Early Dislocation Rate in Ceramic-on-Ceramic Total Hip Arthroplasty

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Abstract Wear debris from metal-on-polyethylene articulation in conventional total hip arthroplasty (THA) may limit THA longevity. Bearing surfaces made of modern ceramic material, with high wear resistance and low fracture risk, have the potential to extend the longevity of THA and make the procedure more suitable for young, active patients. Concerns regarding a ceramic-on-ceramic bearing surface have included potential for a higher incidence of dislocation caused by limited modular neck length and liner options. This prospective study assessed the early dislocation incidence for a ceramic-on-ceramic THA system. Out of the 336 consecutive ceramic-on-ceramic THA performed at our institution over an 8-year (1997–2005) period, 2 (0.6%) sustained dislocation during, and none after, the first postoperative year. Both dislocations were treated with closed reduction. No component fracture or revision for any reason has occurred in this series.

Key words total hip arthroplasty · dislocation · ceramic-on-ceramic

Introduction

Total hip arthroplasty (THA) has been a successful operative procedure for the relief of pain and improvement

of quality of life for patients with end-stage arthritis of the hip. The longevity of THA has been related to avoidance of wear debris-induced osteolysis or aseptic component loosening [1]. A ceramic-on-ceramic (COC) bearing surface, with high wear resistance, may improve longevity of THA by minimizing wear debris.

Dislocation ranks second to aseptic component loosening in frequency of complication after THA. Dislocation occurs most frequently during the first year after THA and can be problematic [2, 3]. Although the incidence of dislocation at academic centers with a high volume of primary THA procedures can be lower, the incidence can be as high as 4.2% at nonacademic centers where a greater percentage of THA procedures are performed annually [4]. Currently available COC THA systems do not offer the degree of modularity available with metal-on-polyethylene THA systems. Ceramic acetabular liners are not available with offset or elevated rim modularity. Ceramic femoral head components do not allow effective lengthening of the femoral neck more than 5 mm. Although desirable for potential prevention of wear debris, use of a COC THA system has raised concern regarding a potential adverse effect on dislocation prevalence.

The effect of surgical approach on the incidence of dislocation after THA has been previously studied. Concern has been offered that the posterolateral approach, when compared to transtrochanteric or anterolateral approaches, raises the risk of dislocation [5, 6]. However, improved surgical technique when utilizing a posterolateral approach, specifically posterior capsular repair and reinforcement, has been shown to substantially reduce dislocation incidence after THA [7, 8].

The purpose of this study was to report the incidence of dislocation in a multisurgeon, single institution, single manufacturer series of primary COC THA performed through a posterolateral approach employing capsular repair and reinforcement.

Level of Evidence: Level II Prospective cohort study

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Materials and methods

From July 1997 through July 2005, 337 THA using an alumina-on-alumina COC bearing surface were performed in 307 patients at our institution. All but one patient consented to participate in the prospective data collection for this Institutional Review Board-approved study, creating a study cohort of 336 consecutive COC THA procedures in 306 patients. All procedures were performed by one of four senior surgeons with the patient in a decubitus position using a posterolateral approach with posterior capsulotomy, posterior capsular repair, and piriformis tendon reattachment to the greater trochanter.

All THA components were from a single manufacturer (Stryker Orthopaedics, Mahwah, NJ) and were noncemented. Three titanium alloy acetabular components were used, including ten porous-coated PSL cups, 23 SecurFit-HA arc-deposited hydroxyapatite-coated cups, and 303 Trident-HA arc-deposited hydroxyapatite-coated cups. The 303 Trident ceramic liners were titanium metal-backed; the 33 PSL and SecurFit-HA ceramic liners were not. Four titanium alloy femoral components were used, including 103 SecurFit stems with C-taper neck, 19 SecurFit-Plus stems with C-taper neck, 211 Super SecurFit-Plus stems with V40-taper neck, and 3 Accolade stems with V40-taper neck. The V40 taper necks had a smaller neck geometry than the C-taper necks. Alumina ceramic liner inner diameter was dictated by chosen cup outer diameter, thereby determining head component diameter. A 28 mm alumina ceramic head was used in 28 THA, 32 mm in 207 THA, and 36 mm in 101 THA. A head size of 32 or 36 mm was used in 91.7% of hips (Table 1). The greatest available modular head addition to neck length was 5 mm. No skirted heads were available.

