White Paper WP-1
Surface characterisation of SurfLink® Dental treated titanium implants

1. Introduction

Improving biocompatibility of an implant surface is a long standing challenge in the medical field. Several approaches have been developed over the years consisting mainly of mechanical (e.g. blasting, machining and polishing) and chemical (e.g. anodisation and acid etching) treatments of the implant surface [1].

SurfLink® Dental surface treatment by NBMolecules® produces a monolayer of permanently bound multi-phosphonate molecules, presented to the surrounding implant environment. Such a phosphonate-rich surface mimics one of the main constituents of bone, hydroxyapatite. This monolayer also provides a favourable environment for cell colonisation.

The SurfLink® Dental surface treatment is designed to give a quicker integration and more stable bone-to-implant fixation. Earlier characterisations have shown that SurfLink® binds covalently to titanium surfaces [2]. The aim of this study was to further characterise binding of SurfLink® to the surface of titanium as well as to determine surface wettability.

2. Materials and Methods

Four complementary techniques compared SurfLink® Dental treated titanium (grade 4) surfaces against non-treated titanium surfaces (control): QCM-D (Quartz Crystal Microbalance with Dissipation), XPS (X-ray Photoelectron Spectroscopy), FTIR (Fourier Transform Infra Red) spectroscopy and wettability studies.

QCM-D: Titanium coated quartz crystals were mounted on the cells of a QCM-D E4 model instrument (Q-sense, Sweden). SurfLink® Dental solution was flowed over the quartz crystals and changes in the crystal's resonance frequency and dissipation were monitored.

XPS: The elemental composition of the titanium implant surface was characterised using an Axis Ultra spectrometer (Kratos, Manchester, UK).

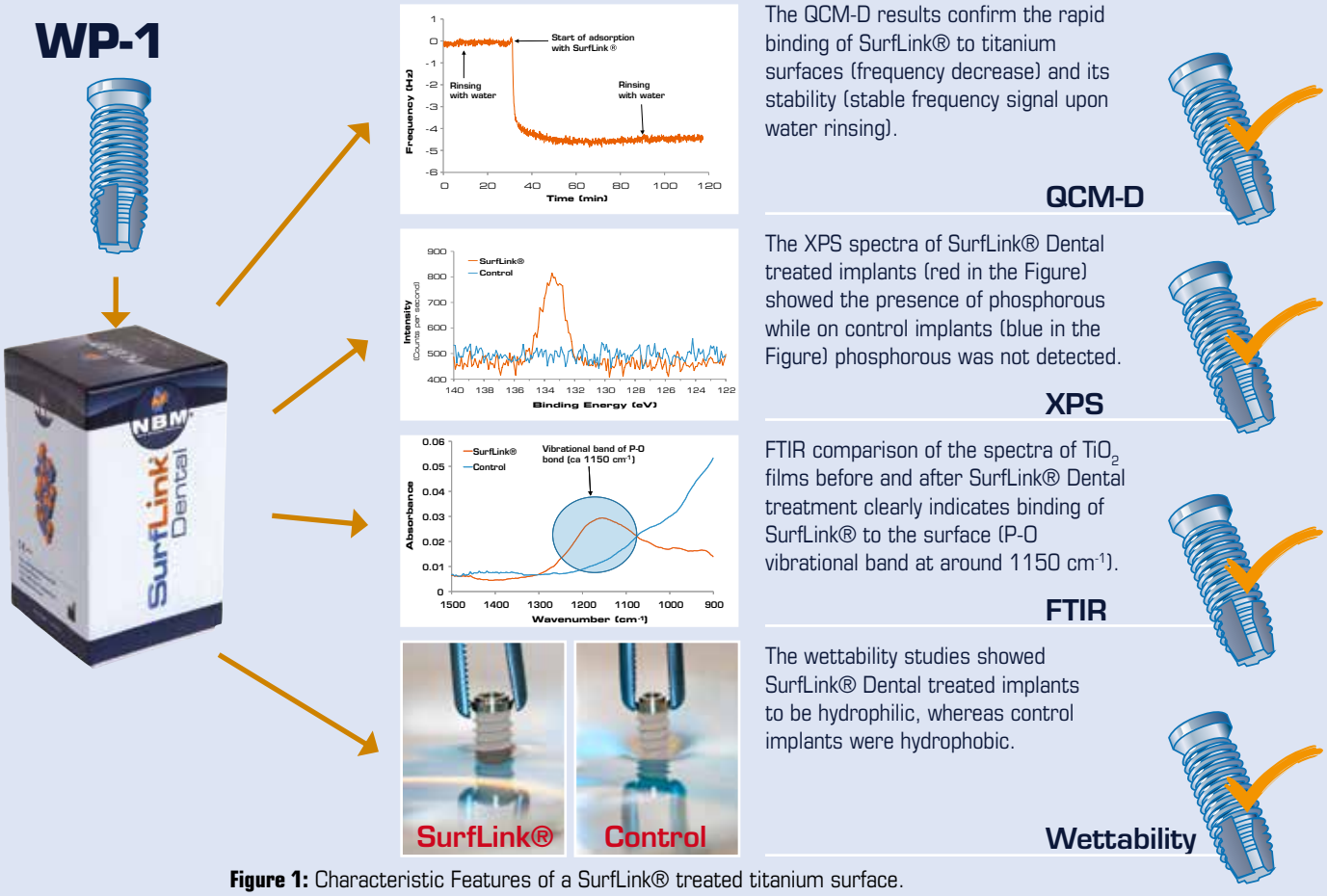
FTIR: Infrared spectra of titanium dioxide (TiO_2) films on glass slides were acquired by FTIR MIR (Multiple Internal Reflectance, Perkin Elmer, USA).

