OSSEOINTEGRATION

DEPARTMENT OF PERIODONTICS AND IMPLANTOLOGY

KARPAGA VINAYAGA INSTITUTE OF DENTAL SCIENCES

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INTRODUCTION

- DEFINITION:
  - **ALBERKSTON → Direct structural and functional connection between ordered, living bone and the surface of a load-bearing implant without intervening soft tissues.**

INTRODUCTION

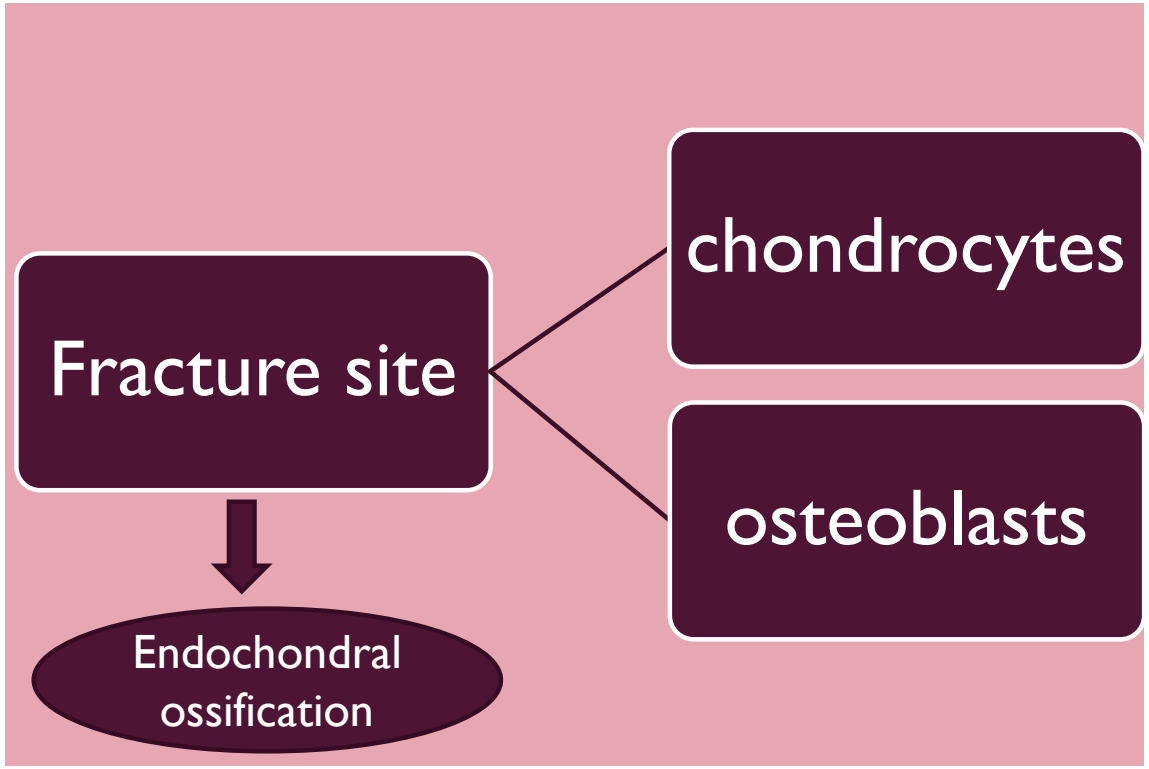
OSSEOINTEGRTION AND FRACTURE HEALING

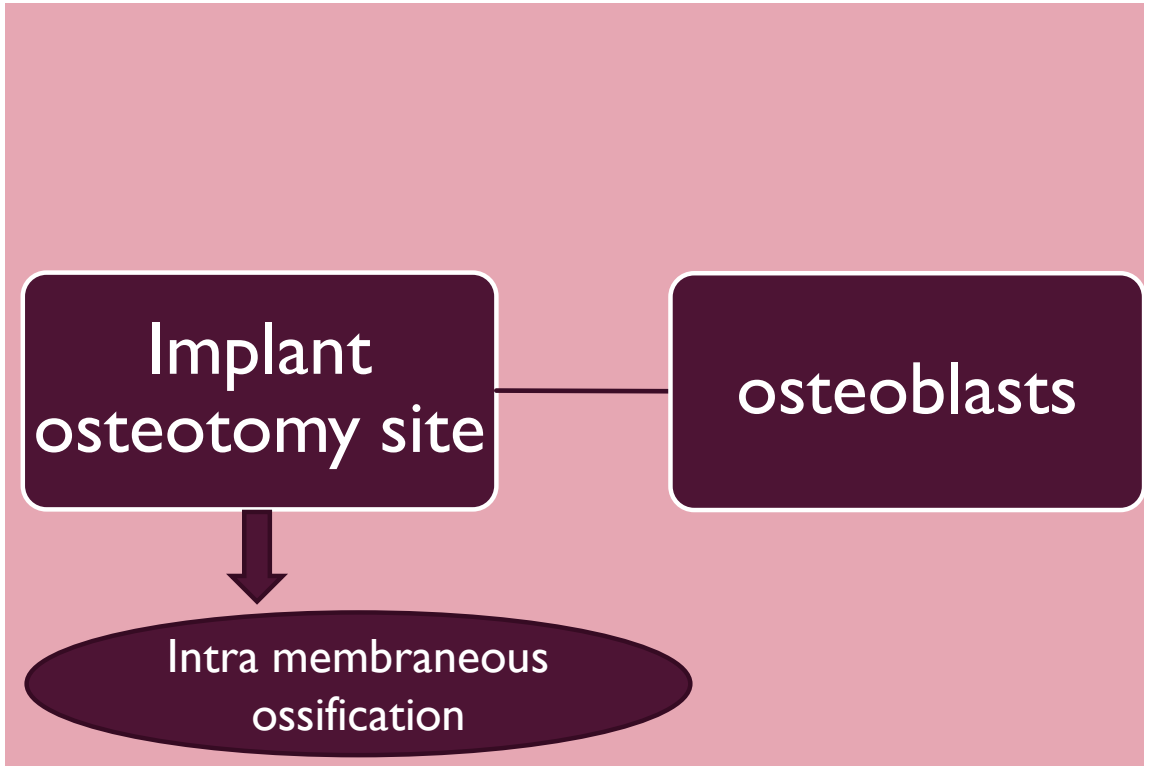
Immune response

Angiogenesis

Recruitment of progenitor cells

COMPARISON

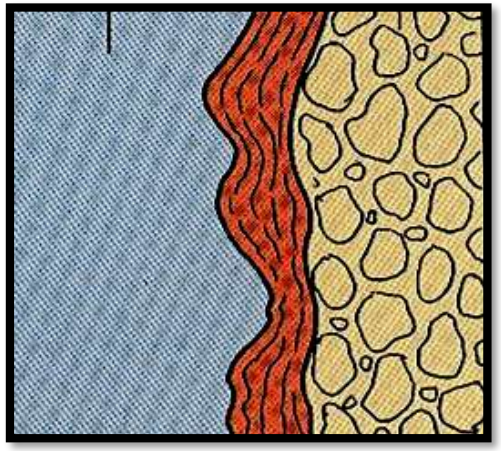

Fracture site
chondrocytes
osteoblasts
Endochondral ossification

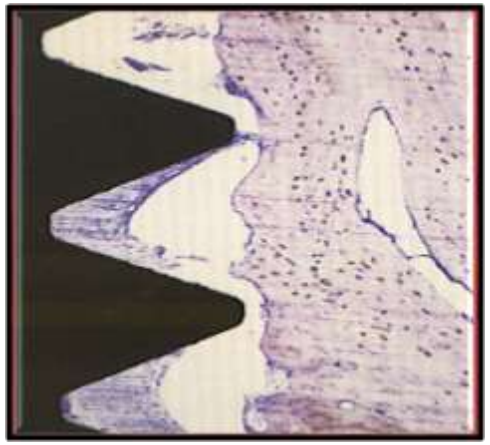

Implant osteotomy site
osteoblasts
Intra membraneous ossification

IMPLANT-BONE INTERFACE

I. Fibro-osseous integration *[Linkow (1970), James (1975), and Weiss (1986)]*

- **In 1986, the American Academy of Implant Dentistry defined fibrous integration as "tissue-to-implant contact with healthy dense collagenous tissue between the implant and bone."**
- **In this theory, collagen fibers function similarly to Sharpey's fibers in natural dentition.**
- **The fibers affect bone remodeling where tension is created under optimal loading conditions (Weiss, 1986).**



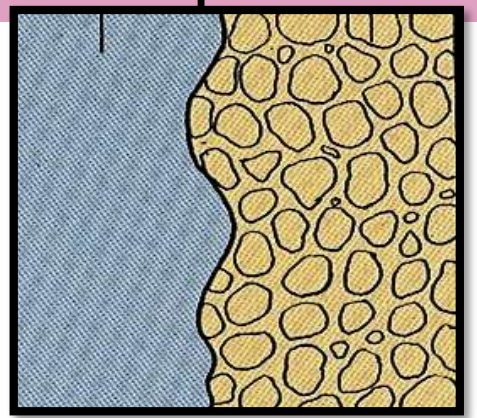


IMPLANT-BONE INTERFACE

- **Branemark theorizes that the implant must be protected and completely out of function, as he envisions a period of healing of at least 1 year, in which new bone is formed close to the immobile resting implant.**

***Meffert, et al (1987)* redefined and subdivided Osseointegration into**

- ***Adaptive Osseointegration*** **: It has osseous tissue approximating the surface of the implant without apparent soft tissue interface at the light microscopic level**
- ***Bio integration*****: It is a direct biochemical bone surface attachment confirmed at the electron microscopic level.**



PROCESS OF OSSEOINTEGRATION

Osteotomy

Bone debris removed by Osteoclasts

Bone resorption 50-100 micrometers per day

Woven bone formation

Stimulation of osteoblast progenitor cells

Bone coupling

Random orientation of collagen fibrils, high cellularity, and limited degree of mineralization
Poor biomechanical strength.

