

DEGRADATION OF AN EXPERIMENTAL CALCIUM-PHOSPHATE CEMENT IN A SHEEP MODEL

A. Gisep¹, R. Wieling¹, M. Bohner², S. Matter³, E. Schneider¹, B. Rahn¹

¹[AO Research Institute, Clavadelerstrasse, CH-7270 Davos Platz](#), ²[RMS Foundation, Bischmattstrasse 12, CH-2544 Bettlach](#), ³[STRATEC Medical, Eimattstrasse 3, CH-4436 Oberdorf](#)

INTRODUCTION: In orthopaedic surgery, reconstruction of bone defects – be it after tumour resection or comminuted articular fractures – is still a challenging problem. The use of autologous bone as a filler material for these voids is known as the golden standard. However, there are problems like limited availability and donor site morbidity which led to the use of allografts or the development of synthetic bone graft materials. For more than 100 year already, different materials such as coral or gypsum have been implanted. Among these, the calcium-sulphates were the first ones that hardened in situ and proved their potential as bone substitute materials. Later, different types of calcium-phosphate cements (CPC) were introduced. Various CPCs are currently commercially available, whereas others are still in an experimental phase. One of these experimental cements consists of two phases: a brushite matrix with β -TCP granules in it. This should lead to a different degradation pattern as compared to the monophasic apatite-cements. This study investigated the in vivo degradation patterns of experimental biphasic CPCs and the concomitant bone remodelling processes in a sheep model.

MATERIALS AND METHODS: As implant materials, 2 different Ca-P cements were used: an experimental biphasic material consisting of a brushite matrix ($\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$; DCPD) and β -tricalcium-phosphate ($\text{Ca}_3(\text{PO}_4)_2$; β -TCP) granules which are embedded in the matrix after the hardening process. As a comparison to this experimental cement, a monophasic hydroxyapatite cement ($\text{Ca}_5(\text{HPO}_4)_3\text{OH}$; HA) was implanted.

As an animal model, the canine model published by Frankenburg et al.* was adapted to the Swiss Mountain Sheep (animal permit GR 01/2000). The following defects were created: a) a slot defect with a height of 6 mm to the proximal tibial metaphysis, 10 mm below the articular surface. It penetrated the tibial head to 50% of its depth, leaving the posterior cortex intact;

b) in both femoral condyles, a drill hole (8 mm diameter and 16 mm) depth was created. All defects were filled with the ceramic bone cements.

Post operative x-rays on a weekly basis and clinical observation was done to ensure the sheep's healthy status. The animals were sacrificed 8 and 20 weeks. After harvesting of bone specimens, his-

tologic processing included embedding in polymethylmethacrylate, 200 μm sectioning (Leitz Saw Microtome 1600), grinding (Exact) and surface staining (Giemsa-Eosin). Microscopic analysis and digital imaging was done to evaluate cement resorption and bone remodelling.

RESULTS: In the biphasic cement, the brushite matrix was resorbed faster than the β -TCP granules. This resulted in free granules which were used by newly growing bone as a guidance. Bone filled most of the spaces which were left from the degrading cement. The granules acted as a “negative scaffold”. There was intimate contact from new grown bone to the implant material, indicating good biocompatibility of the cement. The new cancellous bone showed a 3-D structure.

An unexpected effect was the accelerated resorption of β -TCP granules once they were no more totally surrounded by DCPD matrix. This could be due to the fact that the porosity of the granules was higher as compared to the matrix. The granules mostly showed faster resorption in their centre. After advanced resorption, the granules got incorporated into the formation of new bone, lamellar structures also growing through the TCP granules. This points to a bone remodelling process that follows the regional demands more than the “negative scaffold effect”.

The monophasic HA-cement showed slower resorption in all defects. There always was a very close contact between bone and implant material, again revealing a good compatibility. Resorption only occurs on the surface of the implant. All cracks and pores in the cement were filled with bone or osteons.

All these effects were observed in all tibial and femoral defects, regardless of the loading situations occurring at the specific site.

CONCLUSIONS: The degradation patterns of both types of cements, monophasic and biphasic, seem to allow for a continuous load bearing function during their replacement by bone. According to the required duration of function and the expected loading situation, the monophasic HA-, or the more rapidly degrading biphasic DCPD/ β -TCP-cement may be chosen.

REFERENCES: *Frankenburg et al. (1998) JBJs Am, 80-8, 1112 - 1124