matrix® SCIENTIFIC WHITE-PAPER

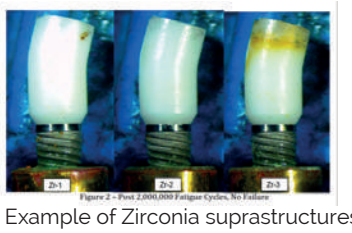
TRI DENTAL IMPLANTS

Evaluation of the wear between matrix® titanium implants and directly screw-retained zirconia crowns.

Study executed by renowned and independent lab RMS foundation.

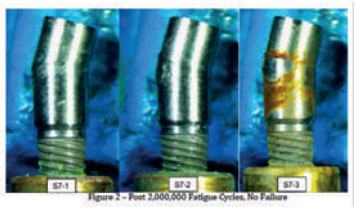
RMS

Objective: This study addresses the question of wear in the interface between the **matrix®** titanium implant and the zirconia crown. The wear and ageing of the connection is also compared between titanium-zirconia and titanium—titanium **matrix®** configurations.



Example of Zirconia suprastructures after the 2 million cycles of dynamic fatigue testing.

Materials & Methods: **matrix®** bone level implants with the narrow platform P37 are selected as worst case. Three assemblies Ti-Zr and Ti-Ti go through an ageing simulation according to ISO 14801:2016. The load is 218N, number of cycles is 2m and the frequency is 2 Hz.



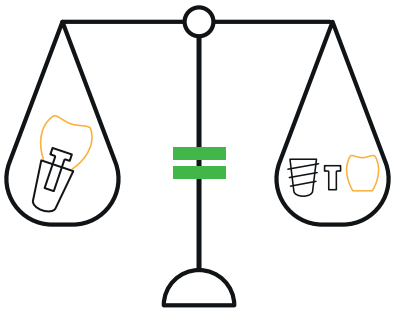
Example of Titanim suprastructures after the 2 million cycles of dynamic fatigue testing.

The following analysis is performed with all samples Zr-1,2,3 and S7-1,2,3:

Gravimetry	Specimen are washed thoroughly before disassembly. After disassembly, any potentially available particles are washed into a filter. Filter are weighed before and after particle collection to determine if any particles are washed off.
Control of the loosening torque	The abutments are torqued to 35 NCm before dynamic fatigue testing. When releasing the abutments after dynamic fatigue testing, the torque is measured again. In case of any wear between implant and abutment, a lower torque or even a screw loosening would be expected.
Optical Microscopy	Contact surfaces of screw seat and abutment seat on implant are analyzed with optical microscopy.
Topography	The topography of above-described contact surfaces are measured.
Scanning electron microscopy	Additionally, the contact surfaces are investigated by scanning electron microscopy.
Cut polished images	Cut polished images will be created and analysed by light microscopy to document that the interface remains intact after dynamic fatigue testing.

RESULTS:

Gravimetry



Identical weights of fix assembly (implant, screw, crown) and separate components (implant, screw, crown) after washing off potential wear captured inside assembly after patient's lifetime simulation. Sensitivity of the high precision scale is < 0.05mg.

Table 3: Weight of PC membrane filters before and after filtration.*

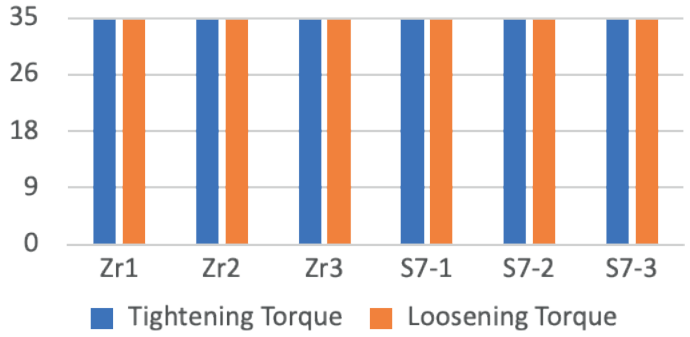
Filter	mass before filtration /mg	mass after filtration /mg	mass difference /mg	average mass difference /mg	standard deviation of mass difference /mg
blank S7-1	40.17	40.14	-0.03		
blank S7-2	40.46	40.48	0.02	-0.01	0.03
blank S7-3	40.51	40.47	-0.04		
blank Zr1	39.10	39.11	0.02		
blank Zr2	42.88	42.86	-0.02	-0.02	0.03
blank Zr3	40.88	40.83	-0.05		
S7-1	40.17	40.24	0.06		
S7-2	39.53	39.56	0.03	0.04	0.03
S7-3	39.91	39.92	0.01		
Zr1	40.94	40.96	0.02		
Zr2	41.22	41.25	0.03	0.02	0.005
Zr3	38.98	39.00	0.02		

