




Development of GBR

IMPLANTOLOGY YEAR COURSE
Module 3

STUART ELLIS BDS MFGDP(UK) DPDS MSc
Course Director
Cambridge Academy of Dental Implantology




Aims & Objectives

- What is is GBR?
- How does it work?
- Does it work?




What is GBR?






What is GBR?

GBR:
Guided Bone Regeneration

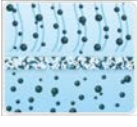
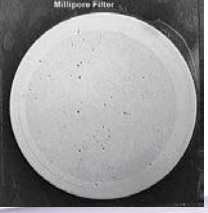




What is GBR?

Guided Tissue Regeneration:

GTR developed by Nyman *et al* in early 1980s for periodontal regeneration using Millipore filters



What is GBR?

Guided Tissue Regeneration:

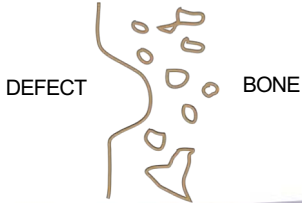
Millipore filters (cellulose esters) replaced by expanded polytetrafluoroethylene (ePTFE) membranes in mid-late 1980s.



What is GBR?

Application of a physical barrier:

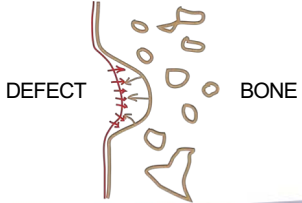
Allows proliferation of angiogenic and osteogenic cells from bone without interference from fibroblasts



What is GBR?

Application of a physical barrier:

Allows proliferation of angiogenic and osteogenic cells from bone without interference from fibroblasts




What is GBR?



Fibroblasts:
Fast & aggressive

What is GBR?



Bone cells:
Slow moving, gentle


What is GBR?



.v.



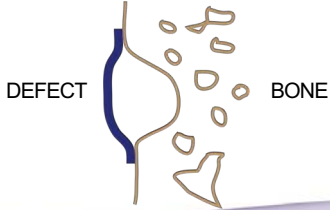
What is GBR?



What is GBR?

Application of a physical barrier:

Allows proliferation of angiogenic and osteogenic cells from bone without interference from fibroblasts

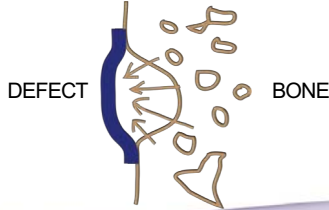


The diagram illustrates a cross-section of a bone defect. A blue curved line represents a physical barrier placed over the defect. To the left of the barrier is the 'DEFECT' area, and to the right is the 'BONE' area. The barrier is designed to allow cells from the bone to proliferate and fill the defect without being interfered by fibroblasts.

What is GBR?

Application of a physical barrier:

Allows proliferation of angiogenic and osteogenic cells from bone without interference from fibroblasts

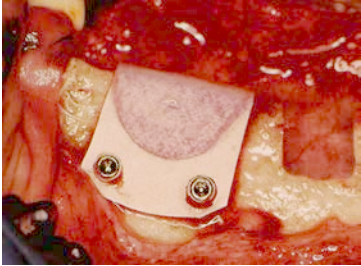


This diagram is identical to the one in the first slide, showing a cross-section of a bone defect with a blue physical barrier placed over it. The barrier separates the 'DEFECT' from the 'BONE', allowing for the proliferation of angiogenic and osteogenic cells from the bone without interference from fibroblasts.

What is GBR?

Foxhound study :

Schenk et al (1994)



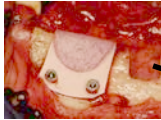
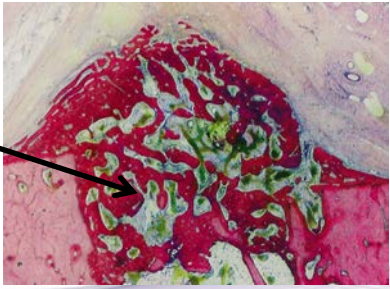
A photograph showing a surgical site in a dog's mandible. A white, semi-circular membrane is being applied over a bone defect. Two metal screws are visible, securing the membrane in place.

