Introduction to implant design and features

IMPLANTOLOGY YEAR COURSE
Module 1

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RICHARD MILLHOUSE BDS MFGDP(UK) MSc
Cambridge Academy of Dental Implantology

Aims and objectives

- to highlight the variety of dental implants available
- to review the history of the development of dental implants
- to explain the main design features/terminology of implant systems
- to review historic and contemporary implant surface characteristics and coatings
- to review the influence of the surface topography on the success of osseointegration
- to assess the evidence-base in implant design

Variety

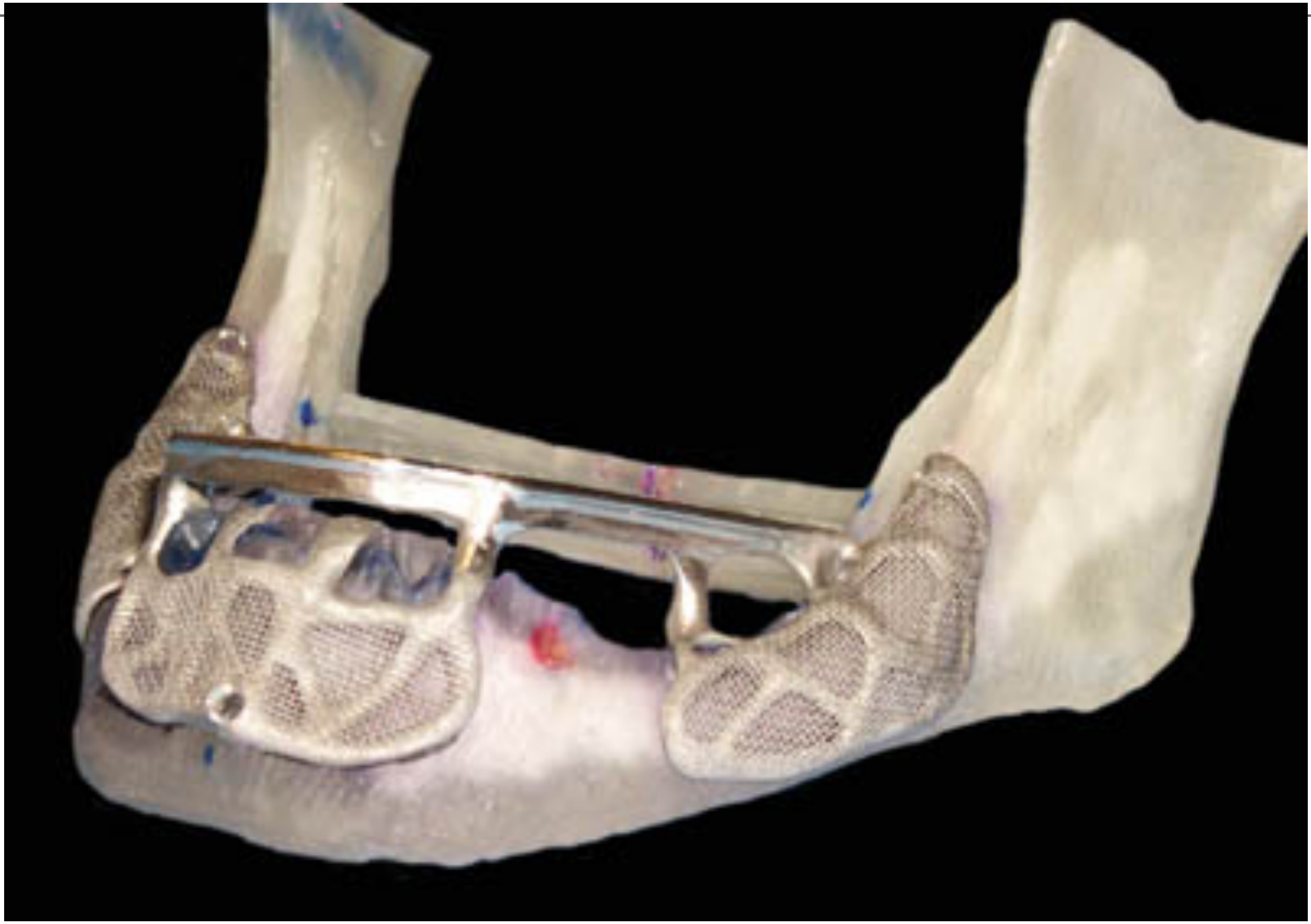
- over 1300 types of dental implants available
- which differ in terms of:
  - materials used: commercially pure titanium, Ti alloy, zirconia
  - shape: parallel, tapered, scalloped
  - diameter, degree of taper
  - length
  - abutment connections: internal, external, hex, tri-channel, octagon, morse taper
  - surface characteristics: thread design, micro & nanotopography and surface coatings

Historical development of implants

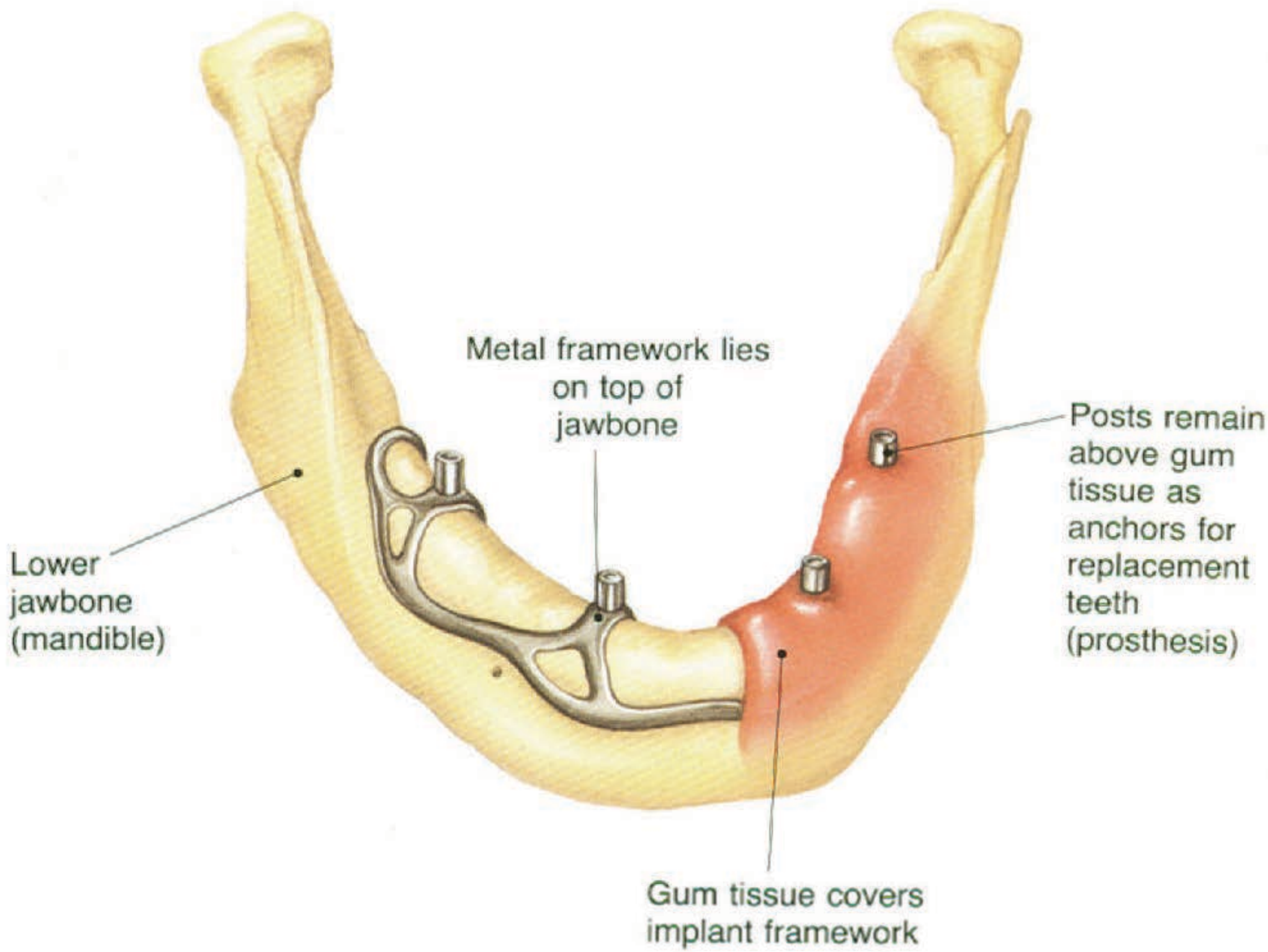
- use of xenograft and alloplastic materials to replace missing teeth dates back centuries
- Etruscan artefacts (7-800BC), animal bones carved into tooth shapes, ligatured to adjacent teeth with gold wire
- Mayan mandible (600AD), tooth shaped pieces of shell implanted into alveolus, x-rays show bone formation and therefore placed ante-mortem

