Midterm results with monobloc ceramic acetabular component and ceramic heads in THA

Chandeep Singh¹, Shitij Kacker¹, Gur Aziz Singh Sidhu¹, Rajesh K Bawari², SKS Marya¹,²

Abstract

Introduction: Total hip arthroplasty [THA] has established itself as the surgery of the century and with the advent of improved prosthetic design and developments in the bearing surfaces and materials, more is expected by surgeons and patients. The purpose of this study was to evaluate the clinical and radiographic results of Delta Motion hip system in patients undergoing THA.

Materials and Methods: This study comprised of 32 hips (31 patients) conducted at Max Hospital, Delhi. Patients with degenerative hip diseases were included whereas patients with an active infection, unable to give consent for surgery, neuromuscular diseases and revision total hip replacement were excluded. The mean age was 44.7 years (range, 35-66 years) and mean follow-up was 65.6 months (range, 48-74 months).

Results: The Harris Hip Score improved from a mean of 47.8 (30-60) preoperatively to 86.8(85-90) post operatively. 97.5% patients were able to participate regularly in leisure and daily routine activities. One patient had acetabular cup migration with an angular change of more than 10° and experienced squeaking. The mean abduction angle and anteversion of acetabular component were 38.6 degrees +/- 6.2 (range 27-54 degrees), 16.4 degrees +/- 4.6 (9-24 degrees).

Conclusion: Delta Motion hip system shows excellent function, Harris Hip Score and a low rate of complications. As a monobloc system, it allows optimization of head diameter to acetabular cup ratio, head engagement and stability of hip.

Keywords: Total hip arthroplasty (THA), delta motion hip system, ceramic on ceramic, Harris Hip Score (HHS).

Introduction

Total hip arthroplasty has established itself as the surgery of the century and with the advent of improved prosthetic design and developments in the bearing surfaces and materials, more is expected by surgeons and patients⁴. Alternative bearings and large-diameter femoral head articulations in total hip arthroplasty (THA) have been developed in an attempt to improve implant longevity, reduce wear debris and meet high-activity demands. Most common mode of failure of total hip arthroplasty (THA) is production of wear debris, the resultant wear induced osteolysis, and eventual loss of fixation. Ceramic bearings are one of the most preferred choices for THA now days. These have mechanical advantage of superior wear characteristics and high wettability, which reduce the risk of osteolysis and aseptic loosening⁴. However, despite a lower wear rate, concerns exist about cost and adverse events, such as ceramic breakage and squeaking (incidence range of 0.48% to 7%)⁴,⁵. Boutin reported the first experience of ceramic on ceramic (COC) THA in 1970⁶. Early and midterm COC THA clinical outcome reports from the initial experience in the USA had been encouraging⁷. At a minimum of 18.5 years follow-up, Hamadouche et al. reported minimal wear, limited osteolysis, and a low rate of complications with COC total hip arthroplasty ⁸. However, fractures and squeaking of early generation COC articulations is well documented. Early ceramic component materials were of large grain size and contained a lot of impurities, resulting in unacceptable component fracture rates as high as 13% in some studies⁹. Although the second-generation has been much improved, the reported fracture rate is still up to 0.014% ¹⁰,¹¹. Improved manufacturing processes such as hot isostatic pressing, laser etching and proof testing, the third-generation ceramic Biolox Forte [Ceram Tec Medical Products, Plochingen, Germany], approved by the US FDA in 2003 have tried to overcome this drawback¹². The average size of the grains has been reduced from 3.2 mm to 1.8 mm and the bending strength has been increased to 580 MPa for alumina ceramics. The third-generation alumina ceramics commercialized today benefit from all of these improvements, and the fracture rate has been reduced to 0.004%. Compared to the old alumina ceramic in previous

¹Department of Bone and Joint Institute Medanta , The Medicity, Gurgaon.
²Max Superspeciality Hospital, Saket, New Delhi.

