DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20243911

Case Report

Masquelet technique for infected femur bone defect in low resource setting: a case report

Mario D. Simatupang[1], Stevanus I. Ario[2]*

[1]Department Orthopaedic and Traumatology, Merauke Public Hospital, South Papua, Indonesia
[2]School of Medicine and Health Sciences, Atma Jaya Catholic University of Indonesia, Indonesia

Received: 13 October 2024
Accepted: 19 November 2024

***Correspondence:**
Dr. Stevanus I. Ario,
E-mail: Stevanus.irfan.a@gmail.com

ABSTRACT

Our hospital is located on the east edge of Indonesia, in the rural city of Merauke, South Papua. In this setting, procedures to bridge large bone defects are limited. The Masquelet technique is a two-stage orthopaedic procedure to treat large bone defects. This technique has a promising future for treating large bone defects, especially in low-resource settings. A 27 years old male experienced a traffic accident. The patient went unconscious and was brought to a nearby hospital where he underwent open reduction and internal fixation of his right femur open fracture. In the 4th week after the trauma, he was diagnosed with osteomyelitis. After multiple procedures in other hospitals, in the 74th week, he arrived at our hospital in Merauke, South Papua. We used Masquelet technique to bridge the bone gap and treat the osteomyelitis. In the first stage, we did debridement and sequesterectomy, then filled the bone defect with antibiotic impregnated PMMA spacer. After 5 weeks, the infection had subsided and the second stage of Masquelet technique was done. We removed the spacer while preserving the membrane and filled the gap with iliac bone autograft and allograft mixture. Union was attained 56 weeks after stage 2. The patient and family are satisfied with the outcome. Masquelet technique is a promising technique with a good success rate for large bone defects, especially in infected bone cases. No need for microvascular and other specialized tools made Masquelet technique can be done in a low-resource setting.

Keywords: Chronic osteomyelitis, Masquelet technique, Induced membrane, Bone defect

INTRODUCTION

The availability of orthopaedic resources is uneven in the world. There might be only basic resources available in hospitals of low and middle-income countries. Our hospital is located on the east edge of Indonesia, in the rural city of Merauke, South Papua. In this setting, procedures to bridge large bone defects are limited. In this case report, we present a case of femoral chronic osteomyelitis with a 6.6 cm bone defect treated with Masquelet technique in Merauke Public Hospital, South Papua, Indonesia.

The Masquelet technique is a two-stage orthopaedic procedure with the aim of treating large bone defects.[1] In the first stage, debridement of all infected and devitalized tissue is done. The defect is then filled with a cement spacer, with polymethylmethacrylate (PMMA) being the most popular. The body responds with a foreign body reaction to the spacer, creating a fibrous membrane. This membrane has the ability to release high concentrations of growth, osteogenic, and pro-angiogenic factors.[2] The bone defect with the spacer is then fixed with external fixation, intramedullary nail, or plate.[1] In the second stage, the surgeon carefully preserves the membrane, removes the spacer, and fills the membrane with bone graft.[1] Intact membrane able to prevent resorption of bone graft by the immune system.[2] Masquelet technique has been reported to treat large diaphyseal, metaphyseal or epiphyseal defects in infected, irradiated, or poorly vascularized bone.[3] From previous reported cases, Masquelet technique could bridge bone defects up to 25 cm.[4] On the other hand, the absolute contraindication for the procedure is poor

compliance among patients. Relative contraindications are chronic steroid use, smoking, malnutrition, radiation and massive tissue necrosis, which are conditions that inhibit bone healing.[5]

Masquelet technique has shown good outcomes, but further study has to be done to decrease its complication rate. The overall success rate of the technique from various pathologies and anatomical locations has been reported to be 86% (478/554 defect).[6] Another source by Mi et al who looked into cases from the year 1985 to 2018 (680 defects) has found an 88,82% union rate.[7] This result increased to 92.35% after 24 cases reached union with additional procedures. The mean time of union on average was 245 days after stage 2. The complication rate was 26.03%, with non-union (8.97%) and deep infection (8.09%) being the most common complications.[7] This high rate of complication might be happened because Masquelet technique is relatively new and less researched than distraction osteogenesis, so the technique may still not be optimal yet.

