

Research Article*Open Access, Volume 3*

Five-Year Survival of the Delta One TT and Revision TT Systems after Primary Complex and Acetabular Revision Surgery

Dirk P Hogerzeil^{1}; Menno R Bénard²; Anke HC Gielen³; Rachid Mahdad⁴; Suzan HM Verdegaal⁵*¹*Department of Orthopaedic Surgery, Erasmus MC, Doctor Molewaterplein 40, 3015 GD Rotterdam, the Netherlands*²*Department of Orthopaedic Surgery, Alrijne Ziekenhuis, Simon Smitweg 1, 2353GA Leiderdorp, the Netherlands*³*Department of Surgery, Maastricht University Medical Centre, P. Debye laan 25, 6229HX Maastricht, the Netherlands*⁴*Department of Orthopaedic Surgery, Alrijne Ziekenhuis, Simon Smitweg 1, 2353GA Leiderdorp, the Netherlands*⁵*Orthopaedic Surgeon, Department of Orthopaedic Surgery, Alrijne Ziekenhuis, Simon Smitweg 1, 2353GA Leiderdorp, the Netherlands***Abstract**

Introduction: Use of Trabecular Titanium™ cups in total hip arthroplasty is expected to reduce the incidence of loosening of the acetabular component of the prosthesis. We reviewed clinical outcomes of the Delta One TT and Delta Revision TT acetabular systems during five-year follow-up after primary complex or acetabular revision surgery.

Methods: Retrospective cohort study included 72 consecutive patients that received a Delta one TT implant in acetabular (revision) surgery between April 2011 and December 2014.

Discussion: The Delta One TT cup was placed in 52 cases; 20 patients received a Delta Revision TT cup. Eight patients (11.1%) required cup revision surgery during five-year follow-up: six Delta One TT cups and two Delta Revision TT cups failed. Cumulative survival of the Delta One TT and Delta Revision Cup after five-year follow-up was 88.9%.

Conclusion: Five-year survival of the Delta One TT and Delta Revision TT shows promising and encouraging results in patients undergoing primary complex or acetabular revision surgery.

Keywords: Total hip arthroplasty; Trabecular Titanium™; Acetabular revision surgery; Complex primary acetabular surgery.

Manuscript Information: Received: Jan 11, 2023; Accepted: Feb 08, 2023; Published: Feb 16, 2023

Correspondance: Dirk P Hogerzeil, Registrar Orthopaedic Surgery, Department of Orthopaedic Surgery, Erasmus MC, Doctor Molewaterplein 40, 3015 GD Rotterdam, the Netherlands.

Email: d.hogerzeil@erasmusmc.nl

Citation: Hogerzeil DP, Bénard MR, Gielen AHC, Mahdad R, Verdegaal SHM. Five-Year Survival of the Delta One TT and Revision TT Systems after Primary Complex and Acetabular Revision Surgery. *J Surgery*. 2023; 3(1): 1080.

Copyright: © Hogerzeil DP 2023. Content published in the journal follows creative common attribution license.

Introduction

The introduction of two new fully cementless acetabular implants in 2008 has revolutionized total hip arthroplasty (THA) as well as THA acetabular revision surgery in the past decade. The use of Trabecular Metal (TM) implants has shown satisfactory results since their introduction in the late twentieth century [1,2]. Despite the development of several different designs and operating techniques, elimination of the most common cause of prosthesis failure, and subsequently revision acetabular surgery, has not yet been achieved. Risk of a revision significantly increases in the second decade following primary THA and is mostly due to loosening of the acetabular component [3,4]. With the growing demand for THA as well as acetabular revision surgery, use of Trabecular Titanium (TT) has increased significantly [5]. Pure Trabecular Titanium (Delta Trabecular Titanium, Limacorporate, Udine, Italy) is designed as a honeycomb-like structure, with highly porous material consisting of multi-planar hexagonal interconnected cells [6,7]. In vivo studies have shown that Trabecular Titanium is capable of inducing complete and quick osseointegration by means of its porous, hexagonal cell structure [8,9]. Use of the Electron Beam Melting (EBM) technique produces the microstructure Trabecular Titanium, which provides continuity between the solid part of the acetabular cup cavity and the external honeycomb-like structure. This one-step production process makes the Trabecular Titanium less susceptible for common risks in coated implants, such as detachment [9,10]. The Delta One TT THA is designed to have a reduced caudal size in order to be applicable in challenging conditions such as hip dysplasia or revision surgery. The Delta Revision TT THA has a cage construct with a hook and three arms to provide the implant with sufficient stability. In order to further enhance stability, it is possible to insert screws through the holes of the arms, fixating them to the pelvis [1,7]. This makes the Delta One TT and Delta revision TT systems promising implants, especially for complex primary surgery (due to osteonecrosis, dysplasia or otherwise poor bone quality) or challenging revision surgery [11].

