Research article
Masquelet technique in management of infective non-union of long bones- A prospective study

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ABSTRACT

Introduction and Aim: Masquelet’s technique is a 2-staged procedure, for treatment of infected segmental bone defect. 1st stage involves radical debridement with antibiotic-induced cement spacer. During second stage, the spacer is removed and the autologous bone graft is applied into the biomembrane formed. In this study, we evaluate the Masquelet’s technique for the management of infective non-union of long bones.

Materials and Methods: 15 patients with infective non-union of long bones- tibia, femur and a case of congenital pseudoarthrosis of tibia, were treated with Masquelet’s technique. They underwent 2 stages of procedures 6–8 weeks apart and was followed up for about 9 months and radiological and clinical outcomes were assessed.

Results: Out of 15 patients with infective non-union, 8 patients attained union. Out of the 7 patients with failure of the technique, higher failure rates were attributed to Pseudomonas infection.

Conclusion: Masquelet’s technique is a cost-effective method for treating infective segmental non-unions, not requiring special training or sophisticated instruments. This method shows good results with Gram positive infections. Although, the outcome with Pseudomonas aeruginosa infection, have not shown satisfactory results.

Keywords: Masquelet’s technique; antibiotic-induced cement spacer; biomembrane; pseudomonas infection; infective non-union.

INTRODUCTION

Non-union with bone defects are complicated to treat, with resultant significant morbidity (1-3). The complex treatment and unpredictable outcome often add to the problem. Historically due to complications, amputation was preferred treatment of large segmental bone defects. Limb salvage procedures have been developed only over half a century back (4,5). Bone defects of 2–4 cm are treated with conventional bone grafts. But excessive bone resorption from these grafts was often an unavoidable risk. Larger bone defects of more than 4 cm require the need for bone transport to achieve limb length. Ilizarov bone transport, vascularised bone graft, Limb Reconstructive System are used with varying success rates. All of these methods, technically do not function against infection (6). A novel method, has been developed by Masquelet which utilises body’s natural foreign body response and regenerative capabilities (7). Masquelet Technique is an efficient method of managing segmental bone defect, involving 2 staged procedures.

1st Stage
1. Radical debridement of the bone edges and fixation and stabilisation of bony fragments with External Fixators in case of open fracture, and plates and nails in case of closed fractures.
2. Placement of Antibiotic Bone Cement (PMMA) spacer at the site of defect.
3. As described by Masquelet and Begue, the antibiotic of choice in these spacers are Vancomycin 2g and Gentamycin 80mg.

2nd Stage
1. Further debridement of bone ends with opening up of medullary cavity for Endosteal communication.
2. Identification of biomembrane formed around the spacer and incising it carefully.

This stage is usually done at an optimal period of 4-8 weeks after 1st stage (cementation). The membrane formation and maturation take around 4-5 weeks.

The biomembrane is formed around the spacer as a result of foreign body reaction to it and it consists of high concentrations of growth factors including those facilitating vascular growth and osteogenesis. This, therefore increases bone growth and reconstruction, reduces bone resorption and increases vascularity. This causes an improved bone healing and union at the defect site with bone graft.

In our study, we summarise the outcomes of 15 cases treated with Masquelet technique for the treatment of infective non-unions of long bones.
MATERIALS AND METHODS
Fifteen patients with infected non-union of long bones were taken up for the study.

Out of 15 patients with non-union
- 10 patients with Tibial Non-union
- 4 patients with Femoral Non-union
- 1 patient with Congenital Pseudoarthrosis of Tibia

In our study, during the stage 1, for bone fixation, External Fixators were used when soft tissue cover was deficient. Nailing was done when soft tissue cover was adequate.

Out of 10 patients with Tibial Non-union:
- 7 patients underwent Intramedullary Nailing
- 3 patients underwent External Fixator Application

Out of 4 patients with Femoral Non-union:
- 3 patients underwent Intramedullary Nailing
- 1 patient underwent External Fixator Application

1 patient with congenital Pseudoarthrosis underwent K-wire fixation

In the study, during Stage 1, Bone cements with appropriate antibiotics were placed as spacer.

In patients with Gram positive organism, Vancomycin 1.5 g + Meropenem 500 mg were added to Cement Spacer. In case of Gram-Negative infections, Meropenem 1.5g was added.

Out of total of 15 patients in the study, 9 patients had gram positive infection and 6 patients suffered from Gram negative (E. coli and Pseudomonas) infection.

The bone cement spacer was then applied to fill the bony defect. Care is taken to ensure the bone ends are completely covered with the spacer and the fracture surfaces are overlapped by the cement spacer. Over stuffing of the defect with bone cement should also be avoided.

After 8 weeks, fracture site is identified. Biomembrane is recognised and carefully dissected to completely extract the bone cement enbloc.

After bone cement removal, Autologous Bone Graft harvested from iliac crest was used to fill up the bone defect. Membrane is carefully closed and left intact over the bone graft.

Patients who underwent IM Nailing were allowed to mobilise with full weight bearing, while patients on External fixators were permitted only for non-weight bearing mobilisation.

Postoperatively, serial x-rays were taken at 6 weeks, 3 months, 6 months and 9 months. At each visit, ESR and CRP values were also assessed to check for infections.

