The essential conditions of success of the implantation.

Biocompatibility. Osseointegration.

Dr. Kinga Bérczy

Semmelweis University, Faculty of Dentistry

Department of Oral and Maxillofacial Surgery

Conditions of success of oral implants

- Biocompatibility
- Gingival seal
- Optimal transmission of masticatory forces

Parts of the human body replaceable with biomaterials

Function of oral implants claims great mechanical and biological demands

Terms used for the evaluation of biomaterials

- **Biocompatibility**

Biocompatibility

the totality of characteristics, which define the connection of the implant and the neighbouring tissues

Terms used for the evaluation of biomaterials

- Biocompatibility
- **Biomechanical**

functional ability

Biomechanical functional ability:

the characteristics of solidity and alterability of form, which enable the implant to transmit masticatory forces to the bone without damaging it

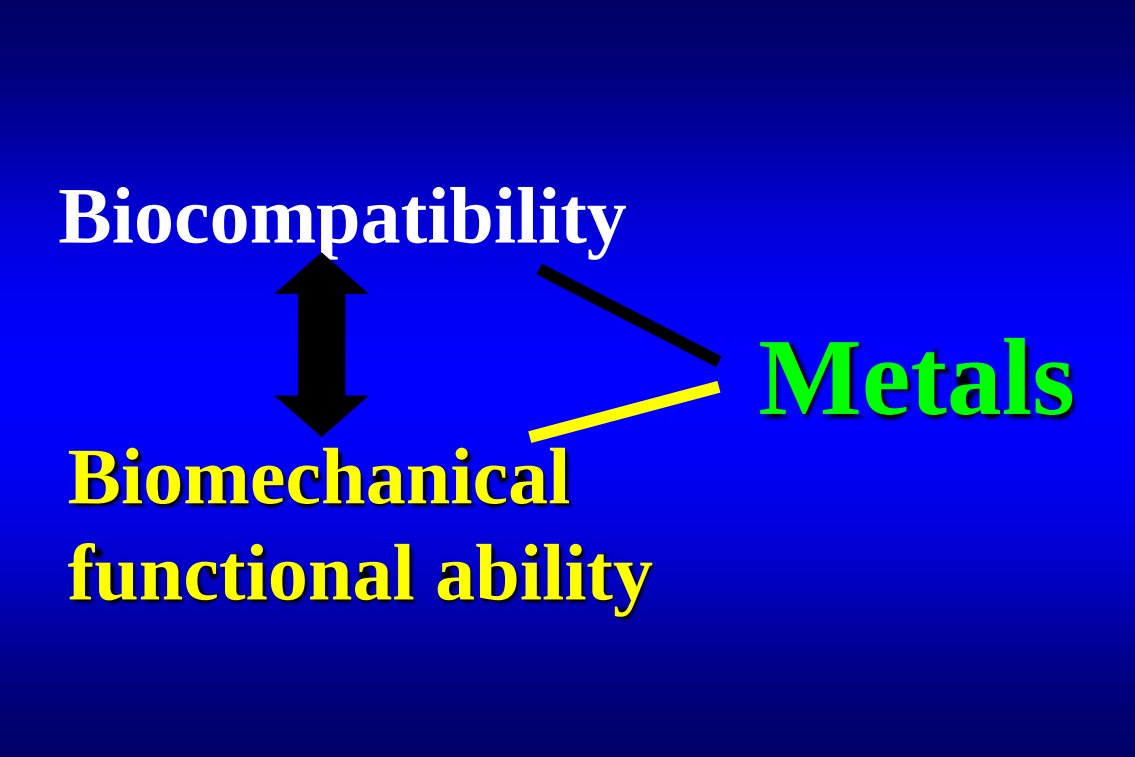
Terms used for the evaluation of biomaterials

- Biocompatibility
- Biomechanical functional ability
- **Biological stability**

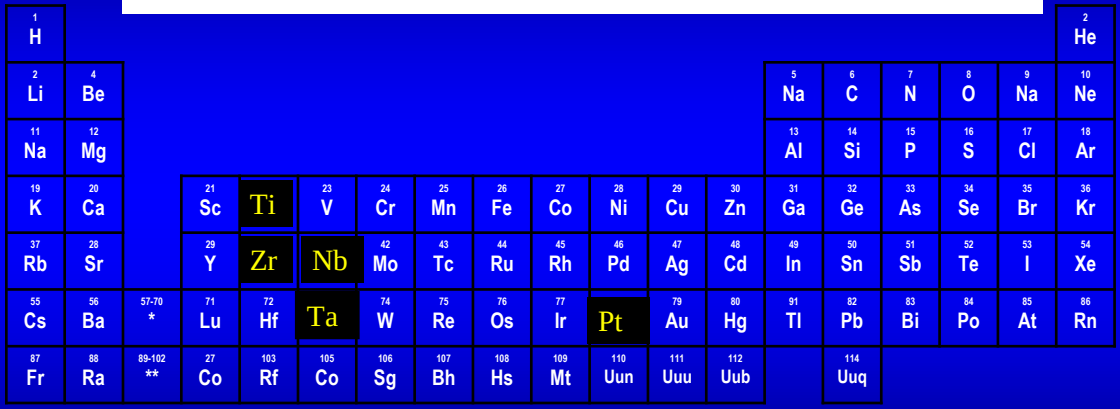
  Corrosion

  Biodegradation

  Metallosis


Biocompatibility
Metals
Biomechanical
functional ability

From the periodical chart of elements the *non cytotoxic metals*:



