INTRODUCTION

There is currently intense interest in hip resurfacing arthroplasty due to its conservation of femoral bone stock and its apparent suitability for younger, more active people. The greatest short-term concern is fracture of the femoral neck. Although surgeons generally avoid varus placement of the femoral stem, there does not appear to be a strong clinical or biomechanical basis to decide between neutral or valgus placement. Our research question was whether neutral or valgus placement resulted in the greatest static fracture strength when the femoral neck was notched superolaterally, as may occur during surgery.

METHODS

We loaded 10 paired fresh-frozen notched proximal cadaveric femora (8 female, 2 male, age range: 66 to 80 years) to failure. The UBC ethical review board approved the testing. In each case, the right femur was implanted with a resurfacing component aligned neutrally with respect to the femoral neck whereas the left femur was implanted at 10° valgus. Ante/reversion was always neutral. While variability of the neutral placement with respect to the femoral neck axis did exist despite using the manufacturer’s instrumentation and fully exposing the femur, the difference between neutral and valgus placement was always within 0.5°. For each specimen, we chose the smallest head size that could avoid notching; 3 femoral heads were reamed for a 40 mm component, 14 for a 44 mm component and 3 for a 48 mm component (twice, valgus placement required one femur in a pair to be fitted with a head one size larger than the other side). Machined steel components with the same nominal outer and inner dimensions and same pin diameter and length as the standard femoral head resurfacing components were fixed to the femoral heads using bone cement prior to testing. All femurs, right and left, received a standardized 3 mm wide by 2 mm deep superolateral notch directly beside the component following cementation. The notch exposed cancellous bone in all cases. The femurs were rotated 10° in the coronal plane and then potted up to below the lesser trochanter. Each right-left pair was tested in sequence. The potted femur was mounted on roller-bearing plates on a flat steel surface in an Instron 8874 materials testing machine. An increasing load was applied to the femoral head until placement control at the testing machine. We loaded the test manually after either fracture or compressing had occurred. Prior to testing, we scanned all 20 femora using a QDR Dual-Energy X-Ray Absorptiometry (DXA) system. The femora were scanned parallel to the femoral shaft and the bone mineral density (BMD) analyzed within the neck. We measured the neck-shaft angles (NSA) from the DXA scans.

RESULTS

The effect of neutral versus valgus placement is complex. The first issue was failure type: two femur pairs failed slowly, in a crushing manner; the remaining femurs experienced a clear fracture. All femurs failed within the notch, mimicking the normal clinical situation. We removed one of the fracture-specimens from the data because the femur loosened from the potting during loading. When all other femur pairs were analyzed together (Fig. 1) the increase in fracture load after either fracture or crushing had occurred. Prior to testing, we scanned all 20 femora using a QDR Dual-Energy X-Ray Absorptiometry (DXA) system. The femora were scanned parallel to the femoral shaft and the bone mineral density (BMD) analyzed within the neck. We measured the neck-shaft angles (NSA) from the DXA scans.

DISCUSSION

This study demonstrated several key points: (1) fracture load was primarily controlled by bone mineral density; (2) nevertheless, varus/valgus placement of a femoral resurfacing component did affect the fracture load, at least in a notched state, which is a normal risk in surgery; (3) the magnitude and direction of this effect depended on fracture type, bone mineral density and the original neck-shaft angle; (4) for the level of bone quality typical of patients undergoing hip resurfacing (i.e. good), and for low-to-average neck-shaft angles (up to ~132°), the fracture load for 10° valgus placement was significantly higher than for neutral placement. Although we cannot make firm conclusions regarding the high stem-shaft angles because all of the femurs with higher neck-shaft angles also had lower bone mineral density, both this study and a pilot study on identical artificial bone models had lower fracture loads for higher stem-shaft angles. 10° valgus also appears to be the approximate geometric limit for implant placement. In the pilot study, we found that placing the stem at 20° valgus substantially increased the likelihood of notching or required a larger head size to avoid notching, leading to the undesirable removal of more bone stock on the acetabular side. Two of ten femurs in the present series required larger heads at 10° valgus. These results suggest a “target zone” for the stem-shaft angle; that is, the stem should be placed in up to 10° valgus for low neck-shaft angles (while maintaining the same head size and being careful to avoid notching), but more neutrally for medium-to-high neck-shaft angles. The results of this study may help surgeons to formulate an optimal surgical plan, with the hope of increasing the longevity of the implant.

REFERENCES


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