proper oxygen tension
Poor o2 tension → fibroblast formation and implant failure

PROCESS OF OSSEOINTEGRATION

Lamellar bone formation

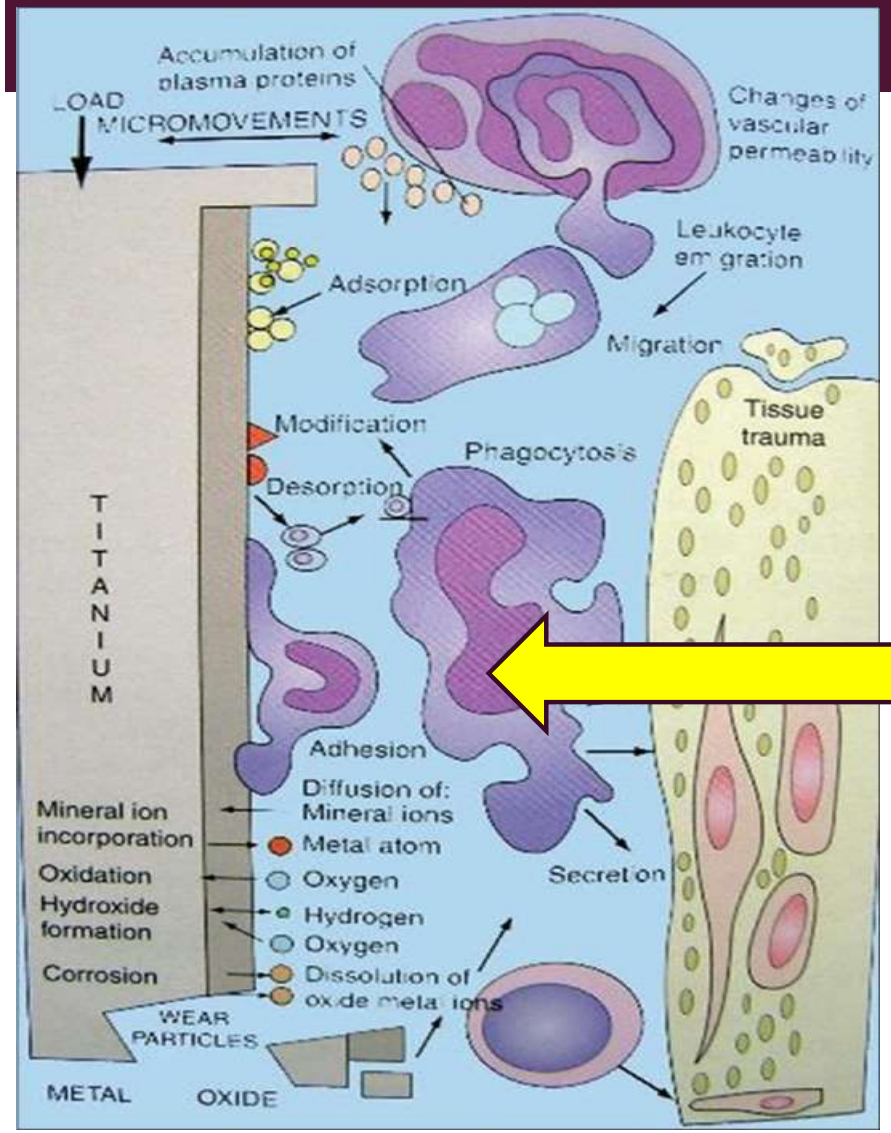
parallel layers of collagen fibrils Dense mineralization. slow pace (only a few microns per day).

Bone Remodelling

after 18 months of healing, a steady state is reached where lamellar bone is continuously resorbed and replaced

Stress shielding

HISTOLOGICAL HEALING

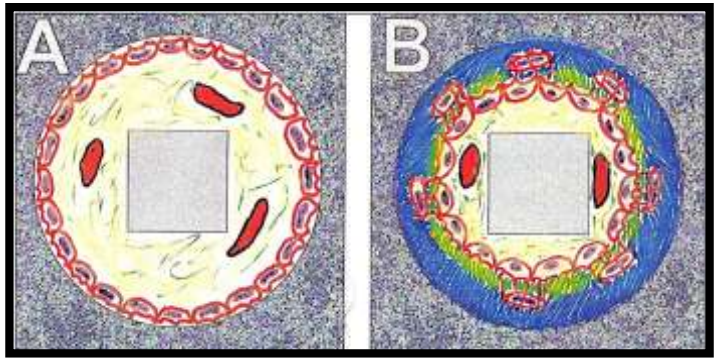


WOUND CHAMBER

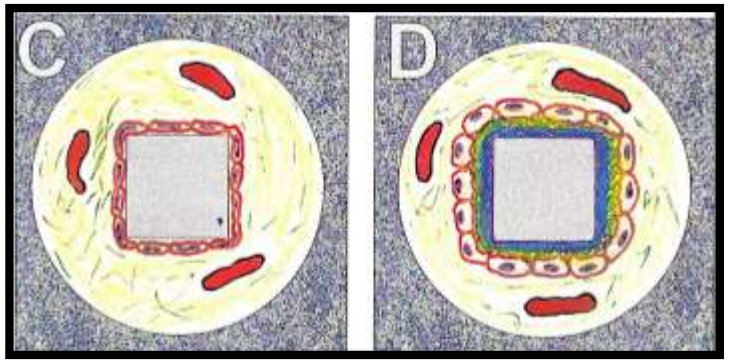
HISTOLOGICAL HEALING

TIME AFTER INSERTION OF IMPLANT	CHANGES
2 HOURS	• BLOOD CLOT→ ERYTHROCYTES, NEUTROPHILS, MACROPHAGES
4 DAYS	• GRANULATION TISSUE→ MESENCHYMAL CELLS, MATRIX COMPONENTS, VASCULAR STRUCTURES (PROVISIONAL CONNECTIVE TISSUE)
I WEEK	• PROVISIONAL MATRIX → INCREASE IN VASCULAR STRUCTURES AND MESENCHYMAL CELLS, DECREASED INFLAMMATORY CELLS. • SURROUNDING THE VASCULAR STRUCTURE→ WOVEN BONE FORMATION (CENTRE OF THE CHAMBER)
2 WEEKS	• WOVEN BONE IN ALL COMPARTMENTS OF THE WOUND CHAMBEFR, INCRESINGLY PRESENT IN THE APICAL REGION
4 WEEKS	• NEW BONE→ FROM CUT BONE INTO CHAMBER (DISTANT OSTEOGENESIS) • CELL RICH WOVEN BONE COVERING THE Ti WALL (CONTACT OSTEOGENESIS)

