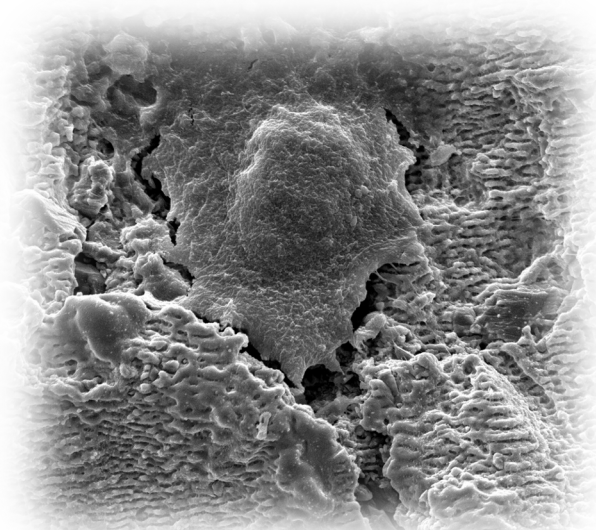




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Biological effect of silver nanoparticles in PEO coating

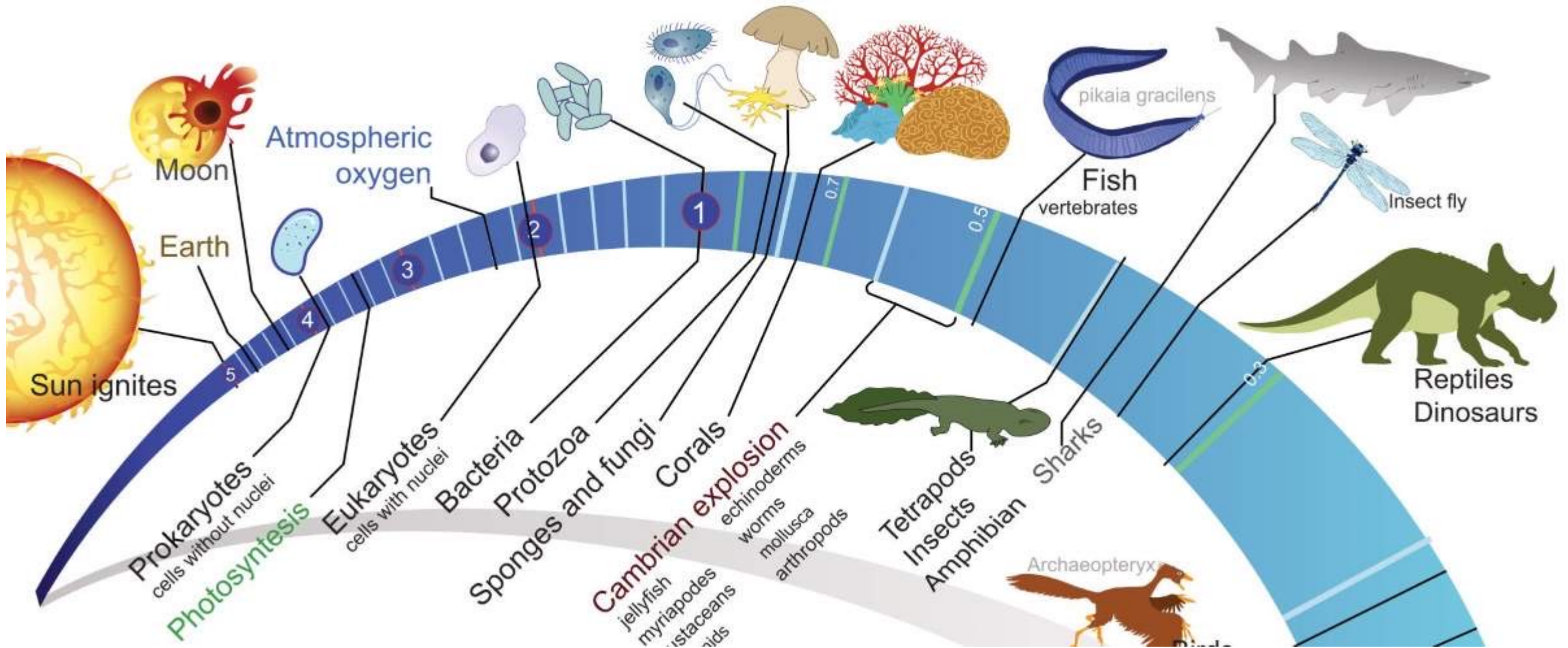


mag = WD spot det HFW 5/15/2019 10 µm

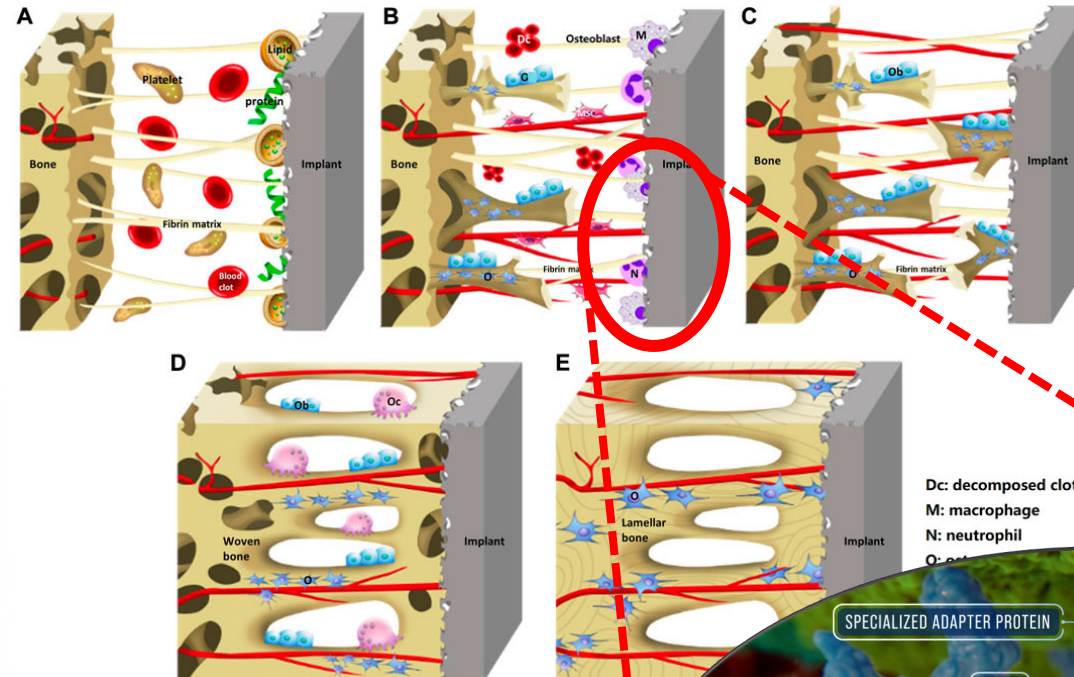
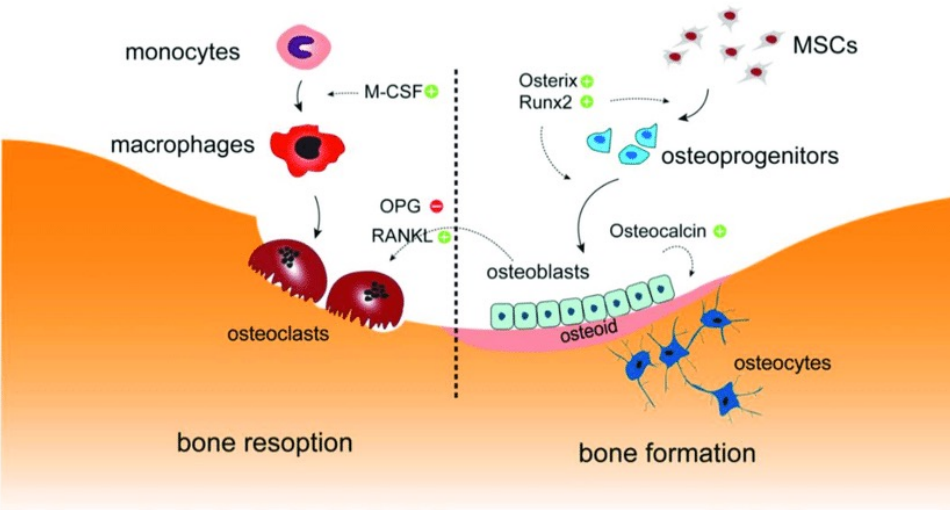


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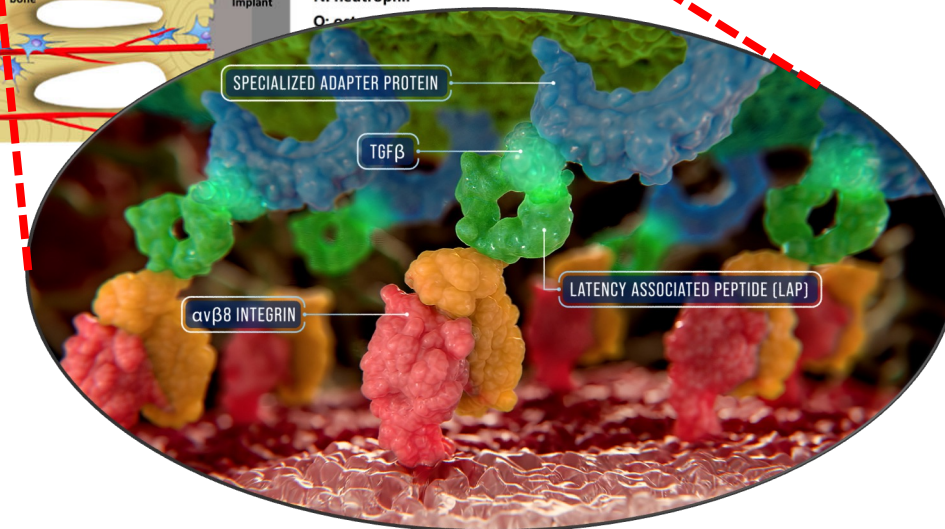
Implant-tissue interface