Titanium, Zirconium, Niobium, Tantalum, Platinium

Classification of biomaterials /Osborn 1979/

Biotolerant materials

steel alloys

Cr-Co-Mo alloys /Vitallium/

plastic materials

Bioinert materials

tantalum, titanium, niobium

aluminium oxide ceramics

carbon compounds

Bioactive materials

bioglass

Classification of biomaterials /Osborn 1979/

mechanics

biology

Biotolerant materials

steel alloys

Cr-Co-Mo alloys /Vitallium/

Bioinert materials

tantalum, titanium, niobium, aluminium oxide ceramics, carbon compounds

Bioactive materials

bioglass

hydroxyapatite

tricalcium phosphate

Classification of biomaterials /Osborn 1979/

mechanics

Biotolerant materials

steel alloys

Cr-Co-Mo alloys /Vitallium/

Bioinert materials

tantalum

niobium

oxide ceramics,

carbon compounds

titanium

Bioactive materials

bioglass

hydroxyapatite

tricalcium phosphate

logy

Material composition of commercially pure /CP/ titanium

recommended for dental implants:

Titanium	99.75%
Iron	0.05%
Oxygen	0.10%
Nitrogen	0.03%
Carbon	0.05%
Hydrogen	0.012%

The material composition of

titanium alloys

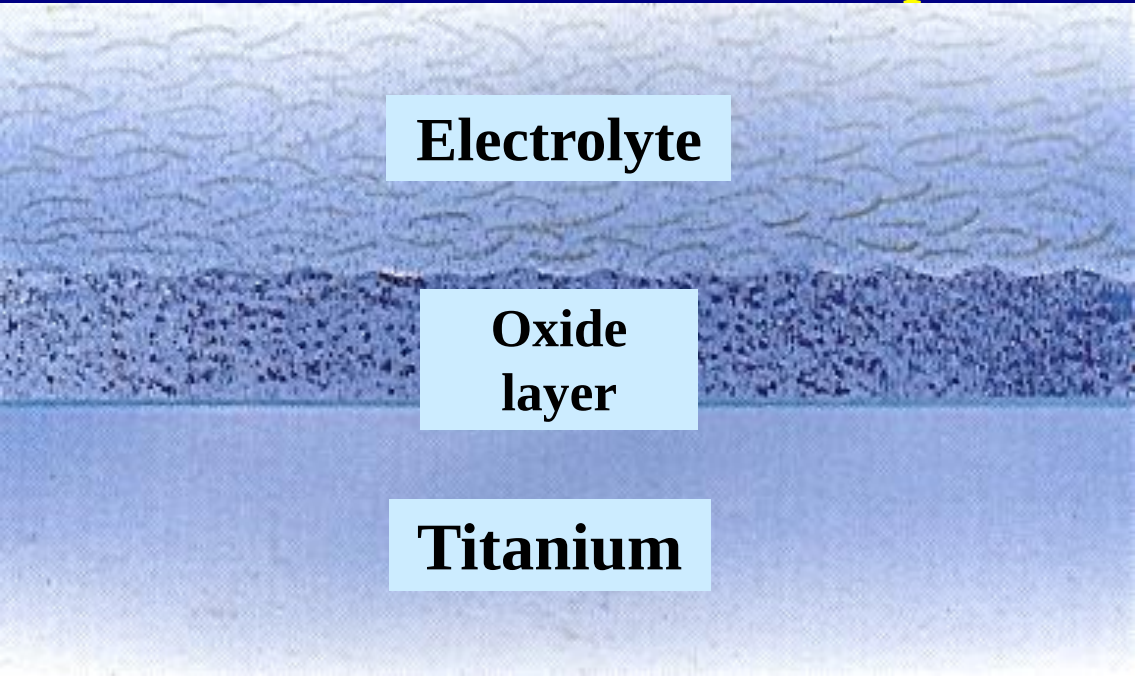
recommended for oral implants

Ti 6Al 4V

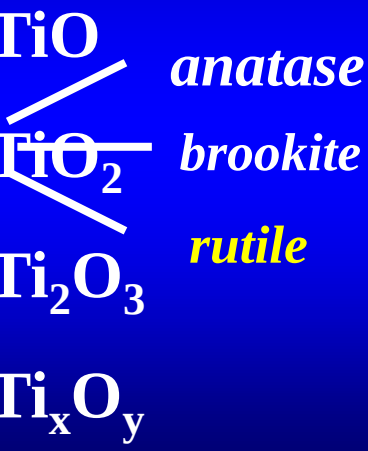
Ti 5Al 2,5Fe

Ti 6Al 7Nb

Outer surface of titanium implant



Forms of titanium oxide

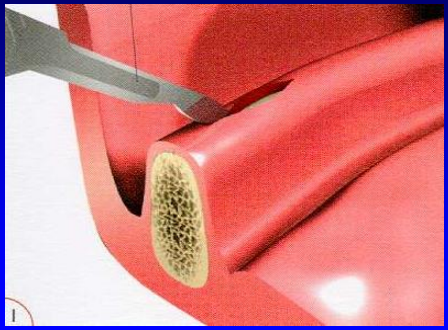


The healing and remodeling of bone around osseointegrated implants

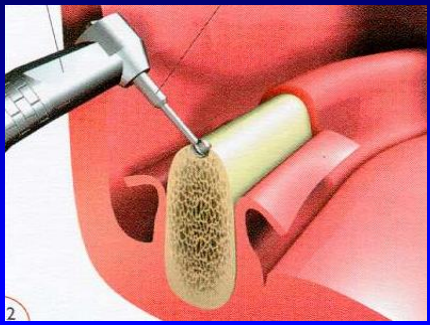
(James, McKinney 1982)

- **Operation on bone, implant placement**

Surgical access, flap preparation



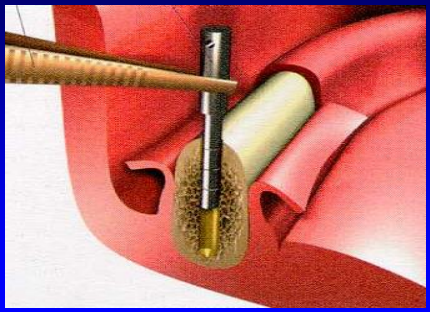
Marking drilling (max. 1500 rpm)



Marking drilling (max. 1500 rpm)

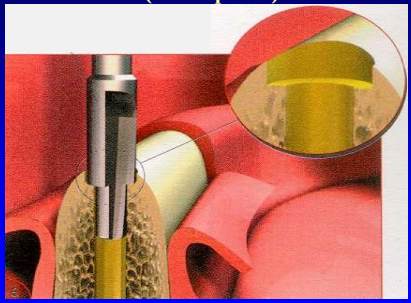
Pilot drilling

Controls



Widening drilling I.

