The Journal of Arthroplasty 30 (2015) 1187–1190

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Early Outcomes of Titanium-Based Highly-Porous Acetabular Components in Revision Total Hip Arthroplasty

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ARTICLE INFO

Article history:
Received 7 November 2014
Accepted 11 February 2015

Keywords:
revision hip arthroplasty
total hip arthroplasty
highly porous
titanium
acetabular cups
aseptic survivorship

ABSTRACT

Titanium-based highly-porous metal cups have been introduced as a relatively new alternative for enhanced acetabular fixation during revision THA; limited number of studies have evaluated its outcomes. We aimed to assess the clinical, functional, and patient-reported outcomes following the use of new generation highly-porous titanium acetabular implants in the revision setting. Seventy-one revisions were (1:1) matched to a conventional porous-coated cohort and were followed-up clinically and radiographically for at least 2-years. Non-significant differences in overall aseptic-survivorship were found across all types of acetabular defects comparing both cohorts ($P = 0.3$). The overall HHS, UCLA, and SF-36 scores were similar between both cohorts. It remains to be seen if the great potential for enhanced osseointegration translates into improved long-term survivorship compared to conventional-porous devices.

Revision acetabular surgery provides arthroplasty surgeons with multitude of challenges, including restoring the biomechanics of the hip, obtaining initial stable fixation and long-term durable implant survivorship, preserving bone stock, and reconstructing bone defects [1,2]. Over the past decade, a variety of highly porous titanium-based and tantalum-based metals of varying frictional coefficient and porosity have been introduced commercially as viable new alternatives to conventional porous devices for enhancing osseointegration and optimizing component stability during acetabular reconstructions [3]. Their interconnected open-celled dodecahedron structure provides large surface areas for bone on-growth/in-growth [4–7]. This may be especially important in revision settings where stable implant fixation becomes challenging in the presence of variable amounts of bone loss [8]. In addition to their improved frictional resistance, it is believed that their lower modulus of elasticity compared to conventional porous metals may minimize stress shielding and bone loss in the periacetabular region in the long run [9,10].

A number of early observational studies in primary and revision total hip arthroplasties have reported durable implant survivorship with porous tantalum based acetabular components in the revision setting at short and mid-term follow-up [11–15]. However, there has been a paucity of studies reporting on the clinical, functional, and patient-reported outcomes of highly-porous titanium in revision hip arthroplasties.

Therefore, in this study we aimed to evaluate the clinical, functional, and patient-reported outcomes following use of new generation of highly-porous titanium acetabular implants in the revision setting. We specifically evaluated: (1) aseptic implant survivorship; (2) Harris Hip Scores; (3) University of California Los Angeles Activity Scores; (4) SF-36 scores, (5) satisfaction scores; and (6) complication rates, and compared these outcomes to a matched cohort of patients who had received conventional porous-coated acetabular prostheses.

Methods

The prospectively collected total joint arthroplasty database of our institution was searched to identify patients, who had undergone revision total hip arthroplasty with a highly porous titanium acetabular component, during the period January 2009 to June 2012. The inclusion criteria were: (1) patients who had either isolated acetabular revisions or revision of both femoral and acetabular components; (2) minimum follow-up of 2 years. The patients who had isolated femoral revisions or liner exchange were excluded from the analysis.

A total of 71 patients were identified who underwent 71 revision acetabular reconstructions. All revision surgeries were performed by two experienced adult reconstructive surgeons (MAM and RED). The acetabular cup utilized was the Trident Tritanium multi-hole design (Stryker Orthopaedics, Mahwah, New Jersey) in all cases, while the femoral component used was Accolade TMZF (n = 13; Stryker

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.2015.02.013.

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http://dx.doi.org/10.1016/j.arth.2015.02.013
0883-5403/

Orthopaedics, Mahwah, New Jersey); Accolade II (n = 4; Stryker Orthopaedics, Mahwah, New Jersey), and a Restoration Modular femoral component (n = 31; Stryker Orthopaedics, Mahwah, New Jersey). These patients were compared to a matched cohort (1:1) of patients who underwent revision arthroplasties with conventional porous acetabular cups (Trident; Stryker Orthopaedics, Mahwah, New Jersey) during an overlapping time period. Patients were matched by age (±3 years), gender (1:1), body mass index (±3), and by the type of acetabular defect as described by Paprosky et al [16] (1:1). All revisions in both cohorts had a metal-on-highly cross-linked polyethylene liner (X3; Stryker Orthopaedics; Mahwah, New Jersey).

Demographic, clinical, radiographic, and patient-reported outcomes data were reviewed from the office charts, medical records, discharge summaries, pre-operative studies, and imaging reports. Comorbidities were evaluated between cohorts to assess for any confounding variables. Patients in both cohorts were followed-up clinically and radiographically, at approximately 6 weeks, 12 weeks, 6 months, 12 months, and yearly thereafter. Functional evaluations were based on modified Harris Hip Scores (HHS), activity levels were assessed using the University of California Los Angeles (UCLA) activity ratings scale, and patient-reported physical and mental health status was evaluated using the SF-36 questionnaire. The patient-reported physical and mental health status was analyzed using SF-36 questionnaires. These scores were available for all patients pre-revision and at the time of final follow-up. In addition, during each follow-up evaluation, patients were assessed for medical and surgical complications such as superficial and deep wound infections, wound discharge, hematoma formations, deep vein thrombosis, pulmonary emboli, limb length discrepancy, nerve palsy, dislocation, and loosening.

