

Surface Modifications to Reduce Bacterial Attachment

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The Patient Impact

Infection has become the #1 cause of revision



Table HT15 Primary Total Conventional Hip Replacement by Reason for Revision (Primary Diagnosis OA)

Reason for Revision	Number	Percent
Infection	2972	22.7
Prosthesis Dislocation/Instability	2879	22.0
Fracture	2856	21.8
Loosening	2753	21.0
Pain	255	1.9
Leg Length Discrepancy	229	1.7
Malposition	201	1.5
Lysis	164	1.3
Implant Breakage Stem	125	1.0
Implant Breakage Acetabular Insert	102	0.8
Incorrect Sizing	84	0.6
Wear Acetabular Insert	79	0.6
Metal Related Pathology	59	0.5
Implant Breakage Acetabular	46	0.4
Implant Breakage Head	23	0.2
Progression Of Disease	1	0.0
Other	270	2.1
TOTAL	13098	100.0

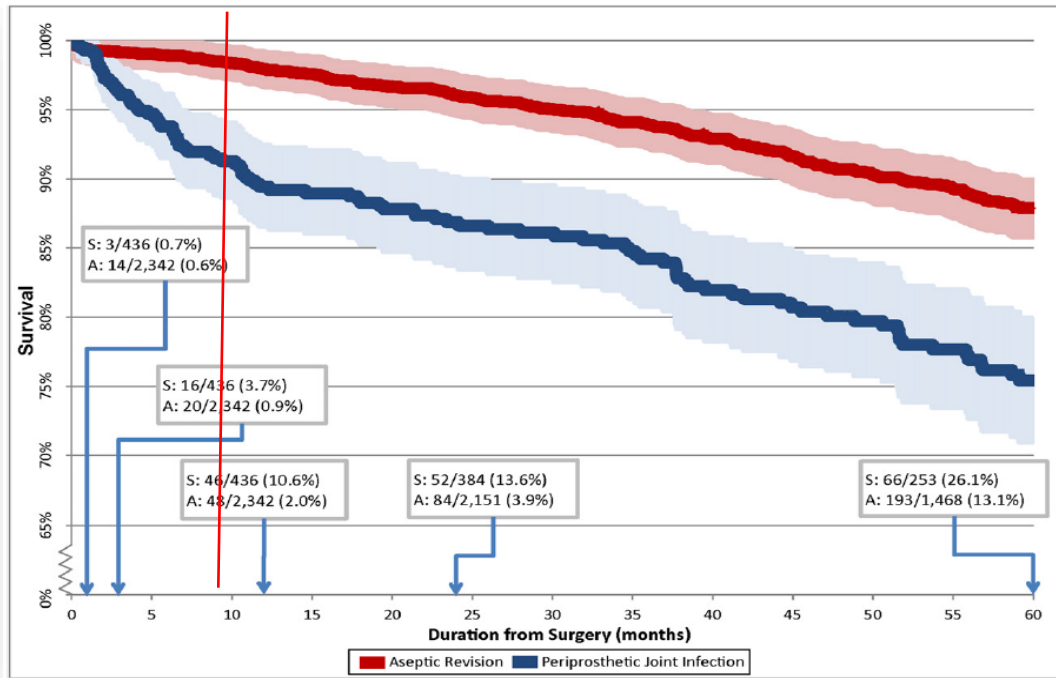
Table KT13 Primary Total Knee Replacement by Reason for Revision (Primary Diagnosis OA)

Reason for Revision	Number	Percent
Infection	6724	26.6
Loosening	5667	22.4
Instability	2427	9.6
Pain	2020	8.0
Patellofemoral Pain	1994	7.9
Patella Erosion	1655	6.6
Arthrofibrosis	989	3.9
Fracture	893	3.5
Malalignment	584	2.3
Wear Tibial Insert	351	1.4
Lysis	340	1.3
Incorrect Sizing	253	1.0
Metal Related Pathology	113	0.4
Other	1241	4.9
TOTAL	25251	100.0

