Case Report

Two Staged Procedure for Infective Non-Union of Radial Shaft Fracture Treated with Masquelet Technique Followed by Modified Nicoll's Graft: A Case Report

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Abstract

We present a case of an infected non-union of the radial diaphysis treated with ORIF and plating, following which the patient developed continuous pus discharge at the surgical site and loss of functional forearm movement. Treatment included the Masquelet technique of induced membrane with intramedullary Kirschner wiring, followed by Modified Nicoll's Grafting after two months. Six weeks' post-surgery, the patient achieved an excellent functional outcome and infection control.

Keywords: Masquelet Nicolls's, Non-unions, Infected non-unions, Graft, Radius, Iliac.

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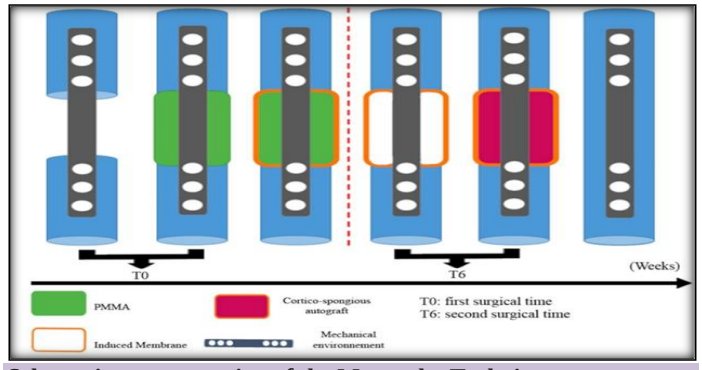
Introduction

Infected non-union of the radius and ulna poses a significant challenge for orthopedic surgeons, often associated with severe anatomical and functional impairment. Treatment is complex as it may involve segmental osteolysis, sinus tracts with sequestrum formation, necrotic bone tissue, interosseous membrane disturbances, and scar and soft tissue adhesions.[1,2]

The Masquelet technique (the induced membrane technique) is a two-staged approach for treating critical defects. The cement spacer induces a foreign body reaction, forming a fibrous membrane. The induced membrane provides optimized healing, as it contains osteoprogenitor cells, a highly vascularized outer layer rich in mesenchymal stem cells and type IV collagen, and a synovial-like inner membrane predominantly composed of type I collagen. It also secretes osteoinductive factors such as BMP-2 and growth factors like VEGF and TGF-β1 into the defect.[3]

In the second stage, when autologous bone grafting is needed, the iliac crest bone graft is preferred due to its osteoinductive, osteoconductive, and osteogenic properties.[4,5] The Modified Nicoll's Grafting technique involves key-stoning a block of corticocancellous graft (iliac graft) into the defect and securing it with a plate.[2,6] We have improvised by tunnelling within the Iliac Crest graft by brill bit and securing it further with Gene X Paste. Placing the cortical part of the graft opposite to the plate allowed considerable compression without crushing the cancellous portion.

Optimizing the Masquelet technique aligns with the "Diamond Concept" of fracture healing, which suggests that the mechanical stability of a fracture is as crucial as the combination of osteogenic, osteoinductive, and osteoconductive properties of the graft.[7] A well-planned osteosynthesis strategy facilitates the conversion of woven bone to lamellar bone following Wolff's law.[8]



