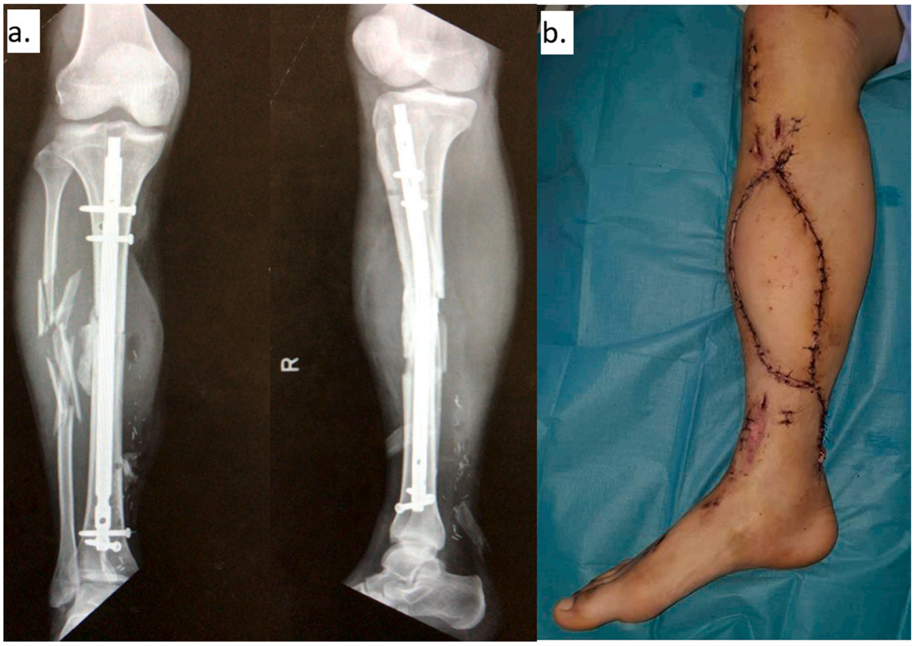

Fig. 4. a: Post-operative radiographs and b: clinical photograph of right leg after Masquelet stage I.

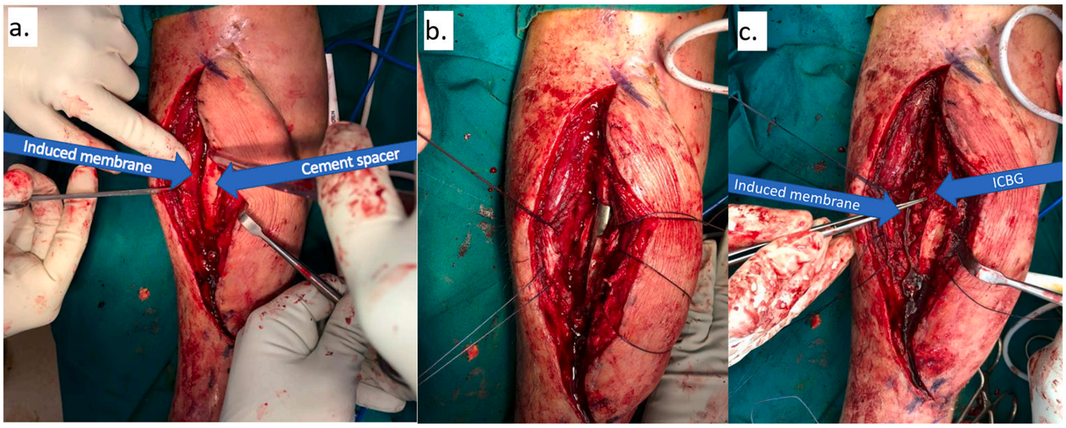

Fig. 5. Clinical photos of a: induced membrane elevated over cement spacer, b: removal of cement spacer and c: bone grafting using autologous anterior iliac crest bone graft (ICBG).

Discussion

We have found the Masquelet technique to be both versatile and effective for addressing bone defects in the setting of acute open fracture. This is in concurrence with multiple case reports on the use of Masquelet technique in addressing bone loss [4]. All cases presented achieved bone union and remained infection free however, one case required additional procedures due to arthrofibrosis.

