Sumy State University
Medical Institute

International Scientific and Practical Conference of Students, Postgraduates and Young Scientists “TOPICAL ISSUES OF THEORETICAL AND CLINICAL MEDICINE”

Dental implant surface – from micrometer to nanometer

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Dental implant

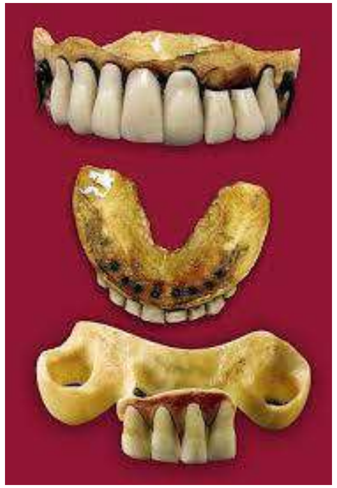
A dental implant is an artificial tooth root that is placed into your jaw to hold a replacement tooth or bridge. Dental implants may be an option for people who have lost a tooth or teeth due to periodontal disease, an injury, or some other reason.

What reason?

- There are up to 32 teeth per person
- There are 7 bn. people around the world
- Up to 225 bn. teeth
- Dental extraction is the most frequent surgical procedure performed upon humans

Brief history

- The first evidence of the use of implants back to 600 BC in the Mayan population
- In 500 BC, the Etruscans replaced missing teeth with artificial teeth carved from the bones of oxen
- Ancient Egyptians used tooth shaped shels for missing teeth restoration
- In the 1700s John Linter suggested the possibility of transplanting teeth of one human into another

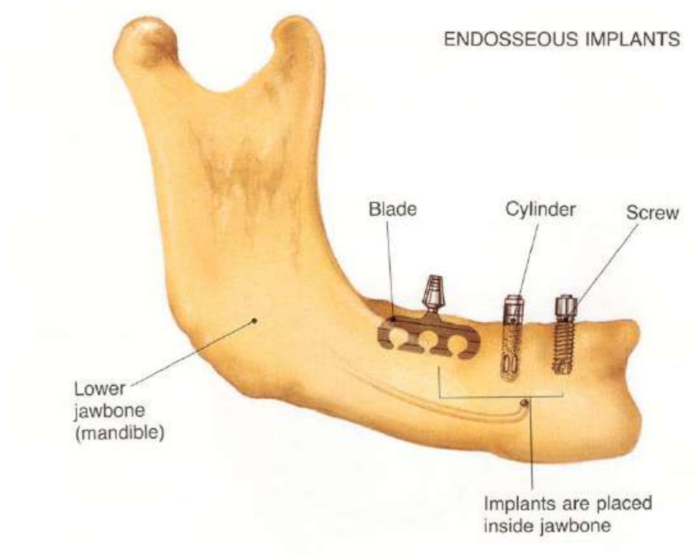


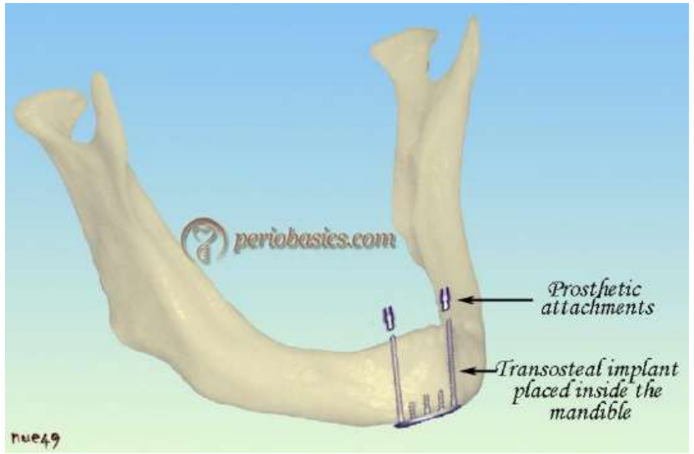
Brief history – modern period

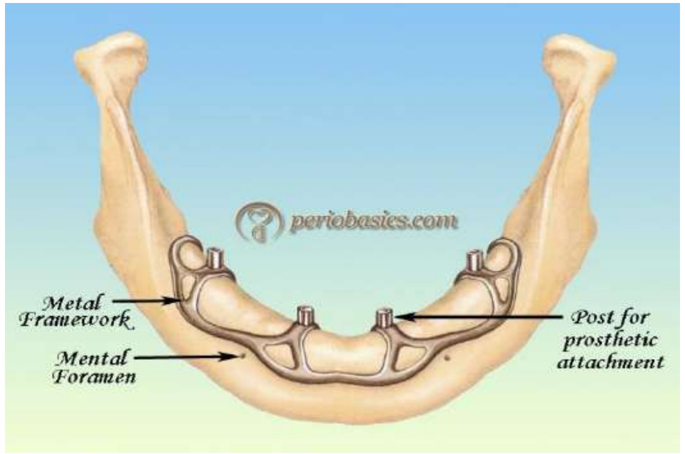
- In 1809, Maggiolo fabricated a gold implant wich was placed into fresh extraction socket
- In 1886 Edmunds implanted platinum disc into the jawbone and fixed porcelain crown
- In the early 1900s Lambotte fabricated implants with aluminum, silver, red copper, magnesium, gold and soft steel
- In the 1909 Greenfield made first iridoplatinum root design
- In 1938 Dr. Strock A.E. introduced Co-Ch-Mo alloy for implantology
- Boths first reported bone fusing to Titanium

Types of dental implant

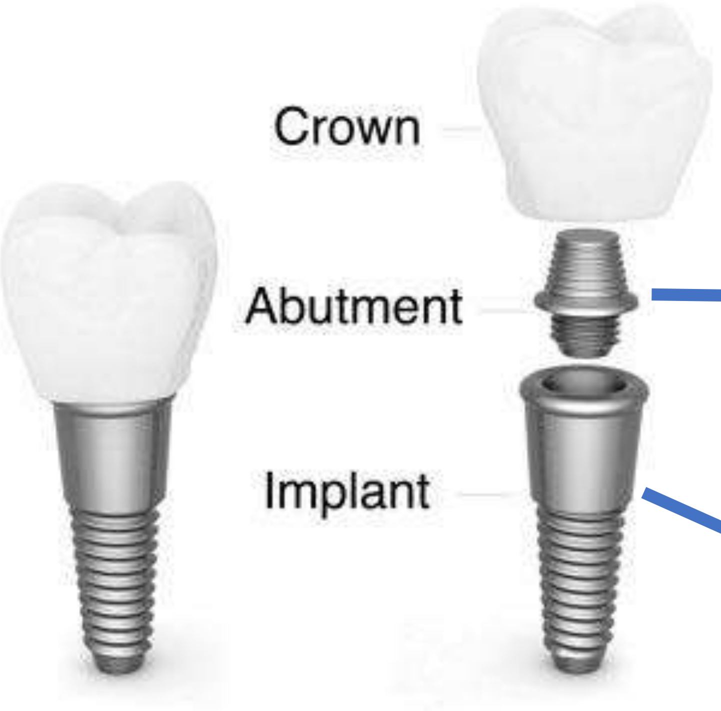
- **Subperiosteal implants**
- **Endosseous implants**
- **Transosseous implants**