Address of Correspondence:
Dr. SKS Marya,
# 115 Vista Villas Sector 46, Gurgaon.
Email: sksmarya@yahoo.co.in

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clinical studies, for which the 10-year survival rate was 90.8%, third-generation highly purified alumina has an almost 100% 10-year survival rate[13]. Larger-diameter femoral heads combined with an alumina matrix composite ceramic (BIOLOX Delta; Ceram Tec AG, Plochingen, Germany) articulation was developed to improve implant longevity and meet patients’ activity demands while reducing the risk of component-related complications. Cai et al conducted randomized, controlled trial on 93 patients (113 THAs) with more than 3 years of follow-up. They suggested that in the short term, the large-diameter Delta COC articulation results in better range of motion with no higher complication rates; however, mid-term (8-10 years) or longer follow-up is necessary to determine its superiority in young, active patients[14]. A newer hip system (Delta Motion, DePuy) was developed to allow the use of thin liners and consequently larger femoral heads even in small-diameter acetabular shells with added advantages of ceramic on ceramic with respect to wear performance. It was the first monobloc system consisting of a metal shell with a preassembled ceramic liner which allowed optimization of head diameter to acetabular cup ratio, better range of motion, head engagement and stability of hip. The use of preassembled liner reduces the chances of improper liner seating and its associated complications like liner fracture as seen in few studies during intraoperative assembly. The literature also supports that femoral heads reduce impingement, improve range of motion (ROM), and have a lower dislocation rate[15]. However; little literature is available to validate this newer hip system. The purpose of this study was to evaluate the results of Delta Motion hip system in patients undergoing THA. Clinical and radiographic results were collected to evaluate the outcomes, complication rates, implant-related failures, osteolysis, noises and other unforeseen complications.

Materials and Methods
This study was conducted from January 2011 to September 2012 at Max Hospital Saket. Inclusion criteria included patients between 35 and 66 years undergoing primary THA for degenerative hip diseases. Exclusion criteria included patients with an active infection, unable to give consent for surgery, neuromuscular diseases and revision total hip replacement. The final patient cohort comprised 31 patients (32 hips). Mean age was 44.7 years (range, 35-66 years). Mean body mass index was 25.50 (range, 18.2-31.8). The most common cause of degenerative hip disease is primary osteoarthritis in 17, avascular necrosis (AVN) in 5, post traumatic osteoarthritis in 4 patients and one patient had osteoarthritis following ankylosing spondylitis. All surgeries were performed by the senior author (SKSM) through an anterolateral approach. The femoral component used was Proxima (Depuy) stems in 9 patients and the Corail (Depuy) stems in 23 patients. All patients received a press-fit porous-coated pre-assembled Delta Motion acetabular component (Depuy). Postoperatively, all patients received intravenous antibiotics. Low molecular weight heparin (LMWH) was given and a lower-extremity venous pump was used to prevent thromboembolic incidents. Patients were mobilized as per pain status starting with a toe touch weight bearing with walker on the 1st post op day. Mean follow-up was 65.6 months (range, 48-74 months). All patients were routinely followed up with orthogonal radiographs and modified Harris hip scores were recorded pre and post operatively. The
patients were followed up clinically and radio-graphically at 6 weeks, 3 and 6 months, and annually postoperatively. At each follow-up, the patient answered questionnaires regarding pain severity, satisfaction, and were scanned for possible complications.

Results
Thirty one patients (32 hips) were available for analysis. The mean follow was 65.6 months (range, 48-74 months). All wounds healed uneventfully. There were no intra operative complications and liner issues like incomplete seating, liner chip off or fractures. No post operative infections, nerve or vascular injuries were observed in our cohort. One patient had acetabular cup migration with an angular change of more than 10° squeaking. The Harris Hip Score improved from a mean of 47.8 (30-60) preoperatively to 86.8(85-90) 48 months post operatively; 97.5% patients were able to participate regularly in leisure and daily routine activities. This group of our patients was back to work after surgery and most of them engaged in office work. Consecutive radiological analysis of 32 hips postoperatively showed evidence of osteointegration at last follow. The mean abduction angle and anteverision of acetabular component were 38.6 degrees +/- 6.2 (range 27-54 degrees), 16.4 degrees +/- 4.6 (9-24 degrees). No radiographic evidence of any osteolysis was seen and 1 cup migration was seen in our cohort. No stem osteolysis or subsidence was seen in our cohort.

Discussion
With the advances in prosthetic design and tribology of components, THA has become a favorable option in patients with advanced hip disease. In the current study, we evaluated the functional outcome of Delta Motion hip system in patients undergoing THA. The main advantages of this hip system are preassembled ceramic liner, optimum head diameter to acetabular shell ratio and use of large diameter head in smaller acetabuli and ceramic on ceramic articulation.