HISTOLOGICAL HEALING



DISTANT OSTEOGENESIS



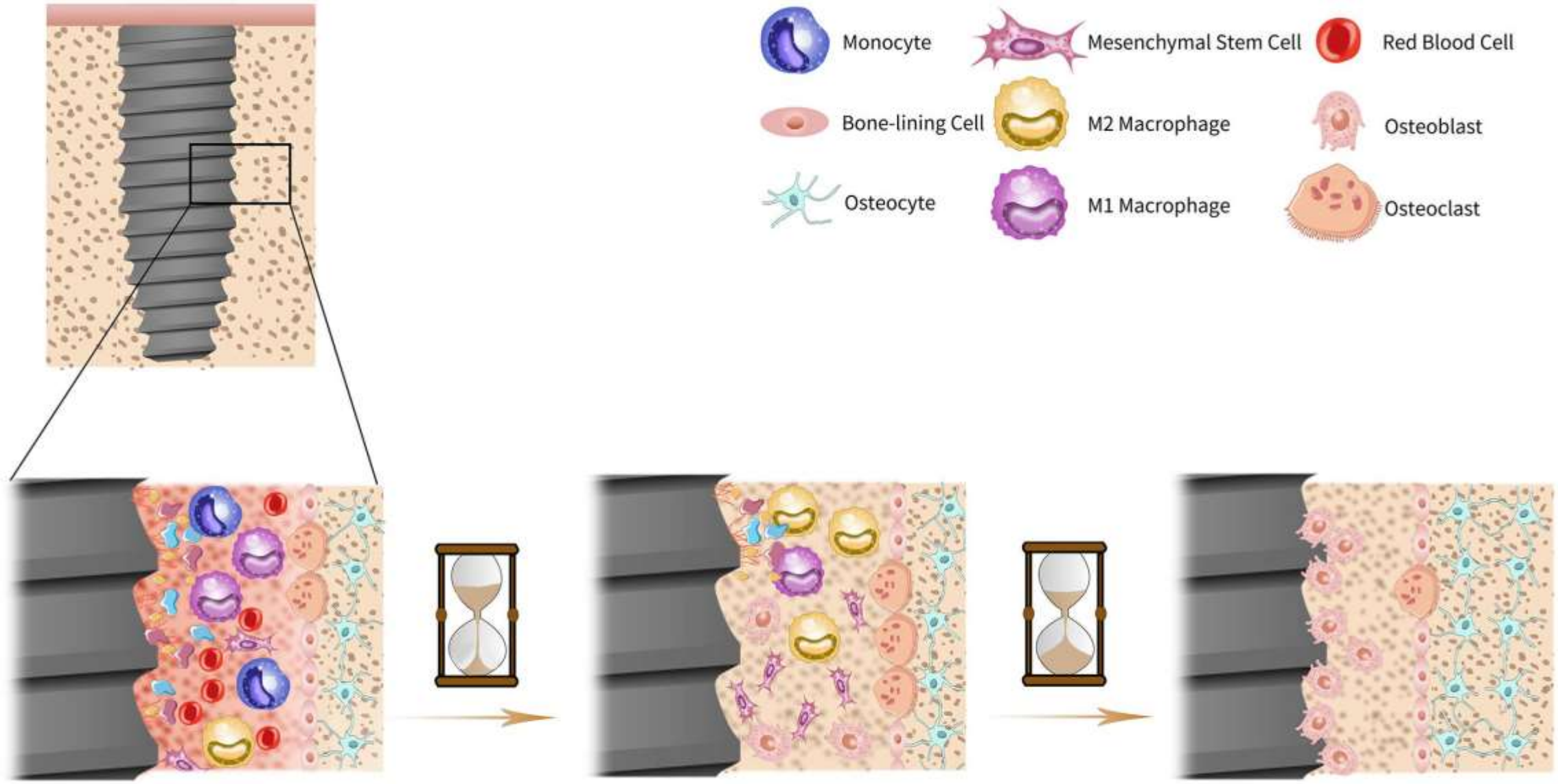
CONTACT OSTEOGENESIS

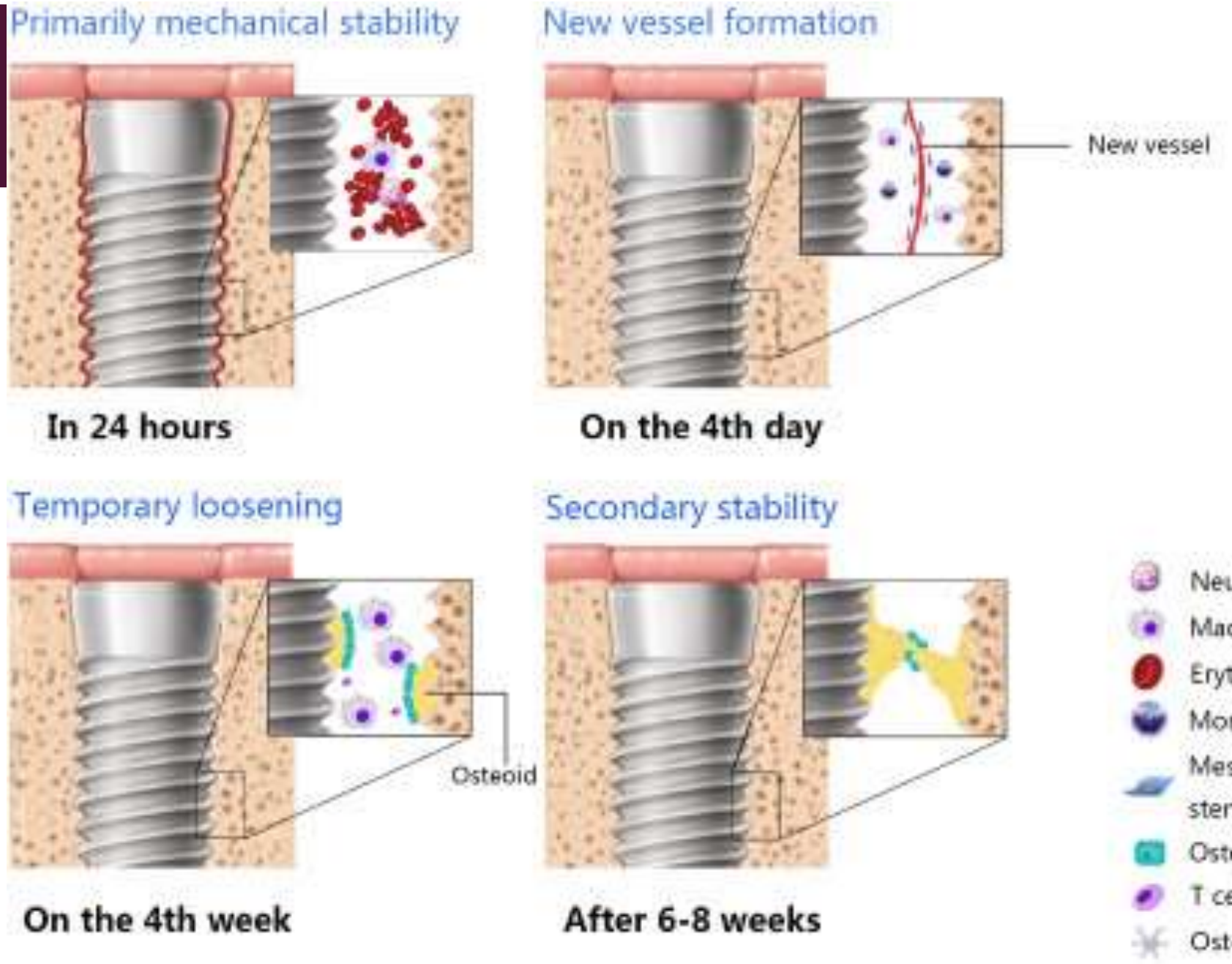
Davies et al

HISTOLOGICAL HEALING

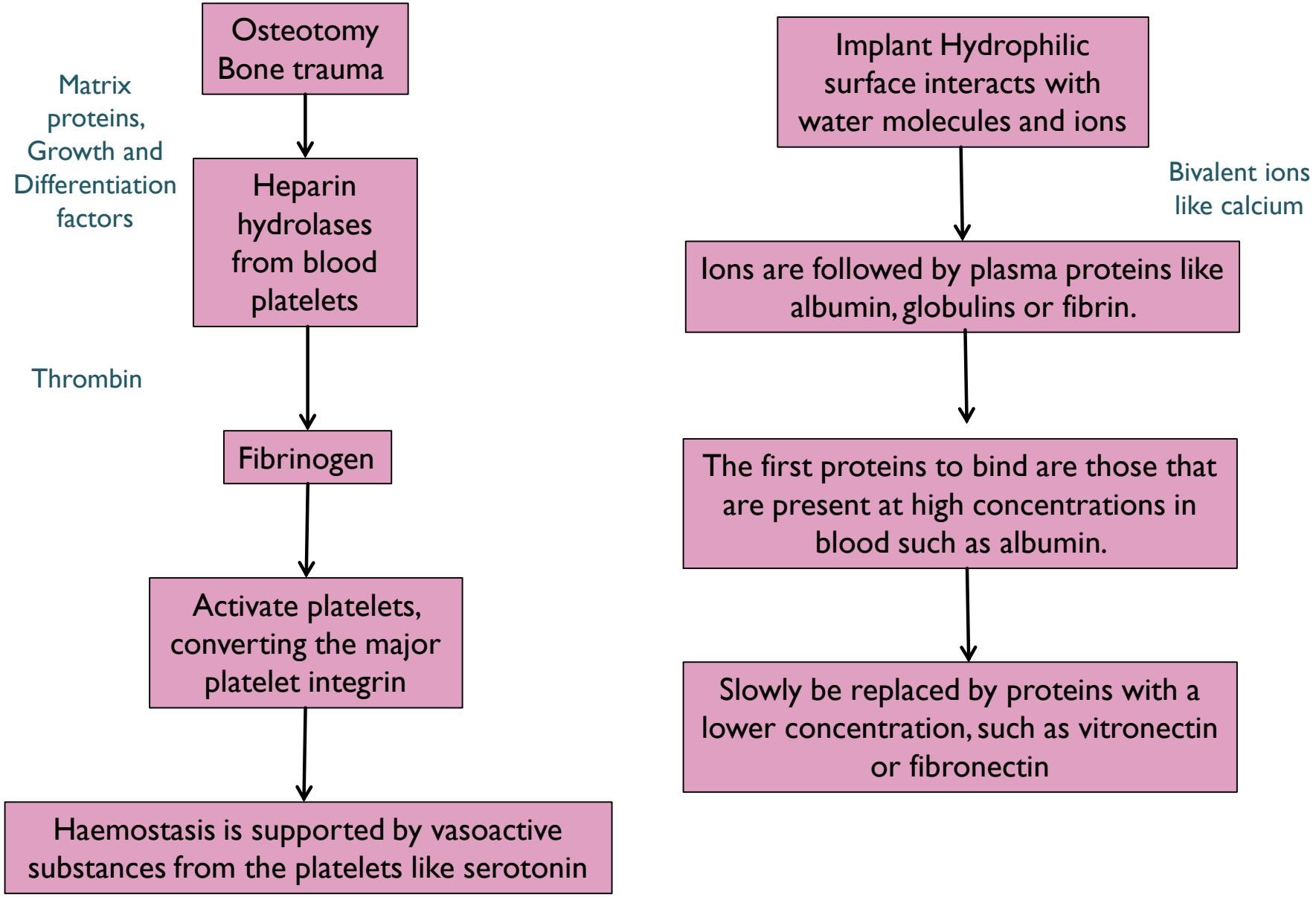
TIME AFTER INSERTION OF IMPLANT	CHANGES
6-12 WEEKS	WOUND CHAMBER→ MINERALISED BONE BONE MARROW WITH BLOOD VESSELS, ADIPOCYTES, MESENCHYMAL CELLS SURROUNDING THE RABECULAE OF MINERALISED BONE.

Bergludh et al2003
Abrahanum et al 2004

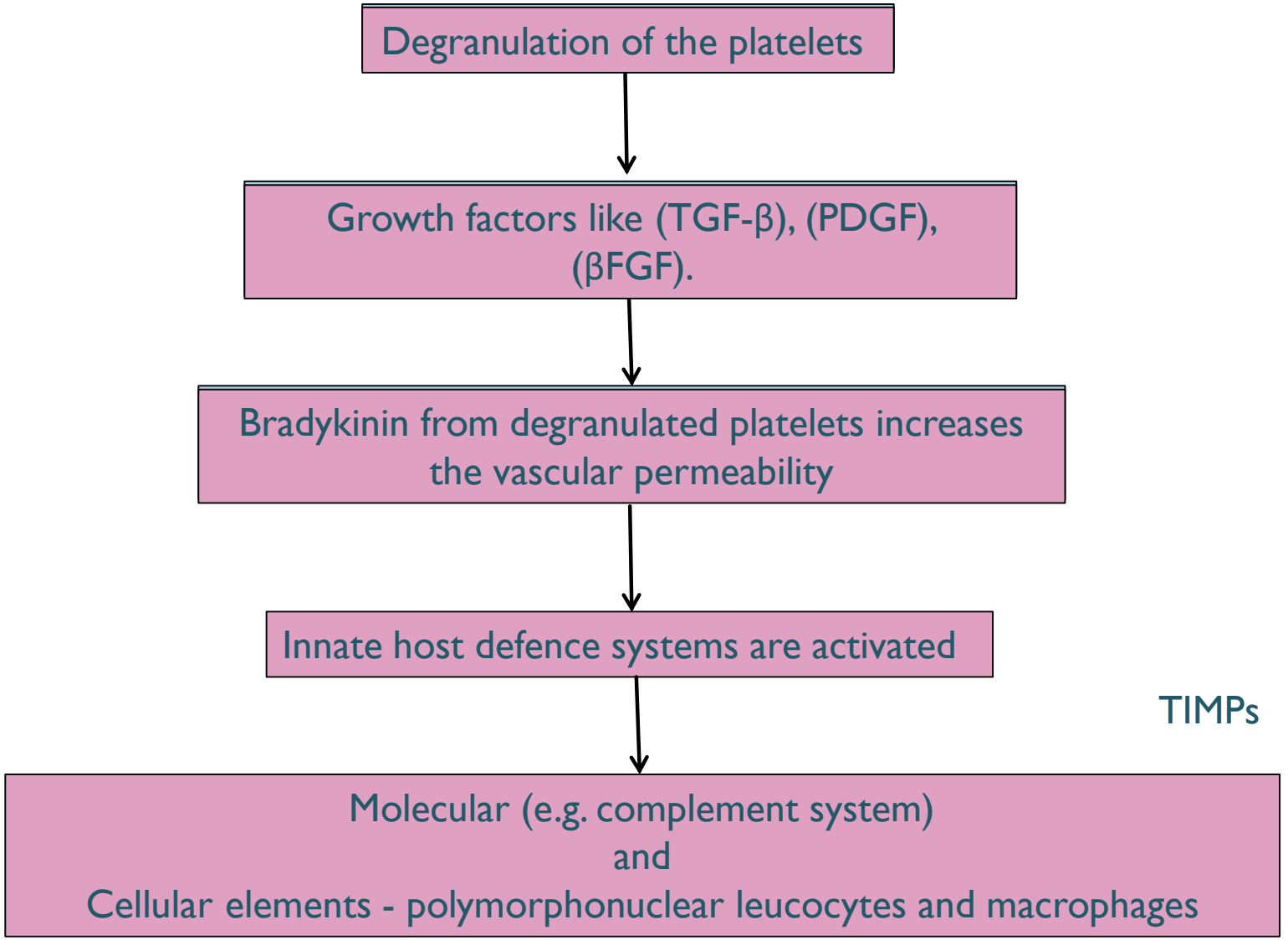

Monocyte
Mesenchymal Stem Cell
Red Blood Cell
Bone-lining Cell
M2 Macrophage
Osteoblast
Osteocyte
M1 Macrophage
Osteoclast
Phase 1
Phase 2
Phase 3


Primarily mechanical stability
New vessel formation
New vessel
In 24 hours
On the 4th day
Temporary loosening
Secondary stability
Osteoid
On the 4th week
After 6-8 weeks
Neutrophil
Macrophage
Erythrocyte
Monocyte
Mesenchymal stem cell
Osteoblast
T cell
Osteocyte

HAEMOSTASIS PHASE (exudative phase)