Several studies have investigated the physiology of the induced membrane formed during the Masquelet technique. Klaue et al. showed in a sheep model that the membrane without bone graft was inefficient and that bone graft without a membrane was rapidly resorbed [5]. However, the combination of autogenous bone graft and preservation of the membrane resulted in bone segment reconstruction. The induced membrane prevents the resorption of the bone graft and promotes its vascularity and cortication by secretion of growth fractures such as vascular endothelial growth factor, transforming growth factor-b and bone morphogenic protein (BMP-2) [6].

The choice of bone graft in the second stage of the Masquelet technique is varied. The use of autograft confers osteogenetic,

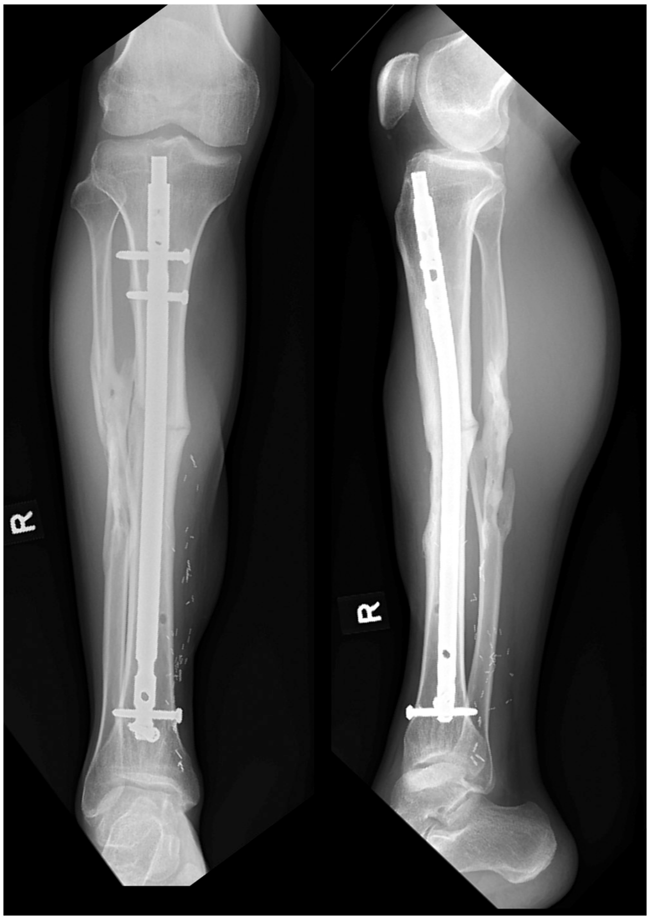

Fig. 6. One year post-operative radiodiographs of right leg.

osteoconductive and osteoinductive properties however, this may also be complicated by donor site morbidity as well as limited volume in large size bone defects. Where necessary, the addition of allograft bone chips to autogenous bone graft may be helpful and has been well described. In our practice, we aim to use autograft for smaller defect and mix auto/allograft (3:1 ratio) for larger defects with good results similar to existing literature although the optimal type of material for filling of the defect at the second stage also remains to be answered [7].

The duration of antibiotics post fixation is an area of controversy. In our institution, the duration of antibiotics is decided collaboratively with our medical team and plastic surgeons aided by clinical and biochemical indicators. In addition, we do not routinely perform intra-operative tissue cultures during stage two unless there are any concerns for infection. For case one, in the presence of a free-flap, the total duration of antibiotics given post fixation was two weeks. In case two and three, the total duration of antibiotics post fixation was one week. In the third case, intra-operative cultures were taken during stage two which revealed positive cultures growing *Enterobacter cloacae*. A total of six weeks antibiotics was given post stage two for case three. In the third case above, intra-operative cultures were taken during stage two as there was a poorly formed pseudomembrane which was worrisome for a low grade infection. With regards to choice of cement for Masquelet stage one, we prefer to use an gentamicin laden bone cement.

In the setting of diaphyseal fractures, we prefer the use of an intramedullary device as it has a faster time to full weight bearing, lower reoperation rates and because the nail acts as a central core, it reduced the overall volume of bone graft needed and limits the central graft necrosis [8].

Fig. 7. a-d. Clinical photographs showing patient at one year sitting cross-legged, with no clinical evidence of infection and performing a straight leg raise.