Liner Issues
In the current study, we observed no liner related issues like incomplete seating, liner chip off, liner fractures etc, as this system has pre assembled liner. Few studies have quoted about liner related issues in total hip replacement. Incomplete seating of the ceramic liner in the socket theoretically could lead to liner dissociation from the shell, and metal fretting attributable to motion between the interfaces. Both of these problems have led to reports of failure[16,17]. Hamilton et al in a multicentre trial reported three intraoperative events involving the ceramic liner. The surgeon had difficulty in seating the ceramic liner and on impaction; the liner fractured which was removed. The cup was retained and a 32-mm polyethylene liner and a ceramic femoral head were implanted. In another patient, surgeon on initial impaction found the liner was not symmetrically seated in the cup. The surgeon attempted to remove the liner by tapping the edge of the metal cup, but the process of doing so fractured the ceramic liner. The cup, fractured liner, and ceramic fragments were removed and replaced with a new cup and ceramic liner without difficulty. In the last patient, the same surgeon had difficulty seating the ceramic liner. The cup and liner were removed and replaced with a new cup and ceramic liner without difficulty. The overall rate of insertional liner fracture was 1.1% (two of 177)[18]. Miller et al reported 50 (7.2%) out of 694 hips had evidence of incomplete seating of the liner in the metallic shell. They postulated several causes of malseating like soft tissue interposition, permanent shell deformation during impaction of the cup, placement of the ceramic liner in a canted position before impaction[19].

Large Diameter Head
Large diameter femoral head adds advantage to total hip replacement in form of better range of motion and low dislocation rate. Smaller head diameters (22–28 mm) tend to have optimal wear characteristics but are more likely to dislocate. Head sizes above 28 mm are considered to be safer because of a favorable head-neck ratio and a larger “jump distance.” In acetabular cup sizes beyond 56 mm, head diameter of 36 mm is recommended by some authors[20]. Larger head sizes are associated with a lower dislocation risk, however, the potential for greater polyethylene wear secondary to the increased sliding distance must be considered[21]. This system allows the use of thin liners and consequently large femoral heads can be used even in relatively small diameter acetabuli. Smaller stature patients will get larger heads due to the pre fixed liners (thin shell).

Squeaking
The reported incidence of squeaking with modern ceramic bearings ranges from 0.48% to 7% [22]. Squeaking is a significant concern for both patients and clinicians with ceramic bearings. Possible etiologies include microseparation associated with impingement and stripe wear, edge loading, cup malposition, and entrapment of third-body wear debris[22]. Restrepo et al. reported an incidence of squeaking of 28 of 999 (2.7%); four of these underwent revision, all with stripe wear observed from the retrievals (Trident; Stryker) [22]. Owen et al performed a meta analysis on 16,828 patients with ceramic bearings and found that the incidence of squeaking was 4.2% and 0.2% in revision surgeries[23]. Our cohort had one case of squeaking post acetabular cup migration likely due to edge loading.
Head Breakage
All bearing surfaces have the potential to break, including polyethylene. Heck reported a polyethylene fracture or dissociation rate over a 5-year period of 0.45% [24]. More recent case reports of fractured highly cross linked polyethylene have similarly raised concern with that material [25]. Femoral head fractures with modern COC are rare with a reported incidence of alumina femoral head fractures of 0.004% [49]. Reasons for this include the processing of the material yielding better tolerance between the femoral head and trunion, smaller grain size and fewer impurities, and the process of implants undergoing regular proof testing before release. Still, sporadic reports showing modern COC designs breaking do exist. One study reported a rate of alumina head fractures in five of 359 (1.4%) [26]. No ceramic head fractures were observed in this study.

Pressfit Acetabular fixation
Acetabular fixation is the most challenging component in total hip replacement. Nizard et al. reported results from 1977 to 2004 with several different acetabular components and methods of fixation used; they had an overall survivorship of only 82% at 10 years and 72% at 15 years. Most of their failures were due to isolated loosening of the acetabular component [27]. Patients with a press-fit cup without screws reported less pain and had better ROM; however, their preoperative pathology was not similar, so this finding must be interpreted with caution. One in vitro study suggested that the addition of supplemental screws did not improve the stability of uncemented cups under proper press-fit conditions [28]. Press-fit acetabular implantation helps to distribute compressive forces to the periphery of the acetabulum, so most of these designs have a flattened pole area to facilitate complete seating and are oversized to optimize press fit. Won et al. observed in the laboratory that the use of screws increases micromotion at the opposite side of the screw due to distractive cyclic loads, and all cyclic loads were compressive in the press-fit component [29]. Roth et al. reported there were no advantages in using screws with a press-fit cup and fewer radiographic changes in cups without screws [30]. They concluded there could be more micromotion in a hip with a cup implanted with screws. Kress et al. in a study with CT-assisted osteodensitometry (using the same designs as in our series), reported nonprogressive bone radiolucent lines that were not related to the appearance of loosening of this cup [31]. Several studies suggest it is important to maintain the subchondral bone and acetabular angle less than 50 degrees to reduce the risk of cup migration [32]. One patient in our study had acetabular cup migration with an angular change of more than 10°, and had squeaking after change of acetabular inclination. The patient has been advised revision surgery.

