COMPARISON BETWEEN TWO-DIMENSIONAL AND THREE-DIMENSIONAL RADIOGRAPHIC MEASUREMENTS OF POLYETHYLENE WEAR

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Introduction: The negative effects of particulate wear debris on the outcome of total hip arthroplasty have been well documented. Thus, for orthopaedists trying to assess the amount of wear occurring in a total hip replacement, there is a continuing need to evaluate the in vivo movement of the femoral head into the polyethylene liner. Until recently researchers were limited to two-dimensional (2D) radiographic methods to evaluate wear in vivo. While it was recognized that 2D analysis of polyethylene wear provided only an estimate of the true three-dimensional (3D) process, 2D techniques were justified by the assumption that the majority of wear occurs in the plane of an anteroposterior (AP) radiograph. With the recent development of a radiographic measurement technique to determine the 3D movement of the femoral head into the polyethylene liner, it is now possible to compare 2D and 3D wear measurements and examine the assumption that the majority of wear occurs in the plane of an AP radiograph. The present study directly compares the 2D amount of femoral head penetration measured on AP pelvic radiographs to the 3D amount of femoral head penetration determined from the combination of AP and lateral radiographs. The purpose of this study was to determine if 2D measurements of head penetration in the AP plane were reliable indicators of the magnitude of the true 3D wear vector, and if there was a certain patient population for whom 2D measurements were not predictive of 3D wear.

Materials/Methods: We studied 202 hips from 171 patients who had primary total hip replacement surgery performed by the senior author with uncemented porous coated components, and who had follow-up AP pelvic and cross-table lateral radiographs of their replaced hip. The acetabular components were in situ from 0.8 to 11.7 years (mean: 5.3 years) and consisted of 125 Duraloc cups (DePuy, Warsaw, IN), 30 Harris-Galante cups (Zimmer, Warsaw, IN), 27 Triloc cups (DePuy, Warsaw, IN), and 20 Arthropor cups (Joint Medical Products, Stamford, CT). Femoral head movement was measured radiographically by a single observer using 2 different and previously published computer-assisted measurement techniques. [1,2] The first method calculated the 2D movement of the femoral head into the polyethylene liner in the plane of the AP radiograph. [1] The second method calculated 3D movement of the femoral head into the polyethylene liner, using lateral radiographs to provide information about the movement of the femoral head in the plane perpendicular to the AP radiograph. [2]

Results: Comparison of 2D and 3D measurements showed that, for the average of all 202 cases, the mean amount of 3D head penetration (0.81 ± 0.71 mm) was larger than the mean amount of 2D head penetration (0.74 ± 0.67 mm, $p < 0.01$). However, linear regression analysis showed that the 2 measurements were highly correlated ($r^2 = 0.87$, $p < 0.01$, slope = 0.99, intercept = 0.08 mm). Examining the graph of 2D versus 3D measurements revealed a subset of patients (11 out of 202 cases, 5%) for whom 3D measurements were 3 times greater than corresponding 2D measurements. For the remainder of the patients (191 out of 202 cases, 95%), the mean amount of 3D head penetration (0.78 ± 0.72 mm) was nearly equal to the mean amount of 2D head penetration (0.75 ± 0.68 mm).

Discussion: The present study provides practical information for the orthopaedic surgeon trying to assess polyethylene wear in hip replacement cases. First, for most patients the majority of head penetration occurs and therefore can be measured in the plane of the anteroposterior radiograph. However, the strong relationship between 2D and 3D wear presented here could be due in part to the sophistication of the two-dimensional and three-dimensional computerized measurement techniques used. We are not certain that 2D measurements made by other, less sophisticated techniques will reflect three-dimensional measurements as closely. Second, one should be aware of a small percentage of patients for whom 2D measurements of head penetration are not at all reflective of 3D measurement. Moreover, there does not seem to be a single characteristic that can be used to identify this small group of patients. It may take further study of an even larger number of cups before a common characteristic among this small subset of patients can be identified.

References:
1. Sychterz et al., J Bone Joint Surg 79A: 1040-1046, 1997.
2. Devane et al., Clin Orthop 319: 303-316, 1995.

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