Orthopedic surgeons will often opt for placement of a Dual Mobility Cup (DMC) in patients with higher preoperative risk of instability and possible dislocation after THA. A DMC consists of a small prosthetic head inside a larger polyethylene liner. Primary motion occurs between the femoral head of the prosthesis and the inner surface of the polyethylene liner, allowing a secondary motion to occur between the polyethylene liner and the acetabular cup [10,12]. This construction has proven to prevent implant dislocation, improve range of motion, and decrease the risk of dislocation [13,14]. Utilization of the TT scaffold is expected to reduce the incidence of (aseptic) loosening of acetabular component of the prosthesis. To the best of our knowledge limited data has been published in literature regarding the survival of TT acetabular implants, even more so regarding the use of TT implants in complex primary and acetabular revision surgery. The aim of this study was to evaluate five-year survival of the Delta One TT and Delta Revision TT systems in patients undergoing primary complex or acetabular revision surgery.

Materials and methods

A retrospective, single-center cohort study was performed using prospectively collected data from our hospital's electronic

medical records. We included all patients who received a Delta One TT or Delta Revision TT implant in acetabular (revision) surgery between April 2011 and December 2014.

ASA classification was determined by the anesthesiologist during routine pre-operative screening [15]. Routine pre-operative antibiotic prophylaxis consisted of two grams of Cephazolin, intravenously administered at least 30 minutes before the start of the procedure. All patients were operated one by one of four experienced orthopedic surgeons. Surgery was performed under general anesthesia, via the direct lateral approach to the hip as first described by Hardinge except for two cases where an anterior approach according to Smith-Petersen was performed based on preference of the surgeon [16,17]. A DMC was implanted in patients with higher risk of instability and possible dislocation after THA. Acetabular defects were evaluated during the surgical procedure, classified according to the Paprosky classification, and addressed if necessary [18]. Defects were primarily corrected by use of autograft, harvested from the patient's iliac crest, or allograft bone substitutes. When needed, further defects were addressed by use of hemispheric modules or augments.

Venous Thromboembolic (VTE) prophylaxis consisted of Nadroparine (low molecular weight heparin) 9500 IE/mL daily. Patients weighing less than 100 kg received 0.3 ml (2850 IE) and those weighing more than 100 kg received 0.6 ml (5700 IE) once daily. This was administered during six weeks starting the first post-operative day. Postoperative x-rays in anteroposterior and lateral views were routinely performed one day after surgery to confirm correct placement of the prosthesis. Patients were instructed by a physical therapist to follow standard precautions after hip replacement surgery, according to hospital standards. Partial weight-bearing mobilization using a walking aid was allowed for six weeks after surgery, followed by full weight-bearing mobilization.

Follow-up occurred according to our hospital standard protocol, i.e. patients were reviewed at our outpatient clinic at two weeks, six weeks, three months, one year, three years and five years postoperatively. X-rays in both anteroposterior and lateral views were routinely performed. Cut-off point for follow-up was determined as December 31st 2019 and maximum follow-up time was set at five years.

Primary outcome consists of survival of the Delta One TT and the Delta Revision TT cup. Also, clinical outcomes were analyzed, and peri- and postoperative complications were registered and graded according to the Clavien-Dindo classification [19].