* The mass increase of the filters was with up to 0.04 ± 0.03 mg below the 3 mg threshold specified in the standard VDA 19 for high precision balances.

Control of Loosening Torque

Crowns were torqued with 35NCm before the assemblies went into patient's lifetime simulation.

The loosening torque after 2 million cycles remained at 35Ncm. This is a strong sign that there is no wear in the connection and no screw loosening will happen during the patient's lifetime.



Optical and Scan Electron Microscopy

Titanium

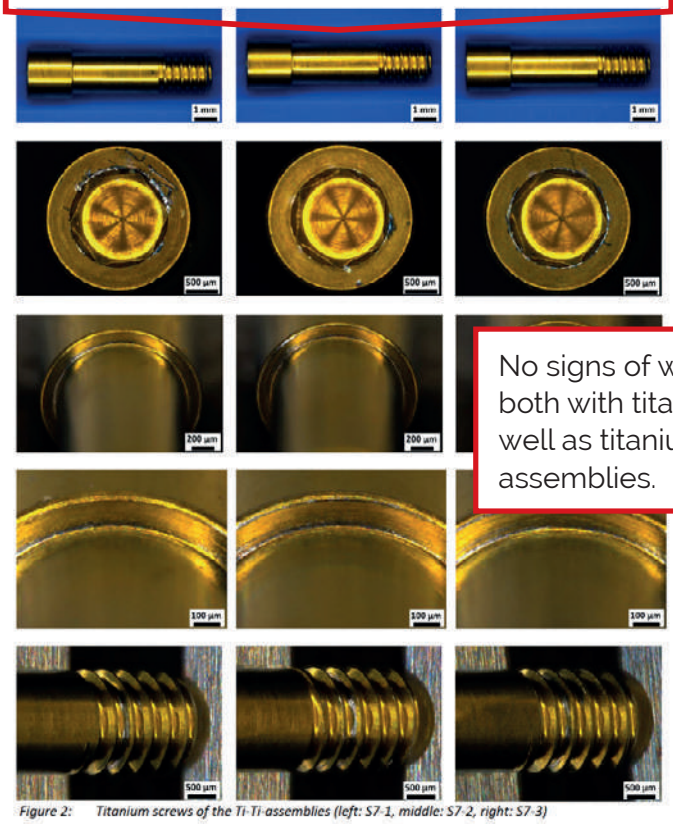


Figure 2: Titanium screws of the Ti-Ti-assemblies (left: S7-1, middle: S7-2, right: S7-3)