Masquelet technique is relatively new. It has been reported and researched further, but there is still more research to be done for technique optimisation. This technique has a promising future for treating large bone defects, especially in low-resource settings. We present a case report of a patient who underwent Masquelet technique in a low-resourced, rural hospital with a non-union osteomyelitis of the femur.

CASE REPORT

A 27 years old male experienced a traffic accident where he was riding a motorcycle in the rain when he slipped and broke his right femur bone. He experienced an open fracture to his right femur and a traumatic amputation of his right middle finger. The patient went unconscious and was brought into a hospital nearby where he underwent open reduction and internal fixation of his right femur bone and treatment of his other injuries.

Four weeks after the operation, the patient experienced fever and increasing pain in his right thigh. There was wound dehiscence with pus. He went back to the hospital. His x-ray showed signs of osteomyelitis and at week seven, he underwent debridement and his osteosynthesis changed into external fixation. After several debridement attempts and antibiotic regiments, his wound still showed signs of infection and his x-rays still showed osteomyelitis. At this moment of the narrative, it had been 74 weeks from the initial trauma.

He arrived in our hospital in Merauke, South Papua at week 74th of his disease progression. He still experienced fever and worsening pain in his right thigh. His wound was still exposed with pus discharge. In addition, there was some significant leg length discrepancy and stiffness in his right knee and hip. Pre-operation antibiotic with Cefazolin 1 gr was administered. The patient underwent the first stage of Masquelet technique with debridement and sequestrectomy of infected bone and tissue. Incision and exposure were made at the previous procedure scar. Dead tissues and bones were excised, which left us with 6.6 cm of bone defect. PMMA cement impregnated with gentamycin was moulded into shape and put in the bone defect as a spacer and external fixation was placed to give some stabilization and allow dynamization of the limb (Figure 1). Ceftriaxone 1gr BID and gentamycin 80 mg BID were used for post-operative antibiotics.

Figure 1: Stage 1 of Masquelet technique-PMMA spacer inside bone defect.

The second stage of Masquelet technique was done 5 weeks after the first stage. Signs of infection had subsided with good wound healing, absence of pain, and no fever. Incision and exposure were made to the skin and muscle, following the previous scar. The membrane that formed around the PMMA spacer was then cut longitudinally. We removed the spacer and then debrided the bone end until bleeding could be seen. Iliac crest bone graft was obtained and mixed with synthetic bone graft as a volume expander in a ratio of 8 to 2. The mixed graft was placed inside the membrane (Figure 2) and the wound was stitched up. A similar antibiotics regimen as stage 1 was used for stage 2.

Serial femoral x-rays were taken at 4, 10, 20, 28, and 54 weeks after the second stage with signs of radiological union found at 54 weeks after (Figure 3). Then, the external fixation was removed and changed into an internal fixation with a plate and screw for easier mobilization. The wound had healed completely and he experienced minimal stiffness and pain in his knee and hip joint. He still had some leg length discrepancy but could weight-bear to the extremity without pain (Figure 4). Despite the deformity, the patient and family were satisfied and could accept the deformity. Correction to the leg-length discrepancy could be planned in the future. An overview of the patient's history is summarized in Table 1.