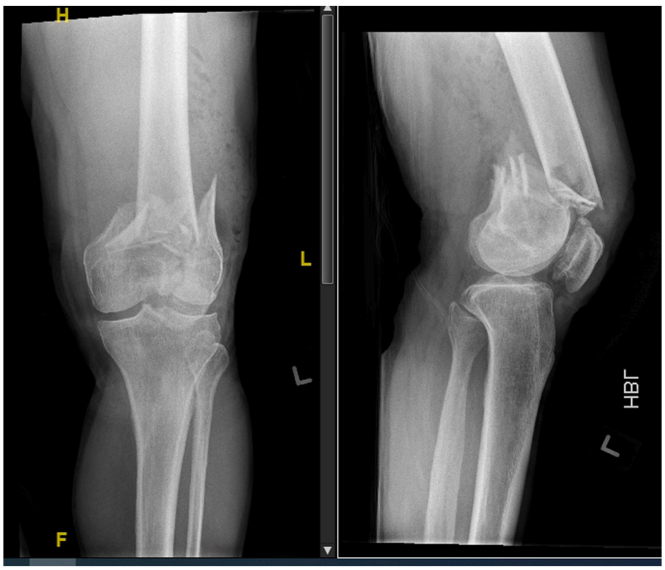

Fig. 8. Initial left knee radiographs after accident.

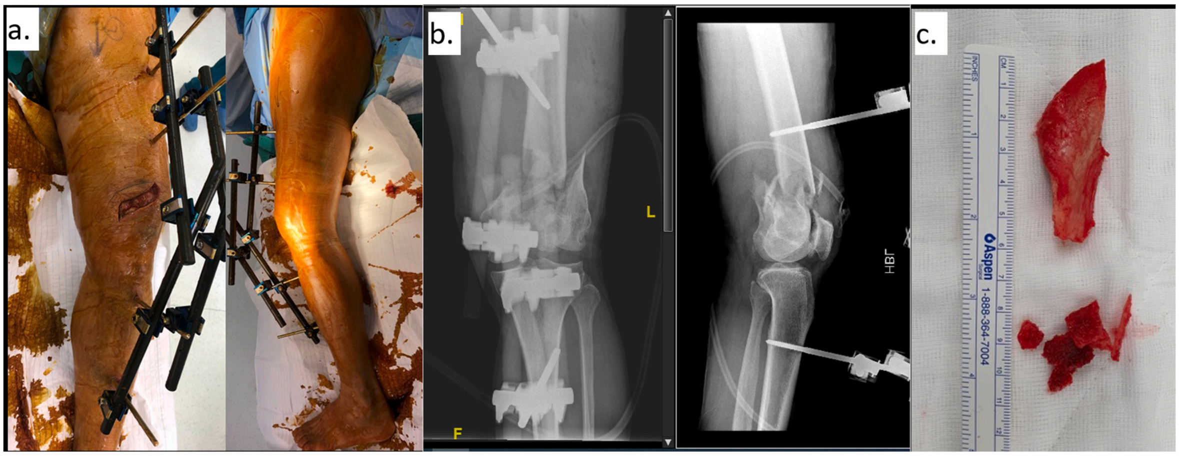

Fig. 9. Intra-operative photographs showing a: size of wound, b: bony alignment after application of a temporary external fixator and c: size of devitalised bone fragments removed.

