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Reconstruction of a post-traumatic tibial defect of 10 cm in a 6 month old induced membrane by non-vascularised fibula autograft – A case report

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ABSTRACT

Reconstruction of post-traumatic large bone defect in tibia is a surgical challenge. Masquelet technique is a two stage procedure to achieve bone union. After cement spacer implantation in defect, optimal time for 2nd stage bone grafting is at 1 month. After 2 months, osteoinductive property of induced membrane is doubtful. We managed a post- traumatic tibial defect of 10 cm with cement spacer as 1st stage of Masquelet procedure. But 2nd stage was delayed for 6 months at which time osteoinductive property of induced membrane was doubtful. Osteopenia, pin track infection with stiff knee and ankle made 2nd stage surgery more challenging. We reconstructed 6 months old induced membrane with 12 cm non-vascularised fibula autograft in combination of cancellous autograft from iliac crest. The construct was fixed with locking compression plate on medial side. Patient achieved bone consolidation and successful union at 9 months with knee flexion of 100 degrees. This case demonstrated that induced membrane is able to preserve osteoinduction property even up to 6 months and with good structural support like fibula strut graft, successful reconstruction is possible in delayed 2nd stage of Masquelet technique.

Introduction

The induced membrane technique described by A.C.Masquelet is a two step procedure to treat bone defects and nonunion [1]. In first stage, after debridement a polymethyl methacrylate cement spacer is placed in the bony defect which is stabilised by a temporary external fixator. The spacer prevents fibrous invasion of defect and induces development of a surrounding pseudo-synovial membrane. In second stage, cement spacer is removed from induced membrane and grafting of the defect is done with definitive fixation.

The optimal period for 2nd stage surgery is considered to be 6–8 weeks. Around this period, membrane is secreting growth factors like bone morphogenic protein – 2 (BMP-2), vascular endothelial growth factor (VEGF) and transforming growth factor beta 1(TGF-beta1) optimally. Autologous bone grafts acts as scaffold allowing osteogenesis.

The optimal conditions for secondary graft union are based on empirical rules that are difficult to quantify, although the gold standard technique being the morselized cancellous autograft [2]. The optimal time for 2nd stage of Masquelet technique and ideal graft or bone substitute to fill large defects are still the subject of debate.

Here, we report a case with acute traumatic bone loss of tibia leading to 10 cm bone defect. After successful 1st stage with cement spacer implantation with flap cover of wound, his second stage surgery got delayed for 6 months. At 6 months, with doubtful

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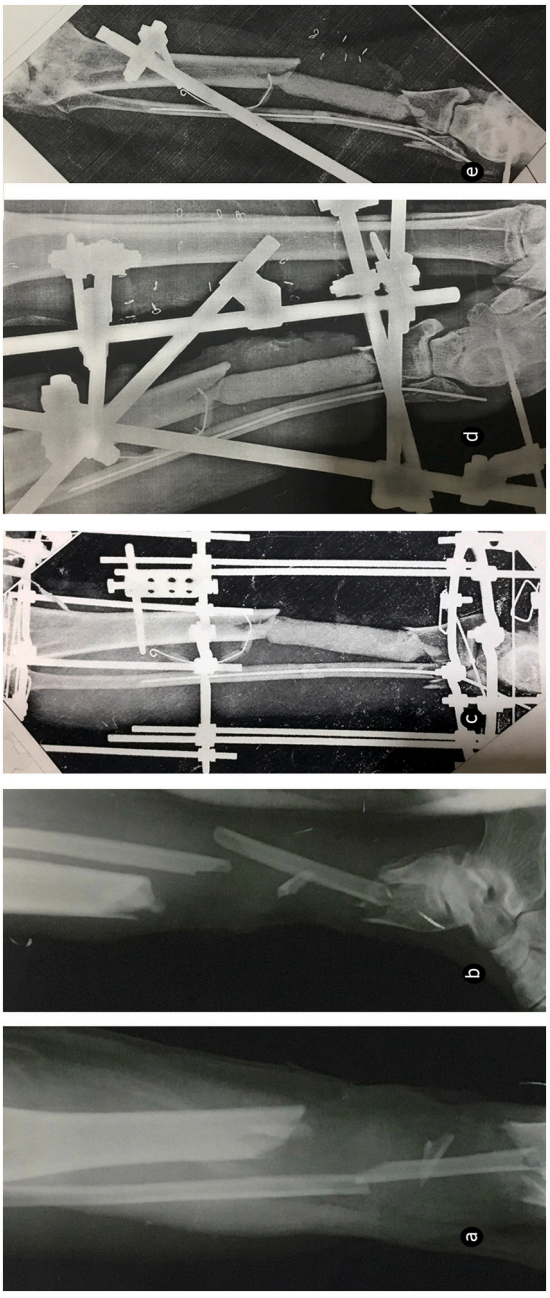

Fig. 1. a – Preoperative anteroposterior radiograph.
b – Preoperative lateral radiograph.
c – Postoperative radiograph after 1st stage of Masquelet technique.
d – Postoperative radiograph at 6 weeks after cross leg flap with external fixator.
e – Postoperative radiograph at 7 weeks after flap detachment.

osteogenesis quality of induced membrane, his large bone defect was filled with non vascularised fibula strut graft with definitive plate fixation. This is a rare scenario where 2nd stage was delayed and fibula strut was used as graft which posed surgical challenge in this experimental field of a biological chamber.

