## Gap Defects: Limb lengthening or Induced Membrane Technique

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No disclosures

## Learning objectives

- Expose the clinical management of large bone defects
- Describe the strategies to manage these complex injuries
- Discuss the basic science for the Induced Membrane Technique and Limb Lengthening



#### Large Bone Defects

Continues to be a difficult Clinical problem to manage





The clinical management of large bone defects is often complicated by patient factors, soft tissue injury, and the physiology of injury.

### The induced Membrane Technique



## Strategies to manage complex injuries and achieve bone union



Journal of Orthopaedic Research 22 (2004) 73-79

Journal of Orthopaedic Research

www.elsevier.com/locate/orthres

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

Ph. Pelissier<sup>a,\*</sup>, A.C. Masquelet<sup>b</sup>, R. Bareille<sup>c</sup>, S. Mathoulin Pelissier<sup>d</sup>, J. Amedee<sup>c</sup>

Initially developed in the late 1970s for the management of bone loss resulting from the treatment of septic nonunion of the leg.<sup>[1]</sup>

Masquelet AC, Fitoussi F, Begue T, et al. Reconstruction of the long bones by the induced membrane and spongy autograft. Ann Chir Plast Esthet. 2000;45:346–353

## The induced Membrane Technique



This technique has been adopted as a technique to manage segmental bone defects, irrespective of the etiology of bone loss.

Masquelet AC. Induced membrane technique: pearls and pitfalls. J Orthop Trauma. 2017;31 (suppl 5):S36–S38.

## The induced Membrane Technique

## Consist of a planned two-stage Procedure

First stage Debridement,



In the setting of infection, surgical debridement should be aggressive and may require multiple debridements.





#### Aggressive removal of all Devitalized Bone



Residual open wounds, draining wounds, or deep infection will negatively affect the outcome of this technique.



## A wide resection in order to assure the eradication of infection.

## The induced Membrane Technique

Bone stabilization, Placement of a (PMMA) cement spacer to preserve the potential dead space for later grafting.





The cement spacer can be placed in one block or multiple pieces.



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The Bone Cement (PMMA) spacer secondarily Causes

The induction of a membrane that envelops the spacer and contains the space.



Gruber HE, Ode G, Hoelscher G, et al. Osteogenic, stem cell and molecular characterisation of the human induced membrane from extremity bone defects. Bone Joint Res. 2016;5:106–115.

The induced membrane is **biologically** active and has been shown to be

- .- Highly vascularized,
- .- Secrete osteoinductive and
- .- Angiogenic growth factors,
- .- Contain mesenchymal adult stem cells (MSCs),



Gruber HE, Ode G, Hoelscher G, et al. Osteogenic, stem cell and molecular characterisation of the human induced membrane from extremity bone defects. Bone Joint Res. 2016;5:106–115.



## which are the conditions for eventual tissue regeneration





Success of the Induce Membrane Technique is predicated on both an adequate soft- tissue envelope and an adequate biologic environment to induce healing.

#### Second stage





#### The timing of the second stage is variable and is often dependent upon the status of the soft tissue and confirmation that an infection has been eradicated.

Pelissier P, Masquelet AC, Bareille R, et al. Induced membranes secrete growth factors including vascular and osteoinductive factors and could stimulate bone regeneration. J Orthop Res. 2004;22:73–79.

#### Second stage





Basic science evidence, as mentioned above, shows peak membrane with biologic activity around the 4 to 6 week window

Pelissier P, Masquelet AC, Bareille R, et al. Induced membranes secrete growth factors including vascular and osteoinductive factors and could stimulate bone regeneration. J Orthop Res. 2004;22:73–79.



#### Autograft is the gold standard either from the iliac crest

Nauth A, Lee M, Gardner MJ, et al. Principles of nonunion management: state of the art. J Orthop Trauma. 2018;32 Suppl 1:S52–S57.





#### RIA bone graft from the femur.

Sagi HC, Young ML, Gerstenfeld L, Einhorn TA, Tornetta P: Qualitative and quantitative differences between bone graft obtained from the medullary canal (with a reamer/irrigator/aspirator) and the iliac crest of the same patient: J Bone Joint Surg Am 2012;94:2128-2135.

### **Clinical case**

26 y Male pac. Motorcicle accident Expose fracture A wide debridement Stabilization



### 3 weeks later 2nd Wide debridement





9 weeks 3rd Wide debridement bone cement (PMMA) spacer

12 weeks External fixator removal

## A Bone cement (PMMA) nail was applied





## Bone Defect Healed

## Conclusion



The Induced Membrane Technique is an effective option for the treatment of segmental bone defects

## Disadvantage

Adequate infection control, is paramount to success, and surgeons should consider repeated debridement



### 10 risk factors for non union

.- location,

- .- soft tissue damage,
- .- vascularization,
- .- displacement,
- .- type of fracture,
- .- method of reduction,
- .- mechanical stability,
- .- presence of a fracture gap,
- .- infection, and
- .- smoking.