Patients were followed-up postoperatively at 3, 6, and 12 months and then annually. Telephone interviews were conducted for patients who could not return for an office visit.

Results

All 306 patients, accounting for all 336 THA procedures, were followed-up for at least 2 years with a mean follow-up of 3.4 years (range, 2–9). The study cohort gender was 54% male and 46% female. Mean age at time of surgery was 56 years (range, 21–81). Mean body mass index was 27 (range, 18–48). The predominant diagnosis was osteoarthritis, in 88% of the cases (Tables 2 and 3). Operative side was right in 55% and left in 45% of cases. Mean operative duration was 111 min (range, 70–195; Table 4).

Three patients died of unrelated causes after 1 year follow-up; all hips were functioning well before the time of death. Dislocation occurred in 2 (0.6%) of the 336 COC bearing surface THA, both with 32 mm heads. One posterior dislocation occurred on the day of surgery without dislocation recurrence. One anterior dislocation occurred 10 months postoperatively and recurred once, 12 months postoperatively.

Table 1 Frequencies of implant type and sizes of ceramic-on-ceramic THA

Description	Number	Percent
Acetabular cup size (mm)		
46	7	2.1
48	12	3.6
50	50	14.9
52	54	16.1
54	51	15.2
56	42	12.5
58	67	19.9
60	34	10.1
62	13	3.9
64	6	1.8
Femoral head size (mm)		
28	28	8.3
32	207	61.6
36	101	30.1
Femoral stem type		
V40 Super Secur-Fit Plus	211	62.8
C-taper Secur-Fit	103	30.7
C-taper Secur-Fit Plus	19	5.7
Accolade	3	0.9

The posterior dislocation occurred in a 60-year-old man on the day of surgery and was noted on routine radiographic examination in the post anesthesia care unit (PACU). The dislocation was treated by closed reduction with sedation in the PACU. Ensuing rehabilitation was benign. The patient experienced no recurrent dislocation or instability through 4 years of follow-up. Latest radiographs showed no sign of component fracture or debris generation.

The anterior dislocation occurred in a 54-year-old woman during sexual activity 10 months postoperatively. The dislocation was treated by closed reduction under general anesthesia. A second anterior dislocation occurred while dancing 2 months later, 12 months postoperatively. The dislocation was again treated by closed reduction under general anesthesia. The patient experienced no recurrent dislocation or instability through 12 months of follow-up. Of interest, this patient's THA procedure was complicated by displacement of the femoral trial head anteriorly into the pelvis. The release of the gluteus maximus and anterior hip capsule required to retrieve the femoral trial head were not standard in other THA procedures in the study cohort. During postoperative rehabilitation, the patient was noted to have weakness of hip abduction, flexion and adduction, which gradually improved.

Of the 336 COC THA in this study, none have demonstrated component fracture, infection, or revision for mechanical loosening. No revisions have been performed in this patient cohort.

Discussion

The rationale for the use of COC bearing surfaces in this THA patient cohort was to avoid the potentially adverse long-term effects of polyethylene wear. The longevity of more conventional THA systems available during the

Table 2 Patient characteristics (all baseline characteristics were analyzed per hip, not per patient)

Description	Mean (sd)	Range
Age ^a	56.0 (8.6)	21–81
Height (in)	68.2 (4.1)	58–78
Weight (lbs)	182.4 (43.4)	91–340
BMI	27.4 (5.4)	18–48

^a Age at time of surgery

period of this study, employing metal-on-polyethylene bearing surfaces with conventional polyethylene, warranted concern regarding potentially adverse wear debris-induced osteolysis or component loosening. The alumina COC THA system used in this study was the evolutionary result of the use and improvement of prior ceramic systems in Europe and was initially implanted (1997–2003) under the jurisdiction of a multicenter, prospective, randomized study overseen by the Federal Drug Administration (FDA). The FDA approved the system for general availability in the USA during the period of this study (March 2003).

