




**Bone defect reconstruction:
the Reamer – Irrigator – Aspirator (RIA)**

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Outline

- Introduction
- Indications
- Technique
- Clinical experience



RIA: Reamer – Irrigator – Aspirator

- Polytrauma patients
- Osteomyelitis: debridement
- Bone defects: bone graft harvesting
 - ✓ Femur
 - ✓ Tibia




Bone defect reconstruction



Introduction

- Segmental bone loss after trauma remains a challenging problem for orthopedic trauma surgeons.
- When a bone defect exists combined with infection, the chances of successful bone consolidation and clearance of infection are reduced.



Introduction

- A critical segmental defect is a bone void that will not heal without intervention.
- This type of defect is difficult to characterize because diagnosis is subjective.
- In adult patients, a critical bone defect generally has circumferential loss 50% or a length of '1 – 2' cm.^{1,2}
- Management of these defects depends on size, patient age, overall health and surgeon experience.

1. Mauffrey C, et al. Letter to the Editor: Management of Segmental Bone Defects. J Am Acad Orthop Surg 2015;23:143-153.
2. Sanders DW, et al. Critical-sized defect in the tibia: is it critical? Results from the SPRINT trial. Journal of Orthopaedic Trauma. 2014;28(5):450-455.



Treatment options

- Autologous bone grafting
 - ✓ Masquelet technique
- Bone transport
- Free vascularized bone grafting
- Massive allograft
- Acute shortening



Treatment options



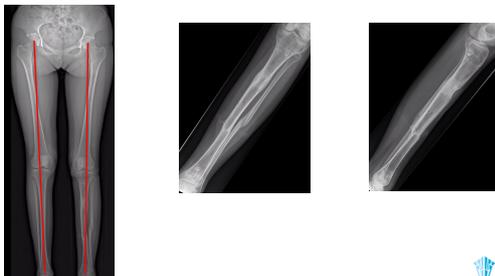
Treatment options



Treatment options



Treatment options



EDITORIAL

Tibial Defect Reconstruction: A Plea for Standardization

Cyril Mauffrey, MD, FACS, FRCS and David J. Hak, MD, MBA, FACS

- From preoperative considerations to intraoperative decision making and postoperative management, "experts" will have their preferred way to manage a specific patient.
- The current standard is "*dealers choice*".



Masquelet (induced membrane) technique



Introduction

- The induced membrane (IM) technique has been used for more than 30 years.
- It has recently gained popularity and is more and more widely accepted technique for reconstruction of segmental bone defects.
- Initially described for bone loss resulting from septic nonunion of the leg, it has been extended to all long bone segments, whatever the etiology of the bone defect.



Introduction

- The technique comprises 2 surgical stages.
- In the first stage, debridement and placement of a cement spacer into the bone defect.
- A few weeks later, the cement is removed and the cavity formed surrounded by the IM and filled with bone graft.
- Overtime this leads to bone healing.



Concept: the induced membrane

- A local tissue response to an enclosed foreign body (i.e. PMMA spacer) leads to the formation of a surrounding biological active (*induced*) membrane (IM).
- The IM is well vascularized, it secretes growth factors and contains mesenchymal adult stem cells, which are the conditions for tissue regeneration.
- The overall function of the induced membrane is to protect bone graft from the environment and to vascularize it.



Concept: the induced membrane



Concept: the induced membrane



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Induced membranes secrete growth factors including vascular and osteoinductive factors and could stimulate bone regeneration

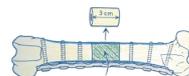
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Optimal source of autograft

- When compared with autograft obtained from the iliac crest, autograft harvested using the RIA technique achieves **similar union rates** with significantly **less donor-site pain**.
- RIA also yields a **greater volume** of graft compared with anterior ICBG and has a shorter harvest time compared with posterior ICBG.
- For larger volume harvests, cost analysis **favours** using RIA.



