Integration of Neoss ProActive implants in comparison with other brands of dental implants

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The present paper summarizes the experiences from an experimental rabbit model, which has been used by the research group to evaluate different brands of dental implants using removal torque measurements.

INTRODUCTION

Osseointegration is a biomechanical and biological treatment concept using bone-integrated fixtures to provide patients with anchorage for predictable long-term function of various types of dental and extra-oral prostheses and hearing aids. An implant obtains mechanical stability already at the time of placement surgery due to compression of the bone.

The level of primary stability is mainly determined by bone density but also drilling technique and implant design will have impact. The surgical trauma when preparing the osteotomy induces a repair process, which for a successful implant results in bone integration, i.e. new bone formation and remodeling at the bone-implant interface.

Historically, osseointegration has been studied and evaluated in histological ground-sections where the bone-implant interface is studied by light microscopy. The bone response can be quantified by measurements of different parameters such as percentage of direct bone-implant contact (BIC) and bone fill inside the implant threads. However, the morphometric data do not say anything about implant stability. For this purpose, removal torque (RT) measurements in Ncm have been used in many animal studies, where threaded implants have been unscrewed until failure after different time points following placement surgery. This technique measures the strength of the interface and is, for the same implant design, determined by the degree of direct bone contacts, type of bone (cortical vs cancellous) and maturation (time after surgery). It is anticipated that high degrees of BIC and RT indicate a stronger bone tissue response than low degrees of BIC and RT.

Research has shown that different surface topographies may result in different integration patterns and show different degrees of BIC and RT values. It is generally believed that moderately rough surfaces are superior to smooth surface topographies in this respect. Clinical studies have indicated higher survival rates for moderately rough implants compared to smooth ones and particularly in challenging situations such as in immediate/early loading and bone augmentation protocols.

Today, the majority of the commercially available implants have a surface texture as produced by different techniques such as blasting, acid etching, oxidation, coating and combinations of methods. This means that different brands also have different surface characteristics, which may well result in different bone tissue responses during healing.

The first generation of Neoss implants were provided with a Bimodal surface, which was created by double blasting. This resulted in a surface topography with relatively
low surface roughness. Although the overall clinical outcomes were good in the majority of cases, increased failure rates have been experienced in challenging cases such as GBR procedures and immediate/early loading protocols.\textsuperscript{13,14} Since 2009 the Neoss implants have a moderately rough ProActive surface, which is created by a combination of blasting and acid etching. The surface is hydrophilic due to electrowetting when in contact with fluids such as blood. Clinical data points to excellent outcomes also in GBR and immediate loading cases, which indicates a rapid and strong bone tissue response to ProActive implants.\textsuperscript{14-16}

The purpose of this paper was to present removal torque data from a rabbit model used by the authors to evaluate different types of commercial dental implants.

### MATERIALS & METHODS

The present research team have conducted a number of experimental studies to evaluate the integration and stability of various implant systems after different time points of healing.\textsuperscript{17-19} Data from three rabbit studies using removal torque measurements of in total eight implant types representing different geometries and surfaces (Table 1) were compiled in the present report. This rabbit model have been used extensively by many researchers and described in detail elsewhere. In brief, the implants had been surgically placed in the distal femoral condyles and proximal tibial metaphyses in adult rabbits. The implants had been used for histological ground-sectioning and subsequent histomorphometric analyses or subjected to removal torque measurements (Table 1).

A specially-designed rig consisting of an electrical torque transducer and a torsion rod was used for removal torque measurements. The rod was connected to the implant, an electric motor ramped the torque, which was registered and stored by a microprocessor. At the point of interfacial failure, the peak dropped and a slight rotational movement of the implant was observed. The peak torque was registered for each implant. A mean value was calculated for each implant type and time point. Only torque data from implant sites in the tibia were used for comparison.

### RESULTS

Histological analyses showed bone integration by contact osteogenesis for both ProActive and Bimodal surfaces. This means that bone formation is induced directly on the implant surface and, consequently, bone forms from the surface and outwards (Figure 1).

