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Research Article

MASQUELET PROCEDURE: A NOVEL APPROACH FOR ADDRESSING POST-TRAUMATIC BONE DEFECTS

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ABSTRACT

Objectives: This study aims to assess the efficacy of the Masquelet technique in addressing post-traumatic long bone defects. Through a two-stage process involving temporary spacer implantation and subsequent staged bone grafting, the objective is to evaluate the technique's ability to provide mechanical stability, combat infections, and promote successful osseous consolidation, affirming its viability as a surgical solution.

Methods: From January 2019 to December 2022, we enrolled patients with post-traumatic bone defects treated using the Masquelet technique. Comprehensive evaluations included injury nature, defect location, soft-tissue condition, defect extent, antibiotics, and cementation duration. We documented fixation methods, infections, and the patient's current health status for a thorough assessment.

Results: In this study of 15 consecutive patients (ten men, five women; average age 43), bone defects were diverse in location (six tibia, four femur, three humerus, one olecranon, and one calcaneum). Eight cases involved closed fractures with infection/nonunion; seven were open fractures (Gustilo II/IIIA). Spacer antibiotic use (gentamicin/vancomycin), bone consolidation, and limb stabilization were successful, with no reported complications in the 40-day average follow-up period.

Conclusion: The delayed bone grafting approach, following cement spacer placement, presents a promising solution for significant bone loss in extremity reconstruction. This method, whether immediate or delayed, demonstrates favorable outcomes, with the induced membrane fostering a conducive environment for bone formation. As broader adoption occurs, ongoing clinical evidence will further clarify optimal graft materials, solidifying the efficacy of this innovative strategy in addressing segmental bone loss.

Keywords: Masquelet technique, Posttraumatic bone defects, Biomembrane.

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INTRODUCTION

Segmental bone defects resulting from traumatic injuries pose complex challenges and can lead to significant long-term health issues. Historically, due to the formidable nature of managing such defects, amputation was commonly favored as the treatment of choice. However, over the past five decades, advances in limb salvage techniques have revolutionized patient care.

Previously, the primary treatment approach relied heavily on the use of massive cancellous bone autografts. Subsequently, various methods, including the Ilizarov technique, vascularized fibular grafts, and acute limb shortening, were employed to address bone defects of varying lengths. Conventional bone grafting techniques, despite recipient sites being well vascularized, are hindered by the challenge of graft resorption, which cannot be controlled [1].

More recently, a promising treatment strategy has emerged. This involves the use of an antibiotic cement spacer followed by grafting within this spacer, facilitated by the development of an induced biomembrane [2,3]. This paper documents a series of patients at our institution who have undergone successful treatment using this innovative technique.

METHODS

From January 2019 to December 2022, we enrolled all patients who were admitted with post-traumatic bone defects and underwent treatment using the Masquelet technique (Table 1). These patients underwent a comprehensive evaluation that included an assessment of the nature of their injuries, the specific location of the defects, the condition of the surrounding soft tissues, the extent of the bone defect, the antibiotics administered, and the duration of cementation. In addition, we documented the method of fixation, the presence of any infections, and the current health status of all the patients.

Surgical technique

During the initial phase of the procedure, the affected limb was prepared and draped following standard sterile protocols. The area where bone loss occurred was meticulously cleaned and flushed with a sterile solution to remove any debris and unhealthy tissue. Careful dissection was then performed to reach the site of the fracture, where the fractured ends were identified and cleaned once again. The length, alignment, and rotation of the injured limb were determined according to pre-operative planning. The choice of fixation method depended on the type and location of the fracture. In cases of open fractures with significant defects, a temporary external fixator was applied. Once the fracture was properly aligned to ensure anatomical length, alignment, and rotation, the fixation was carried out. After successful fixation, the focus shifted to addressing the bone defect. The size of the defect was measured and filled with a spacer made of polymethylmethacrylate (PMMA) bone cement. Typically, we preferred to mix 2 g of vancomycin or gentamicin with every 40 g of cement prepared.

The second stage of the bone grafting procedure took place 4–12 weeks after the initial surgery. Bone graft material was harvested from the iliac crest. The fracture site was accessed through the previous incision, and careful dissection was performed to reach the defect. The biomembrane surrounding the cement spacer was delicately opened, and the spacer was removed. After spacer removal, the biomembrane capsule was

