UNILATERAL UNICOMPARTMENTAL REPLACEMENT IN SHEEP:
EXAMINATION OF FIXATION IN A LOADED MODEL

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INTRODUCTION

Fixation of prosthetic components in arthroplasty continues to be controversial. Aseptic loosening in cemented as well as cementless implants have been reported with a variety of implant design, materials, and fixation surfaces in humans. Animal models of bone ingrowth/ongrowth have traditionally relied upon transcortical models with idealized implant geometries [1-3] or cancellous models with custom design plugs to achieve loading [4]. Large animal models of hip replacement have also been reported and provide important information on the performance of surfaces or treatments [5-8]. Differences in mechanics and implant design between the hip and knee however, may make direct comparison of uncremented surfaces difficult. Large animal models of knee replacement has been reported [9] but requires extensive surgery. A simplified loaded model of bone ingrowth to assess different uncremented surfaces was examined using a unilateral unicompartmental replacement of the femoral condyle.

METHODS

A unilateral unicompartmental knee replacement was performed in 16 adult sheep following ethical approval. Grit blasted or CoCr beaded implants were implanted on the right medial femoral condyle using a medial parapatellar approach. The femoral condyles were prepared with a cutting jig and an extra small size Acuris Unicompartamental Knee implant (Smith & Nephew, Memphis, TN) implanted in a press fit manner. A recess was placed on the implant (Figure 1) to facilitate mechanical testing. The menisci and tibia were left intact. Animals were sacrificed at 12 weeks following surgery for macroscopic dissection, radiographs, mechanical testing or histology. The mechanical fixation of the implants was examined in uniaxial tension at a rate of 10 mm per minute. The pull-out peak load and stiffness were determined (N=4 per group). Mechanical data was analyzed using an unpaired T-test using SPSS for Windows. The femoral condyles of 4 animals per group were dehydrated in ethanol, embedded in polymethylmethacrylate and sectioned in the sagittal plane to assess fixation. Faxitron radiographs were taken to assess the implant bone interface. The sections were also examined under light microscopy using toluidine blue.

RESULTS

All animals recovered following surgery and were weight bearing by day 2. Lateral radiographs at twelve weeks revealed 8/8 CoCr beaded implants to be well fixed and positioned. In contrast, the grit blasted implants presented radiolucent lines at the interface in 8/8. Macroscopic dissection confirmed that the CoCr beaded implants were adherent to bone whereas the grit blasted implants were loose and noted to have a fibrous layer between the implant and the boney surface.

Mechanical testing confirmed these findings with CoCr implants requiring 424 N for pull-out to be achieved compared to 32 N for the grit blasted implants (P<0.01) (Figure 2). Histological examination showed the fibrous layer present in all grit blasted implants compared to bone/implant adherence in the CoCr beaded implants. The Faxitron radiographs (Figure 3) demonstrated the status of the interface to be either bone ingrown in the CoCr group or fibrous in the Grit blasted group. Bony resorption was noted in the Grit blasted group.

DISCUSSION

The unilateral unicompartmental knee model was well tolerated by the animals in this study. An implant used in the human knee was able to be used in the sheep model thus avoiding any custom designed components. The grit blasted surface, while able to provide a bony ongrowth surface in the hip or transcortical plug models, did not support any bone ongrowth in the complex loading of the knee. A CoCr beaded surface provides a substrate for bone ingrowth with a significant force required to remove the implant. Care should be taken when extrapolating the results of implant fixation between loaded and unloaded models, hip and knee model and human and animal considering differences in implant design, surgical technique and kinematics.

Retrieval analysis of the implants tested mechanical revealed bone ingrowth into the porous domains of the CoCr beads similar to human retrievals. The bone resorption in the Grit blasted group may also reflect micromotion due to the lack of a stable interface. This study is limited in terms of long-term follow up and small sample size. This sheep model may be useful to compare other implant fixation strategy for the knee without the need for significant implant modifications.

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REFERENCES