<table>
<thead>
<tr>
<th>Brand</th>
<th>Implant</th>
<th>Dimensions</th>
<th>Surface</th>
<th>Number per time point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straumann</td>
<td>BoneLevel RC SLActive</td>
<td>4.1 x 8 mm</td>
<td>SLActive: Sandblasted and acid etched</td>
<td>10</td>
</tr>
<tr>
<td>AstraTech</td>
<td>OsseoSpeed Implant</td>
<td>4.0 x 8 mm</td>
<td>OsseoSpeed: Grit blasted with TiO\textsubscript{2} particles, fluoride modified</td>
<td>10</td>
</tr>
<tr>
<td>Zimmer</td>
<td>Tapered Screw-Vent Implant</td>
<td>3.7 x 8 mm</td>
<td>MTX: grit-blasted with a soluble medium</td>
<td>10</td>
</tr>
<tr>
<td>Implant Direct</td>
<td>ScrewPlant Implant</td>
<td>3.7 x 8 mm</td>
<td>PB: Blasted with Soluble HA Particles</td>
<td>10</td>
</tr>
<tr>
<td>Osstem</td>
<td>GS II Fixure Implant</td>
<td>4.0 x 8.5 mm</td>
<td>RBM: Blasted with Soluble HA Particles</td>
<td>10</td>
</tr>
<tr>
<td>Nobel Biocare</td>
<td>Replace Select Tapered</td>
<td>4.3 x 10 mm</td>
<td>TiUnite: Oxidized</td>
<td>10</td>
</tr>
<tr>
<td>Neoss</td>
<td>ProActive Straight</td>
<td>4.0 x 11 mm</td>
<td>ProActive: Blasting with Ti particles, acid etching, chemically modified</td>
<td>10</td>
</tr>
<tr>
<td>Neoss</td>
<td>Bimodal Straight</td>
<td>4.0 x 11 mm</td>
<td>Bimodal: Double blasting with ZrO\textsubscript{2} spheres and Ti particles</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 1: Type of implants and surfaces used in the studies

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**Figure 1:** Light micrograph of the ProActive surface after 10 days of healing showing contact osteogenesis. New bone (NB) has been formed directly on the implant (Ti) surface. Active osteoblasts (arrows) followed by a layer of osteoid (O) can be seen. BM = bone marrow.
One study comparing 4.0 x 11 mm Neoss ProActive and Bimodal implants showed a marked and significantly higher RT for the ProActive surface after 10 days, 3 and 6 weeks after insertion (Figure 2). The ProActive surface reached the same stability already after 10 days as the Bimodal surface showed after 6 weeks.

Figure 3 shows the outcome of the removal torque tests of the various commercial brands of dental implants. It is obvious that the blasted and acid etched and hydrophilic implants (Neoss ProActive and Straumann SLActive) as well as oxidized implants (Nobel Biocare) showed higher torque values than the implants subjected to blasting with Ti- or HA-particles only (Osstem, AstraTech, Implant Direct).

Although no statistical test have been applied, the Neoss ProActive implant showed numerically higher RT values after three weeks when compared with the other brands. However, after six weeks both the Straumann SLActive and Nobel Biocare TiUnite surfaces showed similar high RT values as the Neoss ProActive surface.

**DISCUSSION**

The removal torque test measures the strength of the bone-implant interface and the result depends on many factors, such as the anatomy of the implant site, time after placement, implant geometry and implant surface. The test reflects how bone is interlocking with the implant surface as a result of bone formation and maturation. This is of particular importance in cases where short healing periods are used, since the implants will be subjected to rotational forces when attaching and loosening abutments, impression copings and prosthetic devices.

The implant types evaluated in this report represented different geometries (length, diameter, thread design) and surface characteristics (blasting, acid etching, oxidation), while the site anatomy and time factors were the same. It can be rightfully argued that the comparison of different diameters is unfair as, for instance, the implant radius has an impact on the outcome. From a strict scientific point of view only one parameter at the time should be varied.
This can be done by changing the surface properties on identical implant designs,21 which was also the case when comparing ProActive and Bimodal surfaces.19 However, the experimental studies comparing different brands were performed in order to evaluate the actual implant types recommended by the manufacturers for routine clinical use. From this perspective, the Neoss ProActive surface showed the highest RT values followed by the Straumann SLActive and Nobel Biocare TiUnite surfaces, particularly after 3 weeks of healing. However, since no statistical tests were applied due to the design of this report, it is not known if the differences were significant.

It is concluded that the Neoss ProActive surface provokes a rapid and strong bone tissue response after surgical placement, which results in high resistance to torque after 10 days, 3 and 6 weeks of healing in a rabbit model. In this respect, the Neoss ProActive surface performs better or similar to other brands of dental implants.

REFERENCES