All patients had antero-posterior and frog lateral radiographs pre-operatively and during their follow-up. These were reviewed by two senior authors at the time of their office visits. Pre-operatively, the acetabular defects were classified according to Paprosky et al's classification [16]. These defects were further subcategorized in minor (type 1–2b) and major loss group (type 2c–type 3a). In the post-operative radiographs, presence of progressive radiolucent zones of 2 millimeters or more around the implant in the three radiographic zones was considered as defining radiographic criteria for aseptic loosening, as described by DeLee and Charnley [17].

There were 28 men and 43 women who had a mean age of 58 years (range, 26–78 years) with a mean BMI of 30 (range, 19–53 in the highly-porous cohort). The mean follow-up period in this cohort was 30 months (range, 24–42 months). Isolated acetabular revisions were performed in 23 patients, while the remaining 48 patients had revision of both femoral and acetabular components. There were 16 hips that had type 1 acetabular defects, 12 with type 2a defects, 14 with type 2b defects, 22 with type 2c defects, 4 with type 3a defects, and 3 with type 3b defects. The mean age of the patients in the matched cohort was 60 years (range 28–80 years) who had a mean BMI of 31 (range, 16–55, see Table 1). The mean follow-up in the conventional porous cohort was 2.7 years (range, 2–3.5 years). There were no significant differences in the incidence of diabetes ($P = 0.2$), ischemic heart disease ($P = 0.5$), hypothyroidism ($P = 0.9$), and peripheral vascular disease ($P = 0.8$) among the two cohorts. There were no significant differences in the pre-operative HHS (46 vs. 47 points; $P = 0.5$), UCLA scores ($P = 0.06$), and SF-36 mental ($P = 0.07$) and physical ($P = 0.7$) component scores.

All data were extrapolated in to an Excel spreadsheet (Excel, Microsoft Corporation, Redmond, Washington) for initial tabulation and further descriptive and statistical analysis. Graph Pad Prism version 5.01 (GraphPad Software Inc., La Jolla, California), statistical software was used for the statistical calculations. Statistical comparisons between cohorts were performed using the Student's t-test, Z-test, or the Wilcoxon signed ranked test to determine difference in means between measurements. Kaplan–Meier plots were measured for comparison of cumulative survivorship between cohorts. A p-value of less than 0.05 was considered to be significant.

Results

No significant differences in the overall aseptic survivorship rates were found across all types of acetabular defects in the highly-porous cohort compared to the conventional cohort (96 vs. 98.6%, respectively; $P = 0.3$). The three cups that failed in the highly-porous cohort failed at 14, 14, and 8 months after the revision surgery. These patients had type 2b, 2c, and 3a acetabular defects, respectively. The patient in the conventional porous cup failed 2 months after the revision surgery. Her acetabular defect was classified as a type 2c bony defect.

The specific failure in each group will now be described. A 59 year-old man who had a BMI of 20 kg/m^2 and rheumatoid arthritis, underwent revision THA with a highly-porous acetabular cup, due to aseptic failure and a type 2b acetabular defect. Fourteen months later, follow-up radiographs demonstrated loosening around the acetabular cup, at which time a re-revision was suggested, because of these findings with recent onset groin pain. The revision was uneventful and at 10 months follow-up the patient is doing well with a modified Harris Hip Score of 92 points. A 58 year-old woman who had a BMI of 23 kg/m^2 underwent revision arthroplasty with a highly-porous cup, due to acetabular prosthesis loosening and type 2c bony defect. Fourteen months later, the patient presented with complaints of severe hip pain, and subsequently underwent re-revision arthroplasty with bone grafting for loose cup. Currently, 2 years after re-revision, she is doing well, and able to perform activities of daily living without pain, with a modified Harris Hip Score of 88 points. A 55 year-old man who had a BMI of 27 kg/m^2, underwent revision arthroplasty with a highly porous cup due to a femoral neck fracture and a type 3a acetabular defect after resurfacing hip arthroplasty three years prior. The patient underwent re-revision arthroplasty 8 months later due to acetabular fixation failure. He subsequently developed an infection two years after re-revision that required multiple irrigation and debridement, but is currently doing well at 1-year follow-up with a modified Harris Hip Score of 83 points. A conventional cup revision was performed on a 49 year-old woman who had a BMI of 35 kg/m^2 that due to acetabular osteolysis (type 2c defect). Two months

Table 1
Demographic Characteristics.

Demographic Characteristics				
		Matched Cohort Conventional Porous Cups (Trident)	Study Cohort Highly Porous Cups (Tritanium)	*P*-Value
Gender (proportion of men)		39%	39%	1
BMI in kg/m^2 (range)		31 (16–55)	30 (19–53)	0.58
Age in years (range)		60 (28–80)	58 (26–78)	0.34
Paprosky et al [16]	Type 1 defects (n)	16	16	1
	Type 2a defects (n)	12	12	1
	Type 2b defects (n)	14	14	1
	Type 2c defects (n)	22	22	1
	Type 3a defects (n)	4	4	1
	Type 3b defects (n)	3	3	1

BMI, body mass index.