Progression of Bone Formation in a New Tantalum-Based Porous Implant

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1 Background

A number of porous coatings have been adapted for dental implant use to enhance the osseointegration and minimize micromovements at the bone-implant interface. [1,2] Bone ingrowth was however limited by the degree of surface porosity and pore size of the coating.[2] A biomimetic and highly porous tantalum material, branded as Trabecular Metal™ (TM) material, was developed to facilitate bone ingrowth via a porosity up to 80%. A dental implant assembly with a combination of conventional threaded region and new TM material was developed. Review of early clinical findings of a new tantalum (Ta)-based porous implant under immediately loaded conditions indicate high survival rate and minimal peri-implant bone loss.[1] However, there is still limited understanding on how bone ingrowth into tantalum implant pores affect the implant's clinical performance. The objective of this study was to investigate how bone formation progresses into tantalum pores over extended healing periods in canines.

2 Materials and Methods

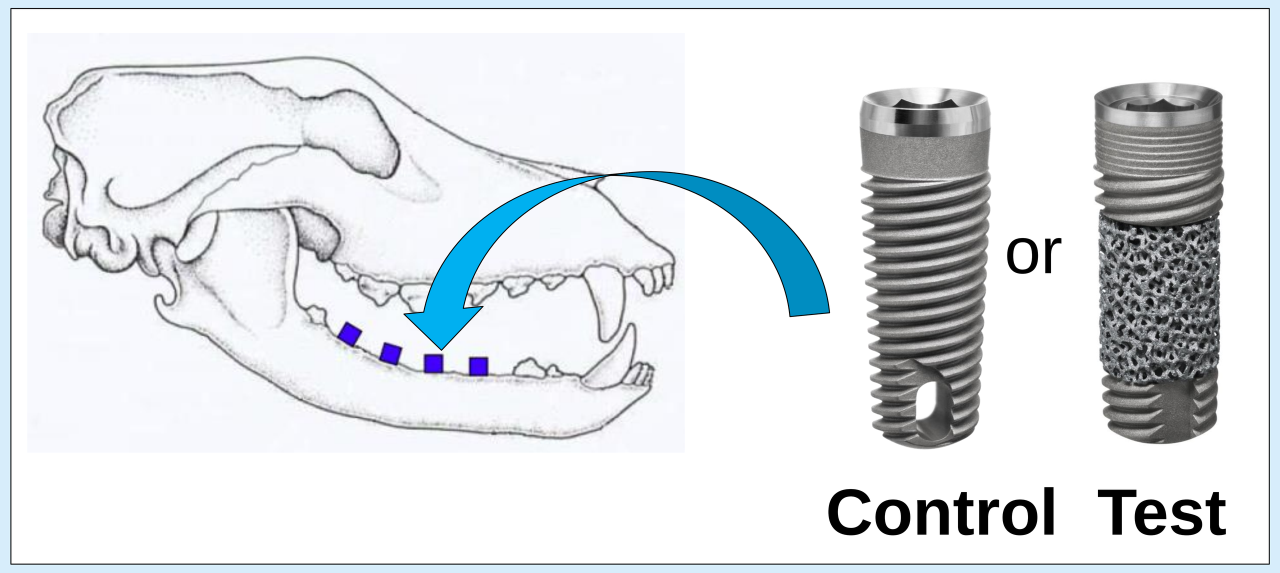

Figure 1: *Implant placement in premolars and molars in a canine model.*

Extractions of 2 premolars and 2 molars in mandibular sockets were conducted bilaterally on 10 canines. Forty porous test implants (TM dental implants) and 40 threaded control implants (Tapered Screw-Vent® implants) were immediately placed after extractions (4 test and 4 control implants per dog) by random assignment. All implants were 4.1mm diameter by 13mm in length. The extraction sockets were filled with bone graft material (Puros® Cancellous Particulate) and covered with a collagen membrane (BioMend® Extend). Resonance frequency analysis (RFA) was performed at implant placement and at necropsy. Two dogs each were euthanized at 2, 4, 12, 24 and 38 weeks. Histological sections (one section per dog) were obtained at necropsy and were stained with Sanderson's rapid bone stain to assess percent bone-implant-contact (%BIC), amount of bone formed. %BIC was measured along the entire length of the implant and total amount of bone formed was compared due to the differences in the geometries of the implants. Effects of implant type on the histomorphometric parameters were statistically analyzed.

