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Predictors of Femoral Neck Fracture Following Hip Resurfacing: A Cadaveric Study

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Abstract: We aimed to establish if radiological parameters, dual energy x-ray absorptiometry (DEXA) and quantitative CT (qCT) could predict the risk of sustaining a femoral neck fracture following hip resurfacing. Twenty-one unilateral fresh frozen femurs were used. Each femur had a plain digital anteroposterior radiograph, DEXA scan and qCT scan. Femurs were then prepared for a Birmingham Hip Resurfacing femoral component and loaded to failure. Results demonstrated that gender and qCT measurements showed strong correlation with failure load. QCT could be used as an individual measure to predict risk of post-operative femoral neck fracture. However, when qCT is unavailable; gender, pre-operative DEXA scan and Neck Width measurements can be used together to assess risk of post-operative femoral neck fracture in patients due to undergo hip resurfacing. **Keywords:** hip resurfacing, femoral neck fracture, predictors, qCT, DEXA scan.

The new generation of hip resurfacing has excellent early to mid-term results [1-3]; however the risk of early femoral neck fracture still remains a concern. The 2010 Australian National Joint Replacement Registry data from 13,307 hip resurfacings revealed that 35.6% of hip resurfacing revisions were performed for femoral neck fracture [4]. The overall rate of femoral neck fracture has been found to be approximately 1-2% [5-9]. In the selection of patients for hip resurfacing, the importance of young age and good bone density has been suggested [9-11]. It has also been suggested that proximal femoral geometry is important with smaller femoral component size being associated with an increased failure rate in resurfaced hips [12-14].

The use of proximal femoral bone mineral density has been associated with proximal femoral fracture in patients without hip arthroplasty [15-18]. Dual energy X-ray absorptiometry (DEXA), quantitative Computed Tomography scanning (qCT) and femoral neck width has also been shown to be correlated with femoral neck fracture [17]. We aimed to establish if radiological parameters, DEXA and qCT are associated with the risk of sustaining a femoral neck fracture following hip resurfacing. This information may aid surgeons and patients in the decision making of whether to consider hip resurfacing or total hip replacement.

Methods and Materials

Local ethics committee approval was granted to obtain 21 unilateral fresh frozen cadaveric femurs. The median age of the donors was 71 with a range of 53 to 90 years. Twelve of the donors were male and 8 were female. The femurs were stored frozen and then thawed for 24 hours prior to testing. Femurs were stripped of any remaining soft tissue prior to preparation.

Radiological assessment of the proximal femur was made using pre-preparation scaled digital radiographs. Digital templating software (Magicview 300, Siemens, Germany) was used to assess morphological parameters including femoral head diameter and neck width taken at the isthmus of the femoral neck. In addition, all femurs underwent a bone mineral density scan (DEXA, Hologic, Bedford, MA) as well as a qCT scan. DEXA scan measurements were made of the proximal femur (Total) and of the femoral neck. DEXA scanning assesses the bone mineral density (BMD) by measuring calcium mass in a projected bone area, this is a two dimensional measure that provides an estimate of bone density. Quantitative CT measurements were made in four areas

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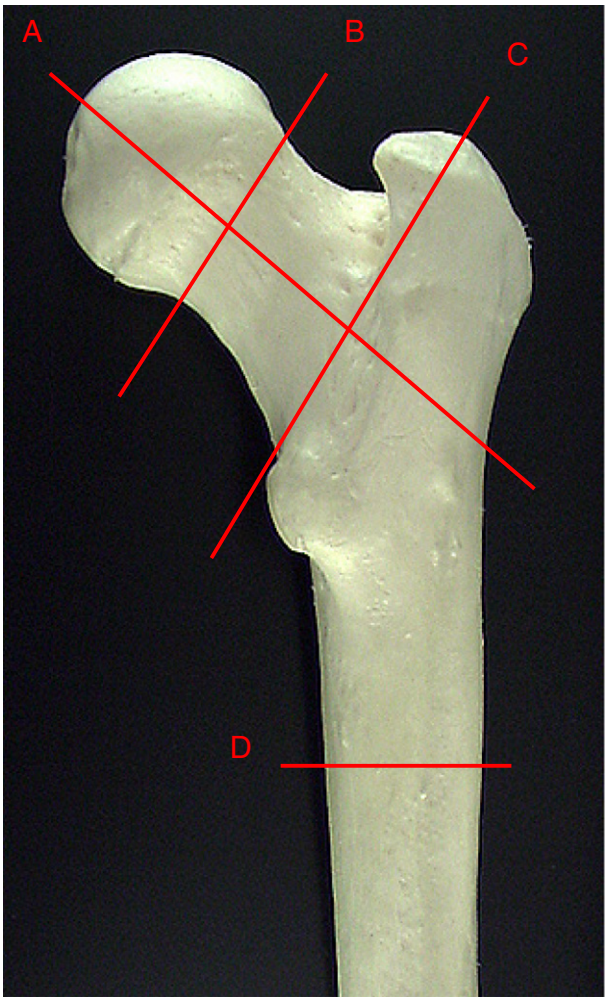