Zirconia

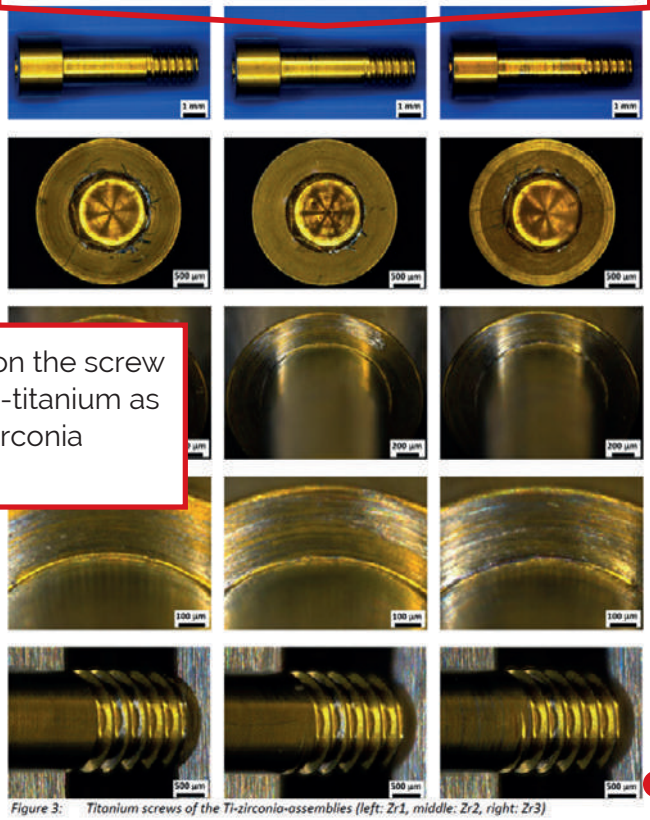


Figure 3: Titanium screws of the Ti-zirconia-assemblies (left: Zr1, middle: Zr2, right: Zr3)

No signs of wear on the screw both with titanium-titanium as well as titanium-zirconia assemblies.

Optical and Scan Electron Microscopy

Titanium

Zirconia

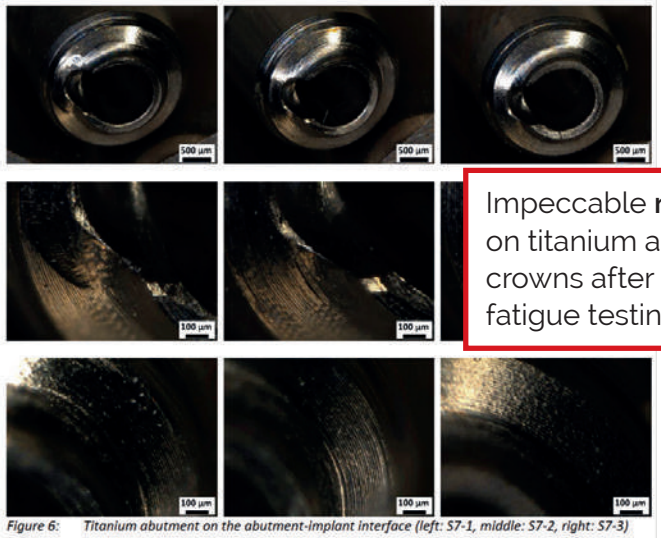


Figure 6: Titanium abutment on the abutment-implant interface (left: S7-1, middle: S7-2, right: S7-3)

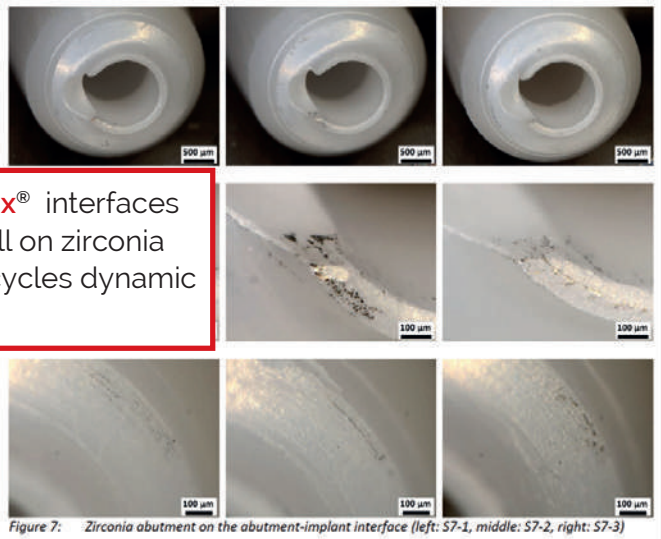


Figure 7: Zirconia abutment on the abutment-implant interface (left: S7-1, middle: S7-2, right: S7-3)

Impeccable **matrix**® interfaces on titanium as well on zirconia crowns after 2m cycles dynamic fatigue testing.

