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Clinical Study

Clinical and Radiographic Outcomes with a Hydroxyapatite and Porous Coated Cup Design

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Press-fit, hydroxyapatite-coated acetabular cup designs may offer a lower incidence of loosening and migration than older designs. Our study evaluated the initial clinical and radiographic success of a cementless acetabular shell in a large cohort of primary total hip arthroplasty (THA) patients. We queried our institution's prospectively collected registry for a series of 771 primary THAs (695 patients) implanted with this cup by 4 high-volume arthroplasty surgeons. Of the 613 hips with minimum 2-year followup, average HHS (Harris Hip Score) was 93.6, WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) was 87.6, and VAS (Visual Analog Scale) pain score was 1.2. While there was a 2% reoperation rate (12 hips), none of the cups were revised for aseptic loosening. No radiolucencies were found and there was no evidence of acetabular loosening. At early followup, this newer cementless acetabular cup implant design exhibits high survivorship and clinical success.

1. Introduction

When cementless acetabular cups were initially introduced in primary total hip arthroplasty (THA), studies showed mixed clinical outcomes, with problems such as failure of the locking system of the liner and the thinness of the polyethylene. Newer generations of press-fit acetabular components have been used with increasing frequency and high success rates [1–3]. Its advantages over previous generation cementless cup designs include the elimination of screw/cup fretting and corrosion, decreased neurovascular injury risk, and elimination of screw holes. Mid- and long-term studies have shown it to have favorably low rates of osteolysis and loosening [4–15].

However, in an effort to improve on the performance of press-fit cups, attention has turned towards the use of hydroxyapatite coating (HA) in conjunction with the porous coating found on most commercially available acetabular cups. Previous designs of HA-coated acetabular shells have shown mixed results at mid-term followup [3]. Studies have demonstrated that HA-coated, porous acetabular components significantly enhanced bone ongrowth in the presence of wear particles, preventing migration and reducing osteolysis [16]. HA-coated porous and sintered beaded components provided a more effective seal against the ingress of wear debris when compared with cemented cups [1]. However, other studies have shown that HA-coating has no effect on the revision rate of cementless cups [17]. Some of the unfavorable results could be attributed to manufacturing techniques such as the quality of powder, roughness of implants, method of spray coating, and the thickness of coating.

In this study, we report on a large, retrospective consecutive series of the Stryker Trident acetabular shell (Stryker Orthopedics, Mahwah, NJ). The Trident shell is a press-fit, porous, HA-coated acetabular design. We hypothesized that this newer cementless shell design would lead to excellent bone ongrowth and patient outcomes at early followup.

2. Materials and Methods

We queried our prospectively collected registry for a consecutive series of 771 primary total hip arthroplasties in 695 patients implanted with a Stryker Trident acetabular shell

Table 1: Published data on outcomes of similar cementless primary THAs.

Manuscript	Implant used	Number of hips	Mean age	Mean Followup (years)	Revision (acetabular aseptic loosening)	Revision (all cause)	Dislocation	Osteolysis
Anseth et al. (2010) [18]	Harris-Galante I/II	113	54	17.2	2 (1.8%)	4 (3.5%)	NR	2 (1.8%)
Baker et al. (2010) [19]	ABG I	69	53	15	8 (11.6%)	8 (11.6%)	0	10 (14.5%)
Belmont et al. (2008) [12]	Trispike (DePuy)	223	71.8	20	9 (4%)	26 (11.7%)	1 (0.45%)	17 (7.6%)
Della Valle et al. (2009) [13]	Harris-Galante I	204	52	20.6	5 (4%)	10 (8.1%)	5/124	NR
Chen et al. (2006) [20]	Duraloc	145	56.2	6.7	0 (0%)	2 (1.4%)	9/148 (6.1%)	3 (2%)
Streit et al. (2012) [21]	Fitmore	89	49	12	0 (0%)	5/81, 2 liner exchange	1/81	0 (0%)
Berli et al. (2007) [22]	Morscher	112		14.7	2.5%	4.7%		
Della Valle et al. (2004) [23]	Trilogy	308	64	4–7	1 (0.3%)	8 (2.4%)	NR	12 (5%)
Sugano et al. (2012) [24]	Biolox forte	93	56	12.4	1 (1.1%)	2 (2.2%) (cup only)	1 (1.1%)	0 (0%)
de Witte et al. (2011) [25]	CementLess Spotorno	102	55.9	11.8	9 (8.8%)	10 (cup)	NR	NR
Stefl et al. (2012) [26]	Harris-Galante I	120	NR	23.3	1 (0.8%)	22 (18.3%)	NR	8 (6.7%)
Gottliebsen et al. (2012) [27]	Mallory-Head	77 HA coated 73 non-HA coated	57 (HA) 63 (non-HA)	11	HA coated: 0 (0%) Non-HA coated: 7 (9.6%)	HA coated: 0% Non-HA: 9.6%	NR	NR