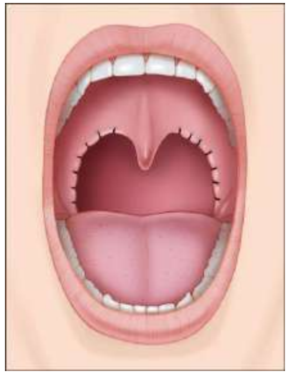


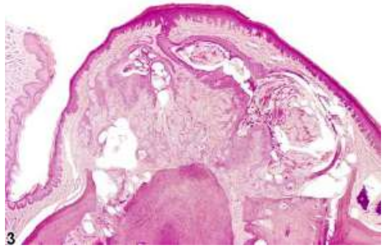


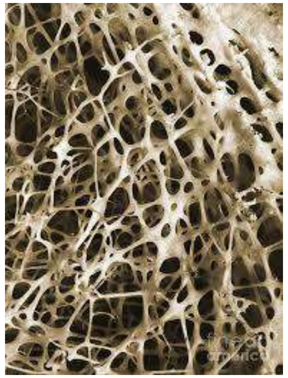


Structure of endosseus dental implant





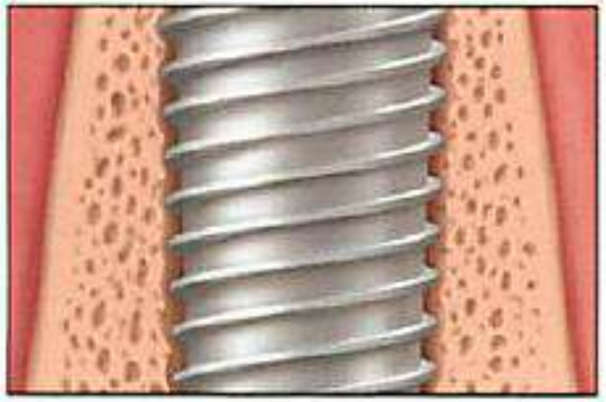


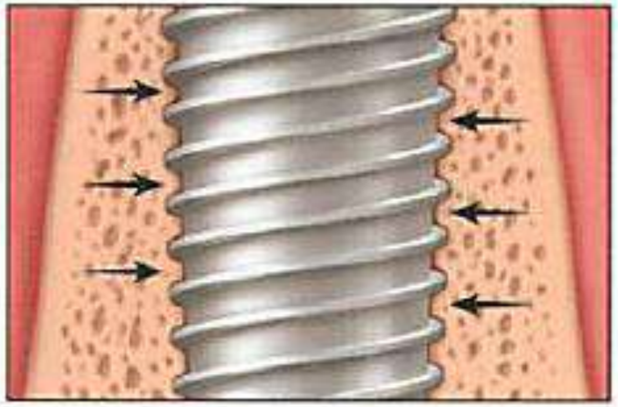


Osteointegration
Per-Ingvar Brånemark

Osteointegration – is a direct connection between living bone and a load-carrying endosseous implant at the light microscopic level.
Prof. Per-Ingvar Brånemark (1969)

The apparent direct attachment or connection of osseous tissue to an inert, alloplastic material without intervening connective tissue





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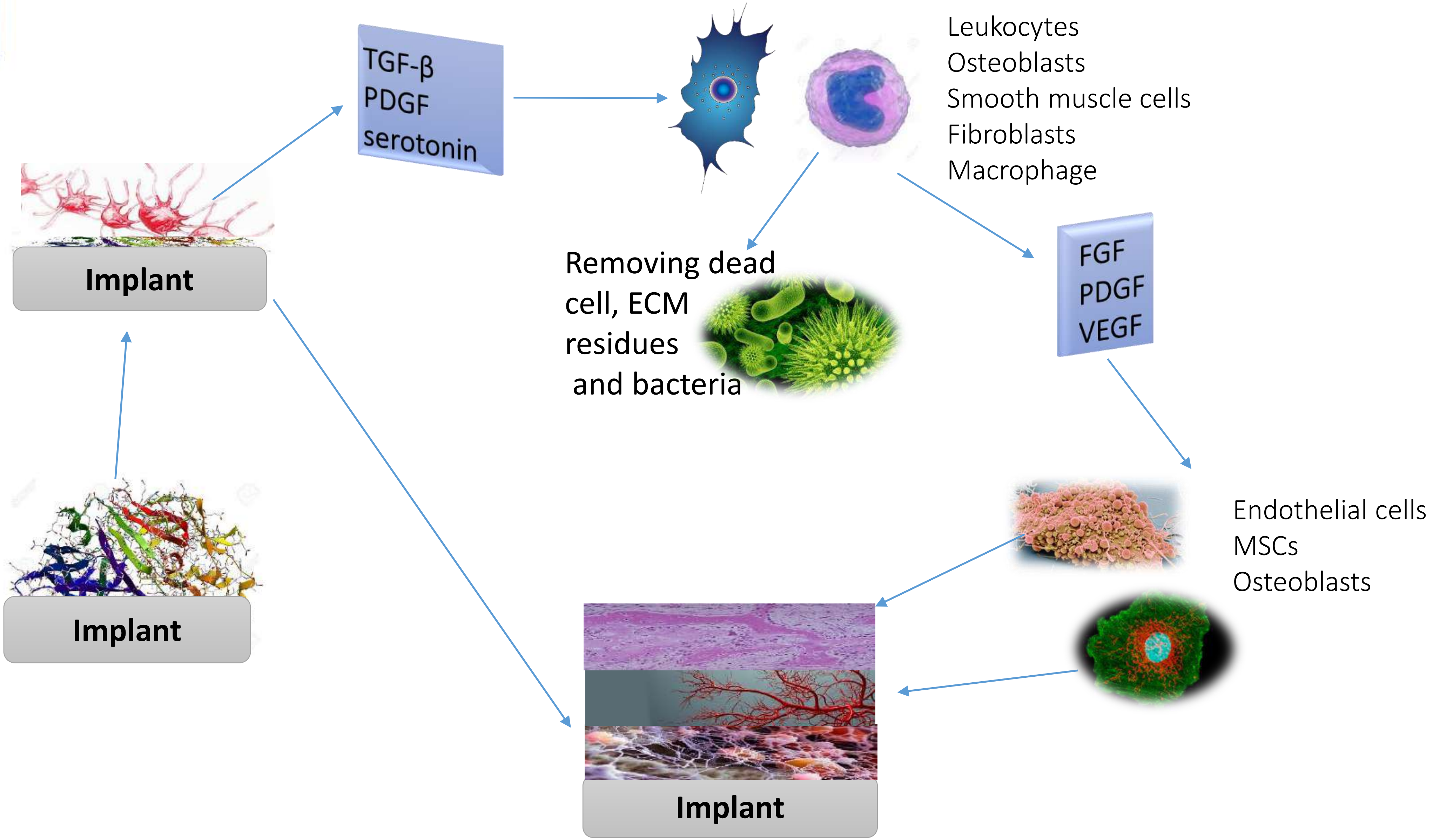
Mechanisms of osteointegration



