Clinical Performance of a Highly Cross-linked Polyethylene at 5 Years in Total Hip Arthroplasty: The Impact of Elliptical Distortion on a Clinical Wear Series

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Introduction: Crossfire highly cross-linked polyethylene represents a non-renmetal, ten mega rad material that has demonstrated 90% reduction in wear in hip simulation testing(1,2). Early clinical results at two years follow-up demonstrated a significant reduction in wear compared to a three mega rad polyethylene irradiated in an inert environment. In this study we present the clinical wear performance of Crossfire highly cross-linked polyethylene in conjunction with a cobalt chrome femoral bearing at five years follow-up. In addition, we present the wear data for this clinical series with and without correction of the elliptical distortion which results from variable patient positioning when obtaining follow-up radiographs.

Materials and Methods: The patients included in this study consisted of 169 primary hips with Crossfire polyethylene and 39 hips with standard polyethylene from 4 independent institutions. Polyethylene wear detection was performed using computer assisted edge detection software on digital radiographs (Hip Analysis Suite - HAS). All radiographic wear measurements were performed using two versions of the software. One version fit circles to the radiographs and did not correct for off beam elliptical distortion, and a new version that fit ellipses to the radiographs, allowing correction of elliptical distortion. Wear analysis was performed by individuals trained in the use of the software by the inventor of the technique. The bedding-in effect could not be avoided in this data set due to a lack of suitable one year radiographs for analysis. Wear rates were calculated by two different techniques. In the first technique, the regression slope method, all wear measurements for each patient were plotted against the years since the surgical procedure. A linear regression line was then fit to this data and the slope of the line taken as the wear rate for the population. In the second technique, the average wear method, the 6 week post-operative radiograph was used as a baseline and paired with the longest follow-up for each patient. The total wear detected, divided by the follow-up interval in years, represented the wear rate for each patient. The difference in wear rates for the standard vs. the Crossfire group was tested for significance at the 95% level using the Mann-Whitney non-parametric test.

Results: Using the newest version of HAS and the regression slope method, the wear rates for standard and Crossfire polyethylene were 121 and 48 microns per year respectively. (Figure 1) Using the average wear method the wear rates were calculated at 109 and 42 microns/year for standard and Crossfire polyethylene respectively. This difference was statistically highly significant (p=.006).

Discussion: Elliptical distortion introduced by non-hip centered radiographs in this clinical series resulted in aberrant high and low wear rates (Figure 2). Edge detection, combined with elliptical curve fitting, allowed for mathematical correction for elliptical distortion. This resulted in fewer negative wear values and less scatter in the regression plots (Figure 1), and should improve the precision and accuracy of clinical wear detection in future studies.

The clinical performance of Crossfire highly cross-linked polyethylene showed significantly reduced wear at 5-6 years follow-up compared to conventional polyethylene sterilized in a nitrogen atmosphere. We have observed no wear or liner related complications in this series, and see no clinical evidence for accelerating wear as these implants age in-vivo.


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