Long-term Results of a First-Generation Annealed Highly Cross-Linked Polyethylene in Young, Active Patients

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Abstract

The survivorship of total hip arthroplasty in younger patients is dependent on the wear characteristics of the bearing surfaces. Long-term results with conventional polyethylene in young patients show a high failure rate. This study assessed the long-term results of a first-generation annealed highly cross-linked polyethylene (HCLPE) in uncemented total hip arthroplasty in young, active patients. Between 1999 and 2003, 112 total hip arthroplasty procedures performed in 91 patients with an average University of California Los Angeles activity score of 8 and mean age of 53 years (range, 24-65 years) were included from a prospective database. In all patients, a 28-mm metal femoral head on annealed HCLPE (Crossfire; Stryker, Mahwah, New Jersey) was used. At minimum 10-year follow-up (11.5±0.94 years), Kaplan-Meier survivorship was 97% for all failures (1 periprosthetic infection and 1 late dislocation) and 100% for mechanical failure (no revisions for osteolysis or loosening). This study showed low revision rates for wear-related failure and superior survivorship in young, active patients. Oxidation causing failure of the locking mechanism has not been a problem with Crossfire for up to 10 years. [Orthopedics. 2016; 39(2):e225-e229.]

Total hip arthroplasty (THA) can relieve pain, restore function, and improve quality of life in patients with advanced arthritis of the hip.1 In recent years, the average age of patients requiring THA has steadily decreased.2,3 These younger patients have higher activity levels and longer life expectancy and therefore a higher incidence of wear-related failure requiring revision surgery.4,5 The longevity of THA in younger patients is often limited because of wear-related osteolysis and aseptic loosening.6,7 Long-term results with conventional polyethylene in young patients showed a high failure rate (up to 33% at 10 years).8-10 Hard-on-hard bearings, such as metal-on-metal and ceramic-on-ceramic bearings, and hip resurfacing have been advocated for younger patients in an attempt to reduce revisions related to wear or osteolysis.11 However, these options did not significantly increase survivorship,3 and debate about the optimal type of bearing in these young patients continues.

Since the introduction of highly cross-linked polyethylene (HCLPE) in the 1990s, there has been an increase in its use as well as significant improvement in wear reduction at the bearing surface.4,12,13 Several studies and registry reports confirmed improvement in midterm survivorship in HCLPE compared with conventional polyethylene in younger patients.2,5,14-17 To the authors’ knowledge, there are no...
long-term reports of the clinical and radiographic results of uncemented fixation with metal-on-HCLPE bearings in young, active patients. This study assessed the minimum 10-year results of a first-generation HCLPE in young, active patients with uncemented THA.

**MATERIALS AND METHODS**

Between January 1999 and December 2003, the senior surgeon (C.S.R.) performed more than 900 consecutive THA procedures at the authors’ institution. These patients were prospectively followed at 2, 5, and 10 years. A total of 112 THA procedures in 91 young, active patients (57 men and 34 women) were included. Inclusion criteria were age 65 years or younger and University of California Los Angeles (UCLA) activity score greater than 5 at the time of surgery. Mean patient age was 53±8 years (range, 24-65 years), and mean UCLA activity score was 8±1.5 (range, 5-10). Indications for surgery included osteoarthritis in 101 hips and avascular necrosis in 11 hips. All procedures were performed with a posterolateral approach. Components were an uncemented SecurFit femoral stem (Stryker, Mahwah, New Jersey), a 28-mm cobalt-chromium femoral head, and a Trident PSL acetabular shell (Stryker) with a Crossfire HCLPE acetabular liner (Stryker).

At a minimum 10-year follow-up, 2 patients (2 hips) had died of unrelated causes and 7 patients (7 hips) were lost to follow-up despite several attempts to contact them. The final cohort consisted of 103 hips (82 patients) that were available for analysis. Clinical assessment included the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score, a patient-administered questionnaire score, the Hospital for Special Surgery hip score, and the UCLA activity score. Anteroposterior weight-bearing pelvic radiographs obtained 6 weeks postoperatively and at final follow-up were evaluated for fixation, changes in component position, radiolucency, malalignment, loosening, and osteolysis by 2 blinded reviewers (A.A.R., M.M.). The radiographic abduction angle and anteverision of the cup on anteroposterior pelvic radiographs were measured with EBRA software (Einzel-Bild-Roentgen-Analyse, University of Innsbruck, Austria).

All descriptive statistics (mean, SD) and Kaplan-Meier survival analyses were performed with SPSS version 16.0 software (SPSS Inc, Chicago, Illinois). Two-tailed P values less than .05 were considered statistically significant.