The Patient Impact – Mortality

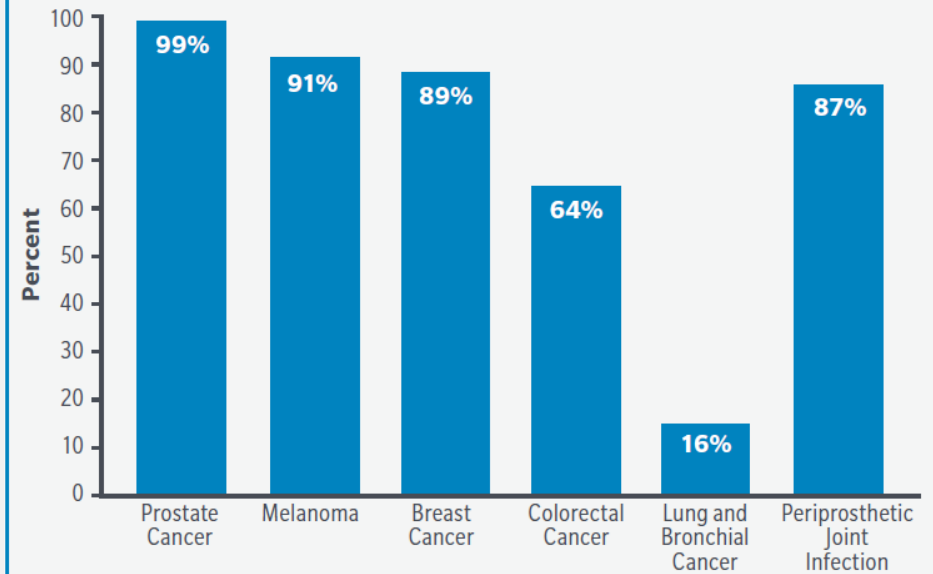
Periprosthetic Joint Infection Increases the Risk of One-Year Mortality

Benjamin Zmistowski, BS, Joseph A. Karam, MD, Joel B. Durinka, MD, David S. Casper, BS, and Javad Parvizi, MD, FRCS