Baseline characteristics and complications were studied using descriptive statistics, with mean (SD) and numbers (%) shown when appropriate. To study the survival a Kaplan-Meier analysis was performed and to study the effect of Paprosky score and bonegraft on survival, a Pearson Chi-square test was performed on the status at five years. Statistical significance is defined as a p-value <0.05. Analysis was performed using IBM SPSS version 27.0 (IBM corp.).

This research has been approved by the IRB of the authors' affiliated institution.

Results

72 patients received a Delta TT implant in complex primary and acetabular revision surgery. The study population consisted of 18 (25%) male and 54 (75%) female patients, with a mean age of 72.4 (SD 12.4) years (Table 1). The prosthesis was implanted on the right side in 29 (40.3%) cases and on the left side in 43 (59.7%) cases. No bilateral procedures were performed.

The Delta One TT cup was placed in 52 cases; 20 patients received a Delta Revision TT cup. The indication for surgery was aseptic loosening of previous prosthesis in 18 cases (25%), dislocation in 13 cases (18%), polyethylene wear in eight cases (11%), Girdlestone in seven cases (9.8%), instability of prior implant in seven cases (9.8%), migration of prior implant component in three cases (4.2%) and osteolysis in three cases (4.2%), or 'other' in 13 cases (18%, e.g. secondary osteoarthritis due to hip dysplasia or metallosis and pseudotumor after metal-on-metal prosthesis). Dual mobility cups were implanted in 51 cases. Patients in our cohort presented with Paprosky scores varying from 1 to 3B (Table 1). When present, defects were corrected by use of autograft bone substitution, harvested from the pelvic ring, in six cases (8.3%) or allograft bone substitution in 18 cases (25%) in order to provide sufficient stability for the implanted prosthesis. Five cases (6.9%) received both varieties of bone grafts in order to achieve optimal stability.

A total of eight patients required cup revision of their Delta implant resulting in a cumulative survival of the Delta One TT and Delta Revision Cup of 88.9% after five years of follow up (Figure 1).

Indications for revision surgery were prosthetic joint infection (PJI) in four patients (5.6%), aseptic loosening in one patient (1.4%), persistent instability of the affected hip in two patients (2.8%) and migration of the cup in one patient (1.4%). Cumulative survival of the implants for the Paprosky classification groups was 100% in Paprosky 1, 87.0% in Paprosky 2 and 81.8% in Paprosky 3 (Figure 2), but Paprosky score had no significant effect on the survival ($p = 0.272$).

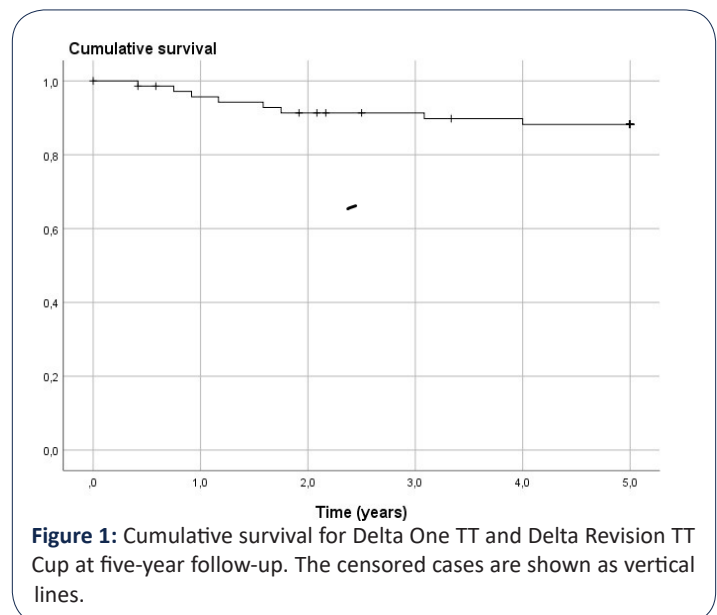
Also, the use of autograft, allograft, both types of bone substitution, or no bone substitution did not have an effect on risk of revision of the implant ($p=0.211$).

Eight patients (11.1%) died during follow-up. Of these eight, one patient deceased on the third postoperative day from the effects of abdominal ischemia and aspiration. The remaining seven patients died of unrelated causes during the follow-up period.