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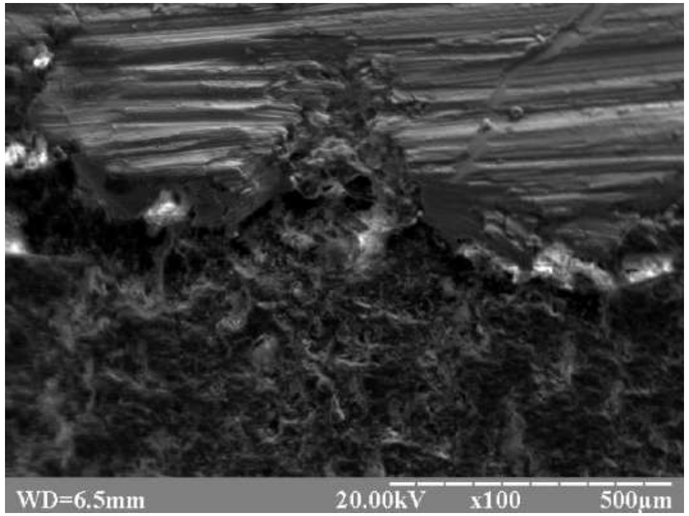
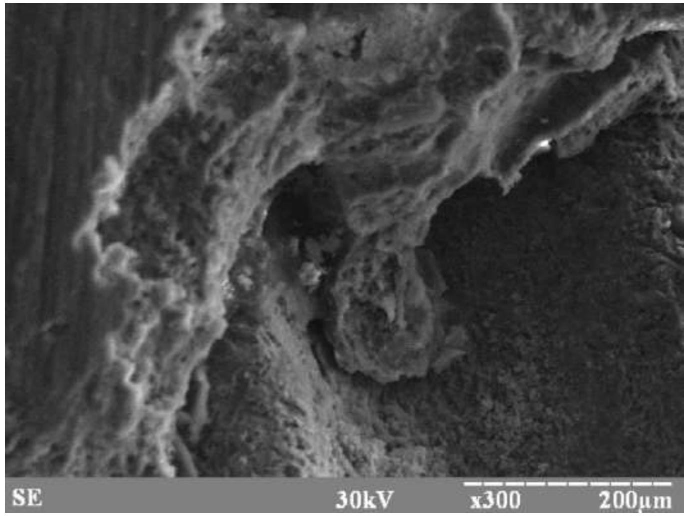
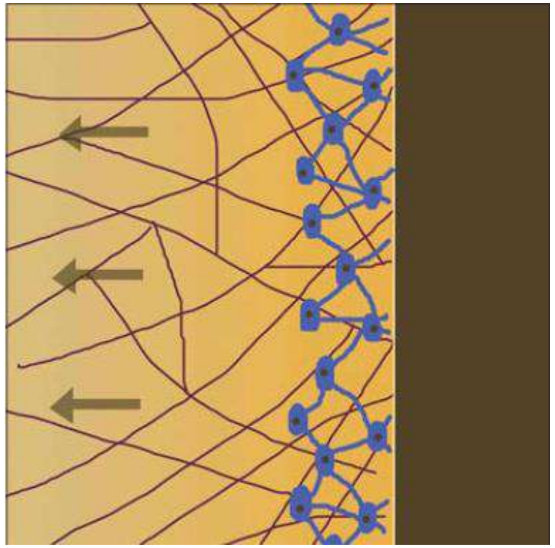
Mechanisms of osteointegration



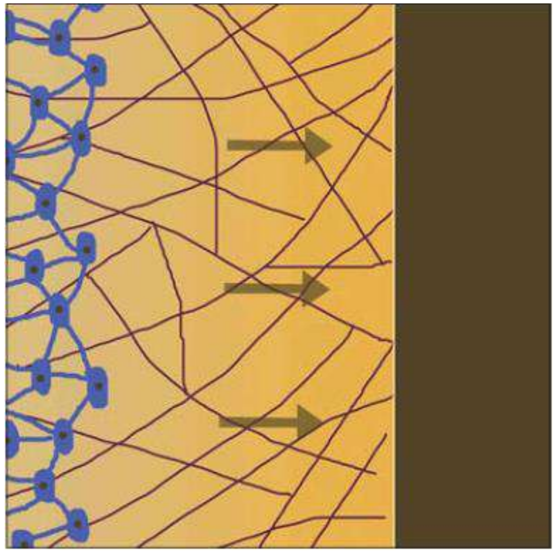
2 weeks



2 months



Contact osteointegration



Distant osteointegration

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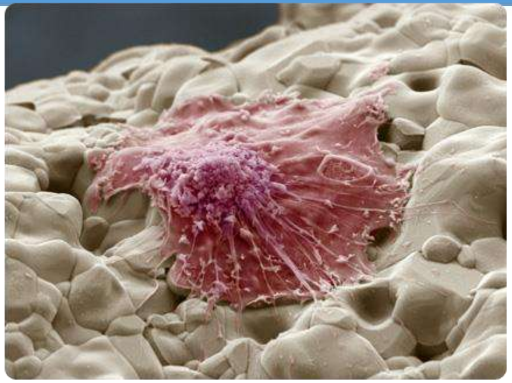
Implant surface. Why it's important?



RGD-Domain

Fibronectin, vitronectin, laminin, serum albumin, collagen, bone sialoprotein, osteopontin

Implant

Micro- and nano-topography

Physicochemical composition

Surface free energy

Micrometer roughness

- Sand-blasting
- Acid-etching
- Alkali-etching
- Plasma spraying
- Anodic oxidation

	S_a value	Degree of roughness	Gritblasted	Etched	Plasma sprayed	Electrochemically oxidized
Straumann TPS	>2.0 μm	Rough			x	
Straumann SLA	1.78 μm*	Moderately rough	x	x		
Straumann SLActive	1.75 μm*	Moderately rough	x			
Astra Tech TiOblast	1.1 μm*	Moderately rough	x			
Astra Tech Osseospeed	1.4 μm*	Moderately rough	x	x		
Dentsply: Ankylos/ Friadent/Xive/ Frialit	>2.0 μm	Rough	x	x		
Nobel Biocare: TiUnite	1.1 μm*	Moderately rough				x
Zimmer TSV MTX	Unknown	Unknown	x			
Zimmer TSV MP-1 HA	>2.0 μm	Rough	x			
Camlog	>1.1–2.0 μm	Moderately rough	x	x		
SPS Endopore	>2.0 μm	Rough				
Biomet Prevail (Ti-6Al-4V)	0.3 μm*	Smooth		x		
Biomet3i Osseotite	0.68 μm*	Minimally rough		x		

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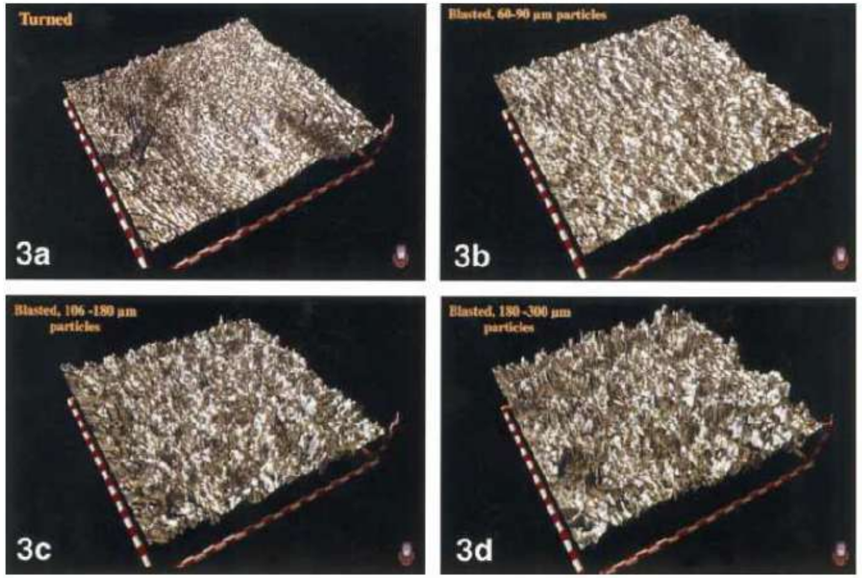
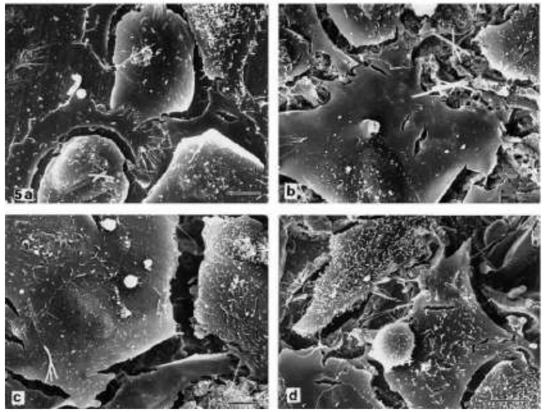
Micrometer roughness