Technical aspects



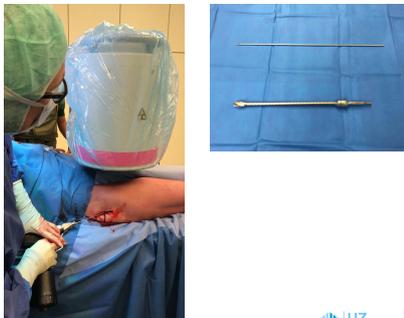
Technical aspects



Technical aspects



Technical aspects



Technical aspects



Technical aspects



Technical aspects



Clinical outcome



Masquelet technique: myth or reality? A systematic review and meta-analysis

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Clinical outcome

- Seventeen papers met the inclusion criteria (427 patients). Among these, only 10 studies reported individual patient's data (137 cases).
- The union rate was **89.7%** and the infections rectified in **91.1%** of cases.
- Persistence of infection or non-union was noted in **18%** of cases necessitating re-interventions.
- This systematic review was limited by the few studies that could be included, and their high variability in data reporting.



Clinical outcome

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ORIGINAL ARTICLE

Reamer-Irrigator-Aspirator bone graft harvesting for treatment of segmental bone loss: analysis of defect volume as independent risk factor for failure

W. J. Metsemakers^{1,2}, G. Claes³, P. J. Terry⁴, A. Belmans⁴, H. Hoekstra^{1,2}, S. Nijs^{1,2}

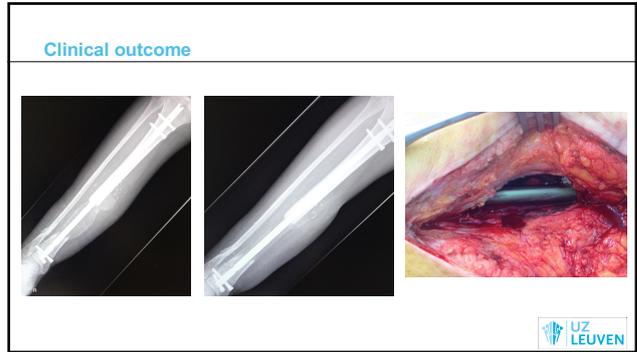
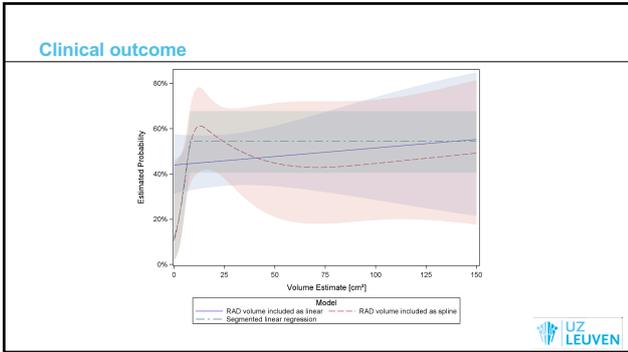
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Clinical outcome

- During the study period, 72 patients met the inclusion criteria.
- In total, 39 patients (**54.2%**) were classified as having clinical and radiographical bone healing.
- Twenty-five (62.5%) of the 40 patients who underwent a one-stage procedure showed bone union, compared with 14 (**43.8%**) of the 32 patients who underwent a two-stage (i.e. Masquelet) procedure.
- Although univariate analysis could not reveal any significant influence of specific risk factors to predict the outcome, there was a trend towards statistical significance for **defect volume**.





Clinical outcome

THE BONE & JOINT JOURNAL

■ TRAUMA
Induced membrane technique for treating tibial defects gives mixed results

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A. Evans,
I. Pallister

From Morrison Hospital, Swansea, United Kingdom

Aims
This study describes the use of the Masquelet technique to treat segmental tibial bone loss in 12 patients.