**RESULTS**

Mean follow-up in the final cohort was 11.5±0.94 years (range, 10-13 years). Average WOMAC score, patient-administered questionnaire score, and Hospital for Special Surgery hip score were 94, 65, and 37, respectively (Table 1). Based on patient-administered questionnaire scores, 98% of patients were satisfied with the results. Most patients were participating in 1 or more recreational sports activities at the time of final follow-up (Table 2).

Mean radiographic inclination angle and anteverision measured with EBRA were 42.8°±5° (range, 35°-52°) and 17.1°±4° (range, 13°-23°), respectively. No revisions were performed for osteolysis or loosening. Two patients underwent reoperation: 1 patient with periprosthetic infection who underwent 2-stage revision (7 years after surgery) and 1 patient with late dislocation after a major fall that required open reduction and a constrained liner (11 years postoperatively). Intraoperative examination showed no significant polyethylene wear. At final follow-up, both patients were doing well, without further complications. Kaplan-Meier survivorship was 97% for all failures and 100% for mechanical failures.

**DISCUSSION**

Young, active patients with early arthritis present a challenge to surgeons when deciding on the optimal bearing surface for THA because these patients have higher levels of physical activity and longer life expectancy than older patients with more severe disability. Previous studies recommended hard-on-hard bearings, including hip resurfacing, metal-on-metal, and ceramic-on-ceramic bearings, the optimal bearing types for this group of patients. However, because of several issues with hard-on-hard bearings (ie, with a ceramic head or liner, fracture, squeaking, and stripe wear; with metal, ion toxicity and adverse tissue reaction), HCLPE has been the most commonly used bearing material in THA worldwide. This material offers durability and low wear rates, without the disadvantages of hard-on-hard bear-
Simulator studies investigating wear rates with HCLPE showed a reduction of wear by 42% to 100% compared with conventional polyethylene.\textsuperscript{1,13,22} However, few studies have reported the long-term performance of HCLPE in young, active patients (Table 3).

Limitations of the current study include the 7 patients who were lost to follow-up despite many attempts to contact them. However, the final radiographs in all 7 patients showed failure for fixation or wear at a minimum of 5 years postoperatively. The strengths of this study are the prospective design and the thorough clinical and radiographic analysis.

No revisions for osteolysis or loosening occurred in this cohort of young patients with high-demand activity levels who had uncemented THA with Crossfire, a first-generation annealed HCLPE. In a retrieval study of 12 polyethylenes, Currier et al\textsuperscript{23} reported reduction of mechanical properties as a result of oxidation, especially in the presence of impingement. However, similar to the findings of Kurtz et al,\textsuperscript{24} the current study found no indirect evidence of significant oxidation on radiographs, such as osteolysis or wear-related failure of the locking mechanism.

Recent concerns about the higher failure rate and local and systemic toxicity of metal ions resulted in several recalls and reduction of metal-on-metal articulations.\textsuperscript{2,25-27} The adverse tissue reaction to metal debris in metal-on-metal THA at the bearing articulation or the head-neck junction has been reported as the major cause of early failure and poor clinical results.\textsuperscript{28} As with large head metal-on-metal THA, hip resurfacing has been considered an effective intervention for young, active men who seek an alternative to THA.\textsuperscript{4,27} However, in addition to complications with metal-on-metal bearings, such as adverse local tissue reaction, there is a risk of femoral neck fracture and avascular necrosis with hip resurfacing.\textsuperscript{28,29} Daniel et al\textsuperscript{30} reported a 16% revision rate in a prospective case series of 184 patients who underwent hip resurfacing. This study reported a mean patient age of 54 years and a mean follow-up of 10.5 years.