Schenk RK, Buser D, Hardwick R, Dahlin C. Healing patterns of bone regeneration in membrane-protected defects: A histologic and histomorphometric study in the mandible of dogs. Int J Oral Maxillofac Implants 1994;9:13-30.

What is GBR?

Foxhound study :

Schenk et al (1994)

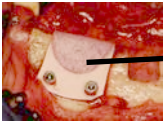
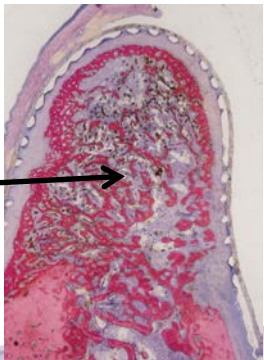



Two histological sections are shown. The left image is a small inset showing a surgical site with a membrane. The right image is a larger histological section showing a bone defect with a membrane. An arrow points from the surgical site in the left image to the corresponding area in the right image, indicating the location of the defect and the membrane.

What is GBR?

Foxhound study :

Schenk et al (1994)

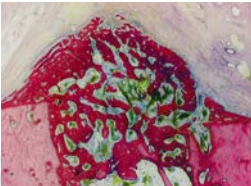
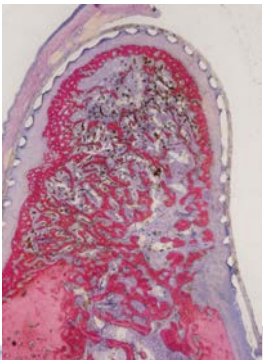



Two histological sections are shown. The left image is a small inset showing a surgical site with a membrane. The right image is a larger histological section showing a bone defect with a membrane. An arrow points from the surgical site in the left image to the corresponding area in the right image, indicating the location of the defect and the membrane.

What is GBR?

Foxhound study :

Schenk et al (1994)

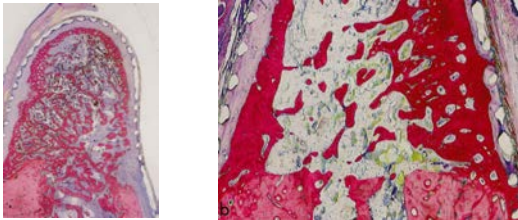



Two histological sections are shown. The left image is a small inset showing a surgical site with a membrane. The right image is a larger histological section showing a bone defect with a membrane. An arrow points from the surgical site in the left image to the corresponding area in the right image, indicating the location of the defect and the membrane.

What is GBR?

Foxhound study :

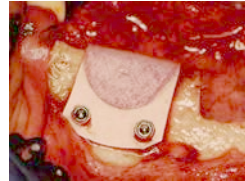
Schenk et al (1994)



Development of 'fillers'?

Problems with membrane GBR clinically:

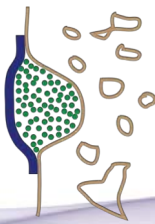
- Membrane collapse
- Formation of a 'periosteum-like' soft tissue under the membrane



Development of 'fillers'

Solution - fillers (autografts/allografts):

- Supports the membrane
- Stopped 'periosteum-like' tissue formation under membrane



Indications

Coronal dehiscences:

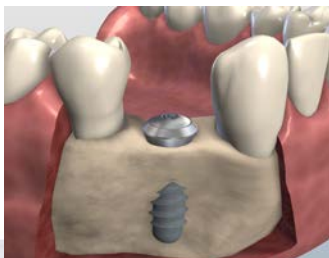
- The more walls, the better the success rate



Indications

Apical dehiscences:

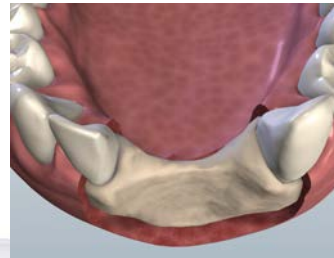
- The more walls, the better the success rate



