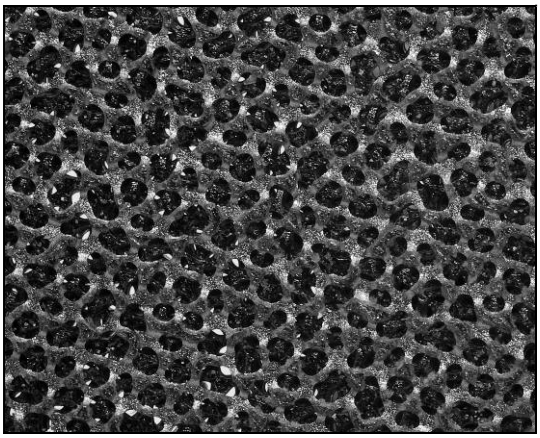
Bone Ingrowth Performance of *OsteoSync™ Ti*

Sites Medical Research and Development

Introduction

OsteoSync™ Ti[*] is a three-dimensional, open-celled titanium scaffold for bone and tissue ingrowth (Figure 1). It can be used as a standalone implant or combined with metal or polymer components to provide a region for bone ingrowth.

Figure 1:



A close-up view of the *OsteoSync* Ti microstructure.

OsteoSync Ti has a mean porosity of 58.8%, pore sizes ranging from 434-660 μm, and a mean pore interconnectivity of 229 μm[1]. It is manufactured from grade 2 commercially pure titanium satisfying ASTM F67[2]. *OsteoSync* Ti can be manufactured in thicknesses of 0.5 mm and greater. The standard thickness for most implants is 1 mm. If desired, *OsteoSync* Ti can be machined before or after it is attached to a substrate.

OsteoSync Ti can be metallurgically attached to pure Ti, Ti alloy, or CoCr alloy substrates using a proprietary diffusion bonding process. *OsteoSync* Ti also can be combined with a polymer via injection or compression molding.

Ingrowth Assessment using a Canine Cementless Total Hip Model (Dynamic Model)

The first animal study for assessing the bone ingrowth characteristics of *OsteoSync* Ti employed a canine cementless total hip model[3]. A hip model was selected because of the preference to use a dynamic model rather than a static one. A dynamic model can result in micromotion between the bone and scaffold. This is the worst case situation for ingrowth structures. Thus, a dynamic hip model allowed this effect to be examined during the study.

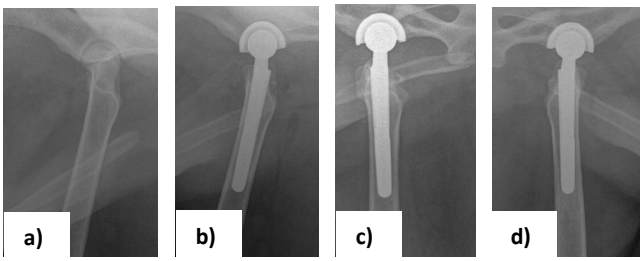
A cementless hip stem with *OsteoSync* Ti was implanted unilaterally into 6 animals at Purdue University. Clinically available hip stems (BioMedtrix BFX) were modified to remove the standard beaded coating and replace it with *OsteoSync* Ti pads on the anterior and posterior surfaces in the proximal region of the stem (Figure 2). The endpoints assessed were subsidence and bone and tissue ingrowth into the *OsteoSync* Ti scaffold at a time point of 12 weeks.

Figure 2:

The device for the canine total hip study. Clinically available canine hip stems (BioMedtrix BFX) were modified to remove the standard sintered beaded coating and replace it with *OsteoSync* Ti pads on the anterior and posterior surfaces in the proximal region of the stem.

Using open leg lateral radiographs, stem subsidence was assessed by comparing the stem position at 6 weeks and 12 weeks post-surgery to its location immediately after surgery to measure distal displacement (Figure 3). Subsidence was less than 3 mm in all cases. A previous study considered stem subsidence to be present if distal displacement was 3 mm or more[4]. Thus, stem subsidence for this study was negligible, demonstrating good fixation and performance of the implant.