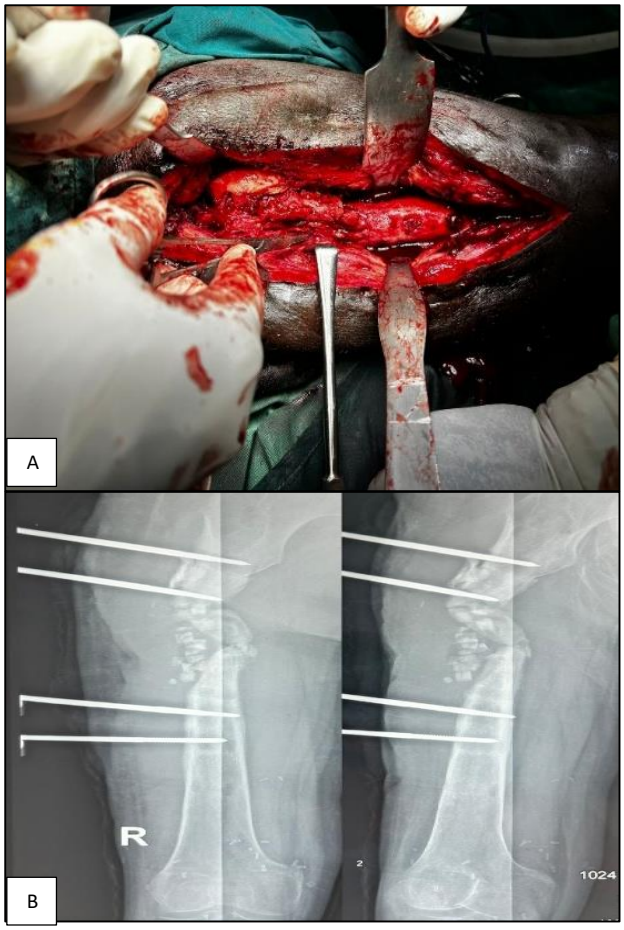

Figure 2 (A and B): Stage 2 of Masquelet technique-preservation of the membrane and mixed bone graft inside membrane.

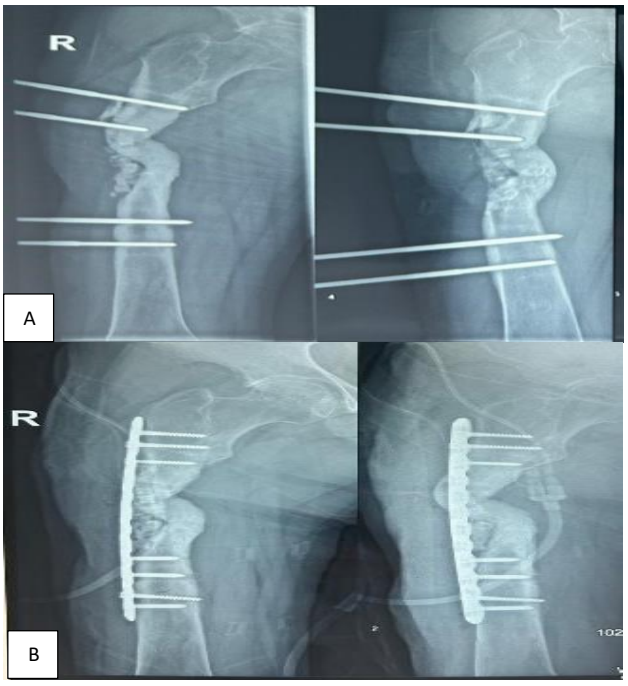

Figure 3 (A and B): Union achieved 54 weeks after stage 2 of Masquelet technique and ORIF procedure.

Figure 4 (A and B): Result of the procedure.

Table 1: Patient care timeline.

Time from trauma (week)	Event
0	Motor vehicle trauma and initial open reduction and internal fixation
4	Osteomyelitis, debridement
7	Osteomyelitis, debridement and change osteosynthesis into external fixation
21	Chronic osteomyelitis, debridement and change osteosynthesis into new external fixation
74	Patient arrived in our hospital. Chronic osteomyelitis, first stage of Masquelet technique
79	Second stage of Masquelet technique
132	Radiographic union (54 weeks from 2nd stage), revision of osteosynthesis into internal fixation with plate and screw

DISCUSSION

Other than Masquelet technique, procedures such as fibula transfer or Ilizarov intercalary bone transport have been reported to bridge bone defects of more than 6 cm. For this

patient, Masquelet technique is the best procedure. Resources and tools for both fibula transfer and Ilizarov bone transfer are not available in our hospital. In addition, infection is a contraindication for fibula transfer.[8] Ilizarov technique also has been reported to get unsatisfactory results in osteoporotic bone, bad soft tissue condition, tissue edema, and infected non-union, which are present in this patient.[9]