Schematic representation of the Masquelet Technique

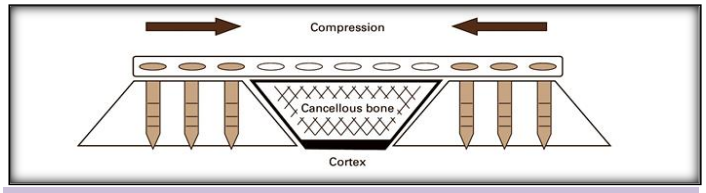


Diagram representing the modified Nicoll Technique

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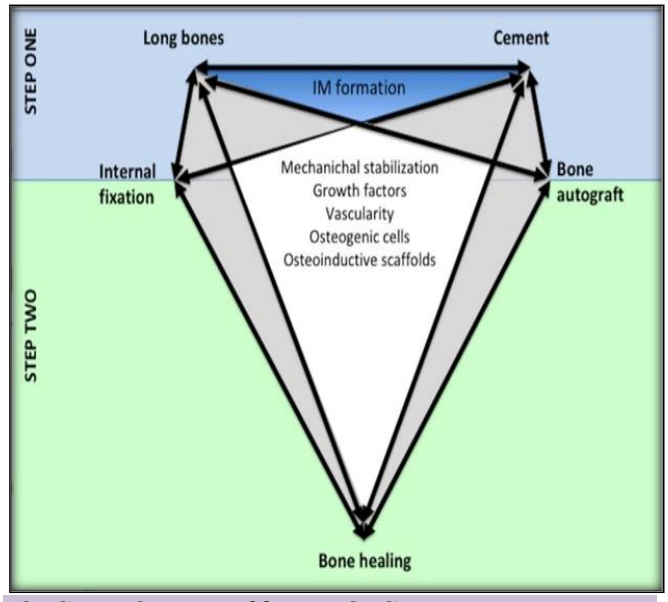


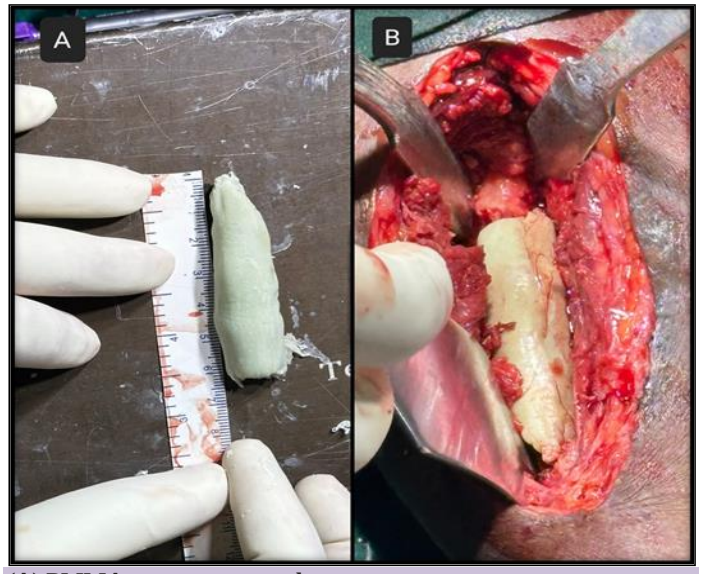
The diamond concept of fracture healing

Case: A 30-year-old male patient presented to the OPD with an infected non-union of the radius and ulna, initially treated with plating and TENS nailing for the ulna. The patient had continuous pus discharge from the surgical site.
At the time of presentation, the patient had an active infection, and routine blood investigations revealed elevated total counts, ESR, and Q-CRP. The culture report confirmed MRSA infection. The patient exhibited loss of forearm supination and pronation. Radiographic imaging showed osteolysis with absent callus formation at the operated sites of the radius and ulnar diaphysis.

(A) Patient exhibiting loss of pronation and supination of forearm
(B) Patient presenting with active purulent discharge from previous surgical site

Radiograph of the patient showing infected non-union of the radius-ulna treated with plating and TENS nailing for the Ulna

Surgical Technique: The patient was planned for two staged surgical procedures.
First stage - Masquelet Technique: The radius was accessed through the previous Henry's approach, edges were freshened, and necrotic tissue was removed. The 3.5 mm DCP plate was extracted, and approximately 6.3 cm of necrotic radial shaft was excised. Debridement was performed until healthy, bleeding bone margins were achieved. Debrided bone tissue was sent for culture and sensitivity. An antibiotic-eluting PMMA spacer loaded with gentamicin and vancomycin, measuring 6.3 cm, was placed in the defect. A 2 mm Kirschner wire was inserted intramedullary through the spacer, bridging the two main radial shaft fragments. Wound closure was performed after hemostasis, and an above-elbow POP slab was applied for stabilization. The patient was immobilized for six weeks with systemic antibiotic coverage based on the antibiogram.
Inflammatory markers were assessed after six weeks and had returned to baseline, allowing progression to the second stage.