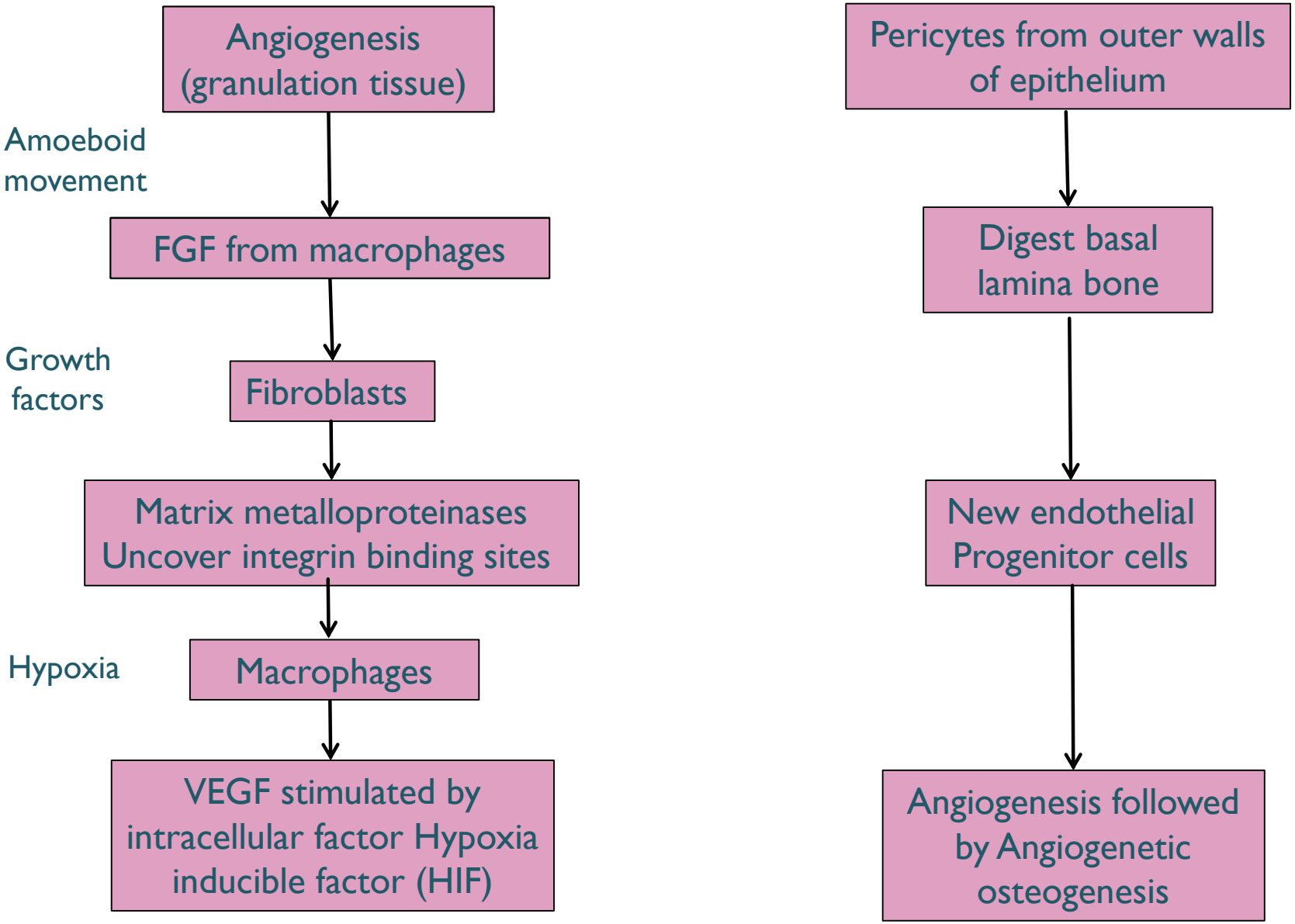


INFLAMMATORY PHASE

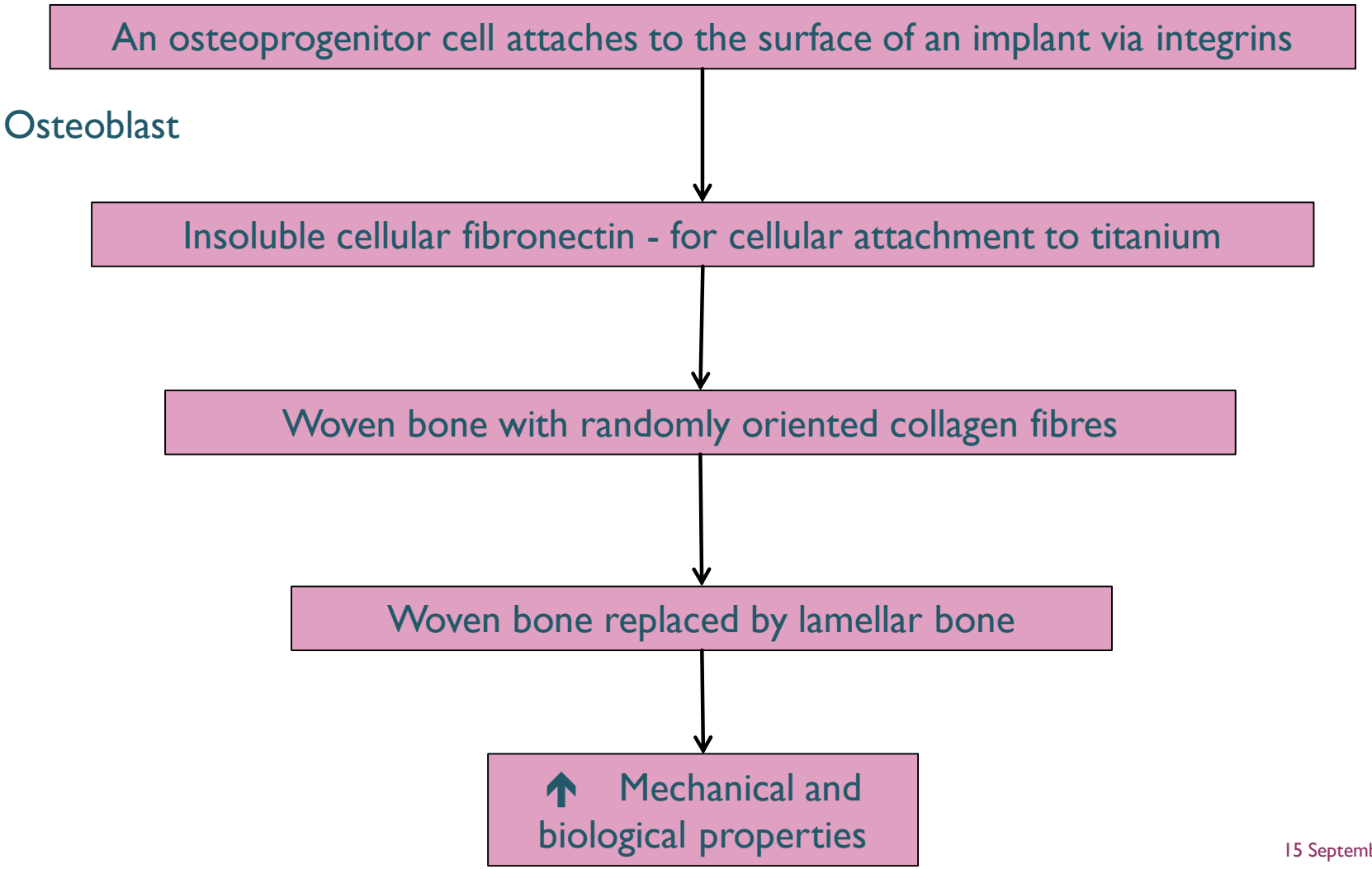


TIMPs

PROLIFERATIVE PHASE



PROLIFERATIVE PHASE



REMODELLING PHASE

Osteoclasts

↓

Remove primary bone implant contact

↓

Lamellar bone and parallel orientation of collagen fibres

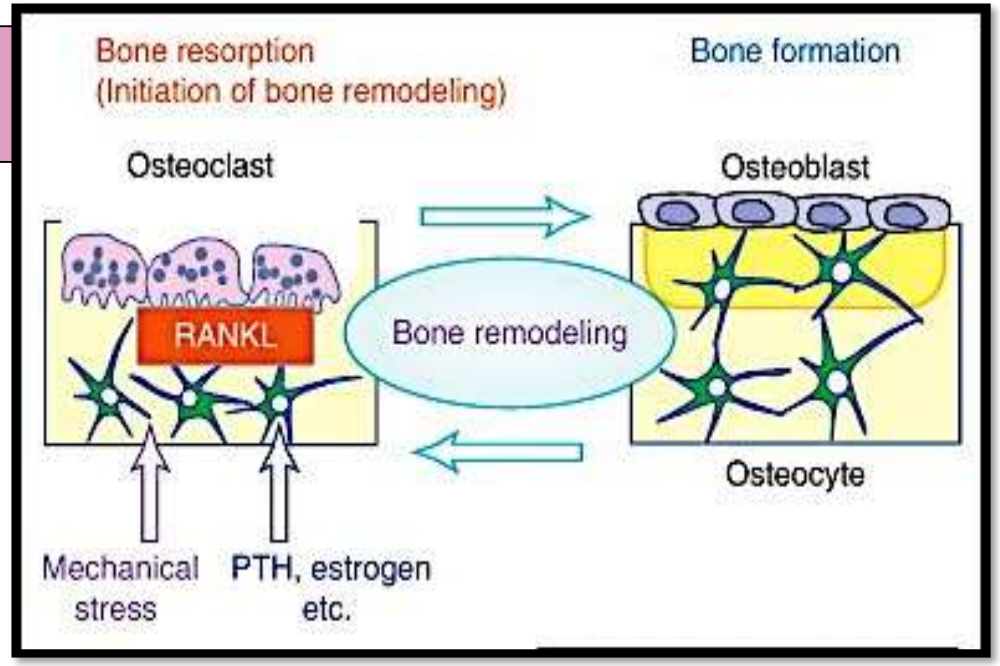
↓

Coupling mechanism
(Or can lead to Osteopenic or osteopetrotic)

↓

Bone enhancing molecules

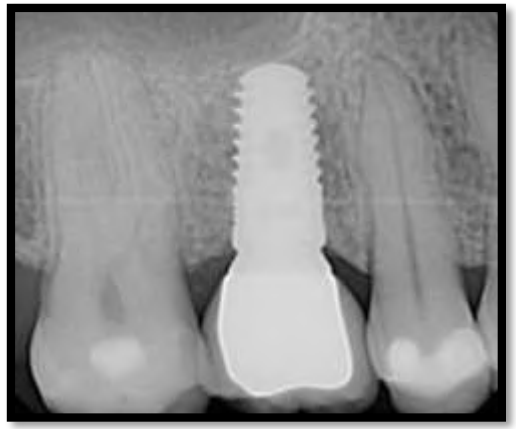
- IL 11
- Sclerostin
- PGE2
- PTH
- Vit D and
- Estradiol



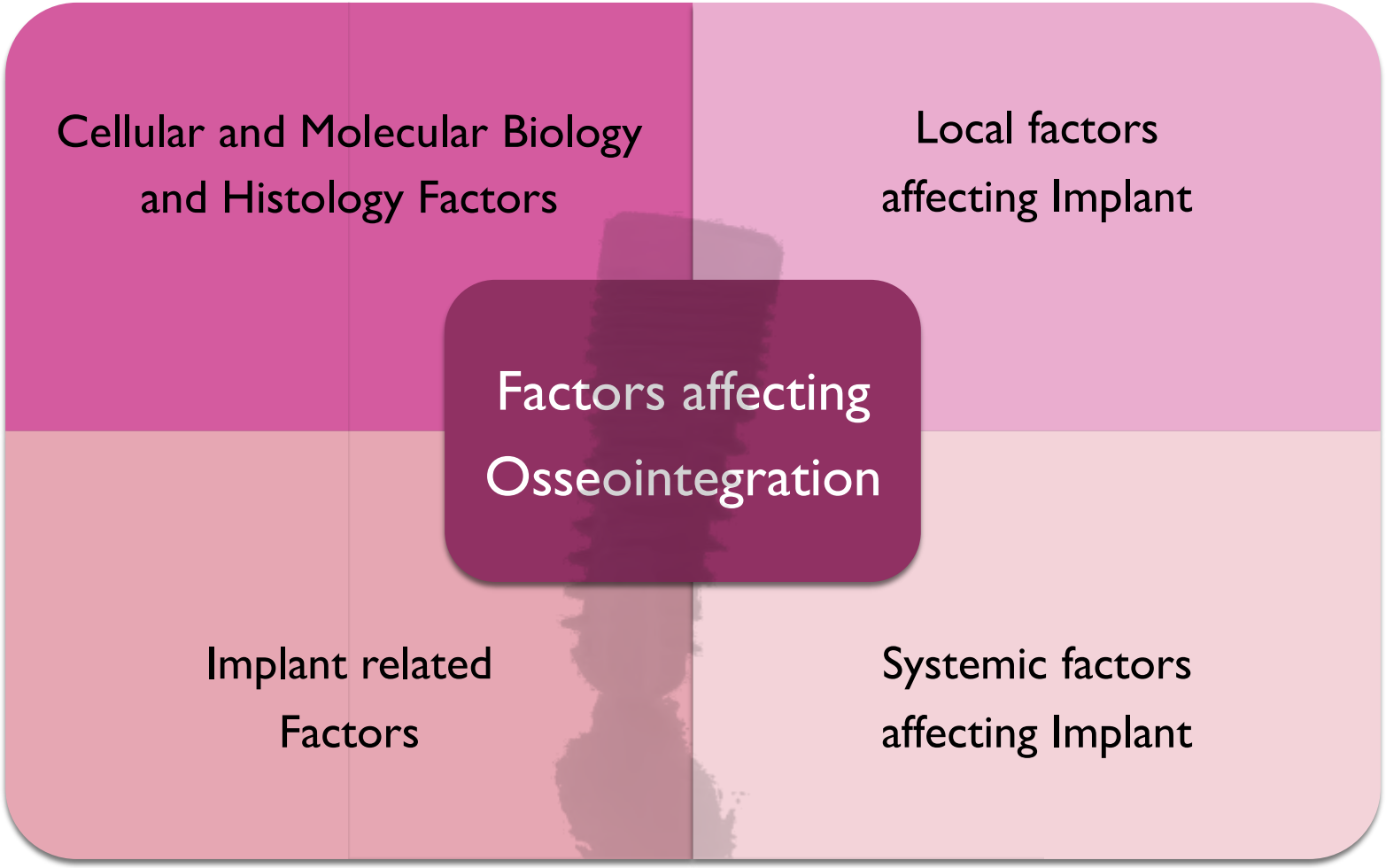
SUCCESS CRITERIA FOR OSSEOINTEGRATED IMPLANTS

Following criteria should be Considered:

- Durability
- Bone loss
- Gingival health
- Pocket depth
- Effect on adjacent teeth function
- Esthetics
- Presence of infection, discomfort, paresthesia or anesthesia
- Intrusion on the mandibular canal
- Patient emotional and psychological attitude



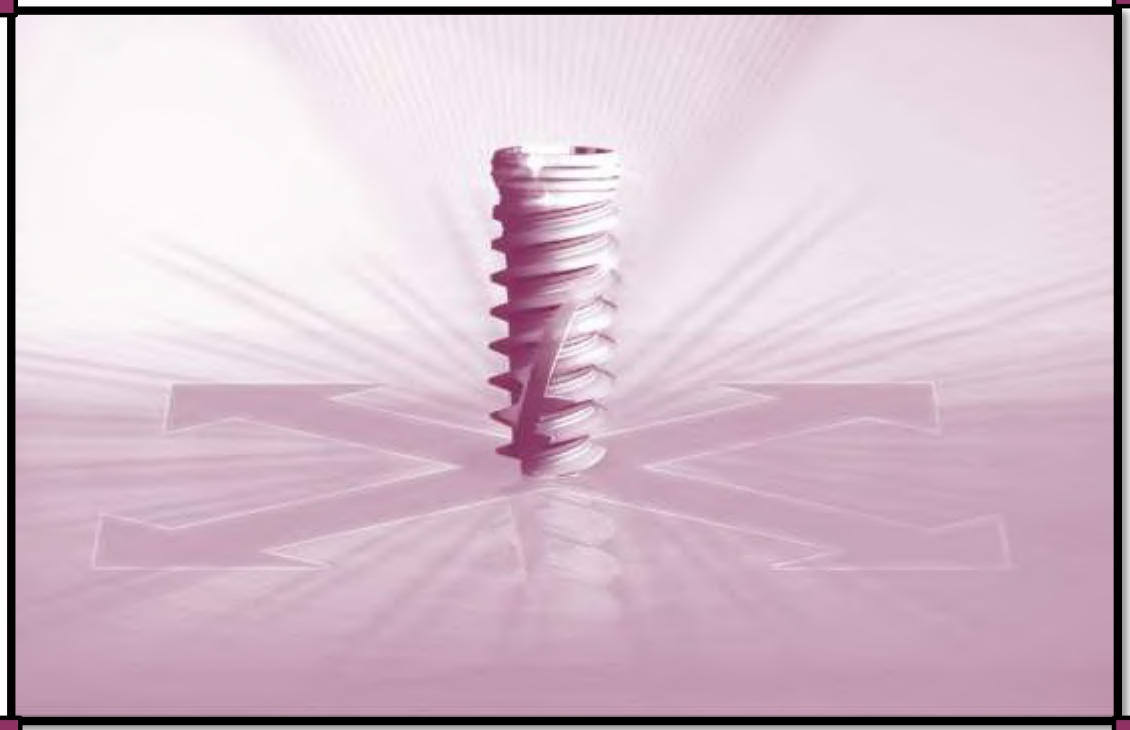
Smith D.E et al


Cellular and Molecular Biology and Histology Factors
Local factors affecting Implant
Factors affecting Osseointegration
Implant related Factors
Systemic factors affecting Implant