during the period of January 2006 to December 2007. The Stryker Trident acetabular shell is manufactured of titanium with an improved locking mechanism and a hydroxyapatite outer coating to improve bony ongrowth and incorporation. The standard technique utilized for cup implantation was line to line reaming since the cup outer diameter is approximately 1.7 mm larger than the base diameter with the HA-coating.

The surgeries were performed by the four senior authors (Mathias Bostrom, Bryan Nestor, Douglas Padgett, and Geoffrey Westrich), who are all high-volume arthroplasty surgeons. All patients underwent a combination of spinal and epidural anesthesia for postoperative pain management. Patients were placed in a lateral decubitus position with the operative side facing up, and all surgeries were done using a standard posterolateral approach with soft tissue repair. Exclusion criteria barred patients that had undergone revision hip surgery and that had less than 2-year followup from our study.

Diagnosis, age, gender, implant data, postoperative complications, and revisions were collected for all patients with a minimum followup of two years. Clinical outcome measures included HHS, WOMAC, and VAS pain scores preoperatively, at 6 weeks after surgery, and annually thereafter. Radiographic analysis was performed to assess cup position and radiolucencies. Radiographic analysis was conducted by an orthopedic surgery fellow in adult reconstruction (John Wang). Osteointegration of the acetabular component was evaluated by assessing bony ongrowth on two orthogonal X-ray views, namely, the AP pelvis and Lowenstein's cross-table lateral views. Clinical and radiographic findings were compared to published data on outcomes of similar cementless primary THAs (Table 1).

3. Results

In this patient cohort, the main indications for primary hip replacement were osteoarthritis, avascular necrosis, and post-traumatic arthritis; however, a detailed list of preoperative diagnoses is available in Table 2. During the study period, 30 patients out of the 771-patient cohort died, leaving 741 hips for analysis. Of this group, 613 hips had completed two-year minimum follow-up visits (83% followup), and the average followup was 3 years (range 2–5.1 years; median 2.95 years). Of the 613 patients in the final study group, 349 patients had right hip replacements and 264 had left hip replacements. In addition, there were 319 women and 294 men in the remaining study cohort. A polyethylene liner was used in 64% of the acetabular shells and a ceramic liner was used in the remaining 36% of shells.

Table 2: Detailed list of preoperative diagnoses.

Diagnosis	Number of patients
Osteoarthritis	671
Avascular necrosis	28
Posttraumatic arthritis	21
Childhood hip problem	15
Dysplasia	12
Rheumatoid arthritis	9
Osteonecrosis	6
Hip fracture	5
Multiple epiphyseal dysplasia	2
Septic arthritis	1
Paget's disease	1

At the latest followup the clinical outcomes were excellent, with an average HHS score of 93.6 (31–100), an average WOMAC score of 87.6 (13–100), and an average VAS pain score of only 1.2 (0–10). No differences in outcomes scores on the HHS/WOMAC/or VAS were noted between the patients that received polyethylene or ceramic liners ($P < 0.05$).

