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, localized treatment using metal tack implants, and thus maintaining the surrounding and opposite healthy cartilage, are being developed. A well-fixed implant is essential for articular congruity and limits subchondral alterations, thus it is important to evaluate the biocompatibility and osseointegration of different materials when varying the insertion height.

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 implant was 9.1mm in length with a 3.5mm diameter-articulating surface. The OxZr components are produced from a wrought zirconium alloy (Zr-2.5%Nb) that is oxidized by thermal diffusion to create a zirconia surface that is about 5μm thick. The oxidized component is burnished to produce an articular surface at least as smooth as that of a CoCr implant. Thus, the oxide is not an externally applied coating, but rather a transformation of the original metal surface into zirconium oxide ceramic.

Two different bearing materials and three different insertion depths were evaluated. The implants were placed either flush (n=9), one millimeter deep (n=5) or one millimeter protruding the surrounding cartilage (n=4). Pre-operative fluoroscopy 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 femoral condyles were embedded in polymethylmethacrylate. Five to ten μm thick sections were sawed in a longitudinal direction at the middle of the implant using the Leica® SP1600 Saw Microtome system and subsequently stained with basic fuchsin and eosin. Subsequently, image analysis was carried out with a PC-based system equipped with the KS400 version 3.0 software (Carl Zeiss Vision, Oberkochen, Germany). Parameters of bone formation were quantitatively analyzed using histomorphometry. After pseudocoloring the bone, a rectangle was drawn around the outer diameter of the implant. Subsequently, the articulating part of the implant was excluded. First, the area of the rectangle minus the implant area was determined. The percentage of bone in this area was calculated and defined as the amount of bone around the implant. Secondly, the amount of bone in contact with the implant circumference was determined. The depth influence of the implants and the differences between CoCr and OxZr was analyzed using a paired Student T-test.

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 X-rays showed no signs of malposition, loosening or other complications. Four implants (2 OxZr and 2 CoCr) were lost during the sawing process, due to the hardness of the materials and therefore excluded from statistical analysis.

Figure 2: Sections of implants under different insertion positioning. A. Deep positioning, B. Normal positioning, C. Protruding positioning.

Bone contact was observed in all samples; loosening of the implants and inflammatory responses was not seen. Roughly, there was 40 to 60 percent of bone-implant contact. There was significantly more bone contact to CoCr compared to OxZr in a deep position (p=0.02). However, in a flush- and protruding position there were no differences. The most bone formation around the implants was observed in a protruding position. This was significant more compared to a deep position (p=0.01). The amount of bone around each implant was the same for OxZr and CoCr at all depths.

DISCUSSION
The absence of loosening and inflammation reaction around the implants confirmed a good biocompatibility of both bearing materials. The osseointegration was examined by the percentage of bone-implant contact and the amount of bone around the implants. The amount of bone-implant contact was high for both materials, varying between 40 and 60 percent, which is expected to result in a firm bone fixation. This contact percentage is comparable to data found in literature.

The most bone formation surrounding the implants was seen in a protruding position, which is probably due to more loading of the implant compared to the deep and flush position.

In conclusion, both OxZr and CoCr implants showed a good osseointegration when used as a localized cartilage defect treatment in the rabbit knee. Since implantation in a protruding position might cause tibial cartilage damage, flush to surrounding cartilage is the best positioning for both materials.