

## Original Research Article

# First metatarsal bone reconstruction using Masquelet's technique after bone loss in open III B injury

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### ABSTRACT

**Background:** Masquelet technique involves two stages for reconstruction of bony defects. During stage one decontamination and debridement is performed. The bone defect is filled by a spacer made of bone cement. After a gap of around 6 weeks, a bio-membrane is established around the cement spacer. During stage two, the cement spacer is removed and cancellous autologous bone graft is used to fill the space that was previously occupied by the cement spacer. However, there is a huge scarcity of literature on reconstruction of bone defects in foot metatarsals, especially open injuries that require soft tissue coverage also.

**Methods:** This prospective study involved 25 patients with a minimum follow-up of 12 months. Masquelet's technique was used to reconstruct large bony defects in metatarsals of foot in a staged manner. The primary outcome variable was union and consolidation of the bone. The secondary outcome variables included complications and functional outcome using Maryland foot score.

**Results:** One of the patients needed a below knee amputation for extensive bone and soft tissue infection. Pin site infection was the commonest indication observed and deep infection was observed on table at the time of second stage in two patients. Both the patients needed a re-do of stage one and a new cement spacer was placed which was removed at six weeks. Hallux varus deformity was observed in two patients at the final follow-up. Excluding the patient that needed amputation, all the patients had consolidation and union at the final follow-up and the mean Maryland foot score was  $79.45 \pm 8.8$ . Good to excellent functional outcome was observed among 91.66% patients.

**Conclusions:** Masquelet's induced membrane technique is a potentially fruitful method to deal with bone defects created by open fractures of metatarsals of feet. However, due to limited sample size and lack of control group, we recommend large scale randomized control trials be conducted on the subject.

**Keywords:** Masquelet's technique, Induced membrane, Metatarsal fracture

### INTRODUCTION

Management of diaphyseal bone defects of metatarsals of foot is very complex. Bone defects of less than 5 cm can be managed with autogenous bone grafting.<sup>1</sup> However, for larger defects few options of management are available, which include distraction osteogenesis by bone transfer and vascularized fibula graft. Both mentioned

options have various disadvantages. Distraction osteogenesis requires mini external fixators (distractors) to be placed which are complicated with pin tract infections and malunion, in addition to patient compliance issues.<sup>2</sup> Vascular free fibula grafting leads to significant donor side morbidity and high degree of skill.<sup>3</sup>

Induced membrane technique (IMT) was pioneered by Masquelet to reconstruct large bony defects in long

bones.<sup>4</sup> Masquelet technique involves two stages for reconstruction of defects. During stage one decontamination and debridement is performed. The bone defect is filled by a spacer made of bone cement. After a gap of around 6 weeks, a bio-membrane is established around the cement spacer. During stage two, the cement spacer is removed and cancellous autologous bone graft is used to fill the space that was previously occupied by the cement spacer. Extensive research has been conducted verifying the effectiveness of the Masquelet technique.<sup>5-18</sup>

However, there is huge scarcity of literature on reconstruction of bone defects in foot metatarsals, especially open injuries that require soft tissue coverage also.<sup>19,20</sup> In present study, we present series of 25 patients with open type IIIB fractures of first metatarsal with significant bone loss managed with Masquelet technique.

## METHODS

The present prospective study was carried out at government medical college, Jammu from August, 2018 to October, 2022. We included 25 patients with open IIIB fractures of the 1<sup>st</sup> metatarsal managed with Masquelet's staged induced membrane technique. All the patients provided informed written consent for participation in the present study and ethical clearance was given by institutional ethical committee.

### Inclusion criteria

Patients with age >18 years, open Gustilo-Anderson type IIIB fracture of 1<sup>st</sup> metatarsal of foot, early presentation (injury <48 hours old) were included in the study.

### Exclusion criteria

Children with age <18 years, closed fractures and delayed presentation (>48 hours old injury) excluded.

All the patients were initially received in the emergency wing of the orthopedics and were initially stabilized using advanced trauma life support (ATLS) protocol. The patients received prophylactic antibiotics and tetanus toxoid in the emergency. A thorough decontamination of the open wounds was carried out with copious saline irrigation and initial anti-septic dressings and splintage was performed. Requisite radiographs were ordered and base line bloodwork was collected.

Spinal anaesthesia was used in all the patients. Once the patients were stabilized, stage one of Masquelet technique was performed in emergency operating room. This included soft tissue debridement and removal of the devitalized bone (Figure 1). The defect was filled with a spacer molded from bone cement and a mini-external fixator (distractor) was used fix the bone. The exposed soft tissue reconstructed using a rotational/a free flap.

Wound dressings were changed on 3<sup>rd</sup> post-operative day and after a time gap of 6-10 weeks the cement spacer was removed during the second stage of Masquelet. The mini-external fixator was also removed at this stage and was replaced by a 2.0 mm Kirschner wire (K wire) and gap filled with fibula strut and morselized cancellous graft harvested from iliac crest. In patients with significant infection detected on table during stage two, thorough debridement was done followed by a new bone cement spacer. Toe touch weight bearing was started immediately post-surgery as pain allowed. Patients were advised full weight bearing only after radiological union appreciated.