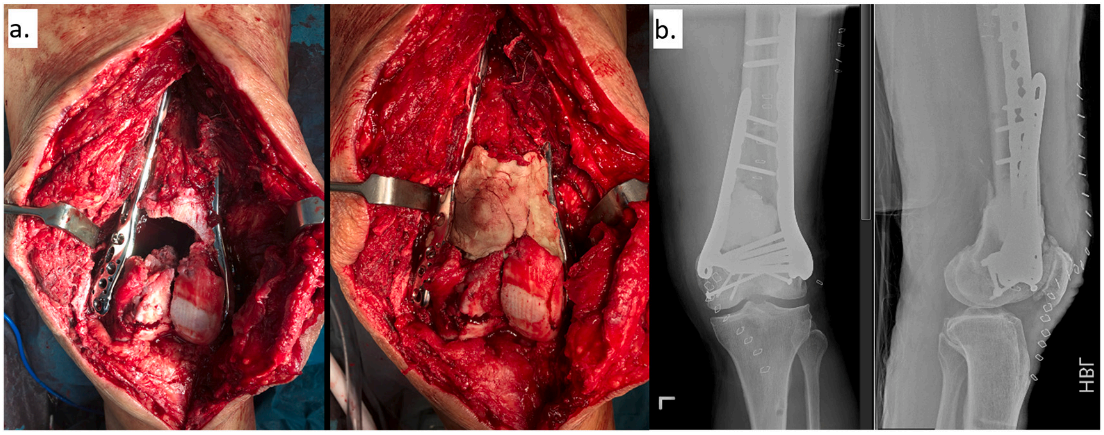

Fig. 10. a: Intra-operative photos post fixation with anterior metaphyseal bone defect and addition of cement of Masquelet stage I. b: Post-operative radiographs after Masquelet stage I.

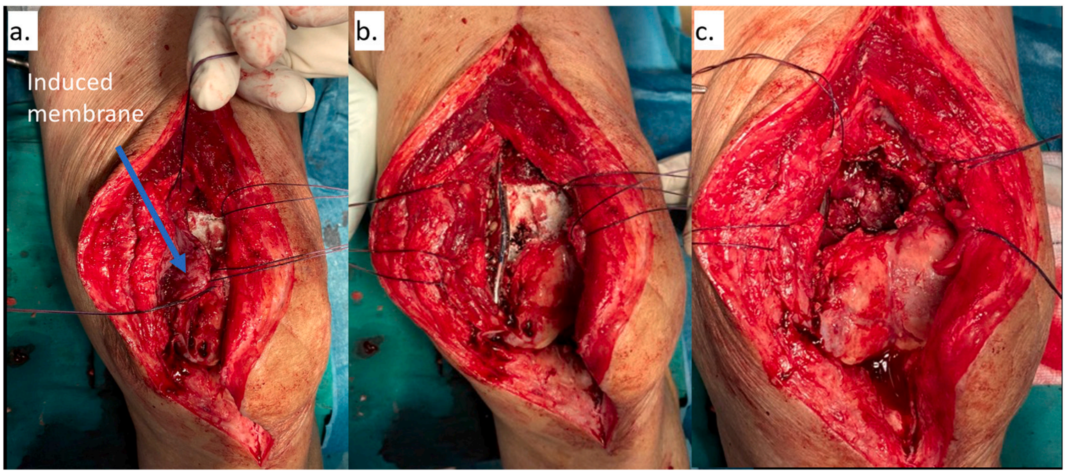

Fig. 11. Intra-operative photos showing a: the formation of induced membrane, b: cement spacer and c: bone defect after removal of cement spacer.

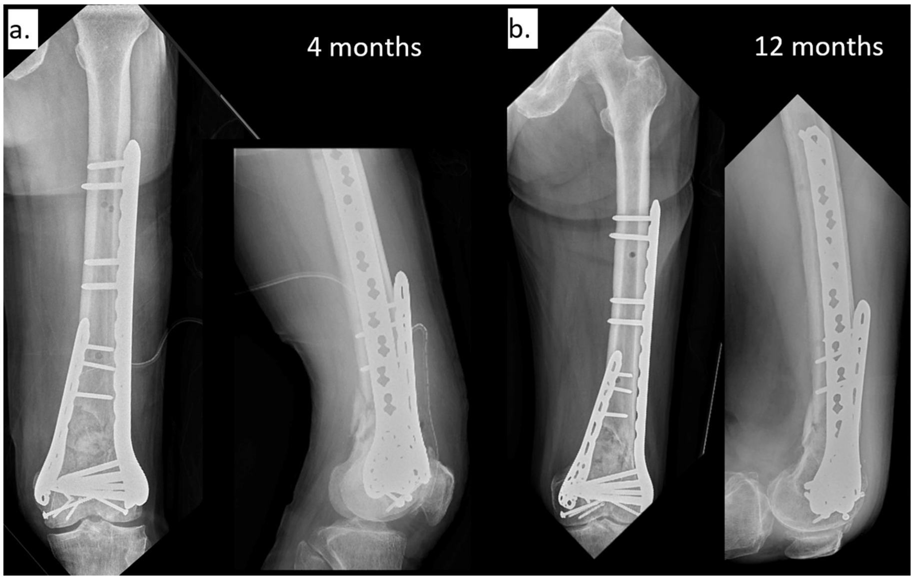

Fig. 12. Post-operative radiographs at a: 4 months and b: 12 months showing interval callus formation and union.