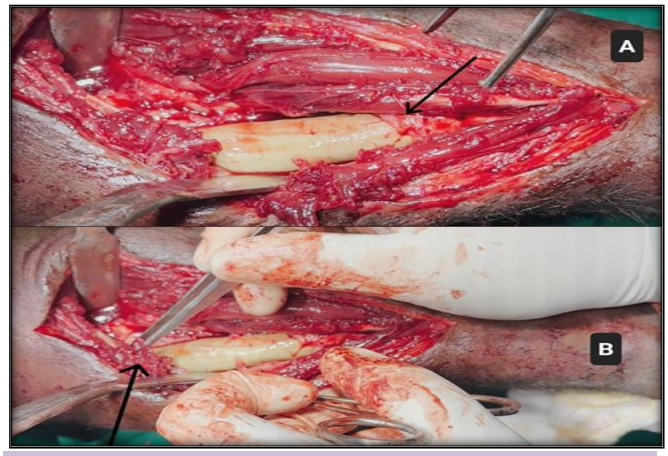
(A) PMMA spacer measured
(B) PMMA spacer placed in critical defect with intramedullary K-wire insertion

Second Stage - Modified Nicoll's Grafting: The radial shaft was approached through the same incision. The induced membrane (IM) was noted covering the entirety of the spacer. The IM was carefully incised, maintaining its integrity and vascularity, and the cement spacer was removed. Bone edges were gently debrided to fresh, vascularized bone. The defect size was measured to be 6.5 cm.

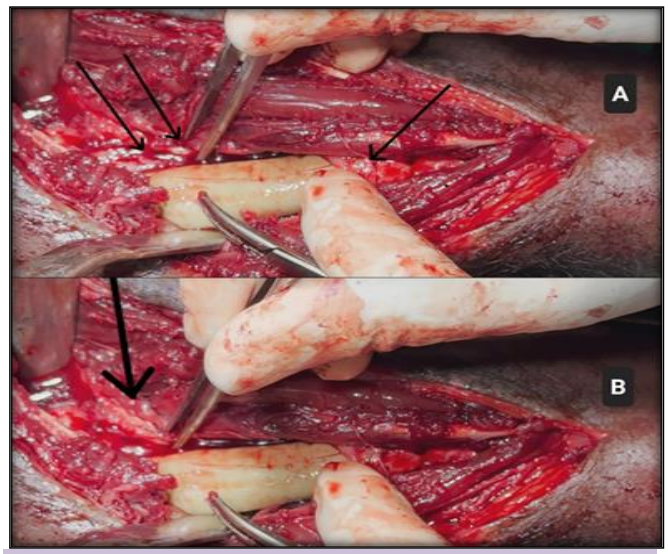
A straight length of corticocancellous graft measuring 7.5 cm was harvested from the iliac crest. The edges were freshened, and soft tissue was removed. Intramedullary tunneling was performed within the iliac crest graft using a drill bit.

Both the graft and donor site bone edges were chamfered to increase bony contact area and improve wedge accommodation. The graft was further secured with Gene X Paste (β-tricalcium phosphate/calcium sulfate hemihydrate compound). Compression and stabilization were achieved with a 13-hole DCP plate. The ulna was also stabilized.

Follow-up radiographs showed good bone union.