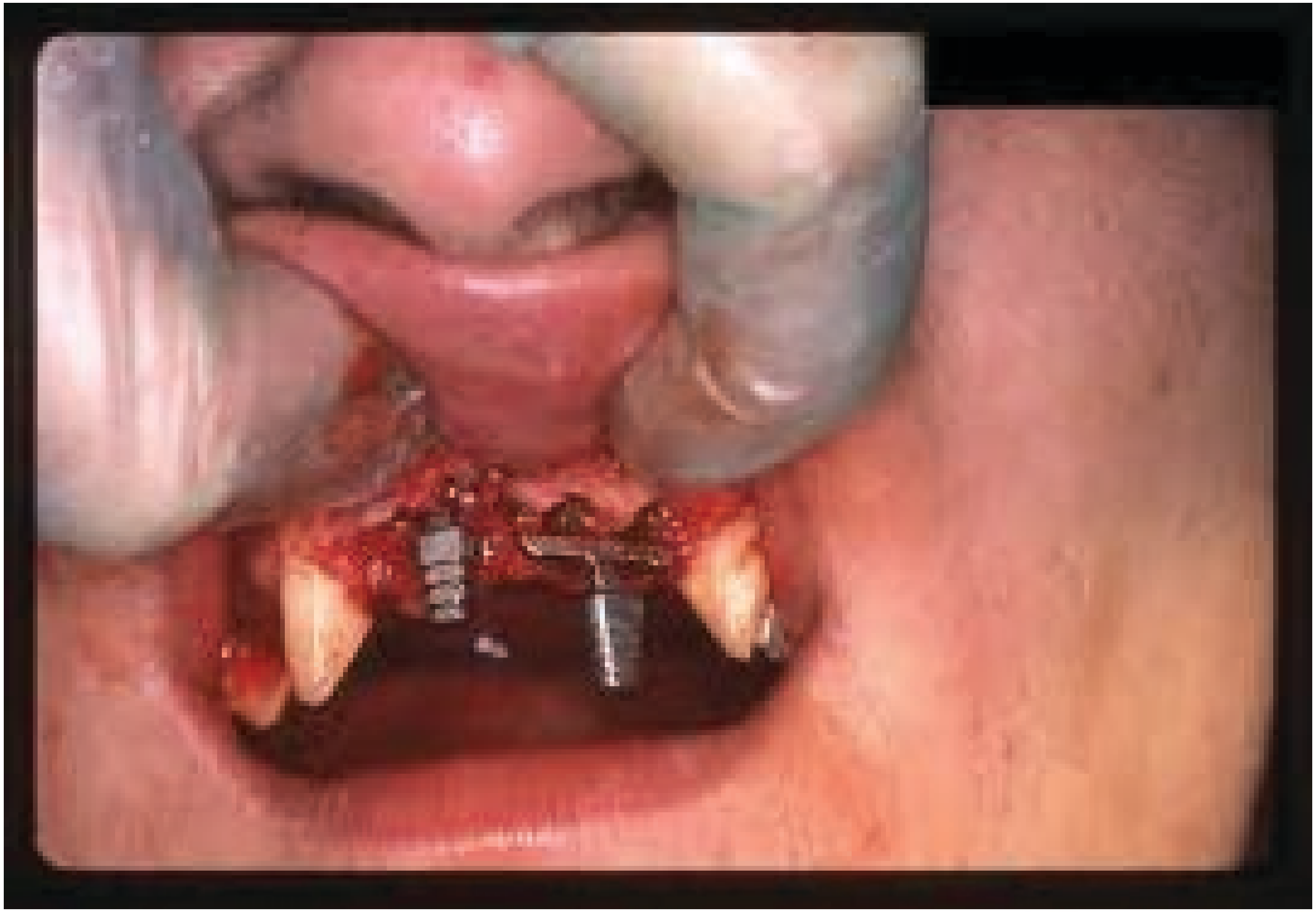
Historical development of implants

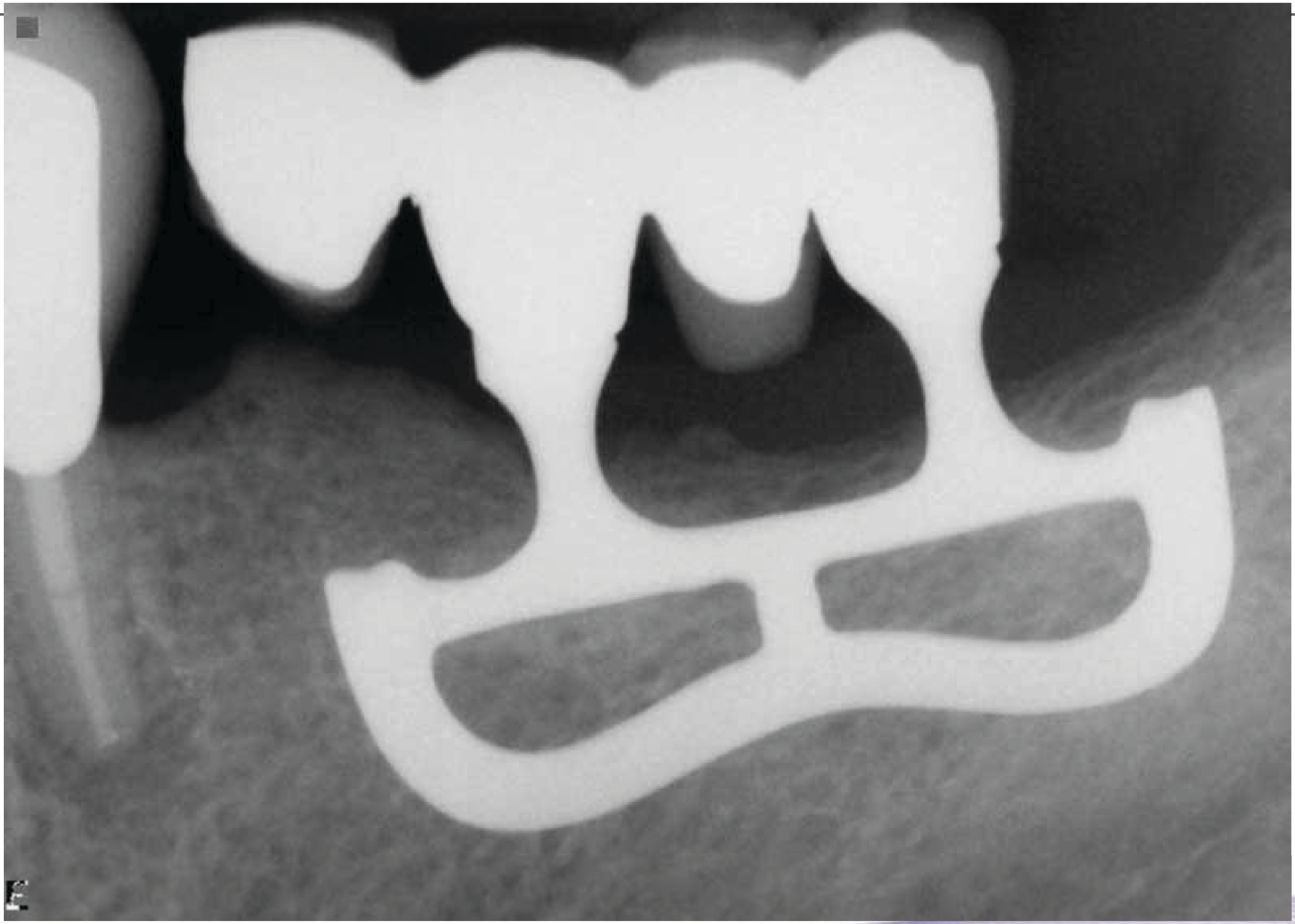
- **Subperiosteal frame implants** (1940s), from impression of the ridge and cast metal frameworks
- **Blade** implants by Linkow in 1960s, later early **screw** form

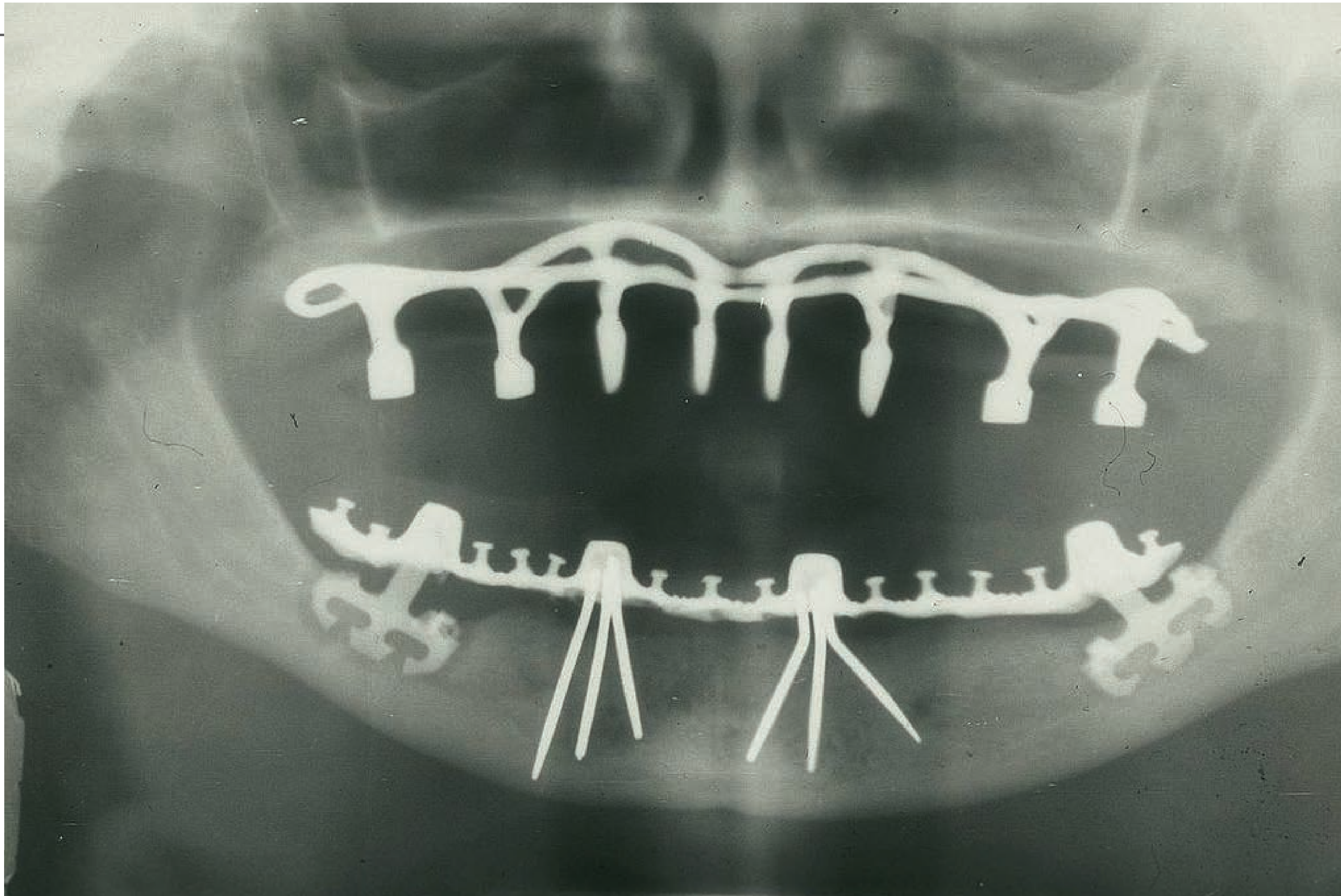


SUBPERIOSTEAL IMPLANT





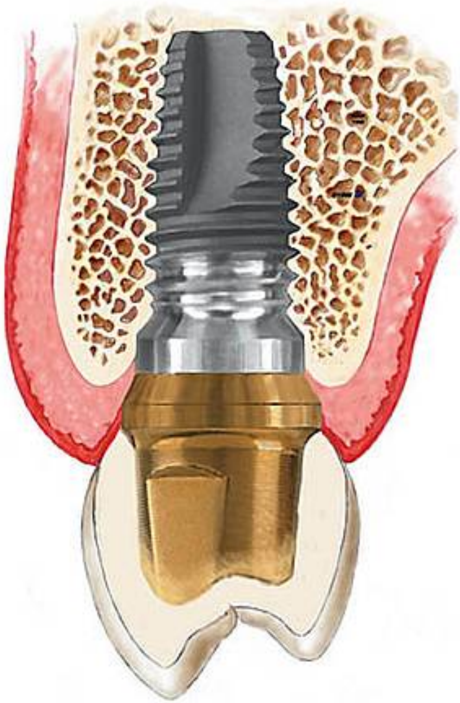




- **Per-Ingvar Brånemark** is credited as being the father of modern dental implantology
- 1965, Brånemark placed the first dental implant into a human volunteer, Gösta Larsson
- 1969, 1972 publication of short and long-term clinical data
- replica study by Zarb and the Toronto osseointegration conference of 1982

Design features of a dental implant

1. basic shape: parallel vs tapered
2. length
3. diameter
4. implant collar: polished vs micro-threaded
5. screw thread
6. implant-abutment connection
7. abutments
8. implant surface topography



Nobel Biocare implants

- Brånemark
- Nobel Replace Tapered
  - Replace Select
  - Replace Groovy
- Nobel Replace Straight
- Nobel Replace Conical Connection
- Nobel Parallel CC
- Nobel Active
- Nobel Speedy
- Zygoma

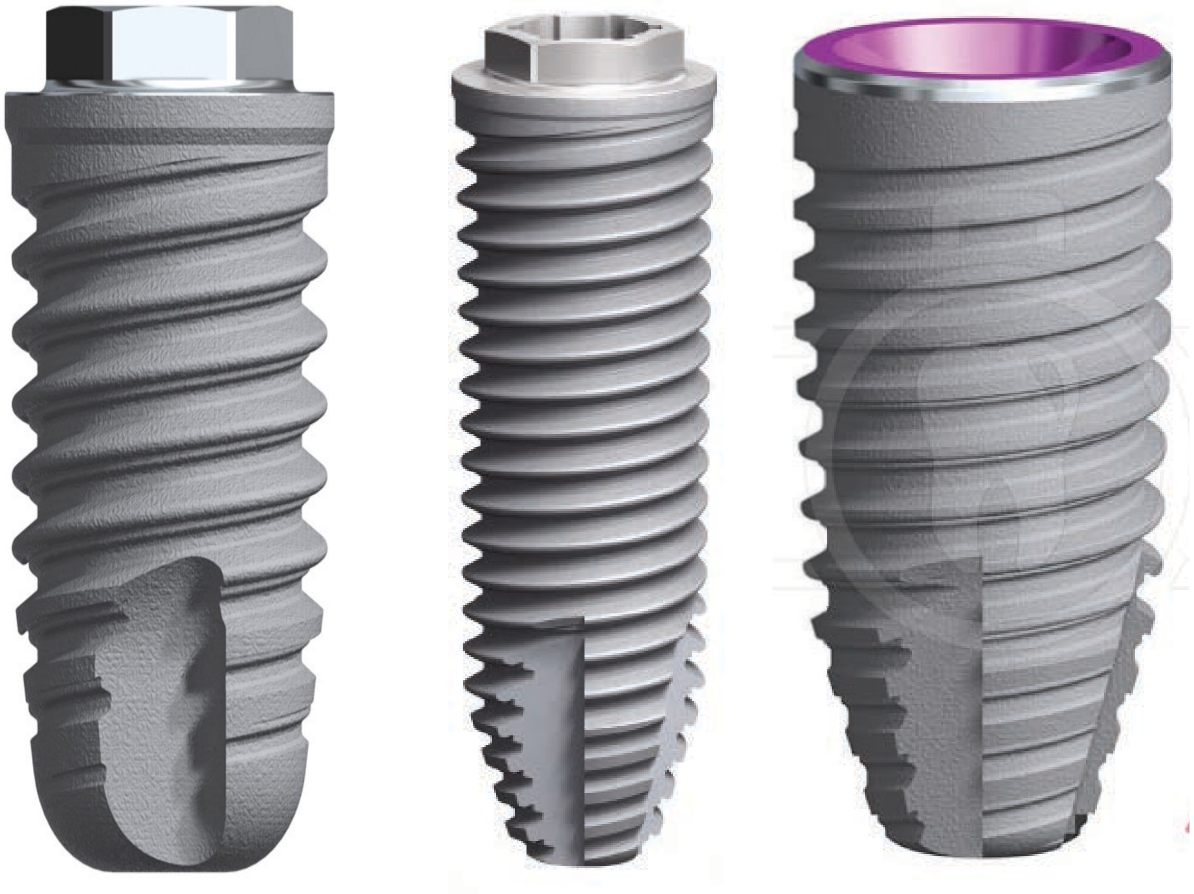
Nobel Biocare implants

“Nobel Replace Conical “Connection”

