

## Chemical- Physical Characterization and Histological Outcomes after Implantation of KyphOs™ and KyphOs R™ in Vertebral Bodies of Sheep

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**INTRODUCTION:** KyphOs and KyphOs R are self-setting calcium phosphate bone substitutes, with and without BaSO<sub>4</sub> radiopacifier. These biomaterials contain TCP and magnesium phosphate compounds in the powder, which set into a hardened mass when mixed with an aqueous ammonium phosphate solution. These bone substitute materials provide the combined advantages of biomechanical support and the inherent potential to be replaced by natural bone.

**METHODS:** 10 grams of KyphOs powder was mixed with a 3.5 molar aqueous (NH<sub>4</sub>)<sub>2</sub>HPO<sub>4</sub> solution at a liquid to powder ratio of 0.50 (ml liquid / g powder) to form a paste, which was transferred into cylindrical molds (6x12mm) and incubated in 0.9% NaCl for 1 hour, and 12 weeks. After the respective incubation times the samples were fixed in acetone and crushed, then XRD analysis was performed to determine the crystallographic compositions after these setting times.

Four sheep underwent implantations in L3, L4 and L5 with KyphOs or KyphOs R. Implantation was made by a retroperitoneal lateral approach through the oblique abdominal muscle to the lateral aspect of the vertebral body (VB). All animal surgeries were performed under general anaesthesia. A defect of 7 mm in diameter and 15 mm in depth was created on the lateral aspect of the VB and the defect was completely filled with biomaterial.

Four months after implantation the sheep were sacrificed, the VB's retrieved and processed for undecalcified histology and for back scattered microscopy.

**RESULTS:** Figures 1 and 2 show the XRD pattern of KyphOs 1 hour and 12 weeks after preparation of the test samples. The first setting phase that forms at 1 hour is struvite (MgNH<sub>4</sub>PO<sub>4</sub>) while TCP remains unchanged. At 12 weeks struvite remains the predominant phase, TCP occurs in a lesser amount, and there is a broadening of the peaks in the 30°-35° 2θ angle. Struvite seems to be the primary initial crystallographic phase. Figure 3 shows a CT scan of a retrieved sheep VB demonstrating the status of the implant in the VB.

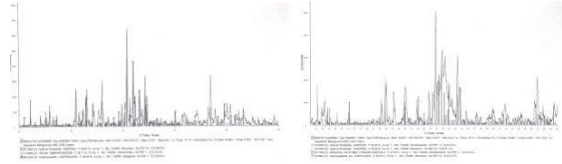


Fig. 1: XRD, 1 hour

Fig. 2: XRD, 12 weeks

Undecalcified sections (Fig. 4) revealed a tight connection between host bone and both KyphOs and KyphOs R.



Fig. 3 Post-operative CT image.

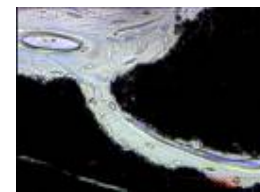


Fig. 4: 4-month implant, undecalc. sect. (black=KyphOs mat'l.)

Resorption lacunae are observed on the surface of the biomaterial, indicating remodelling and new bone formation in direct apposition to the material surface. In some areas BaSO<sub>4</sub> particles are embedded in newly-formed bone.

**DISCUSSION & CONCLUSIONS:** The predominant crystalline phase of KyphOs and KyphOs R is struvite, which forms due to the transformation of magnesium phosphate salts with ammonium phosphate solution (<sup>1</sup>). This explains the early biomechanical support provided by the setting biomaterial. At later incubation times the peak height of TCP gets smaller with a concomitant broadening of the superpositions of the peaks, indicating the formation of an apatite (<sup>1</sup>). Apatite forms through the conversion of TCP and strontium carbonate into an apatitic structure. The undecalcified histological sections of implanted KyphOs and KyphOs R reveal the active resorption of the material by osteoclasts with concomitant formation of new bone by osteoblasts, thus resembling the remodelling process of bone. The material demonstrates excellent biocompatibility with direct apposition of new bone and viable osteocytes on the surface.

**References:** Mulliez, M.A. (2002) ESB abstracts