Greater Bone Formation within Tantalum-based Porous Engineered Dental Implant

Jin Whan Lee, PhD, Suneel Battula, PhD, Hai Bo Wen, PhD, Michael Collins, MSE, MBA, Georgios E. Romanos, DDS, PhD, Prof. Dr. med. dent.

1 Zimmer Dental, Carlsbad, CA, 2 Stony Brook University, Stony Brook, NY

Background

Tantalum (Ta)-based porous dental implants were designed for bone-to-implant contact as well as bone ingrowth into the porous structure in order to augment anchorage of the implant. The Ta-based porous implant uniquely differs from other implants due to the structural and mechanical features of its pores, such as a cancellous bone-like 3D structure, high coefficient of friction, high porosity up to 80%, average pore size of 430μm, and low modulus of elasticity of 3GPa. When Ta-based porous implants were placed in the healed extraction sites of canines, new bone formation within the pores and implant stability were confirmed during early healing. This study was aimed at further histological evaluations of bone tissue response to the porous mid-section of Ta-based porous implants placed in the fresh extraction sockets of canines.

Methods

Twenty-four Ta-based porous test implants (Trabecular Metal™ Dental Implants, Zimmer Dental Inc.) and 24 threaded control implants (Tapered Screw-Vent® Implants, Zimmer Dental Inc.), 4.1mm in diameter and 13mm in length, were placed into 2 premolar (P3 and P4) and 2 molar (M1 and M2) mandibular fresh extraction sockets bilaterally in 6 canines. Implants were allowed to heal for 2, 4 or 12 weeks (two animals per time point). The mandibular jaws from all animals were removed and implants were retrieved en bloc. The specimens were immediately placed in 10% neutral buffered formalin for 48 hours. After fixation, the tissue blocks were trimmed and embedded in PMMA, yielding a total of 48 blocks. Each block was cut to make two sections in the buccolingual direction along the central plane. Each section was ground and polished to approximately 80 μm in thickness. Sections were surface-stained with Sanderson and Van Giesen, and histologically analyzed. For histomorphometric analysis, the region of interest (ROI) was defined as the area encompassing the entire length of porous Ta section (6.00 mm long × 0.35 mm deep) in the test group and the corresponding threaded region in the control group (Fig. 1).

Results

As no implant failures occurred during or after the surgeries, none of the implants were removed prior to the scheduled necropsy. Both groups showed a progression of new bone formation over the healing periods.

Discussion

The histologic and histomorphometric evaluations of the implant midsections revealed different types of bone tissue responses between the control and test groups. Test group demonstrated progressive osseointegration and bone growth into the Ta pores (osseocorporation), while control group was limited to bone growth onto the Ti alloy surfaces (osseointegration).

Significance

In a canine fresh extraction socket model, histologic and histomorphometric evaluations revealed more new bone formation associated with the Ta pores than with the conventional threaded design during the early healing phase.

References


Figure 1. The region of interest (ROI): The entire length of porous Ta section (6.00 mm long × 0.35 mm deep) for the test group and the corresponding threaded region for the control group.

Figure 2. Representative histologic images for control and test groups per healing time. Sanderson and countered Van Giesen stains. 4×, 10×, 20× mag, respectively.

Figure 3. Progression of newly formed bone along with active bone-forming cell activities was identified to the surface of Ta pores in the test group (Sanderson and countered Van Giesen stains. 4×, 10×, 20× mag, respectively).

Figure 4. Amount of new bone observed in Ta pores of the test group vs. corresponding threads of the control group (*: Statistical significance at p<0.05).