THE EFFECT OF TRABECULAR METAL POROUS SURFACE ON GAP HEALING AND BONE INGROWTH
FIXATION IN A CANINE TOTAL HIP MODEL

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Introduction
An exciting approach to reducing aseptic loosening of cementless implants is the stimulation and acceleration of bone ingrowth into the porous coatings of the implants. Improved fixation of components is an important factor for long term success of total hip and total knee replacement. While one method of stimulating bone formation utilizes biological agents such as BMP-2 or OP-1. Another method utilizes biomaterials which are either osteoconductive or osteoinductive. Tantalum trabecular metal has been identified as one such biomaterial and represents a novel porous surface for use in cementless arthroplasty. Prior experimental studies suggest that bone ingrowth is enhanced with this new material, but these studies were uncontrolled, [1]. Using a canine total hip replacement model, this study was designed to directly compare the effects of using tantalum trabecular metal versus traditional titanium beads on bone ingrowth into the porous layer when intimate bone/implant contact is achieved, and also to quantify both gap filling and bone ingrowth into the porous layer beneath the gap when intimate contact is not achieved.

Methods
Institutional approval was received for this study using 7 adult male canines. Pre-operative radiographs were obtained to ensure maturity and assess for skeletal abnormalities and size of the femoral canal. Each dog received a right total hip replacement using a porous coated acetabular shell, consisting of a tantalum trabecular metal shell with a 28mm outer diameter. A polyethylene liner having a 14mm inner diameter and a 20mm outer diameter was cemented into the tantalum shell. After reaming the acetabulum, a 1.5 millimeter deep gap, 2 centimeters in diameter, was created in the acetabular bone bed between the acetabular component and the underlying bone using a specially designed reamer. The tantalum shell was then impacted into the bone bed which provided a 1.0 mm press fit. A 14 mm femoral head, attached to the morse taper of a press fit femoral stem with a proximal porous coating of tantalum trabecular metal, articulated against the polyethylene insert. The animals were radiographed postoperatively and after 12 weeks. The animals were exercised daily and allowed unrestricted weight bearing for the 12 week in vivo period. All animals were euthanized at 12 weeks and the whole pelvis and both femora harvested. The specimens were dehydrated, embedded in methylmethacrylate, and serially sectioned using a diamond wheel. Contact radiographs were obtained of all sections. Five sections from each specimen were further examined using scanning electron microscopy and an image analysis program in order to quantify bone ingrowth into the porous trabecular metal. Acetabular sections were divided into two regions: gap region, and non-gap regions for bone ingrowth quantification. Our previous identical study which used a titanium fiber mesh acetabular component (1) served as the control.

Results
All animals ambulated well postoperatively, showed no signs of infection, and completed the 12 week study period. In contrast to our previous studies with a titanium beaded porous acetabular component, the bone/implant gap was substantially more bridged with new bone at 12 weeks using the tantalum trabecular porous metal acetabular components, figure 1A and B.

Moreover, scanning electron microscopy revealed bone ingrowth within the trabecular porous surface in the porous regions beneath the gap (figure 2). Excellent bony ingrowth also occurred in areas of intimate contact (figure3). Quantification of the amount of bone ingrowth into the gap and into the porous tantalum metal is in progress.

Discussion
Bone ingrowth into the trabecular metal porous coating beneath the gap occurred in the areas where bone bridging of the gap occurred. This canine acetabular gap model has shown for the first time bone bridging of a critical sized gap defect behind the acetabular component plus bone ingrowth into the underlying porous surface of the implant, without the addition of calcium phosphate or other agent to the gap at 12 weeks postoperatively. In areas of initial intimate bone/implant apposition, the amount of bone ingrowth into the porous trabecular surface was similar to that which occurred into the titanium beaded surface. The ability of a biomaterial such as trabecular metal to augment bone ingrowth across void space and deep into the porous surface of a total hip component is of great interest to the future of total joint arthroplasty, and of particular value in revision situations.

References

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