Fig. 13. Clinical photos at 1 year.

In the setting of articular fracture, current guidelines on open fractures suggest retention of articular cartilage large enough to contribute to articular stability [9]. However, often in open articular fractures, articular fragments may be lost and articular reconstruction may pose a challenge. We have attempted to address this articular bone defect in case three with Masquelet technique. An induced membrane was also noted over the cement spacer for articular bone loss during Masquelet stage II. Intra-operative confirmation after 18 months showed that fibrocartilaginous remodelling of the bone defect occurred with the use of masquelet technique in case 3.

In conclusion, we have found the Masquelet technique to versatile and effective in addressing diaphyseal, metaphyseal, epiphyseal bone defects in the setting of acute open fracture with bone loss.

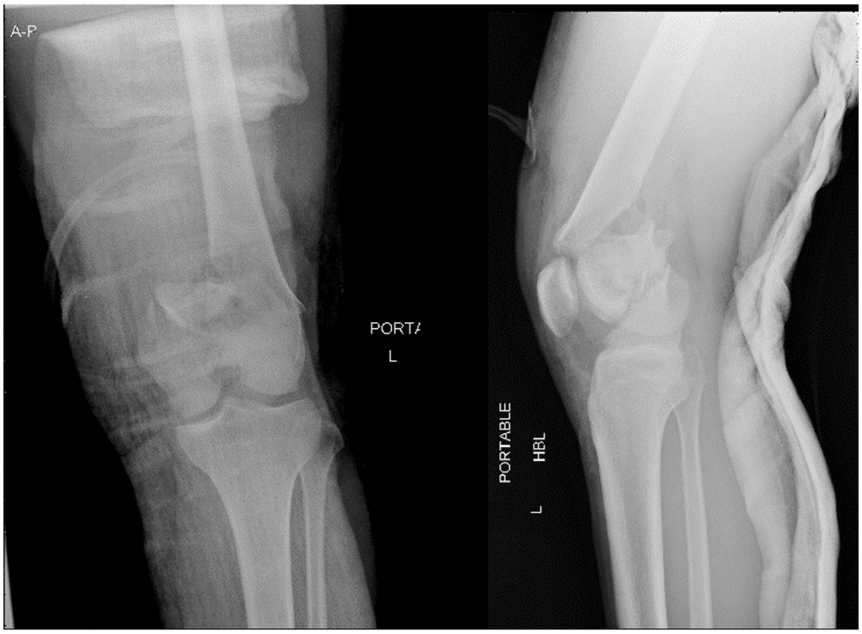

Fig. 14. Initial radiographs showing left distal femur intra-articular fracture.

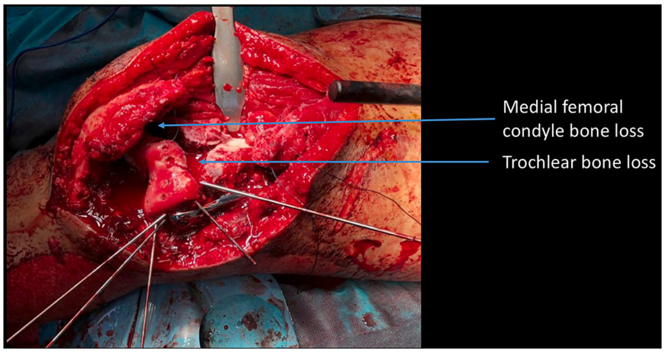

Fig. 15. Intra-operative photo showing bone defect over medial femoral condyle and trochlear.

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Declaration of competing interest

The authors declare that they have no conflicts of interest.