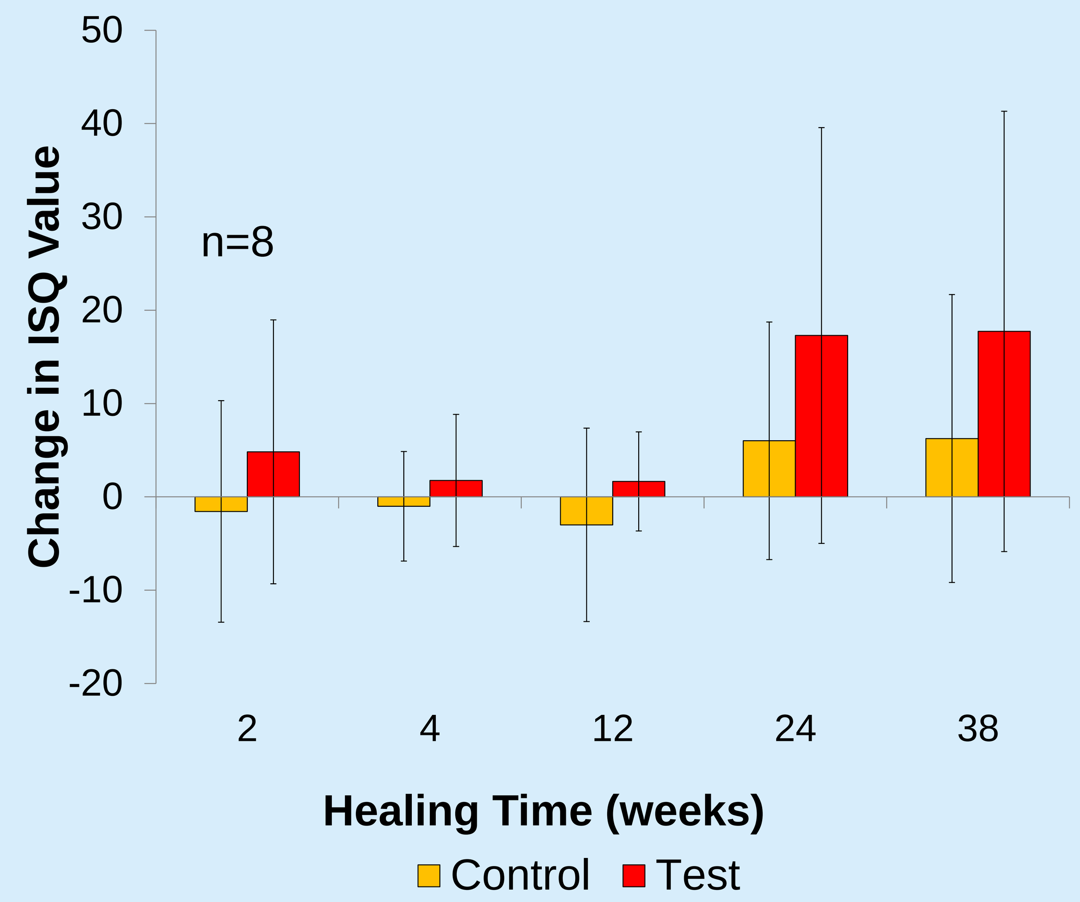

Figure 2. *Change in ISQ values from the time of placement for different time points.*