RESULTS
Total of 15 patients with 10 tibial non-unions, 4 femur non-unions and 1 congenital pseudoarthrosis of tibia were included in the study.

Of 10 tibial non-unions, 7 patients acquired complete healing of non-union site. Membrane formed after 8 weeks and subsequently fracture went into union 8 months after bone grafting. Remaining 3 patients had deficient membrane by the end of 8 weeks, of which 1 patient underwent repeat bone cement application. 2 people were subsequently converted to Ilizarov fixator and bone transport.

Out of 4 cases of femur non-unions, 3 patients required alternative treatment because of deficient membrane and only 1 attained union.

One patient with congenital pseudoarthrosis of tibia required secondary debridement and showed failure of biomembrane formation, subsequently converted to Ilizarov fixator with bone transport.

In total, 8 patients achieved union and 7 patients were switched to other forms of treatment. Out of these 7 patients, 6 patients were found to have Gram negative infection and 1 patient was with MRSA infection.

Higher failure rates are hence seen more in Gram Negative infections particularly those with Pseudomonas infection.

Fig. 1: 50 years’ old male with an infected non-union of Tibia with IMIL nail in-situ and a pus culture, which grew Pseudomonas aeruginosa. (A) X-ray appearance showing the non-union with a bony defect. (B) Intraop picture showing the defect, after IMIL nail has been removed. (C) 8 weeks postop after application of PMMA showing deficient formation of biomembrane.
DISCUSSION

Infective non-unions remain a challenging herculean task to treat in orthopaedic trauma (1-4). There is significant morbidity associated with treatment of non-union with a negative long-term effect on patients with functional outcome being less than satisfactory. Various treatment modalities are used to treat infective non-union. The use of bone cement as a carrier of Antibiotics have been used since a long time. Masquelet described his procedure for treating segmental gap infective non-unions. This is a two staged procedure involving radical debridement of the bone ends and application of cement spacer with Antibiotics. Fixation is done by nail, plate or external fixator. In our study, we fixed the non-union with IM nails and one child with congenital pseudoarthrosis with K wire. We used Vancomycin for Gram positive and Meropenam for Gram negative organisms. The cement spacer is removed at 8 weeks and bone graft is harvested from iliac crest and defect is filled. The cement spacer provides and maintains a well-defined void for the later placement of bone grafts by inhibiting the fibrous ingrowth into the space and reinforcing the structural stability of the construct. The membrane is carefully dissected from bone cement and it is closed after application of bone graft.

Kasha et al., in their study, have proved that the membrane avoided the resorption of cancellous bone graft and had a positive impact on healing of autograft (6). In our study, 7 patients had deficient membrane and subsequently converted to Ilizarov technique. It was found that, patients with Pseudomonas infection had deficient membrane, probably due to the slime layer secreted by the organism over bone cement. 8 patients had developed membrane and subsequently went on for healing. The average duration of healing in our study was 8 months.

Kasha et al., also stated that the best period to perform bone grafting is after 1 month of cement application due to highest level of BMP-2 (Bone Morphogenetic Protein) secretion by the end of 4th week (6). In our study, we monitored ESR and CRP weekly and it took 6-8 weeks for the inflammatory markers to come down. Hence, second procedure was done 6-8 weeks after the first.

Pellisier et al., have observed through their study that the biomembrane secretes a large amount of growth factors including vascular and osteoinductive factors(7).

Studies have shown that use of Bone adjuvants like Demineralised Allograft, in addition to Cancellous bone autograft can be considered if the amount of Autograft is inadequate, but the ratio of allograft to autograft should not exceed 1:3. In our study, we have used only Cancellous Bone grafts from iliac crest.

He stated that loose packing of the bone graft should be avoided as the central grafts in such cases can go for resorption. We did not loosely pack the graft, instead, the membrane was closed adequately after the graft application.

Woon et al., did a study on the induced membrane and stated the thickness of membrane as 0.5 mm - 1 mm and described it as hyper vascular and impermeable (8). Accadbled et al., in his study reported failure of Masquelet technique in femur non-unions (9). In our study, we noted one failure of Masquelet due to concurrent Pseudomonas infection. There is perhaps no study till date that compares the outcomes of Masquelet technique between Gram positive and Gram-negative infections.

Accadbled et al., (9) in their study reported successful outcome of 17 cm defect in tibia with methicillin resistant Staphylococcus aureus. In our study, we had both MRSA and Pseudomonas infection which went into failure. The higher failure rates with
Pseudomonas infection are attributed to the ability of the organism to grow slime layer beneath the membrane. One of the reasons for the higher failure rates with Gram negative infections may be due to inability to provide prolonged antibiotics in Gram negative infections due to higher incidence of nephrotoxicity.

**CONCLUSION**

Masquelet technique can be considered a good option for treatment of infective non-union. In our study, there was good outcome noted in case of Gram-positive infections and poor outcome with Pseudomonas infection. Further studies are needed to study the outcome of Masquelet technique in Pseudomonas infection.

**CONFLICT OF INTEREST**

The authors declare no conflict of interest.

**REFERENCES**


