AN IMPROVED TECHNIQUE USING THE MARTELL METHOD WITH ELLIPSE FITTING: A COMPARATIVE STUDY USING A MINIMUM 5 YEAR FOLLOW-UP OF HIGHLY CROSS-LINKED POLYETHYLENE

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Introduction  Highly cross-linked polyethylene has been used as the bearing surface of total hip arthroplasty for over 6 years. Several reports now present data on femoral head penetration into various types of highly cross-linked polyethylene in total hip arthroplasty. A three year follow-up study by Diggas et al, using Radiostereometric analysis (RSA) to measure the amount of femoral head penetration, has shown that after the early bedding in period little additional penetration occurred. However, RSA studies are performed on relatively small groups of patients and it is necessary to follow larger groups of patients using non-RSA methods. One of the most commonly used non-RSA methods for measuring femoral head penetration from clinical radiographs is the Hip Analysis Suite software (University of Chicago), (Martell method). The current data on femoral head measurements in various forms of highly cross-linked polyethylene using this and other methods, generally support the results of the RSA studies. However, due to the combination of low magnitude of femoral head penetration with this new material, variations in film quality, and the resolution of the measuring technique, the prevalence of negative as well as unusually large positive femoral head penetration values are more common. These statistical outliers lend a degree of uncertainty to the data. The main cause of these aberrant measurement results appear to be associated with the elliptical projection artifacts related to variations in the position of the patient relative to the radiographic plate in both the x and y planes. The purpose of this study was to evaluate a group of total hip replacement patients who had received highly cross-linked acetabular components and a minimum 5 year follow-up and compare femoral head penetration results using two modified versions of the Hip Analysis software which employ algorithms for elliptic fittings of the surfaces of the femoral head and acetabular shell. In addition, clinical and radiographic evaluation of outcome of this cohort of THR patients was also conducted.

Methods  Seventy-six primary total hip replacements (70 patients) in which electron beam HXLPE liners (Longevity or Durasul, Zimmer Inc.) using either a 28mm or a 32mm femoral head with a minimum 5-year follow-up (range 5-6.2, average 5.7) were evaluated. The clinical measures used were the Harris Hip, WOMAC, and UCLA activity scores. In addition to the standard clinical radiographic assessment, two versions of the Hip Analysis Suite™, (University of Chicago, Chicago IL) software were used to measure the two dimensional change in the position of the center of the femoral head relative to the center of the acetabular component which occurred between the post-operative A/P radiographs of the pelvis and each subsequent radiographic examination. Each version of the software used a new ellipse fitting algorithm. One, Version A, used a standard image matrix while the second, Version B, used a higher pixel matrix of 2X which effectively increased the number of pixels available for defining the best fit ellipse to the femoral and acetabular edge. The results of the Martell analysis are presented as the total average wear rate and standard deviation calculated from the longest follow-up duration. In addition, the penetration rate was derived from the slopes of the linear regression line of all hips with acceptable radiographic pairs.

Results  The average age of the patients in this study was 64.6 (42 – 88) years with 37 males and 33 females. The average HHS, UCLA and WOMAC scores were 94.3, 8.7 and 18.4 respectively. Median post-operative Harris Hip Score was 90 and the pain score was 40.

No component showed radiographic loosening, failure or fracture. There were no osteolytic lesions around the cup or stem. No revisions were performed for polyethylene wear or liner fracture.

The average of all penetration rate measurements between all combinations of film pairs for version A and B were 0.03 ± 0.36 mm/yr (range -2.63 to 2.31) and 0.03 ± 0.42 mm/yr (range -2.76 to 2.87), respectively. Figure 1 is a histogram of the data produced with Version B. With Version B the standard deviation of the mean, the range of the data, as well as the overall distribution of the data is improved over Version A.

The average femoral head penetration rates and the steady state wear rates measured with the two versions of the software were similar and are summarized in Table 1. There was a significant difference in the average total femoral head penetration rate between the two head size groups when read with Version B, (p=0.01), but not with Version A (p=0.07). The average femoral head penetration did not increase over time after the first year and the steady state wear rates were again significantly different for each head size in Version B (p=0.01), but not Version A (p=0.63).

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Table 1 Average penetration and steady state wear rates measured using the two versions of the software

<table>
<thead>
<tr>
<th></th>
<th>28mm</th>
<th>32mm</th>
<th>28mm</th>
<th>32mm</th>
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<tbody>
<tr>
<td>Average Penetration Rate (mm/yr)</td>
<td>-0.01±0.12</td>
<td>-0.06±0.13</td>
<td>-0.04±0.15</td>
<td>-0.06±0.23</td>
</tr>
<tr>
<td>Version A</td>
<td>-0.00±0.08</td>
<td>-0.07±0.14</td>
<td>-0.01±0.10</td>
<td>-0.11±0.20</td>
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<tr>
<td>Version B</td>
<td></td>
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Figure 2 Scatter plot of the penetration values for the two head sizes measured with version B of the software. The slope of the linear regression lines represent the overall penetration rate of each head size group over the 5 year follow-up period.

Conclusion  The use of edge detection with elliptical fitting and an increased pixel density improved the measurement of femoral head penetration from clinical radiographs by decreasing the magnitude of spurious values. In this mid-term clinical follow-up study of THR patients with highly cross-linked polyethylene liners, we have shown excellent minimum 5 year clinical and radiographic results in this group of patients. Longer term follow-up will be necessary to evaluate this implant’s clinical and radiographic durability.

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