Introduction: One of the main advantages of hip resurfacing when compared with total hip arthroplasty is preservation of bone stock in patients who may eventually need one or more revision surgeries [1]. The femoral component of hip resurfacing is also thought to maintain a more natural loading state when compared with the femoral stem of a total hip arthroplasty, which has been demonstrated to cause stress shielding in the proximal femur [2]. There is some clinical evidence of preservation of bone mineral density and therefore a reduction in stress shielding for hip resurfacing implants, although this has yet to be experimentally verified [3]. We hypothesized that hip resurfacing would result in a reduction in strain shielding in the proximal femur and maintenance of physiological loading when compared with an uncemented tapered stem. The aim of this study was to experimentally measure strains in the femur in its native state and to compare these values with strains measured following hip resurfacing and implantation of an uncemented tapered femoral stem.

Materials and Methods: Three pairs of cadaveric femurs were obtained for testing and radiographed to screen for defects and measure femoral head and medullary canal diameters to accommodate specific implant sizes. One rosette and 3 axial strain gauges (Measurements Group, Raleigh, NC) were bonded to the surface of the femur. The rosette gauge was placed directly beneath the lesser trochanter on the postero-medial surface of the bone, and an axial gauge was placed at the same level on the lateral surface. The two remaining axial gauges were placed 10 cm distal of the stem tip on the antero-lateral and postero-medial surfaces of the femur. All gauges were aligned with the long axis of the femur. A fixture designed to reproduce loading conditions during the single leg stance phase of walking as described by McLeish and Charnley [4] was attached to the crosshead of an Instron 1122 Material Testing Machine (Instron Corporation, Norwood, MA) and used to apply a joint force to the femoral head and abductor muscle force to the greater trochanter. A 1000 lb. load cell (MLP-1K, Transducer Techniques, Temecula, CA) was placed between the acetabular cup and test fixture to allow measurement of the joint force. A compressive load of 600 N was applied with the Instron at a rate of 40 mm/min and strains recorded at 10 Hz. The femoral head was then resurfaced using a 49mm Articular Surface Replacement (ASR) implant (DePuy, Warsaw, IN), and testing was repeated. Next, the resurfaced femur was prepared for an 11 x 142 mm uncemented tapered femoral stem (Taperloc, Biomet, Temecula, CA) was placed between the acetabular cup and test fixture to allow examination of the femoral head and neck and do not consider changes in strain which may occur further distally [6, 7]. Kishida et al. performed a comparative clinical study demonstrating significantly greater bone mineral density loss in the proximal femur for a cementless stem when compared with a metal-on-metal hip resurfacing component using dual energy x-ray absorptiometry [3]. Our results complement the findings of this study and confirm that strains in the proximal femur are more similar to the native femur following implantation with a hip resurfacing component.

Results: Principal strains on the proximal medial (PM) surface were compressive and aligned with the long axis of the femur. Following resurfacing principal strains were not significantly different than those for the native femur (Figure 1). Implantation of a tapered stem resulted in a 28% reduction in principal strain that was significantly different from the native state. On the surface of the proximal lateral (PL) femur strains were tensile and were not significantly different for resurfacing compared to the native femur. For the tapered stem, there was a 21% reduction in strain from the native state that was significant. Differences in strain between the resurfacing component and stem were not significant for either location in the proximal femur. Strains measured in the distal medial (DM) and distal lateral (DL) femur were somewhat variable and much less than strains recorded in the proximal femur. Mean axial strains on the postero-medial surface of the distal femur were tensile, while strains on the antero-lateral surface of the distal femur were found to be compressive. Standard deviations were relatively high, and no significant differences in strain were found.

Discussion: Our results demonstrate that there is a significant reduction in strain from the native state in the proximal femur with implantation of a tapered stem when using a cadaveric model. Mean strains measured in the proximal femur following resurfacing were not found to be significantly different from the native femur. The low values of strain measured in the distal femur are consistent with the findings of Otani et al.[5]. To the best of our knowledge there are currently no published experimental studies which evaluate strain shielding for a hip resurfacing implant. There are published finite element analysis studies, but these are limited to examination of the femoral head and neck and do not consider changes in strain which may occur further distally [6, 7]. Kishida et al. performed a comparative clinical study demonstrating significantly greater bone mineral density loss in the proximal femur for a cementless stem when compared with a metal-on-metal hip resurfacing component using dual energy x-ray absorptiometry [3]. Our results complement the findings of this study and confirm that strains in the proximal femur are more similar to the native femur following implantation with a hip resurfacing component.

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