Bone-implant integration

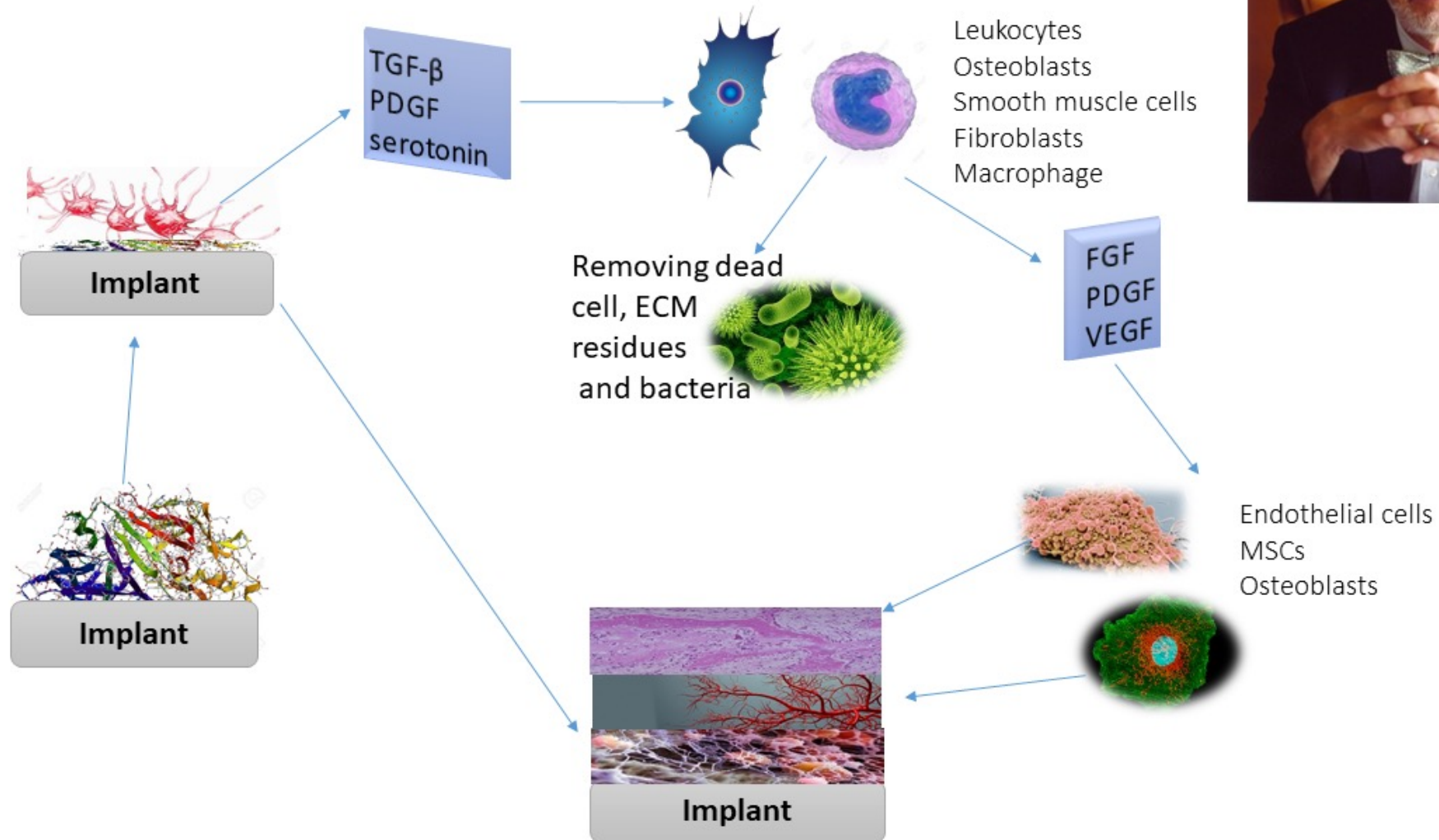


<https://doi.org/10.3389/fbioe.2022.981062>



DOI: [10.3390/ijms22031325](https://doi.org/10.3390/ijms22031325)

What happens after the implantation?



Clinical outcomes

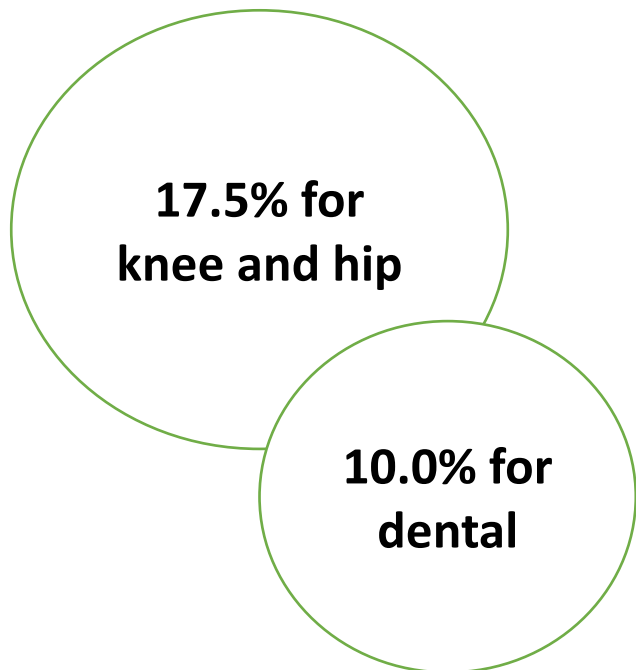
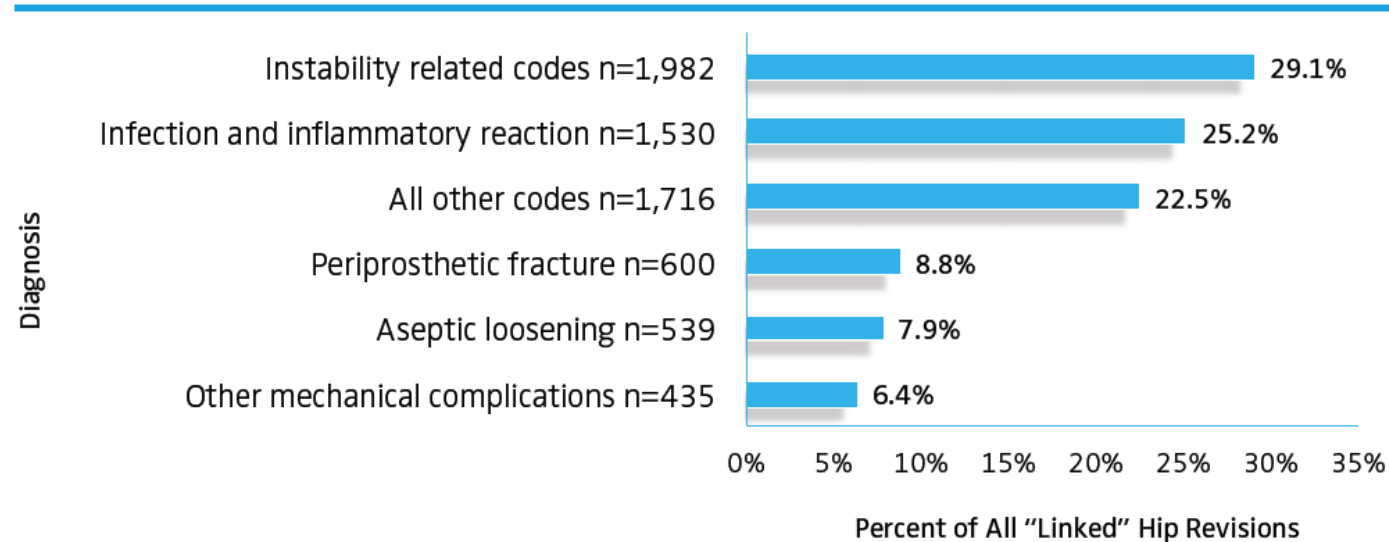
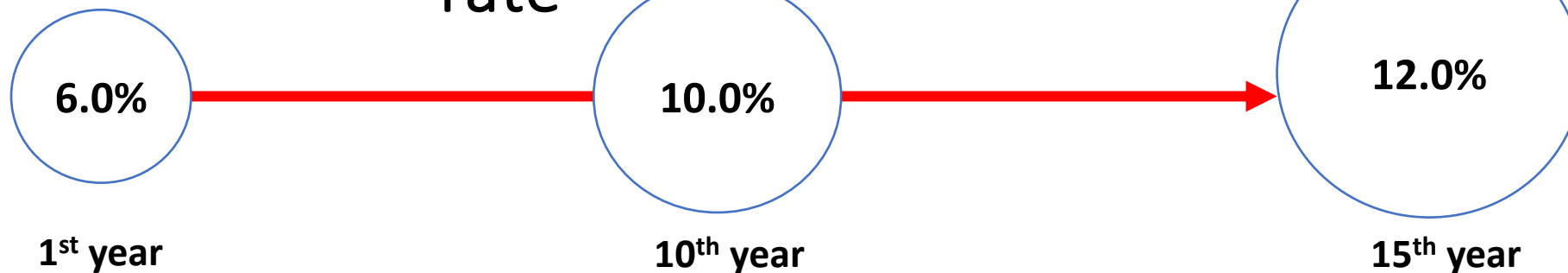


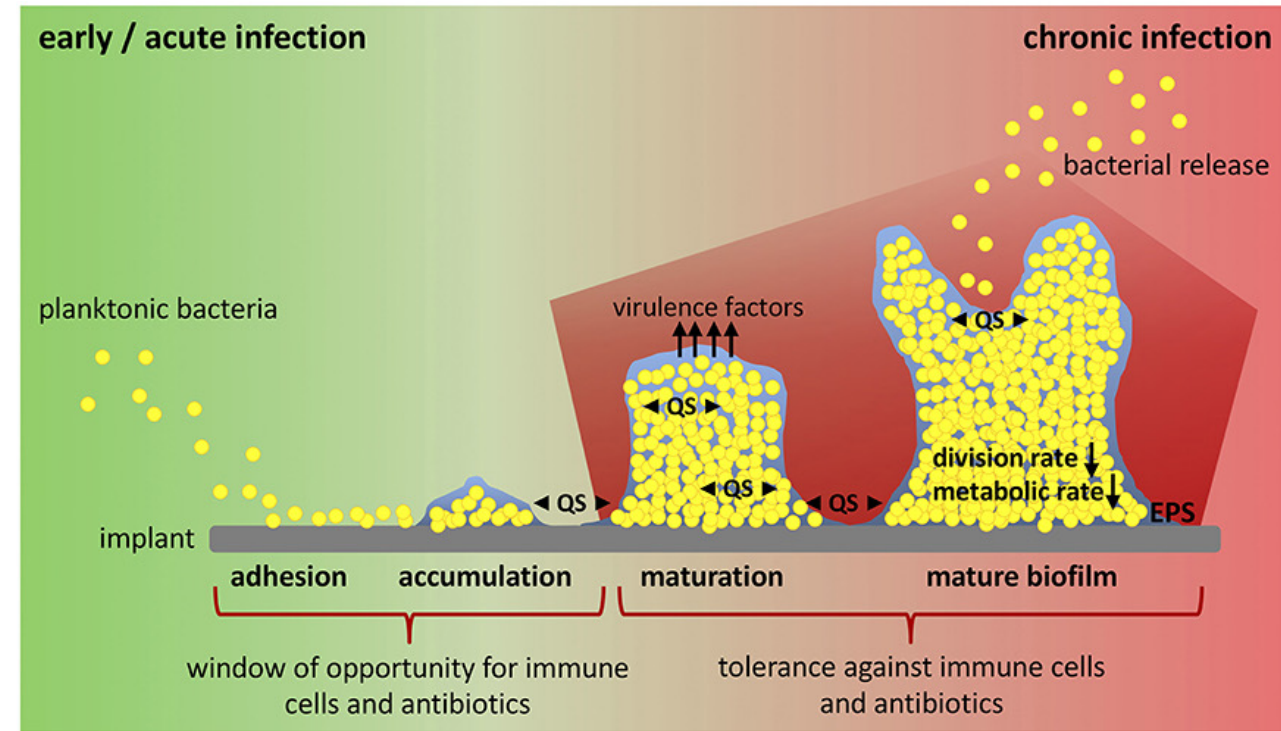
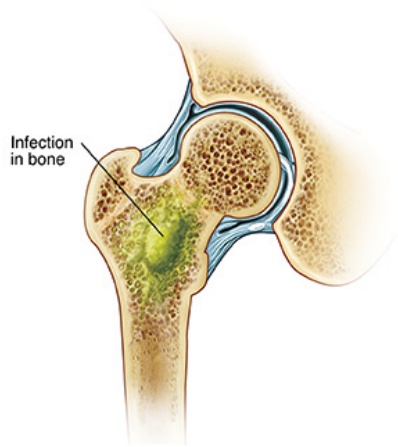
Figure 32: ICD Diagnosis Codes for "Linked" Hip Revisions (N=8,245)