Santolini E, West R, Giannoudis PV. Risk factors for long bone fracture non-union: a stratification approach based on the level of the existing scientific evidence. Injury. 2015;46 (suppl 8):S8–S19.

**Surgical strategies Limb Lengthening** 

Bone transport Bifocal lengthening Compresso-distraction Acute Shortening Lengthening over the nail



## **Limb Lengthening**

## Commonly employed Strategies

## To manage these complex Injuries and achieve Bone union



Aronson J. Limb-lengthening, skeletal reconstruction, and bone transport with the Ilizarov method. J Bone Joint Surg Am. 1997;79:1243–1258.

## **High-energy complex limb injuries**

Extensive tissue damage or loss

Poses a challenge

Orthopaedic Plastic Vascular surgeons



## **Distraction Osteogenesis**

Restoration of large bone Defects

Without the need for Bone grafts or complicated flaps

Avoiding morbidity of donor sites



Ilizarov GA (1989a) The tension-stress effect on the genesis and growth of tissues. Part I. The influence of stability of fixation and soft-tissue preservation. Clin Orthop Relat Res 238:249–281

#### **Bone transport**



### An osteotomy is created

## The intervening segment of bone is transported distally

## Bifocal bone transport can successfully be used

Male patient 30 Yrs old Loss of bone Bone gap 12 cms Bifocal bone transport



## Bifocal bone transport can successfully be used



Multiple bone segment can be transported in the same or opposite direction to facilitate bone regeneration in the affected area

Aronson J, Johnson E, Harp JH: Local bone transportation for treatment of intercalary defects by the Ilizarov technique: Biomechanical and clinical considerations. *Clin Orthop* 1989;243:71-79.

The segment to be transported

Must possess an adequate Blood supply

So that Bone formation can be induced



#### The docking site



Autogenous bone grafting is necessary to enhance healing at the docking site

## **Goals of treatment**



#### 35 Yrs. Male: 2 years infection and atrophic non-union



### Post-op wound infection

## Débridement must include the complete removal of all necrotic bone,



Débridement must include the complete removal of all necrotic bone, foreign material, and tissue with compromised viability.



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External fixation for gradual, controlled mechanical distraction has been effective for both skeletal and soft-tissue reconstruction.





## Bone transport; fill the gap





## Reconstruction with bone transport

## Strategy Compresso - distraction

The ability to stimulate

OSTEOGENESIS

By means of

**COMPRESION – DISTRACTION** 



## Compresso - distraction

## Resection of Infected Bone

Contact Bone end to end

Compression 3 weeks

Gradual Distraction



## Acute shortening

## Bring the wound edges together completely

38-year-old male patientMotorcycle injuryOpen tibial fracture IIIB6 cm bone defect



Ullmann Y, Fodor L, Ramon Y, Soudry M, Lerner A (2006) The revised "reconstructive ladder" and its applications for high-energy injuries to the extremities. Ann Plast Surg 56(4):401–405.





## Acute tibial shaft shortening

The temporary gross deformity thus created

Offers ample soft tissue necessary To cover the bones

Which are placed in contact



#### Management

- Tibial shaft open fracture
- Loss of bone
- acute shortening
- Corticotomy
- Definitive external fixation



## Leg length discrepancy

• Transarticular ankle fixation







Regenerate Bone

/11/2013 (READ)

#### Distal Bone contact

#### Bone transport over the nail

LAT IZQ

ERA

PIZQ

ERA

Proximal bone fragment is moved distally to fill the gap

#### Bone transport over the nail



#### Completely healing THE BONE GAP



## Limb lengthening over the nail

El-Husseini TF, Ghaly NA, Mahran MA, et al. Comparison between lengthening over nail and conventional Ilizarov lengthening: a prospective randomized clinical study. Strateg Trauma Limb Reconstr. 2013;8: 97–101

#### Desired length has been achieved

## Locked the nail & external fixator was removed

El-Husseini TF, Ghaly NA, Mahran MA, et al. Comparison between lengthening over nail and conventional Ilizarov lengthening: a prospective randomized clinical study. Strateg Trauma Limb Reconstr. 2013;8: 97–101



Circular frame can be aesthetically unpleasing for the patient



Large size of the external fixation device requires the use of special clothing to cover the device

## Complications

Pin/wire site Inflammation and deep pin tract infection

The most common Complication



## **Special care**



#### Clean and protect the pins or screws to prevent infection.







### Recalcitrant Infection : pins removed

## **Disadvantages of Bone lengthening**

"Long term placement of an external fixator"

.- Pin problems

.- BOTHERSOME of external fixation



## Conclusion

The mesenquimal tissue between the ends of a non-union retains the capacity to form Osseus tissue

Distraction is osteogenic (histogénic)

Bifocal Distraction decreases the time of treatment

The tensión stress effect stimulates neoosteogenesis at the site of non-union

# Thanks for your attention

