Novel in vivo micro-CT methodology detected a positive effect of resorbable implants on surrounding bone in an osteoporotic rat model

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Introduction: In vivo micro-CT is a noninvasive method for longitudinal monitoring of bone changes in the rat tibia. The tomographs of the tibia are comparable with classic bone histology [1]. By this method, tibial bone loss in the rat following ovariectomy has been observed[2]. New materials are being developed to enhance bone quality in osteoporotic patients. The purpose of this pilot study was to develop an animal model to longitudinally evaluate bone formation associated with implant materials.

Materials and Methods: Ovariectomized (OVX) Sprague-Dawley rats were used in this study. Implants made from two different materials, a nonresorbable and resorbable material, were inserted into the right tibia of each rat one month after OVX. A baseline micro-CT scan of the right tibia was performed on each rat 1 week before the implant was inserted. Follow-up tibial scans to the same region were performed at 1 month, 2 months and 3 months. A volume of interest (VOI) around the implant was selected and 3-dimensional model reconstruction was performed. Bone volume fraction (BV/TV [%]) was measured from this VOI.

Results: At each observation time point (1-, 2- and 3-month), 3-dimensional reconstruction of the VOI revealed qualitatively there was more bone associated with the implant made from the resorbable material than that of the nonresorbable material (Figure 1). Quantitatively, the animal that received the resorbable implant material showed a consistently higher BV/TV during the experimental period (Figure 2). Attenuation of X-ray beam was observed for the implant made from resorbable material whereas no such attenuation was observed for the implant made from nonresorbable material.

Discussion: A higher BV/TV around the resorbable implant material shows that the longitudinal assessment of the bone formation response to implant materials can be assessed with this model. The BV/TV calculated in this study is lower than for perviously reported studies. In part this was caused by the chosen VOI being more distal from the growth plate than for other studies. Additional factors affecting BV/TV include OVX induced progressive bone loss in this VOI and a manual threshold used to correct for the effect of X-ray beam attenuation around the implant.

Currently, we are comparing the in vivo micro-CT results with the end point results obtained from conventional bone histomorphometry in order to better understand the mechanism involved.


Acknowledgements: Dr. Phil Salmon at Skyscan® for technical advise.

Figure 1. Three-dimensional reconstruction of the volume of interest showing bone formed around the nonresorbable implant (upper row) and the resorbable implant (lower row) at each observation time point.

Figure 2. Bone volume fraction (BV/TV) of regions of interest in the 2 rats during the 4 month observation period.