II. Implant related factors effecting Osseointegration

Implant length

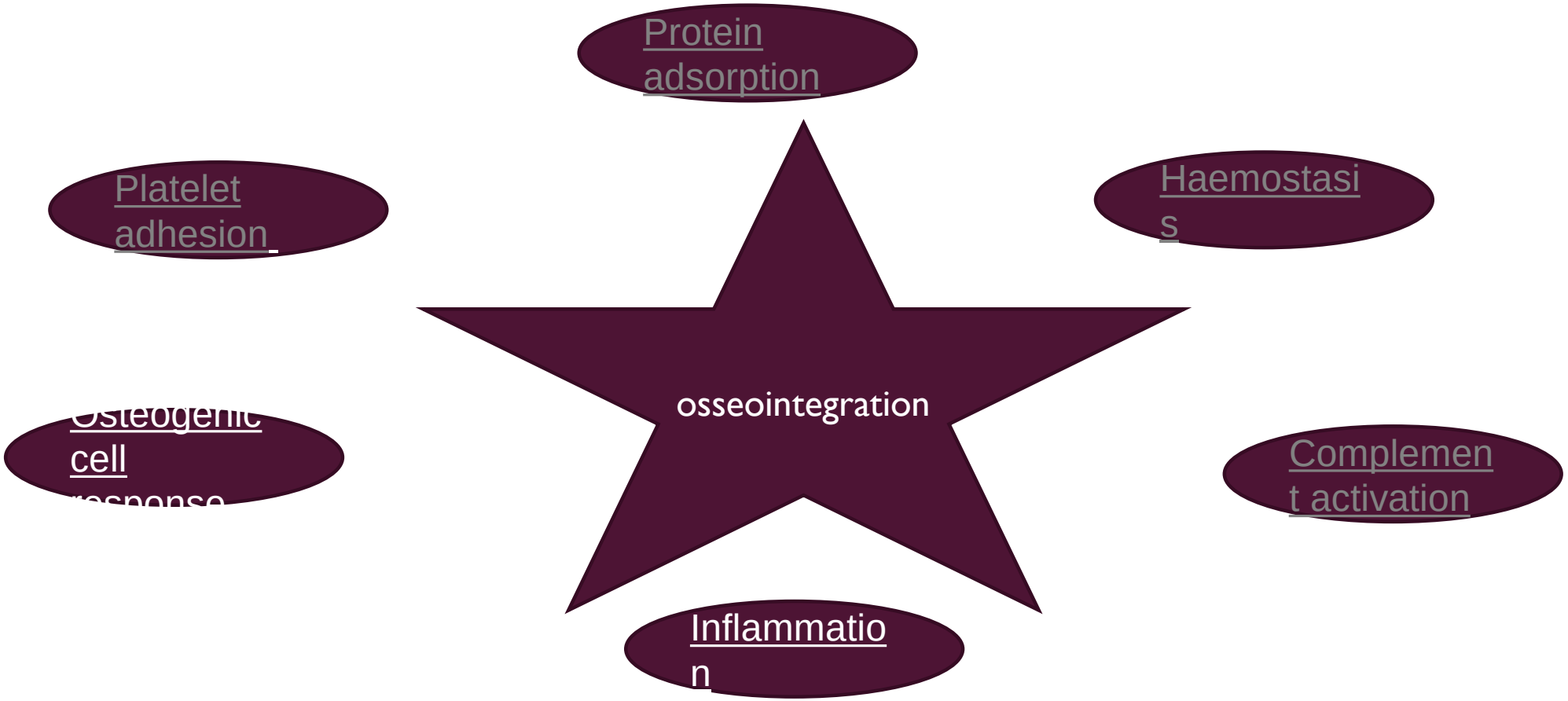
Implant Biocompatibility



Implant Design

Surface Topography

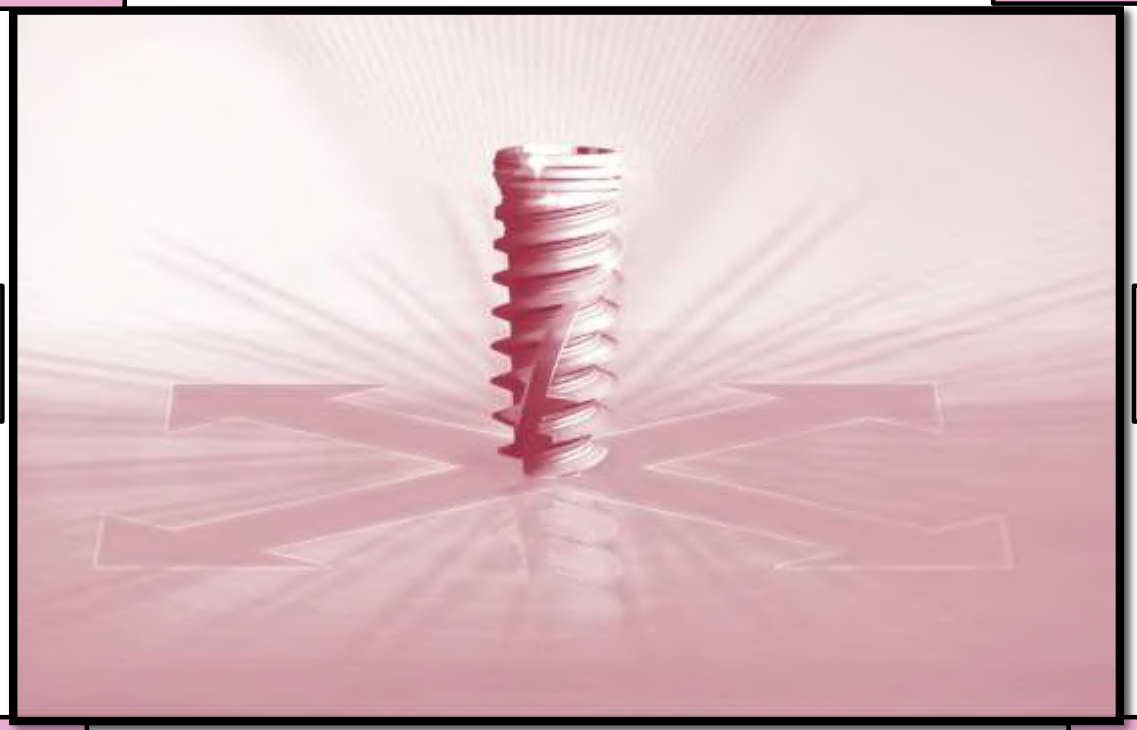
EFFECT OF IMPLANT SURFACE ON OSSEOINTEGRATION



III. Local factors affecting Osseointegration

Infections and advanced periodontal disease

Heat production and Torque application



Bone density Factors

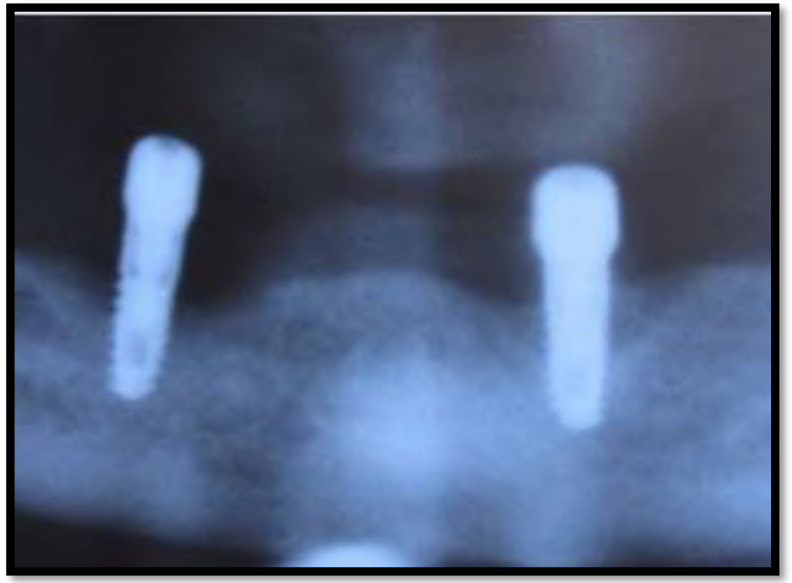
Surgical protocols

Implant loading conditions

Impaired Healing

A. Infections and advanced periodontal disease

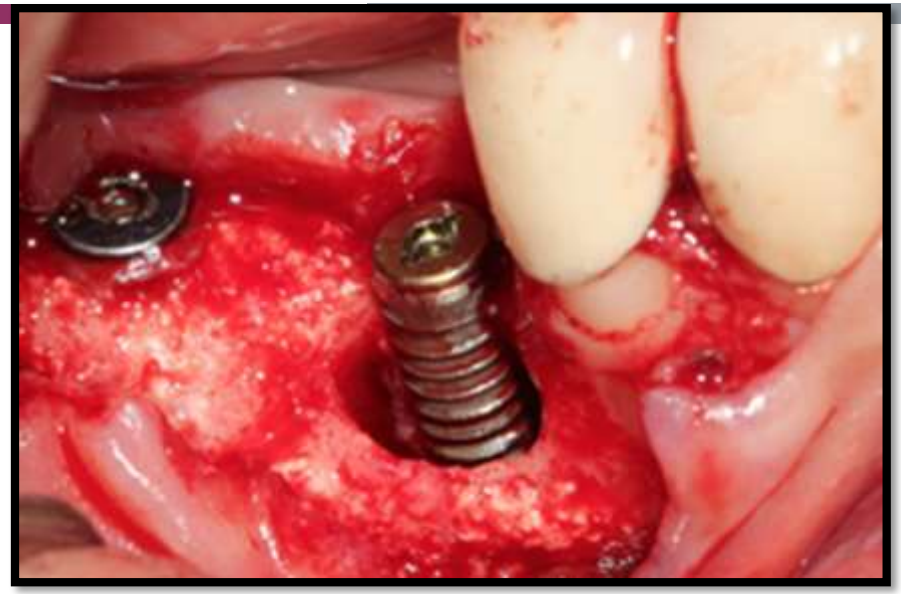
Bacterial infection → Transmission / Translocation → Perimucositis / Periimplantitis



Van der Weijden GA et al

- Strict Aseptic conditions
- Antibiotics & Antiseptics
- Advanced Regenerative surgeries

B. Surgical protocols & Impaired Healing

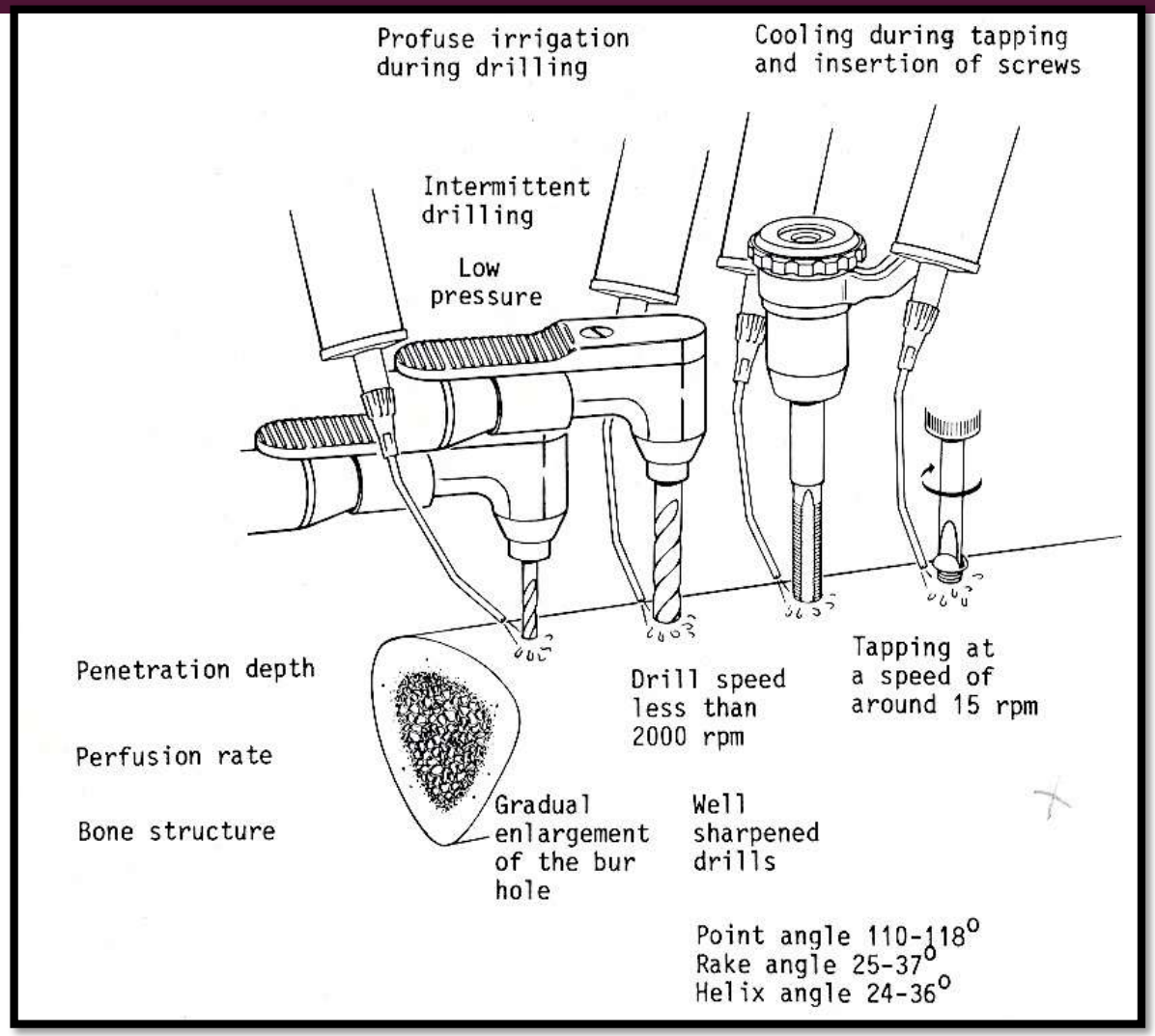


- Principles of surgery
- Surgical trauma
- Overheating - Torque and pressure
- Irrigation

- Minimum tissue violence – Osseointegration
- Profuse irrigation for continuous / adequate cooling
- Use of well sharpened and graded series drills

Eriksson R.A

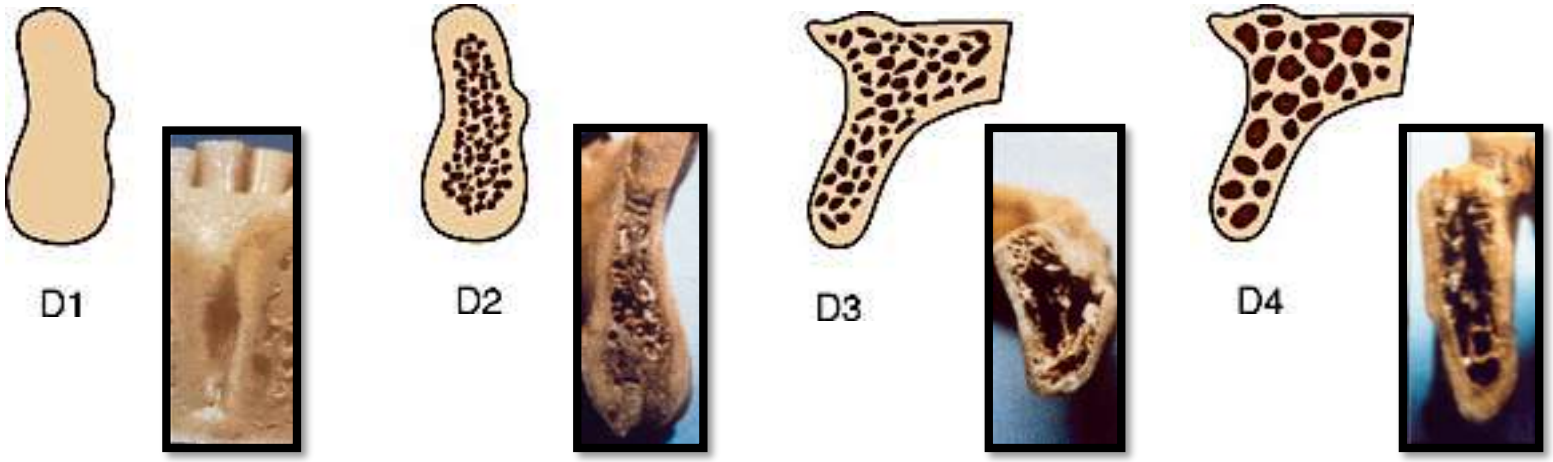
CLINICAL CONSIDERATIONS



C. Bone density Factors

D1	Dense cortical bone	Anterior mandible Posterior mandible
D2	Dense to porous cortical bone surrounding dense trabecular bone	Anterior mandible Posterior mandible Anterior maxilla
D3	Thin porous cortical bone surrounding fine trabecular bone	Anterior maxilla Posterior maxilla
D4	Fine trabecular bone	Posterior maxilla
D5	Immature, non-mineralized bone	

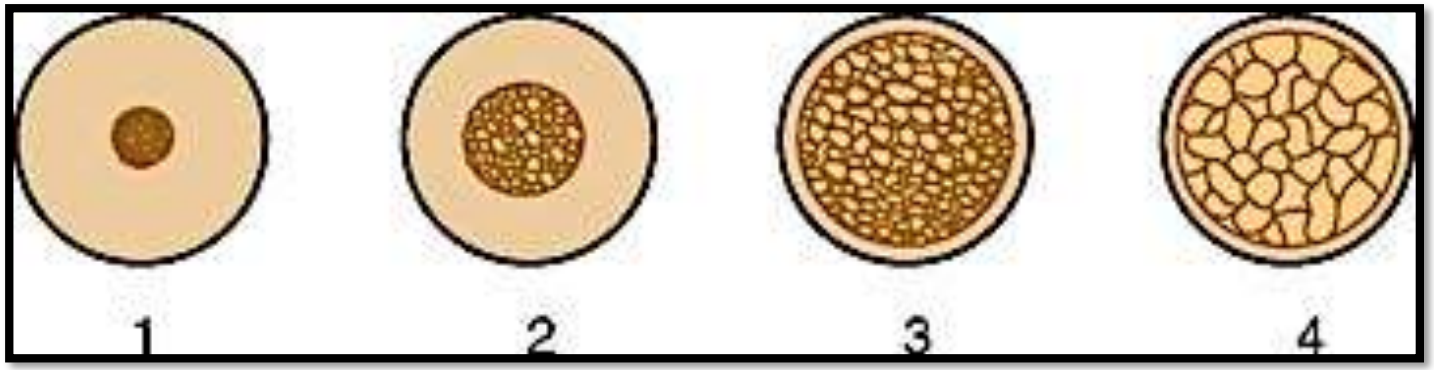
Misch classification (1988) on bone density (based on microscopic structure of bone)



D1 & D2
- Better Osseointegration
- Conventional threaded implants

D3 & D4
- Poor prognosis
- Ti plasma coated implants

In 1985, Lekholm and Zarb listed four bone qualities found in the anterior regions of the jawbone.