Mustafa K, Wennerberg A, Wroblewski J, Hultenby K, Silva Lopez B, Arvidson K. Determining optimal surface roughness of TiO_2 blasted titanium implant material for attachment, proliferation and differentiation of cells derived from human mandibular alveolar bone
Clin. Oral Impl. Res. 12, 2001; 515–525

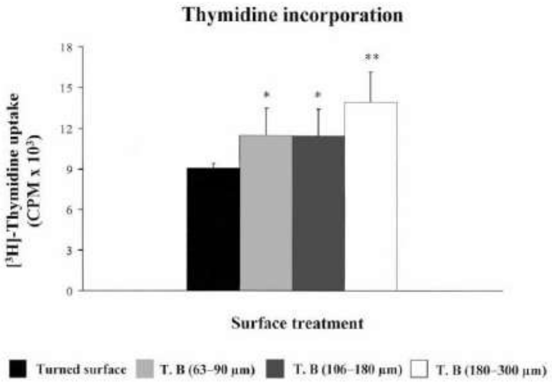
Table 1. The mean and standard deviation of three samples of each surface modification. Each sample was measured at three sites with a laser profilometer

Sample	S_a (SD) μm	S_{cx} (SD) μm	S_{dr} (SD) μm
Turned	0.20 (0.02)	9.81 (0.61)	1.06 (0.02)
Blasted 63–90 μm particles	0.72 (0.04)	14.20 (0.65)	1.32 (0.02)
Blasted 106–180 μm particles	1.30 (0.11)	15.48 (0.71)	1.69 (0.07)
Blasted 180–300 μm particles	1.38 (0.14)	15.73 (0.78)	1.76 (0.07)

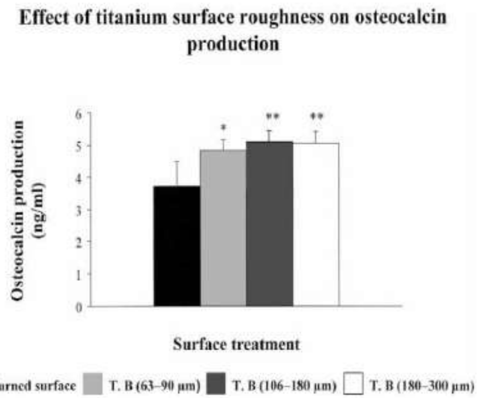




Cell attachment



Cell proliferation



Osteocalcin production

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Micrometer roughness

Dental Materials Journal 2011; 30(2): 183–192

Sandblasted-acid-etched titanium surface influences *in vitro* the biological behavior of SaOS-2 human osteoblast-like cells

Luca RAMAGLIA[1], Loredana POSTIGLIONE[2], Gaetano DI SPIGNA[2], Gabriele CAPECE[1], Salvatore SALZANO[3] and Guido ROSSI[2]

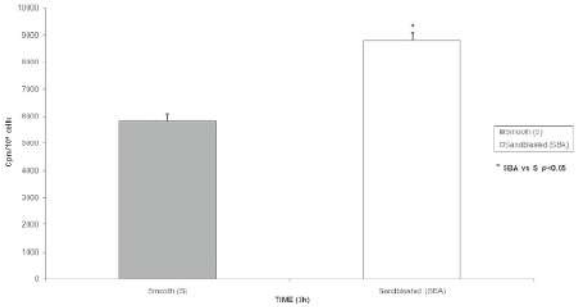


Fig. 3 Cell attachment assay (mean±SD, n=12) of SaOS-2 cells on the experimental titanium surfaces, smooth (S) and sandblasted-acid-etched (SBA), *(SBA vs S p<0.05).

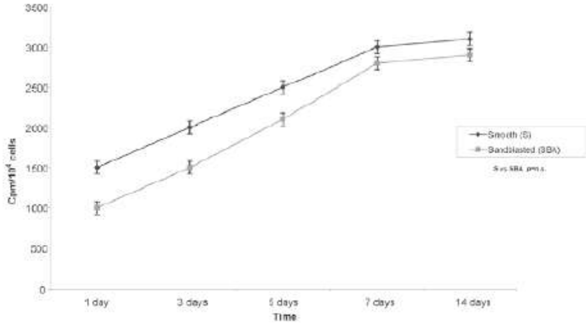
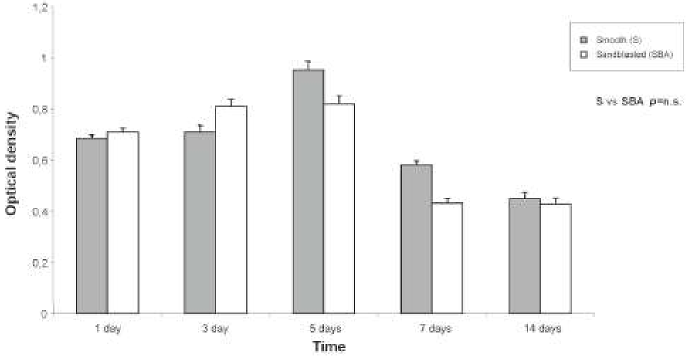


Fig. 2 Cell proliferation curves (mean±SD, n=12) of SaOS-2 cells on the experimental titanium surfaces, smooth (S) and sandblasted-acid-etched (SBA).

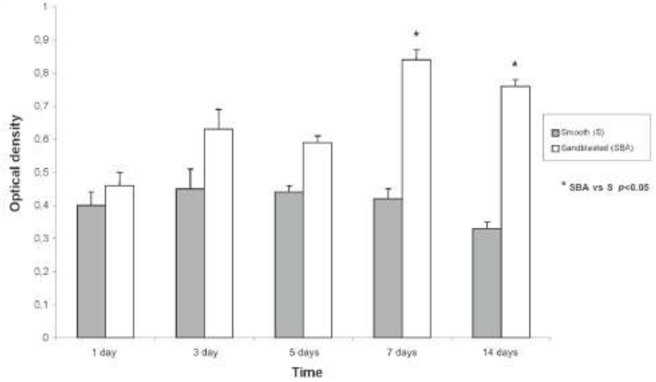
(a)

SYNTHESIS OF FIBRONECTIN



(c)

SYNTHESIS OF TYPE 1 COLLAGEN



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Micrometer roughness

In vitro MC3T3 osteoblast adhesion with respect to surface roughness of Ti6Al4V substrates