1. Basic shape

Parallel

- Brånemark
- Speedy
- Parallel CC



1. Basic shape

Tapered

- Nobel Replace
- Nobel Replace CC
- Nobel Active

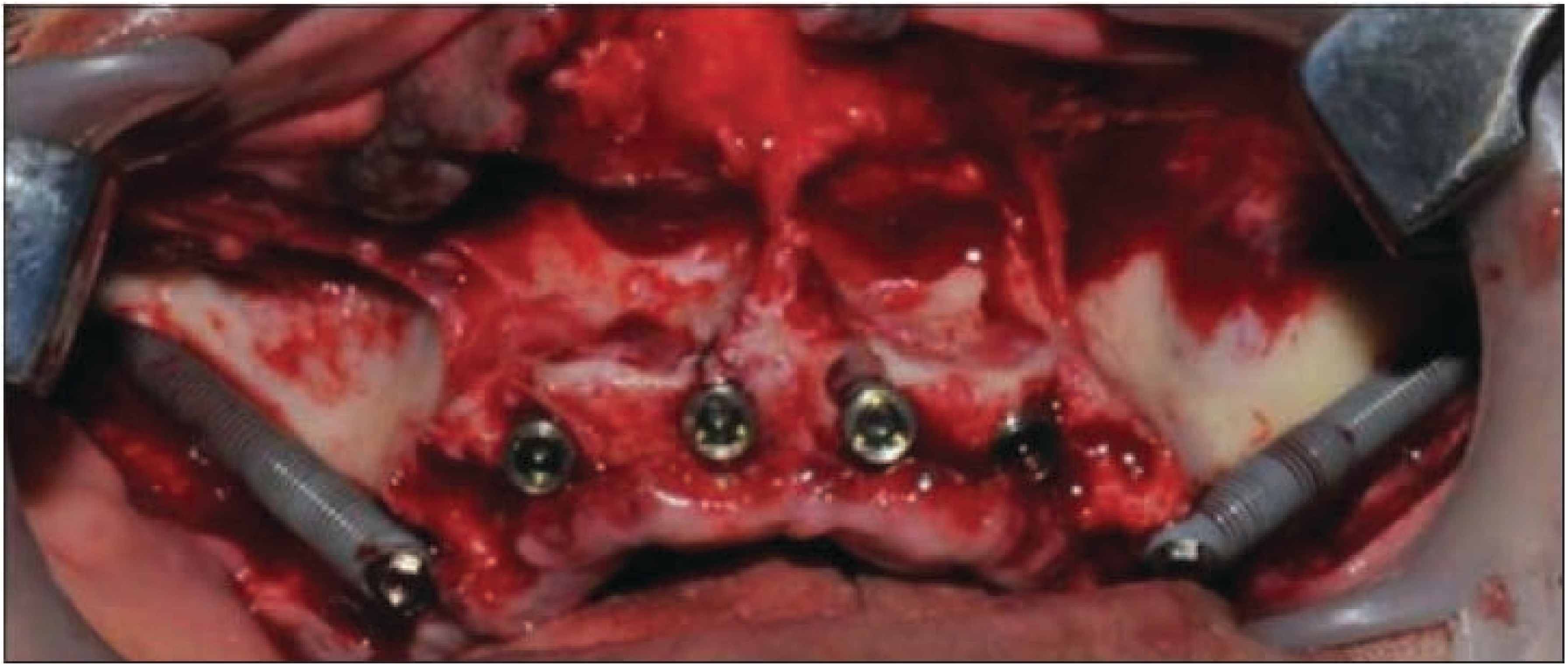
different drilling protocols

2. Length

- Replace CC
- 8, 10, 11.5, 13, 16mm
- many variations between systems
    - implants from 6mm to 52mm!

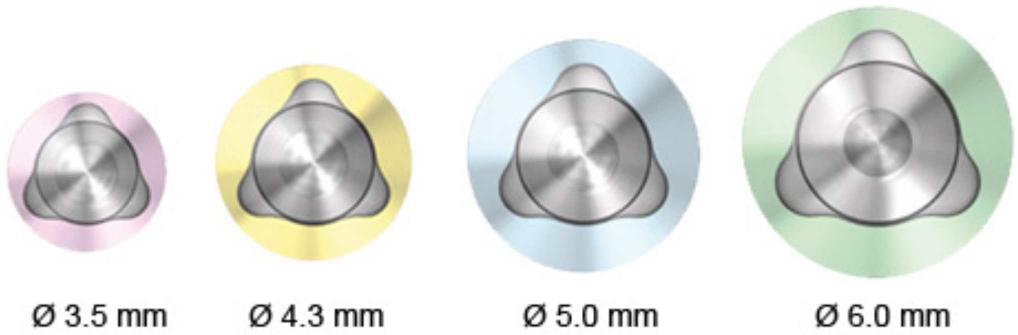
2. Length

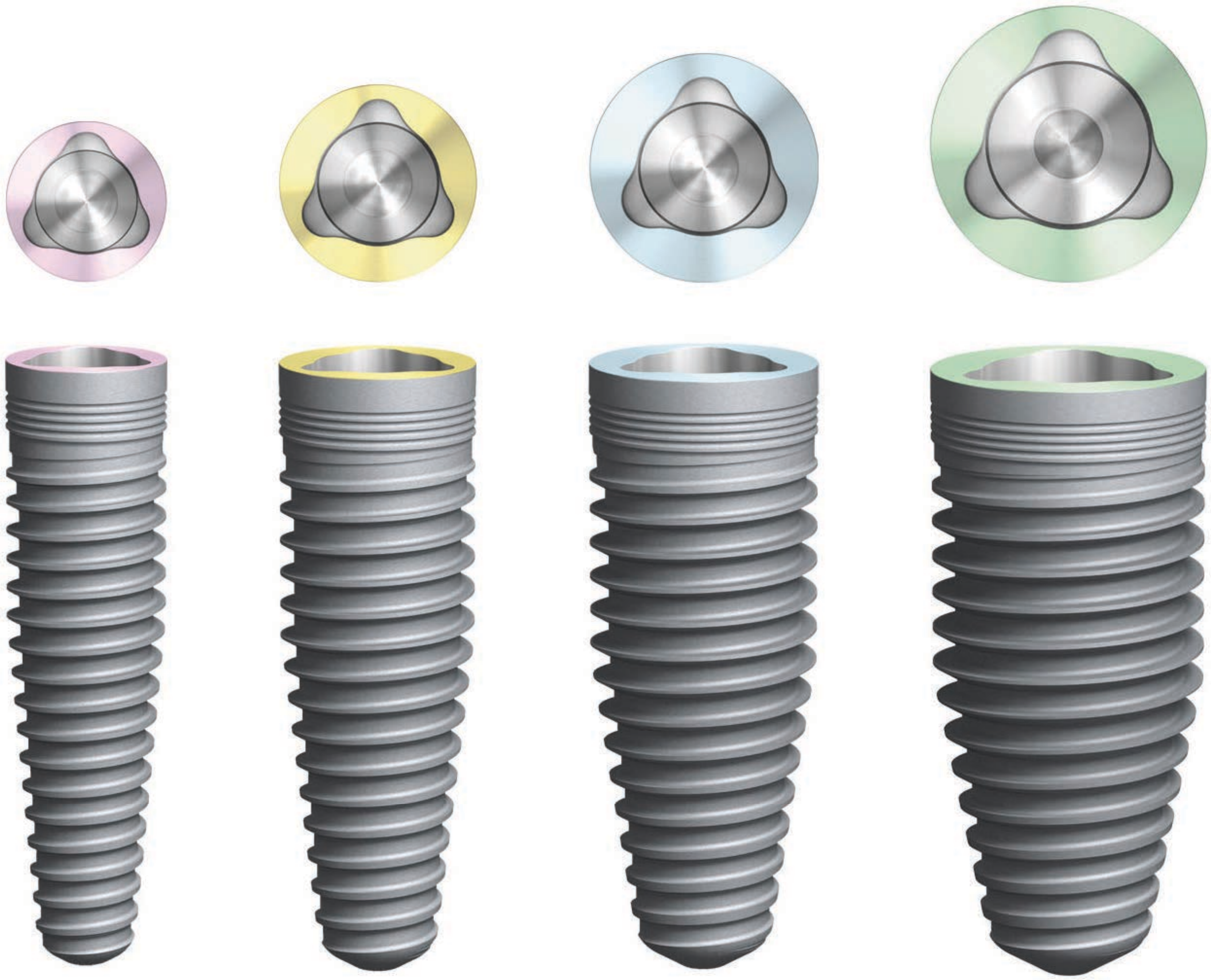
2. Length



3. Diameter

• **narrow platform**	pink	3.5mm
• **regular platform**	yellow	4.3mm
• **wide platform**	blue	5.0mm
• **6.0 implant**	green	6.0mm





3. Diameter

Nobel Replace Conical Connection

• **narrow platform**	pink	3.5mm
• **regular platform**	yellow	4.3mm
• **regular platform**	blue	5.0mm

4. Collar

4. Collar

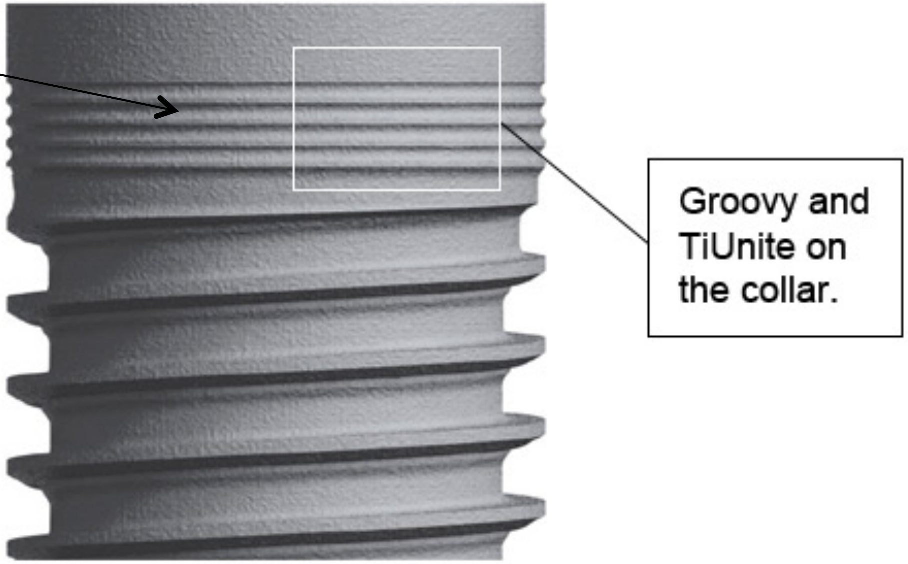
Polished

- no continuation of the microtopography
- useful if we do not wish to place the implant flush with the bone
- kinder to the soft tissues?
- in/out of fashion