Case report

A 25 year old man, a shopkeeper by profession had a road traffic accident. He sustained high energy injury to right leg with wound on anteromedial aspect of lower leg with tissue and skin loss. The distal neurovascular was intact. Radiographs demonstrated fracture of tibia shaft with loss of 10 cm of tibia leading to gap from diaphysis to distal metaphysis. Fibula shaft had segmental displaced fracture (Fig. 1a, b). After debridement cement spacer with antibiotic vancomycin two gram was used to fill the defect, as a first stage of Masquelet technique along with antibiotic cement beads. Fibula was fixed with rush rod and tibia was stabilised with Ilizarov ring fixator (Fig. 1c). After six weeks, cross leg flap was performed to cover soft tissue defect. To allow cross leg flap, Ilizarov ring fixator was replaced with external fixator while antibiotic cement spacer was in situ (Fig. 1d). At seven weeks from index procedure, flap was detached and patient was discharged to home. Patient was asked to come after three weeks for 2nd stage of Masquelet procedure (Fig. 1e).

Unfortunately patient did not report on time due to financial problems. He returned after 6 months of index procedure with loose external fixator and pin track infection. Ankle was in equines deformity and knee was stiff with knee ROM 5–10 degrees. Flap over bony defect was mature and supple. Right leg radiographs demonstrated cement spacer in situ with loose external fixator pins and osteopenia of distal tibia fragment (Fig. 2a, b).

External fixator was removed and pin tracks were debrided one week before 2nd stage of Masquelet procedure. Six months after index surgery, 2nd stage was performed. Spacer was removed and induced membrane was found viable and intact. Non vascularised fibula strut graft of 12 cm was harvested from opposite leg. Fibula strut was drilled unicortically at multiple levels in different directions. This fibula strut was inserted in defect. Medial locking compression plate of 12 holes was inserted below flap as definitive internal fixation. Fibula strut was transfixed proximally with one cortical screw through plate. Fibula graft was also transfixed distally with locking screw through plate. Additional cancellous graft from iliac crest was used at both ends of fibula strut graft (Fig. 2c, d, e, f).

Postoperative knee and ankle range of movement was started immediately. Weight bearing was not allowed till six weeks postoperative. After 6 weeks partial weight bearing was started. Knee ROM improved to 0–90 degrees over period of 3 months. At 6 months, patient was allowed full weight bearing. On radiographs, fibula strut graft showed gradual consolidation and got incorporated with tibia at proximal and distal ends. Fibula fracture also united (Fig. 3a). Due to loosening of cortical screw which was used to transfix proximal end of fibula strut was removed after 2 years. At 3 years, fibula strut was fully incorporated with tibia with good union on radiographs. Clinically patient was walking without support without any sign of infection (Fig. 3b, c, d). Patient was back to his original job.