Dental implant lost rate



Implant infection

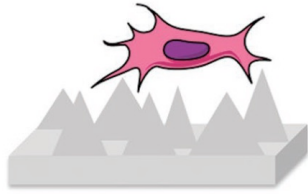


<https://doi.org/10.3389/fimmu.2019.01724>

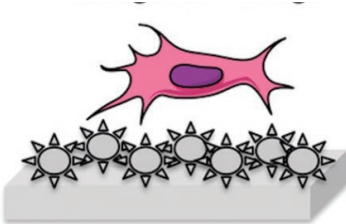
Strategies for surface modification

Improvement of osteointegration

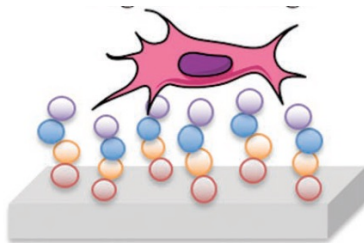
Physical modification



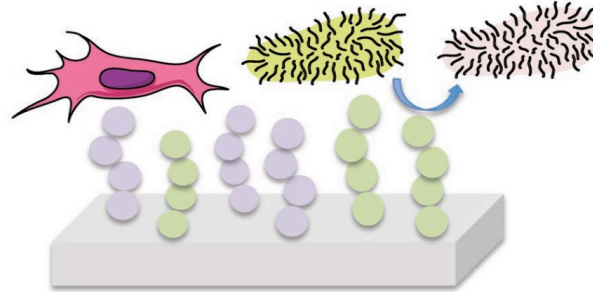
Inorganic coating



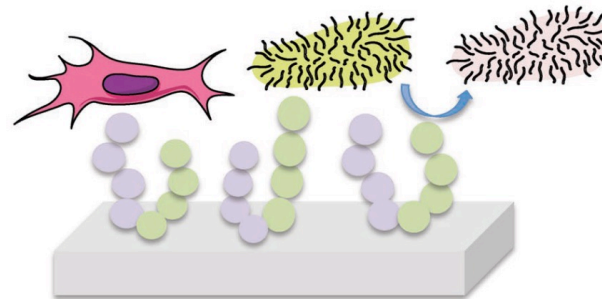
Organic coating



Complex strategies

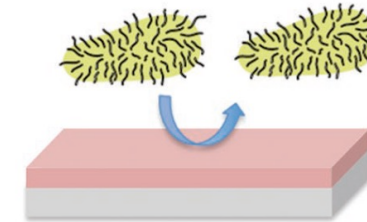


Peptide mixture

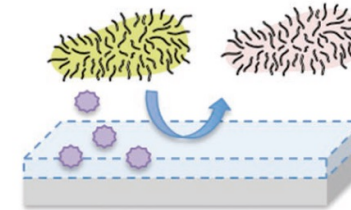


Peptide platforms

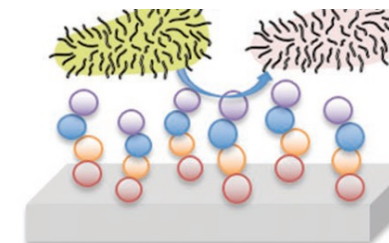
Inhibit bacterial infection



Passive coating



Drug releasing

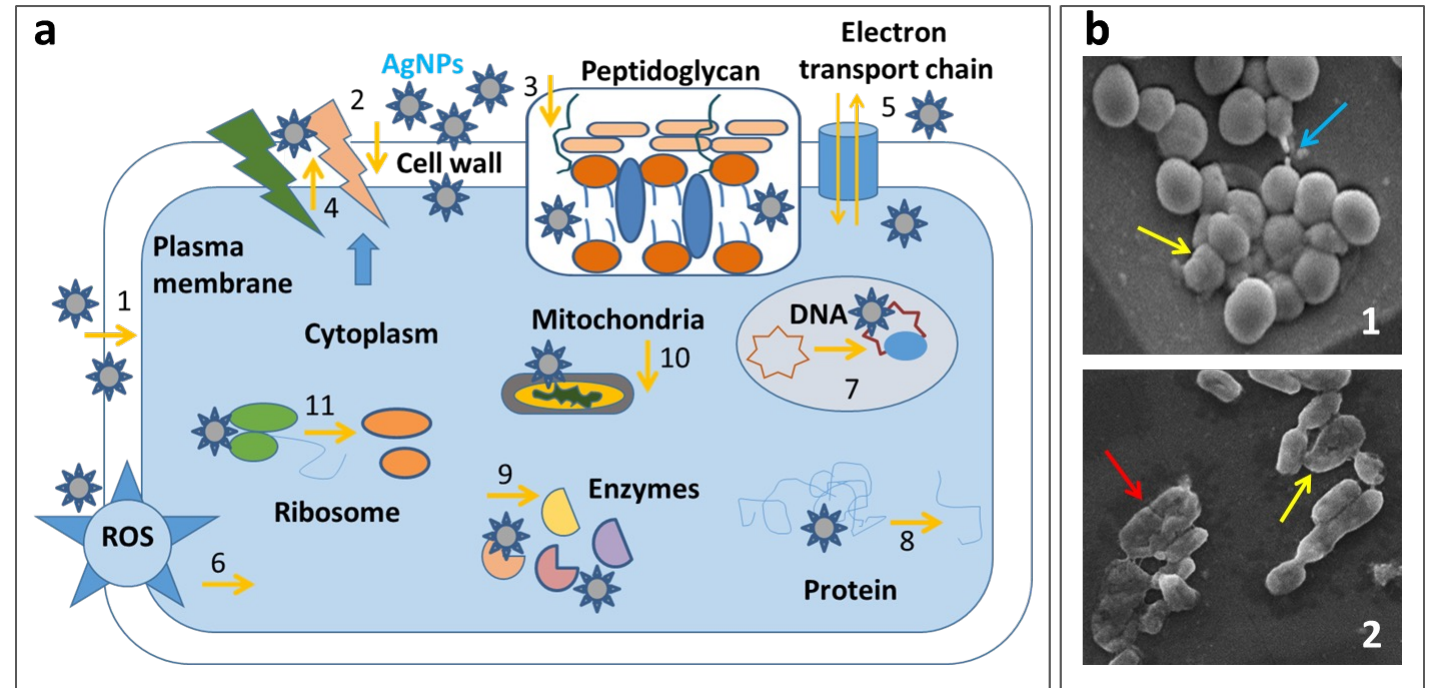
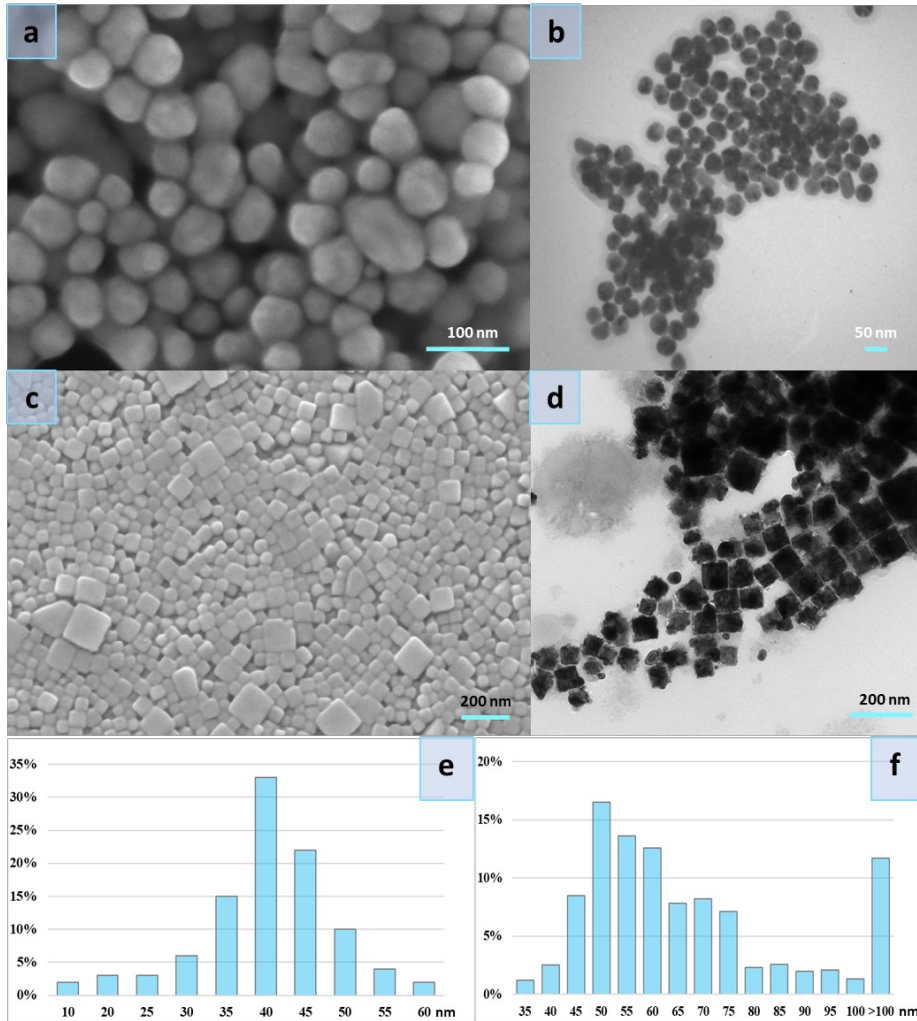


Drug immobilizing

Active coatings

Chemical modification

Silver nanoparticles



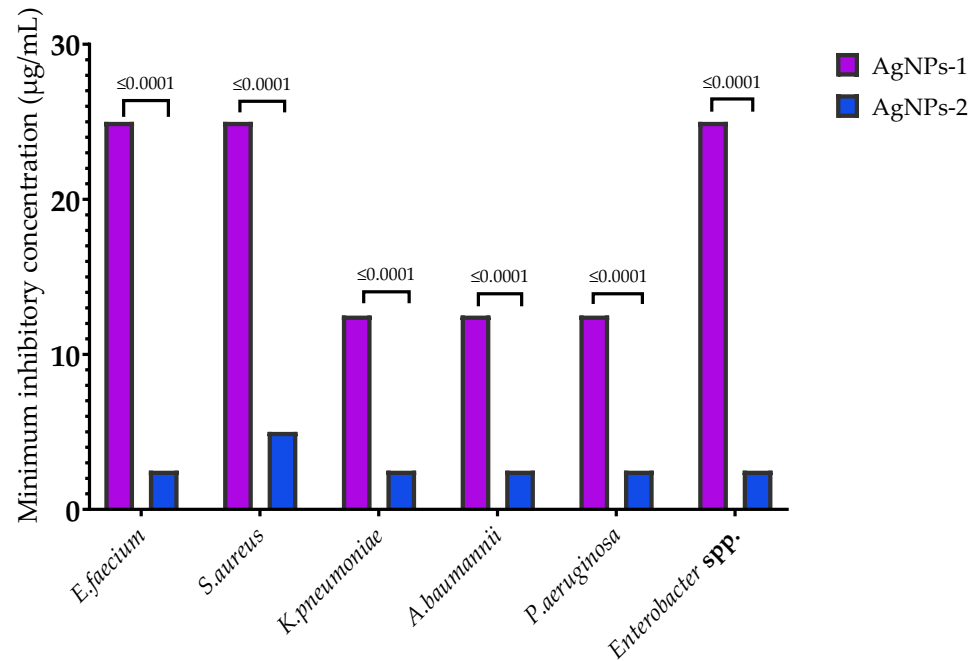
Korniienko V, et al. Applied Nanoscience, Volume 12, Issue 4, p.1061-1070 <https://doi.org/10.1007/s13204-021-01808-5>