Three of the included patients underwent revision surgery after placement of a Delta TT prosthesis; however, the implanted cups were not revised during these procedures. For this reason, these three patients were classified as non-failure. One patient needed revision due to failure of the dual-mobility liner, therefore the cup required no revision and was left in situ. The second patient was in need of revision for complaints of instability due to a stem implanted with too much anteversion. The stem was revised and a 20° liner was placed. The third patient needed revision for a dislocation which could not be treated by closed reduction. The liner was exchanged for a dual-mobility liner.

Table 1: Baseline patient characteristics and surgery outcome.

	Study population (N=72)	No revision (N=64)	Revision (N=8)
Age (average), years	72.4 (SD 12.4)	72.7 (SD 12.8)	69.9 (SD 8.8)
Sex			
♀	54 (75.0%)	46 (71.9%)	8 (100%)
♂	18 (25.0%)	18 (28.1)	0 (0%)
BMI	26.6 (SD 4.1)	26.3 (SD 3.7)	29.1 (SD 6.1)
Laterality			
Left	43 (59.7%)	41 (64.1%)	2 (25.0%)
Right	29 (40.3%)	23 (35.9%)	6 (75.0%)
Acetabular defect			
Paprosky I	15 (20.8%)	15 (23.4 %)	0 (0%)
Paprosky II	46 (63.9%)	40 (62.5%)	6 (75.0%)
Paprosky III	11 (15.3%)	9(14.1%)	2 (25.0%)
Acetabular component			
Delta One TT	52 (72.2%)	46 (71.9%)	6 (75.0%)
Delta Revision TT	20 (27.8%)	18 (28.1%)	2 (25.0%)
Bone graft			
Allograft	18 (25.0%)	15 (23.4%)	3 (37.5%)
Autograft	6 (8.3%)	4(6.25%)	2 (25.0%)
Both	5 (6.9%)	4(6.25%)	1 (12.5%)
None	40 (55.6%)	38 (59.4%)	2 (25.0%)
Missing data	3 (4.2%)	3 (4.7%)	-



as a reliable representation of implant survival in primary complex and acetabular revision surgery.

It should be noted that our study was focused on complex primary acetabular surgery and need for revision of previous implants as indication for surgery. For this reason, the outcomes of this study should be interpreted as such and not as outcomes of the use of implants in simple primary acetabular surgery. Furthermore, outcome data for Delta One TT and Revision TT was pooled.

Limitations

This study has two limitations. Firstly, the retrospective design with its inherent limitations. We expect that for the execution of the study a prospective design would not have yielded different results as all parameters were collected from the hospital information system and patient selection would not have been different. Secondly, our study presents mid-term follow-up results and further long-term follow-up is needed in order to gain valuable insight in the long-term reliability of this particular type of implant. However, the current results are valuable information concerning these systems.

Conclusion

Five-year survival of the Delta One TT and Delta Revision TT acetabular systems shows promising and encouraging results in patients undergoing primary complex or acetabular revision surgery.

References

1. Gallart X, Fernandez-Valencia JA, Riba J, Bori G, Garcia S, et al. Trabecular Titanium™ cups and augments in revision total hip arthroplasty: clinical results, radiology and survival outcomes. *Hip Int.* 2016; 26: 486-491.
2. Unger AS, Lewis RJ, Gruen T. Evaluation of a porous tantalum uncemented acetabular cup in revision total hip arthroplasty: clinical and radiological results of 60 hips. *J Arthroplasty.* 2005; 20: 1002-1009.
3. Perticarini L, Zanon G, Rossi SM, Benazzo FM. Clinical and radiographic outcomes of a trabecular titanium acetabular component in hip arthroplasty: results at minimum 5 years follow-up. *BMC Musculoskelet Disord.* 2015; 16: 375.
4. Howard JL, Kremers HM, Loechler YA, Schleck CD, Harmsen WS, Berry DJ, et al. Comparative survival of uncemented acetabular components following primary total hip arthroplasty. *J Bone Joint Surg Am.* 2011; 93: 1597-1604.
5. Nečas L, Katina S, Uhlárová J. Survival analysis of total hip and knee replacement in Slovakia 2003-2011. *Acta Chirurgiae Orthopaedicae Et Traumatologiae Cechoslovaca.* 2013; 80.
6. Marin E, Fusi S, Pressacco M, Paussa L, Fedrizzi L. Characterization of cellular solids in Ti6Al4V for orthopaedic implant applications: Trabecular titanium. *J Mech Behav Biomed Mater.* 2010; 3: 373-381.
7. Steno B, Kokavec M, Necas L. Acetabular revision arthroplasty using trabecular titanium implants. *Int Orthop.* 2015; 39: 389-395.
8. Benazzo F, Botta L, Scaffino MF, Callogna L, Marullo M, Fusi S, et al. Trabecular titanium can induce in vitro osteogenic differentiation of human adipose derived stem cells without osteogenic factors. *J Biomed Mater Res A.* 2014; 102: 2061-2071.

