New standards in osseointegration quality – Titanium-zirconium implants

Results from animal studies have shown that there are differences in the quality of osseointegration around TiZr implants compared to titanium.

Introduction

Titanium is a widely used material for dental implants, due to its physical properties and biocompatibility. Furthermore, titanium implants in combination with the SLActive® surface have shown increased treatment predictability. However, some evidence has suggested that the mechanical properties of titanium may be slightly limited, especially in the use of small-diameter implants. There is less surface available for osseointegration, which may make narrow-diameter implants more susceptible to adverse loading forces. To address this, a titanium-zirconium (TiZr) alloy has been developed specifically for dental implantology. Roxolid® has demonstrated excellent tensile strength, providing confidence in the use of small-diameter implants, and excellent clinical outcomes in terms of treatment predictability. Roxolid® has also shown excellent osseointegration comparable to titanium implants.[1,2]

Are there signs that Roxolid® could be the new material of choice for dental implants, not only for small-diameter implants, but generally for other implants with reduced surface area or in critical protocols? The results of some recent preclinical investigations, which had the goal of investigating the osseointegration and peri-implant bone healing around Roxolid® implants with the SLActive® surface, shed some light on these questions.

Preclinical investigations

In the first study (Gottlow et al. 2012)[3], implants made from Roxolid® or titanium, both with the SLActive® surface, were placed in the mandibles of minipigs. The implants were either bone chamber-type (for histological evaluation) or standard with a squared head (for removal torque evaluation) **(Figure 1)**. Histological analyses (using biopsies with the implants and surrounding tissue) and removal-torque testings were performed after 4 weeks. Another recent publication of this study by Anchieta et al. in 2013[4] assessed the mechanical properties of the peri-implant bone.

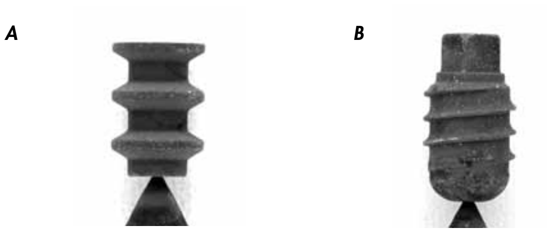

Fig. 1: *The implant designs for histological evaluation (A) and removal-torque testing (B)[3].*

A more recent study (Wen et al. 2013)[5] involved removal of the ovaries from rabbits (ovariectomized group) or a similar surgery without ovary removal (SHAM-operated group). Ovariectomy induces osteoporosis, a skeletal disease often present in post-menopausal women that reduces bone mineral density. Each group received either Roxolid® or titanium implants, both with the SLActive® surface. Removal-torque testings and histomorphometric analyses were carried out after 3 and 6 weeks.

Outcomes

In the Gottlow et al. study, values for removal torque (the amount of force required to remove the implant) were significantly higher for the Roxolid® implants compared to the titanium implants (mean 230.9 ± 22.4 Ncm versus 204.7 ± 24.0 Ncm; $p = 0.013$), indicating higher biomechanical stability around Roxolid® **(Figure 2)**. In the histological analysis, the bone area within the chamber was also significantly greater for Roxolid® compared to titanium (mean bone area 45.5 ± 13.2 % versus 40.2 ± 15.2 %; $p = 0.023$) **(Figure 3)**. The degree of bone-to-implant contact (the amount of bone in direct contact with the implant surface; BIC) was similar between titanium and Roxolid®. These findings suggested that, while the amount of osseointegration around Roxolid® implants is no different to titanium implants, the greater removal torque indicates that the biomechanical quality of the bone may be better.

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The results in the publication by Anchieta et al. showed that the elastic modulus and hardness of the bone around the implants after 4 weeks was similar between Roxolid® and titanium. This suggests that the higher implant stability reported in the Gottlow publication may be due to higher bone area rather than faster mineralization of bone. The higher bone area could be due to the different mechanical properties of the two implant materials and/or to the surface topography, which is similar but not identical between the two types of implants at both micro and nanolevel.