(two step drill)



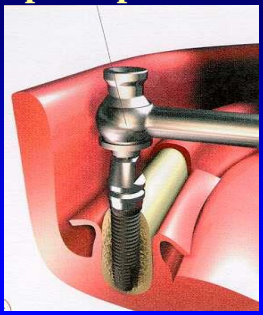
Widening drilling II.

(spiral bur)

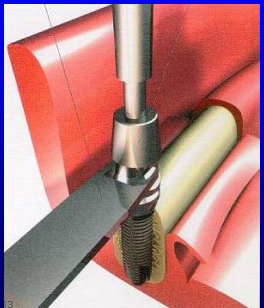
The place of the implant in the bone

Implant placement I.

Implant placement II.



Implant placement III.



Placing the healing screw into a two phase implant

Placement of a one-part implant

Two-part implant,

two-stage surgery

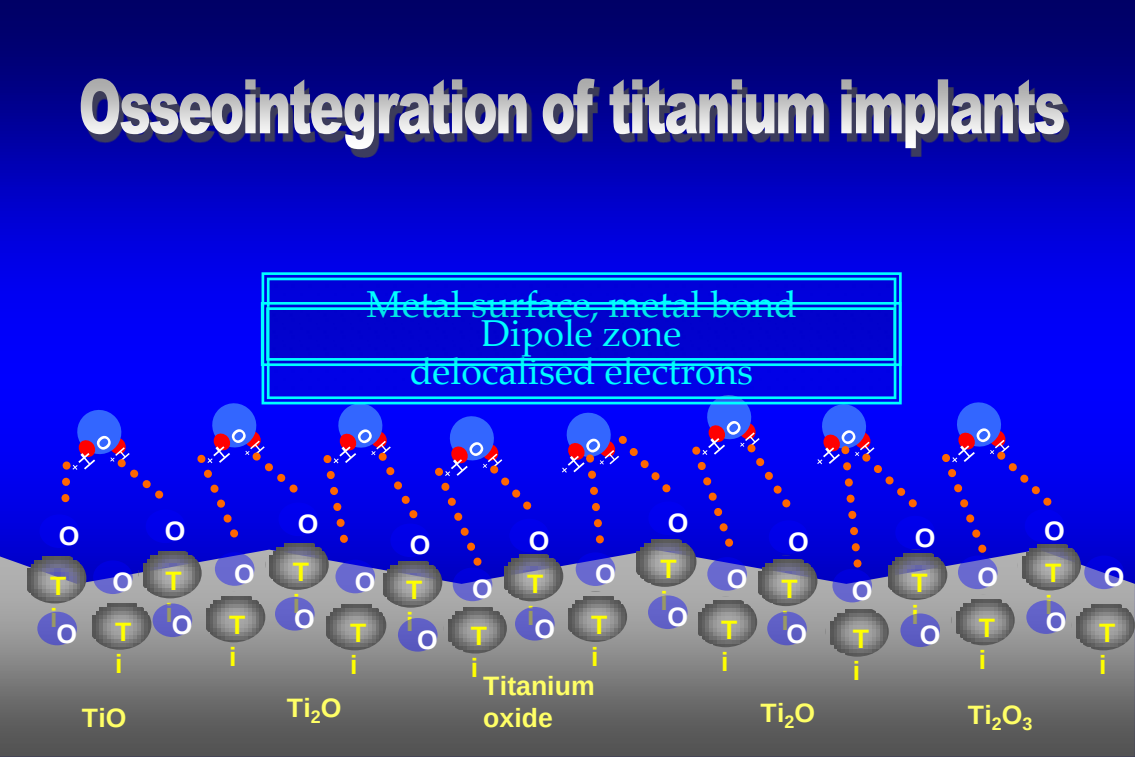
The healing and remodeling of bone around osseointegrated implants

(James, McKinney 1982)

- Operation on bone, implant placement

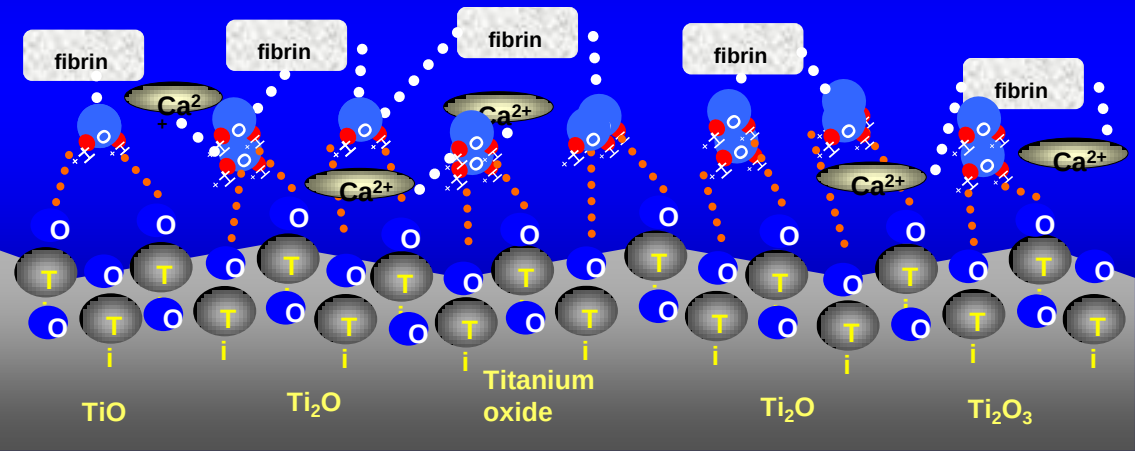
- Healing process of bone, cellular reactions forming the implant-bone interface

