TREATING LOCALIZED CARTILAGE DEFECTS WITH SMALL METAL PLUGS:
AN ANALYSIS OF ARTICULATING CARTILAGE

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INTRODUCTION
Currently, the surgical options for the treatment of localized cartilage defects are mainly biological-based. However, these treatments have their limitations, since they only result in fibrous or fibrocartilage tissue formation and are frequently followed by a total joint replacement. Since treatment of cartilage defects with a total joint replacement at a young age may require one or more early-age revision, smaller localized implants, and thus maintaining the surrounding and opposite healthy cartilage, are being developed. Since these localized implants are developed to articulate against healthy cartilage, it is important to evaluate the effects on the cartilage quality, and to study the variation of insertion height (i.e. not flush with the surrounding cartilage).

We placed implants in the medial femoral condyles of rabbits and compared the effects of implant depth placement (deep, flush and protruding) and bearing material (cobalt-chromium (CoCr) and oxidized zirconium (OxZr)) on the histological aspect of opposing tibial cartilage.

The purpose of the present study was to investigate the effect of implant insertion height and bearing material on the articulating tibial cartilage quality, when localized cartilage defects are treated with small plugs.

METHODS
This study was approved by the local institutional animal care committee. In eighteen adult female New Zealand White rabbits, a standardized medial femoral condyle defect was filled press fit with either an OxZr (left knee) or CoCr implant (right knee), manufactured by Smith&Nephew, Memphis TN USA. The size of the implants was 9.1mm in length with a 3.5mm diameter-articulating surface. Two different bearing materials and three different insertion depths were evaluated.

In the rabbits, the implants were placed either flush with the surrounding cartilage (n=9), one millimeter deep (n=5) or one millimeter protruding the surrounding cartilage (n=4). Pre-operative, postoperative, fluorescopy confirmed normal anatomy of the knee joint. During surgery, correct depth positioning was obtained using specially developed instruments and monitored during and after surgery using fluoroscopy. After four weeks, the rabbits were euthanized using an overdose of pentobarbital. After removal of soft tissues all tibial plateau were decalcified. Five sections were blinded and randomly presented to two readers who applied the Mankin score to determine cartilage quality (Figure 1). The depth influence of the implants (regardless material) was analyzed statistically using an ANOVA with a LSD posthoc test. The difference between CoCr and OxZr was analyzed using a paired T-test with a Bonferoni correction.

RESULTS
Surgery was performed without major complications. All animals recovered well, one rabbit received additional antibiotics during five days due to an extra-articular infection of the left knee. All animals were able to load the limb and move the knee without any limitations. The four-week follow-up fluorescopy showed no signs of malposition, loosening or other complications. The Mankin scores demonstrated considerable cartilage damage of the tibial plateau in direct contact with either implants irrespective of depth. However, when an implant was positioned flush with the surrounding cartilage, there was significantly less cartilage damage compared to the implants in deep (p=0.01) or protruding (p=0.004) position (Figure 2a). The Mankin scores of the tibial plateau were significantly (p=0.011) better for OxZr compared to CoCr when the implant was left protruding (Figure 2b).

Figure 2: Rabbit study
A Depth positioning implants. * Marks a significant difference between the flush group versus the deep (p=0.01) and versus the protruding group (p=0.004); B Mankin score OxZr versus CoCr at different depths. # Marks a significant difference between OxZr and CoCr (p=0.011)

DISCUSSION
This study demonstrates that by placing a cartilage tack implant in the rabbit femoral condyle, considerable cartilage damage and degeneration is induced. If the implant is not placed correctly there is even significantly more tibial cartilage damage. When a tack was left in a protruding position, OxZr caused less cartilage damage compared to CoCr. This might be the result of differences in biocompatibility and wear properties, which were undetectable in the flush and deep position. In vitro tests have shown that oxidized zirconium exhibits a number of relevant beneficial characteristics, which are superior to cobalt-chromium, such as better scratch resistance, less surface roughness after been in use, a lower friction coefficient, more elasticity and equivalent device fatigue strength.

The cartilage damage of the lateral part of the tibial plateau, despite the fact that it is not articulating directly against the implant, may be explained by the concept of joint homeostasis as described by Saris et al. Shortly, this concept describes that there are a number of mechanisms for the control of physiological equilibrium of the synovial knee joint. When this equilibrium is disturbed, for example caused by the cartilage damage of the medial tibial plateau due to directly articulating of the implants, the lateral tibial cartilage is affected as well, resulting in higher Mankin scores.

So care must be taken and consideration should be given to implant position, condyle geometry and bearing material in our human patients as well. In conclusion, caution in warranted using small metal implants for the treatment of localized cartilage defects in the medial femoral condyle, and more research should be done to elucidate aspects that will allow us to implement this hopeful therapy in a reliable and safe manner.

REFERENCES

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