Silver ions release

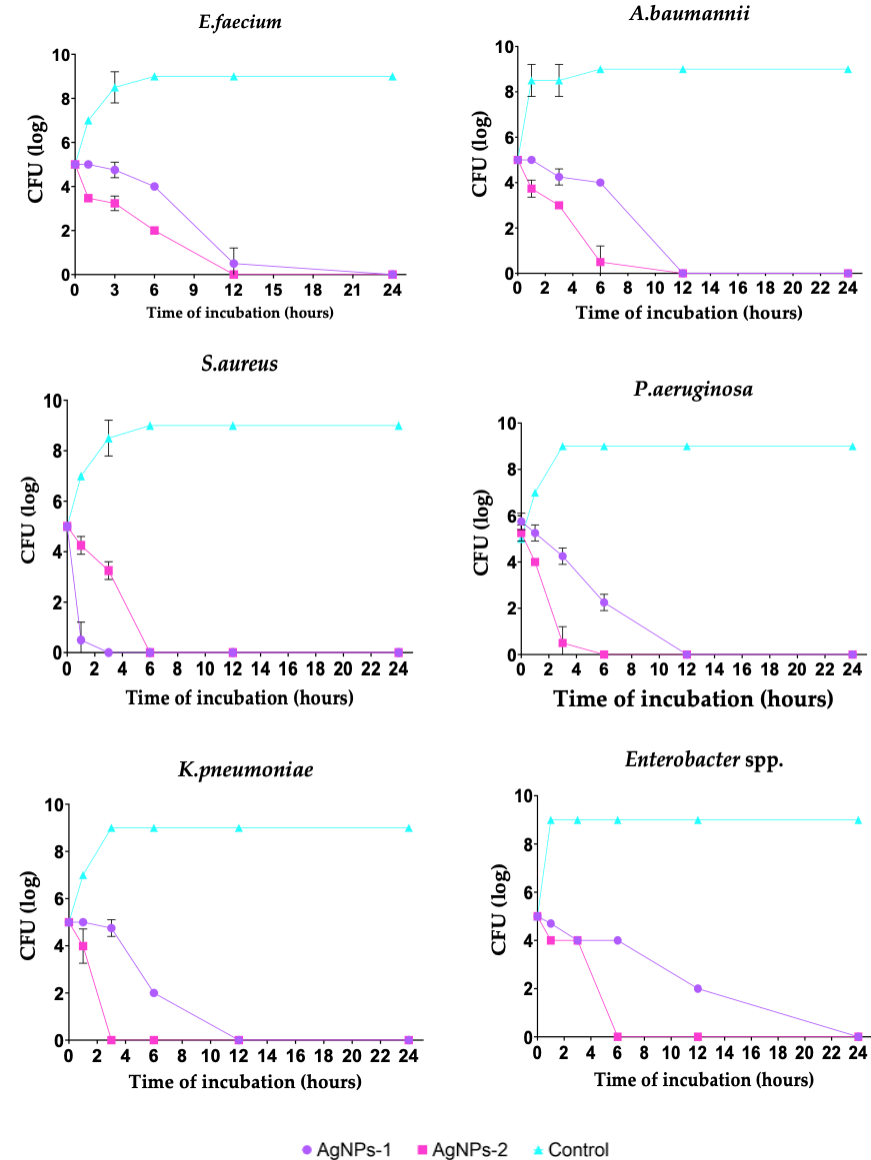
	AgNPs-1		AgNPs-2	
	µg/mL	%	µg/mL	%
Silver content in the working solution	129.0	-	194.7	-
The content of silver ions in the supernatant on the first day after preparation	2.3	1.7	19.7	10.1
The content of silver ions in the supernatant on the second day after preparation	1.1	0.85	25.7	13.1

AgNPs antibacterial effects

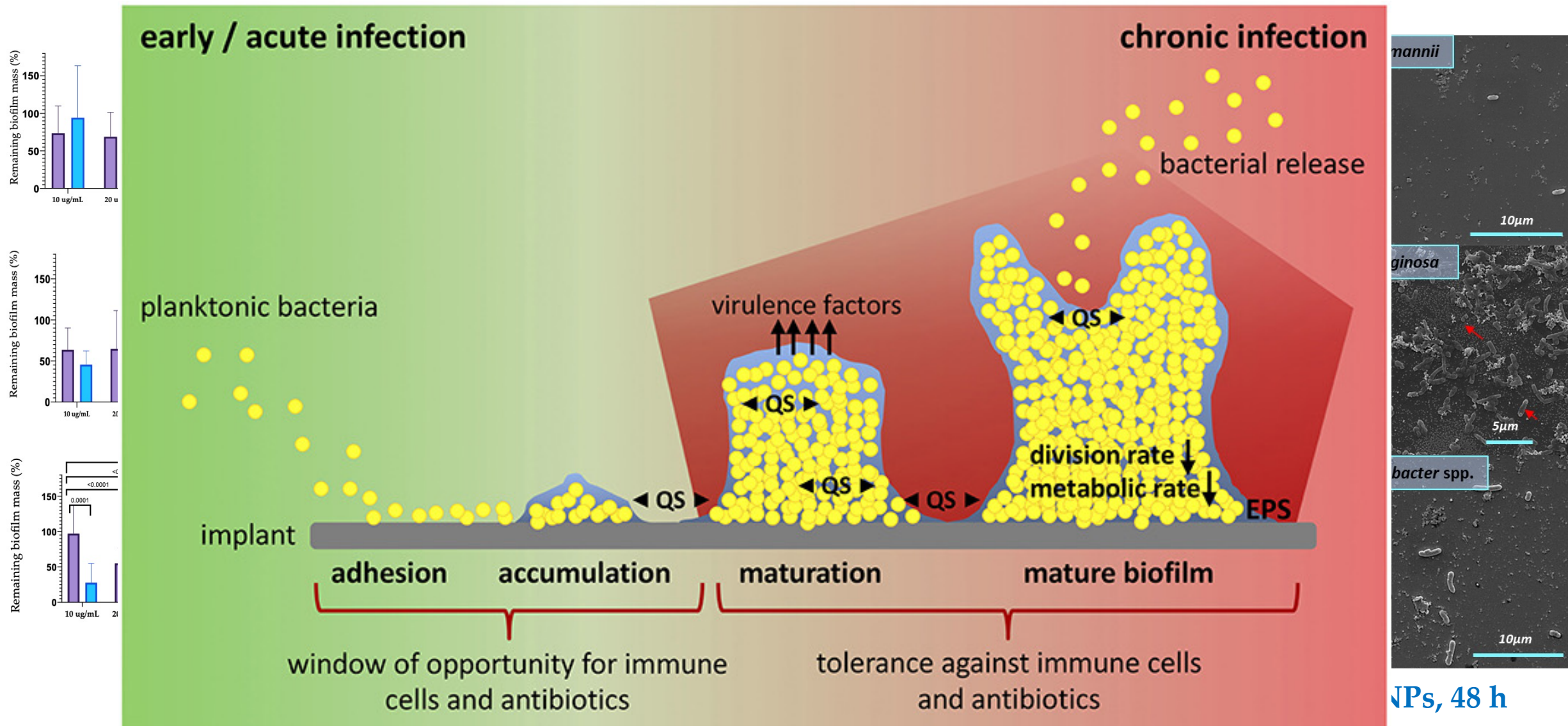
Minimum inhibitory concentration



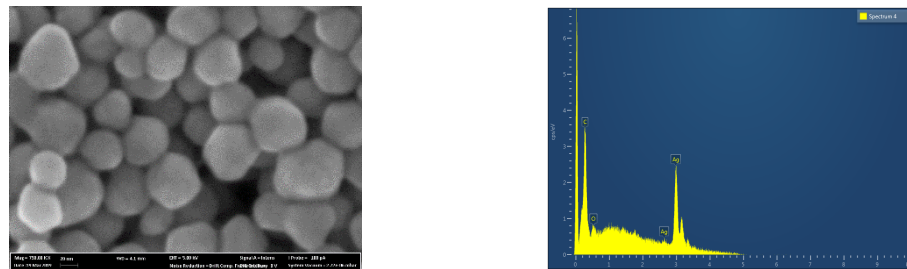
Time dependent bactericidal activity



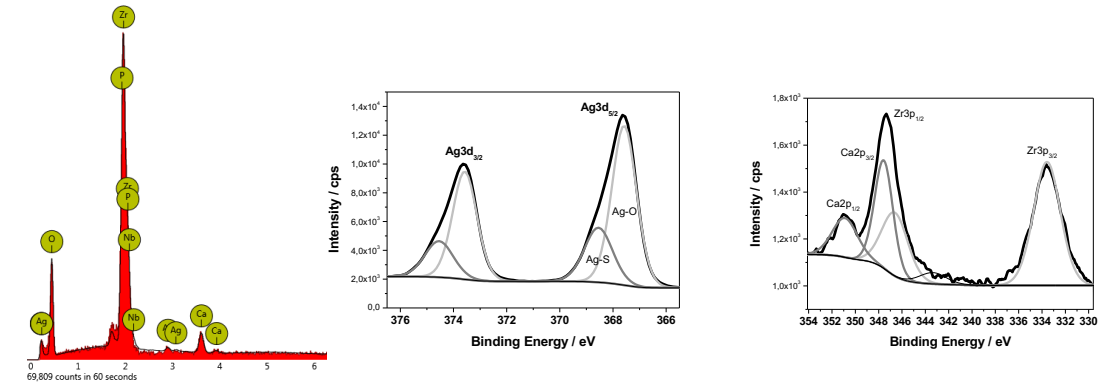
AgNPs antibiofilm effects



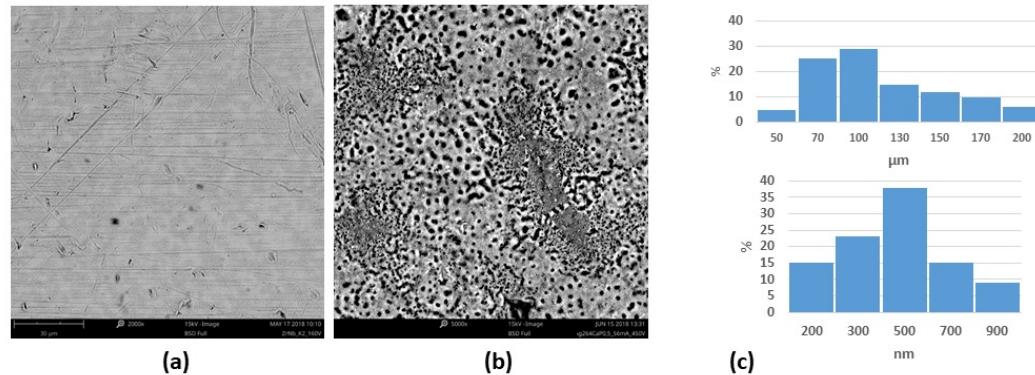
Ag Nanoparticle-Decorated PEO coating of ZrNb Alloy