Osseointegration of titanium implants

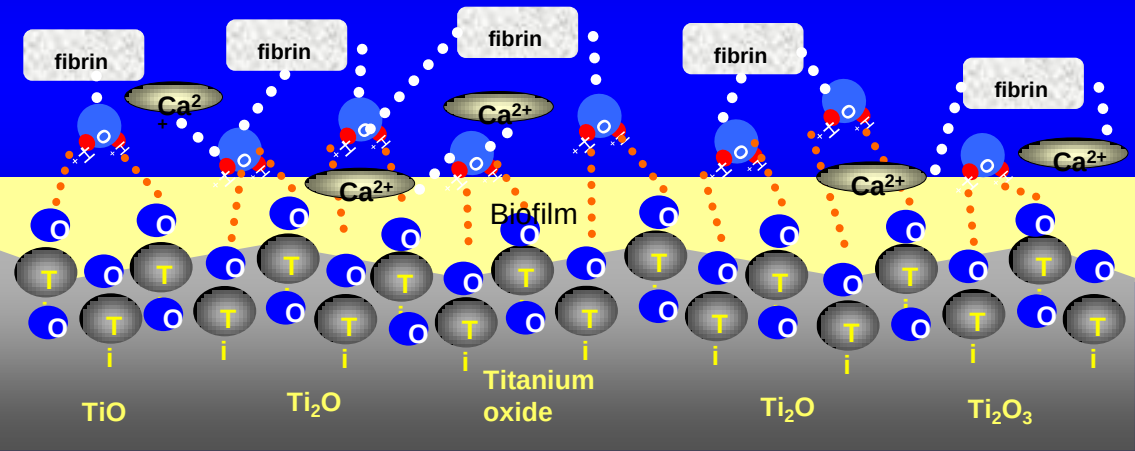


Osseointegration of titanium implants

Ions, serum proteins

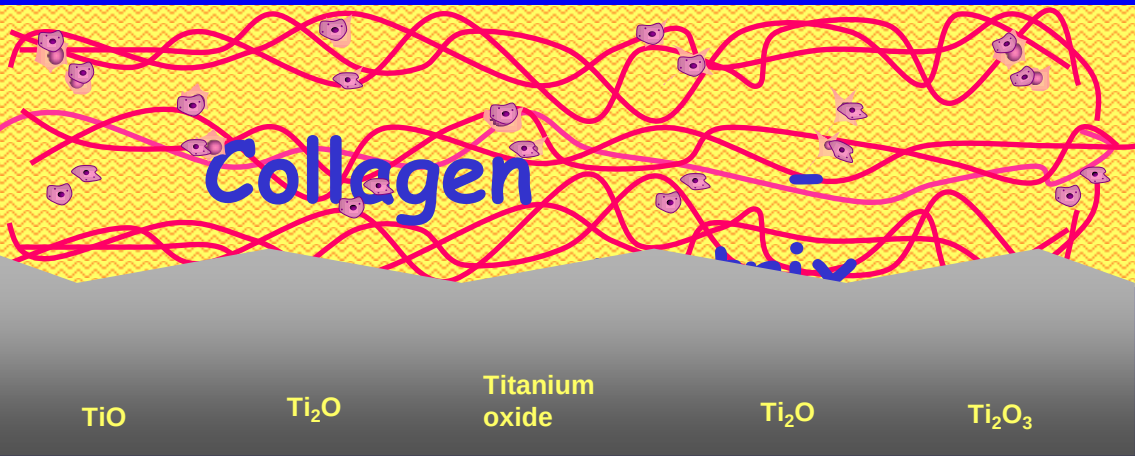


Osseointegration of titanium implants

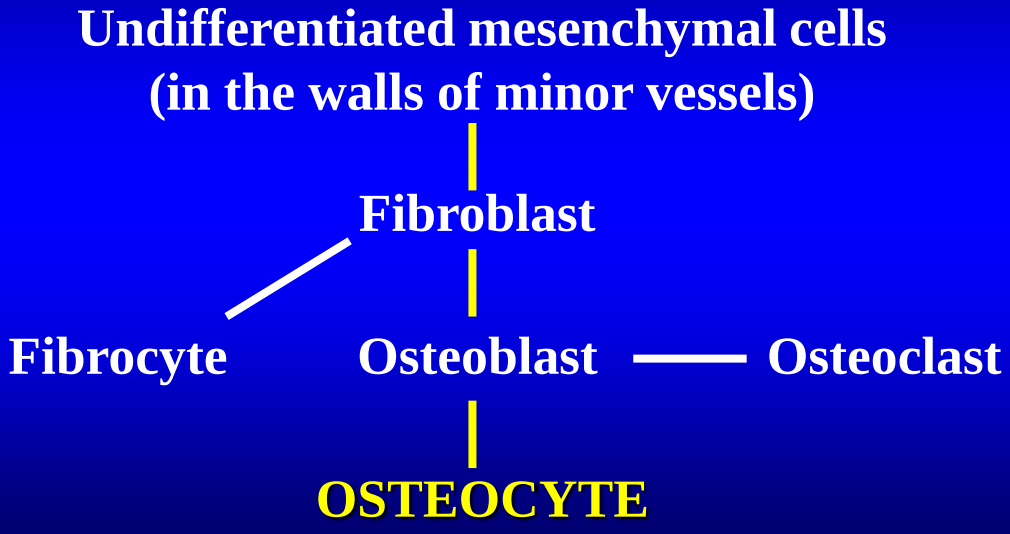


Osseointegration of titanium implants

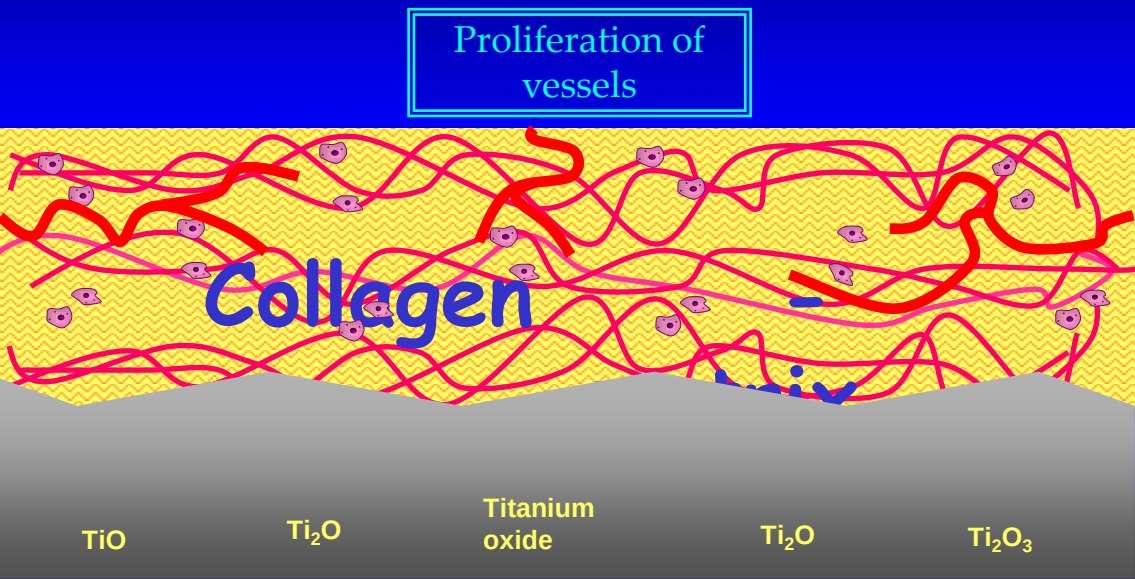
Appearance of mesenchymal cells, their transformation into osteoblasts



