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Original article

Comparison of wear rate and osteolysis between annealed and remelted highly cross-linked polyethylene in total hip arthroplasty. A case control study at 7 to 10 years follow-up

R. Takada , T. Jinno*, D. Koga , M. Hirao , T. Muneta , A. Okawa

Department of Orthopaedic Surgery, Medical Hospital, Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo-ku, 113-8519 Tokyo, Japan

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ABSTRACT

Background: Low polyethylene wear rate and low incidence of osteolysis after total hip arthroplasty using annealed and remelted highly cross-linked polyethylene have been reported. However, there is no previous report that directly compared both types of highly cross-linked polyethylene. We therefore performed a retrospective study on a series of highly cross-linked polyethylene, in order to: (1) compare wear rates and the incidence of osteolysis between annealed and remelted highly cross-linked polyethylene at 7–10 years; (2) identify the frequency of complication related to annealed and remelted highly cross-linked polyethylene.
Hypothesis: There is no difference in the linear wear rate and the incidence of osteolysis between the annealed and remelted highly cross-linked polyethylene in total hip arthroplasty.
Patients and methods: Two hundred and sixteen cases of cementless total hip arthroplasties with annealed or remelted highly cross-linked polyethylene, which were performed between January 2003 and December 2006 in one institution, were followed for 7–10 years and received computed tomography scan, in addition to radiography at the latest follow-up. Annealed and remelted highly cross-linked polyethylene was used in 91 cases and 125 cases, respectively. A 26-mm cobalt-chromium head was used in all cases. Penetration rates from 1 year to the last evaluation were used to estimate the yearly linear wear rate. Existence of osteolysis was evaluated by plain radiography and computed tomography.
Results: There were no significant differences in patients' background between the two groups. The linear wear rate of annealed and remelted group was 0.031 ± 0.022 mm/year and 0.032 ± 0.020 mm/year, respectively ($P = 0.91$). Two cases of small femoral osteolysis were found in the annealed group. Any complication related to highly cross-linked polyethylene was not found in both groups.
Discussion: There was no significant difference in the linear wear rate and the incidence of osteolysis between the annealed and remelted group at postoperative 7 to 10 years. Excellent results of both types of highly cross-linked polyethylene were revealed by this study.
Level of evidence: Level III retrospective case control study.

1. Introduction

Periprosthetic osteolysis caused by polyethylene wear particles is one of the major complications in total hip arthroplasty (THA). The natural history of osteolysis is asymptomatic and progressive until substantial bone loss causes an eventual loosening of the component [1]. To improve wear resistance and to reduce osteolysis, highly cross-linked polyethylene (HXLPE) with annealing or remelting thermal treatment was introduced in the 1990s instead of conventional polyethylene. Annealing method involved a single thermal treatment below the crystalline melt transition in polyethylene to preserve crystallinity and mechanical properties, but also resulted in a material containing elevated residual free radicals with the potential to oxidize in vivo [2]. Remelting method involved thermal treatment above the melt transition. This resulted in a material with undetectable free radicals but at the expense of reduced crystallinity and lower material properties [3].

According to a systematic review of wear rate and osteolysis outcomes at a minimum of 5 years of follow-up, a mean wear rate of 0.042 mm/year could be expected with annealed or remelted HXLPE compared to 0.137 mm/year using conventional polyethylene [4]. Moreover, the incidence of osteolysis was 87% lower with HXLPE when compared with conventional polyethylene. Thus, low polyethylene wear rate and low incidence of osteolysis of

* Corresponding author. Tel./fax: +81 3 5803 4021.
E-mail address: jinno.orth@tmd.ac.jp (T. Jinno).

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both types of HXLPE were reported compared to conventional polyethylene. However, there is no previous report that directly compared wear rates and the incidence of osteolysis of annealed HXLPE with those of remelted HXLPE.

The goals of this retrospective case control study were:

- to compare wear rates and the incidence of osteolysis between annealed and remelted HXLPE at 7–10 years;
- to identify the frequency of complication related to annealed and remelted HXLPE.

Computed tomography (CT) scans, considered to be a more accurate and sensitive method for detecting osteolysis compared to plain radiography [5–7], were used to evaluate osteolysis as well as plain radiography in this study. The study hypothesis was that there was no difference in the linear wear rate and the incidence of osteolysis between the annealed and remelted HXLPE in THA.

2. Patients and methods

2.1. Patients

The institutional research ethics committee approved the study protocol. We retrospectively reviewed 367 primary cementless THAs in 306 patients performed with metal on annealed or remelted HXLPE between 2003 and 2006 by two senior orthopaedic surgeons at one institution. In this period, 508 primary cementless THAs had been performed in our hospital (average 127 cases/year). Of the 508 cases, 407 cases had been performed by the two surgeons (80.1%). Of 367 cases that were reviewed, 2 cases underwent revision surgery for reasons unrelated to osteolysis and liner trouble, 14 cases died of unrelated causes, and 44 cases were lost, before postoperative 7 years. The remaining 307 cases were followed for a minimum of 7 years (83.7% in all consecutive cases). At postoperative 7 years or later, we recommended CT-scans in addition to radiography as a part of routine clinical screening for periprosthetic osteolysis regardless of absence of clinical signs and symptoms. Finally, 216 cases of 174 patients were included in this study. Ninety-one cases followed for a minimum of 7 years who did not receive CT scan screening were excluded from this study (Fig. 1).

