MULDIIRECTIONAL WEAR IN FULLY-CONGRUENT ACETABULAR IMPLANTS OF ENHANCED AND CONVENTIONAL POLYETHYLENE

Introduction: Polyethylene wear has been implicated in osteolysis and implant loosening. Most clinical studies use the linear wear of the acetabular component as an index of acetabular polyethylene wear, with the assumption that wear occurs in a single direction. A recent retrieval study, however, demonstrated evidence of multiple wear (deformation) vectors in acetabular components in which the liner was not fully-congruent with metal backing (1). Multiple vectors apparently are not the result of cup motion in vivo; other possible mechanisms include impingement, un-even head roughness, the gait cycle, impact loading after head separation from the cup in vivo (2), and polyethylene creep with changing contact areas related to non-congruent designs. The purpose of this study is to test the latter hypothesis by evaluating the direction(s) of wear in a fully-congruent acetabular cup design. A secondary goal of the study is to compare the magnitude of wear in retrieved “enhanced” polyethylene (Hylamer; DePuy, Inc) liners compared with conventional polyethylene (Enduron) from the same manufacturer.

Methods: We reviewed our implant registry and identified 37 retrieved acetabular components from a single manufacturer (DePuy, Warsaw, IN). The liners were of identical geometry, but were composed of either acetabular components from a single manufacturer (DePuy, Warsaw, IN). Multiple backings were of a single design (Duraloc, DePuy) and were fully-congruent with the liners. The shadowgraph technique was used to evaluate the extent and direction of articular polyethylene wear; the rim and dome of each implant were examined with a dissecting microscope for evidence of either rim impingement or creep into screw holes. A fluid gravimetric method was also used to measure volumetric wear (wear plus creep) using ethyl alcohol as previously described (3). Clinical and implant information for each case was compiled and the data analyzed statistically using the Mann-Whitney U test for continuous variables and the chi-square test for categorical variables. A value of p<0.05 was regarded as statistically significant.

Results: Thirty-seven liners were retrieved from 33 patients with a mean duration of implantation of 32.6 months (range 4 - 144 months). Twenty-three had been removed for aseptic loosening, 10 for recurrent dislocation, and 4 for infection. All liners showed eccentric deformation on the articular surface. The mean maximum extent of linear wear was 0.86 mm (range 0.025 - 3.59 mm), and the mean rate of maximum linear wear was 0.36 mm/yr (range 0.009 - 2.97 mm/yr). Ten of the 37 liners (28%) showed more than one vector; one implant had three vectors and the other 9 had two vectors. The mean angle between vectors was 46.6° (range 3.1 - 140.2°). Volumetric wear could not be determined in 3 liners; mean volumetric wear in the remaining 34 liners was 510 mm^3 (range 9.38 - 2334 mm^3). The mean rate of volumetric wear was 214 mm^3/yr (range 7.04 - 1135 mm^3/yr). Mean volumetric wear of implants with multiple vectors was greater than implants with a single vector (830 mm^3 and 395 mm^3 respectively) (Fig.1). "Backside" deformation was evaluated in 33 liners; of these, 26 (79%) showed deformation corresponding to screw holes. There was no significant correlation between backside deformation and multiple wear vectors (p=0.76), but backside deformation corresponded to the direction of one wear vector on the articular surface, suggesting that it represents creep into screw holes. Fourteen (38%) of the 37 liners showed an indentation on the rim indicating impingement. With the number of the specimens available, we did not detect a significant correlation between impingement and multiple wear vectors (p=0.08). Liners with multiple vectors had a significantly longer duration of implantation than those with a single vector (p=0.04); there was no significant correlation between multiple vectors and patient age or gender. Mean linear and volumetric wear was 0.94 mm and 513 mm^3 for Hylamer liners, and 0.69 mm and 505 mm^3 for Enduron liners. These values are not significantly different. Mean linear and volumetric wear rates were 0.44 mm/yr and 242 mm^3/yr for Hylamer liners, and 0.18 mm/yr and 145 mm^3/yr for Enduron, respectively (Fig.2), also not significantly different. There was no significant correlation between polyethylene composition and the presence of multiple wear vectors (p=0.55).

Discussion: The number of implants in this study is relatively small, and mean duration of implantation is only 33 months, but the results suggest that multiple wear vectors are relatively common in retrieved acetabular cups, and this phenomenon is independent of congruency between liner and metal backing. Impingement did not significantly correlate with multiple vectors in this series, but further studies are necessary to determine the influence of impingement, regional femoral head roughness, and impact loading on multiple wear vectors. The presence of multiple wear vectors suggests that polyethylene wear is determined most accurately by measuring volumetric deformation rather than linear head migration. With the relatively small number of implants available, we found no significant difference in linear or volumetric wear rates between conventional and enhanced polyethylene from the same manufacturer, but longer, and prospective studies are needed to clarify the properties of these two types of polyethylene in vivo.

References:

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