The Journal of Arthroplasty xxx (2016) 1–5

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Original Article

Polyethylene Wear Associated With 26- and 32-mm Heads in Total Hip Arthroplasty: A Multicenter, Prospective Study

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ARTICLE INFO

Article history:
Received 22 January 2016
Received in revised form
2 May 2016
Accepted 25 May 2016
Available online xxx

Keywords:
total hip arthroplasty
highly cross-linked polyethylene
wear
penetration rate
polyethylene thickness

ABSTRACT

Background: Although there were many clinical studies of highly cross-linked polyethylene (XLPE) wear among different femoral head diameters, few referred to thickness of XLPE in case larger femoral heads were used because smaller sockets were frequently used for Asian population.
Methods: This prospective study included 240 hips that underwent primary total hip arthroplasty using XLPE combined with 26-mm (group S) or 32-mm (group L) cobalt–chromium head with maximum follow-up of 10 years. We measured 3-dimensional (3-D) linear penetration rate of XLPE among same implant design groups except head diameter and estimated the validity of thinner XLPE.
Results: Our study demonstrated comparable 3-D linear penetration rates, which were 0.06 ± 0.07 mm/y for group S and 0.03 ± 0.02 mm/y for group L at 10 years after surgery and penetration rates seemed to be almost constant with no significant difference after 3 years. Minimum liner thickness (5.3 mm for 48-mm socket in combination with 32-mm femoral head) and the second thinnest XLPE (6.3 mm in case of socket from 50 mm to 54 mm combined with 32-mm femoral head) was distributed in 25% and 72% with group L, respectively, and there were no significant differences in penetration rates between 5.3-mm– and 6.3-mm–thickness groups.
Conclusion: Our study suggested that whether to select 26- or 32-mm diameters of femoral head does not affect XLPE wear in combination with this type of articulation.

Osteolysis related to particulated polyethylene wear debris is one of major complications in metal-on-polyethylene total hip arthroplasty (THA) [1], and highly cross-linked polyethylene (XLPE) is an alternative bearing surface, which was developed to reduce polyethylene wear. In in vitro simulations, XLPE has been studied and decreased wear rates compared with conventional polyethylene [2-4], and many clinical studies confirmed these reductions in wear compared with conventional polyethylene in wear at during midterm follow-up [5-7].

There have been trends to select larger femoral head in THA for stability of the hip joint and gain of prosthetic range of motion. Comparing conventional polyethylene, with which larger femoral head diameter has the potential to increase wear due to larger sliding distance [3,8], hip simulator studies have showed no significant differences in XLPE wear among different femoral head diameters [2,9], and some comparative studies have verified these advantages in XLPE wear at midterm period in in vivo retrospective research [10-12]. In Asian population, however, commonly used socket size may be smaller compared with Western population, and the use of larger femoral head diameters may be under necessity of thinner XLPE, leading to diminution in mechanical properties such as surface damage and fracture resulting in polyethylene failure.

This study was sponsored by Zimmer K.K. (Tokyo, Japan). The study sponsor was involved in design of the study, data collection and statistical analysis.

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.arth.2016.05.063.

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http://dx.doi.org/10.1016/j.arth.2016.05.063
0883-5403/

The purpose of the present study was to examine XLPE wear between 26-mm and 32-mm femoral head prospectively and to evaluate relation between wear and polyethylene thickness at 10 years postoperatively.

Materials and Methods

This prospective study included patients who were aged 75 years or younger than 75 years at operation, suffered from osteoarthritis or avascular necrosis, and scheduled to undergo primary THA. The patients who underwent THA with the metal socket 46 mm and under 46 mm regardless of femoral head size were excluded because these sockets are not available in 32-mm head.

A prospective consecutive series of 240 primary cementless THAs in 232 patients were performed by 3 senior surgeons at 3 institutions from July 2002 to September 2005. Institutional review board consent was obtained for this prospective study. Eight hips in 8 patients were excluded from this study because 3 patients were aged older than 75 years at operation, 1 patient was not primary THA patient, 3 patients had rheumatoid arthritis or femoral neck fracture, and 1 underwent THA using 46-mm socket. And excluding those who were ineligible in terms of radiographic measurement conditions or lost to follow-up, overall, a total of 180 hips in 178 patients (24 men and 154 women, with the mean age of 61.0 ± 9.5 years) with available measurements of wear were included in the study with maximum follow-up of 5 years. In addition, 55 of those 180 hips were examined at 10-year visit by 1 institution. The diagnoses were 162 hips with osteoarthritis, 18 with avascular necrosis.