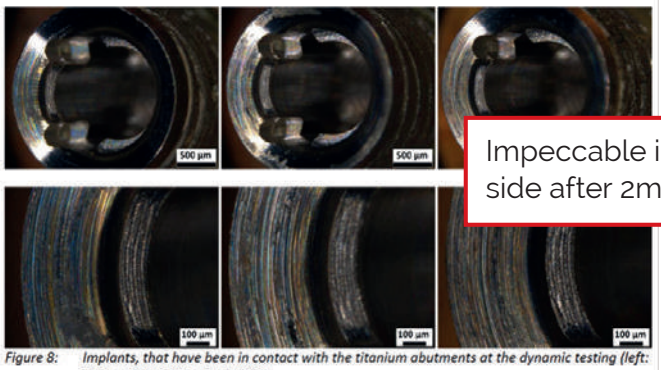


Figure 8: Implants, that have been in contact with the titanium abutments at the dynamic testing (left: S7-1, middle: S7-2, right: S7-3)

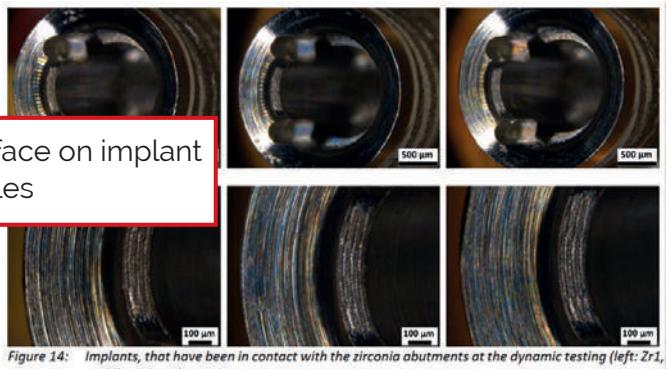


Figure 14: Implants, that have been in contact with the zirconia abutments at the dynamic testing (left: Zr1, middle: Zr2, right: Zr3)

Impeccable interfaces also visualized with scan electron microscopy. Zr samples even show less traces after a patients lifetime simulation.

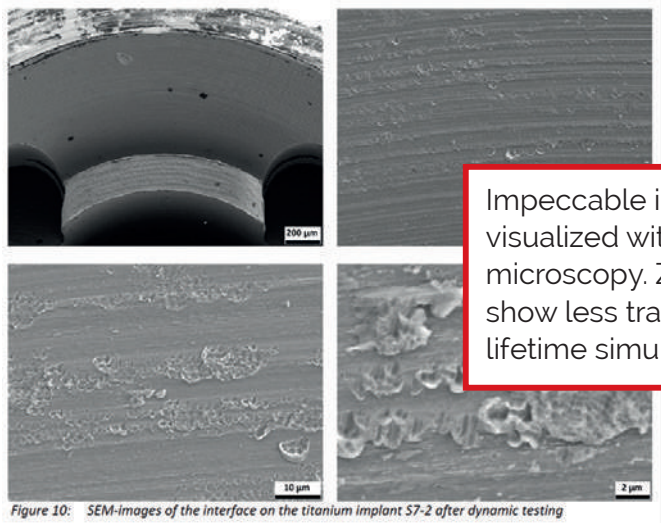


Figure 10: SEM-images of the interface on the titanium implant S7-2 after dynamic testing