Patients were followed for a minimum of 12 months after second stage surgery. The primary outcome variable was radiological union. The secondary outcome variables included Maryland foot score at final follow-up and the complication profile. Mean, percentage and standard deviation was the data was calculated. The statistical analysis of the data was performed using SPSS statistics programme version 20 (IBM, Armonk, NY, USA).

## RESULTS

Demographic details have been tabulated in Table 1. The average age of the study participants was 34.73±9.67 years with a male to female ratio of 3.16:1. Most common cause of injury was road traffic accident (72%) followed by crush due to fall of heavy weight on foot and machine injury. Average time between first and the second stage was 7.16±1.3 (range 6-10) weeks. Average follow-up period for the study was 15±1.9 months.

**Table 1: Demographic details of study participants.**

Variables	Observation, n (%)
<b>Age of patients (Mean ± SD) (Years)</b>	34.73±9.67 (Range: 20-51)
<b>Gender</b>	
Male	19 (76)
Female	06 (24)
Male: female	3.16:1
<b>Mechanism of injury</b>	
Road traffic accident	18 (72)
Crush with heavy weight	04 (16)
Machine injury	03 (12)
<b>Mean time interval between 1<sup>st</sup> and 2<sup>nd</sup> stage</b>	7.16±1.3 weeks
<b>Mean final follow-up</b>	15±1.9 months
<b>Average Marylan foot score at final follow-up</b>	79.45±8.8

The complication profile shown in Table 2. One of the patients needed a below knee amputation for extensive bone and soft tissue infection. Pin site infection commonest indication observed in three patients and managed with pin site dressings and antibiotics. Deep infection was observed on table at time of 2 stage in two patients. Both patients needed a re-do of stage one and a

new cement spacer was placed which was removed at 6 weeks. Hallux varus deformity observed in 2 patients at final follow-up. Both patients were not bothered about the deformity and were able to manage their activities.

**Table 2: Complication profile.**

Complications	N	Percentage (%)
Pin site infection	03	12
Hallux varus	02	08
Deep infection	02	08
Redo 1 <sup>st</sup> stage	02	08
Amputation	01	04

**Table 3: Final functional result as calculated on the basis of Maryland foot score.**

Results	N	Percentage (%)
Excellent	07	29.16
Good	15	62.50
Fair	02	08.30
Poor	0	0
Total	24	100



**Figure 1 (A-E): 32 year old male with Gustilo Anderson open type IIIB injury of right foot. Picture at time of wound debridement in emergency operating room. Pre-op radiograph of comminuted fracture of 1<sup>st</sup> metatarsal shaft, radiograph after stage 1 Masquelet with K-wire and cement spacer *in situ* clinical photo of patient at final follow-up with obvious hallux varus and radiograph of patient of consolidation and union.**

Excluding the patient that needed amputation, all patients had consolidation and union at final follow-up and mean Maryland foot score was 79.45±8.8. Good to excellent functional outcome was observed in nine patients (91.66%) and 2 patients had fair outcome (Table 3).

**DISCUSSION**

Masquelet technique has been evaluated by thorough research in both animal and human studies. The technique has been well established to be a great weapon in the pocket of an orthopaedician for infected and non-infected long bone non-unions. However, there is scarcity of literature on the use of Masquelet’s technique for bony defects in open fractures of foot. In the present series, we evaluated the outcome of the IMT for open type IIIB fractures of metatarsals of foot. To our knowledge, this is the first series on the subject and any literature prior to this are in the form of case reports. Pelissier et al have reported a case report in which they reconstructed the dorsal aspect of foot using Masquelet technique and reported satisfactory results.<sup>10</sup> However, they reported many difficulties during the process. Makridis et al also presented a case report in which they successfully treated a patient of 1<sup>st</sup> metatarsal bony loss using induced membrane technique of Masquelet.<sup>19</sup> Largey et al presented a case of crush foot with extensive bone loss of medial cuneiform and managed the patient with a cross leg flap and IMT.<sup>8</sup>

There are many advantages of the IMT for reconstruction of 1<sup>st</sup> metatarsal bone defects. The cement spacer acts as a scaffold and also helps deliver high concentration of antibiotics which is very fruitful to prevent infection. In addition to this, the biomembrane provides a good environment to the graft and prevents graft resorption. However, initial debridement at first stage is the key to prevent infection.

In the present series, most of the patients had a good outcome, although few complications were observed. The one patient who landed up with a below knee amputation developed serious infection and had uncontrolled diabetes. Barring that, all the patients were satisfied with the final result and the primary outcome variable of consolidation and union was achieved in all patients. Two patients with hallux varus could be attributed to the use of only K-wires and inadequate stability that ensues. Hence, plating would be a better option than K-wires. The obvious limitations of the present study include a small sample size and lack of a control group. Hence, we recommend large scale randomized control trials on the subject to be carried out.

**CONCLUSION**

Masquelet’s induced membrane technique is a potentially fruitful method to deal with bone defects created by open fractures of metatarsals of feet. However, due to limited

sample size and lack of control group, recommend large scale randomized control trials be conducted on subject.

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