(A, B) Intra-Operative pictures showing adequate Induced Membrane formation (Black Arrows)



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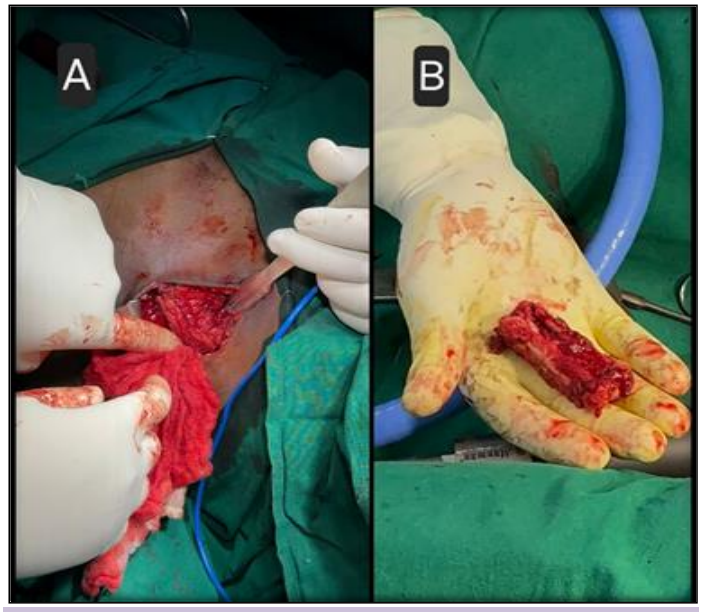
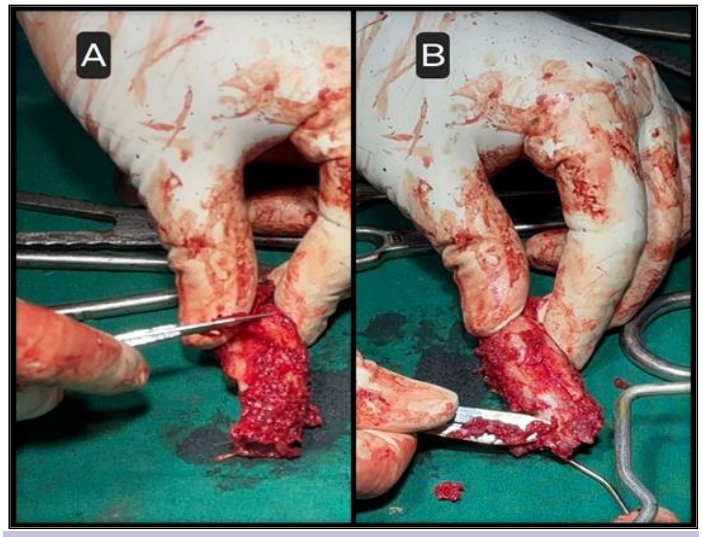
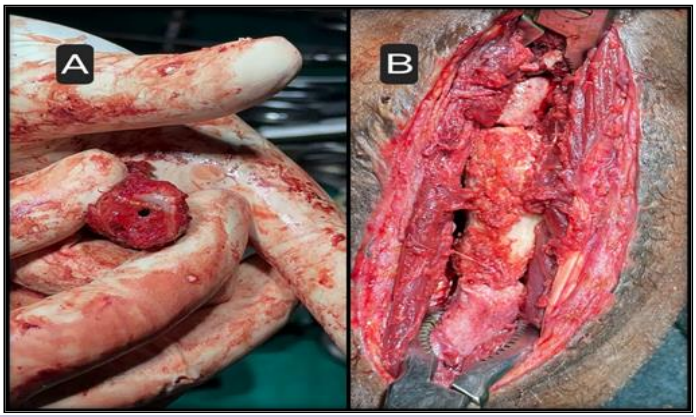