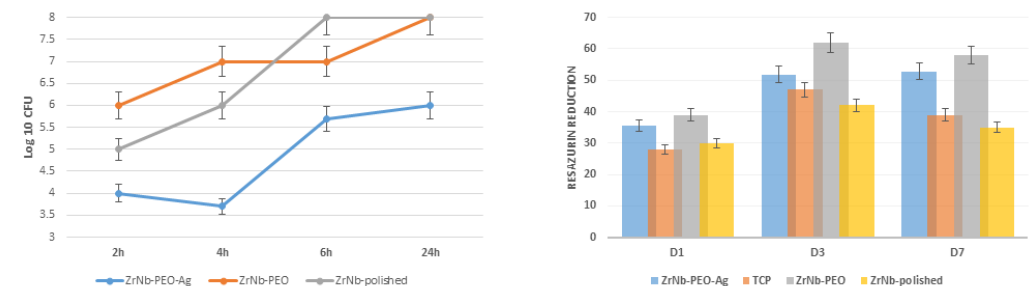
SEM image (a) and EDX spectra (b) of Ag nanoparticles



EDX and XPS of anodizing surface

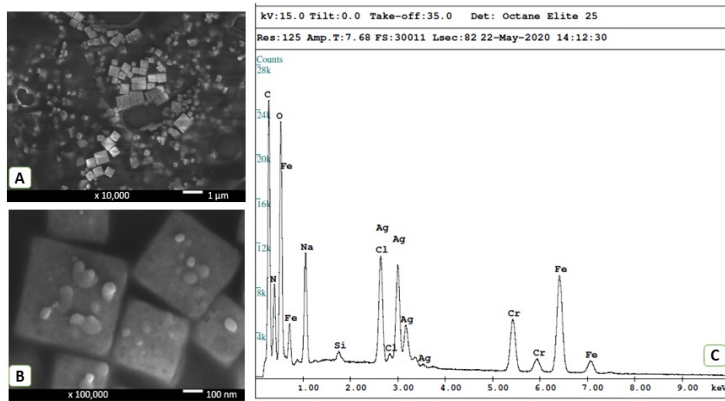


SEM image of the ZrNb alloy surface before (a) and after (b) the plasma electrolytic oxidation (PEO) process with pore distribution (c)

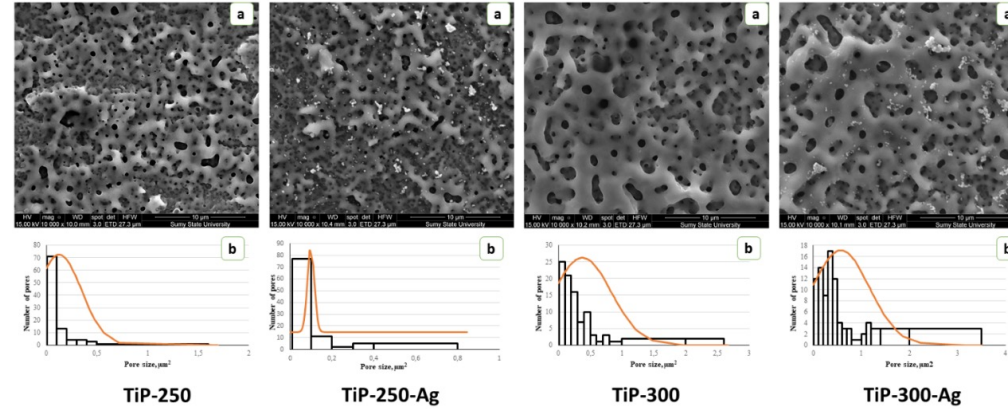


Bacterial adhesion and osteoblast proliferation

Ag Nanoparticle-Decorated PEO coating of Ti Alloy



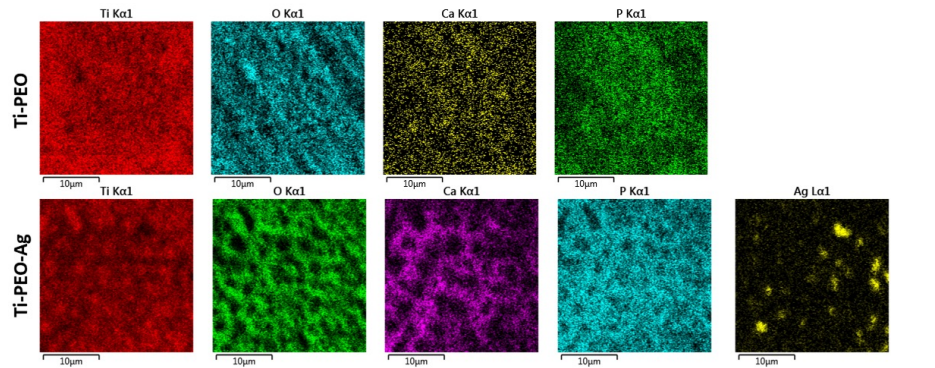
SEM image of AgNPs with EDX data



SEM images (a) and pore size distribution (b) after PEO of Ti implants

Sample	Ti	O	C	Ca	P	Ag
TiP-250	52.6	12.3	5.2	16.8	13.1	-
TiP-250-Ag	49.2	9.8	7.2	17.6	15.9	0.3
TiP-300	57.3	7.5	4.0	19.7	11.5	-
TiP-300-Ag	54.8	7.9	6.1	18.3	12.2	0.7

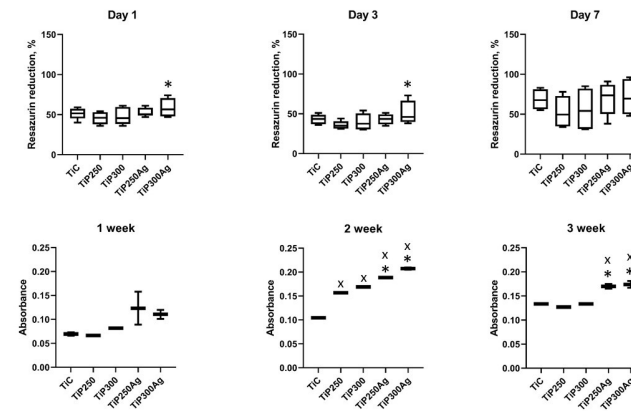
The semi-quantitative EDX analysis results, wt.%



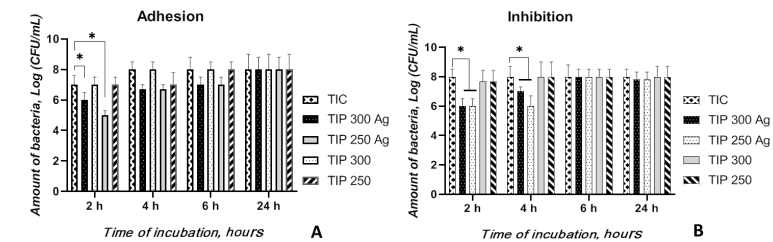
Untreated Ti TiP-250 TiP-250-Ag TiP-300 TiP-300-Ag

Contact angle 97.3±5.8 54.9±6.3* 58.5±3.6* 34.2±4.0 *£ 31.9±5.1 *£

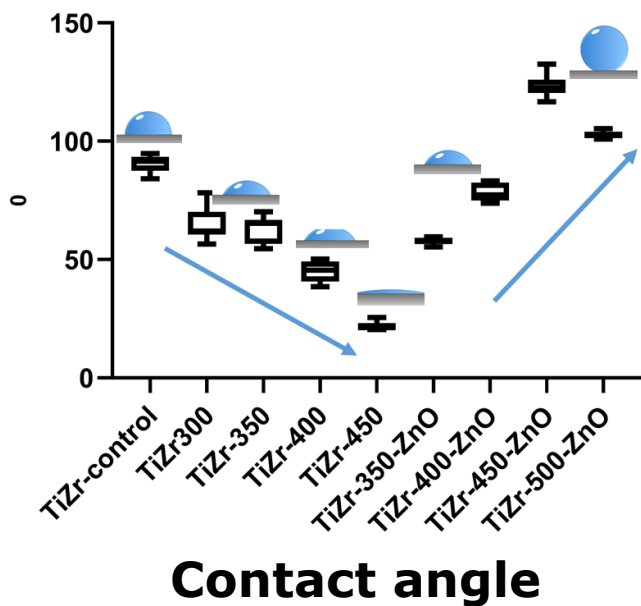
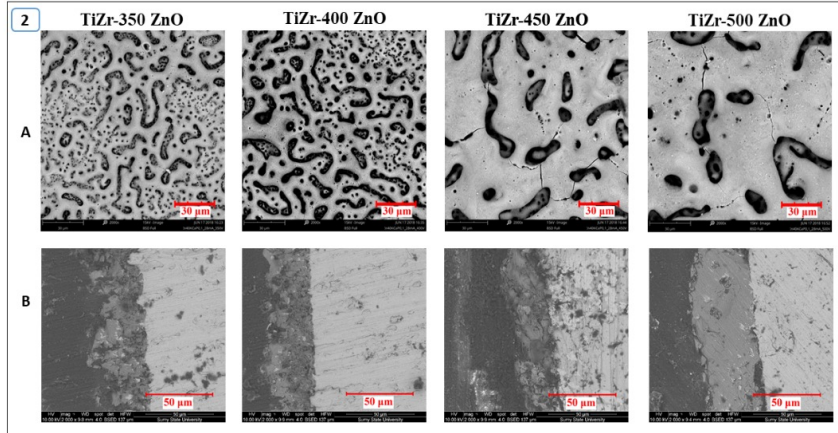
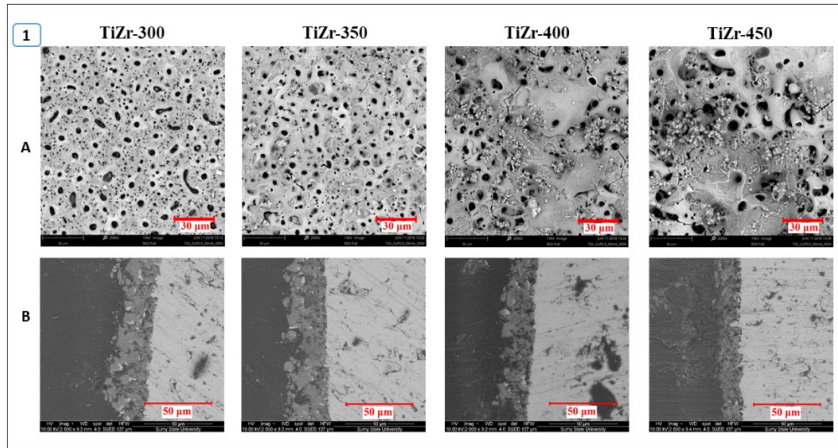
EDX mapping and contact angle