Table 1: List of patients who underwent treatment using masquelet technique

S. No	Age	Type of injury	Fracture type	Type of fracture	Indication	Bone defect length	Spacer	Fixation	Current status	Duration of cementation
1.	26/M	Open	# tibial plateau	Type-II	Bone loss	4 cm	Genta mycin	Plate and screws	Bone graft and Heald	45 days
2.	42/M	Closed	# shaft tibia	-	Post-operative wound infection with bone loss	6 cm	Genta mycin	Plate and screws	Bone graft and Heald	30 days
3.	29/M	Open	# distal tibia	Type-IIIA	Non-union	4 cm	Genta mycin+Vanco mycin	Plate and screws	Bone graft and Heald	49 days
4.	41/F	Closed	# distal tibia	-	Non-union	4 cm	Genta mycin	Plate and screws	Bone graft and Heald	35 days
5.	33/M	Closed	# distal tibia	-	Post-operative wound infection with non-union	4 cm	Genta mycin	Plate and screws	Bone graft and Heald	42 days
6.	44/F	Open	# shaft tibia	Type-IIIA	Bone loss	8 cm	Genta mycin+Vanco mycin	Plate and screws	Bone graft and Heald	50 days
7.	29/M	Open	# distal femur	Type-II	Non-union	10 cm	Genta mycin+Vanco mycin	Plate and screws	Bone graft and Heald	49 days
8.	37/M	Closed	# shaft femur	-	Non-union	6 cm	Genta mycin	Plate and screws	Bone graft and Heald	32 days
9.	40/F	Open	# distal femur	Type-II	Post-operative wound infection with bone loss	7 cm	Vanco mycin	Plate and screws	Bone graft and Heald	32 days
10.	46/M	Open	# distal femur	Type-IIIA	Bone loss	9 cm	Genta mycin	Plate and screws	Bone graft and Heald	46 days
11.	34/M	Open	# distal humerus	Type-II	Non-union	5 cm	Genta mycin	Plate and screws	Bone graft and Heald	40 days
12.	47/M	Closed	# distal humerus	-	Post-operative wound infection	4 cm	Genta mycin	Plate and screws	Bone graft and Heald	45 days
13.	32/F	Closed	# olecranon	-	Post-operative wound infection	5 cm	Genta mycin+Vanco mycin	Plate and screws	Bone graft and Heald	49 Days
14.	45/M	Closed	# osclacis	-	Post-operative wound infection	4 cm	Genta mycin	Plate and screws	Bone graft and Heald	30 days
15.	38/M	Closed	# shaft humerus	-	Post-operative wound infection	4 cm	Genta mycin	Plate and screws	Bone graft and Heald	42 days

thoroughly irrigated to eliminate any remaining debris. With the defect exposed, the bone graft was inserted to fill the defect. It is important to ensure that the defect is filled without overstuffing it. Once the defect was filled, the biomembrane was closed using absorbable sutures.

RESULTS

Fifteen consecutive patients were identified during a specific period for this study. Among them, there were ten men and five women, and their average age was 43 years, with a range from 26 to 60 years. The bone defects were found in various locations: six cases in the tibia, four cases in the femur, three cases in the humerus, one case in the olecranon, and one case in the calcaneum. Eight of the cases involved closed fractures complicated by infection or non-union, while the remaining seven cases were open fractures with bone loss, classified as Gustilo Type II or IIIA.

The length of the bone defects varied from 4 to 10 cm. Antibiotics such as gentamicin or vancomycin were used in the cement spacer. The average time between the first and second surgeries was 40 days, with a range of 30–50 days. All affected limbs were stabilized with a combination of screws and plates, and all patients showed radiographic evidence of bone consolidation at the defect site after treatment. There were no reported complications in any of the cases in this series.

DISCUSSION

Treatment of large segmental bone defects can be a complex challenge for orthopedic surgeons. One approach, as described by Masquelet *et al*. [4] involves a procedure that combines induced membranes and cancellous autografts. Typically, bone grafting in such cases is delayed after the initial fixation to allow for soft-tissue healing, reduce infection risk, and prevent graft resorption [5].

In cases of traumatic wounds, orthopedic surgeons may use antibiotic-impregnated cement beads or spacers to administer antibiotics to the soft-tissue bed. These spacers offer benefits such as maintaining a void for later graft placement, providing structural support, relieving stress on the implant, and promoting biomembrane formation. The biomembrane, as proposed by Masquelet and Begue, plays a role in preventing graft resorption, and enhancing vascularity, and corticalization.

Research has shown that this biomembrane can be 0.5–1 mm thick [6] and has both a rich blood supply and impermeable characteristics [7]. Studies, such as those conducted by Viateau *et al*. [8], have found that the membrane alone is insufficient to heal a large defect, but when combined with autologous bone graft, successful healing occurs.

The timing of the second-stage surgery is crucial, and recent studies have suggested that performing it within a month after implanting foreign material [9] may be optimal. In addition, the induced membrane appears to secrete growth factors that stimulate bone regeneration, as reported by Pelissier *et al*. [7].

This technique has been applied to various types of bone defects, including those in long bones, as seen in cases described by Biau *et al*. and Accadbled *et al*. The choice of fixation method varies among surgeons, and construct rigidity may impact the healing process. A balance between stability and stress shielding near the plate is essential.

The grafting material used can also vary, with autografts from sources such as the iliac crest and femoral canal being common choices. Some studies suggest that femoral cancellous bone may contain higher concentrations of growth factors than iliac crest and platelet preparations [10].

In summary, the Masquelet technique, which combines induced membranes and autografts, is a promising approach for treating large segmental bone defects. Further, research and clinical series will help

refine the optimal components and strategies for achieving successful healing in these challenging cases.

CONCLUSION

The approach of postponing bone grafting until after the initial placement of a cement spacer offers a viable solution for the challenging issue of significant bone loss in extremity reconstruction. This method can be employed either in an immediate or delayed manner, with similarly promising outcomes. The induced membrane formed within large bone defects filled with cement fosters a favorable environment conducive to bone formation and the consolidation of a substantial void. As the adoption of this technique becomes more widespread, the question of which graft materials are best suited for filling the void may become clearer. Increasing clinical evidence will also help substantiate the effectiveness of this approach in addressing segmental bone loss.

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AUTHORS CONTRIBUTIONS

All authors participated in every aspect of the study, including conceptualization, design, data collection, data analysis, interpretation, manuscript preparation, critical review, and approval of the final version to be published.

CONFLICTS OF INTEREST

The authors confirm that they have no conflicts of interest related to this research, authorship, and publication of this article.

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