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Original Article

Fifteen-Year Comparison of Wear and Osteolysis Analysis for Cross-Linked or Conventional Polyethylene in Cementless Total Hip Arthroplasty for Hip Dysplasia—A Retrospective Cohort Study

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ABSTRACT

Background: Cross-linked polyethylene (XLPE) acetabular liners used in cementless total hip arthroplasty (THA) have demonstrated better wear resistance at 10 years compared with conventional polyethylene (CPE) liners. No clinical studies have compared XPLE to CPE liners beyond 10 years.
Methods: We performed a 15-year retrospective cohort study on cementless THA performed in patients with developmental hip dysplasia to measure the differences in polyethylene wear rates and the presence of osteolysis. Twenty-four THAs with XLPE and 17 THAs with CPE were evaluated. The mean age of patients was 55.9 years (41-68) in the XLPE group and 54.4 years (40-67) in the CPE group. The mean follow-up period was 15.1 years (13.9-16.1) in the XLPE group and 15.2 years (14.5-16.0) in the CPE group.
Results: The XLPE group had a significantly lower wear rate at 5 and 10 years compared with the CPE group; however, no significant difference was found at 15 years (XLPE group, 0.040 mm/y; CPE group, 0.034 mm/y). In addition, the incidence of osteolysis did not differ significantly between the groups. However, the incidence of excessive wear between 10 and 15 years after surgery in the XLPE group was significantly higher than that in the CPE group.
Conclusion: XLPE demonstrated no advantage in the wear rate or the incidence of osteolysis at 15 years, despite having superior wear resistance up to 10 years. It is concerning that the incidence of excessive wear was higher in the XLPE group between 10 and 15 years, and this finding should alert the arthroplasty community to this possible problem with the more highly cross-linked polyethylene.

Excessive wear after total hip arthroplasty (THA) using conventional polyethylene (CPE) is known to cause osteolysis followed by implant loosening [1,2]. The main reason for revision of a metal-on-polyethylene bearing couple is related to polyethylene wear and periprosthetic osteolysis.

Recently, several studies have compared highly cross-linked polyethylene (HXLPE) and CPE and revealed that HXLPE has superior wear resistance for 10 years postsurgery [3-5].

However, whether HXLPE is superior with regard to osteolysis incidence remains controversial. Engh et al [3] demonstrated lower osteolysis incidence in an HXLPE group compared to a control group in a 10-year comparative study. In contrast, Johanson et al [4] showed that HXLPE does not reduce osteolysis followed by aseptic loosening in a 10-year randomized study of cemented THA. These results suggest that the decreased wear rate associated with HXLPE does not necessarily affect osteolysis incidence.

However, the high radiation volume for polyethylene during production induces a decrease in its mechanical properties [6]. In fact, several studies have reported the breakage of HXLPE after THA [7-10].

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ArCom (Biomet, Warsaw, IN) is a cross-linked polyethylene (XLPE) [11], and the isostatic molding process used to create it promotes more effective cross-linking of polyethylene compared with extruded molding. Thus, ArCom's special features are sustained mechanical properties and reinforced wear resistance owing to efficient cross-linking without increased radiation volume in process of production.

Higher cross-linking levels of polyethylene yielded better wear resistance during a 10-year follow-up period in a cementless system [3-5]. However, no comparative studies with more than 10 years follow-up exist for cementless cups, and there are a few comparative studies for cement cups [12,13]. The purpose of this study was to evaluate the polyethylene wear rate and osteolysis incidence associated with XLPE and CPE used in cementless THA during 15 years of follow-up.

Materials and Methods

We performed a retrospective cohort study on cementless THA with CPE or XLPE for developmental dysplasia of the hip (DDH). DDH was defined by preoperative radiographic abnormalities of the femoral head or the acetabulum [14].

We evaluated 68 primary THAs using the Mallory-Head cementless system (Biomet) with 28-mm-diameter femoral head and 4.8-mm-thick liner (46-mm or 48-mm cup) for DDH (Crowe classification I or II) by 3 surgeons at our institution between April 1993 and December 1998. Twenty hips were excluded because the X-ray films of 18 hips had been discarded before we started this study and 2 patients were lost to follow-up due to moving just after discharge. As a result, we assessed 48 hips. Before April 1995, 19 primary THAs were performed with CPE (Biomet). From April 1995 onward, 29 primary THAs were performed with XLPE (ArCom; Biomet). At the final follow-up, we evaluated 24 patients with XLPE (XLPE group) and 17 patients with CPE (CPE group). The follow-up rate was 85.4%. The follow-up data are summarized in Table 1. This study was approved by the ethics review committee for clinical research of the University of Occupational and Environmental Health.