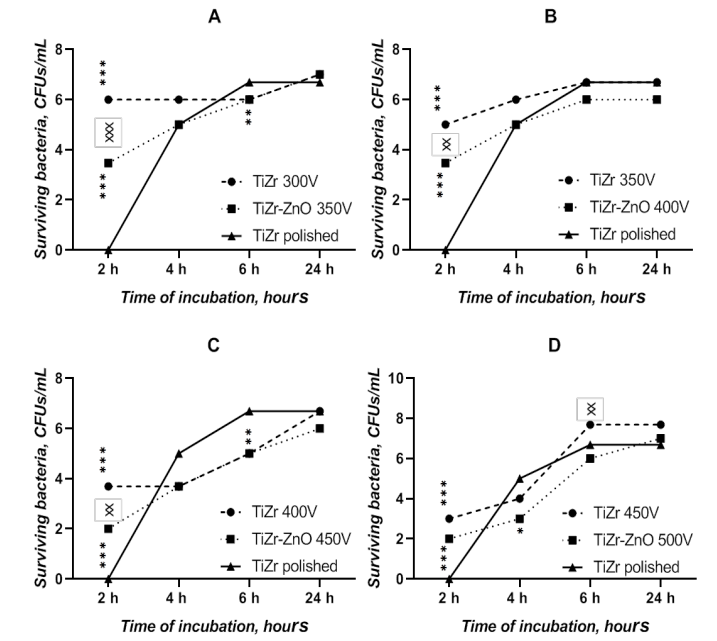
Cell proliferation, collagen production and bacteria adhesion/inhibition



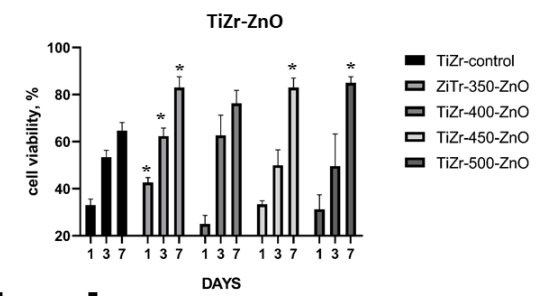
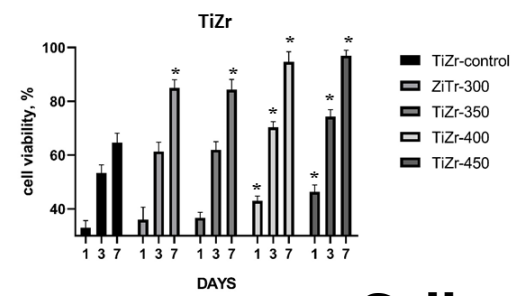
ZnO Nanoparticle-Decorated PEO coating of TiZr Alloy



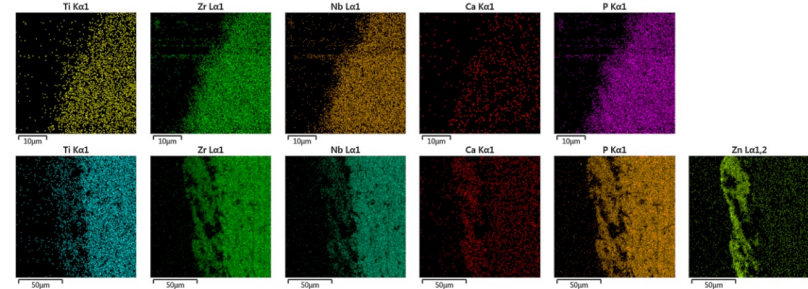
Contact angle



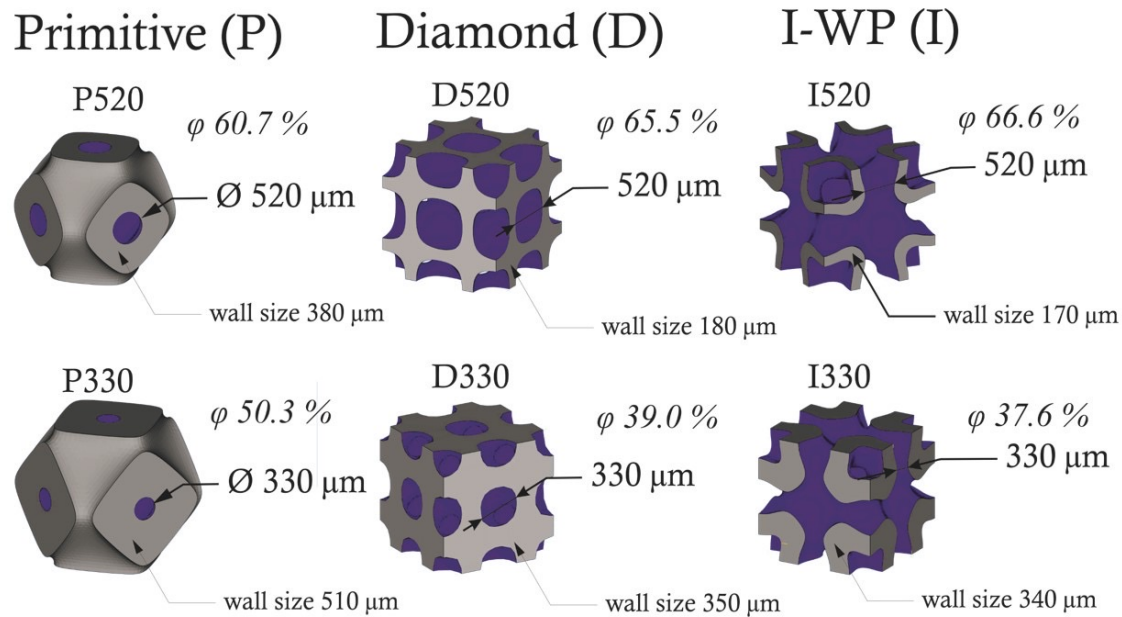
Bacteria inhibition



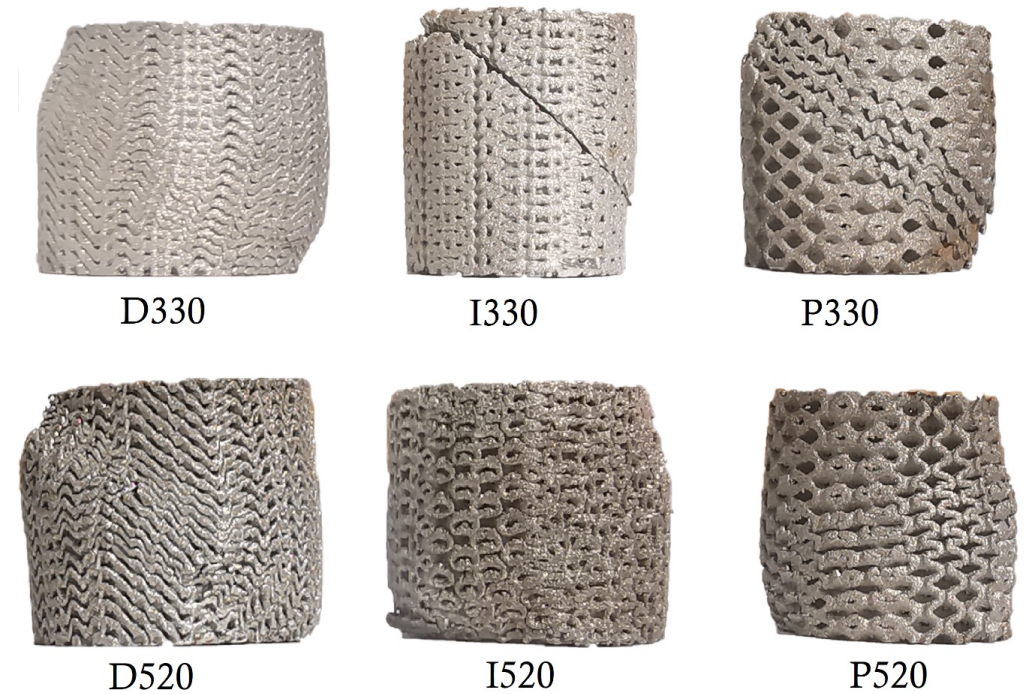
Cell adhesion



AgNPs incorporation in 3D scaffolds



The basic cells parameters of different samples with TPMS architectures

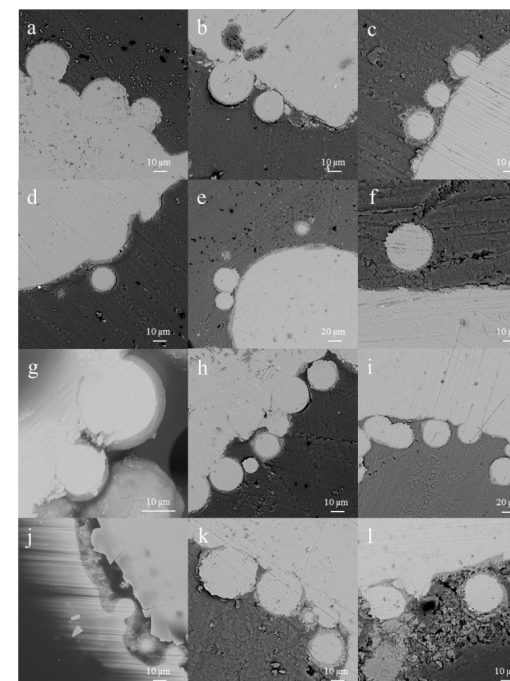
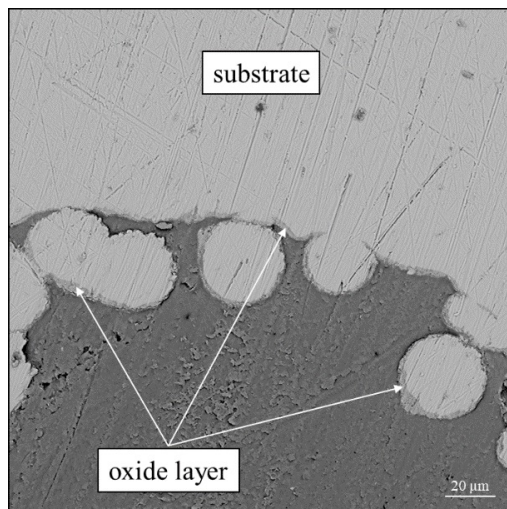
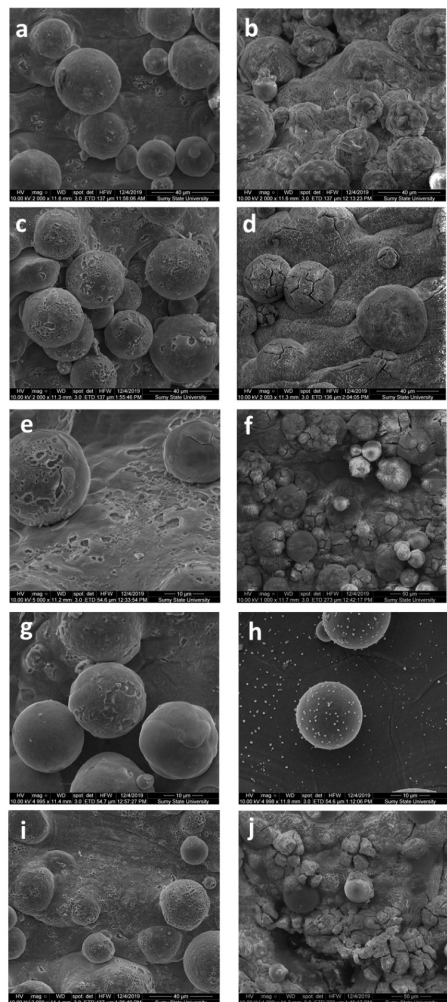