P. Linez-Bataillon[a,*], F. Monchau[a], M. Bigerelle[b], H.F. Hildebrand[a]

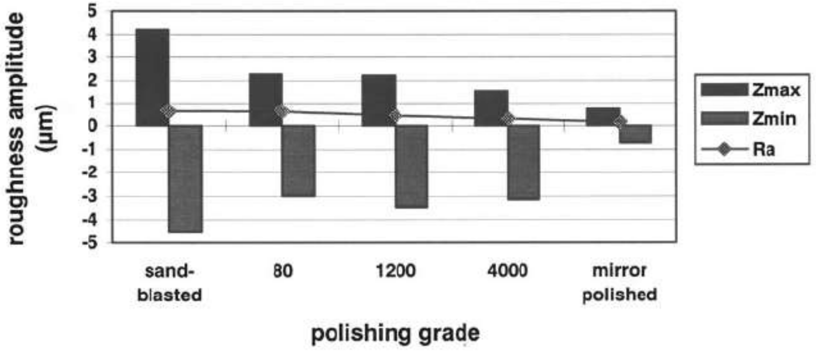
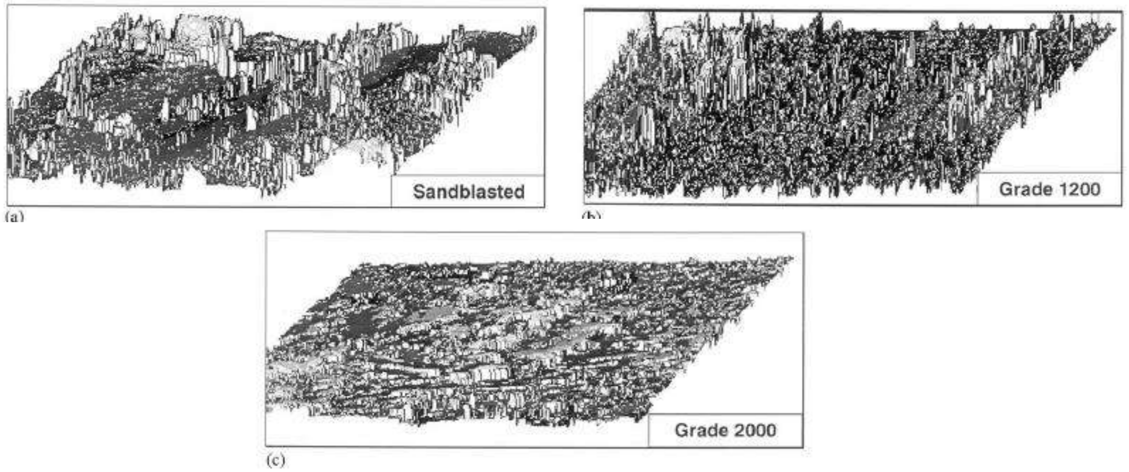
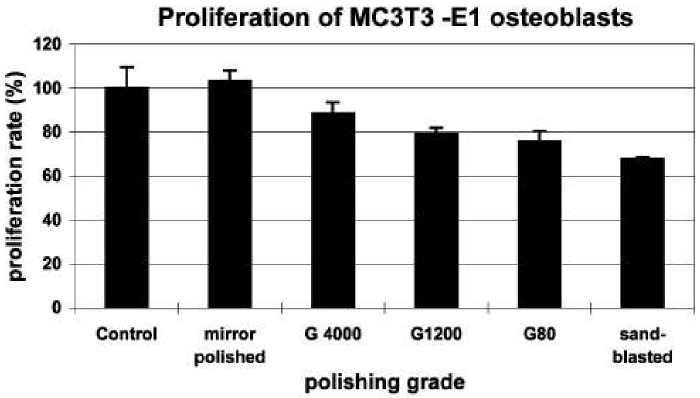
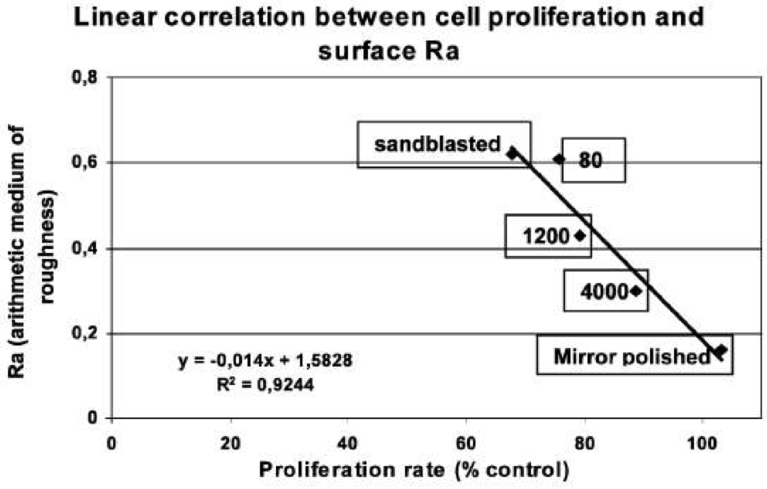


Fig. 2. Medium principal roughness parameters of each grade.







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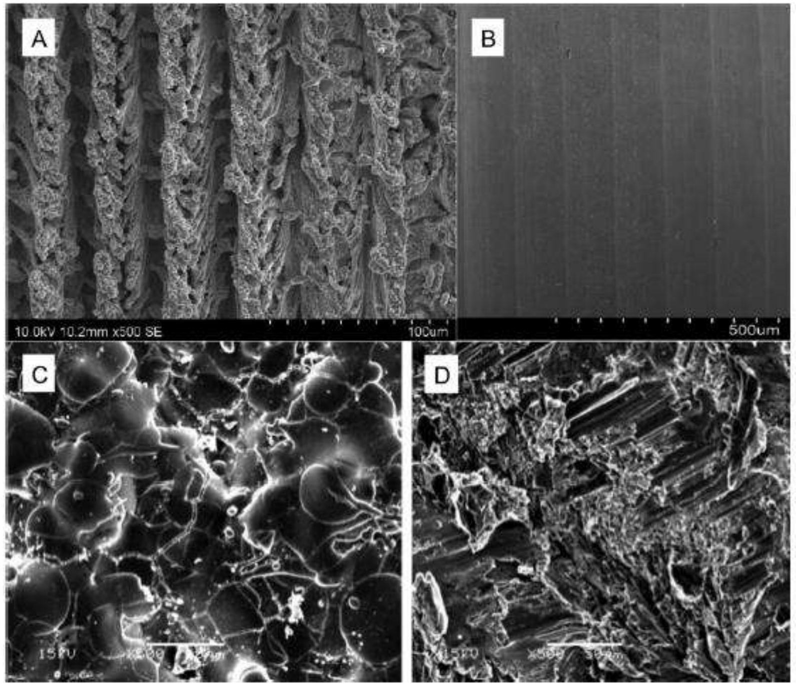
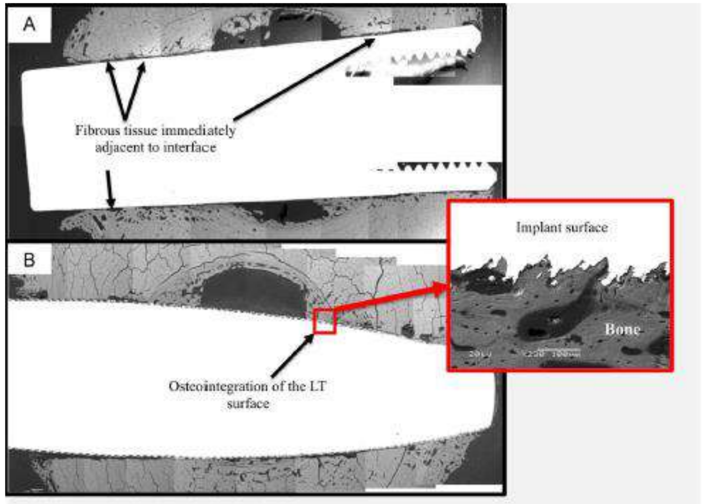
Nanometer roughness