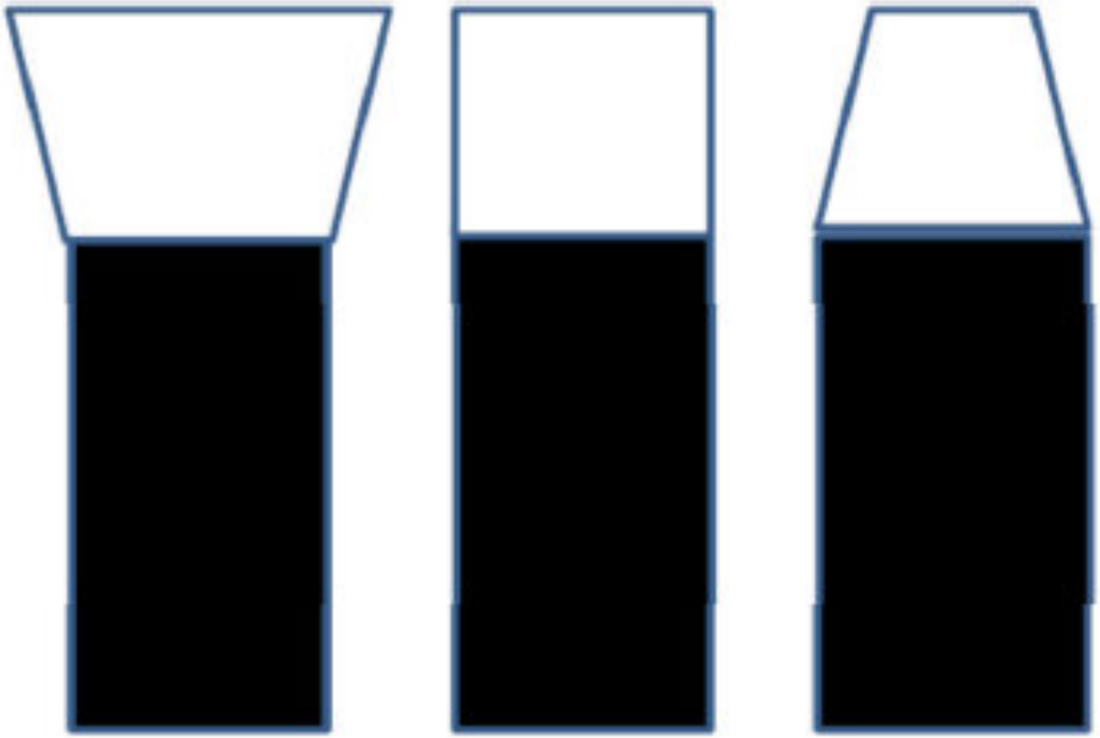
4. Collar

<u>Threaded</u>

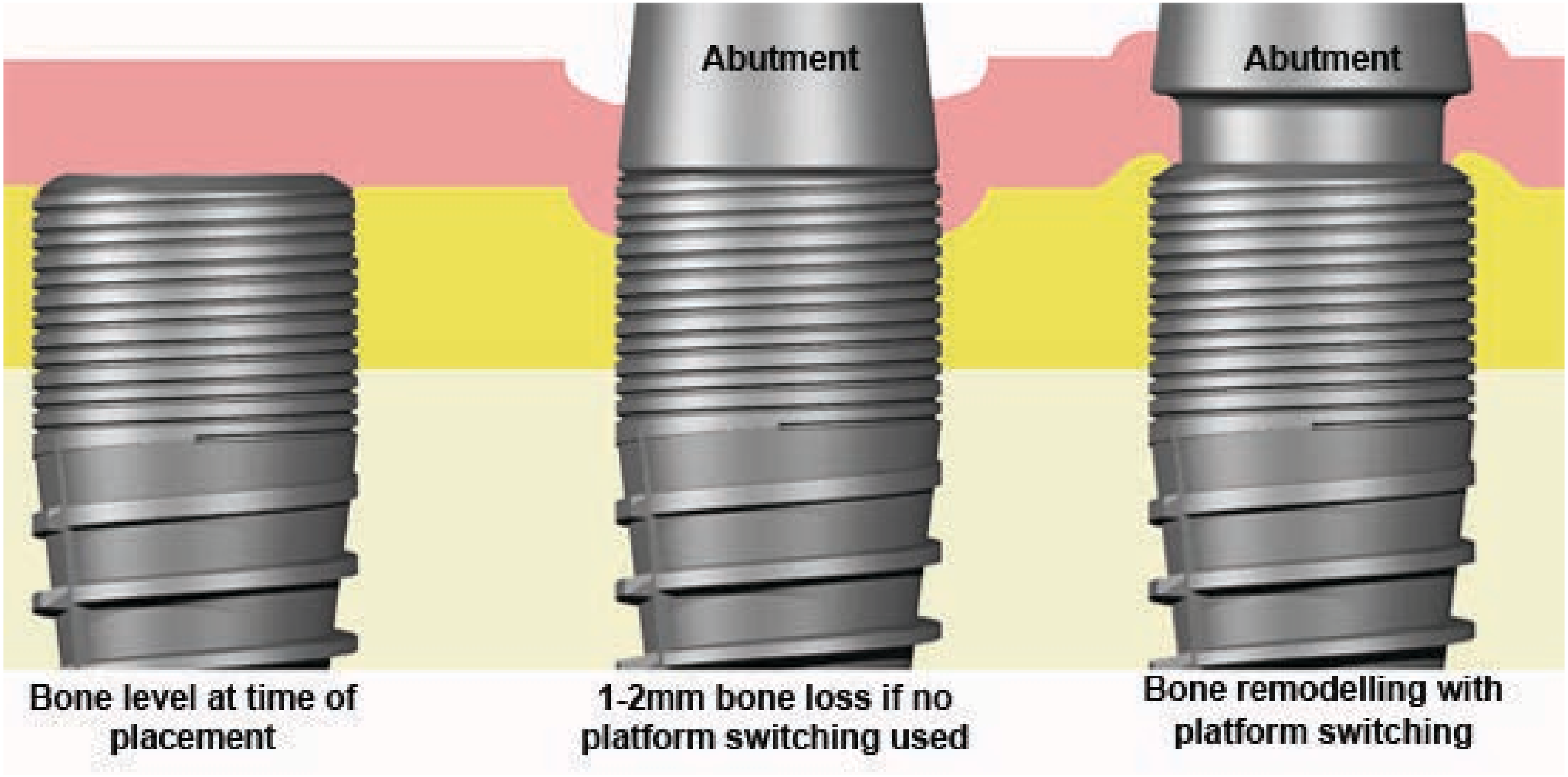
- collar engages cortical plate and generates insertion torque
- continuation of the microtopography up to the top of the implant
- said to retain bone in this region



4. Collar



4. Collar/Platform shifting



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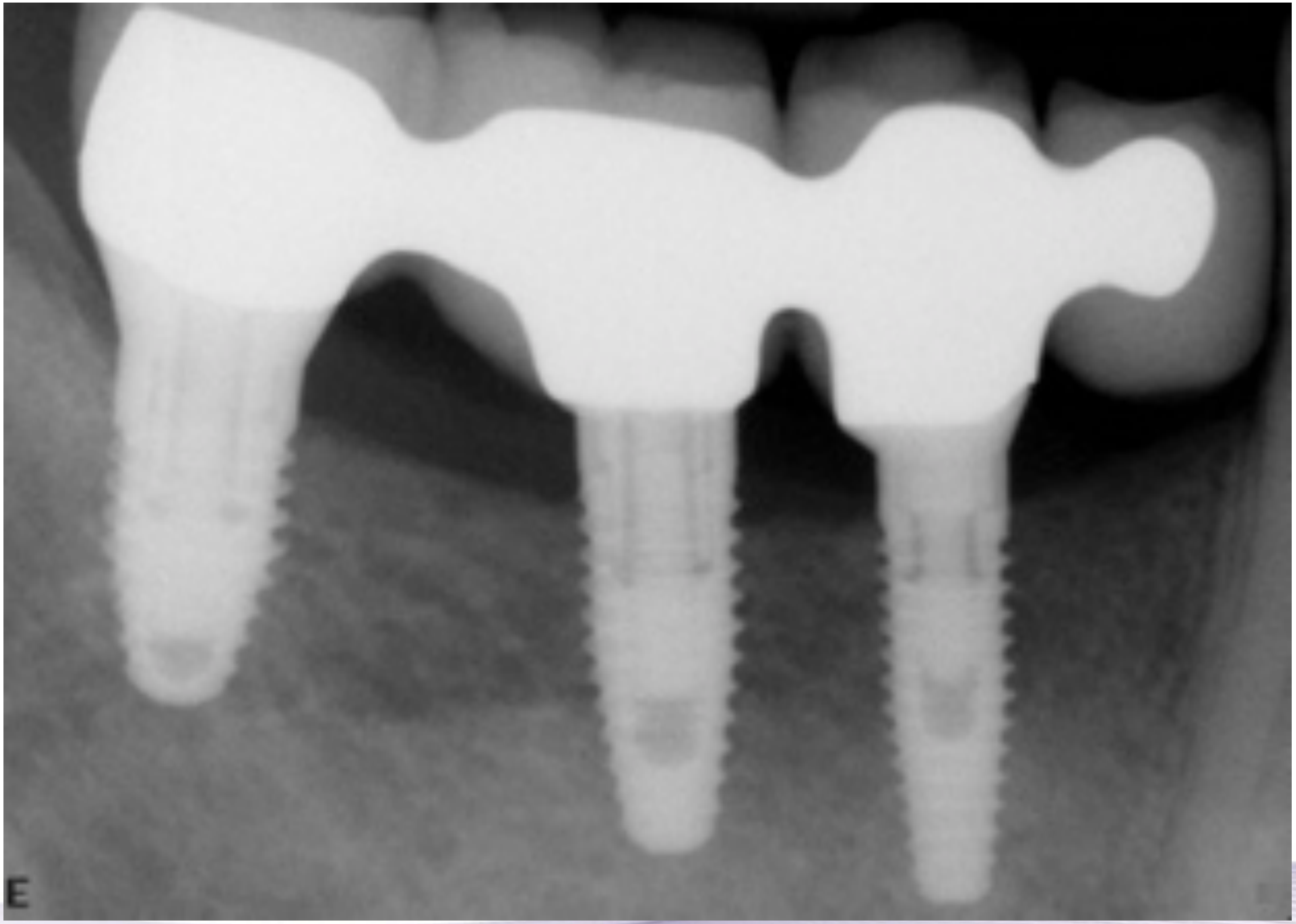
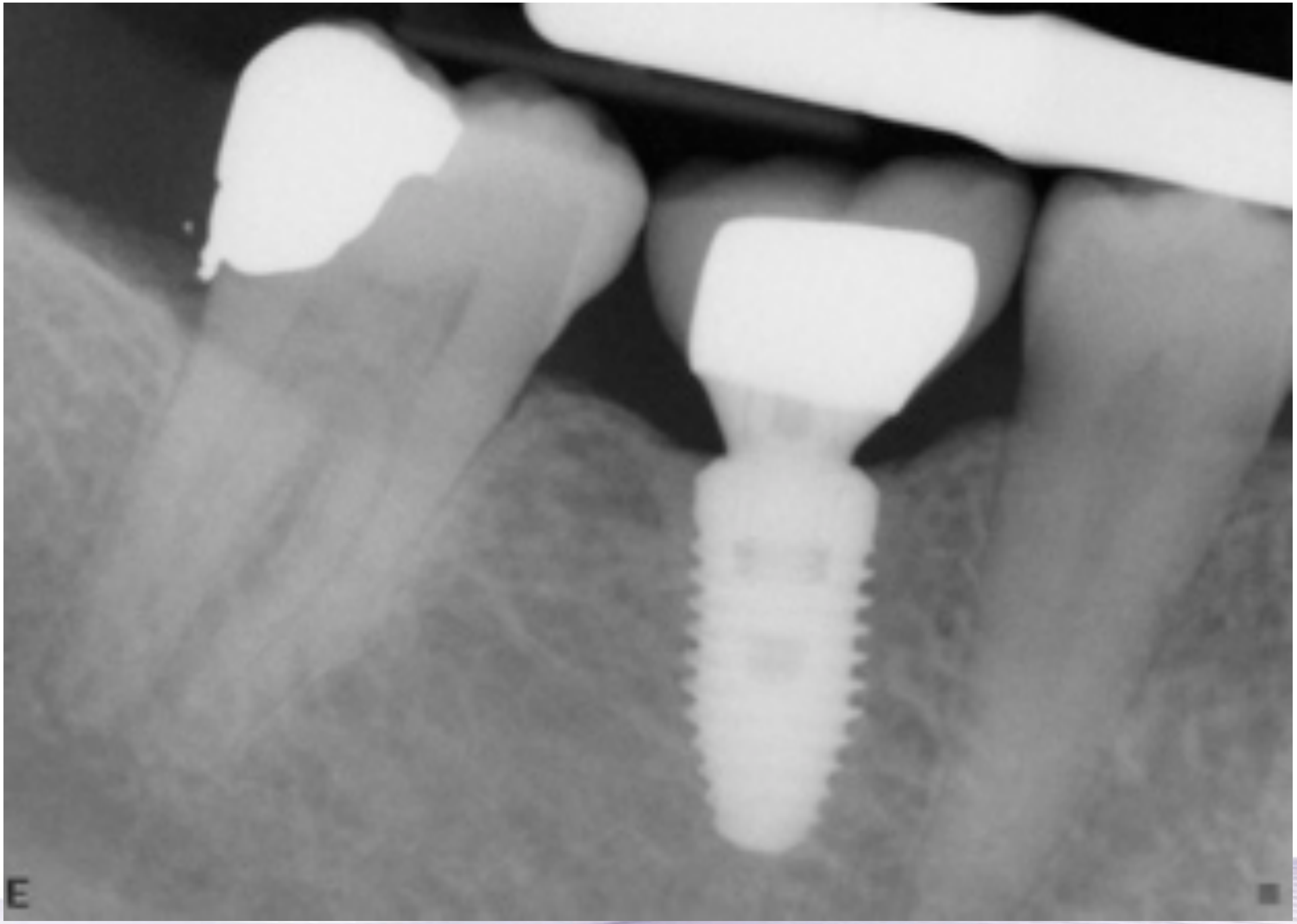