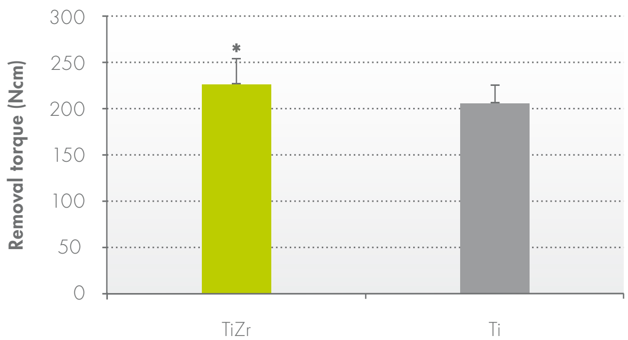

Fig. 2: *Removal-torque values for TiZr (Roxolid®) versus Ti (*p < 0.05)[3]*

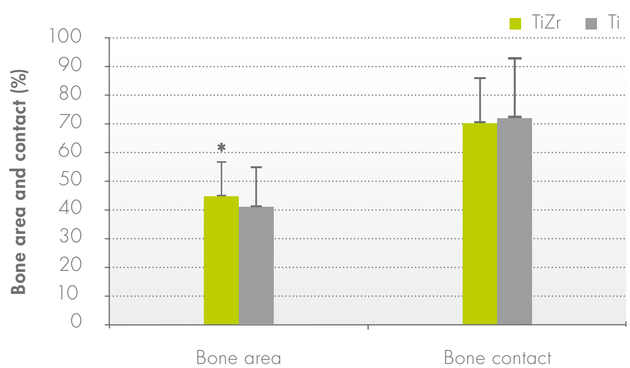

Fig. 3: *Bone-area and bone-contact values for TiZr (Roxolid®) and Ti (*p = 0.023)[3]*

The Wen et al. study showed similar findings for removal torque, with significantly higher values for Roxolid® compared to titanium in both the ovariectomized and SHAM-operated groups **(Figure 4)**. Peak torque was increased in all groups after 6 weeks. BIC and bone area to total area (BA/TA) increased in the SHAM-operated group from weeks 3 to 6. The BIC and BA/TA values were similar for Roxolid® and titanium implants. This study demonstrated the excellent biomechanical properties of Roxolid® for the first time in a compromised model. The higher removal torque, which suggests superior bone quality around Roxolid® implants, may be related to greater mineral content and deposition.

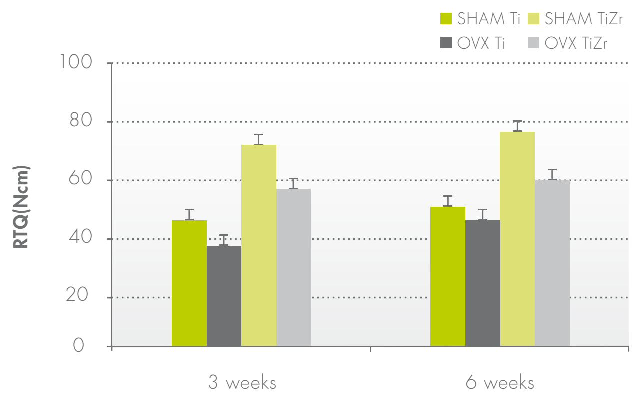

Fig. 4: *Higher removal-torque values for TiZr (Roxolid®) and titanium implants in ovariectomized and SHAM-operated animals[5]*

Conclusions

The outstanding osseointegration values of Roxolid® implants with the SLActive® surface were demonstrated in these studies. Besides demonstrating these properties for the first time in a compromised animal model, the higher removal-torque values show excellent osseointegration with Roxolid® with the SLActive® surface and may indicate superior bone quality around Roxolid® implants, compared to Ti implants.

References

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International Headquarters
Institut Straumann AG
Peter Merian-Weg 12
CH-4002 Basel, Switzerland
Phone +41 (0)61 965 11 11
Fax +41 (0)61 965 11 01

Straumann North America Headquarters
Straumann USA, LLC
60 Minuteman Road
Andover, MA 01810
Phone 800/448 8168 (US) ■ 800/363 4024 (CA)
Fax 978/747 2490
www.straumann.us ■ www.straumann.ca

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