IN VIVO EVALUATION OF β-TCP BONE GRAFT SUBSTITUTES IN A BILATERAL TIBIAL DEFECT MODEL

Auld, J; Langdown, A; Butler, AM; Vizesi, F; Smitham, P; Bruce, W; Rawlinson, J; *Hiroyuki, I; +Walsh, W.R.
Surgical & Orthopaedic Research Laboratories, University of New South Wales, Sydney, Australia
W.Walsh@unsw.edu.au

INTRODUCTION
A well accepted limitation of many bone graft substitutes is their slow in vivo resorption profiles. Long-term presence of a slowly resorbing bone graft substitute can potentially impede bone formation. Clearly, an ideal bone graft substitute should resorb fully and at a predictable rate but also provide a three dimensional matrix to support bone ingrowth and ongrowth during resorption. The rationale behind more rapid resorption of calcium phosphate based bone graft substitutes is related, in part, to a diagnostic purpose so new bone can be assessed using x-rays. The degradation of the implant also allows for additional space for new bone formation and decreases the load-sharing environment. Ultimate replacement with the bodies own tissue while the implant resorbs needs to be titrated with the rate of new bone ingrowth. This study evaluated the in-vivo response of three β tricalcium phosphate (β-TCP) bone graft substitutes in a bilateral tibial defect model in NZ white rabbits based on radiographic, mechanical, histomorphometry and histology.

METHODS
A bilateral defect model [1] (5 mm wide and 15 mm long) spanning the metaphyseal and epiphyseal region were created 3 mm below the joint line in the anteromedial cortex of the proximal tibia in 66 skeletally mature New Zealand white rabbits following ethical approval. Defects were created using a microburr with a 3 mm diameter tip under saline irrigation. The defects were flushed with sterile saline prior to being filled with the three different β-TCP bone graft substitutes (table 1) to the height of the original cortex. Samples were x-rayed in the A-P and M-L planes using high resolution mammography film. Tibias were embedded in Wood’s metal and torsion tested to failure. The tibias were embedded in PMMA, sectioned and examined using back scattered SEM histomorphometry and mechanical data was analysed with a 2-way analysis of variance. Radiographs and histology were qualitative assessed in a blinded fashion for implant resorption and in vivo response.

RESULTS
Radiographs revealed a progression in new bone formation, implant resorption and healing of the defect over time. There were insignificant changes in all materials between time zero and the 2 week time points with some evidence of new bone formation at the margins of the defect. By 4 weeks new bone formation was observed in all groups with evidence of initial resorption. Implant resorption was notable by 12 weeks in the Osefion and Vitos group and appeared to lag in the Chronos group. All defects appeared well healed by 12 weeks with new bone formation at the margins of the defect. Implant resorption appeared to be complete in defects filled with Osefion and Vitos at 26 weeks while some evidence of Chronos was noted.
During torsion testing all samples failed in a spiral fashion initiated at the distal margin of the defect. The mechanical properties increased with time as the defects healed and new bone formed within the defect and as the cortex reconstituted. A decrease was noted at 12 weeks where implant resorption was well advanced and the cortex had yet to completely form. New bone formation within the medullary canal decreased at 12 weeks presumably through a remodelling process. Osefion and Vitos were nearly completely resorbed by 12 weeks in the medullary canal with only residual materials present surround by remodelled cortical bone. Chronos on the other hand was still evident in the medullary canal and confirmed the radiographic findings. The 12 and 26 week SEMS revealed various levels of cortex reconstitution in all groups. Similar to the radiographic findings, the Chronos group appeared to lag behind the Osefion and Vitos groups which were similar.

DISCUSSION
X-rays of the raw materials at time zero revealed marked differences in the appearance and pore structure between Osefion, Vitos and Chronos. Vitos had the most open structure followed by Chronos and Osefion. The Chronos appeared the densest followed by Osefion and Vitos. SEMS from the animals revealed a progression of new bone formation as early as 2 weeks in all materials. At two weeks new bone ingrowth into the porous domains and ongrowth to the surface of the material was evident in the Osefion and Vitos materials. SEM images of Chronos at 2 weeks did not demonstrate the same ingrowth into the porous domains of the material. This may reflect a lack of interconnecting pores in this material compared to the others. The 4 week time point revealed a continued progression of new bone ingrowth and ongrowth in all materials. Implant resorption was noted to begin at this time point compared to the 2 week time point and progressed for all materials at 12 and 26 weeks.
Bone graft substitutes provide surgeons with alternatives for grafting of bony defects. The β-TCP materials examined this study provide a scaffold for new bone formation with the majority of the material resorbed by 26 weeks compared to other calcium phosphate based bone graft materials [1].

REFERENCES

AFFILIATED INSTITUTIONS
* Olympus Japan