Implants

A Mallory-Head cementless prosthesis with a XLPE or CPE liner was used for all THAs. An acetabular component for all THAs was Ring-loc acetabular shell and Hi-Wall liner. These 2 polyethylenes are sterilized with the same amount of gamma irradiation (3.3 mRad) in the presence of argon gas, but the molding system differs between them. XLPE (ArCom) inserts are made from isostatic compression-molded H1900 ultra-high molecular weight polyethylene (UHMWPE) bars. The CPE inserts are made from ram-extruded GUR4150 or GUR1050 UHMWPE bars. The molecular weight of all resins is approximately 5 million, and the manufacturing process explains the real difference in the degree of cross-linking in 2 materials. ArCom's isostatic compression-molded system effectively induces higher levels of cross-linking in XLPE than in ram-extruded molded polyethylene (Supplementary data 1: Internal research of Biomet).

Table 1
Follow-up Summary.

Variable	XLPE Group	CPE Group
THA period	4/1995 to 12/1998	4/1993 to 3/1995
No. of THAs	29	19
Deceased, *n* (%)	4 (13.8)	2 (10.5)
Reoperations, *n* (%)		
Wear-related	0 (0)	0 (0)
Breakage of acetabular liner	0 (0)	0 (0)
Lost to follow-up, *n* (%)	1 (3.4)	0 (0)
Radiographic analysis of cases at 15 y, *n* (%)	24 (82.8)	17 (89.5)

THA, total hip arthroplasty; XLPE, cross-linked polyethylene; CPE, conventional polyethylene.

Surgical Technique

All THAs were performed at a single facility by 3 senior hip surgeons using a posterolateral approach without trochanteric osteotomy. An acetabular component was inserted into a line-to-line reamed acetabulum.

Postoperative Therapy

Postoperative therapy was identical for all cases in both groups. Standing and parallel-bar gait exercise without weight-bearing limitations began 1 week after surgery. Walking with crutches was begun after 2 weeks. T-cane gait training was performed from 6 weeks onward.

Preoperative and Postoperative Baseline Data

All radiological analyses were performed by the same coauthor. In both groups, the degree of hip subluxation was categorized according to Crowe classification from preoperative radiographs [15]. We evaluated the cup orientation (cup inclination and cup anteversion angle [16]) through postoperative anteroposterior radiographs with the patient in a supine position and the X-ray beam centered on the symphysis pubis by using the software program Image VINUS Web (Yokogawa Electronics Inc, Tokyo, Japan).

Polyethylene Wear

We measured linear penetration of the liner by using the Sychterz method [17]. All measurements were taken based on anteroposterior radiographs with the patient in a supine position. Each radiograph was digitized using the X-ray film scanner CanoScan 9950F (Canon Inc, Tokyo, Japan). The 2-dimensional penetration analysis was performed by the PolyWare version 7 (Draft Inc, Vevay, IN), which is a validated computer-assisted edge detection method. We measured total head penetration for each case, using postoperative radiographs from the first few weeks and at 1, 5, 10, and 15 years of follow-up. We calculated wear rates based on penetration differences between 1 and 5, 1 and 10, and 1 and 15 years of follow-up because previous studies on polyethylene wear demonstrated substantial proximal penetration 1 year after surgery due to creep or bedding-in [17,18]. The intraobserver intraclass correlation coefficient was 0.896 (0.830-0.937).

Incidence of Excessive Polyethylene Wear

Excessive polyethylene wear was defined as 0.1 mm/y or more because Dowd et al [19] showed that osteolysis does not develop in hips with a wear rate of less than 0.1 mm/y. In this study, we assessed the incidence of excessive wear between 1 and 15, 1 and 5, 5 and 10, and 10 and 15 years, respectively, in both groups.

Osteolysis Incidence

Osteolysis was assessed by the same co-author. The area of osteolysis surrounding the acetabular or femoral component was measured at 5, 10, and 15 years of follow-up. Osteolysis was defined as a localized area of trabecular bone loss or cortical erosion that was not apparent in the preoperative assessment or within 1