Tritanium™ induces rapid bone ingrowth in a canine hip arthroplasty model
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INTRODUCTION
Biological fixation by bone ingrowth is necessary for stability and longevity in uncemented, press-fit joint arthroplasties. The porous surface of an implant should mimic cancellous bone to optimize bone ingrowth. Tritanium™ is a 3-dimensional porous titanium (Ti) material fabricated by the application of a thin layer of vapor-deposited Ti to an open-cell polyurethane (PU) foam, that is assembled to a Ti alloy substrate, thermally decomposed and completely removed, leaving a Ti foam exoskeleton coating that mimics the original open-cell structure. Spherical Ti powder is sintered to the Ti exoskeleton to strengthen it and to obtain the desired final porosity (60%), pore size, and pore morphology. The performance of this material on uncemented acetabular cups was examined in canine hip arthroplasty model after 6 and 16 weeks.

METHODS
Experimental Design
Twelve skeletally mature dogs with a mean weight of 27.9 ± 2.4 kg (range 25.1 - 32.1 kg) were randomly assigned to 2 treatment groups: 6 weeks (n=6) or 16 weeks (n=6). Pelvic radiographs were taken of each dog under sedation for preoperative planning and implant sizing. Total hip arthroplasty (THA) was performed using 26 mm metal-backed acetabular shells of Tritanium™ manufactured by Stryker Orthopaedics, Mahwah NJ, with average porosity of 60% and average interconnecting pore of 300 μm and modular femoral stems and heads. The procedure was performed on the left hip in the 16-week group and on the right hip in the 6-week group. Radiographs were taken after surgery to document the position of the implants. The dogs were allowed moderate exercise after surgery and then, after the assigned time period, were euthanized and the hip with implants were harvested en bloc and fixed in formalin.

Histology Analysis
Samples were processed, embedded in epoxy resin, and sectioned. Slides were ground and polished for scanning electron microscopy (SEM). The slides were carbon coated and scanned using a Philips XL-40 SEM. Eight to 9 images were taken of each slide along the cup circumference. Images 1-3 represented the peripheral ilial zone, images 4-5 the central zone, and images 6-9 the peripheral ischial zone. Image analysis software (Image Pro Plus 5.1, Media Cybernetics Inc, Silver Springs, MD) was used to measure the bone ingrowth volume and depth and bone apposition on the porous surface.

Statistic Analysis
Analysis of variance was performed using SYSTAT ver. 8 to assess the effect of time on percentages of bone ingrowth, bone apposition, and depth of bone ingrowth. The level of significance was p ≤ 0.05.

RESULTS
All dogs tolerated the total hip arthroplasty well and were bearing weight on the operated limb within 24 hours of the procedure. Subjectively, the amount of limb use progressed and they appeared to have normal weight bearing by the end of the first week after surgery. The limbs were well muscled and the coxofemoral joint capsules were thickened, but intact at specimen collection.

On histologic examination, there was good bone ingrowth, bone apposition, and depth of bone ingrowth in the specimens after both 6 and 16 weeks of implantation (Fig 1). There was minimal implant-bone contact in one of the 6-week specimens, so the data reported are for 5 dogs in that group.

Bone ingrowth was 23.2 ± 12.1% (range, 10-35%), bone apposition was 67.3 ± 22.8% (range, 36-96%), and depth of bone ingrowth was 54.3 ± 25.2% (range, 23-79%) in specimens from the 6-week group (n=5). There was less variation in the data among the specimens in the 16-week group. Bone ingrowth was 20.6 ± 2.4% (range, 18-25%), bone apposition was 75.5 ± 16.4% (range, 54-90%), and depth of bone ingrowth was 51.2 ± 11.6% (range, 36-64%) for the 16-week specimens (n=6). There were no significant differences between the two groups for amount or depth of bone ingrowth or bone apposition (p > 0.05).

DISCUSSION
Differences in the acetabular reamers used, in the position and movement of the reamer during acetabular preparation, and in the exact positioning of the cups following reaming may have contributed to the variability in the results for each parameter. These factors may result in uneven contact of the porous surface and the remaining cancellous bone in the prepared acetabular bed. This kind of variation occurs during clinical joint arthroplasty performed without the benefit of robotic guidance. The imprecise reaming may have resulted from using an acetabular reamer that was not custom made for the implants used in the study. However, it appears that bone ingrowth progresses and differences in initial bone-porous surface contact diminish over time. Tritanium™, a dimensionalized porous titanium coating, generated good osseointegration of press-fit acetabular cups in this in vivo canine model. Bone ingrowth occurred 6 weeks after implantation, but the amount of new bone was quite variable among the canine patients. The degree of bone-implant contact may affect bone ingrowth in the initial postoperative period. However, the quantity and quality of bone ingrowth progressed over time and ultimately provided good osseointegration of the acetabular implants by 16 weeks.