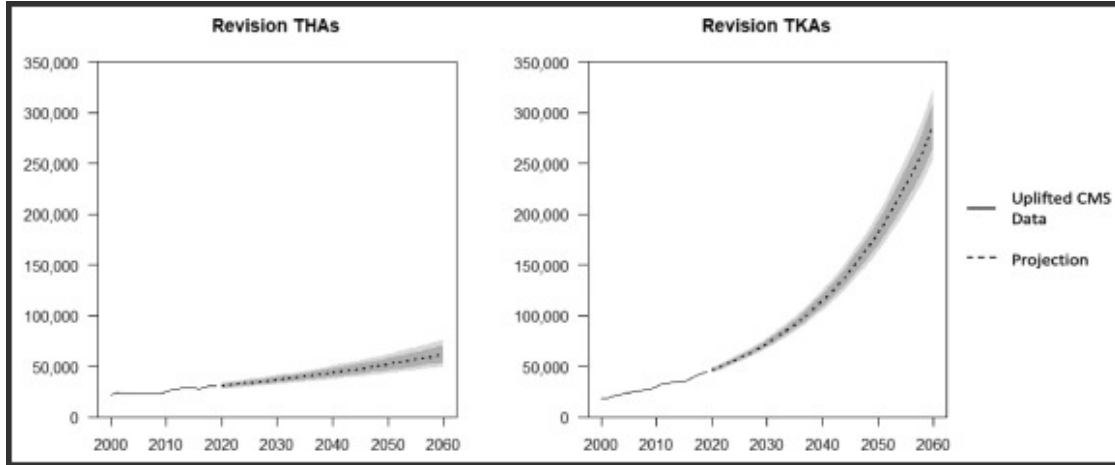
J Bone Joint Surg Am. 2013;95:2177-84

Relative Survival



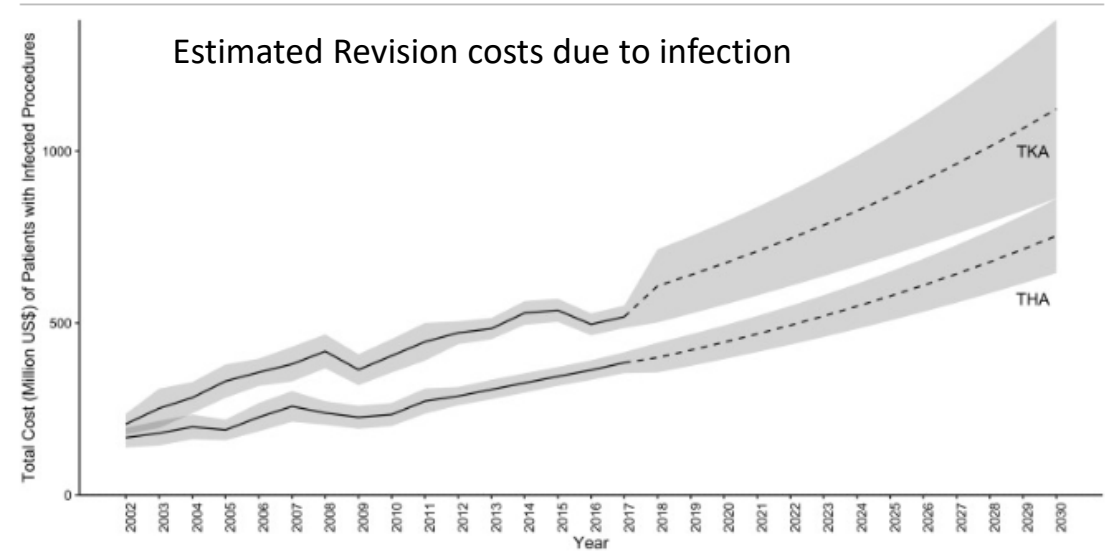
Zmistowski, A quarter of patients treated for PJI dead within 5 years. Orthopedics Today, 2012.

The Financial Burden

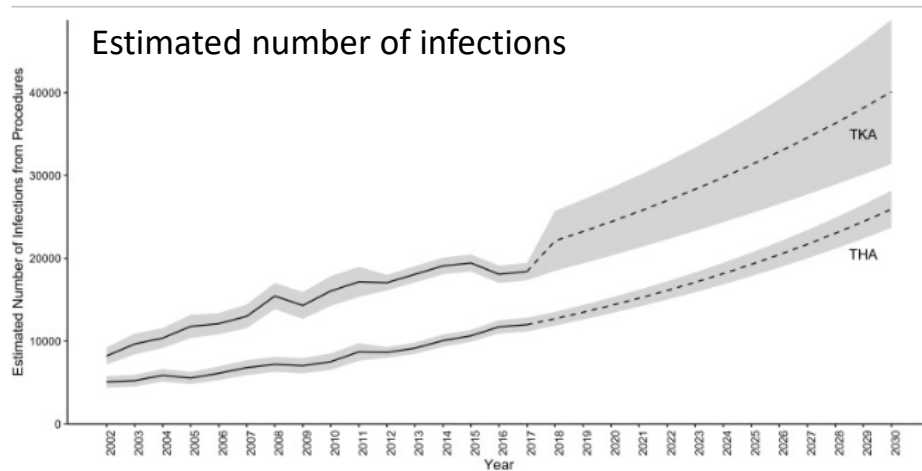


Revision THAs and TKAs Prediction

Ittai Shichman et al, Projection and Epidemiology of Revision Hip and Knee Arthroplasty in the US to 2040-2060, Arthroplasty Today, Vol 21, 2023