Wettability: Titanium implants dipped in pure water were visually inspected for hydrophilicity.

3. Results

Analyses of SurfLink® Dental treated titanium surfaces showed (see also Figure 1):

- **QCM-D:** Treatment of titanium coated quartz crystals with SurfLink® Dental was associated with a significant and rapid decrease of frequency and little or no change in dissipation. The decrease in frequency is indicative of adsorption of the molecule to the surface. The results show that a SurfLink® monolayer formed already within minutes. No difference in dissipation suggests that the SurfLink® molecules do not change the viscoelastic properties of the surface. Rinsing of the crystals with water after SurfLink® Dental treatment results in an unaltered frequency, implying a stable bond of SurfLink® to the titanium surface.
- **XPS:** The spectra showed the presence of phosphorous, titanium, oxygen and carbon on the surface of SurfLink® Dental treated implants. The chemical shift of the phosphorous peak is consistent with a phosphate-like structure (133.5-134.5 eV). In contrast no phosphorous could be detected on the control implants.
- **FTIR:** The characteristic vibrational band of the P-O bond [3] was observed at around 1150 cm^{-1} after surface treatment with SurfLink® Dental, while it was not present on control surfaces.
- **Wettability:** SurfLink® Dental treated titanium implants were observed to be highly hydrophilic (i.e. implant surface with high affinity to water) by virtue of the SurfLink® chemical structure resembling that of phosphates, which are highly soluble in water. In comparison control implants were noted to be hydrophobic (i.e. water repellent implant surface).



The QCM-D results confirm the rapid binding of SurfLink® to titanium surfaces (frequency decrease) and its stability (stable frequency signal upon water rinsing).

The XPS spectra of SurfLink® Dental treated implants (red in the Figure) showed the presence of phosphorous while on control implants (blue in the Figure) phosphorous was not detected.

FTIR comparison of the spectra of TiO_2 films before and after SurfLink® Dental treatment clearly indicates binding of SurfLink® to the surface (P-O vibrational band at around 1150 cm^{-1}).

The wettability studies showed SurfLink® Dental treated implants to be hydrophilic, whereas control implants were hydrophobic.

Figure 1: Characteristic Features of a SurfLink® treated titanium surface.

4. Conclusion

SurfLink® binds efficiently to titanium and results in a highly hydrophilic dental implant by virtue of a biomimetic phosphate-like monolayer on the surface.

Hydrophilicity is an important feature for cell adhesion and cell colonisation onto the implant surface [4,5,6]. In contrast to very hydrophobic surfaces (e.g. Teflon), SurfLink® Dental treated implants are expected to favour bone cell colonisation, thus furthering biocompatibility [7].

5. References

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