2.2. Methods

Primary cementless THAs with metal-on-HXLPE (MOHXLPE) bearings using a posterolateral approach were performed in all cases. Annealed HXLPE (Crossfire, Stryker Orthopaedics, Mahwah, NJ) were used in 91 cases and remelted HXLPE (Longevity, Zimmer Inc., Warsaw, IN) were used in 125 cases. One surgeon performed 41 surgeries in annealed group and 56 in remelted group. The other surgeon performed 50 surgeries in annealed group and 69 in remelted group. There was no specific reason for the types of HXLPE which were chosen. Cementless cups (Ti-6Al-4 V alloy) and fit and fill stems with a 26-mm cobalt-chromium head, which was the most common choice of the head material in Japan at that time, were used. In the annealed group, TriAD HA PSL cups were used in combination with Super SecurFit HA stems (Stryker Orthopaedics, Mahwah, NJ). In the remelted group, Trilogy HA/TCP cups were used in combination with VerSys HA/TCP Fibermetal Midcoat stems (51 hips) or VerSys HA/TCP Fibermetal Taper stems (74 hips) (Zimmer Inc., Warsaw, IN). The cups were inserted in a press-fit fashion, and additional screws were used at the surgeon's discretion. Postoperatively, the patients were allowed full weight bearing as tolerated.

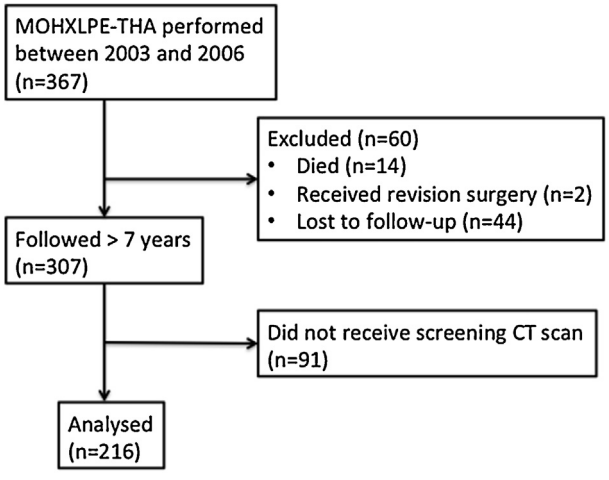

Fig. 1. Flow chart showing the selection of the patients. MOHXLPE, metal-on-highly cross-linked polyethylene; THA, total hip arthroplasty.

2.3. Methods of assessment

The Japanese Orthopaedic Association (JOA) Hip Score was evaluated preoperatively and at the latest follow-up (a score of zero is equivalent to maximum disability and a score of 100 is equivalent to no disability) [8]. Additional examination and therapy were performed when they had any hip symptoms. They were followed-up with annual medical examination and screening radiography after the surgery. CT scan was also performed at 3 to 6 months before surgery and at 3 months postoperatively in all cases. Postoperative radiography was routinely performed at 3, 6, and 12 months postoperatively, and annually thereafter. The postoperative radiographs were compared with those taken immediately postoperatively. Femoral and acetabular osteolysis was defined as an area of localized loss of trabecular bone or cortical erosion adjacent to the implants that was not apparent on the immediate postoperative radiographs [9]. The osteolysis was reported on the acetabular side if it was present in any of the three DeLee and Charnley zones [10] and on the femoral side in any of the Gruen zones [11]. The acetabular components were defined as stable, stable with a suboptimal interface, or unstable [12,13]. The femoral prostheses were considered bone-ingrown, fibrous stable, or unstable [14]. Cup size and the number of screws used for cup fixation were recorded. Radiographic cup inclination and anteversion were measured.

All CT scan images were acquired using multidetector CT (Aquilion64, TOSHIBA Medical System Inc., Tokyo). A metal-artifact-minimizing protocol was used [6]. The scanning parameters were as follows: axial plane at 140 kV, 100 to 300 mA, 1.0-mm thickness for slice images. All CT scan images were obtained in supine position. The area from anterior superior iliac spine to the distal end of femoral condyle was evaluated. CT scans were performed before surgery, at postoperative 3 months, and at postoperative 7–10 years in all cases. Osteolysis was defined as the same as in the radiographs, by comparing the CT scan images with those performed at postoperative 3 months. Existence of soft tissue mass related to polyethylene wear [15] in CT images was noted. Existence of abnormal signs in radiographs or CT images suspecting fracture of liner was also noted. Each radiograph and CT scan image was evaluated by two of three independent orthopaedic surgeons including one that did not participated in surgery. Kappa (κ) coefficients, used to quantify the extent of agreement among the surgeons, denoted good to excellent inter-observer reproducibility ($\kappa = 0.67$ to 1.00).

Postoperative femoral head penetration was evaluated using a computer-assisted method (PolyWare™ Digital Version 7.24; Draftware Developers, Inc, Vevay, IN, USA) by two observers (RT, MH) independently. Spearman's correlation analysis showed good intra-observer reliability ($r = 0.81$, $P < 0.01$) and inter-observer