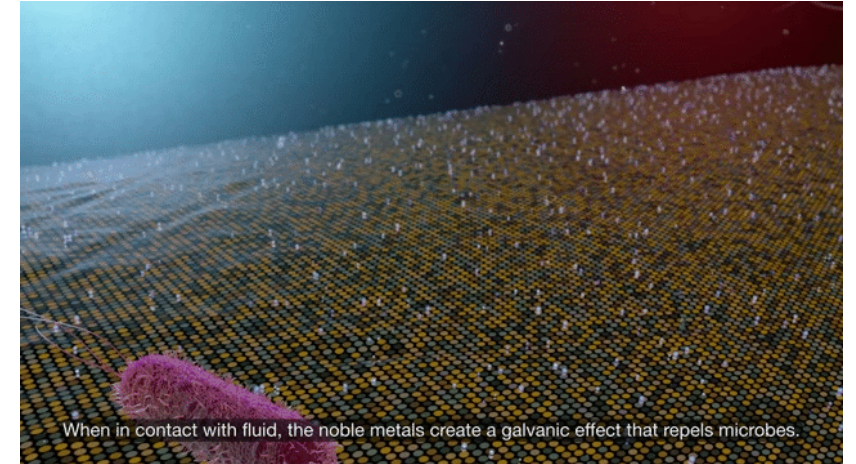


Ajay Premkumar et al, Projected Economic Burden of PJI of Hip and knee in the US, the journal of Arthroplasty, Vol 36, Issue 5, 2021; 1484-1489



Treatment Options – Surface Modifications

- Coatings:
- Bactiguard: ZB launched Bactiguard coated Trauma nails in Europe
- Thin, durable, non-eluting noble metal coating that creates galvanic effect creating tiny pico currents on the implant surface, designed to reduce bacterial adhesion
- Proprietary chemical process that setup galvanic reaction



<https://znnbactiguard.com/>

*Bactiguard is not cleared in the US

Silver coatings

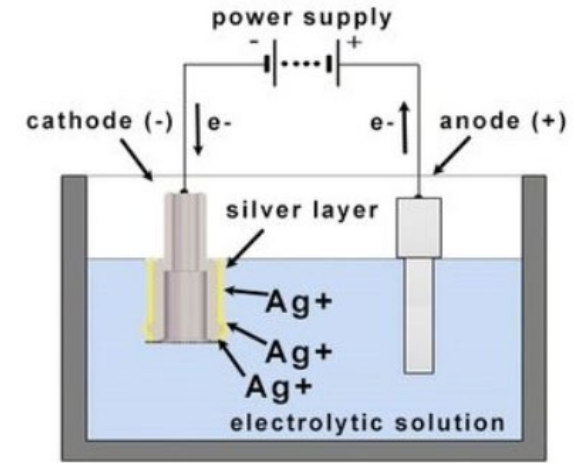
- ImplantCast

- Company based in Germany
- Silver coated products are sold by commercial name Mutars[®]
- 0.2 μ m gold layer as a carrier and bonding layer
- 15 μ m thick silver coating applied by electroplating

- Kyocera, Japan

- AG_Protex[®]
- Thermal spray HA containing silver
- Combining osseointegration with antibacterial properties