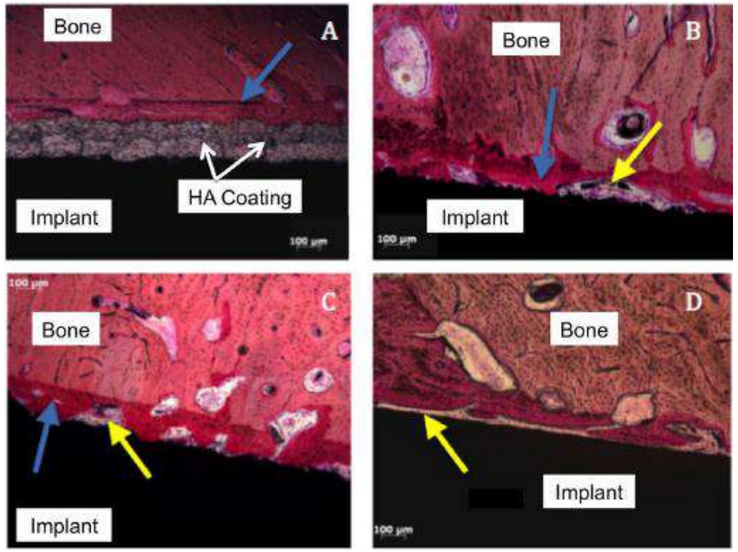
Controlled Laser Texturing of Titanium Results in Reliable Osteointegration[†]

Melanie J Coathup BSc, PhD[1*], Gordon W Blunn BSc, PhD[1], Nazanin Mirhosseini BSc, PhD[2], Karen Erskine BSc, MBBS[1], Zhu Liu BSc, PhD[3], David R Garrod MA, PhD, FRSA[4], Lin Li BSc, PhD, FREng[2]





Laser Texturing (LT)
Machine-finished (MF)
Grit-blasted (GB)
HA-coated (HA)



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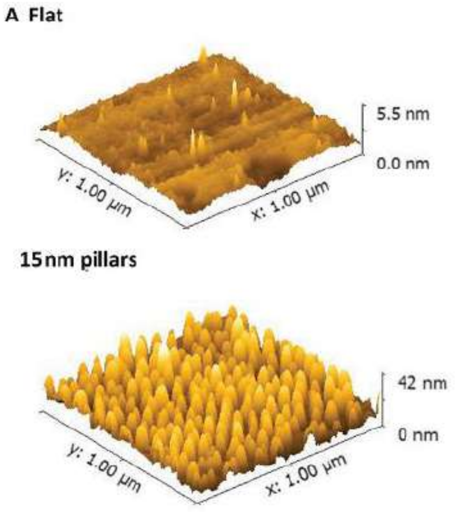
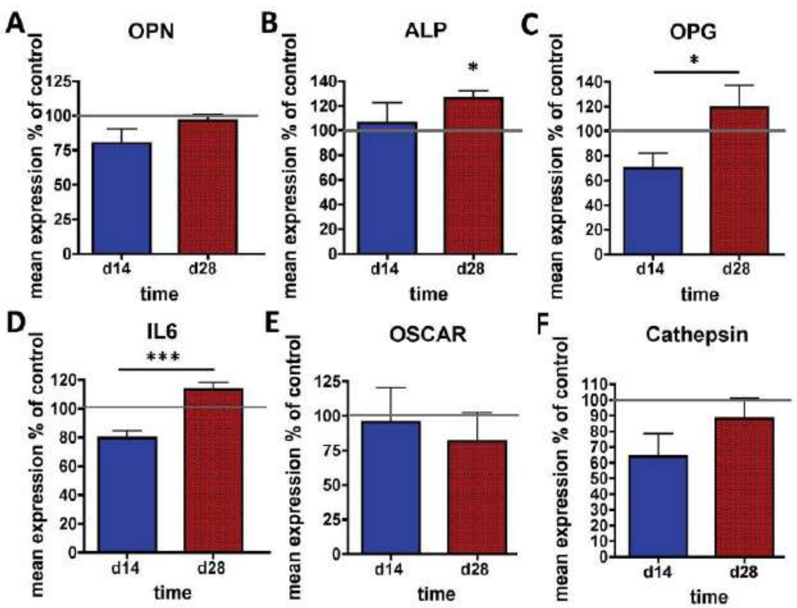
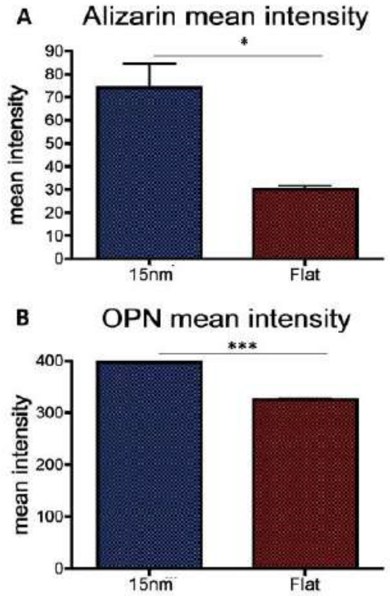
Nanometer roughness

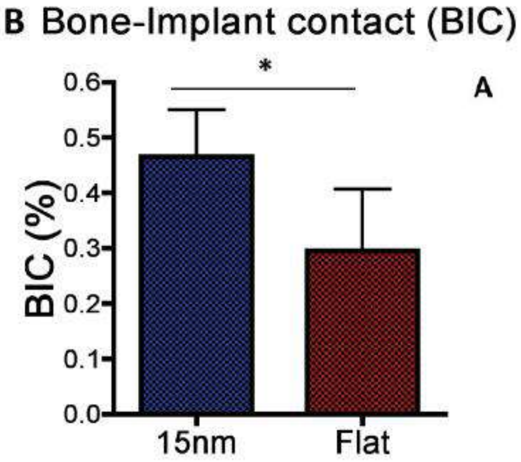
Analysis of Osteoclastogenesis/Osteoblastogenesis on Nanotopographical Titania Surfaces

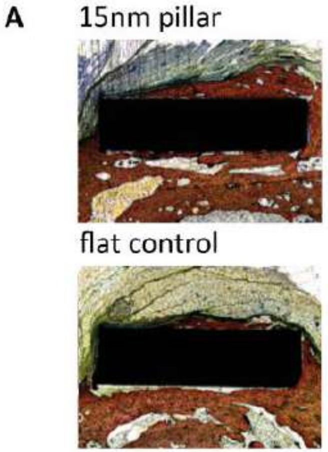
*Robert K. Silverwood, Paul G. Fairhurst, Terje Sjöström, Findlay Welsh, Yuxin Sun, Gang Li, Bin Yu, Peter S. Young, Bo Su, Robert M. D. Meek, Matthew J. Dalby, and Penelope M. Tsimbouri**