The destruction behavior of porous scaffolds with different architecture

AgNPs incorporation in 3D scaffolds

The semi-quantitative EDX analysis of scaffolds after the PEO process

Sample	O	Al	P	Cl	Ca	Ti	V	Ag	Ca/P ratio	Sum
P330-PEO	37.9	3.1	2.7	0.1	0.4	53.6	2.2	-	0.2	100.0
P330-PEO-Ag	34.7	2.1	2.2	4.2	1.6	41.7	1.8	11.7	0.7	100.0
D330-PEO	37.9	3.1	2.7	0.1	0.4	53.6	2.2	-	0.2	100.0
D330-PEO-Ag	34.0	2.7	1.4	3.9	-	48.8	2.3	6.8	-	100.0
I330-PEO	39.2	2.2	3.7	0.2	2.6	50.7	1.5	-	0.7	100.0
I330-PEO-Ag	37.2	3.2	2.2	1.0	1.0	46.8	2.4	6.1	0.5	100.0

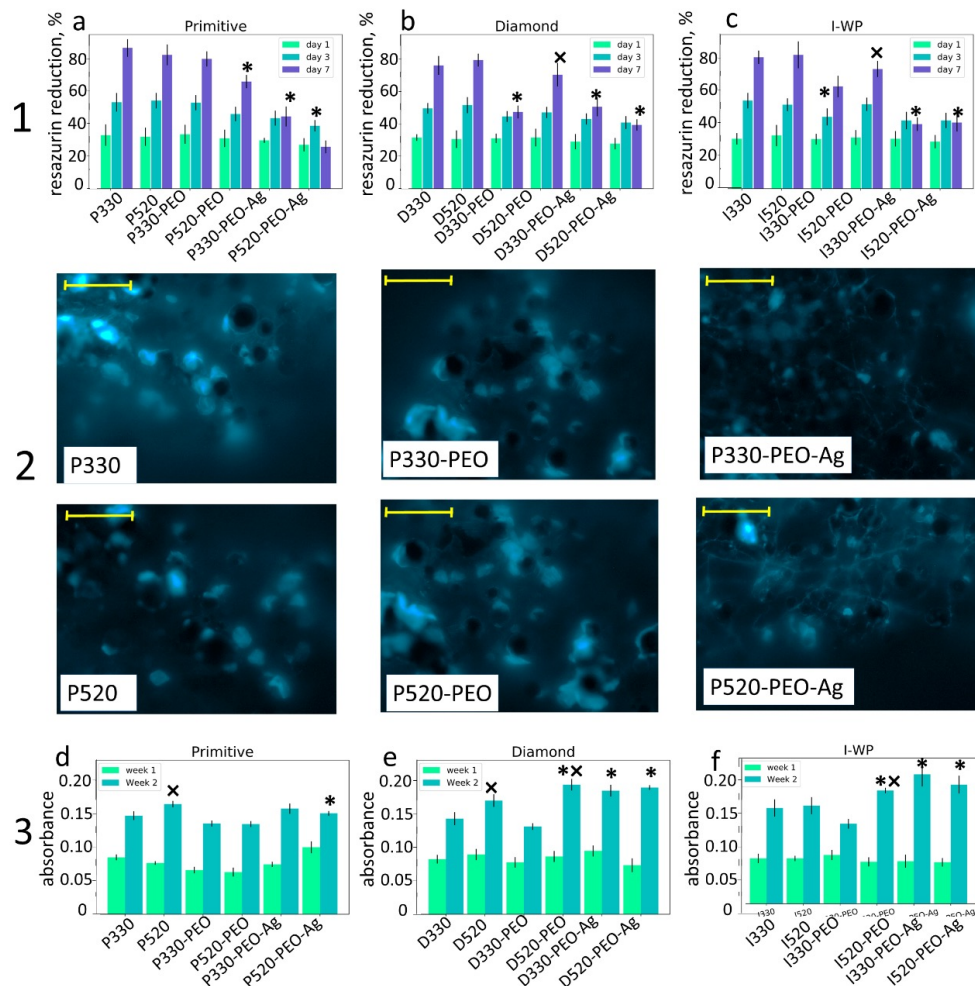


The SEM images of scaffolds after the PEO treatment

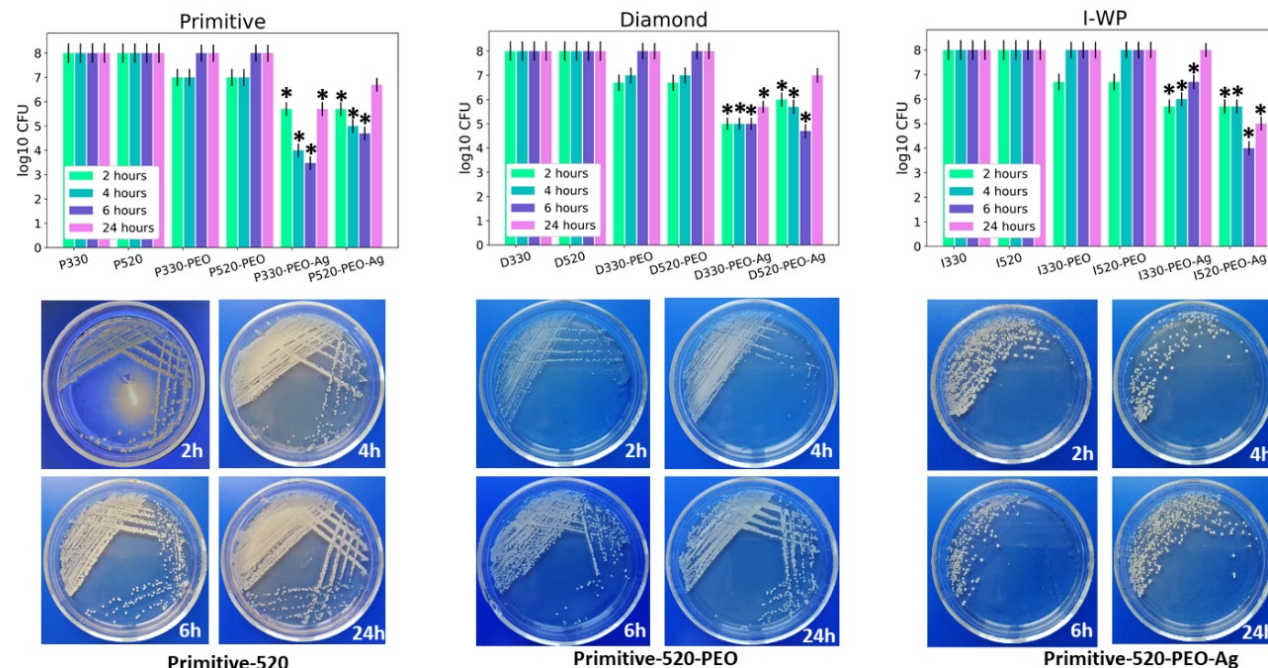
The SEM image of I330-PEO-Ag sample cross section

The SEM images of cross-sections of scaffolds after the PEO process

AgNPs incorporation in 3D scaffolds

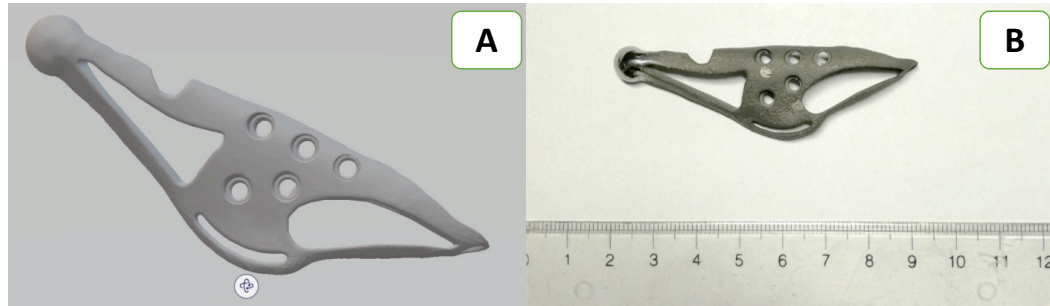


Resazurin reduction assay demonstrating U2OS adhesion on day one and proliferation in 3 and 7 days (**1**) with fluorescent DAPI staining in day 7 and the absorbance intensity of Sirius red

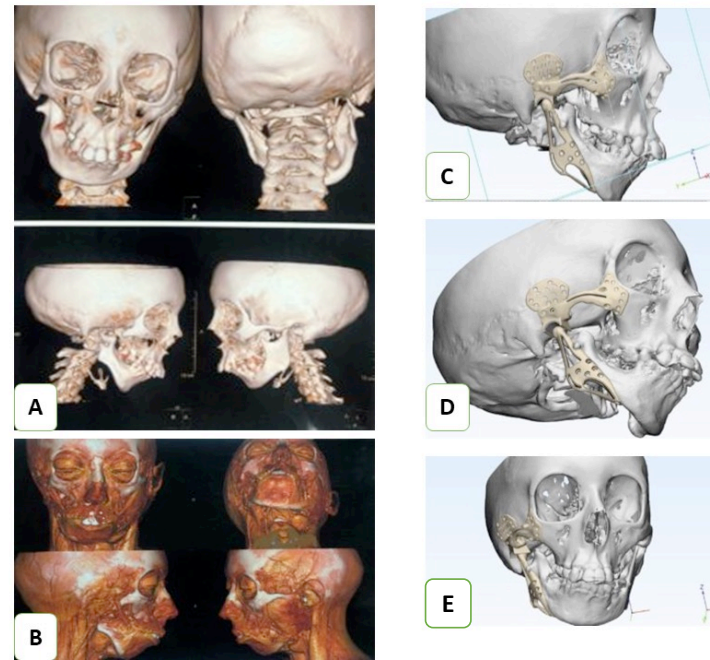


Bacteria survival rate in different time-points (2, 4, 6 and 24 hours) after *S. aureus* co-cultivation calculated in Log₁₀ CFU

