BIOMECHANICAL AND HISTOMORPHOLOGICAL RESULTS OF HYDROPHILIC SURFACE MODIFICATION

S.J. Ferguson [1], J.D. Langhoff [2], K. Voelter [2], B. von Rechenberg [2], T. Hefti [3], F. Schlottig [3]

[1] MEM Research Center for Orthopaedic Surgery, University of Bern, Bern, Switzerland
[2] MSRU, University of Zürich, Zürich, Switzerland
[3] Thommen Medical, Waldenburg, Switzerland

INTRODUCTION

The use of osseointegrated dental implants is a predictable and successful treatment method for functional restoration of the endentulous patient. A satisfactory clinical outcome relies on primary stability for load bearing immediately following implantation. This requires mechanical anchorage and osseointegration within a short healing time. While the geometric design of an implant contributes towards mechanical stability, the nature of the implant surface itself is of critical importance for achieving solid osseointegration [Albrektsson et al, 1981]. The most important surface properties are topography, chemistry, surface charge and wettability.

In the present study, titanium dental implants with the same geometry, but with two different surface treatments, were tested. The osseointegration and the removal torque were compared after 2 weeks of implantation. The first surface treatment was sandblasting and acid etching (SA), the second treatment was sandblasting and acid etching with an additional weak alkaline rinsing (SA+) to create a hydrophilic modified implant.

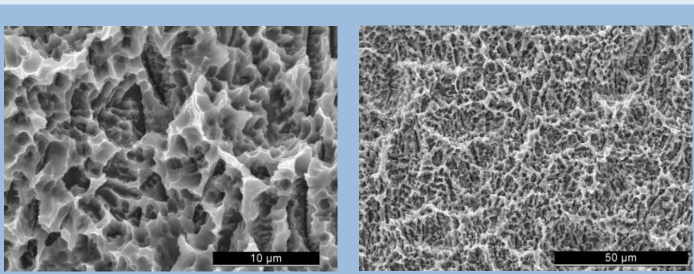

Figure 1: Scanning electron microscopy images of the surface topography of the tested implants. Both tested implants were sandblasted and acid-etched (SA), and therefore had identical surface topography. The SA+ implant group had an additional weak alkaline rinsing.

METHODS

Implants were inserted in the pelvis of sheep, a location which provides relevant bone structure while allowing comparative testing of many implants in one animal. Per group, 6 implants were used for biomechanical evaluation and 6 implants for histomorphometric evaluation.

Following sacrifice after a two week healing period, macroscopic, radiographic and histomorphometric examinations were conducted. Implants and surrounding bone were removed en bloc, PMMA embedded and thick sections (100 – 400 µm) were prepared on a diamond saw microtome. Micro-radiographic images were obtained using a Faxitron X-Ray system. Thick sections were surface ground and stained with Toluidine blue, mounted on a macroscope, digitally photographed and the images transferred to image analysis software. 12 sectors per image were analyzed to determine the Bone Implant Contact Line (% of implant interface in direct contact with bone).

Removal torque measurements were performed on the day of sacrifice. Individual bone blocks with implants were separated and embedded in dental plaster. Implants were first attached via a custom coupling to the rotary actuator of an MTS MiniBionix servohydraulic testing machine to ensure alignment of the implant with the axis of the actuator. Implant-and-bone blocks were then lowered into a metal container and the container filled with a low-melting-temperature (47°C) alloy to rigidly couple the bone block to the testing frame. Removal torque was performed at a constant rotation rate of 0.1°/sec and the torque-rotation curves were analyzed for the maximum removal torque (N.mm).

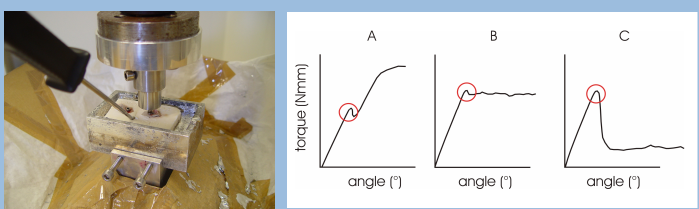

Figure 2: Removal torque testing was performed on a MTS MiniBionix testing machine (left). Implants were rotated counter-clockwise at 0.1°/sec and the resulting torque-rotation curves recorded. Typical torque-rotation curves (right) show possible biomechanical performance of the implant-bone interface. The removal torque value was defined as indicated by the red circles. Implants typically displayed the response C.