A concern comes up when antibiotics are combined with PMMA cement because some antibiotics are heat-sensitive. The exothermic reaction of PMMA during curing could decrease antibiotic concentration. The main example is gentamycin which undergoes a 25% decrease in concentration, while other aminoglycosides are unaffected.[10] Some antibiotics could change the biomolecular environment inside the membrane which could lower the number of osteogenic cells.[11] However, antibiotic-loaded PMMA has been widely used in reported Masquelet technique without any effect on the union rate. A single-centre case series which used antibiotic-loaded PMMA for various bone defects found a 93% (40/ 43 patients) union rate.[12] Moreover, a review listing several case series with more than 15 cases each from 2000 to 2018 (342 patients) also reported indifference of time to union and union rate between PMMA with or without antibiotics.[6]

The success of treating this case was mainly because we were able to control the infection of chronic osteomyelitis. Stage 2 of Masquelet technique should only be performed if the patient is infection-free. Stage 1 could be repeated until signs of infection have subsided fully. This was one of the reason for delayed stage 2 on previous reported cases.[13]

There is still a debate about how long the spacer needs to be in the defect for optimal membrane formation. From the available reports on Masquelet procedure, the interval between the first and second stage could range from 4 to 96 weeks depending on patient circumstances.[13] A literature review has reported that the optimal time between 2 stages is at least 1 month.[6] This statement comes from biomolecular findings of the membrane, which finds the highest level of neo-angiogenesis, bone morphogenic protein (BMP-2), and Vascular endothelial growth factor (VEGF) at around 4 weeks.[6] Conditions like infection resolution, patient transfer to more resourced hospital, or soft tissue damage resolution are the reason of late second stage.[13] However, time alone is not a reliable measure of membrane readiness.[14] Theoretically serum biomarkers, such as serum MMP, IGF1 and PDGF could become a predictor of a mature membrane but further researches are needed.[15]

One drawback of Masquelet technique to fill sizeable bone defects is that there might not be enough bone grafts to fill the defect, especially in people with small stature. To face this challenge, surgeons use an allograft, xenograft, or synthetic graft as a volume expander. Surgeons have reported successful results using volume expander, with the optimal amount of volume expander not to be more than 30% of total graft volume.[12] A higher amount of volume expander is associated with higher non-union and absorption of bone graft.[16] Another way to obtain larger graft material is to use a graft from rearmed intramedullary bone with the RIA (rearmer/irrigator/aspirator) technique. RIA technique appears to obtain a higher volume of bone graft with a comparable rate of union with iliac crest bone graft.[17,18] However, RIA is associated with higher cost and blood loss compared to ICBG, with a 5.32 greater likelihood for transfusion.[17]

Stability throughout the first and second procedures can be attained by external fixations, plate fixations, or intramedullary nails. In this case, we use external fixation to avoid placing osteosynthesis directly on previously infected bone. There wasn't strong evidence to only use external fixation for bridging the defect as different types of osteosynthesis have been used with successful results. Some articles have recommended the use of external fixation in chronic infection cases.[6] The choice of osteosynthesis should be decided by personal preferences, but still follow the diamond concept of bone grafting. All grafts need a favourable mechanical environment, adequate cellular population, inductive stimulating protein, osteoconductive matrix and vascularity.[12]

CONCLUSION

Masquelet technique is a promising technique with a good success rate for large bone defects, especially in infected bone cases. No need for microvascular and other specialized tools made Masquelet technique can be done in a low-resource setting. Important factors for success are eradication of infected or dead tissue and stable osteosynthesis. Further researches should aim to optimize the procedure and understand the underlying mechanism of successful Masquelet technique procedure.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. Careri S, Vitiello R, Oliva MS, Ziranu A, Maccauro G, Perisano C. Masquelet technique and osteomyelitis: innovations and literature review. Eur Rev Med Pharmacol Sci. 2019;23(2):210-6.
2. Alford AI, Nicolaou D, Hake M, McBride-Gagyi S. Masquelet's induced membrane technique: Review of current concepts and future directions. J Orthop Res Off Publ Orthop Res Soc. 2021;39(4):707-18.
3. Masquelet AC, Fitoussi F, Begue T, Muller GP. Reconstruction of the long bones by the induced membrane and spongy autograft. Ann Chir Plast Esthet. 2000;45(3):346-53.
4. Scholz AO, Gehrmann S, Glombitza M, Kaufmann RA, Bostelmann R, Flohe S, et al. Reconstruction of