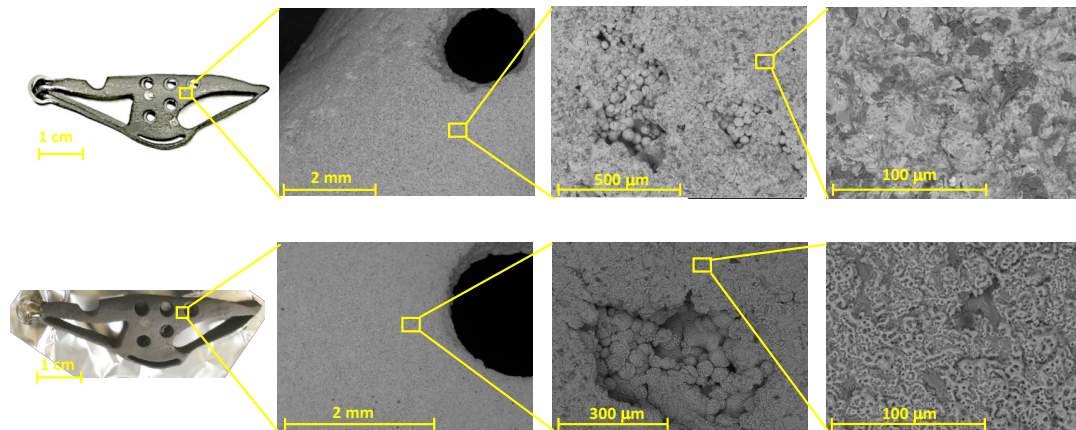
Craniofacial reconstruction using 3D personalized implants



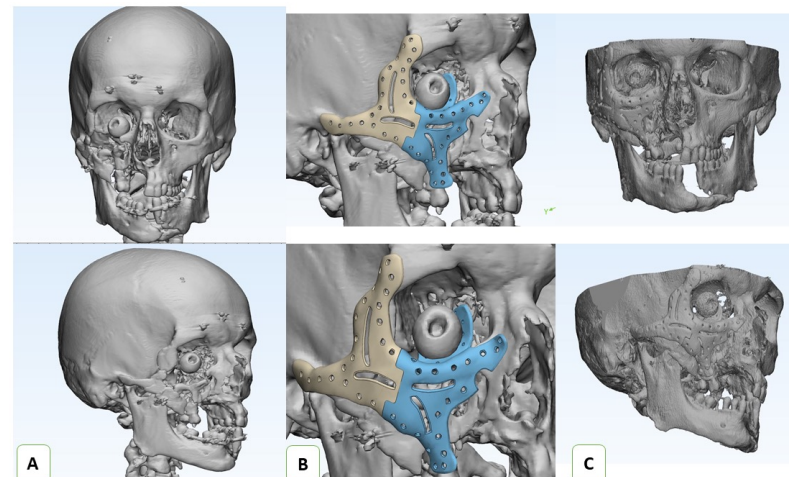
CAD-model of the upper part of mandible from the patient (A) and real three-dimensional implant



Patient with Goldenhar syndrome (hemifacial microsomia, syndrome of the first and second brachial arches, craniofacial microsomia, otomandibular dysostosis and lateral facial dysplasia)



Optical and SEM images of an implant before (upper row) and after (bottom row) PEO processing

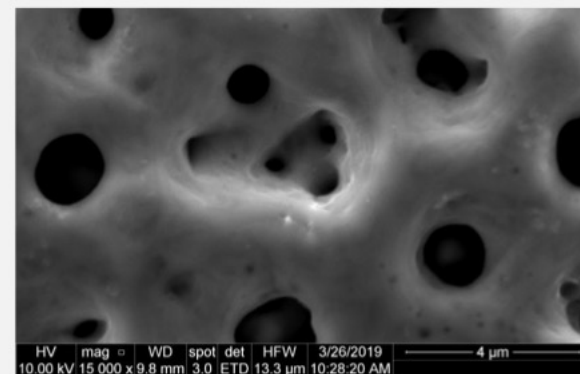
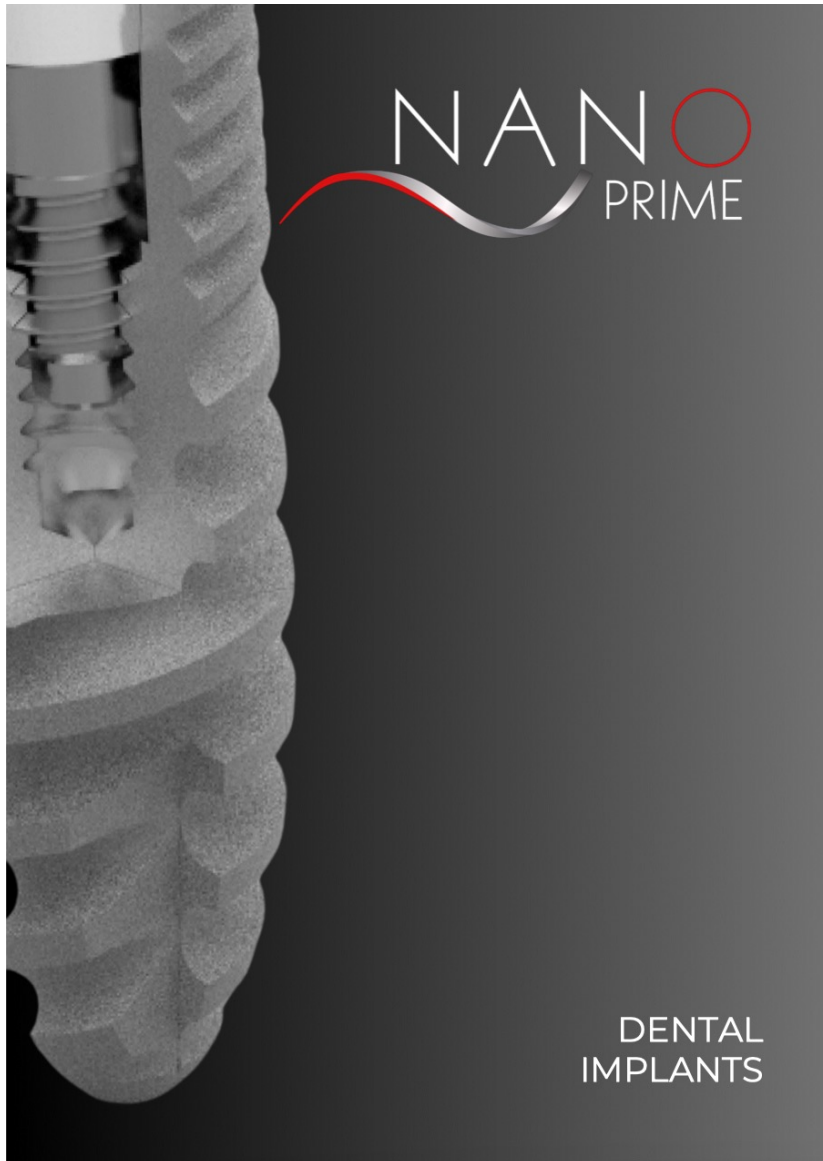


Patient with a high-energy trauma - a fire-wound injury from a Kalashnikov

From research to market



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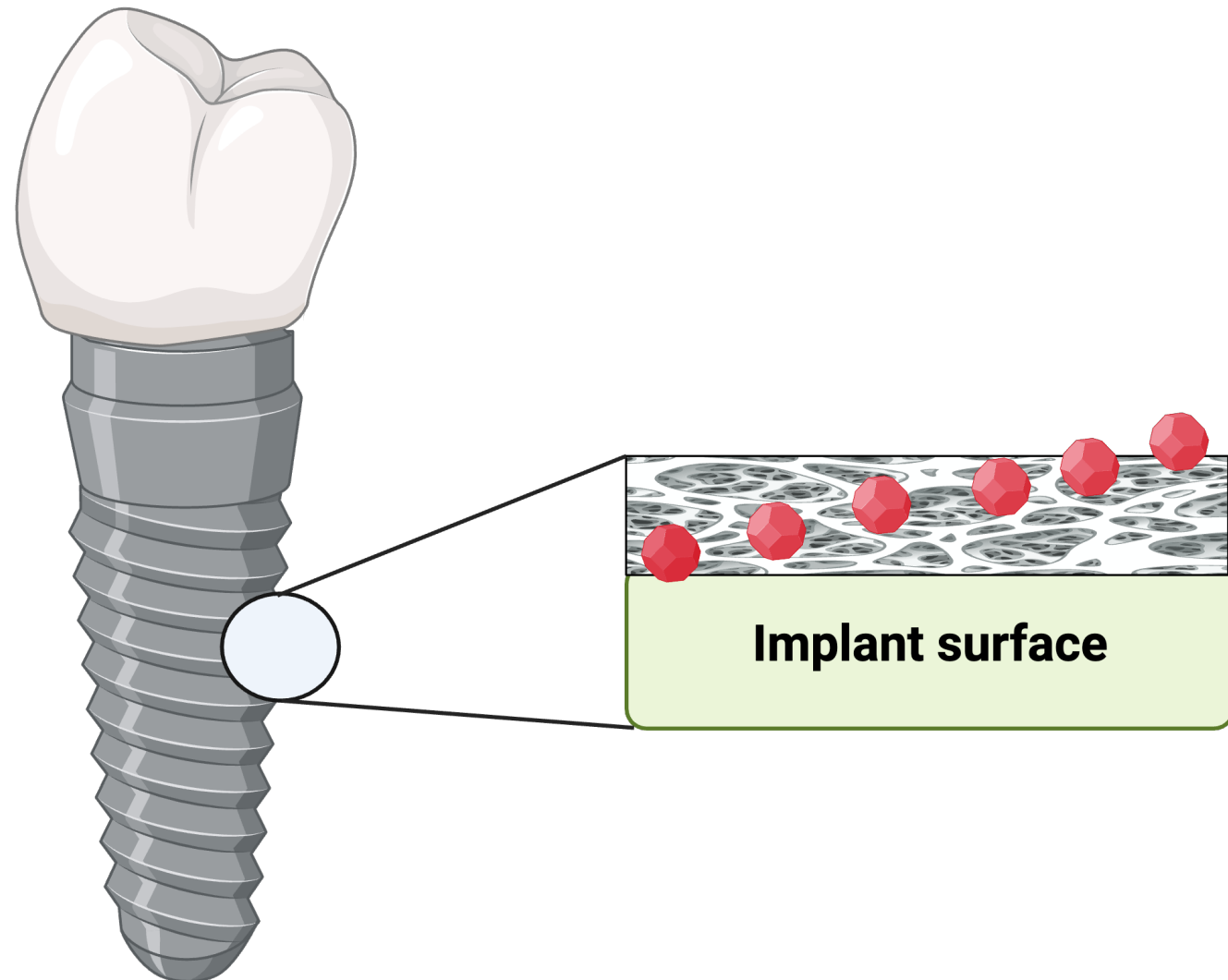


DENTAL IMPLANT WITH PEO SURFACE

Plasma electrolytic oxidation (PEO)

- The application of PEO coating for surface modification provides better adhesion of osteoblasts to the implant surface compared to the SLA surface.
- The presence of over 9%!!! of Ca ions on the PEO surface provides additional stimuli for cell adhesion and proliferation.
- PEO is the main factor influencing cell adhesion and proliferation..

The main problems in PEO with AgNPs



- Unpredictable concentration of AgNPs in PEO layer
- Unpredictable AgNPs distribution
- Contact VS ion-release mechanism of action
- Moderate cell toxicity

Main outcomes



- PEO can provide stable distribution of AgNPs on implant layer
- Long-term silver ions release
- AgNPs decorated layer can prevent bacteria adhesion in first term after the implantation
- Prevention of biofilm formation



Acknowledgement



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VARIANT - Design and implementation
of silver-based nanoparticles for
combating antibiotic resistance



Funded by
the European Union

HORIZON-Europe MSCA-SE-2021
project “Towards development of new
antibacterial strategy for dentistry”
(project No 101086441)