Indications

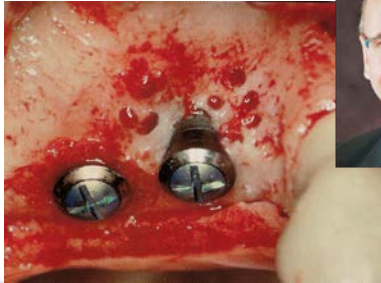
Narrow ridges:

- May respond better to block onlay grafts



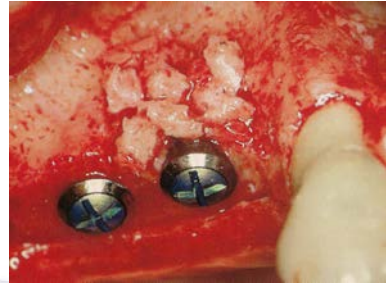
Early clinical cases – Professor Buser

UR4/5 implants with bone dehiscence:



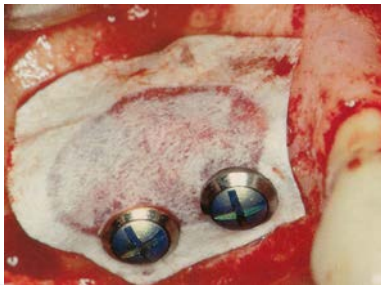
Clinical case example

Application of locally harvested bone chips:



Clinical case example

ePTFE membrane placed:



Clinical case example

Periosteum incised & wound closed:



Clinical case example

4 months post-op:



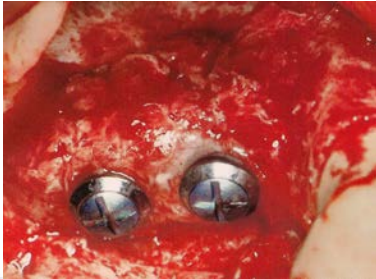
Clinical case example

4 months post-op - surgery to remove membrane:



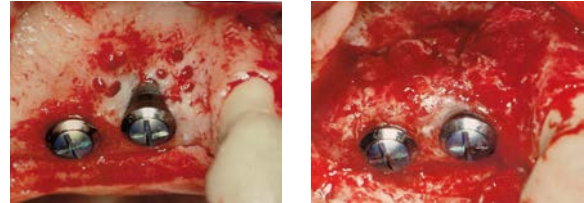
Clinical case example

4 months post-op - underneath membrane:



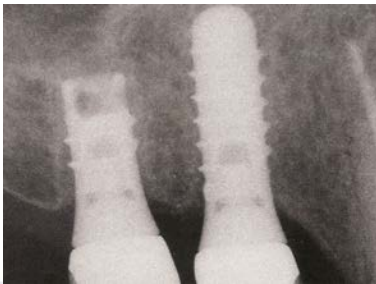
Clinical case example

4 months post-op - underneath membrane:



Clinical case example

15 years post-op PA:



Membranes & fillers

Problems with membrane & filler clinically:

- Significant rate of membrane exposures from soft tissue dehiscences
-often leading to infections
- Hydrophobic ePTFE membranes difficult to handle, needed tacking
- Need for 2nd surgery to remove membrane



Membranes

Non
resorbable



Resorbable

Membranes

Requirements:

- Occlude cells
- Biocompatible
- Good handling properties
- Low complication rate
- Tissue integration

Membranes - cell occlusion

Cell occlusion:

Exclude connective tissue cell invasion but still allow nutrient transfer.