The scheme of transformation of bone forming cells



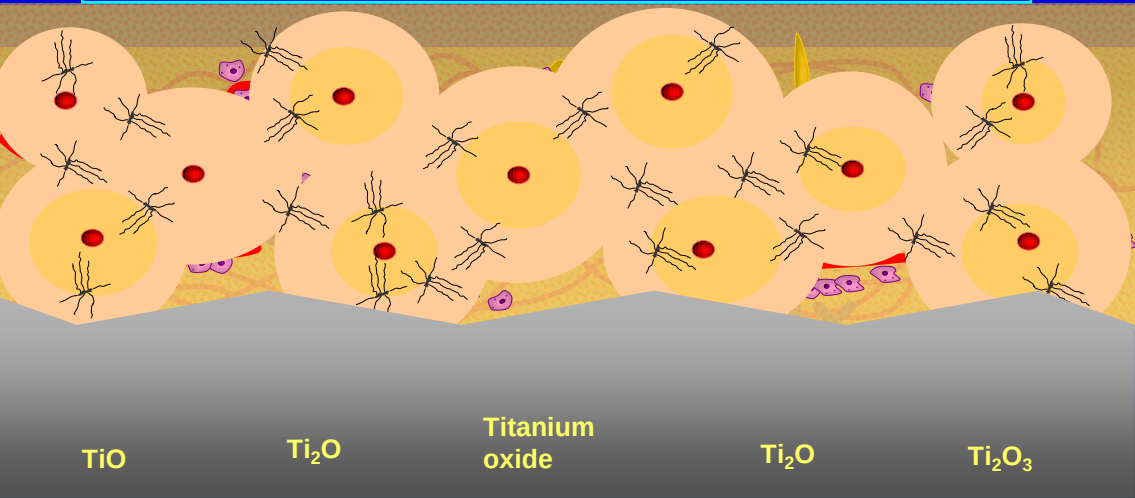
Osseointegration of titanium implants



Osseointegration of titanium implants

Formation of lamellar bone

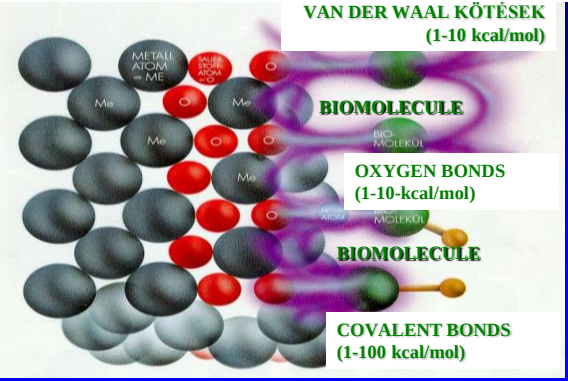
Formation of osteoid (reticular bone tissue)



The dynamic oxid interface

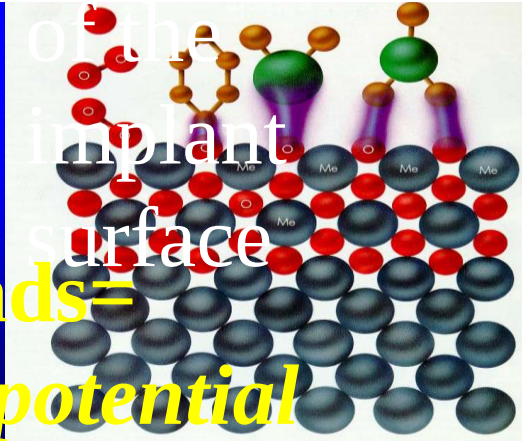
The oxid surface is a dynamic system, which creates an interchange with the molecules of the surrounding tissues