- *Quality 1* was composed of homogeneous compact bone.
- *Quality 2* had a thick layer of compact bone surrounding a core of dense trabecular bone.
- *Quality 3* had a thin layer of cortical bone surrounding dense trabecular bone of favorable strength.
- *Quality 4* had a thin layer of cortical bone surrounding a core of low-density trabecular bone

D. Factors related to heat production and Torque application

Heat Production during Osteotomy preparation

- Denaturation of alkaline phosphate enzyme
- Inhibition of Alkaline Po_4synthesis
- Loss of Osseointegration (Errickson 1986, Albrektsson 1984)

Insertion torque

- Moderate torque should be applied (35 - 45 N/cm)
- High torque leads to stress / compression in bone

E. Factors related to Implant loading conditions

Early Loading

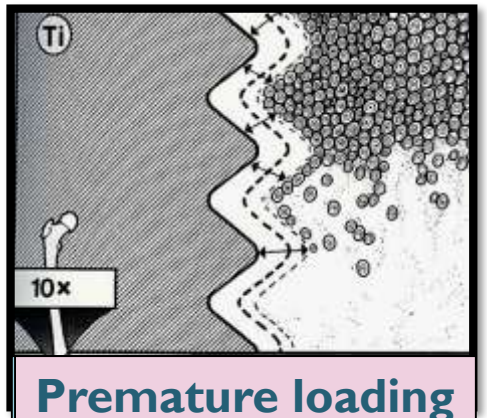
Few days

Progressive Loading

Few weeks

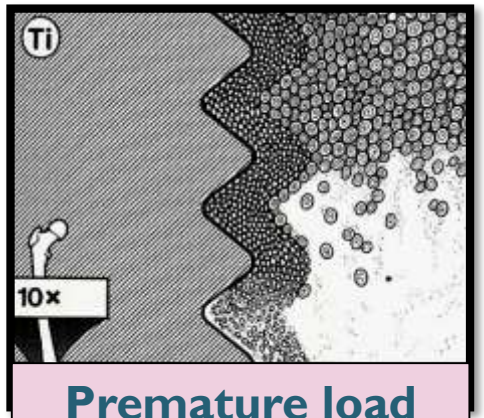
Late Loading

3-6 months



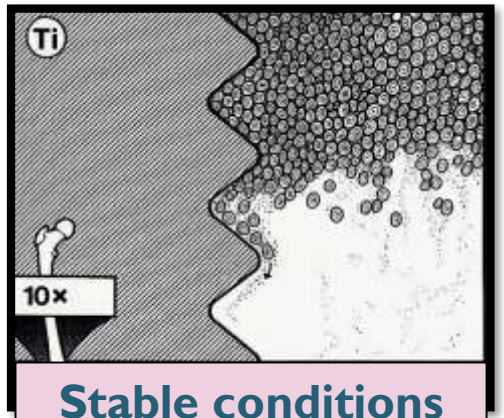
Premature loading

leads to implant movement



Premature load

The end result "Soft tissue interface"



Stable conditions

"Bony interface"

IV. Systemic Factors affecting Osseointegration

Diabetes mellitus

Immune deficiency

Cardiovascular disease

Bleeding disorders

Osteoporosis

Hypothyroidism

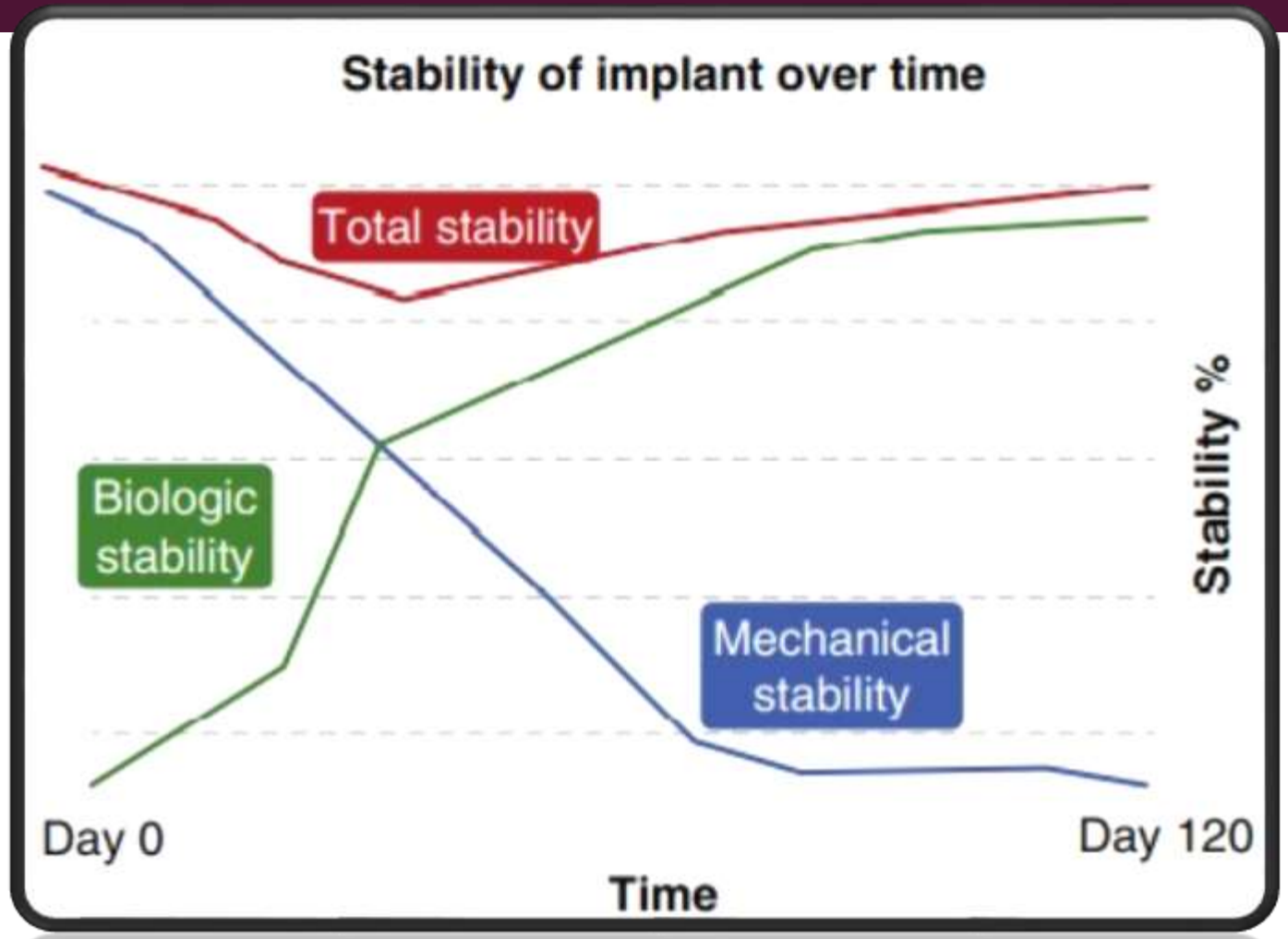
Condition	How it affects Osseointegration	How condition could be managed to increases success rate
Osteoporosis	• Reduced bone density • Possibility of osteonecrosis	• Increase primary healing • Adjunctive drugs and hormone replacement
Corticosteroid therapy	• Osteoporosis • Immune deficiency • Adrenal suppress	• Antimicrobial therapy adrenal suppress consideration
Diabetes mellitus	• Impaired wound healing • Vascular disorders • Immune deficiency	• Glycemic control • Antimicrobial therapy • Oral hygiene reinforcement
Immune deficiency	• Increase risk of infection • Impaired wound healing	• Antimicrobial therapy, CHX • Oral hygiene reinforcement
Bleeding disorders	• Increase bleeding before and after procedure	• Evaluation of coagulation factors • Anticoagulation drugs alterations

Condition	How it affects Osseointegration	How condition could be managed to increases success rate
Cardiovascular disease	• Impaired tissue repair	• Antibiotic prophylaxis • Considering anticoagulant drugs • Avoid general anesthesia
Oncology : Chemotherapy / Radiotherapy	• Reduced tissue healing potency • Osteoradionecrosis	• Prevent early loading • Hyperbaric oxygen therapy • Antimicrobial therapy • 21 days before or 9 months after radiation therapy
Hypothyroidism	• Reduced osteogenesis	• Use hormone replacement therapy
Mucocutaneous disorders	• Immunity • Adrenal suppression • Xerostomia	• Consider corticosteroid therapy

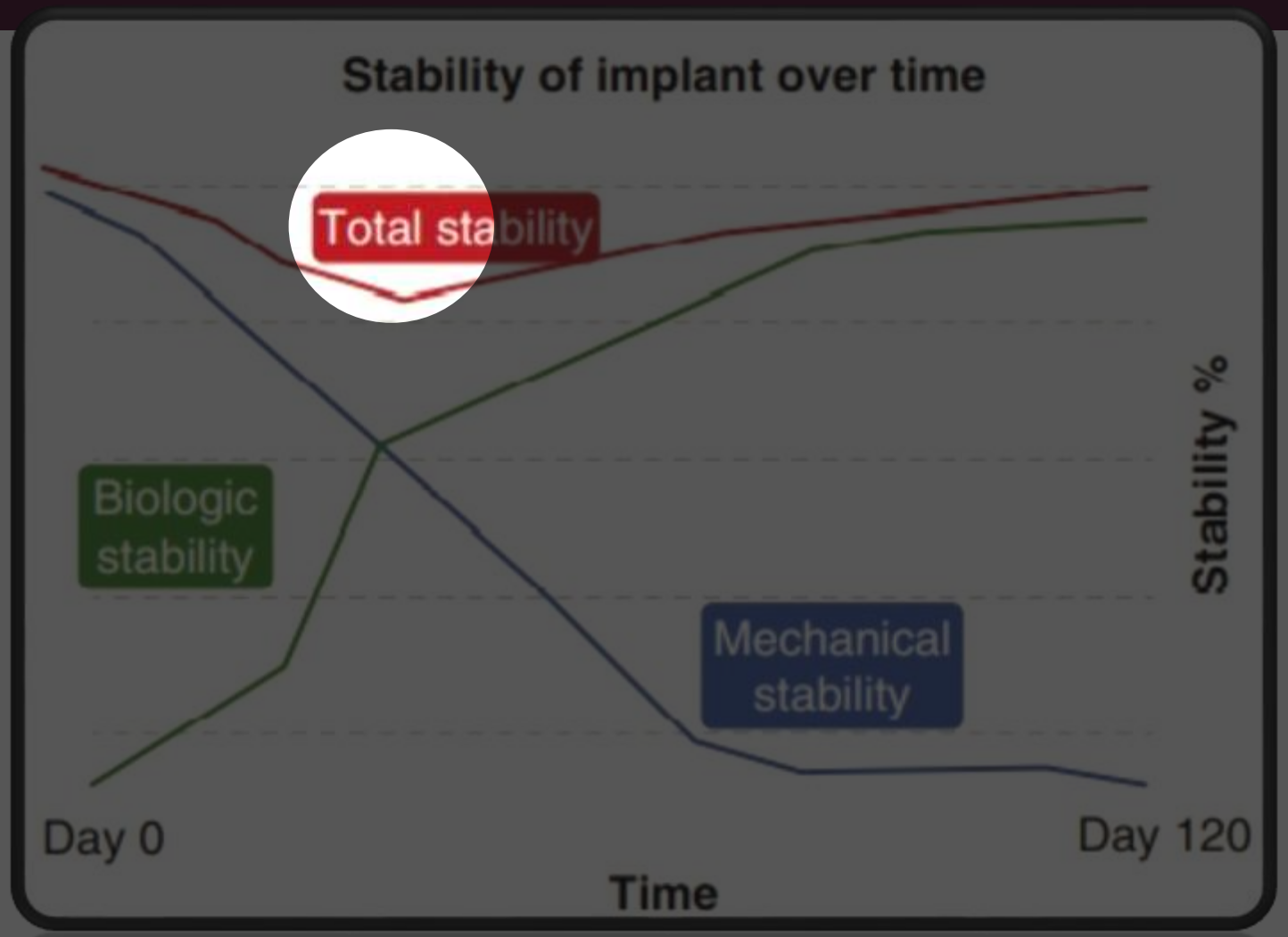
PRIMARY STABILITY AND SECONDARY STABILITY

- Primary stability → Apical stability

- Secondary stability, achieved over time with healing, depends on the implant surface (microdesign), as well as the quality and quantity of adjacent bone, which will determine the percentage of contacts between the implant and bone.