Studies have shown that macroporous membranes have lower complication rate than totally occlusive barrier membranes

Membranes - biocompatibility

In general:

Inert materials less of an issue than degradable materials

Membranes - biocompatibility

Degradable materials:

The material, the intermediate breakdown products and the final breakdown products all need to be taken into account

Membranes - tissue integration

Tissue integration:

Non-porous, non textured materials result in fibrous tissue capsulation - no tissue attachment

Materials which integrate with tissues allow the tissues to improve mechanical stability of membrane

Non-resorbable membranes


Non-resorbable membranes ePTFE

PTFE - polytetrafluoroethene (Teflon)



PTFE (Teflon) – Roy Plunckett 1938

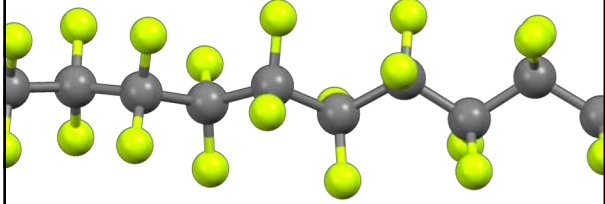
1938 – working on refrigeration gases (CFCs)



A circular portrait of Roy Plunckett, an older man with glasses, wearing a white shirt and tie. To his right is a vintage white refrigerator with its doors open, showing shelves stocked with various food items.

PTFE (Teflon) – Roy Plunckett 1938

1938 – working on refrigeration gases (tetrafluoroethylene)



A ball-and-stick molecular model of tetrafluoroethylene (C₂F₄). It shows two carbon atoms (grey) connected by a double bond, with each carbon atom also bonded to two fluorine atoms (yellow).

PTFE (Teflon) – Roy Plunckett 1938

1938 – working for DuPont




A blue gas cylinder with a yellow valve on the left. To its right is a row of several glass laboratory flasks containing a white, milky liquid.

PTFE (Teflon) – Manhattan Project



A black and white photograph showing a large industrial construction site, likely the Manhattan Project's chemical separation facility. Several workers in hard hats are visible near large cranes and structural steel frameworks.


PTFE (Teflon) – Fishing Tackle



A color photograph of a fisherman in a blue long-sleeved shirt and a cap, holding a large, silvery fish (likely a largemouth bass) while standing on a boat.

Non-resorbable membranes ePTFA

Tefal



- Extremely strong bonds C-F
- No known enzyme can cleave C-F bond
- Allows material to be biologically inert

$$\left(\begin{array}{cc} \text{F} & \text{F} \\ | & | \\ -\text{C} & - & \text{C}- \\ | & | \\ \text{F} & \text{F} \end{array} \right)_n$$

Non-resorbable membranes ePTFA

ePTFE - *expanded* polytetrafluoroethylene



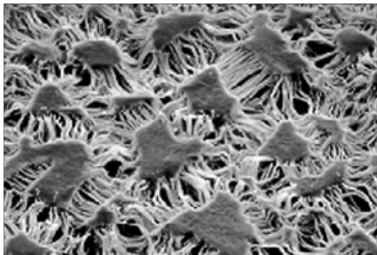
- William Gore - chemist
- Until 1957 worked for DuPont!
- Started a company in his basement in 1958, making PTFE insulated computer cabling.

Non-resorbable membranes - ePTFA



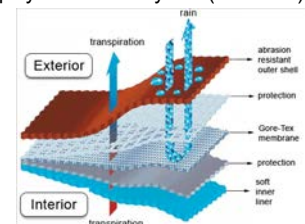
I decided to give one of these rods a huge stretch, fast, a jerk... and it stretched 1000%

Non-resorbable membranes - ePTFA



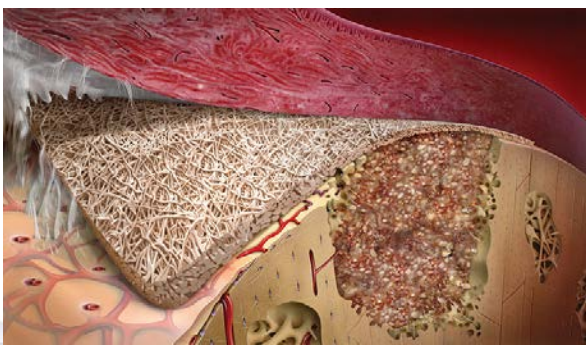
Non-resorbable membranes ePTFA

ePTFE - *expanded* polytetrafluoroethylene (Gore-Tex)