Limitations
This study had several limitations. First, the follow-up period was relatively short to reach a conclusive decision in terms of implant longevity. However, with a mean follow-up of 65.6 months (range, 48-74 months), the study provides baseline comparison data and important results, especially in terms of ROM improvement and complication rates. Second, because of strict inclusion criteria, the number of cases in the study was insufficient for a comparison of device-related complication rates. However, the data is important as an initial investigation for this new bearing combination.

Conclusion
To conclude, delta motion hip system shows excellent function, Harris Hip Score and a low rate of complications. As a monobloc system, it allows optimization of head diameter to acetabular cup ratio, head engagement and stability of hip. It also allows the use of thin liners and consequently larger femoral heads even in small diameter acetabular shells. Thus such system can meet the expectation of young and active patients undergoing total hip replacement.

Table 1: Demographic data of study
| Demography | Total 31 patients(32 hips) | Male / female 10 males/21 females | Age (years) 44.7 years (35-66 years) |
| Causes | | | |
| Primary OA | 17 | | |
| Secondary OA | 14 | | |
| Avascular necrosis | 5 | | |
| Post traumatic arthritis | 4 | | |
| Fracture neck of femur | 4 | | |
| Ankylosing spondylitis | 1 | | |
| Technique | Anterolateral approach | | |
| Acetabular component | Delta motion cup | | |
| Femoral component | Corail (Depuy) 23 | | |
| | Proxima (Depuy) 9 | | |
| Harris Hip Score | Pre op 47.8(30-60) | | |
| | Post op(4 years follow up) 86.8(85-90) | | |
1. Learmonth ID, Young C, Rorabeck C. The operation of the century: total hip replacement. Lancet. 2007 Oct 27;370(9597):1508-19.

2. Pitto RP, Blanquaert D, Hohmann D. Alternative bearing surfaces in total hip arthroplasty: zirconia-alumina pairing. Contribution or caveat? Acta Orthop Belg 2002;68:242.

3. Dumbleton JH, Manley MT, Edidin AA. A literature review of the association between wear rate and osteolysis in total hip arthroplasty. J Arthroplasty 2002;17:51-57.

4. Lang JE, Whiddon DR, Smith EL, Salyapongse AK. Use of ceramics in total hip replacement. J Surg Orthop Adv. 2008;17(1):51-57.

5. Keurentjes JC, Kuipers RM, Wever DJ, Schreurs BW. High incidence of squeaking in THAs with alumina ceramic-on-ceramic bearings. Clin Orthop Relat Res. 2008; (466):1438-1443.

6. Boutin P. Total hip arthroplasty using a ceramic prosthesis. Pierre Boutin (1924–1989). Clin Orthop Relat Res, 2000, 379: 3–11.

7. Murphy SB, Ecker TM, Tannast M. Two- to 9-year clinical results of alumina ceramic-on-ceramic THA. Clin Orthop Relat Res, 2000, 379: 3–11.

8. Hamadouche M, Boutin P, Daussange J, et al. Alumina-on-alumina total hip arthroplasty: a minimum 18.5-year follow-up study. JBone Joint Surg Am, 2002, 84: 69–77.

9. Hannouche D, Hamadouche M, Nizard R, et al. Ceramics in total hip replacement. Clin Orthop Relat Res, 2005, 430: 62–71.

10. Mehmood S, Jinnah RH, Pandit H. Review of ceramic on-ceramic total hip arthroplasty. J Surg Orthop Adv, 2008, 17: 45–50.

11. Tateiwa T, Clarke IC, Williams PA, et al. Ceramic total hip arthroplasty in the United States: safety and risk issues revisited. Am J Orthop (Belle Mead NJ), 2008, 37: 26–31.

12. Bal BS, Aleton TJ, Garino JP, et al. Ceramic-on-ceramic versus ceramic-on-polyethylene bearings in total hip arthroplasty: Results of a multicenter prospective randomized study and update of modern ceramic total hip trials in the United States. Hip Int, 2005, 15: 129–135.

13. Kawanabe K, Tanaka K, Tamura J, et al. Effect of alumina femoral head on clinical results in cemented total hip arthroplasty: old versus current alumina. J Orthop Sci, 2005, 10: 378–384.