Stability of implant over time
Total stability
Biologic stability
Mechanical stability
Stability %
Day 0
Day 120
Time

STABILITY GRAPH



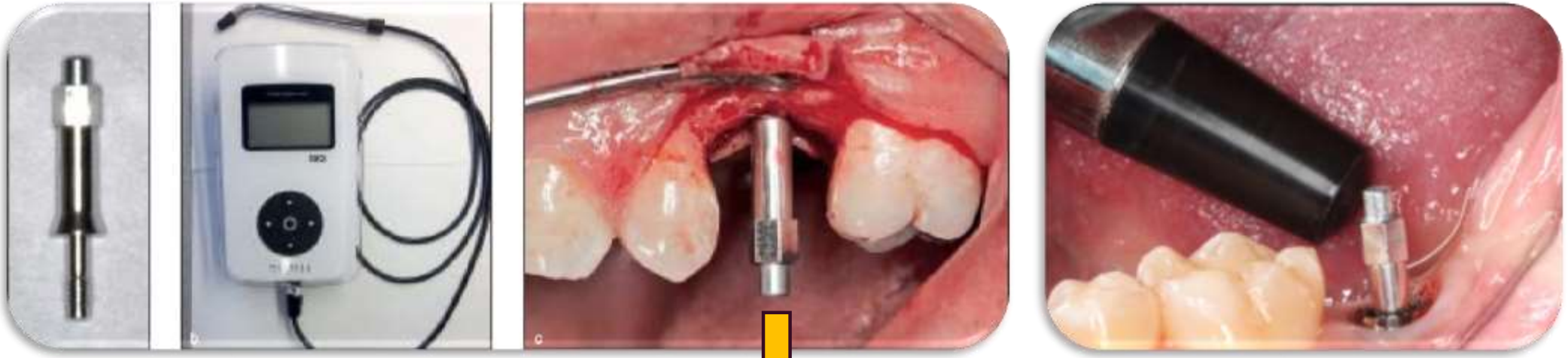
STABILITY DIP

ASSESSMENT OF IMPLANT BIOMECHANICS - PERIOTEST

- This is transformed in an arbitrary unit, which reflects the rigidity of the bone-to-implant continuum values should be below +7, the minimum with the most rigid being −8.

ASSESSMENT OF IMPLANT BIOMECHANICS - RFA

- The resonance frequency analysis (RFA) offers an alternative measurement. With the Ostell device, a small transducer attached to the implant imposes a series of frequencies and measures the over all resonance frequency, because the transducer and the structure are constant, any change in the resonance frequency reveals a change in the implant-bone interface, either in quality or in quantity.
- Primary stability measurements reveal a frequency range of 6–9 kHz, with higher values in the mandible. The measures are transformed into arbitrary values where measurements should exceed 56, which indicate a level of bone support that is consistent with osseointegration. These noninvasive tests reflect the rigidity of the bone to implant interface

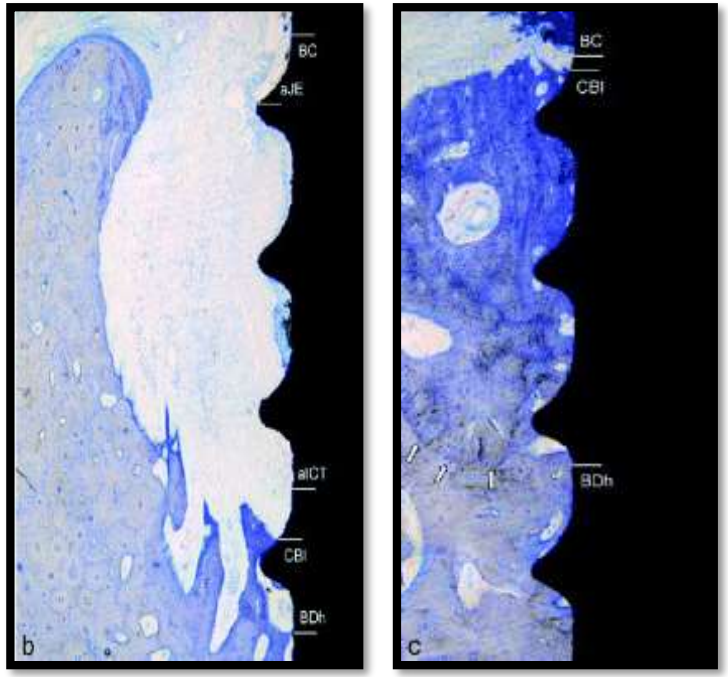


transducer attached to the implant

RE-OSSEOINTEGRATION

It is defined as the establishment of de novo bone formation and de novo Osseointegration to a portion of an implant that, during the development of peri-implantitis suffered loss of bone to implant contact and became exposed to microbial colonization

- Regeneration of bone from the walls of the defect
- Rejuvenation of contaminated implant surface

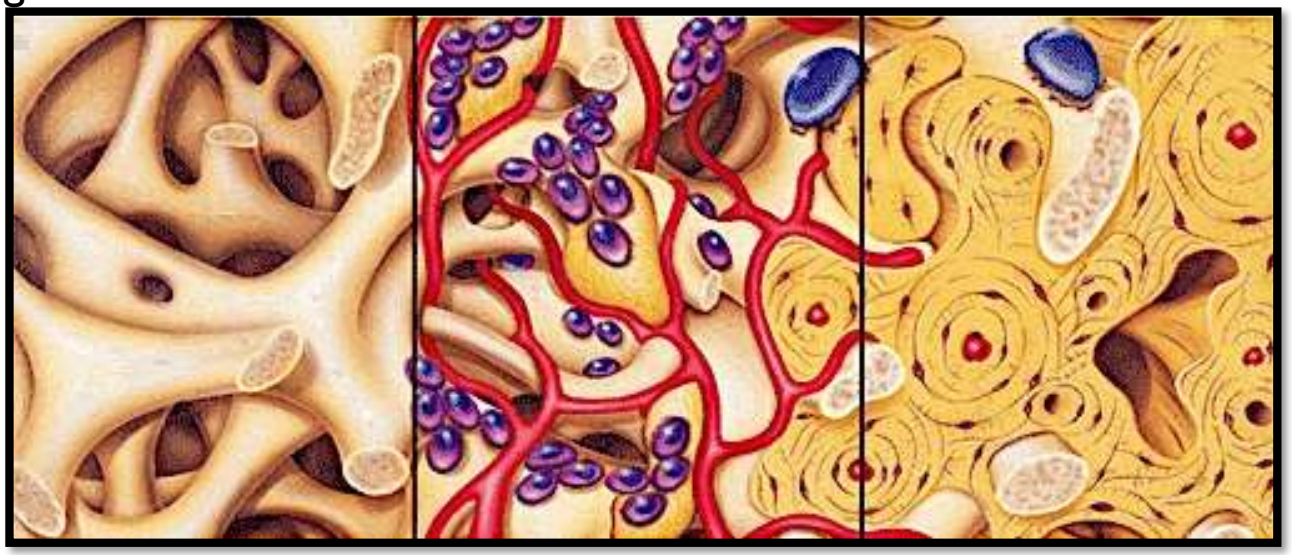


- Influenced by implant surface characteristics
- Complete Re-Osseointegration cannot occur

OSTEOPROMOTION

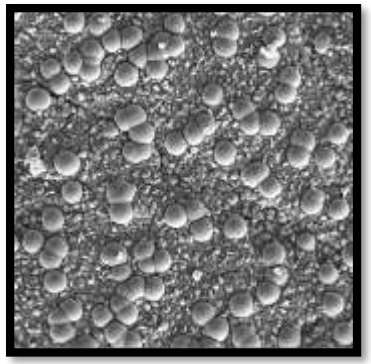
It is a Procedure to enhance the formation of bone approximating the implant surface :

- Bone regeneration techniques (using PTFE membrane)
- Bone growth factors like PDGF, IGF, PRP, TGF-β1 ➔ stimulates osteoprogenitor cells, enhance the bone growth.
- *Stefini CM et al (2000*) recommend to apply PDGF and IGF on the implant surfaces before placing into cervical bed. This method showed better wound healing and rapid Osseointegration.



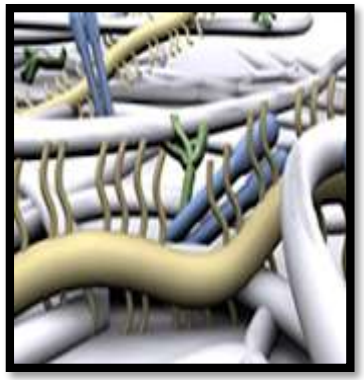
FUTURE PROSPECTIVE OF SURFACE COATINGS THAT CAN EFFECT OSSEOINTEGRATION

- The optimization of implant stability by interacting with natural cascade of Osseointegration



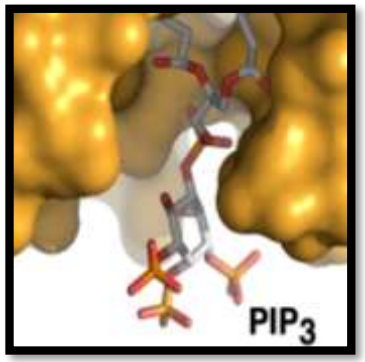
Hydroxyapatite and Nanocomposite coatings

Growth factors

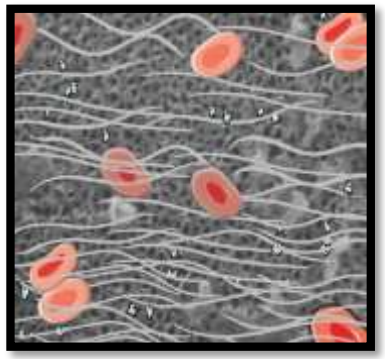


Extracellular matrix proteins

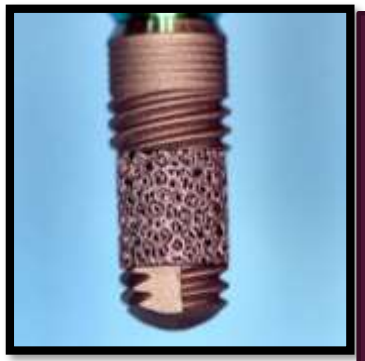
- The improvement of peri-implant soft tissue integration



Messenger molecules



Peptides



Drug Coatings

- Reduction of peri-implantitis by impairing bacterial adhesion to the implant surface

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thank
you