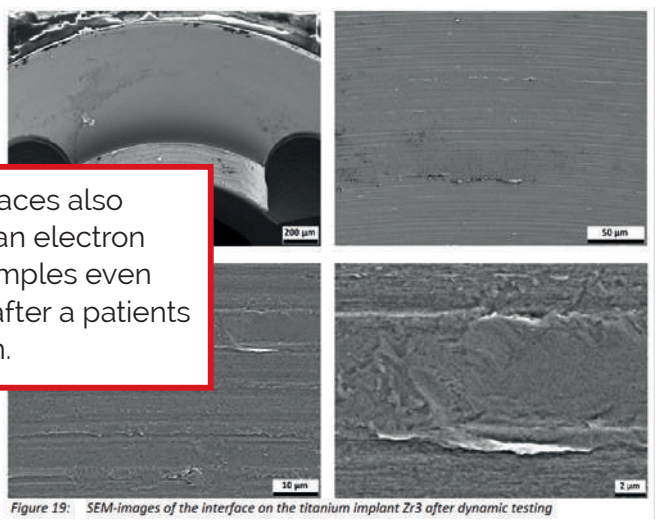


Figure 19: SEM-images of the interface on the titanium implant Zr3 after dynamic testing

Topography

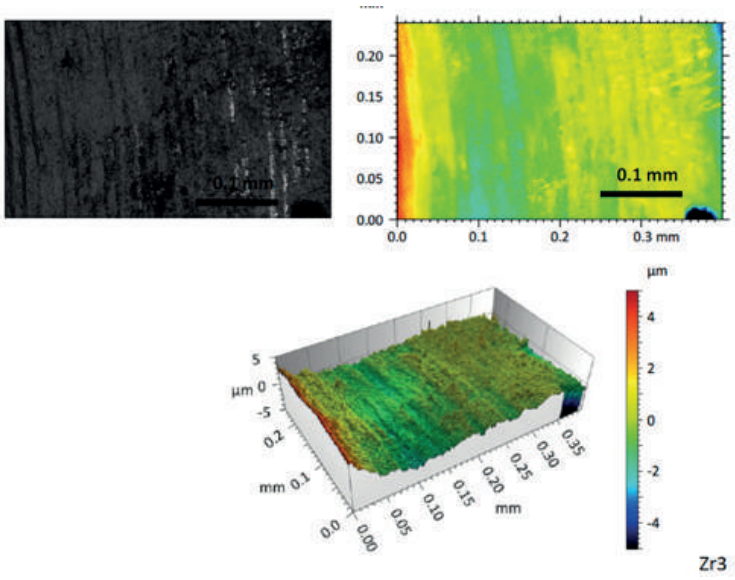


Fig. 28: Intensity (greyscale) and topography (colour) of the zirconia crown abutment position 3: interface with the titanium implant (top: Zr1, middle: Zr2, bottom: Zr3).