All patients underwent cementless THA through a posterolateral approach. A cementless, titanium fiber metal-coated socket with hydroxyapatite (HA) (Trilogy; Zimmer Warsaw, IN) was implanted with a press-fit technique. A cementless, collarless, tapered, proximally titanium fiber metal and HA-coated stem (VerSys Fiber Metal Taper; Zimmer) was used in 122 hips and proximally same as VerSys Fiber Metal Taper, distally nontapered but fluted stem (VerSys Fiber Metal Midcoat; Zimmer) in 58 hips. Ten-Mrad electron beam–irradiated, highly cross-linked and remelted polyethylene liner (Longevity; Zimmer) was inserted in all cases. Twenty-six–mm cobalt–chromium head (Zimmer) was used in 84 patients (84 hips; group S) and 32-mm cobalt–chromium head (Zimmer) in 94 patients (96 hips; group L). The choice of femoral head size was decided based on the operative period.

Clinical outcomes were recorded with the Harris Hip Score [13] preoperatively and at each annual clinical visit. Clinical complications of fracture, infection or dislocation, and so forth were compiled as well.

Standard anteroposterior (AP) and lateral radiography of the pelvis and femur was taken at immediately after the operation and each annual clinical visit. AP radiograph was taken in a supine position with bilateral hip joints on the internal rotation position with the beam center on the pubic tubercle. Component fixation and osteolysis were determined from these sequential radiographic views.

Three-dimensional (3-D) linear head penetration rates were measured using PolyWare software (Draftware Developers Inc; Vevay, IN) on digitized AP and lateral radiographs. Linear penetration rates were calculated by subtraction of the penetration at initial radiography 1 month postoperatively from that of annual radiography and dividing by the follow-up duration. Cup orientation was also measured using this software [14]. Radiographic measurements were made by a senior engineer who was neither involved in any surgeries nor clinical evaluations.

Difference of 3-D linear penetration rates between the 2 groups was estimated annually up to 10 years, and subgroup analyses were conducted by both gender and body mass index (BMI) to estimate any influences of those parameters on wear behavior. Distribution of the socket size and XLPE liner used in the operation was examined, and relation between difference of the thickness of XLPE liner and 3-D linear penetration rates was estimated.

Statistical analysis between the 2 groups was performed using unpaired Student's *t*-test, chi-square test, and Wilcoxon rank-sum test. SAS version 9.2 (SAS Institute, Cary, NC) was used to perform statistical calculations, and values of $P < .05$ (2 sided) were considered significant.

Table 1
Clinical Details.

Variable	26 mm (Group S)	32 mm (Group L)	*P* Value
Number of hips	84	96	
Gender (male/female)	10/74	14/82	.60[a]
Age (years)	59.2 ± 9.7	62.5 ± 8.6	.02[b]
BMI	24.0 ± 3.6	24.1 ± 3.8	.89[b]
Diagnosis (OA/AVN)	75/9	87/9	.77[a]

BMI, body mass index; OA, osteoarthritis; AVN, avascular necrosis.
[a] Chi-square test.
[b] Student's *t*-test.

Results

Patient demographic data for each group including gender, age, diagnosis, and BMI are summarized in Table 1. There were no significant differences between the 2 groups in gender, preoperative diagnosis, and BMI. In group L, mean age at operation was higher compared with that in group S (Student's *t*-test: $P = .02$).

Clinical Results

Mean Harris Hip Score improved from 50.8 ± 13.0/50.1 ± 12.3 (group S/group L) before surgery to 94.5 ± 6.8/93.4 ± 6.3 at 5 years and 91.1 ± 10.7/89.4 ± 10.7 at 10 years after surgery; there was no significant difference between the groups (Student's *t*-test: $P = .92$, $P = .31$, and $P = .62$). At the final follow-up, no significance was identified between the 2 groups for each parameter of Harris Hip Score (pain, 42.2 ± 5.4 in group S, 43.6 ± 1.2 in group L, Student's *t*-test: $P = .27$; function, 28.3 ± 5.7, 25.7 ± 8.5, $P = .27$; activity, 11.9 ± 2.1, 11.7 ± 2.0, $P = .83$; deformity, 4.0 ± 0.0, 3.7 ± 1.1, $P = .17$; and range of motion, 4.8 ± 0.3, 4.8 ± 0.3, $P = .86$).

Radiographic Results

The amount of XLPE wear was measured in 145 hips (group S: 66, group L: 79) at 1 year, 149 (68, 81) at 2 years, 140 (64, 76) at 3 years, 132 (61, 71) at 4 years, 124 (60, 64) at 5 years, and 55 (27, 28) at 10 years after the surgery.

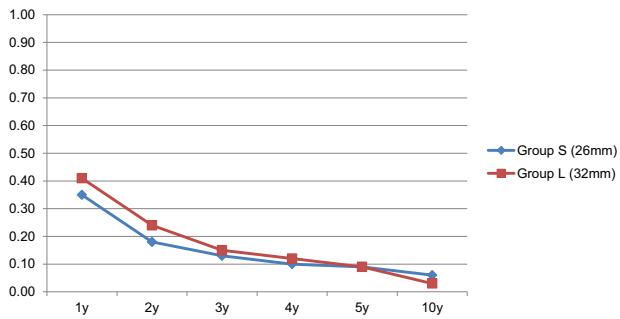

Fig. 1. Line graph shows yearly linear penetration in both group S and group L (mm/y).