Peri-implant and Periosteal Responses of Titanium and Zirconia Implants in a Rabbit Model

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Introduction: Though zirconia implant has been studied for its in vivo response by many researchers, its effect on the periosteal activity in the peri-implant region has never been investigated. The purpose of this project was to study the effect of implant type on periosteal activity using a noncoated threaded zirconia implant and a noncoated threaded titanium implant in a rabbit tibial model.

Methods: Five healthy male New Zealand White Rabbits and a total of 20 implants were used. Two screw-shaped threaded commercially pure titanium implants and two screw-shaped threaded zirconia implants of 7.0 mm in length and 3.5 mm in diameter were randomly inserted into the right and left mid-tibial diaphysis. In order to label the amount of mineralized bone, a 10 mg/kg dose of calcein green solution was administered at both 26 days and 27 days post-implantation. Six weeks after implantation, animals were euthanized and specimens were obtained. Half of the specimens were subjected to biomechanical testing (removal torque analysis; RT) while the other half was embedded in polymethylmethacrylate (PMMA) un-decalcified and sectioned. Only histomorphometry data were reported here. The degree of bone contact with the implant surface (BIC), and bone area in between the threads (BA) were measured at the four-most coronal threads. In addition, the amount of mineralizing surface (MS) was assessed by measuring the length of the labeled bone surface and divided that by the circumferential length of the periosteum. A paired t-test was used. The level of significance was set to $p < 0.05$.

Results/Discussion: Histology shows intimate contact between the implant and regenerated bone (Fig. 1). No statistically significant difference was detected between the zirconia and titanium groups in terms of BIC values. For the zirconia and titanium groups, the BIC was 26.0% ± 17.2% and 35.8% ± 21.8%, respectively. On the other hand, statistically significant differences were demonstrated in a) the BA levels (zirconia = 72.0% ± 11.1%; titanium = 81.0% ± 8.9%) (Table 1). Fluorescence light micrograph of calcein labeled specimens (Fig. 2b) shows statistically significant higher periosteal mineralizing bone surface in titanium samples then zirconia samples (Table 1). We suspect the differences in the periosteal response and the bone area within threads are mainly due to the differences between the elastic modulus of the two implants.

Table 1.

	Bone-to-Implant (%)	Bone Area (%)	Mineralizing Surface (%)
Titanium	35.8% ± 21.8%	81.0% ± 8.88%[a]	40.4% ± 18.2%[b]
Zirconia	26.0% ± 17.2%	72.0% ±11.12%[a]	22.7% ± 14.5%[b]

a, b, Letters indicate statistically significant differences between the two groups ($p<0.05$).
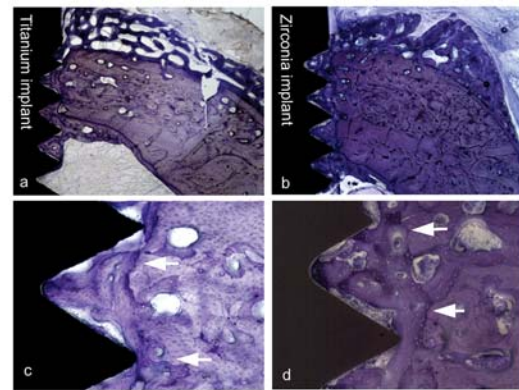

Figure 1 Bone-to-implant contact on a titanium surface (a) and a zirconia surface (b). Original magnification at 2.5x. Higher magnification of titanium implant (c) and zirconia implant (d). Original magnification at 10x (Arrows indicate a demarcation between original cortical bone and new bone growth occurring in between the threads.
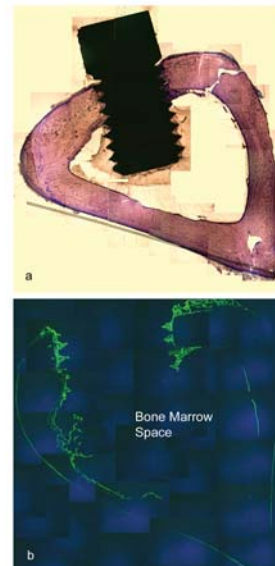

Figure 2 (a) Histological overview of titanium implant. Toludine blue stains. (b) Fluorescence light micrograph of a titanium implant at 6 weeks.

Conclusions: In this project, we demonstrated that zirconia implant significantly reduces the bone formation inside the thread as well as the periosteal mineralizing activity in the peri-implant region, though no differences in the BIC value were found. The cause for the reduced periosteal mineralizing activity and its impact on the long term success of the zirconia implant will be studied in the future.