Boutin reported the first COC THA experience in 1970 [9]. Hamadouche et al. [10], reporting in 2002 on a European experience, found no radiographically detectable wear of COC components at minimum follow up of 18.5 years. Early and midterm COC THA clinical outcome reports from the initial experience in the USA have been encouraging. At a mean follow-up of 5 years, D'Antonio et al. [11] reported equivalent clinical performance of randomized alumina COC THA and conventional metal-on-polyethylene THA groups.

Another result of the evolutionary improvements of COC THA bearing systems has addressed ceramic component fracture. Early ceramic component materials contained larger grain size and greater impurity than current ceramic component materials, resulting in unacceptable component fracture rates during the earlier European experience [12, 13]. Modern ceramic component material is produced with improved manufacturing processes leading to finer grain size, greater purity, and higher burst strength [14]. The addition of universal proof testing has allowed a flawed ceramic component to be detected and removed before distribution for use. The current

Table 4 Operative details of COC THA

Description	Number	Mean (sd)	Range
Length of surgery (min)	336	111.4 (21.1)	70–195
Operative side		Percent	
Right	186	55.4%	
Left	150	44.6%	
Surgical approach			
Posterior	336	100%	

estimated risk of alumina ceramic fracture is one in 25,000 [15], provided the acetabular component, ceramic liner, femoral component, and ceramic head are appropriately implanted and positioned. At a mean follow-up of 5 years, D'Antonio et al. [11] reported no ceramic component fracture in 328 COC THA. In this study, there was no ceramic component fracture in 336 COC THA.

Dislocation is the second most frequent complication after THA, component-loosening being a more frequent complication [2]. The limited options of modular neck length and liner offset offered by this COC THA system, compared to more variable options offered by metal-on-polyethylene THA systems, elicited concern regarding dislocation rate during this series. Ceramic head component choice does not allow the addition of more than 5 mm to femoral component neck length. As well, an elevated or offset ceramic liner option is not available. Accurate optimal placement of the THA components has been emphasized, as impingement and range of motion have been shown to be determined by the orientation of the acetabular and femoral components as well as head size [14]. Soft tissue repair after posterior approach, emphasized by Pellicci et al. [16], has been shown to reduce dislocation rate. In a cohort of 437 consecutive primary THA, White et al. [17] achieved a 0.7% dislocation rate in a non-COC THA series using routine posterior capsular repair and reinforcement. Similarly, Weeden [7] and Milhalko [8] reported 0.85 and 0.95% dislocation rates, respectively, in non-COC THA series using posterior capsular repair and reinforcement. In the current study, all patients had COC THA through a posterior capsular approach with subsequent posterior capsular repair and piriformis tendon reinforcement by attachment to the greater trochanter with a dislocation rate of 0.6%.

Increased head size will increase range of motion before impingement, contributing to a lower dislocation rate, as shown by several clinical studies [14, 18–20]. In 1693, primary THA, Khatod et al. [21] reported a 2% dislocation rate for 28 mm heads and a 0.7% rate for 32 mm heads. With wear characteristics among 28, 32, and 36 mm COC THA systems equivalent at minimally detectable levels, head size may reasonably be increased proportionally with acetabular component size. In the current study, dislocation occurred in two (0.6%) of 336 COC THA with 32 mm heads. Of our patients in this series, 92% had a 32- or 36-mm head.

Table 3 Patient gender and diagnosis

	Number	Percent
Male	181	53.9
Female	155	46.1
Primary diagnosis		
Osteoarthritis	297	88.4
Avascular necrosis	17	5.1
Posttrauma	8	2.4
SCFE/dysplasia	8	2.4
Rheumatoid arthritis	4	1.2
Inflammatory, noninfection	2	0.6

In this series of 336 THA with COC bearing surfaces, performed using a posterolateral approach, a low dislocation rate (0.6%) was achievable during the first postoperative year, with none occurring more than 12 months after surgery. The potential for high long-term wear resistance in vitro [22] and in vivo [10], along with a low risk of component fracture [15], a low dislocation rate, and clinical performance equivalent to nonceramic THA systems [11], combine to make a modern COC THA system an attractive choice for young, active patients.

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