Figure 3:



Open leg lateral radiographs used to assess subsidence. a) Pre-surgery. b) Post-surgery. c) 6 weeks. d) 12 weeks.

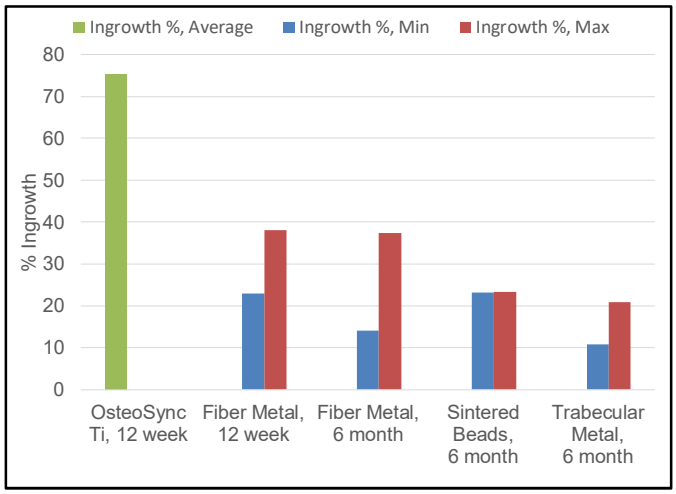
[*] Also marketed as BioSync® Ti and FortiCore®

Bone ingrowth was quantitatively assessed through morphometric analysis of transverse sections taken through the femur and implant in the proximal, middle, and distal regions of the *OsteoSync* Ti pads (Figure 4). The results indicated excellent bone and tissue ingrowth into *OsteoSync* Ti. At 12 weeks, bone and tissue ingrowth as defined as the percentage of available void space filled with bone and tissue was 75.4%. These results compared favorably to the literature for other canine THR studies (Figure 5)[5-13].

Figure 4:

A proximal histological slide used to assess bone ingrowth.

Figure 5:



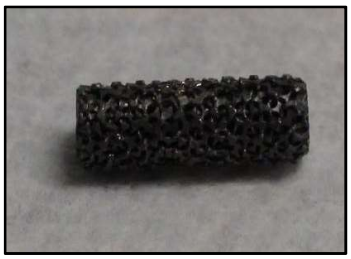
A comparison of ingrowth for different porous scaffolds using a canine THR model[5-13].

It must be emphasized that this was a 12 week study, so greater ingrowth into other scaffolds might have been expected at time points longer than 12 weeks. In comparing this study to the literature cited above via two sample t-tests, ingrowth into *OsteoSync* Ti was statistically greater than that for fiber metal at 12 weeks and 6 months, sintered beads at 6 months, and trabecular metal at 6 months when similar models (canine THR) were employed.

Ingrowth Assessment using a Canine Long Bone Model (Static Model)

Bone ingrowth into *OsteoSync* Ti has been assessed in a static canine long bone model as part of a larger study[14]. Ø4 mm x 10 mm long cylindrical pins were implanted in five cortical and two condylar locations (medial and lateral) along the femur (Figure 6). Two time points were examined, 6 and 24 weeks. Integration of test pins was assessed through push-out testing and histology. Push-out testing was performed on 3 cortical pins for each time point. Likewise, a qualitative histological assessment was performed on 2 cortical and 3 condylar pins for each time point.