4. Collar/Platform shifting

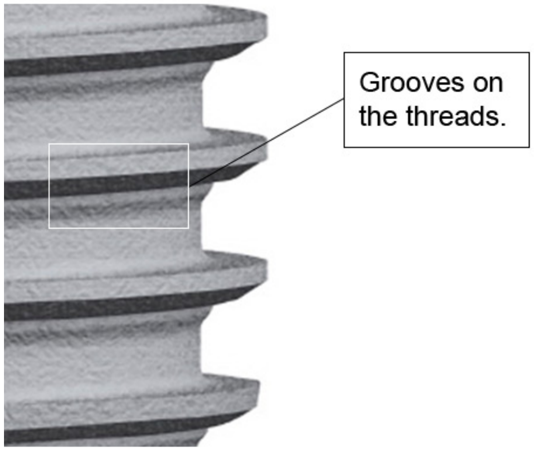


5. Screw thread

- conventional screw thread or basic “corkscrew” design along the outside of the implant
- different designs have different length threads
- threads cut their own path through the bone
- aid in primary stability and help to generate insertion torque

5. Screw thread

- “**Replace Tapered <u>Groovy</u> implants**” have a secondary thread design feature
- threads have an arrangement of macroscopic grooves - Nobel Biocare call this feature “**groovy**”
- said to increase surface area and bone-to-implant contact
- said to improve primary stability

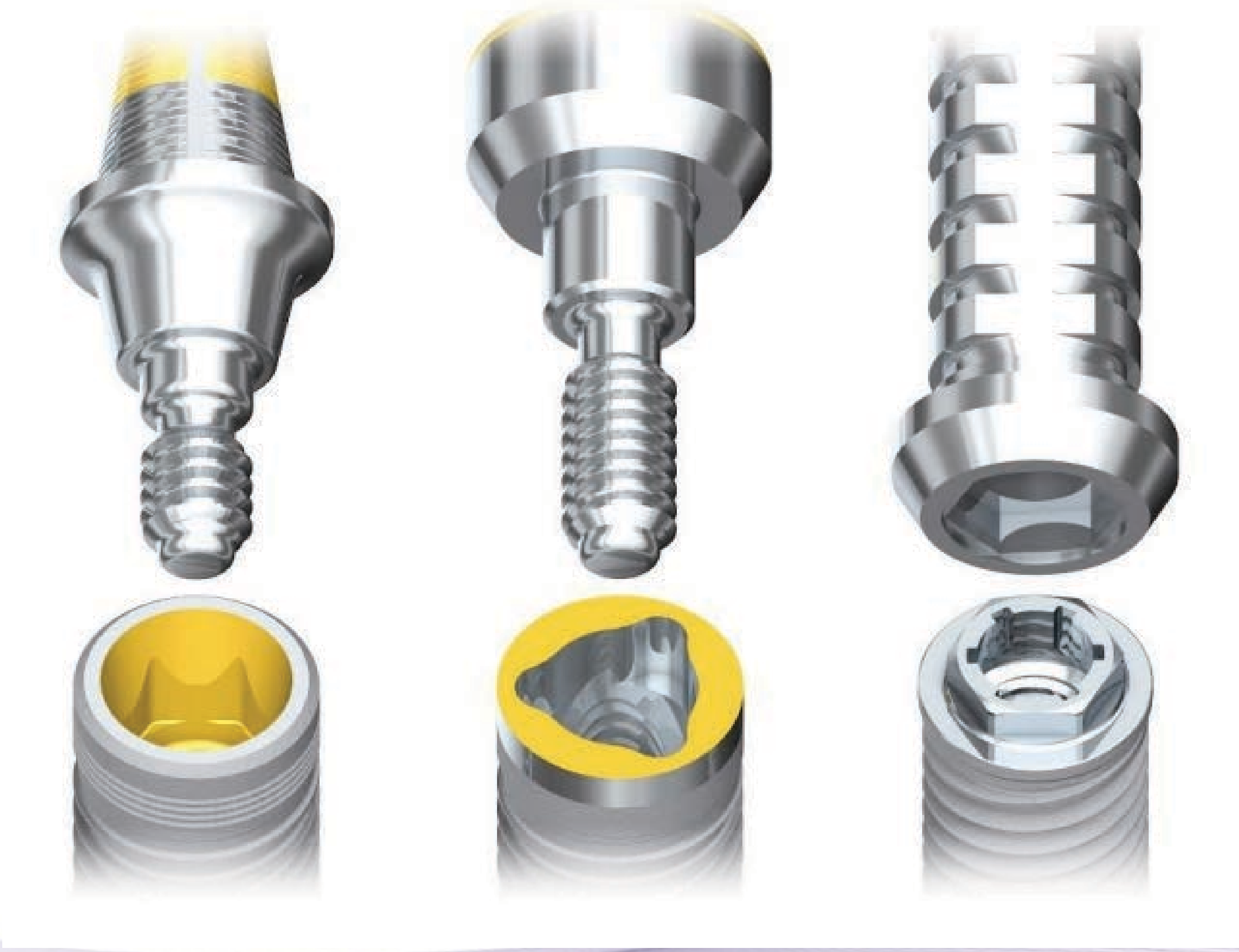


6. Implant-abutment connection

method of fixing the abutment to the implant

- internal connection
- external connection

6. Implant-abutment connection



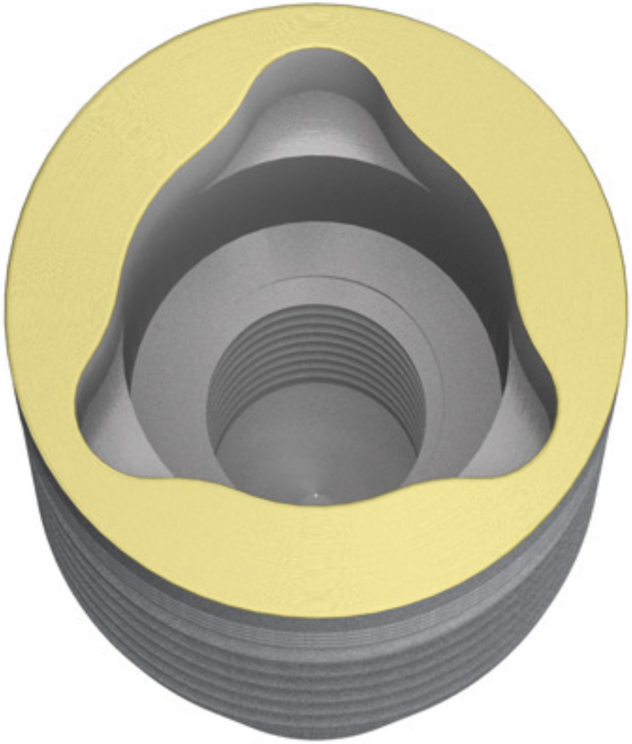
6. Implant-abutment connection

Internal connection

- the abutment fits <u>inside</u> the implant
- anti-rotation feature within the implant (female)
- anti-rotation feature allows specific spacial orientation of abutment on the implant & stops the abutment rotating
- tri-channel, hex, octagon, internal/morse taper

6. Implant-abutment connection

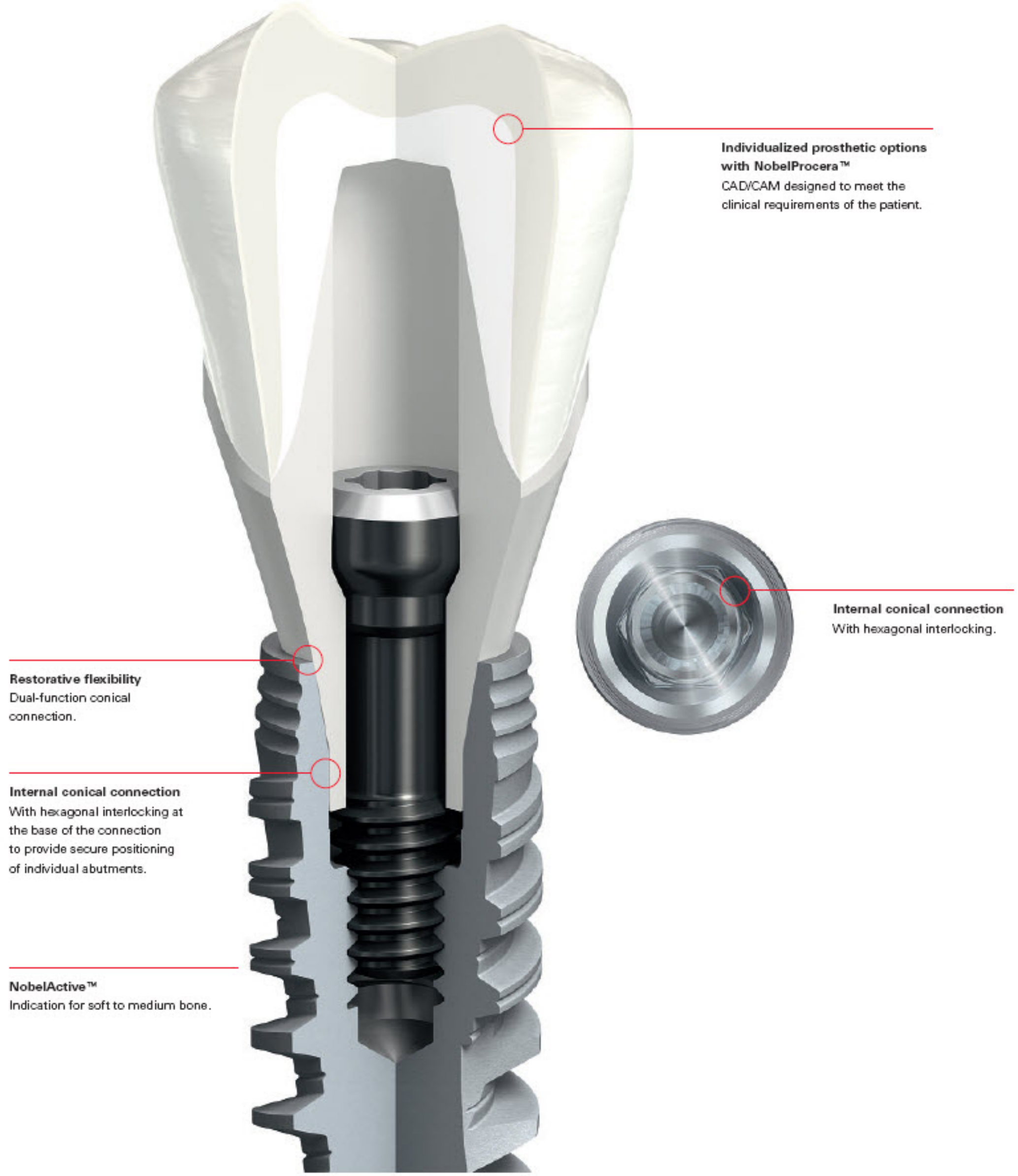
internal tri-channel



6. Implant-abutment connection

internal tri-channel

conical connection



6. Implant-abutment connection

External connection

- abutment connects over the outside of the implant
- anti-rotation feature on the implant (male)
- hex, octagon

6. Implant-abutment connection

7. Abutment

- method of attaching the prosthetic crown to the implant
- anti-rotation feature (male or female)
- may be a separate unit or an integral abutment-crown
  - screw-retained abutment/crown
  - screw-retained abutment and separate cement-retained crown
  - hybrid