septic diaphyseal bone defects with the induced membrane technique. Injury. 2015;46(4):S121-4.
5. Micev AJ, Kalainov DM, Soneru AP. Masquelet technique for treatment of segmental bone loss in the upper extremity. J Hand Surg. 2015;40(3):593-8.
6. Masquelet A, Kanakaris NK, Obert L, Stafford P, Giannoudis PV. Bone Repair Using the Masquelet Technique. J Bone Joint Surg Am. 2019;101(11):1024-36.
7. Jw C, J K, Wt C, Jk K, Jh S, Hj K, et al. Circumferential bone grafting around an absorbable gelatin sponge core reduced the amount of grafted bone in the induced membrane technique for critical-size defects of long bones. Injury. 2017;48(10):2292-305.
8. Taqi M, Llewellyn CM, Estefan M. Fibula Tissue Transfer. In: StatPearls. Treasure Island (FL): StatPearls Publishing. 2024.
9. Orthopaedics MER. Masquelet–Ilizarov technique for the management of bone loss post debridement of infected tibial nonunion. Int Orthop. 2022. Available at: https://www.academia.edu/108353060/Masquelet_Ilizarov_technique_for_the_management_of_bone_loss_post_debridement_of_infected_tibial_nonunion. Accessed on 9 September 2024.
10. Samara E, Moriarty TF, Decosterd LA, Richards RG, Gautier E, Wahl P. Antibiotic stability over six weeks in aqueous solution at body temperature with and without heat treatment that mimics the curing of bone cement. Bone Jt Res. 2017;6(5):296-306.
11. Rathbone CR, Cross JD, Brown KV, Murray CK, Wenke JC. Effect of various concentrations of antibiotics on osteogenic cell viability and activity. J Orthop Res Off Publ Orthop Res Soc. 2011;29(7):1070-4.
12. Giannoudis PV, Harwood PJ, Tosounidis T, Kanakaris NK. Restoration of long bone defects treated with the induced membrane technique: protocol and outcomes. Injury. 2016;47(6):S53-61.
13. Morelli I, Drago L, George DA, Gallazzi E, Scarponi S, Romanò CL. Masquelet technique: myth or reality? A systematic review and meta-analysis. Injury. 2016;47(6):S68-76.
14. Gindraux F, Loisel F, Bourgeois M, Oudina K, Melin M, de Billy B, et al. Induced membrane maintains its osteogenic properties even when the second stage of Masquelet's technique is performed later. Eur J Trauma Emerg Surg Off Publ Eur Trauma Soc. 2020;46(2):301-12.
15. Haubruck P, Heller R, Apitz P, Kammerer A, Alamouti A, Daniel V, et al. Evaluation of matrix metalloproteases as early biomarkers for bone regeneration during the applied Masquelet therapy for non-unions. Injury. 2018;49(10):1732-8.
16. Taylor BC, French BG, Fowler TT, Russell J, Poka A. Induced membrane technique for reconstruction to manage bone loss. J Am Acad Orthop Surg. 2012;20(3):142-50.
17. Marchand LS, Rothberg DL, Kubiak EN, Higgins TF. Is This Autograft Worth It? The Blood Loss and Transfusion Rates Associated With Reamer Irrigator Aspirator Bone Graft Harvest. J Orthop Trauma. 2017;31(4):205-9.
18. Ahmed H, Shakshak M, Trompeter A. A review of the Masquelet technique in the treatment of lower limb critical-size bone defects. Ann R Coll Surg Engl. 2023;NA.

Cite this article as: Simatupang MD, Ario SI. Masquelet technique for infected femur bone defect in low resource setting: a case report. Int J Res Orthop 2025;11:213-7.