Molecular bonds on the implant surface



Importance

Molecular contamination of the implant surface



Molecular bonds=

Electrokinetic potential

The healing and remodelling of bone around osseointegrated implants

/James, MacKinney1982/

- Operation on bone, implant placement
- Healing process of bone, cellular reactions forming the implant-bone interface

- Formation of mature lamellar bone, remodelling of periimplant bone tissue

OSSEOINTEGRATION

Direct contact between implant and bone at light microscopic level

P.I.Branemark 1969, 1977

Osseointegration is an accidental finding by Professor Per-Ingvar Brânemark /Sweden/ and his collegues during the 1950s and1960s. Their vital microscopic studies with titanium observation chambers ,gave the finding of the great adherence of metal to the bone.

/Worthington Ph., et al:Osseointegration in Dentistry, Quintessence 1994./

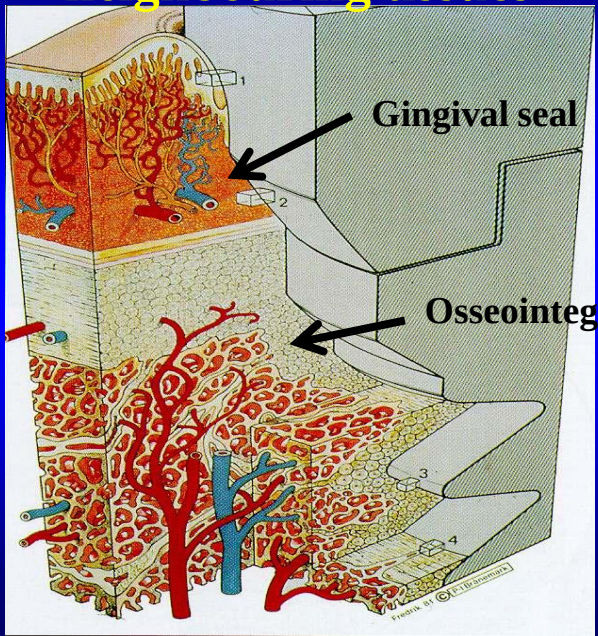
OSSEOINTEGRATION

Direct contact between implant and bone at *light microscopic level*

Electromicroscopic studies revealed, that osteoblast-like cells were separated from the oxide surface by a thin layer of proteoglycan and amorphous zone /with thickness up to 400 nm/

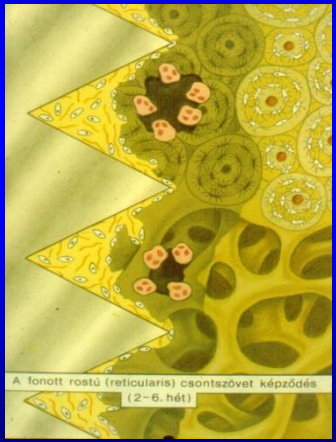
/Linder L., et al. Acta Orthop. Scand.1983/

Connection between the implant and the neighbouring tissues

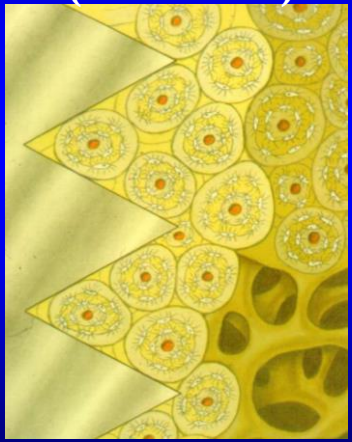


Exsudative, proliferative phase (days 1-14)

Formation of reticular bone (weeks 2-6)



Formation of lamellar bone and remodelling (weeks 6-18)



The healing and remodelling of bone around osseointegrated implants

(James, McKinney 1982)

- **Operation on bone, implant placement**
- **Healing process of bone, cellular reactions forming the implant-bone interface**
- **Formation of mature lamellar bone, remodeling of periimplant bone**

3-6 months

- **Recent studies**

Stages of peri-implant endosseous healing

/John E.Davies:J.Dent.Educ.67.2003/

- Osteoconduction- Migration of osteogenic cells to the implant surface
- de novo bone formation /modeling/
- Bone remodeling

