Replacement of the Medial Tibial Plateau by a Metal Implant in a Goat Model

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Introduction
Damage to, or removal of the menisci alters static load transmission across the knee joint and is associated with degeneration of the articular cartilage of the knee, especially the tibial cartilage. Although very promising, the replacement options of the meniscus are limited. The purpose of the present study was to explore the surgical possibilities for replacement of the medial tibial plateau by a metal implant and to examine the implications for the opposing cartilage.

Materials and Methods
In 6 adult Dutch milk goats, the medial tibia plateau of the right knee was replaced by a cobalt-chromium (CoCr) implant, using PMMA bone cement for fixation. During the procedure, the anterior part of the medial meniscus was dissected, without damaging the integrity of both cruciate ligaments, the collateral ligaments and the femoral cartilage. The unoperated left knee served as a control. After a follow-up period of 26 weeks the animals were sacrificed. The joint was evaluated macroscopically (Macroscopic Articular Evaluation) and cartilage quality was analysed macroscopically (Macroscopic Cartilage Score) and microscopically using the OARSI Osteoarthritis Cartilage Histopathology Assessment System (OOCHAS) and the modified Histological Histochemical Grading System (HHGS). Cartilage proteoglycan turnover and content were determined biochemically. From each of the three separate regions of the knee cartilage explants were cultured during 4 hours in the presence of $^{35}$SO$_4^{2-}$. After 4 hours, the samples were cultured for another 72 hours in the absence of $^{35}$SO$_4^{2-}$. Incorporation was measured by liquid scintillation analysis of tissue digestes. GAG release and total GAG content of explants were measured by Alcian blue assay in conditioned medium and tissue extracts, respectively (Figure 1).

Results
Surgery was performed without complications. All animals were able to move and load the knees without any limitations. The macroscopic articular evaluation scores showed worsening 26 weeks after inserting the implant ($p < 0.05$). Macroscopic and microscopic scores showed more cartilage degeneration of the opposing medial femoral condyle in the experimental knee compared to the control knee ($p < 0.05$) (Figure 2). Biochemical analyses showed higher $^{35}$SO$_4^{2-}$ incorporation at the medial femoral condyle cartilage in the experimental knees ($p < 0.05$). GAG content and release were not significantly different in experimental knees from controls for any of the compartments (Figure 3).

Conclusions
As demonstrated by macro- and microscopic analysis, the replacement of a medial tibia plateau by an implant induced considerable damage to the cartilage of the opposing medial femur. Surprisingly, this damage was only partly reflected by biochemical parameters. Synthetic activity of GAGs seemed to be stimulated in this compartment, although this did not affect final GAG content of the cartilage. Possibly the increased synthesis indicates some compensatory response to the tissue damage induced. Given the results obtained, the current model is a viable tool in the evaluation of bearing materials for implants. However, the introduction of tibial implants in a human clinical setting for the treatment of post-meniscectomy cartilage degeneration of the medial tibial plateau currently does not seem a realistic option.

References