Fig. 1. A picture of the proximal femur with lines drawn indicating the location where qCT measurements were taken from to generate BMC. A: Proximal femur, B: Head-neck junction (measure used for further analysis in this study), C: Intertrochanteric region, D: Proximal femoral shaft.

of the proximal femur as shown in Fig. 1. The measurement taken at the femoral head/neck junction was selected as the measure used for further analysis in this study. Quantitative CT provides true volumetric density separately in trabecular and cortical bone. It is a complex unit made from three dimensional slices of the bone and is a function of both area and density; as such qCT is a true measure of bone mineral content (BMC).

Femurs were then prepared for a Birmingham Hip Resurfacing (BHR, Smith & Nephew Inc., Memphis, TN, USA). Implants were placed in neutral coronal and sagittal orientation with the stem-shaft angle equal to the native neck-shaft angle of the femur with neutral component version. The appropriate prosthesis was cemented onto the prepared femoral head using polymethylmethacrylate bone cement (Simplex, Stryker Corp, Allendale, NJ). Implant size was defined from the femoral neck width using the standard BHR neck gauge instrumentation. Implants were impacted in place and verified by digital radiograph for implant stem-shaft angle and to confirm no fracture had occurred during impaction. Notching of the femoral neck was not detected in any specimens. The prepared femurs were then sectioned 17 cm below the tip of the greater trochanter and fixed distally into square 7 cm high steel potting chambers using industrial anchoring cement. Ten cm of proximal femur was left exposed for testing.

Specimens were mounted vertically into an industrial vice preset at 15 degrees adduction to simulate one legged stance [19]. Load-to-failure for each femur specimen was determined by the application of a vertical force (displacement control = 10 mm/min, preload = 50 N) to generate compression until catastrophic failure of the resurfaced femur occurred (Fig. 2). For the purposes of this study vertical load-to-failure was used as the best substitute for the mechanism of clinical failure of the femoral neck during the common human activity of weight-bearing while walking, as done in at least one prior biomechanical study [13]. In addition, analysis of the varus/valgus positioning of the specimens was considered important however this was not analysed as a part of this study. All mechanical tests were performed using an Instron 8874 mechanical tester (Instron, Norwood, MA, USA). Catastrophic fracture patterns of the resurfacing construct were examined.

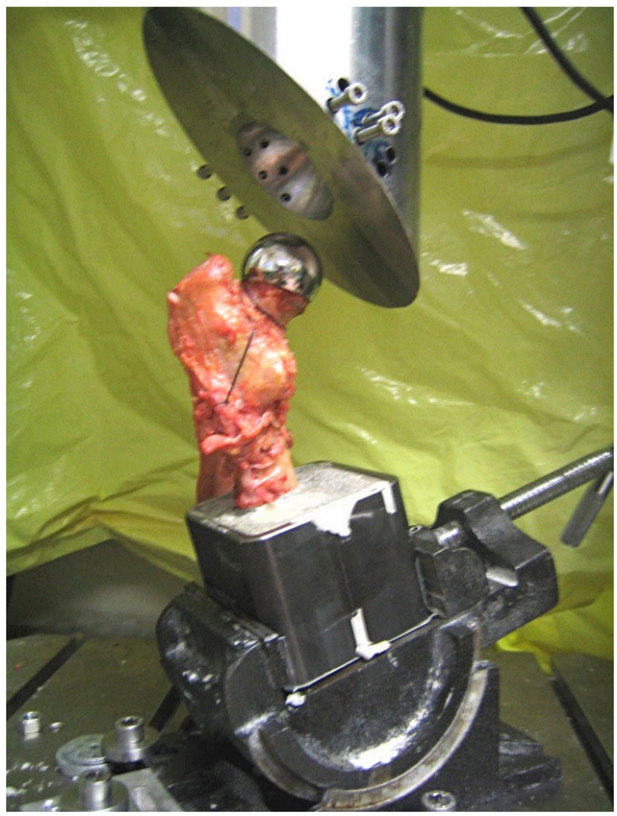

Fig. 2. A photograph of a potted resurfaced femur positioned in mechanical test machine.