### Table 3

<table>
<thead>
<tr>
<th>Study</th>
<th>Mean Age (Range), y</th>
<th>Mean Follow-up (Range), y</th>
<th>No. of Hips</th>
<th>Bearings</th>
<th>Survivorship</th>
<th>Revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>McMinn et al,\textsuperscript{29} 2011</td>
<td>48.3 (27-55)</td>
<td>10.3 (8-15)</td>
<td>403</td>
<td>Hip resurfacing</td>
<td>98%</td>
<td>1.2% femoral neck fracture or collapse, 0.3% (10 hips) adverse local tissue reaction</td>
</tr>
<tr>
<td>Kim et al,\textsuperscript{14} 2013</td>
<td>45.3 (21-49)</td>
<td>12.4 (11-13)</td>
<td>100</td>
<td>Ceramic on ceramic</td>
<td>99% overall 100% wear</td>
<td>5% squeaking or clicking, 1% dislocation</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>99% overall 100% wear</td>
<td></td>
<td></td>
<td>0% aseptic osteolysis, 1% dislocation</td>
<td></td>
</tr>
<tr>
<td>Yoon et al,\textsuperscript{47} 2012</td>
<td>24 (18-30)</td>
<td>11.5 (10-13.5)</td>
<td>75</td>
<td>Ceramic on ceramic</td>
<td>99%</td>
<td>3% squeaking, 1.3% fracture</td>
</tr>
<tr>
<td>Lee et al,\textsuperscript{12} 2010</td>
<td>41 (18-65)</td>
<td>11 (10-12)</td>
<td>86</td>
<td>Ceramic on ceramic</td>
<td>99%</td>
<td>1% squeaking, 2% fracture</td>
</tr>
<tr>
<td>Kim et al,\textsuperscript{16} 2010</td>
<td>45.5 (20-50)</td>
<td>8.5 (7-9)</td>
<td>73</td>
<td>Ceramic on highly cross-linked polyethylene</td>
<td>100%</td>
<td>1.2% dislocation</td>
</tr>
<tr>
<td>Kim et al,\textsuperscript{15} 2013</td>
<td>28 (21-29)</td>
<td>10.8 (10-12)</td>
<td>60</td>
<td>Ceramic on highly cross-linked polyethylene</td>
<td>100%</td>
<td>1 dislocation</td>
</tr>
<tr>
<td>Girard et al,\textsuperscript{33} 2010</td>
<td>25 (15-30)</td>
<td>9 (5-12.8)</td>
<td>47</td>
<td>Metal on metal</td>
<td>94.5%</td>
<td>2% (1 hip) aseptic loosening</td>
</tr>
<tr>
<td>Streit et al,\textsuperscript{48} 2012</td>
<td>49 (25-60)</td>
<td>12 (10-15)</td>
<td>89</td>
<td>Metal on metal</td>
<td>94%</td>
<td>1% (1 hip) aseptic loosening</td>
</tr>
<tr>
<td>Hwang et al,\textsuperscript{49} 2011</td>
<td>39.8 (19-50)</td>
<td>12.4 (11)</td>
<td>78</td>
<td>Metal on metal</td>
<td>98.7%</td>
<td>2.5% (2 hips) aseptic loosening</td>
</tr>
<tr>
<td>Babovic and Trousdale,\textsuperscript{30} 2013</td>
<td>39 (15-50)</td>
<td>10.4 (10-12)</td>
<td>54</td>
<td>Metal on highly cross-linked polyethylene</td>
<td>100%</td>
<td>-</td>
</tr>
<tr>
<td>Current study</td>
<td>51 (24-60)</td>
<td>12.3 (11-13)</td>
<td>103</td>
<td>Metal on highly cross-linked polyethylene</td>
<td>100%</td>
<td>1 dislocation</td>
</tr>
</tbody>
</table>
Ceramic-on-ceramic bearings have also been used in young, active patients because of the lower wear rates and elimination of concern about metal ions. With recent advances in ceramic composites, the risk of fracture is very low (estimated rate, 1:25,000), although edge loading or impingement or technical errors regarding proper liner placement into the acetabular shell can lead to ceramic liner fractures.31 Other complications specific to ceramic bearings, such as squeaking (up to 5%), stripe wear, and fracture (up to 2%), can lead to revision and lower survivorship, and there has been a recent decline in the use of ceramic-on-ceramic bearings.14,32,33

The long-term survivorship of hip resurfacing and THA with different bearings in young, active patients has not been well defined or reported annually by various registries.2,3,5 The Australian registry report in young patients showed that the overall cumulative percentage of revision was highest for metal-on-metal bearings and hip resurfacing (18.6% and 11.2%, respectively; higher for patients 55 years and younger) and lowest for metal-on-HCLPE and ceramic-on-HCLPE bearings (5.4% and 5.6%, respectively) (Table 4).2 This is similar to the 2013 annual report of the England and Wales registry at 9 years (17.6% and 12.3%, vs 4.3% and 3.0%, respectively).5 Moreover, the cumulative revision rate for THA after 12 years was 9% for patients 55 to 65 years and 11.3% for patients younger than 55 years. In the 2013 annual Swedish Hip Arthroplasty report, the revision rate for metal-on-HCLPE bearings was 0.1% at 8 years.3

The 100% survivorship at 10 years for mechanical failures of metal-on-HCLPE bearings reported in the current study is comparable to the other published results.34-37 Several studies analyzing more than 10-year follow-up of HCLPE, ceramic-on-ceramic, and hip resurfacing showed survivorship of 96% to 100%, 96% to 99%, and 88% to 95%, respectively. However, all of these reports included patients older than 65 years.38-46

**CONCLUSION**

The current study found no significant oxidation effect or polyethylene wear that would cause adverse clinical or radiographic outcomes. This study of long-term results with the use of HCLPE bearings in THA performed in young, active patients showed low revision rates for wear-related failure and superior survivorship compared with other reports.

**REFERENCES**


2012; 470(2):373-381.  


34. D’Antonio JA, Capello WN, Naughton M. Ceramic bearings for total hip arthroplasty have high survivorship at 10 years. *Clin Orthop Relat Res*. 2012; 470(2):373-381.