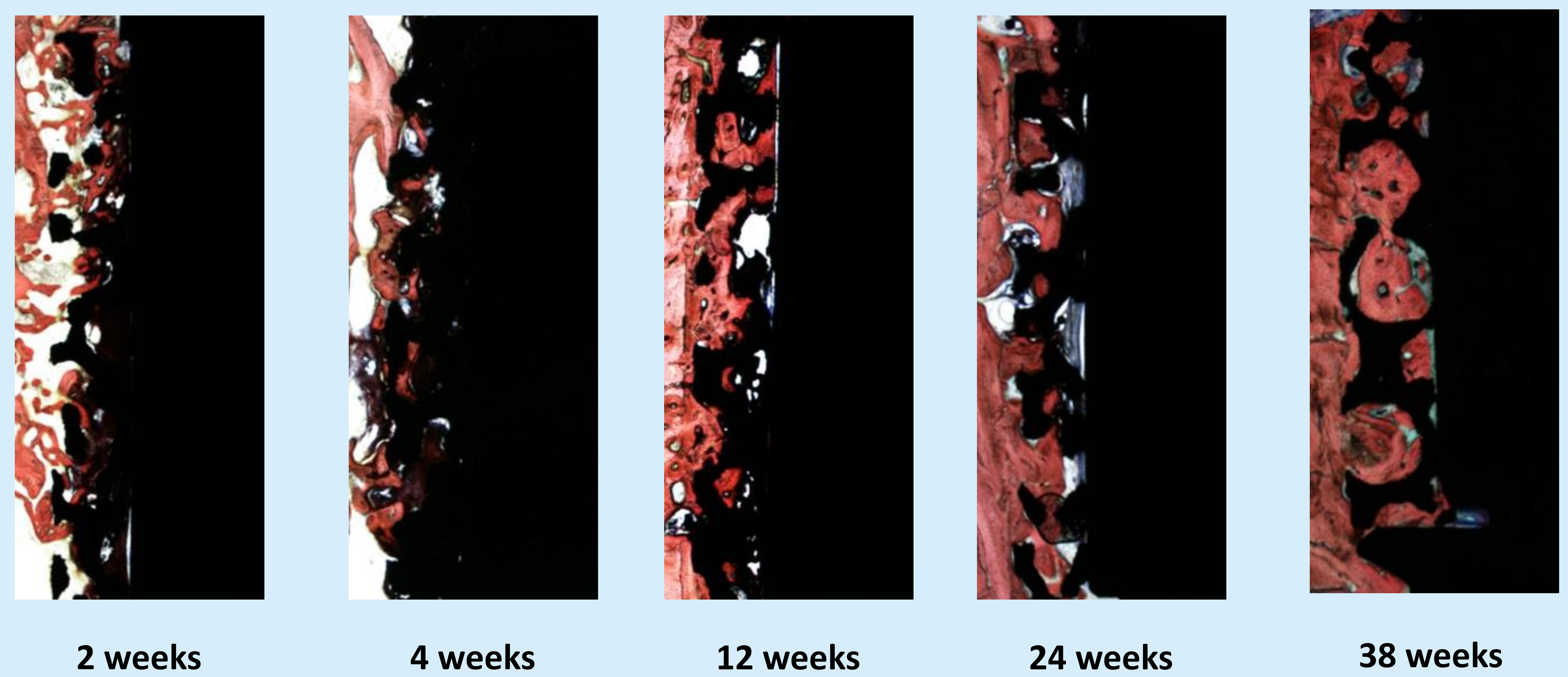

Figure 3. *Representative histology images of bone formation in and around TM pores over 38 weeks of healing (Sanderson stain countered by Van Gieson stain).*