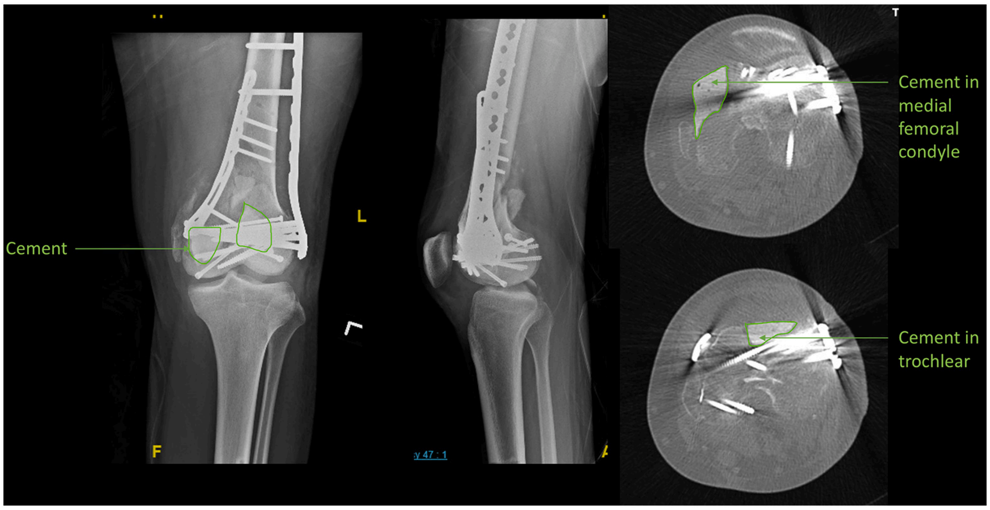

Fig. 16. Post-fixation radiographs with cement spacer inserted over area of articular bone loss.

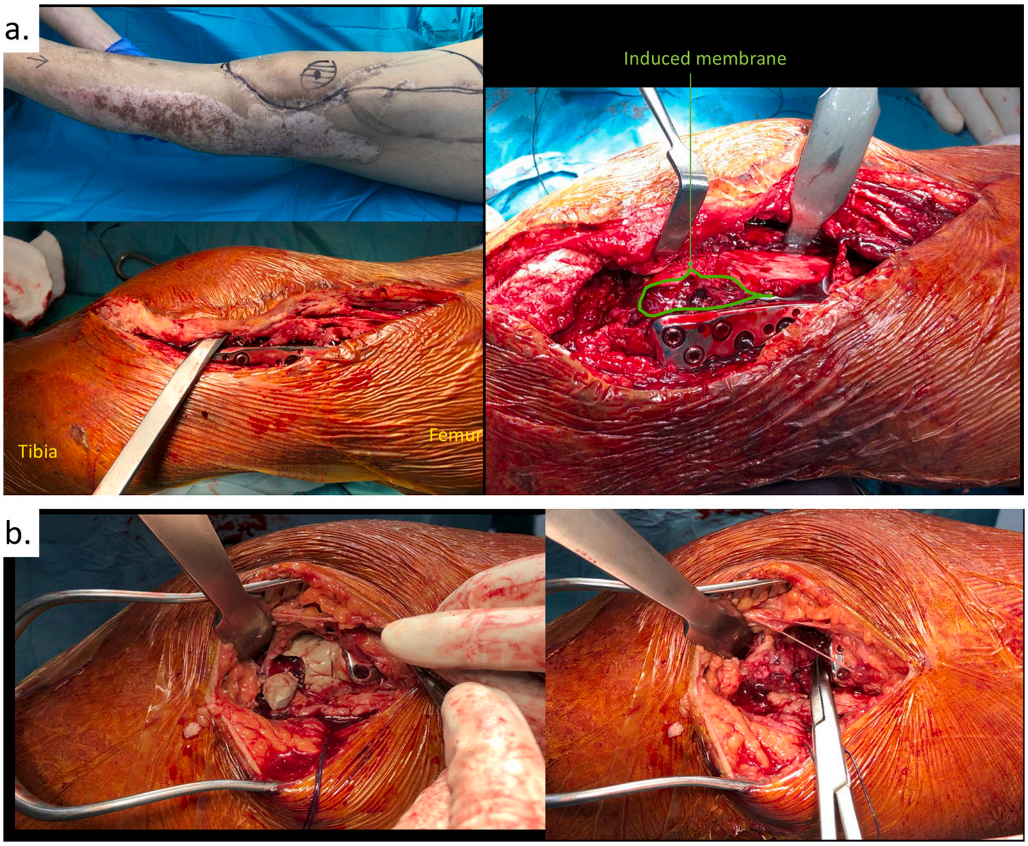

Fig. 17. a: Elevation of lateral soft tissue flap revealing induced membrane over trochlear bone defect. b: Cement spacer over medial femoral condyle with removal of cement spacer.