Patients and Methods
This retrospective case series reviewed 12 patients treated between 2010 and 2015 to determine their clinical outcome. Patients were mostly male with a mean age of 56 years (16 to 82). The outcomes recorded included union, infection and amputation. The mean follow-up was 875 days (403 to 952).

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- Clinical outcome**
- The Masquelet technique was relatively **ineffective** in achieving union in this series.
 - Overall 5 patients (**42%**) were classified as having clinical and radiographical bone healing.
 - Furthermore, the technique was associated with a **high rate** of infection.
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Pathogenesis of increased infection rates

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Acta Biomaterialia

ELSEVIER journal homepage: www.elsevier.com/locate/actbiomat

Mesenchymal stromal cell implantation for stimulation of long bone healing aggravates *Staphylococcus aureus* induced osteomyelitis

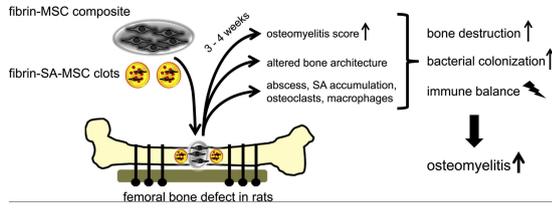
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AOTRAUMA

Pathogenesis of increased infection rates



Pathogenesis of increased infection rates

- Mesenchymal stromal cells (MSCs) have been successfully used to enhance bone regeneration, but their powerful immunomodulatory effects may impose an enhanced risk for osteomyelitis development.
- After fibrin-assisted transfer of *Staphylococcus aureus* (SA), effects of MSC implantation on osteomyelitis development were quantified over 3–4 weeks.
- MSC-treatment of infected defects **aggravated osteomyelitis** according to a significantly elevated osteomyelitis score and enhanced distal bone loss with spongy alteration of cortical bone architecture.

Debridement is key!



Indications based on clinical evidence

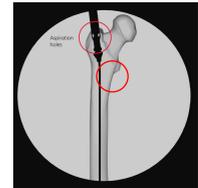
- Partial defects of the femur or tibia are not amenable to bone transport, and the best method for these is the Masquelet (IM) technique¹
- Periarticular defects are also amenable to the IM technique¹
- Overall defect size seems to be an important factor that can predict outcome²
 - ✓ Smaller defects (up to 8 cm³) have higher union rates
- In case of larger the defects the treating surgeon should always consider if he expects full consolidation to be feasible with the IM technique

1. Conway, JD et al. What is the optimal management (e.g. Masquelet technique, bone transport) for of post-infective bone defects in different long bones (femur, humerus, etc)? JCBM 2016
 2. Meestersmakers WJ, et al. Reamer-irrigator-Aspirator bone graft harvesting for treatment of segmental bone loss: analysis of defect volume as independent risk factor for failure. EJOT, 2017.



Complication related to the RIA system^{1,2,3}

- Proximal (and distal) femoral fracture
- Distal (and posterior) anterior cortical perforation of the femur
- Blood loss with the need for transfusion



1. Marchand LS, et al. Is This Autograft Worth It? The Blood Loss and Transfusion Rates Associated With Reamer Irrigator Aspirator Bone Graft Harvest. JOT 2017
 2. Meestersmakers WJ, et al. Reamer-Irrigator-Aspirator bone graft harvesting for treatment of segmental bone loss: analysis of defect volume as independent risk factor for failure. EJOT, 2017.
 3. Chavakis J, et al. The Reamer-Irrigator-Aspirator as a Device for Harvesting Bone Graft Compared With the Crest Bone Graft: Union Rates and Complications. JOT 2014.



Take-home messages

- One of the most challenging complications in musculoskeletal trauma surgery is the treatment of bony defects in case of FRI
- Current indications for the Masquelet (IM) technique seem to be:
 - ✓ Parterial or periarticular defect
 - ✓ Smaller defects (up to 8 cm³)
- The RIA-system is a good option for harvesting autologous bone graft
- Attention for serious complications!

