INTRODUCTION:

The replacement of the subchondral bone plate in the treatment of large osteochondral cartilage defects is reported to be a crucial step for optimal cartilage repair [1]. An optimal implant material should have open pores to enable bone marrow stromal cells to migrate into the cartilage defect and to replace the degraded implant by new bone formation in the subchondral area. However, no artificial implant material can yet fully restore the mechanical properties of the subchondral plate [2]. To address this problem, we asked the research question whether or not the implantation of an open porous degradable scaffold made of a magnesium alloy (AZ91) can serve as a sufficient temporary replacement of the subchondral bone plate. In this study, we evaluated the cartilage morphology of the regenerated tissue in a rabbit animal model after subchondral implantation of a degradable magnesium scaffold in comparison to an autologous bone cylinder at the contralateral side.

METHODS:

An open porous metallic scaffolds were cast in a negative salt-pattern molding process using the magnesium alloy AZ91. The sodium chloride spacers were eluted by sodium hydroxide solution after machining the alloy into cylinders (4 mm diameter, 5 mm height). Thirteen adult New Zealand White Rabbis were used for osteochondral defects with a follow up of 12 weeks. The experiments were conducted under an ethic committee approved protocol in accordance with German federal welfare legislation. A 4 mm diameter defect was drilled into the medial condyle of the left and right knee. The magnesium scaffold was inserted into the right knee while an autologous bone cylinder that was grafted from the left patellar groove was used as a control in the left knee. The magnesium scaffold and the autologous bone cylinder were precisely implanted beneath the cartilage surface (400µm) with a special pestle. The patellar defect was left empty. To determine the characteristics of the implant degradation, the magnesium scaffolds were scanned by micro computer-tomography (µCT) prior to implantation and after harvesting of the specimens. The specimens were fixed in 4% paraformaldehyde. After embedding and polymerisation in methyl-methacrylate, 5 µm thick histological sections were cut, deacrylated, and stained with van-Kossa and Safranin-O. Immunohistochemistry was performed for collagen type II. Safranin-O stained sections were scored by two blinded investigators using the O’Driscoll score.

RESULTS:

Pore sizes of 10-1000 µm were randomly distributed in the magnesium scaffolds. All magnesium scaffolds were fully degraded at twelve weeks postoperative as indicated by µCT (Fig.1). Most of the outer struts were replaced by a calcified tissue, but no sufficient replacement of the subchondral bone plate was present. No correlation was found between the subchondral bone area and the O’Driscoll score values in autologously filled defects on the left side, and with the implanted magnesium scaffolds on the right, while a weak correlation was found in the patellar defect (Fig. 2). The regenerative tissue above the degrading magnesium implant had significantly lower O’Driscoll score values compared to the patellar defect, but no differences were found compared to the control side (Fig. 2). Staining for collagen type II was more intense in the patellar defect and the contralateral side than above the degraded magnesium scaffold (Fig. 3).

DISCUSSION:

In this study, we found that an open porous scaffold made of the magnesium alloy AZ91 is a fast degrading biomaterial that cannot sufficiently replace the subchondral bone plate during the first 12 weeks of cartilage repair. Furthermore, the results confirm that mechanically sufficiently stable replacement of the subchondral bone in osteochondral defect is vital for collagen type II expression in cartilage regeneration [3]. Fundamental osteoconductive properties in the implant rim were however observed during the degradation of the magnesium scaffold. In contrast to the bone inducing effect seen with the rare earth containing alloys in a guinea pig model [4], the open cell porous scaffolds made of an AZ91 magnesium alloy do not induce the formation of subchondral bone necessary for osteochondral defect repair.

REFERENCES:

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