Stages of peri-implant endosseous healing

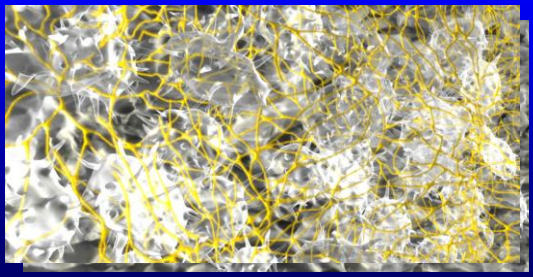
/John E.Davies:J.Dent.Educ.67.2003/

- Osteoconduction- migration of odontogenic cells to the implant surface

1.2. Growth factors accelerate the vascular proliferation, activate the mesenchymal cells

Blood clot, fibrin adherence, platelet activation /cytokines, growth factors/

Thrombogenic properties of titanium
/Thor A.et al.: Biomaterials 2007/



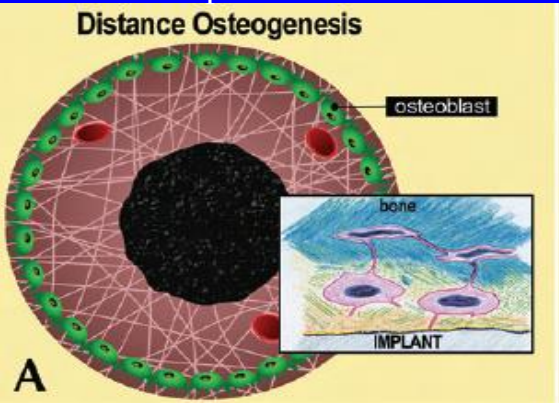
Depends on the microtexture

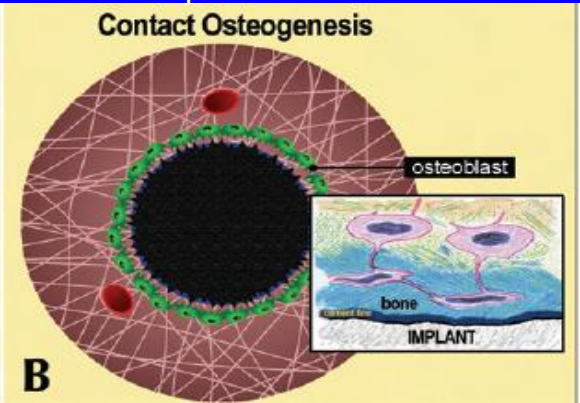
Osseointegration on the implant surface

/Osborn JF.,Newesely H.1980 ,Davies JE. 2005/

A: Machined surface :
bone formation
on the surface
of the pristine bone

B: Microtextured surface :
bone formation
on the surface
of the implant





The rate of the new bone formation

/animal studies/

Distance Ostogenesis: 0.6-1 μ/day

Contact Osteogenesis: 30-50 μ/day

/Abrahamsson et al. 2004/

Stages of peri-implant endosseous healing

/John E.Davies:J.Dent.Educ.67.2003/

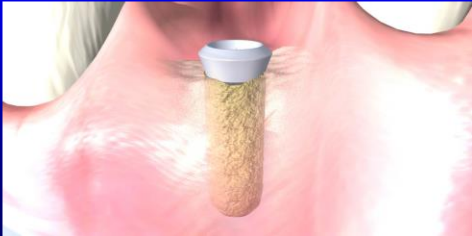
- Osteoconduction- migration of odontogenic cells to the implant surface

- **de novo bone formation** /modeling/

1. Mesenchymal cells transform to preosteoblasts, then osteoblasts
   Developement of extracellular matrix

2. Reticular, woven bone developes around the implant

3. Final stage of the osseointegration, the development of mineralized lamellar bone around the implant

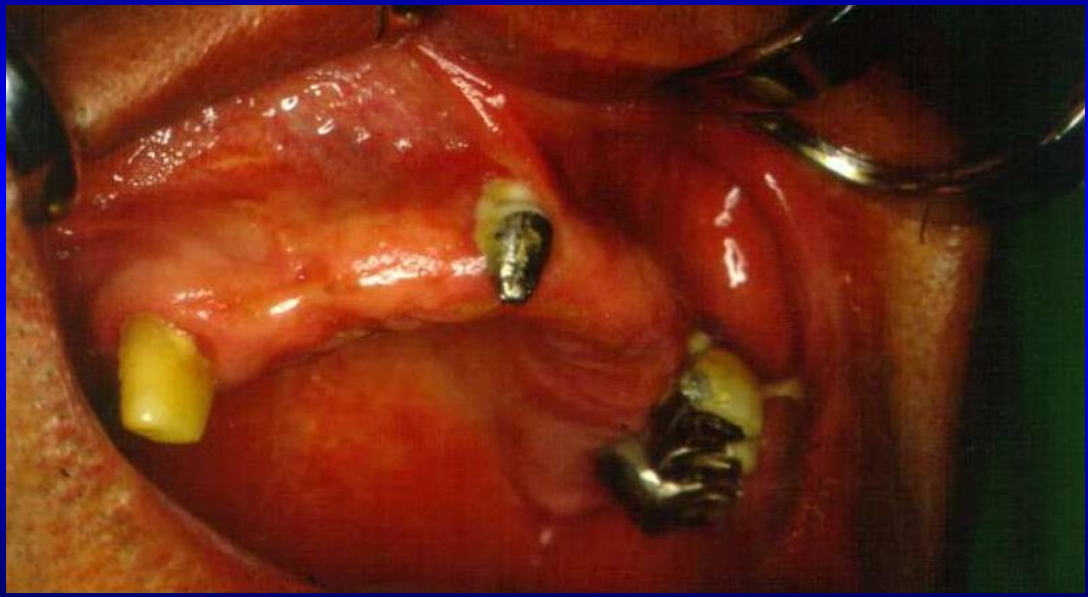


THE CONDITIONS OF OSSEOINTEGRATION

- Atraumatic, aseptic operation
- Bioinert or bioactive material
- Proper implant surface
- Primary stability
- Undisturbed (unloaded) healing?

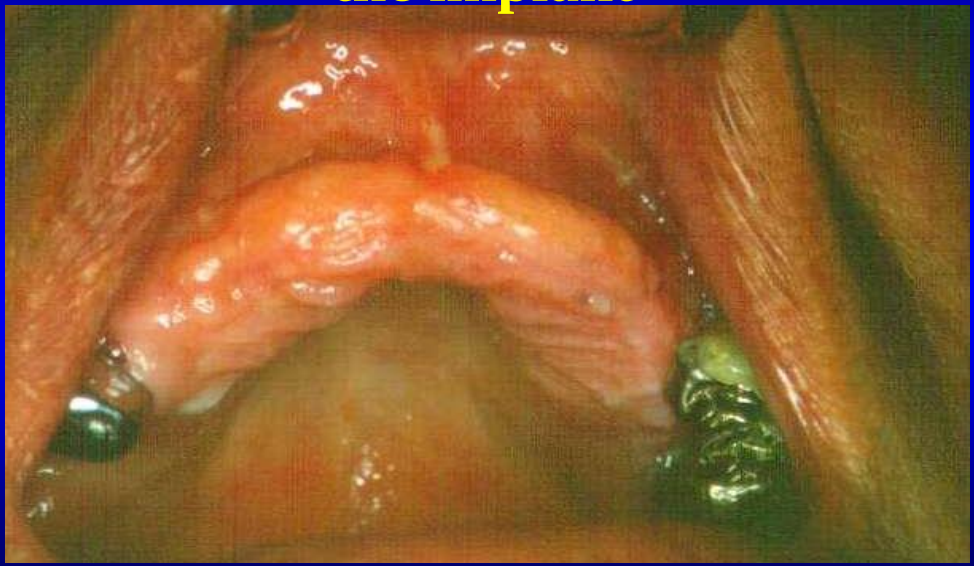
The human histological examinations of osseointegration may raise serious ethical concerns.