Allows passage of gases & vapour but not liquids

Non-resorbable membranes ePTFA (GoreTex)

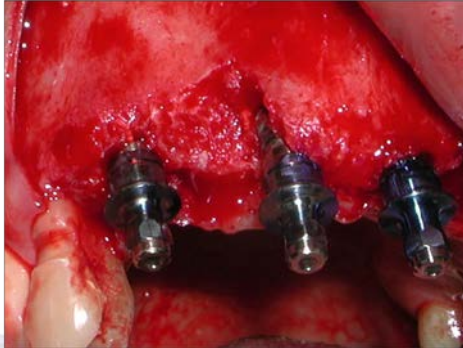


Non-resorbable membranes ePTFA (Gore)

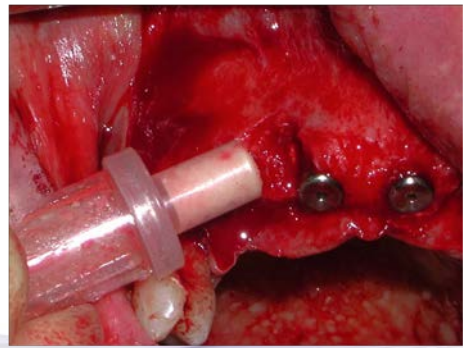


- Used in perio & oral surgery 1980s - early 1990s
- Wound dehiscences common
- Infections common
- Hydrophobic - difficult to handle
- Needed pins & tacks
- No tissue integration
- Second surgery to remove

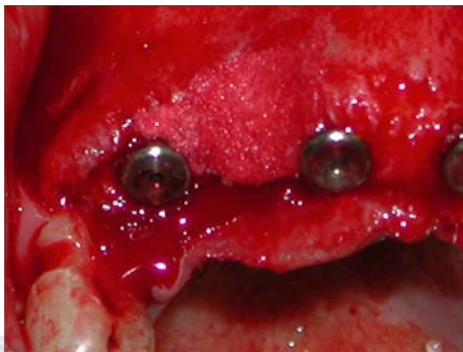
Non-resorbable membranes ePTFA (Gore)



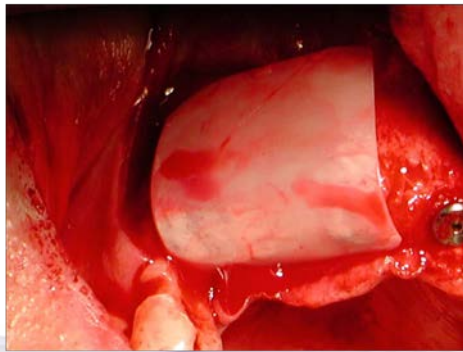
Non-resorbable membranes ePTFA (Gore)



Non-resorbable membranes ePTFA (Gore)



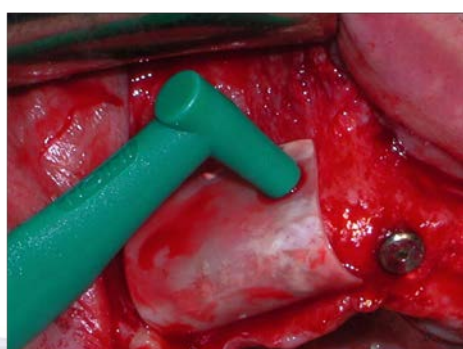
Non-resorbable membranes ePTFA (Gore)



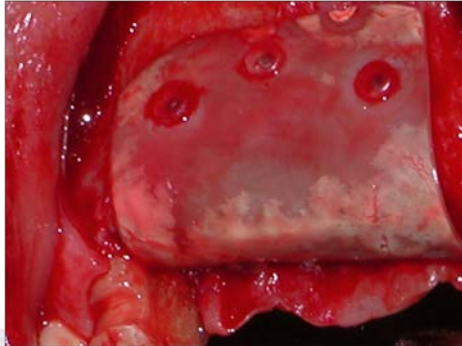
Non-resorbable membranes ePTFA (Gore)