14. Pengde Cai, Yihe Hu, Jie Xie. Large-diameter Delta Ceramic-on-ceramic Versus Common-sized Ceramic-on-polyethylene Bearings in THA Orthopedics. 2012 Sep;35(9):1307-13.

15. Cinotti G, Lucioli N, Malagoli A, Calderoli C, Cassesse F. Do large femoral heads reduce the risks of impingement in total hip arthroplasty with optimal and non-optimal cup positioning? Int Orthop. 2011; 35(3):317-323.

16. Ha YC, Kim SY, Kim HJ, Yoo JJ, Koo KH. Ceramic liner fracture after cementless alumina-on-alumina total hip arthroplasty. Clin Orthop Relat Res. 2007;458:106–110.

17. Park YS, Hwang SK, Choy WS, Kim YS, Moon YW, Lim SJ. Ceramic failure after total hip arthroplasty with an alumina-on-alumina bearing. J Bone Joint Surg Am. 2006;88:780–787.

18. William G. Hamilton, James P. Mcauley et al.THA with Delta Ceramic on Cearmic.Clin Orthop Relat Res (2010)468:358-366

19. Miller AN, Su EP, Bostrom MPG, Nestor BJ, Padgett DE. Incidence of Ceramic Liner Malseating in Trident1 Acetabular Shell .Clin Orthop Relat Res (2009) 467:1552–1556

20. Peters CL, McPherson E, Jackson JD, et al. Reduction in early dislocation rate with large-diameter femoral heads in primary total hip arthroplasty. J Arthroplasty. 2007;22(6 Suppl 2):140.

21. Garbuz DS, Masri BA, Duncan CP, Greidanus NV, Bohm ER, Petrak MJ, et al. The Frank Stinchfield Award: dislocation in revision THA: do large heads (36 and 40 mm) result in reduced dislocation rates in a randomized clinical trial? Clin Orthop Relat Res. 2012;470:351–6

22. Restrepo C, Parvizi J, Kurtz SM, Sharkey PF, Hozack WJ, Rothman RH. The noisy ceramic hip: is component malpositioning the cause? J Arthroplasty. 2008;23:643–649.

23. Owen DH, Russell NC, Smith PN, Walter WL. An estimation of the incidence of squeaking and revision surgery for squeaking in ceramic-on-ceramic total hip replacement: a meta-analysis and report from the Australian Orthopaedic Association National Joint Registry. Bone Joint J. 2014;96-B:181–187.

24. Heck DA, Partridge CM, Reuben JD, Lanzer WL, Lewis CG, Keating EM. Prosthetic component failures in hip arthroplasty surgery. J Arthroplasty. 1995;10:575–580.

25. Moore KD, Beck PR, Petersen DW, Cuckler JM, Lemons JE, Eberhardt AW. Early failure of a cross-linked polyethylene acetabular liner. A case report. J Bone Joint Surg Am. 2008;90:2499–2504

26. Koo KH, Ha YC, Jung WH, Kim SR, Yoo JJ, Kim HJ. Isolated fracture of the ceramic head after third-generation alumina-on alumina total hip arthroplasty. J Bone Joint Surg Am. 2008;90:329–336.

27. Nizard R, Pourreyron D, Raoul A, et al. Alumina-on-alumina hip arthroplasty in patients younger than 30 years
old. Clin Orthop Relat Res 2008;466:317.

28. Kwong LM, O'Connor DO, Sedlacek RC, Krushell RJ, Maloney WJ, Harris WH. A quantitative in vitro assessment of fit and screw fixation on the stability of a cementless hemispherical acetabular component. J Arthroplasty. 1994;9:163–170.

29. Won CH, Hearn TC, Tile M. Micromotion of cementless hemispherical acetabular components: does press-fit need adjunctive screw fixation? J Bone Joint Surg Br. 1995;77:484–489.

30. Roth A, Winzer T, Sander K, Anders JO, Venbrocks RA. Press fit fixation of cementless cups: how much stability do we need indeed? Arch Orthop Trauma Surg. 2006;126:77–81.

31. Kress AM, Schmidt R, Vogel T, Nowak TE, Forts R, Mueller LA. Quantitative computed tomography-assisted osteodensitometry of the pelvis after press-fit cup fixation: a prospective ten-year follow-up. J Bone Joint Surg Am. 2011;93:1152–1157.

32. Zenz P, Stiehl JB, Knechtle H, Titzer-Hochmaier G, Schwagerl W. Ten-year follow-up of the non-porous Allofit cementless acetabular component. J Bone Joint Surg Br. 2009;91:1443–1447.

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