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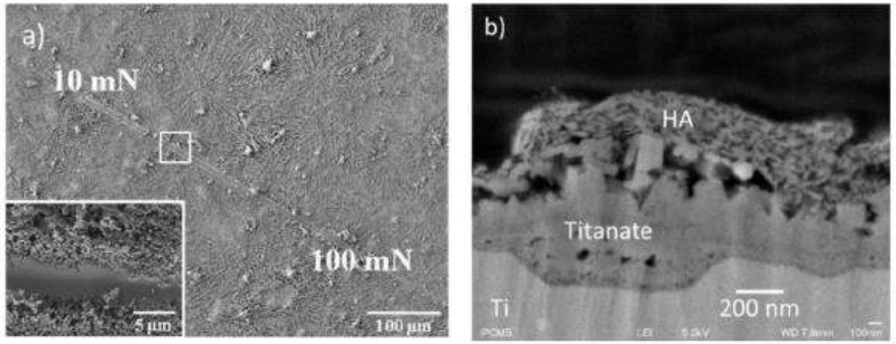
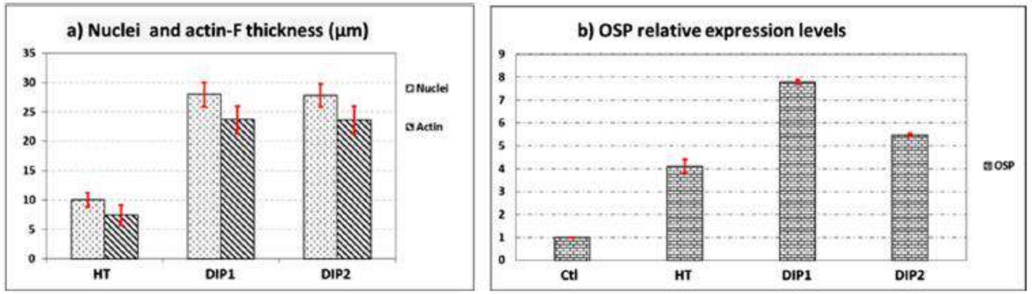
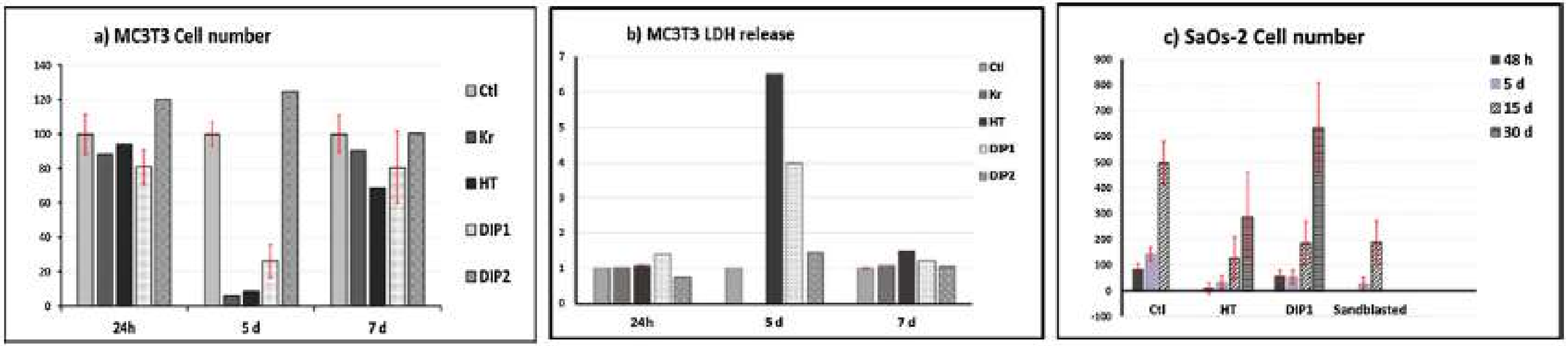
Nanometer roughness

Nanoporous hydroxyapatite/sodium titanate bilayer on titanium implants for improved osteointegration

A. Carradò[a,*], F. Perrin-Schmitt[b,d,**], Q.V. Le[a], M. Giraudel[a], C. Fischer[b], G. Koenig[b], L. Jacomine[c], L. Behr[e], A. Chalom[e], L. Fiette[e], A. Morlet[e], G. Pourroy[a,*]







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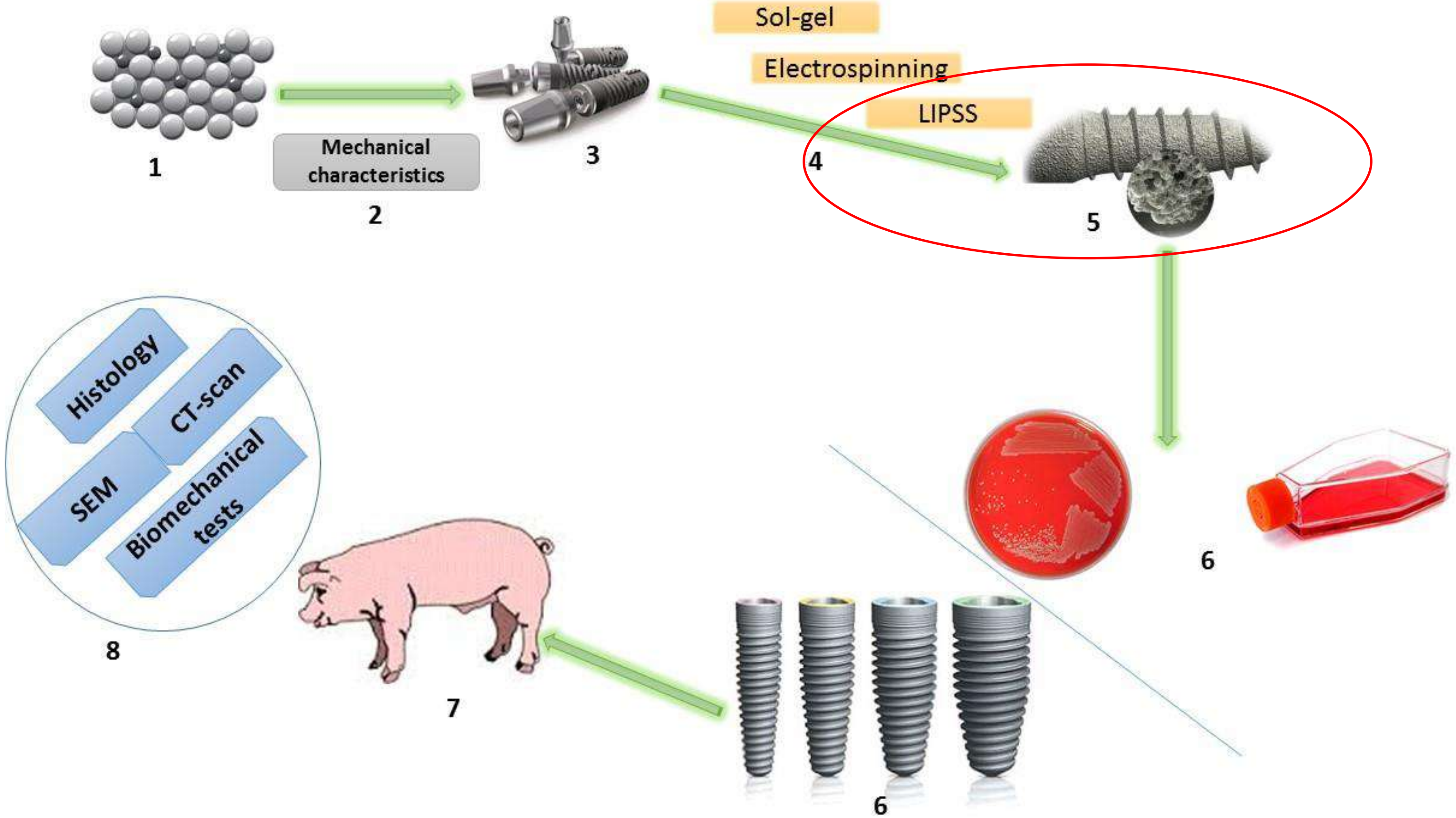
Our results

H2020 project 777926
“Nanostructural surface development for dental implant manufacturing”

Regional Poland projects
“Development and commercialization of innovative dental implants with advances osteoinductive properties”

H2020 project 777926
"Nanostructural surface development for dental implant manufacturing"



Metal alloy (1) will be development and tested (2) to produce dental implants (3) that will modified using different methods (4) to obtain new nanostructures surface (5). Cell culture and bacteriological methods (6). Selected samples with modified surface (6) will implanted to pigs (7) and evaluated (8) in different time-points.