Roughness Parameters			
Sample	Zr1	Zr2	Zr3
Position	3	3	3
Ra /µm	0.32 ± 0.03	0.36 ± 0.04	0.36 ± 0.04
Rq /µm	0.45 ± 0.03	0.48 ± 0.07	0.48 ± 0.07
Rsk	0.78 ± 0.46	1.03 ± 0.34	1.03 ± 0.34
Rku	5.44 ± 1.24	5.12 ± 1.15	5.12 ± 1.15
Rt /µm	2.69 ± 0.23	2.85 ± 0.47	2.85 ± 0.47
Rpt /µm	1.65 ± 0.16	1.89 ± 0.38	1.89 ± 0.38
Rp /µm	1.65 ± 0.16	1.89 ± 0.38	1.89 ± 0.38
Rvt /µm	1.04 ± 0.16	0.96 ± 0.15	0.96 ± 0.15
Rv/µm	1.04 ± 0.16	0.96 ± 0.15	0.96 ± 0.15
Rzmax /µm	2.69 ± 0.23	2.85 ± 0.47	2.85 ± 0.47
Rz /µm	2.69 ± 0.23	2.85 ± 0.47	2.85 ± 0.47
Ral /µm	23.2 ± 13.0	27.8 ± 19.9	27.8 ± 19.9
Rsw/µm	124.1 ± 25.2	213.2 ± 148.6	213.2 ± 148.6
Rsm /µm	53.3 ± 17.2	55.8 ± 27.6	55.8 ± 27.6
Rdq /°	6.3 ± 0.9	7.1 ± 1.2	7.1 ± 1.2
Rk /µm	0.74 ± 0.14	0.89 ± 0.18	0.89 ± 0.18
Rpk /µm	0.91 ± 0.16	0.91 ± 0.26	0.91 ± 0.26
Rvk /µm	0.57 ± 0.17	0.37 ± 0.16	0.37 ± 0.16
Rpkx/µm	1.28 ± 0.21	1.51 ± 0.38	1.51 ± 0.38
Rvkx/µm	0.67 ± 0.18	0.45 ± 0.18	0.45 ± 0.18
Rmrk1 /%	12.6 ± 2.5	16.6 ± 5.9	16.6 ± 5.9
Rmrk2 /%	84.6 ± 4.4	89.9 ± 4.1	89.9 ± 4.1
Wa /µm	0.19 ± 0.02	0.26 ± 0.02	0.26 ± 0.02
Wq /µm	0.22 ± 0.02	0.30 ± 0.03	0.30 ± 0.03
Wsk	0.20 ± 0.19	0.28 ± 0.22	0.28 ± 0.22
Wku	1.82 ± 0.16	1.89 ± 0.31	1.89 ± 0.31
Wp /µm	0.40 ± 0.05	0.56 ± 0.10	0.56 ± 0.10
Wv /µm	0.30 ± 0.04	0.40 ± 0.04	0.40 ± 0.04
Wz /µm	0.70 ± 0.07	0.96 ± 0.11	0.96 ± 0.11

A topography analysis was performed on implants, screws and crowns. Above is an example of the extremely smooth surface (Ra=0.32µ) of a **matrix**®crown zirconia interface to the implant.

The example to the right shows the topography of the titanium implant contact surface to the zirconia crowns after 2m cycles. Traces from machining are still visible. This analysis proves that there is not wear between titanium and zirconia.

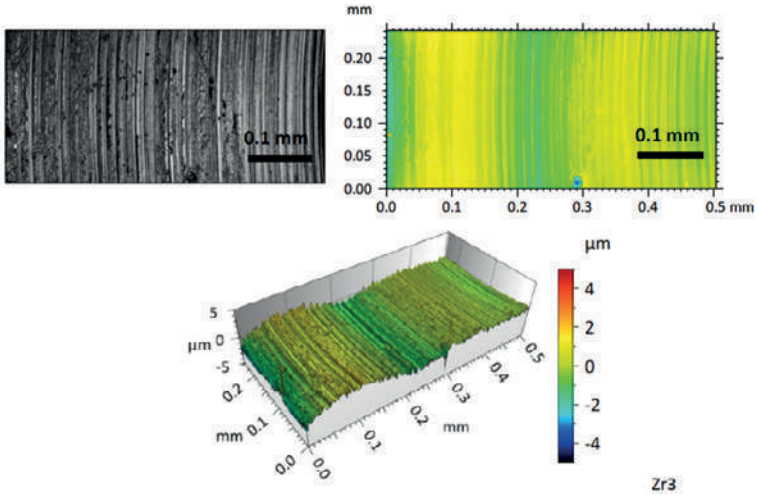


Fig. 30: Intensity (greyscale) and topography (colour) of the tita implant interface with zirconia crown abutment (top: Zr1, middle: Zr2, bottom: Zr3).

A thorough topography analysis of all contact surfaces between implant, screw and crown proves that there is no wear happening during 2m cycles of dynamic fatigue testing that represents a patient's lifetime.

OVERALL CONCLUSION

A vast amount of different scientific analysis has been performed on the **matrix**® connection after 2m cycles fatigue testing that represents a patient's lifetime simulation. No wear has occurred both with titanium-titanium as well as with titanium-zirconia assemblies. Titanium-zirconia assemblies even exhibited less signs of ageing after a patient's lifetime simulation. Interfaces both on implant, screw and crown remained impeccable.