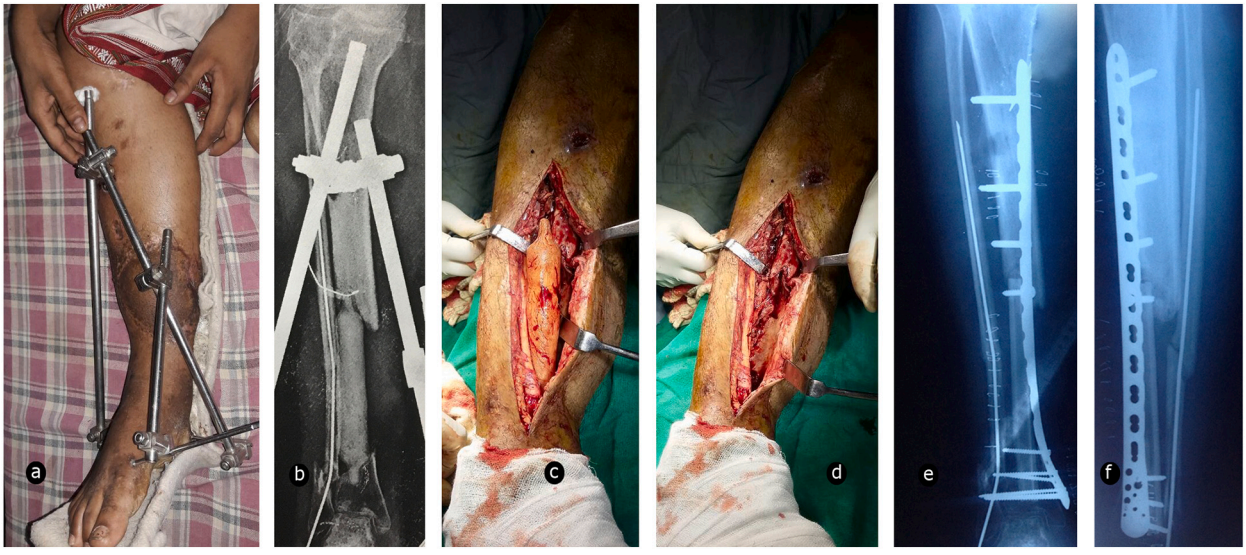

Fig. 2. a – Clinical picture of patient at 6 months with external fixator.
b – Anteroposterior radiograph at 6 months showing loose external fixator and osteopenia.
c – Intraoperative picture of removal of cement spacer at 2nd stage of Masquelet procedure.
d – Intraoperative picture of 6 months old Induced membrane.
e – Posteoperative anteroposterior radiograph after 2nd stage Masquelet procedure.
f – Postoperative lateral radiograph after 2nd stage Masquelet procedure.

Fig. 3. a – Anteroposterior and lateral radiograph at 9 months after 2nd stage Masquelet procedure.
b – Anteroposterior and lateral radiograph at 3 years after 2nd stage Masquelet procedure.
c – Clinical picture of patient with weight bearing and full knee extension.
d – Clinical picture of patient with pain free squatting and 120 degree knee flexion.

Discussion

The reconstruction of wide long bone diaphyseal defects is often the major challenge in limb salvage. When diaphyseal defects larger than 6 cm are reconstructed with autologous bone graft, healing is incomplete because of graft resorption even in a good vascularised muscular envelope [3]. Alain Masquelet [1] developed induced membrane technique to make bone reconstruction more reliable as time of bone consolidation is independent of defect size. In 1st stage, cement spacer is inserted to create an induced membrane. This is a biological chamber which provides vascular supply to bone grafts inserted in 2nd stage and also secretes growth factors.

Ph. Pelissier et al. [4] in their study demonstrated high concentrations of growth factors like VEGF and TGF beta 1 in induced membrane till 6 weeks as compared to control. AHO O M et al. [5] demonstrated the vascularisation of induced membrane was greatest at 1 month and decreases to <60% at 3 months. Highest levels of VEGF, interleukin-6 (IL-6) and type 1 collagen (Col-1) at 1 month decreases to 40% at 2 months. Alkaline phosphatase activity and Ca+ deposition were highest at 1 month compared to 2 month old membrane. They recommended optimal time for performing 2nd stage surgery within a month.

Although all articles studied and discussed the optimal time for 2nd stage, no article has studied the outer limits for 2nd stage. The maximum time possible till which 2nd stage can be delayed while preserving the osteoinductive property of membrane is not mentioned in literature.

Our case was peculiar, as 2nd stage got delayed till 6 months. This surgery was challenging as osteoinductive quality of induced membrane was doubtful in 6 months old membrane.

The other challenge in managing big bone defects by induced membrane technique is to decide which graft material will most likely give quick union and best mechanical support. The gold standard graft material is the cancellous autograft in small chips of no more than 1–2 mm. The graft harvested from medullary cavity of long bones by the RIA (reaming, irrigating, aspirating) procedure increases the capacity of bone reconstruction. But using RIA alone may lead in irregular union due to insufficient revascularisation of the central part of the graft [6]. Other bone graft options are also available like vascularised/non vascularised fibula strut graft, autologous/allogenous graft, demineralised bone matrix (DBM), demineralised bovine bone and bone substitutes.

But these different types of graft material are very sparsely used and are also very rarely discussed in published literature. Use of fibula as graft is one such graft material which is used rarely. Karger et al. [2] has used vascularised fibula grafts for two patients in 84 patient series with successful union. Donegan [7] used vascularised fibula in one case out of 11 which was sarcoma patient with post irradiation bone defect. Kawakami [8] used only one vascularised fibula out of six cases in forearm fracture with MRSA infection. There is no mention of non vascularised fibula graft use in published literature. Morelli et al. [9] in systemic review of Masquelet technique, concluded that since the length of the defect has been variable, different graft expanders have been used to fill in the defect with no standardised ratios used for optimum bone graft integration.

In our case, due to financial constraints, poor compliance and large defect, options like RIA, DBM or vascularised fibula graft were not possible. To our best knowledge, this is a rare scenario where we have used non vascularised fibula strut graft with autologous cancellous graft at both ends of reconstruction to provide structural mechanical support along with osteoinduction in a 6 months delayed 2nd stage Masquelet technique. Overall, the patient was fully weight bearing on affected leg with full consolidation of tibial bone defect without infection and back to his pre injury job. With help of Masquelet technique we were able to reduce morbidity and functional impairment of this patient by achieving bony union.

As Prof. Masquelet [3] had quoted poet Goethe from his book The Metamorphosis of plants; “ The envelope may be bark, skin or shell, all that is living should be wrapped up”, fits well to this case in poetic sense.

Declaration of competing interest

None.

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