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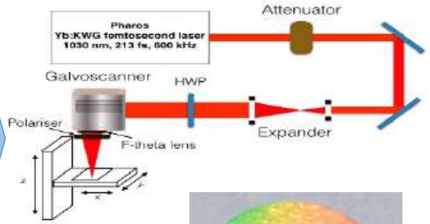
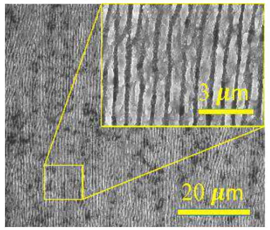
LIPSS treatment

Ti

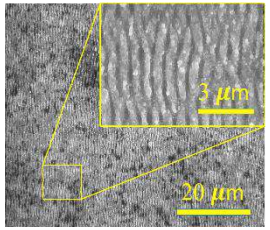
Zr





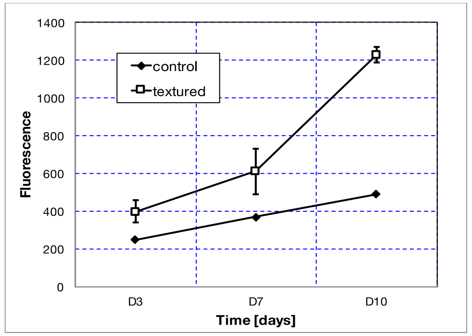
Ti

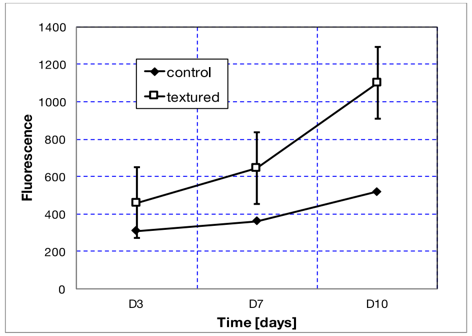
Zr



Roughness parameters, μm	Polished Ti6Al4V	Polished Zr	LIPSS, Ti6Al4V	LIPSS, Zr
Ra	0.006	0.007	0.131	0.148
Rz	0.013	0.017	0.316	0.386

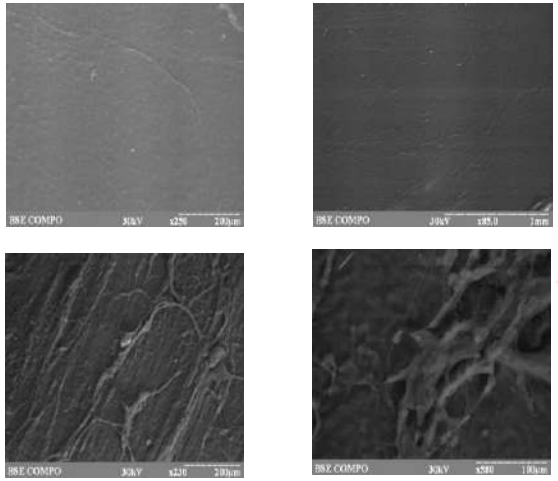
Cell culture (HDFa), 10^4





Ti

Zr

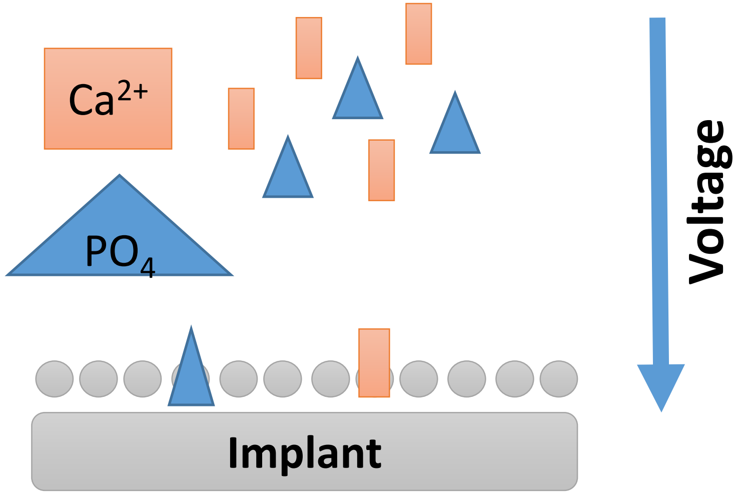


Ti

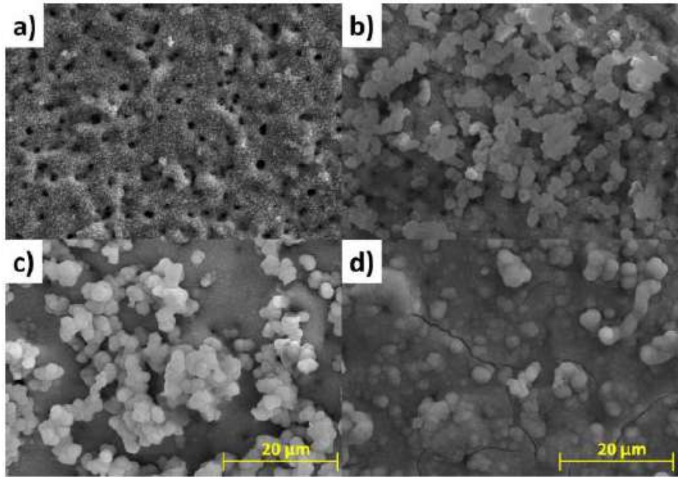
Zr

Plasma electrolytic oxidation

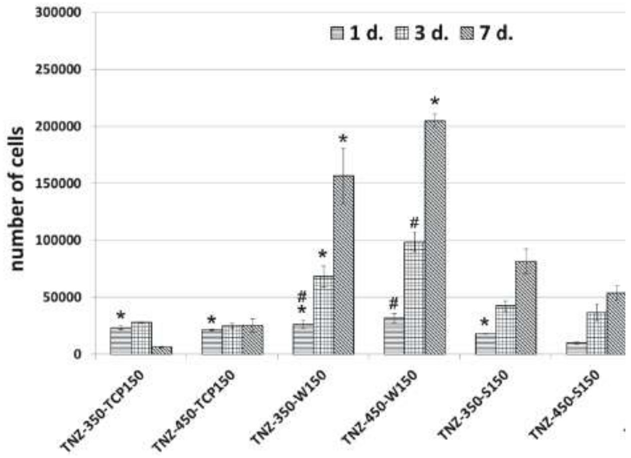
sample no	bath composition				voltage, V	wettability, deg
	$Ca(H_2PO_2)_2$ mol/dm^3	$Ca_3(PO_4)_2$ g/dm^3	$CaSiO_3$ g/dm^3	SiO_2 g/dm^3		
TNZ-350-TCP150	0.1	50	-	-	350	73±7
TNZ-450-TCP150					450	strongly hydrophilic
TNZ-350-W150		-	50		350	61±6
TNZ-450-W150					450	85±5
TNZ-350-S150				50	350	23±4
TNZ-450-S150					450	31±5
Ti-13Nb-13Zr	-				-	120±5



First Results



SBF Ca absorption



MG-63 cell culture

Prof. Simka et al., 2015

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What next?
Perspectives

- **It is not define ideal surface**
- **Method of treatment?**
- **Need surface functionalization**
- **Need increase biological properties**
- **NO clinical evidence**


Lets do
Science!