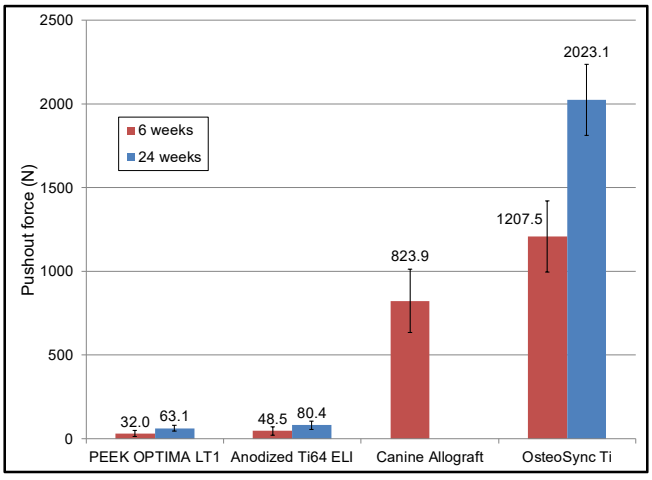
Figure 6:



The *OsteoSync* Ti test pin.

OsteoSync Ti displayed push-out strengths that were higher than the PEEK, anodized Ti64, and canine allograft controls (Figure 7). At 6 weeks, *OsteoSync* Ti had an average push-out force of 1207.5 N, which was 38X the push-out force for PEEK (32.0 N), 25X the push-out force for anodized Ti64 (48.5 N), and 1.5X the push- out force for canine allograft (823.9 N). At 24 weeks, *OsteoSync* Ti had an average push-out force of 2023.1 N, which was 32X the push-out force for PEEK (63.1 N) and 25X the push-out force for anodized Ti64 (80.4 N). (To date, allograft push-out data for 24 weeks has not been received.)

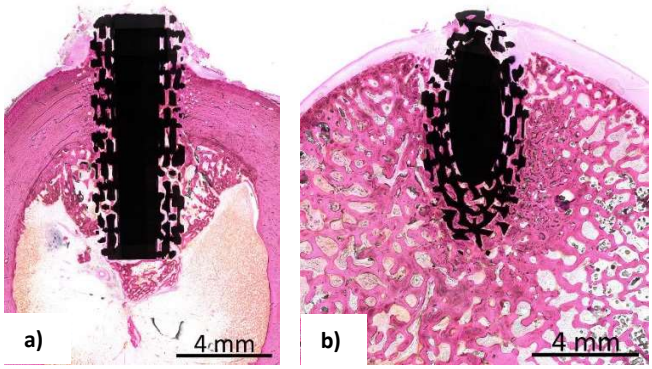
Figure 7:



***OsteoSync* Ti push-out results.**

The push-out results correlated well to the histological assessment of *OsteoSync* Ti, which showed excellent cortical and trabecular bone ingrowth at both 6 and 24 weeks (Figure 8). Cortical pins showed nearly complete infiltration of the *OsteoSync* Ti scaffold with cortical bone at both 6 and 24 weeks, with no apparent difference in ingrowth between the two time points. Based upon a qualitative assessment of the slides, 90-100% of the available *OsteoSync* Ti void space was filled with cortical bone. Similarly, the condylar pins showed good infiltration of *OsteoSync* Ti with trabecular bone, with a qualitative estimate that more than 75% of the available void space was filled with bone. As with the cortical pins, no difference between the amounts of bone ingrowth at the two time points was apparent. These data compared well with data from an earlier study where a canine hip model was used to assess bone ingrowth into *OsteoSync* Ti[3]. Like the earlier study, bone ingrowth results for *OsteoSync* Ti compared favorably to the literature[5-13].

Figure 8:



6 week *OsteoSync* Ti histological slides. a) Cortical plug. b) Condylar plug.

Ingrowth Assessment using a Canine Osteochondral Model (Dynamic Model)

Ingrowth into *OsteoSync* Ti has been examined using a canine osteochondral model[15]. 10 mm SynACART osteochondral plugs, consisting of a polycarbonate urethane articulating surface injection molded into an *OsteoSync* Ti component, were implanted into 6 animals at the University of Missouri (Figure 9). Implantation was in either the medial (n=3) or lateral (n=3) femoral condyle on the right knee. At a time point of 11 weeks, a qualitative assessment of bone ingrowth into the *OsteoSync* Ti component was made.