• Cement-retained

- Separate abutment and crown

• Screw-retained

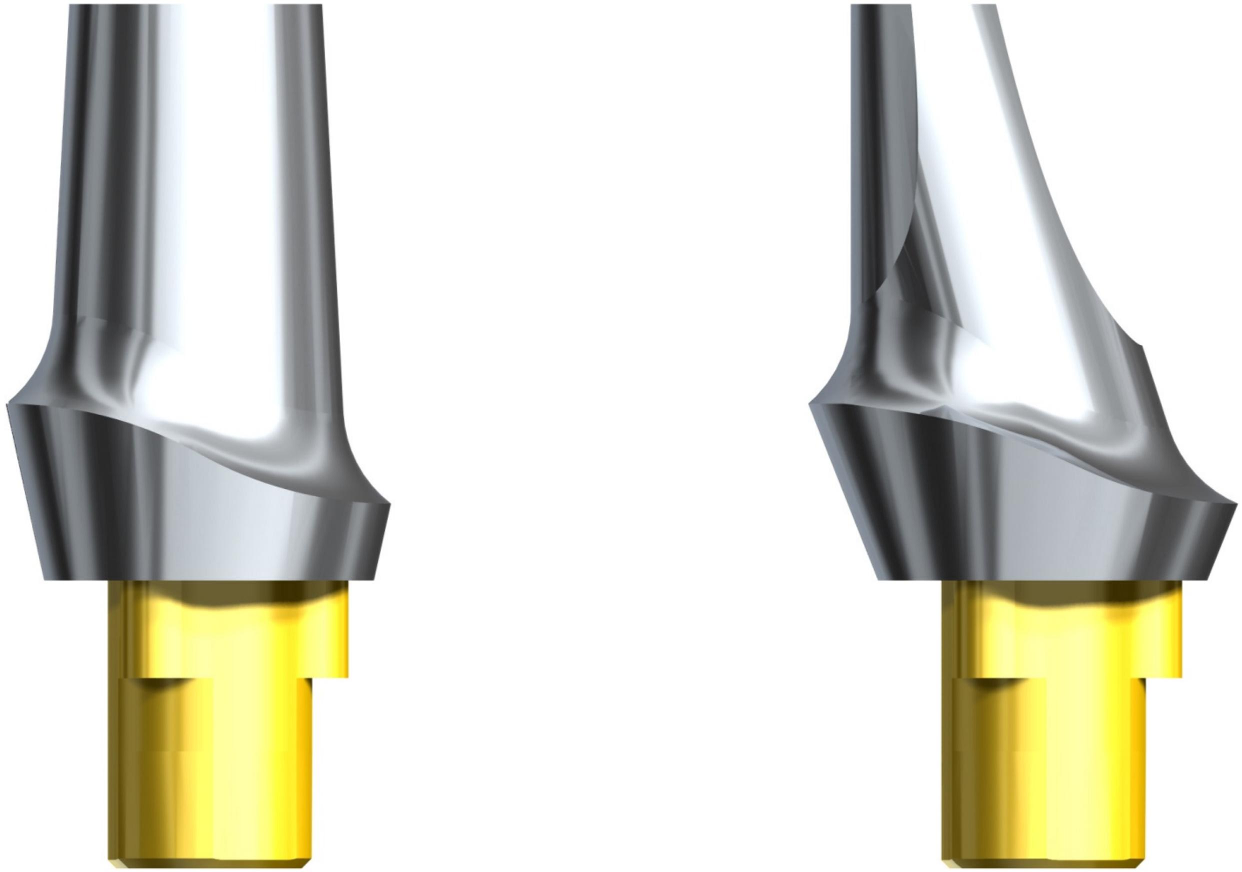
- one piece connection/crown

• Hybrid

- Cement and screw-retained

7. Abutment

- **preformed** – titanium
  - Esthetic
  - Snappy
- **customised**
  - cast gold – “UCLA”
  - cad-cam: Procera (Nobel), Atlantis (Astra), Isus
    - titanium
    - zirconia
    - cobalt-chrome (ISUS-Dentsply)



Abutment for cement-retained crown

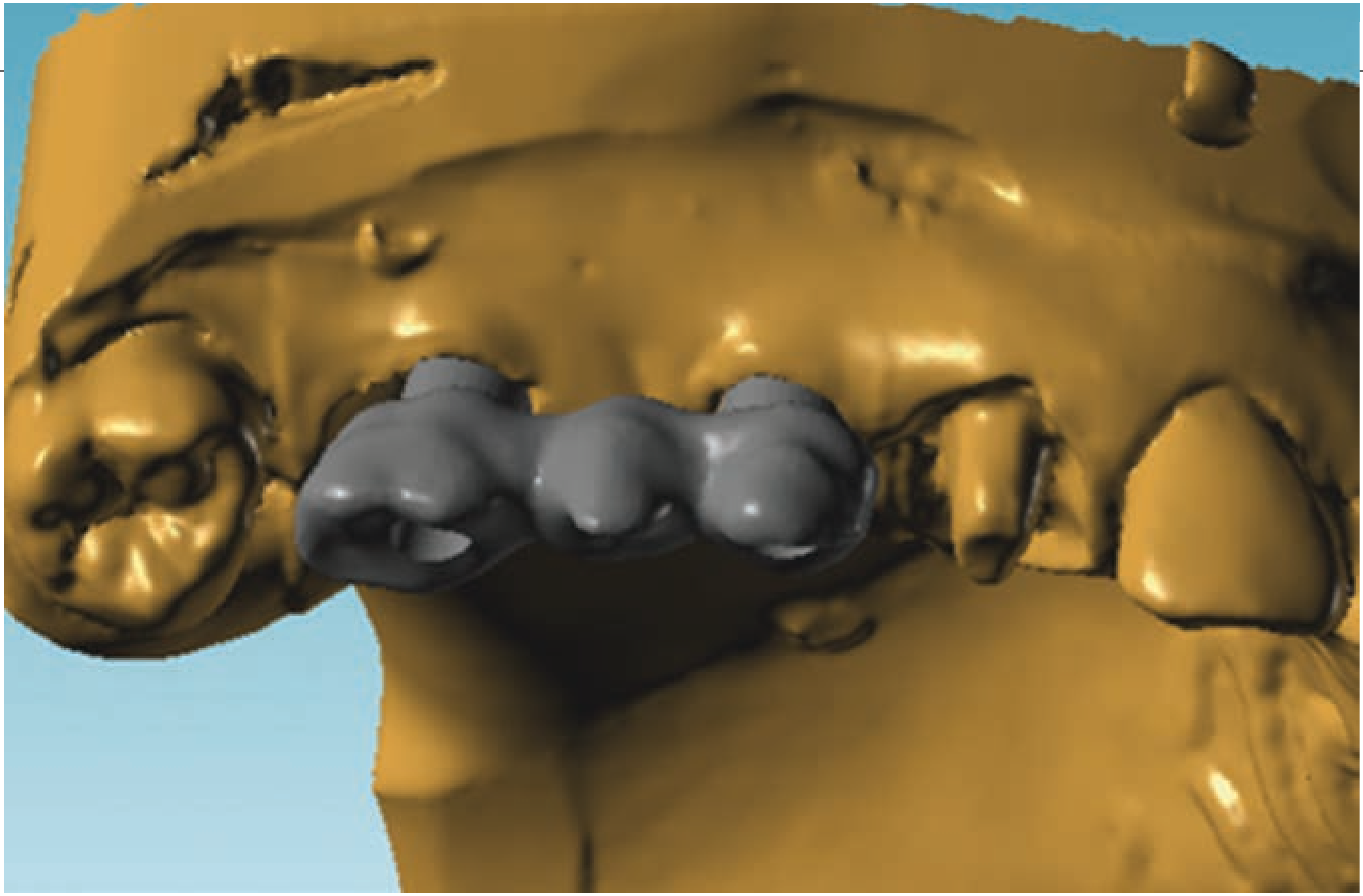
Custom abutment

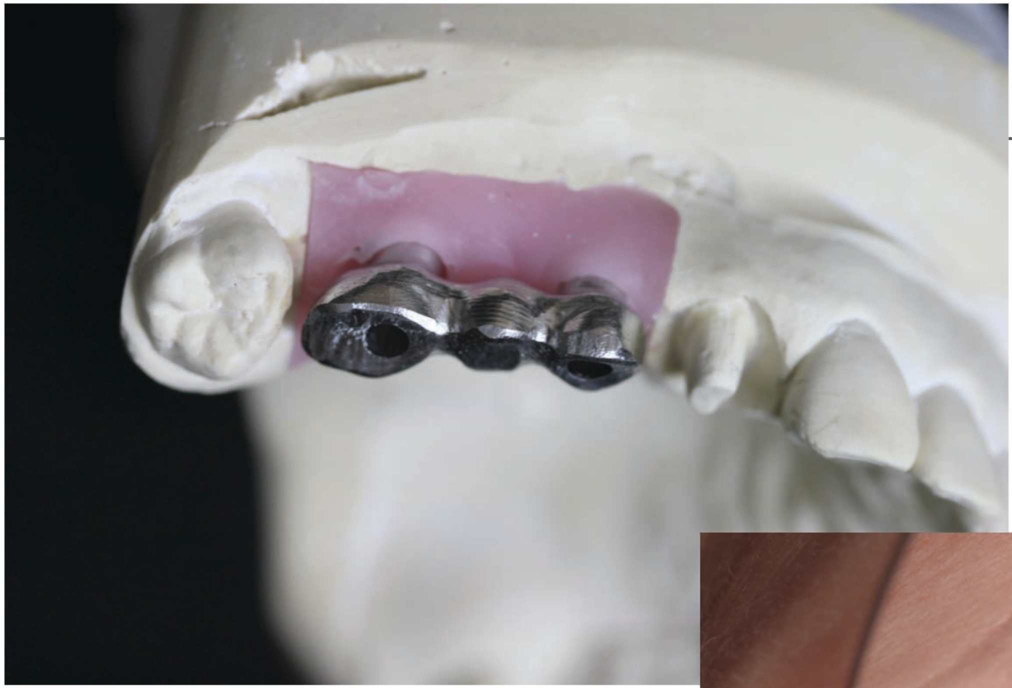
Stock abutmemt

Abutment for screw-retained crown

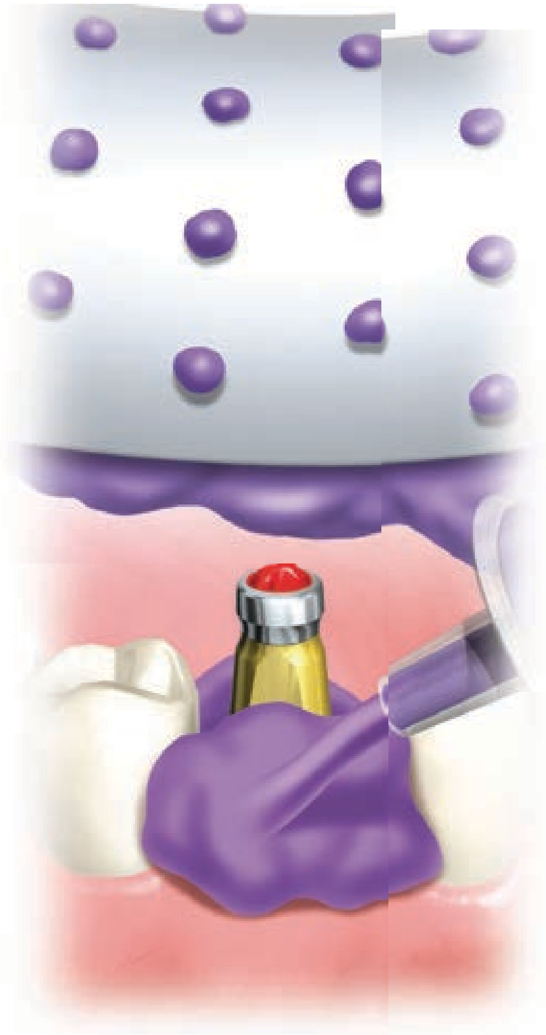
Custom abutment

Stock abutmemt





Closed tray impression coping



- Syringe material as per normal crown impression
  - Impregum Penta (not soft)
  - Silicones?

