CASE REPORT

The Masquelet induced-membrane technique: an option for a tertiary-referral conflict setting

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Abstract
A post-traumatic, infected, non-union of a long bone is a significant challenge to orthopaedic surgeons, especially in zones of conflict and humanitarian settings. We describe a 32-year-old man treated with the two-stage Masquelet procedure for an infected non-union, and the processes required to achieve clinical bony union. The initial injury was a gunshot wound through the left proximal tibia, which lay untreated for three months before the first definitive surgical procedure. Subsequent management required 13 procedures over 18 months with clinical union being achieved 4.5 years after wounding. The management of an infected non-union of a long bone in zones of conflict is difficult. However, a successful outcome is still possible and the Masquelet procedure a suitable choice; amputation is not always the correct solution. There is a need in the humanitarian sector for healthcare facilities within easy reach of a zone of conflict that can undertake complex reconstructive procedures.

INTRODUCTION
The management of a post-traumatic, infected non-union of a long bone remains a significant orthopaedic challenge, especially in zones of conflict and humanitarian settings. Because of the destructive nature of ballistic injuries, the incidence of infection can be 30% [1].

In 2000, Masquelet et al. [2] reported 35 cases of two-stage bone reconstruction for large, infected, diaphyseal defects. However, they did not comment on the technique’s application for ballistic injuries.

We thus present a patient who sustained a gunshot wound to his left tibia, declined amputation, and the steps required to achieve an uninfected clinical union. The patient gave consent to present these findings.

CASE REPORT
Patient M was a 32-year-old male, shot through his left proximal tibia in Syria in 2012. He reached shelter and remained hidden and untreated for three months. All he had available were dressings.

Eventually, he attended a field hospital. An external fixator was applied and antibiotics given, although his tibial wound continued to discharge. The fixator was removed, a plaster back slab applied, and the patient crossed the border into Lebanon.

He was referred to our unit three years after wounding, in a plaster back slab, with an ununited fracture (Fig. 1a,b), and a discharging, 6 cms × 3 cms pretibial wound. Imaging and bacteriology for the period beforehand were not available.

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Amputation was discussed but declined by the patient. A two-stage Masquelet procedure was thus selected. A first-stage excision of the ununited area, 8cms in length, was undertaken and an external fixator applied (Hoffmann II; Stryker Trauma AG Bohnackerweg 1, CH-2545, Switzerland) (Fig. 2). A cement spacer (Hi-Fatigue Bone Cement, Zimmer Biomet, 1800 West Center St, Warsaw, Indiana 46 580, USA) was inserted, without antibiotic impregnation. Cultures revealed methicillin-sensitive and methicillin-resistant Staphylococcus aureus. Sensitivities were obtained, and intravenous vancomycin followed by oral clindamycin were given, for a total of ten weeks.

Wound cover was obtained with a tubularised cross-leg flap, and immobilization achieved with an external fixator (Hoffman II) (Fig. 3).

The flap was next weaned from the donor site, the contralateral component of the fixator removed, and the patient discharged 6 weeks after admission, without antibiotic therapy.

The patient was readmitted 6 months later for the second stage with a dry wound (Fig. 4). At surgery, a pseudosynovial membrane was found and preserved (Fig. 5). Fracture stabilization was with an interlocked 9-mm intramedullary Sign nail (Surgical Implant Generation Network, 451 Hills Street, Suite B, Richland, WA 99 354, USA). Cancellous autograft, obtained using a Reamer-Irrigation-Aspirator (RIA) (DePuy Synthes, Synthes

Figure 1: Anteroposterior (a) and lateral (b) radiographs of the left tibia and fibula on first admission to our unit, three years after initial wounding. The limb is in a plaster back slab with evidence of earlier use of external fixation. An ununited fracture can be seen at the junction of upper and middle thirds of the bone. Projectile debris may be seen posterior to the fracture.

Figure 2: Lateral radiograph after the first-stage Masquelet procedure. An external fixator is in position and a cement spacer bridges the gap left by excision of the infected bone.

Figure 3: Operative photograph of the cross-leg flap. The flap has been tubularised.

Figure 4: The cross-leg flap remains viable, six months after surgery.
GmbH, Eimattstrasse 3, 4436 Oberdorf, Switzerland) from the contralateral femur, was inserted into the cavity (Figs 6 and 7a,b).

The patient was discharged full-weight-bearing one month later, was subsequently readmitted for nail dynamization, then

Figure 5: Operative photograph during the second-stage Masquelet procedure. The incised pseudosynovial membrane is clearly seen.

Figure 6: Operative photograph showing the extensive cancellous bone graft (immediately to the left the suction tube) within the pseudosynovial membrane and around the intramedullary nail.

Figure 7: Postoperative anteroposterior (a) and lateral (b) radiographs of the left tibia and fibula demonstrating a Sign intramedullary nail surrounded by cancellous bone graft.

Figure 8: The broken intramedullary nail.

Figure 9: Anteroposterior (a) and lateral (b) radiographs of the left tibia and fibula 59 months after wounding. The patient was fully weight bearing and showed union of the distal fracture and proximal fibula. The proximal portion of the tibial fracture may possibly be ununited but the patient had returned to full activities, and without discomfort.

GmbH, Eimattstrasse 3, 4436 Oberdorf, Switzerland) from the contralateral femur, was inserted into the cavity (Figs 6 and 7a,b). The patient was discharged full-weight-bearing one month later, was subsequently readmitted for nail dynamization, then
discharged, but sustained additional trauma. Radiographs revealed a broken intramedullary nail (Fig. 8). This was exchanged for a 12-mm nail with bone autograft, the patient being discharged two weeks later. At final review, 59 months after wounding, he was walking painlessly and without sign of recurrent infection (Fig. 9a,b).

DISCUSSION

Infection has long been a problem in conflict wounds, with orthopaedic injuries accounting for approximately 65% of all combat wounds. The goals of orthopaedic management are to prevent infection, promote fracture healing and restore function [3]. To do this in a conflict setting is difficult. Our patient remained untreated for three months after wounding due to local circumstance and with only makeshift dressings being applied to a compound injury of his left proximal tibia. He eventually reached a field hospital. It was three years after the initial injury that the patient reached our unit. His wound had been discharging throughout.

This case highlights the importance of a tertiary surgical facility within range of a conflict zone, which must be able to treat casualties for lengthy periods. Civilians do not have access to the rapid aeromedical evacuation available to many regular forces. Our patient had multiple hospital admissions, required 13 surgical procedures after wounding, of which six were performed by us. It took 59 months from initial wounding for the tibial fracture to unite.

We chose the Masquelet technique [4] because of its two-stage simplicity and the limited need for specialist equipment. Its principle lies with the pseudosynovial membrane, whose main properties are to act as a biological chamber [5] that prevents graft resorption and secretes growth factors.

A meta-analysis of the Masquelet technique reported a union rate of 89.7% and resolution of infection in 91.1%. Bone defects ranged from 0.6 to 26 cms [6]. Although these results are promising [7–9], not all reports are good. One study showed union in only five of 12 patients, with two requiring amputation because of infection [10].

In addition to the need for elective humanitarian facilities within range of a conflict zone, this case also demonstrates that the Masquelet technique is suitable when managing the post-traumatic, infected non-union of a long bone caused by a ballistic injury.

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CONFLICT OF INTEREST STATEMENT

None declared.

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