RESULTS: Histomorphological

All dental implants were well integrated at the time of sacrifice. Both macroradiographic and histological images showed new bone formation around the implants and a good bone implant contact. BIC line values were 59.8% ± 22.8% for the sandblasted and acid etched implant and 70.7% ± 7.1% for the sandblasted, acid etched and alkaline rinsed implant. No signs of inflammation were observed.

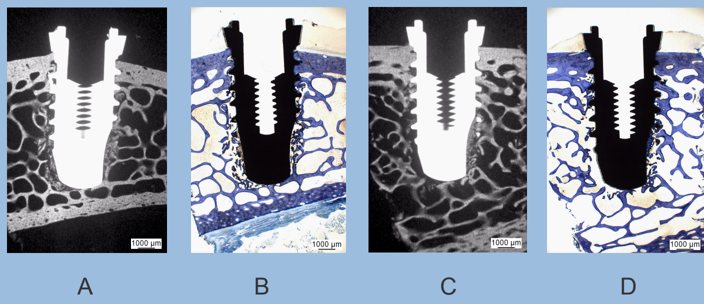

Figure 3: Macroradiographic and histological images of the tested implants. Thick-section (100 µm) histology specimens have been stained with Toluidine blue to highlight new bone formation. Both the sandblasted and acid-etched implants (A, B) and sandblasted, acid-etched and alklaine-rinsed implants (C, D) showed good bone implant contact and new bone formation at the interface already at two weeks. BIC line values were moderately better for the SA+ implants

RESULTS: Torque Testing

No signs of implant loosening were observed in the biomechanical testing. Removal torque values were not significantly different between the two groups. Variability in the torque values was lower for the sandblasted, acid-etched, alkaline-rinsed surface modification. Mean values for removal torque were also higher, although the current test lacked the statistical power to confirm this trend at 2 weeks. Removal torque values were consistent with previous results of in vivo osseointegration, taking into account differences in implant geometry.

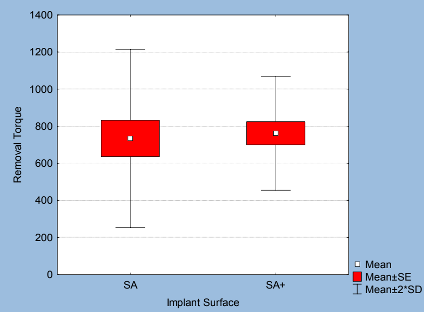

Figure 4: Removal torque values (N.mm) for the sandblasted and acid-etched implants (SA) and sandblasted, acid-etched and alklaine-rinsed implants (SA+). 6 implants were tested per group. No significant differences were found between the two groups, however the hydrophilic modified implant demonstrated a lower variability in the biomechanical testing results and a slightly higher mean value.

DISCUSSION

In the present study, titanium dental implants with the same geometry, but with two different surface treatments, were tested. Although there were no significant differences observed in removal torque values between the investigated surfaces, for the hydrophilic modified implants, there was a trend towards better results for both the histological and biomechanical evaluation, compared to the unmodified surface.

Improved osseointegration and higher interfacial strength has been observed in previous studies of surface-modified implants [Ferguson et al, 2006], although a direct comparison of results is difficult due to varying implant size, geometry and animal model used in each study.

The animal model used for the current study represents a challenging environment for evaluating osseointegration. Implants are placed in regions with both cortical and cancellous bone. Primary stability is potentially lower than in the previously-reported mandible model, thereby highlighting potential benefits of implant surfaces which promote an accelerated formation of new bone.

Further studies are planned to verify these short-term observations in other animal models at different time points.

REFERENCES: [1] T. Albrektsson *et al*, Acta Orthop Scand, 1981; **52**:155 – 170. [2] S.J. Ferguson *et al*, J Biomed Mater Res A, 2006; **78**:291-7

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Correspondence to:
Falko Schlottig
Thommen Medical AG
Falko.Schlottig@thommenmedical.com