<https://www.kyocera.co.jp/prdct/medical/ag-protex/>

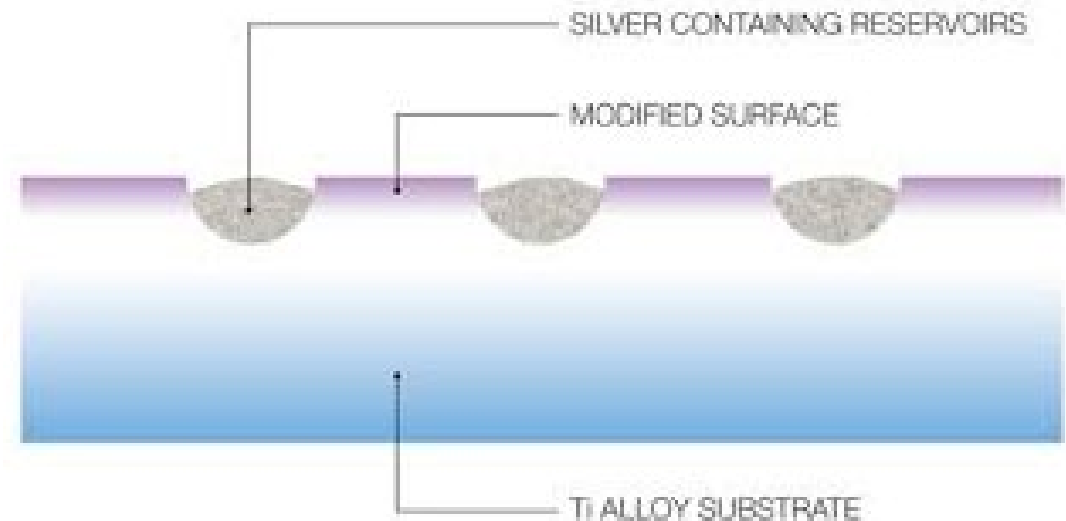


<https://www.implantcast.de/en/company/technology/silver-coating/>



Surface Modification

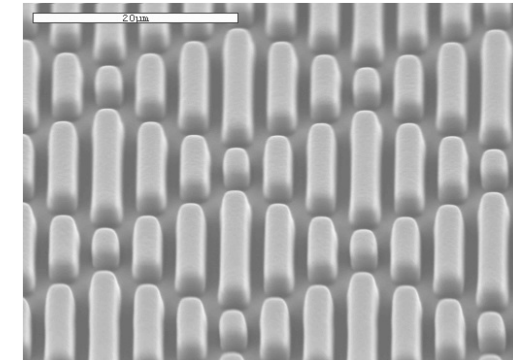
- Accentus Medical – uses Agluna technology
 - Electrochemical process involving acids and voltages
 - Creates titanium oxide layer consisting of circular features, acting as reservoir for ionic silver



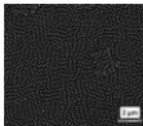
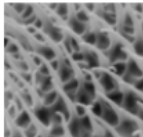

<https://www.accentus-medical.com/technologies/agluna/>

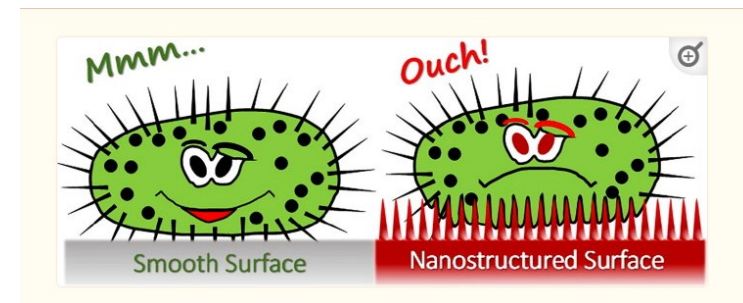
Surfaces Inspired by Nature

- Sharklet
 - Does not use any chemicals, purely structural
 - 3D printing has not been able to print such micro structures yet



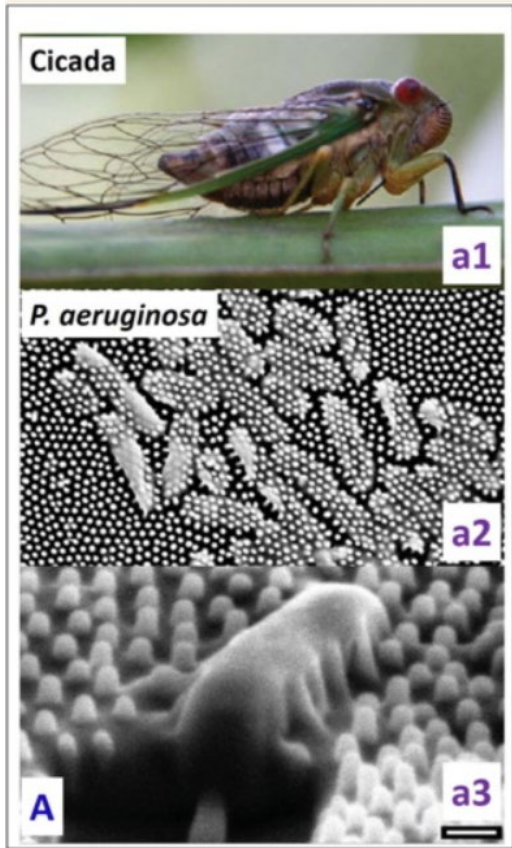
<https://www.sharklet.com/technology-overview/>