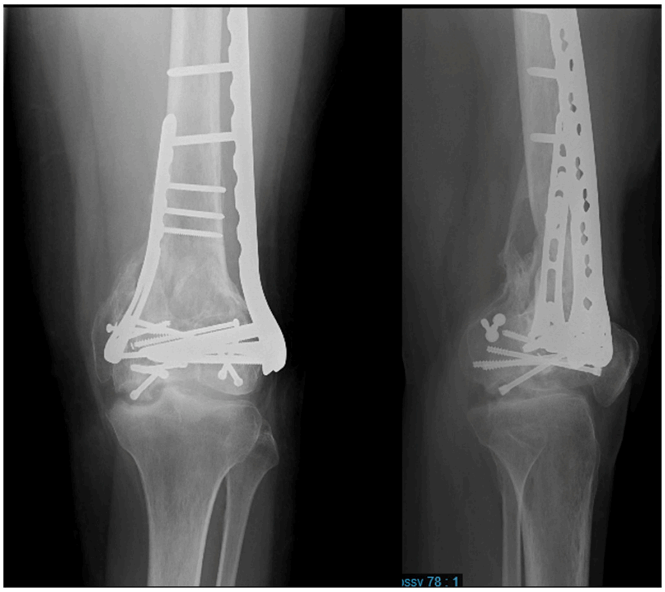

Fig. 18. Radiographs after Masquelet stage II.

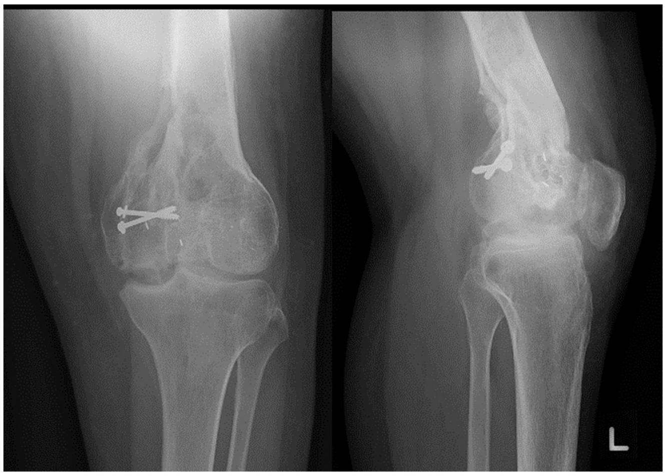

Fig. 19. Radiographs post removal of plates and screws.

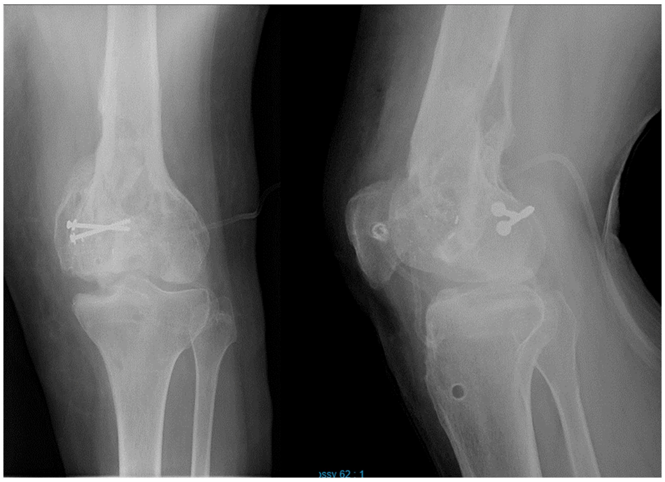

Fig. 20. a: Intraoperative photographs showing fibrocartilaginous remodelling of the trochlear bone defect. b: Post-operative radiographs of his left knee post patella lengthening and augmentation.

Fig. 21. Clinical photographs with left knee in flexion, extension, straight leg raise and standing 2 months post-operatively.

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