Open tray impression coping

Healing abutment

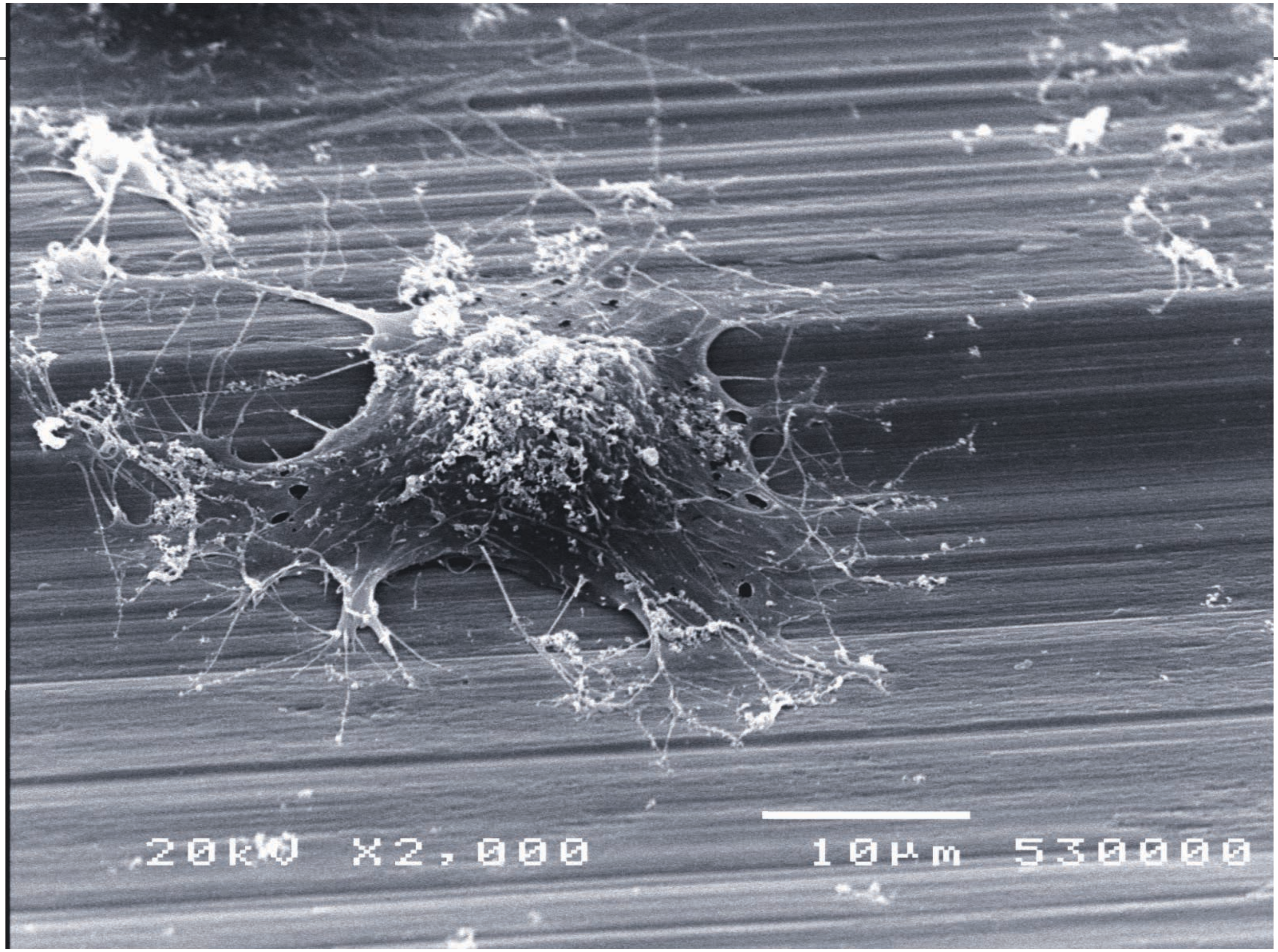
Cover screw

8. The implant surface

- surface is the interface between the bone and the titanium – titanium oxide/dioxide
- the surface characteristics of dental implants have been widely reported to influence the bone formation process
- specifically, the roughness of the implant surface has been shown to affect osteoblast activity
- huge financial investment by implant companies in developing implant surfaces

Types of implant surface

- original Brånemark implants had **machined** surfaces
  - basically formed in a lathe
  - machining grooves visible on the surface
  - smooth surface



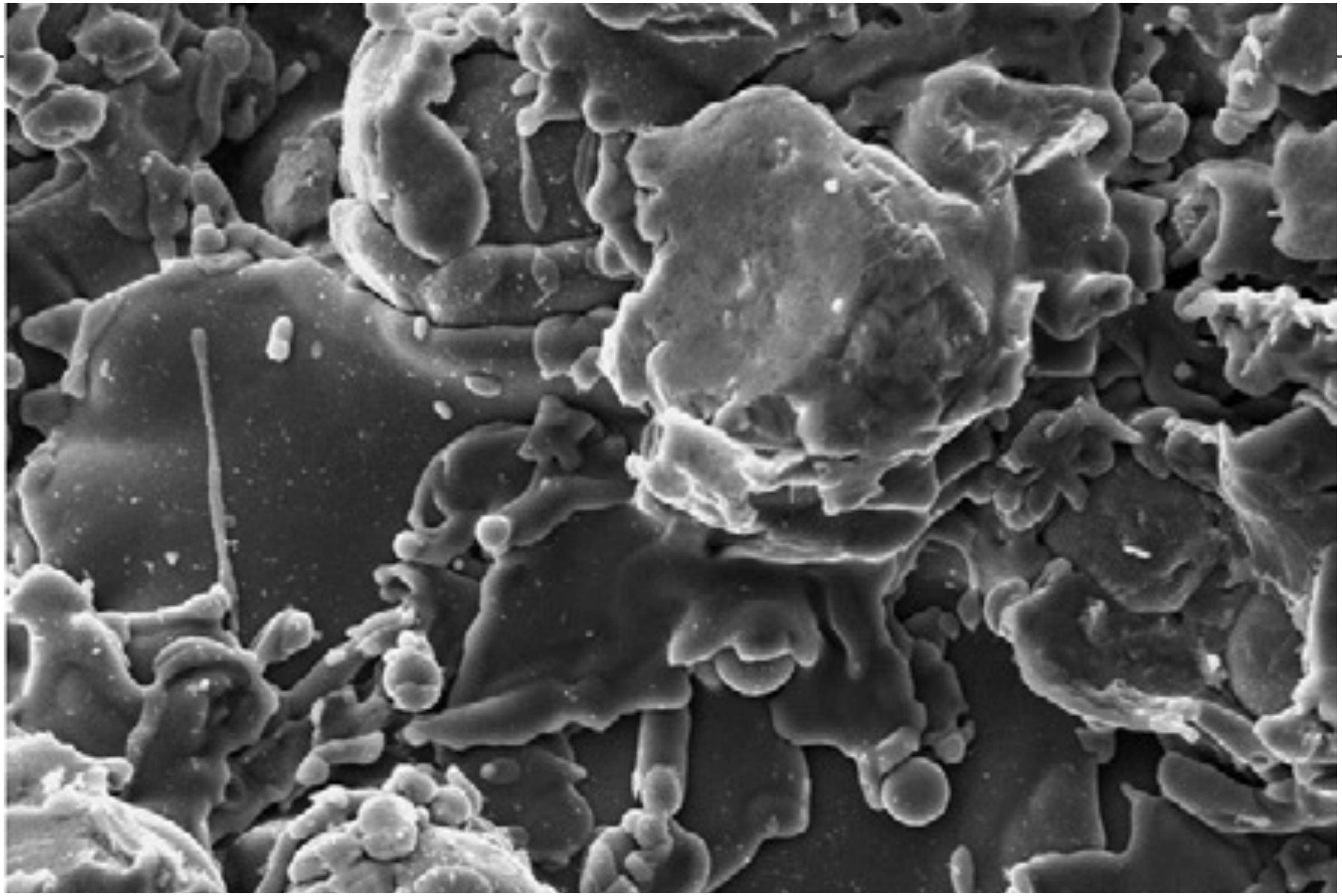
Courtesy of Dr R Sammons

Types of implant surface

- various techniques have been employed by manufacturers to modify the implant surface
- attempt to improve both the surface area and the roughness of the titanium, in a belief that such modifications could improve the bone-to-implant contact
- these techniques have included **mechanical** or **chemical** changes, or a combination of both, and can be categorised as **adding** or **removing** material to or from the implant surface

Additions to the surface

- **<u>t</u>itanium <u>p</u>lasma <u>s</u>praying**
  - titanium particles are projected onto the implant surface via a plasma torch at high temperature and pressure
  - on contact with the implant surface, the titanium particles fuse together in a film
  - very rough surface
  - TPS - Dentsply/Friadent



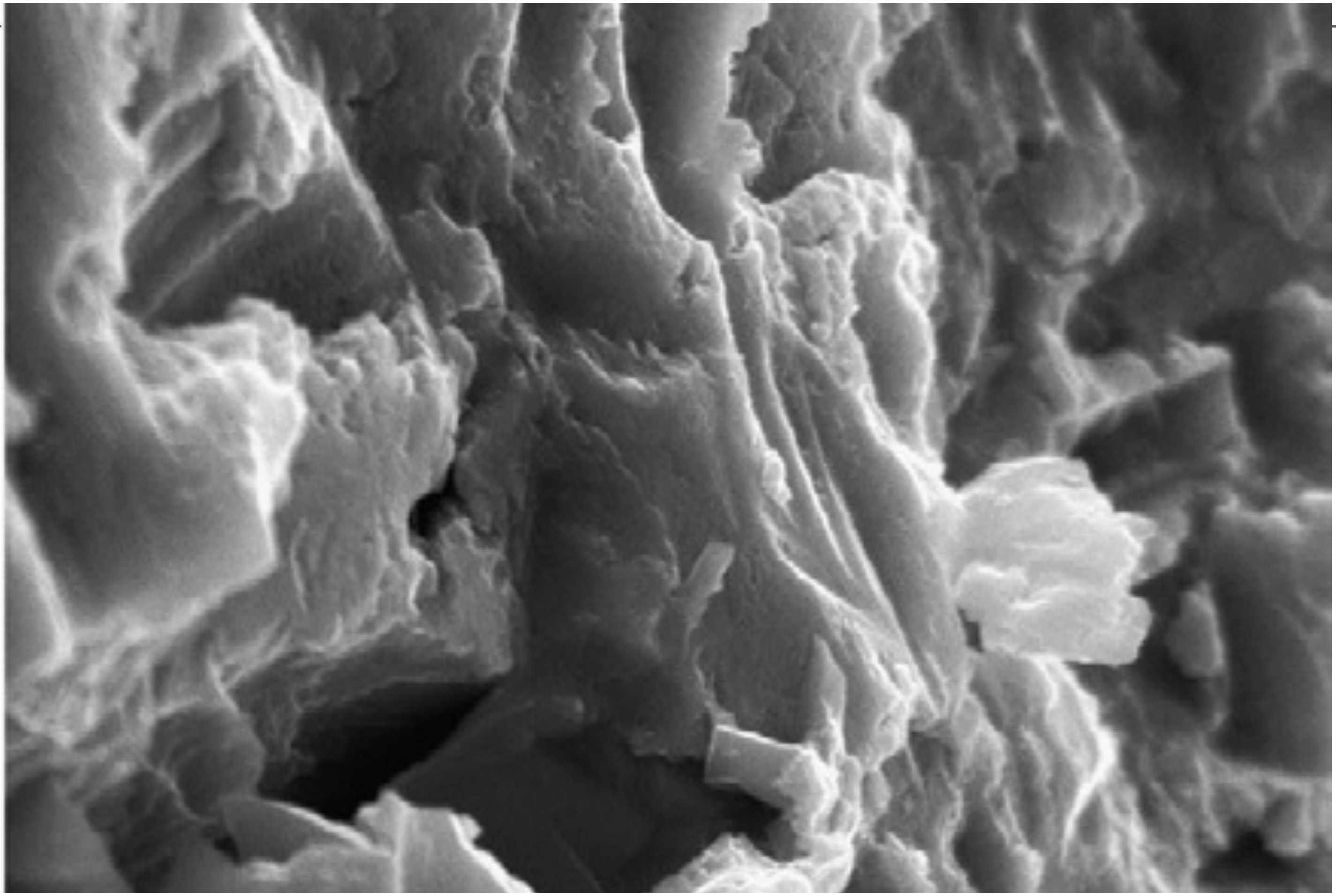
Le Guéhennec et al., 2007

Additions to the surface

- titanium plasma spraying
- **hydroxyapetite coatings**
  - HA occurs as part of the natural inorganic bone matrix
  - calcium phosphate/HA coated onto implant surfaces to characterise the surface with an osteoconductive layer
  - applied to the implant by plasma spraying or sol-gel coating
  - concerns exist within the profession that HA-coated implants have higher failure rates and that the HA undergoes resorption and separation from the titanium
  - macrophage-induced resorption, initiated as a response to loosened HA-particles

Removal from the surface

- **grit-blasting**
  - abrasive particles are forced onto the titanium surface using compressed air
  - the effect on the surface can be modified by varying the size and type of particles used
  - alumina (Al_2O_3), titanium oxide (TiO_2) and calcium phosphates
  - concerns have been expressed that grit particles can become embedded into the titanium surface, could adversely affect the osseointegration process ? corrosion
  - TiOBlast - Astra