Non-resorbable membranes ePTFA (Gore)



Non-resorbable membranes ePTFE (Gore)



Membranes & fillers

Therefore needed was:

- Hydrophilic membranes
- Bioresorbable membranes



Bioresorbable membranes

Two main types developed:

- Polymers (i.e. polylactic acid/polyglycolic acid)
- Collagen membranes



Resorbable membranes

Resorbable membranes

Synthetic

+

Organic

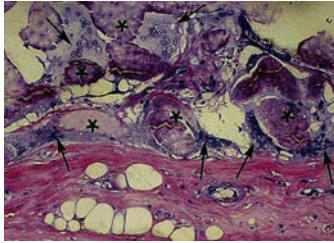
Resorbable membranes - synthetic

Polymers - PGA (polyglycolides)/PLA (polyactides)

- Synthetic - unlimited availability
- Fully degrade (Krebs cycle) to water & CO₂
- Associated with foreign body reactions
- Associated with inflammatory responses

Resorbable membranes - synthetic

Polymers - PGA (polyglycolides)/PLA (polyactides)



Large multinucleated giant cells (arrowed)

Resorbable membranes - organic

Collagen - non cross linked/cross linked

- Type I or Type I & III
- Porcine dermis, equine, bovine dermis/tendon
- Bioresorbable
- Haemostatic
- Hydrophilic - handling properties
- Enzymic degradation by macrophages/PML



Resorbable membranes - organic

Collagen - Geistlich Bio-Gide



Resorbable membranes - organic

Collagen - Creos



Resorbable membranes - organic

Collagen

- Complete degradation 6 - 16 weeks
- Good nutrient permeability
- Low incidence of dehiscences/infections
- Resorbs quickly if exposed (soft tissues heal fast)
- Bilayer design

Resorbable membranes - organic

Collagen - double layer technique



For increased support in larger defects

Resorbable membranes - organic

Collagen - can be secured with resorbable tacks



For increased support in larger defects

Resorbable membranes - organic

Collagen - cross-linked

- Prolongs barrier function times (>12 weeks)
- Prolongs degradation
- Decreases nutrient permeability
- Increased incidence soft tissue dehiscences
- Associated with infections and severe inflammatory responses

Resorbable membranes - organic

Collagen - cross-linked showing dehiscence (canine)



- Resists bacterial enzymatic degradation
- Becomes infiltrated with bacteria and colonised

Conclusion – collagen membranes

Advised collagen membranes:

- Non cross-linked collagen material of choice
- Good handling characteristics
- Hydrophilic
- Stick to bone well (often no need to tack)
- Low risk of post operative complications
- Eliminates need for second surgery
- Can use double layer technique