Surface	SEM image	Surface features
<i>Naturally occurring</i>		
Cicada wing [54]		Nanoneedles, height 200 nm, diameter 60 nm size at the top, 100 nm at the base of the pillar; and spacing 170 nm
Gecko skin [56]		Hair (spinules) like structures with sub-micron spacing and a tip radius of curvature < 20 nm
Dragon fly wing [57]		Nanograss, diameter 50–70 nm, height 240 nm



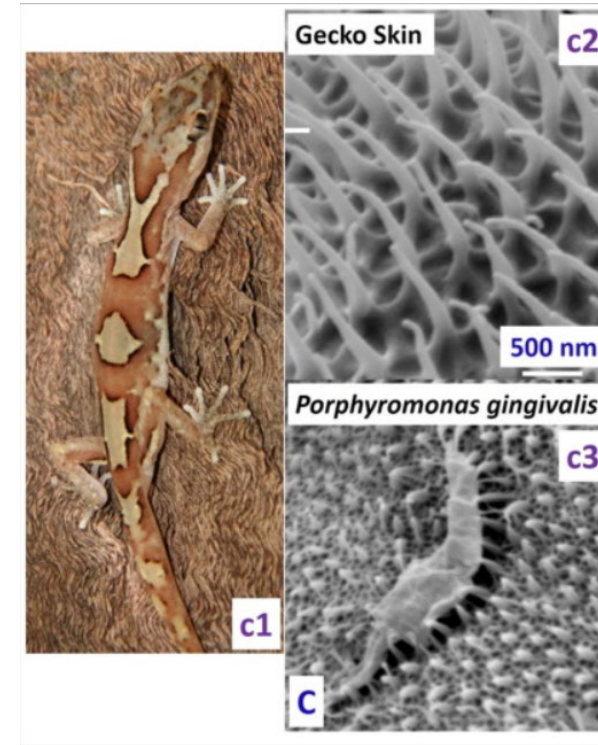
Natural and bioinspired nanostructured bactericidal surfaces, Adv Colloid Interface Sci, 2017 Oct; 248: 85-104

Cicada, Gecko Skin



Ivanova E.P., Hasan J., Webb H.K., Truong V.K., Watson G.S., Watson J.A. Natural bactericidal surfaces: mechanical rupture of *Pseudomonas aeruginosa* cells by cicada wings. *Small*. 2012;8:2489-2494.

- a1: Cicada insect
- a2: *Pseudomonas aeruginosa* cells on cicada wing penetrated by nanopillars
- a3: Representative SEM Image of *P aeruginosa* sinking between nanopillars of cicada wing



Watson G.S., Green D.W., Schwarzkopf L., Li X., Cribb B.W., Myhra S. Acta biomaterialia a gecko skin micro/nano structure - a low adhesion. *Acta Biomater*. 2015;21:109-122.

- c1: Gecko
- c2: Gecko skin with hairlike structure with submicron spacing and radius of curvature <20nm
- c3: SEM image of the *Porphyromonas gingivalis* interacting with nano structured Gecko skin

Images captured from “Natural and bioinspired nanostructured bactericidal surfaces”, Abinash Tripathy et al, *Adv Colloid Interface Sci*, 2017 Oct; 248: 85-104

Summary

- Implant associated infection remains one of the biggest unmet clinical needs in orthopedics
- Limitations on surface modification techniques – need more innovation
 - Various approaches are possible
 - Surface modification can play a major role
- Mechanism of action needs to be well understood
- Regulatory pathway is a challenge

Thank You

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