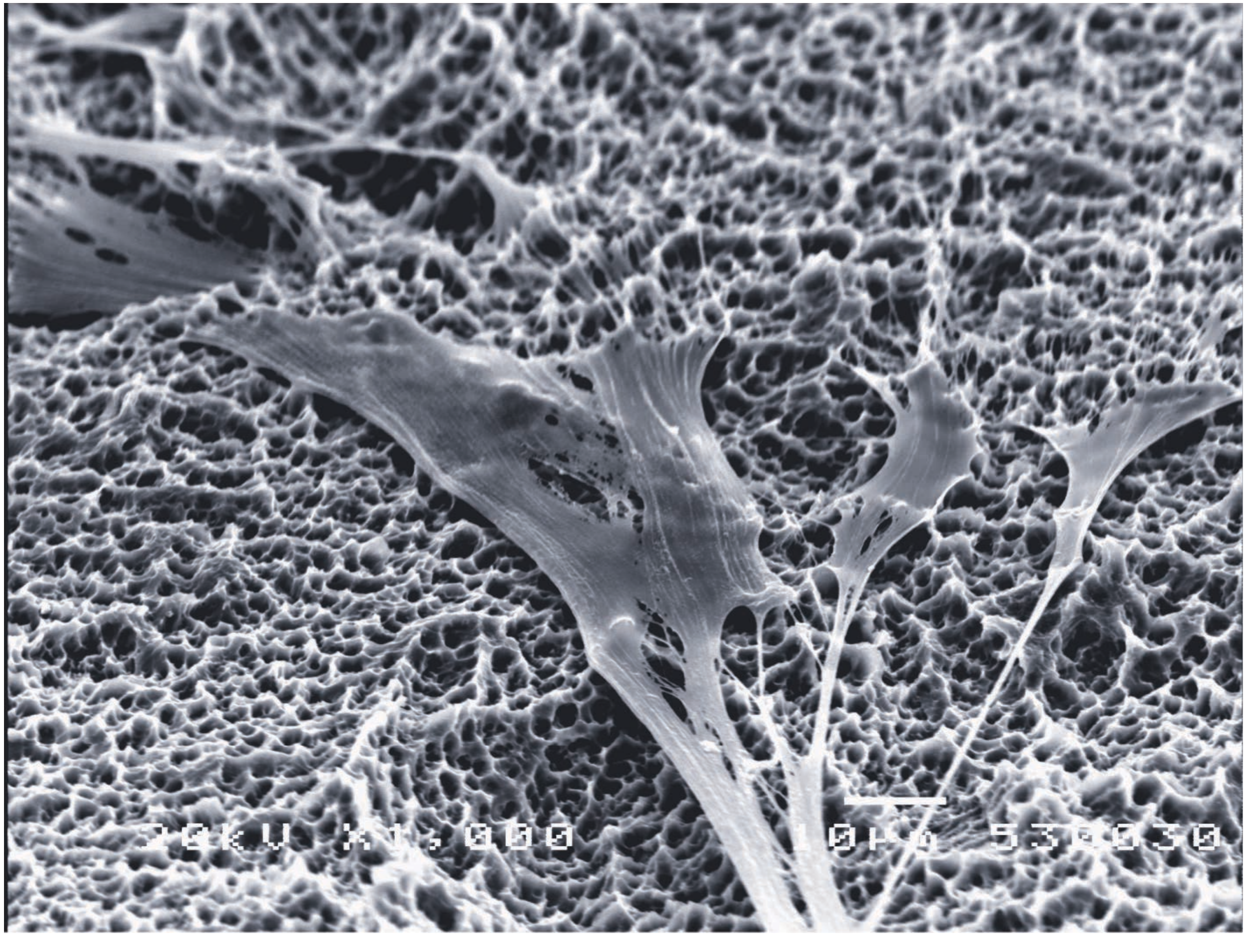
Le Guéhennec et al., 2007

Removal from the surface

- grit-blasting
- **acid-etching**
  - precise effect will depend on the concentration of acid used and on the length of exposure
  - sulphuric, nitric, hydrofluoric and hydrochloric
  - etching process produces "micropits" with a 0.5 to 2μm diameter
  - several techniques have been described, including single and dual etching at various temperatures
  - **Osseotite** – 3i

Removal from the surface

- grit-blasting
- acid-etching
- **combined grit-blasting and acid-etching**
    - craters of 30 to 40μm diameter with a superimposed pitting of 1 to 4 μm
    - examples:
        - **SLA** – Straumann
        - **DPS & Plus** – Dentsply Friadent
        - **Osseospeed** – Astra (HF etched – fluoride enhanced surface)



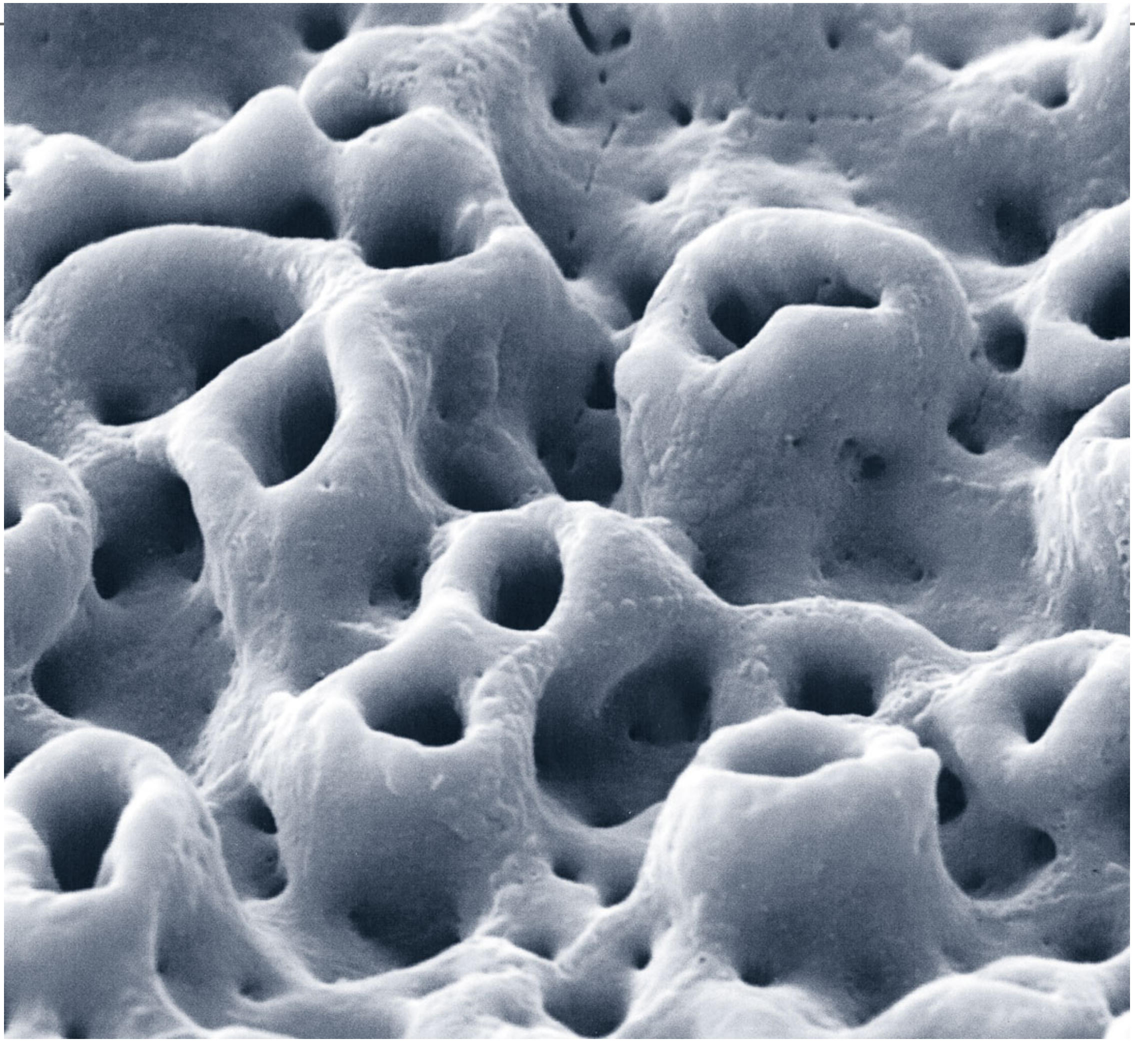
Courtesy of Dr R Sammons

Removal from the surface

- grit-blasting
- acid-etching
- combined grit-blasting and acid-etching
- **anodised**
  - oxidation process which thickens the oxide layer on the implant surface
  - strong acids used and the oxide layer is thickened in some regions and dissolved in others, depending on the convection of the current
  - produces micro- and nano-pores on the titanium resulting in a surface covered by hollow tubes

Removal from the surface

- grit-blasting
- acid-etching
- combined grit-blasting and acid-etching
- **anodised**
  - tubules are commonly 3.5 to 6µm in height, unevenly spaced and with an internal diameter of 1-3µm
  - **Ti-Unite** – Nobel Biocare



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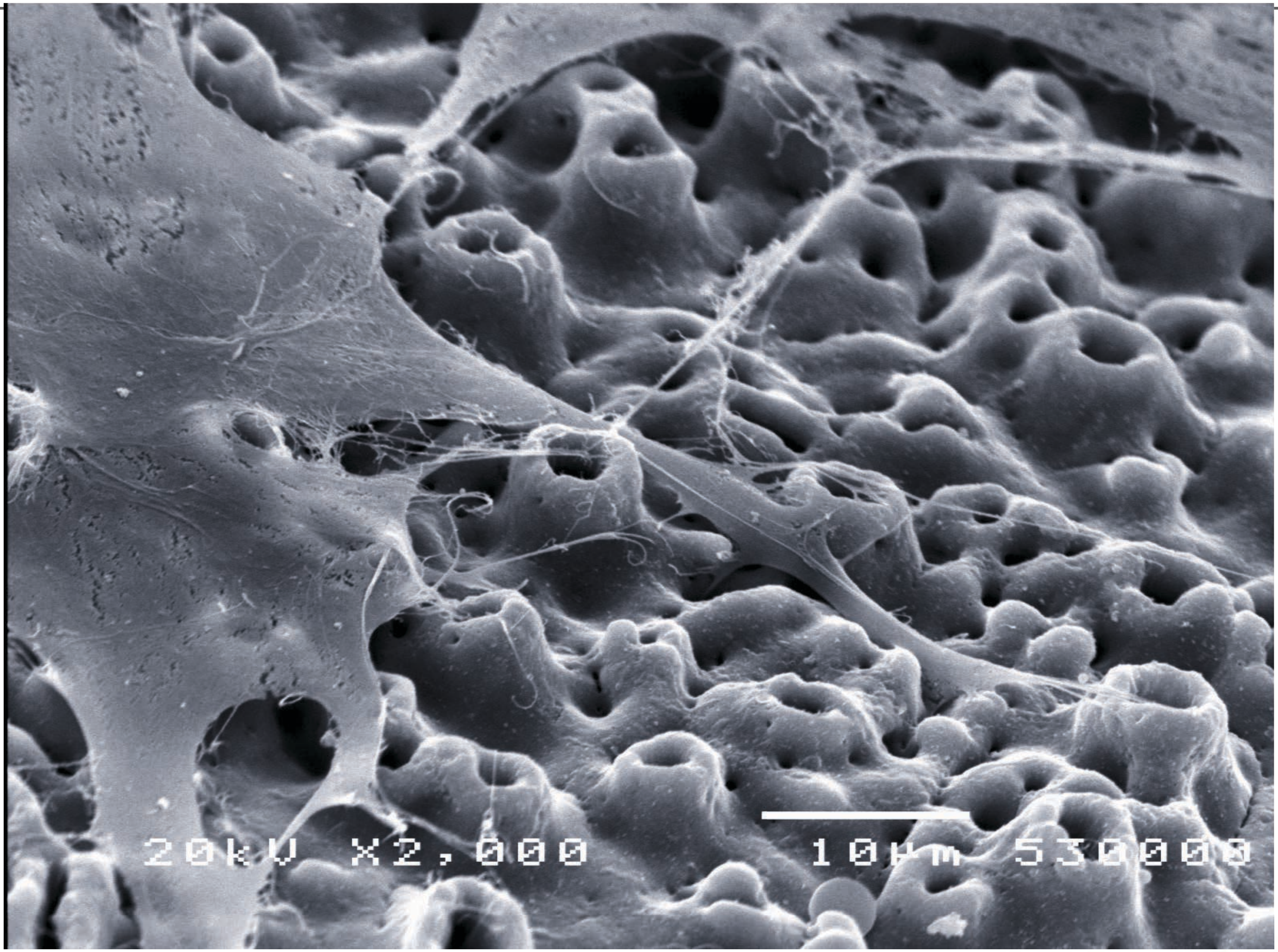

Courtesy of Dr R Sammons

Implant surfaces – the future?

- nanocrystalline (10^{-9}m) deposition of HA
  - Nanotite - 3i Biomet
- coatings with RGD-type peptides (arginine-glycine-aspartate amino acid sequence) to induce osteoblasts
- inclusion of genetically modified vectors (viruses) to induce local bone-forming effects

The evidence-base

- no strong evidence that the material, shape, size, length width or surface characteristics affects the success rates
- no evidence to promote the superiority of any particular type of implant or implant system over another

The evidence-base

- experimental studies on titanium favour the moderately roughened surfaces – osteoblast gene expression
  - combination grit-blasted and acid-etched
  - anodised
- 3D micro- and nano-topography more important than roughness per se

- clinical studies: weak evidence that rougher surfaces have lower failure rates than smooth surfaces
- very rough surfaces higher incidence of peri-implantitis
- the quality of the evidence-base is relatively poor

http://www.cochranelibrary.com