New
Developments

Resorbable membranes - organic

PRF - Platelet Rich Fibrin



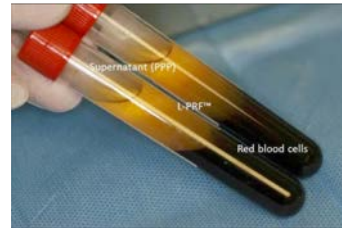
Resorbable membranes - organic

PRF - Platelet Rich Fibrin



Resorbable membranes - organic

PRF - Platelet Rich Fibrin



Resorbable membranes - organic

PRF - Platelet Rich Fibrin



Resorbable membranes - organic

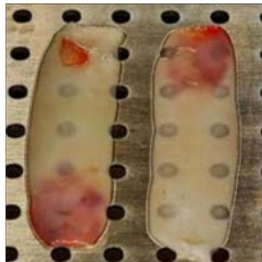
PRF - Platelet Rich Fibrin



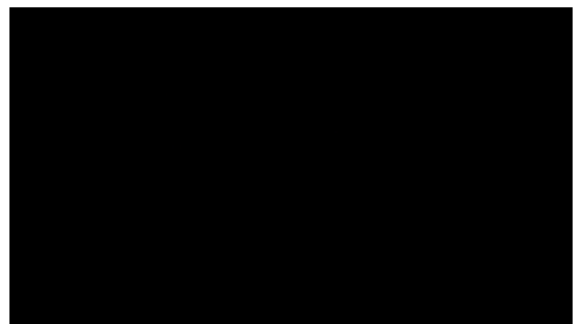
82

Resorbable membranes - organic

PRF - Platelet Rich Fibrin



PRF - Platelet Rich Fibrin

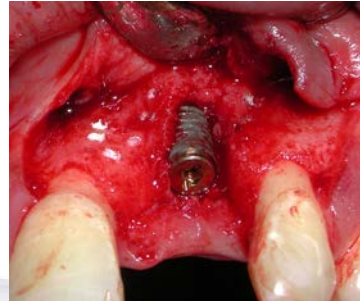


84

THE END

Clinical case example

Dehiscence:



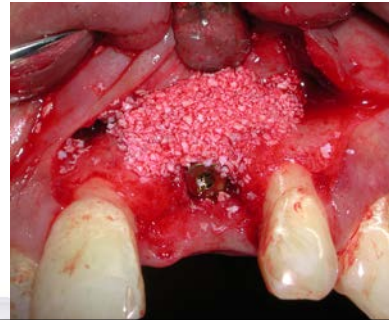
Clinical case example

Particulate graft:



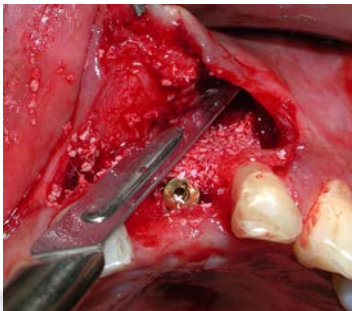
Clinical case example

Packing of material:



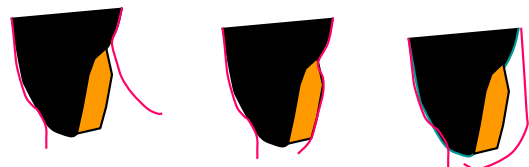
Clinical case example

Releasing periosteum:



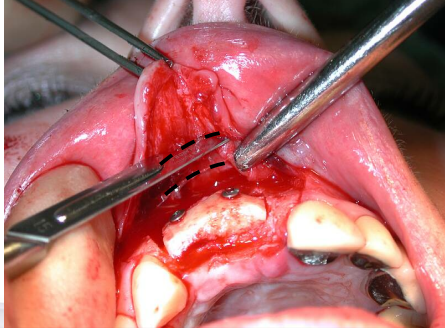
Clinical case example

Releasing periosteum:



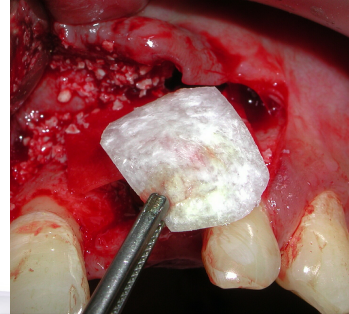
Clinical case example

Releasing periosteum:



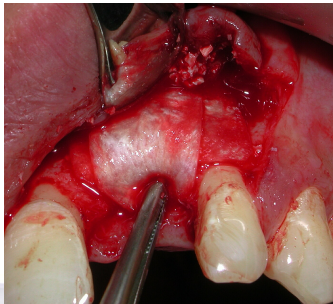
Clinical case example

Barrier membrane placement (collagen):



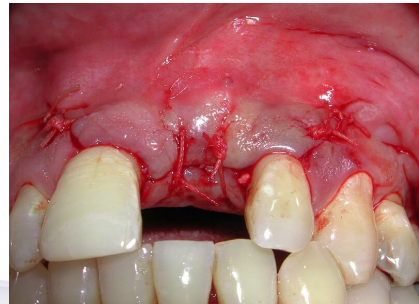
Clinical case example

Barrier membrane placement (collagen):



Clinical case example

Wound closure:



THE END