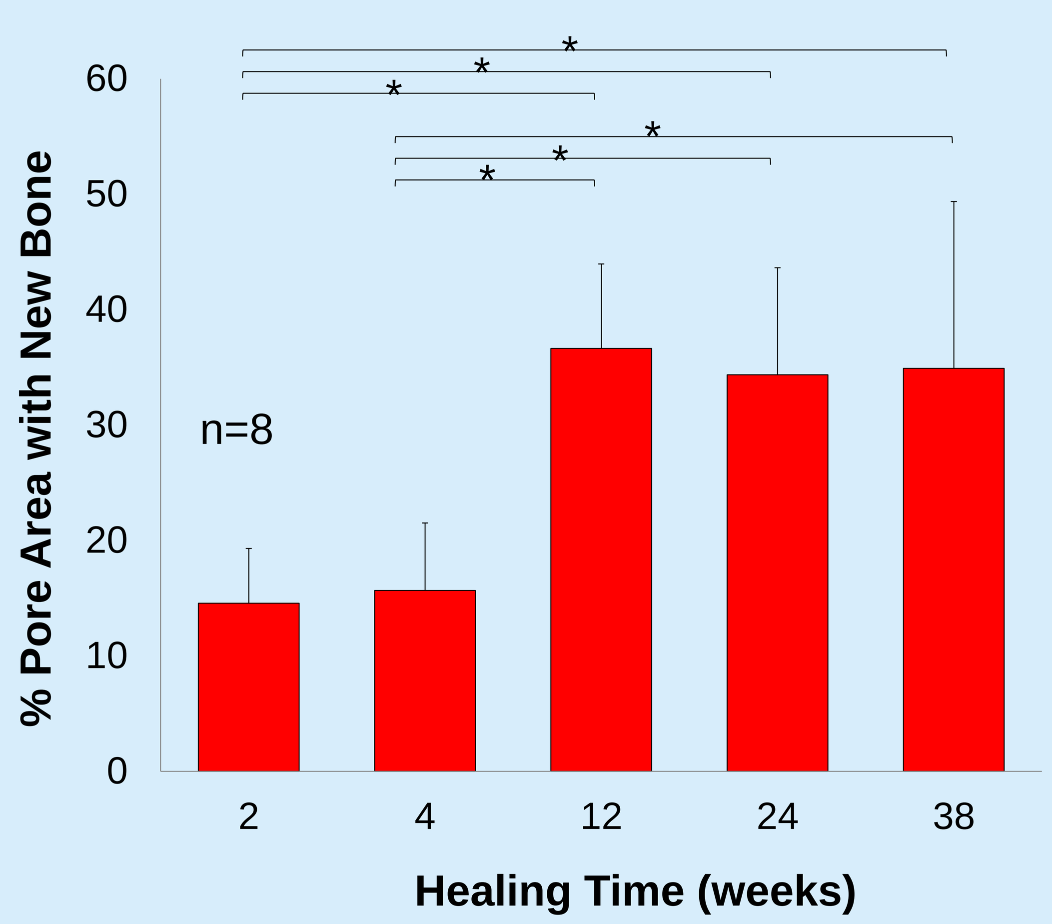

Figure 4. *Percentage of TM Pore Area occupied with new bone (* p < 0.05)*

3 Results

All implants survived, control implants showed osseointegration and test implants showed osseoincorporation clinically and histologically. Implant stability quotient (ISQ) values were measured at implant placement and at necropsy and change in ISQ values was calculated as the difference between the two values for each healing time point. Although the change in ISQ values over the healing was not statistically different between two groups ($p>0.05$), the test group showed a positive trend of increase in average ISQ values (Figure 2). ISQ values have been correlated to the density of marginal bone.[3] Hence the trend observed here can be attributed to increase in density of marginal bone for the test group of implants. The average %BIC at the threaded regions of both implant systems ranged from 25% to 39% at early healing periods (2-4 weeks) to 47% and 73% at later healing periods (12-38 weeks). %BIC values showed no statistical difference between the two groups ($p>0.05$). For the entire porous section, the amount of new bone in the pores was observed to be approximately 15% ($p>0.05$) at 2 & 4 weeks, and then significantly increased to 37% at 12 weeks ($p<0.05$), remaining a plateau at 24 & 38 weeks ($p>0.05$) (Figure 4). The newly mineralized bone formation, modeling and remodeling were consistently observed for both the porous and threaded regions. The porous region was partially occupied with new bone at week 2, substituted with the primary trabeculae of woven bone in the subsequent weeks, and eventually replaced with more mature bone tissue with parallel fibers and marrows, particularly evident at week 38 (Figure 3). Increasing amounts of new bone formed in tantalum pores over healing was well corroborated by histology observations. No evidence of bacterial infection was observed in either group.

4 Conclusion

In a canine model, the new dental implant with tantalum-based porous midsection, though not statistically different, achieved an increased trend in implant stability quotient values when compared to a traditional threaded dental implant. Additionally, the tantalum-based porous midsection showed progressive bone ingrowth over extended healing periods.

5 References

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