Based upon radiographs obtained at sacrifice, the location and orientation of all implants appeared unchanged. An arthroscopic examination of the joints revealed stable implants that did not move when probed with a blunt obturator.

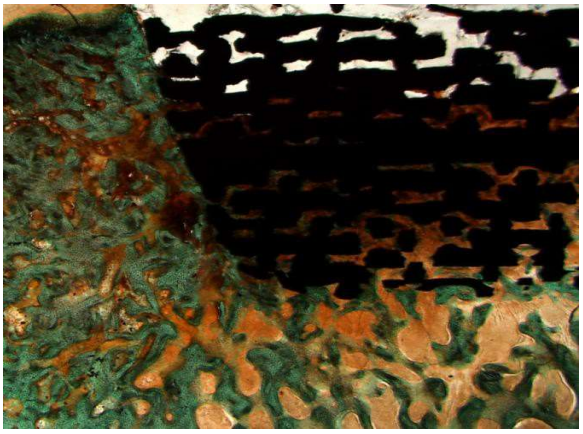
Histological slides were used to make a qualitative assessment of bone ingrowth into the *OsteoSync* Ti component of the implant (Figure 10). Osteoconductivity was defined as degree of definitive bone ingrowth into the

Figure 9:

A 10 mm SynACART osteochondral implant. The polycarbonate urethane articulating surface is backed by an *OsteoSync* Ti bone ingrowth region.

implants and was categorized as poor (<25%), fair (25-50%), or good (>50%). Osteoconductivity of the *OsteoSync* Ti component of the implants ranged from fair (4 of 6) to good (2 of 6). Similarly, integration was defined as total tissue ingrowth into the implants in conjunction with the presence or absence of associated necrosis, inflammatory or immune cell response, or absence of tissue (interface gap), and was subjectively categorized as poor, fair, or good. Integration of the *OsteoSync* Ti component of the implants was considered good for all 6 implants.

Figure 10:



A histological slide used to qualitatively assess bone ingrowth.

Bone Ingrowth Comparisons to Other Scaffolds

As discussed above, the bone ingrowth characteristics of *OsteoSync* Ti compare favorably to other clinically used porous coatings and bone ingrowth scaffolds. For reference, Figure 11 displays the bone ingrowth characteristics of *OsteoSync* Ti along with those of some other bone ingrowth scaffolds.

Figure 11:

	OSTEOSYNC-Ti	ZIMMER TRABECULAR METAL	ZIMMER FIBER METAL	WRIGHT MEDICAL BIOFOAM	BIOMET REGENEREX
INGROWTH AT 2 WEEKS		13.3%[16]			16%[19]
INGROWTH AT 3 WEEKS		23.0%[16]	9.5%[17]	45%[18]	
INGROWTH AT 4 WEEKS		41.5-52.9%[16]	16.6[10]		55%[19]
INGROWTH AT 6 WEEKS			22.4%[17]	62%[18]	
INGROWTH AT 12 WEEKS	75%[3]		23-35%[5]	62%[18]	
INGROWTH AT 16 WEEKS		63.1-69.2%[16]			74%[19]
INGROWTH AT 24-26 WEEKS	85-95%[14]		32.4-37%[8,10]		85%[19]
INGROWTH AT 52 WEEKS		70.6-79.7%[16]	29.9%[8]		

The bone ingrowth characteristics of *OsteoSync* Ti as compared to other clinically used porous coatings and bone ingrowth scaffolds. Differences in these values compared to ones found in Figure 5 are due to the fact that animal models other than the canine hip model are included in this data.

Conclusion

The bone ingrowth performance of *OsteoSync* Ti, an open-celled titanium scaffold for bone and tissue ingrowth, has been assessed through multiple animal models. In all studies, *OsteoSync* Ti has displayed excellent bone ingrowth results, especially when compared to other clinically available bone ingrowth scaffolds and porous coatings.

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