The overall reoperation rate was 2% or (12/613) with 12 hips requiring reoperation. The reasons for revision were as follows: 7 instability (1.14%), 3 periprosthetic fractures (0.49%), 1 infection (0.16%), and 1 heterotopic ossification (0.16%). The seven cases of instability were all treated with revision to a constrained acetabular liner from the same manufacturer. The three cases of periprosthetic fracture all involved the femur and none of the fractures involved the acetabular component. The femur fractures were treated with open reduction and internal fixation. The one revision for infection was treated with a two-stage protocol. The first stage involved explantation of the prosthesis with an extensive debridement and insertion of an antibiotic impregnated cement spacer followed by six weeks of intravenous antibiotics. The second stage involved a reimplantation of a new prosthesis. The one revision for heterotopic ossification involved repeat arthrotomy of the hip joint with excision of the heterotopic bone to improve range of motion followed by postoperative radiation treatment. No revisions were performed for aseptic loosening of the acetabular component during our study. Mean abduction and anteversion angles at latest followup were 45.7 degrees (std. dev. ±6.6) and 24.5 degrees (std. dev. ±7.9), respectively. Radiographic analysis of AP pelvis X-rays revealed no radiolucencies at the bone-implant interface and no evidence of loosening or cup migration.

4. Discussion

Since the introduction of cemented total hip arthroplasties, attention has been focused on improving the mechanical failure rates of acetabular components. While early followup of cemented acetabular components was favorable, longer followups showed increased failure and loosening rates [4–6]. Earlier uncemented designs focused on initial mechanical fixation and stability of the acetabular components to the pelvis. However, high failure rates were evident with followup due to lack of osteointegration [7–9]. Newer acetabular shell designs featuring press-fit for initial mechanical stability and porous-coating for osteointegration have shown improved failure rates at mid- and long-term followups [10–12]. More recently, hydroxyapatite coating has been added to the porous coating in an attempt to improve on the biological fixation. Calcium hydroxyapatite is a naturally occurring substance found in bone and enamel and has been used clinically for over 30 years. It is well accepted that HA exhibits osteoconductive properties which improves early bone ongrowth and mechanical fixation of implants [15]. Hydroxyapatite's purported benefits include better and faster bone ongrowth, the formation of a barrier against wear debris, and allowing for less intimate fit between the cup and the acetabulum for ongrowth. While acetabular designs involving smooth surfaces and HA-coating have shown high early failure rates [13–15], numerous short-term studies have indicated that HA is capable of reducing early migration of the components as compared to the uncoated implants [28, 29]. A few longer-term studies have shown high clinical survival rates with no radiographic signs of failure in revision settings at mid-term followup [30–32]. However, longer-term follow-up studies are sparse, and concerns remain about HA-coated acetabular implants.

This study demonstrates excellent clinical and radiographic results with a contemporary press-fit acetabular component with an HA-coating. Our results compare favorably with the results of other studies from manufacturers with similar uncemented contemporary acetabular shells such as the Trilogy and Duraloc (see Table 1). Our 1.8% revision rate was unrelated to the fixation of the cup and at latest followup, all the Trident acetabular shells had excellent osteointegration to the acetabulum with no radiographic evidence of radiolucencies or cup migration.

5. Conclusions

In this study, a large cohort was able to be retrospectively reviewed. The results at short-term followup showed no radiographic or clinical evidence of failure or loosening. All revisions were performed for reasons other than failure or loosening. Although the length of followup is short, the early results are very encouraging. No early failure mechanisms or causes for concern were identified. Although our short-term results were promising, we clearly advocate further long-term follow-up studies of this patient cohort.

Conflict of Interests

Geoffrey Westrich is a Consultant for Stryker Orthopedics.

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