(A) Donar site (Iliac Crest Exposed)
(B) Harvested Graft from Iliac Crest



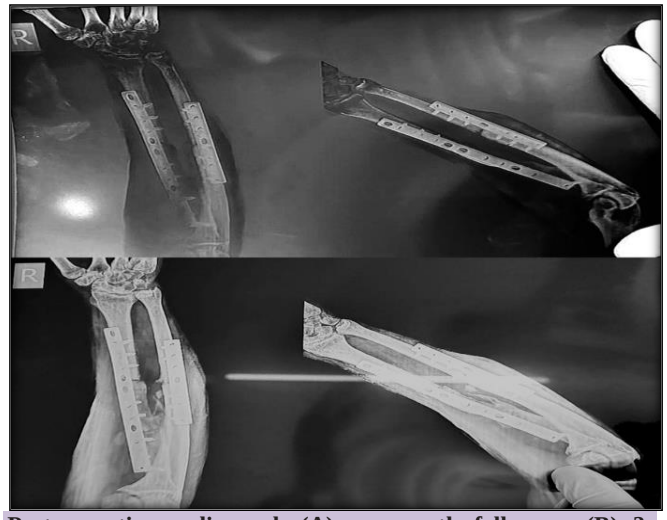
(A, B) Graft made free from all the soft tissues



(A) Intraoperative picture of Intramedullary tunneling by brill bit was done within the Iliac crest graft.
(B) Iliac Crest graft chamfered and placed in critical defect

(A, B) Intraoperative picture of 13-hole DCP compressive plating

(A, B) Gene X paste applied post compressive 13 hole DCP plating



Post-operative radiograph (A) one-month follow-up (B) 3-month follow-up showing good compression.

Discussion

Infected diaphyseal non-union is severely disabling and presents a significant treatment challenge. It differs from other types of diaphyseal non-union due to the intimate relationship between the radius and ulna. Non-union in the presence of infection further complicates management due to osteolysis, sequestrum formation, sinus tract formation, fracture instability, devascularization, and scar adhesions.

Extensive debridement is often necessary, leading to a critical bone defect.

A two-staged surgical approach is usually warranted for better functional outcomes. In the first stage, the Masquelet technique improves healing potential and creates an adequate environment for graft uptake in the second stage[11]. Appropriate antibiotic therapy is essential to eradicate infection and normalize inflammatory markers before proceeding to the second stage.

Although, there are various treatment modalities described in treating forearm bone loss for the second stage include using boiled cadaveric bones,[12] use of cortical tibial graft (Boyd)with screws, grafts using ulnar segment (Miller and Phalen),[13] held by screws, use of iliac crest graft (Spira),[14] to fill the bone gap and fixation with an intramedullary nail, cancellous insert grafts (Nicoll),[6] with plate fixation, bone transport in forearm bones using the principles of Ilizarov,[15] using fibula as an intercalary bone graft (Jupiter).[16]

Nicoll bone grafting technique,[6] stood the test of time after 40 years since it has been described and is still effective. Its lack of complexity, lack of expensive equipment, and cost-effectiveness make it an ideal grafting technique for non-unions of the forearm. It is also clear from both clinical and experimental evidence that a fresh autologous cancellous bone is superior to any other form of graft.[17,18] For physical reasons, solid bone gives more rapid union and less fibroblastic reactions.[19]

This case presents the combining of two established treatment techniques (Masquelet and Nicoll's) with essential improvisation and modifications, which produced excellent results coupled with good clinical outcomes.

Combining two techniques (Masquelet and Nicoll's) also meets the standards proposed in " Diamond Concept Of Fracture Healing".[20]

Conclusion

This case demonstrates that a carefully planned two-staged approach combining the Masquelet technique with Modified Nicoll's grafting can effectively manage complex infected non-unions of the forearm. The initial stage successfully eradicated infection and created a biologically favorable environment through induced membrane formation, while the second stage provided structural stability and enhanced osteogenesis using a corticocancellous iliac crest graft with additional modifications. This combined strategy aligns well with the principles of the Diamond Concept, ensuring both biological and mechanical optimization for fracture healing. The excellent functional recovery and radiological union achieved in this case highlight that this method is a reliable, cost-effective, and reproducible option for treating challenging infected diaphyseal defects of the radius.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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