Cortical Bone Fixation with Highly Porous, Rougher Porous Coatings of Titanium and CoCrMo

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Statement of Purpose: Joint replacement implant surfaces designed for osseointegration are commonly evaluated by implantation in diaphyseal cortical bone.[1-3] In this canine transcortical study, the bone ingrowth fixation of rough, highly porous coatings of CoCrMo and Ti, which may improve the initial mechanical stability of implants against bone,[4] was compared to that with a CoCrMo coating having a long history of clinical use by histomorphometry and push-out testing.

Methods: Control implants were CoCrMo cylinders coated with commercially available CoCrMo Porocoat™ porous coating (CPC) (45% mean volume porosity, 180 µm mean pore intercept length). Test implants were Ti6Al4V and CoCrMo cylinders coated with CP Ti or CoCrMo versions of a highly porous, rougher porous coating. The CP Ti coating (RTPC), available commercially as Gription™ porous coating (63% mean volume porosity, 220 µm mean pore intercept length), has been previously described.[4] The CoCrMo test coating (RCPC) (60% mean volume porosity, 220 µm mean pore intercept length) was prepared using non-spherical alloyed CoCrMo powder (150-300 µm) together with a base of spherical alloyed CoCrMo beads (150-300 µm) applied to a cast CoCrMo substrate and sintered in a typical high temperature vacuum furnace cycle.

Unicortical implants were placed bilaterally in the femoral diaphysis of skeletally mature, mixed breed hounds with 4 implants per femur (MPI Research, Mattawan, MI). All implants were 10 mm long with an axial threaded hole. A best fit to the implant diameter was measured with an optical comparator and the diameter recorded for selection of the final drill size during surgery. A drill guide[2] was used and sequential drilling performed with the final drill size selected for a slight press fit.[3] Implants were left slightly proud of the periosteal surface. Animals were sacrificed at 4 and 16 weeks. Five implants per group were processed undecalcified into ground sections and stained with Stevenel's Blue for quantitative histomorphometry. Bone ingrowth was calculated as the percentage of the total porous coating area within the region of cortical contact that was filled with bone. Statistical analyses were performed using ANOVA followed by pairwise t-tests.

Five implants per group were used for push-out testing. The push-out specimens were moistened with PBS throughout processing. Cancellous bone and soft tissue were carefully scraped to expose the implant to the endosteal surface. There was a 0.5 mm diametrical clearance between the implant and the push-out fixture through hole.[1,3] A threaded pin assembled to the periosteal side of each implant engaged the push-out fixture through hole to establish and maintain alignment during potting in dental acrylic (Bosworth Fastray). A 0.5 mm/min loading rate[3] was used and the push-out strength calculated from the peak load and post-test measurements of peri-implant cortical thickness. Statistical analyses were by 2-factor ANOVA with SNK post hoc tests.

Results: Representative images of bone ingrowth at 4 weeks with the RTCP and RCPC coatings are shown in Fig. 1. Bone ingrowth was significantly higher ($p=0.02$) for the RTPC group at 4 weeks but not 16 weeks (Fig 2). Push-out strengths were similar for each coating group and no significant differences were observed at either time point (Fig. 3). There were no differences in bone ingrowth between time points but there were significant differences ($p<0.05$) in push-out strength between time points for each group, suggesting maturation of the ingrown bone. The 4 week push-out strengths for the RTPC and RCPC coatings were similar to that reported by Bobyn[3] for porous tantalum foam at that time point.

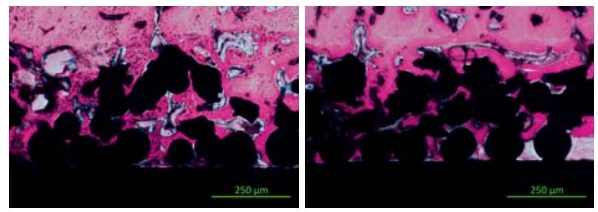

Fig. 1. 4 week bone ingrowth. RTPC (L) and RCPC (R).

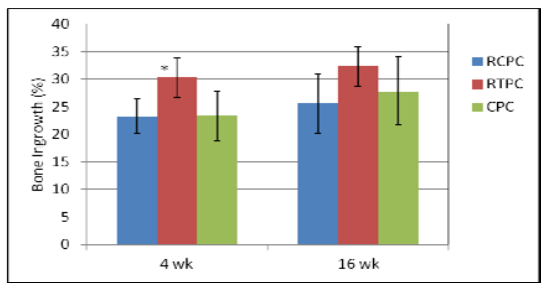

Fig. 2. Bone ingrowth mean and standard deviation

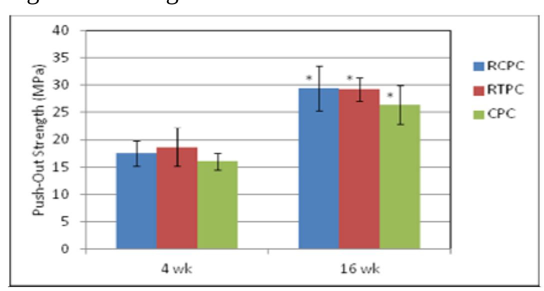

Fig. 3. Push-out strength mean and standard deviation

Conclusions: While the minimal loading of the transcortical implants in this study would not challenge initial implant stability, the results show that, under these conditions, the bone ingrowth fixation of the rougher, highly porous coatings was similar to that with a porous coating having a long history of clinical use and published results for a porous tantalum foam.

References: 1. Bobyn JD. Clin Ortho. 1980:150:263-70. 2. Tanzer M. J Orth Res. 1996:14:901-906. 3. Bobyn JD. JBJSB. 1999:81B:907-914. 4. Minter J. Trans 54th ORS 2008:1870.