Unloaded aluminium- oxide ceramic implant

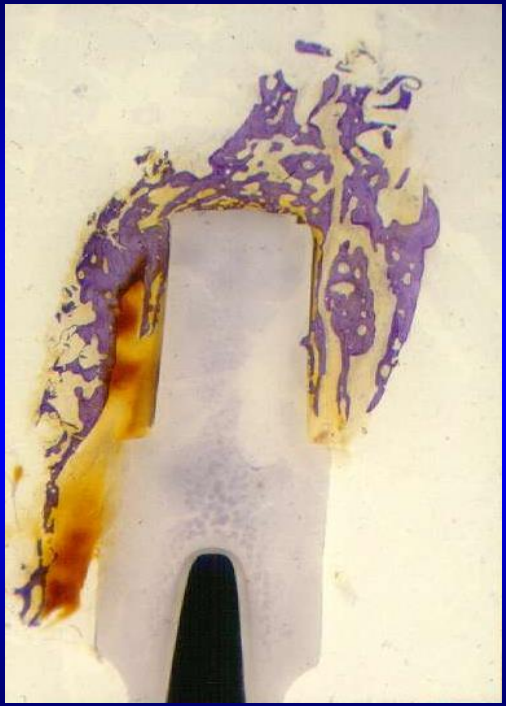


Implant removed together with the surrounding bone

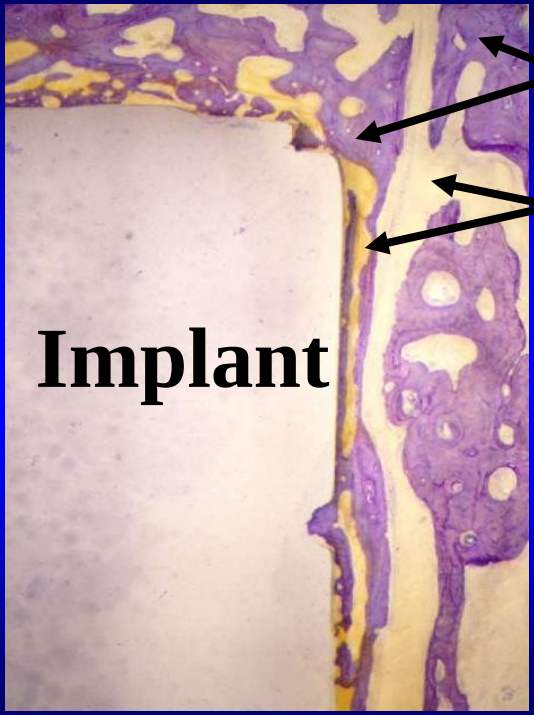
Healed maxilla after the removal of the implant



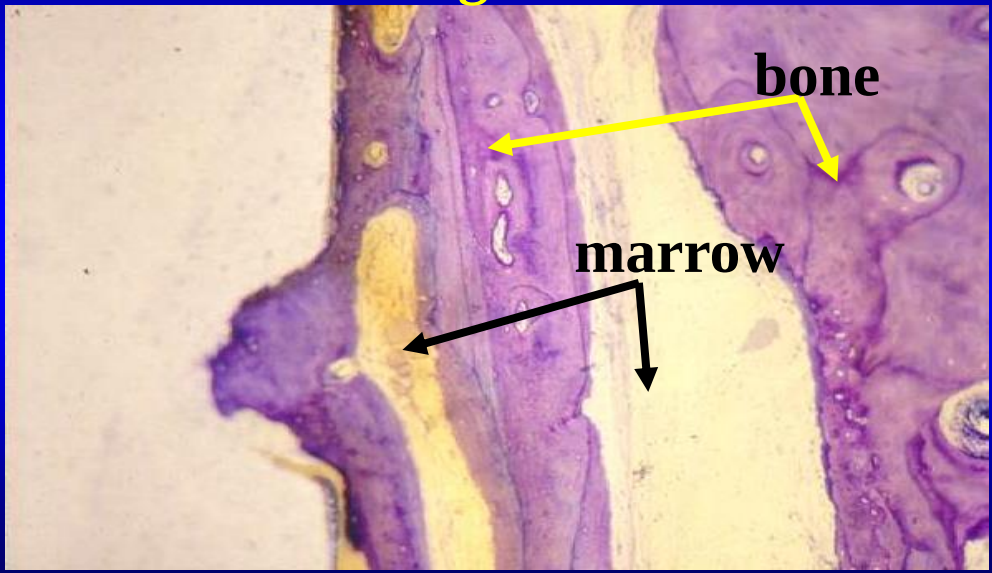
Histological image of the removed implant, 20x magnification



Histological image 50x magnification



Histological image; implant at 100x magnification



The bone-implant-contact /BIC/, can be measured by histomorphometric investigations, and expressed in percentage /%/.

BIC can be regarded as the measure of osseointegration, thus determines the load bearing of implant prosthesis

Thank you your attention!