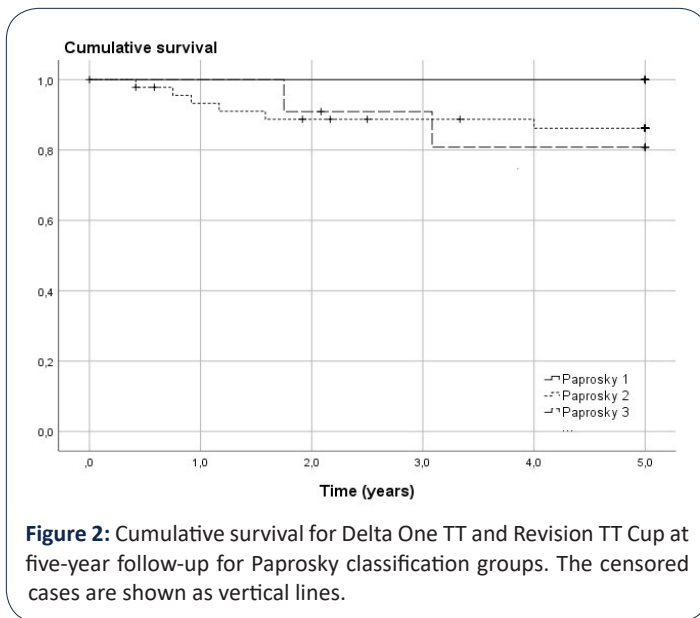


Figure 2: Cumulative survival for Delta One TT and Revision TT Cup at five-year follow-up for Paprosky classification groups. The censored cases are shown as vertical lines.

Discussion

Our study found a cumulative survival of the Delta One TT and Revision TT cups of 88.9% after five years. Compared to the literature this is somewhat lower. Perticarini et al. report a survival of the Delta TT cup after five years 99.3% [3]. This difference in survival may be due to the fact that in our study Delta One TT and Revision TT cups were used for complex primary and acetabular revision surgery, as opposed to the Delta TT used for primary acetabular surgery performed by Perticarini et al.

Whereas several studies have been conducted on short-to mid-term clinical outcomes of Trabecular titanium cups, such as Delta TT, Delta One TT and Revision TT cups, to our knowledge, few studies have been conducted on the use of these cups in complex primary and revision surgery. Munegato et al. report survival of the Revision TT cup in 37 acetabular revisions of 91.7% when using the cup for revision surgery with an indication other than aseptic loosening. In this study mean follow-up was 3.3 years (range 1.0-7.6 years) [20].

Perticarini et al. assessed the mid-term outcomes of Trabecular Titanium cups in revision surgery in 104 cases with a mean follow-up of 7.6 years (range 2-12.2 years), reporting a survival of 88.54% [21]. This is similar to the mid-term survival outcomes of Delta TT systems, both Delta One TT and Revision TT cups in complex primary or acetabular revision arthroplasty found in our study.

With one case of aseptic loosening, our results are comparable to those published by Gallart et al. [1] and Perticarini et al. [3,21] on the use of Trabecular Titanium components, and to the results published for the Trabecular Metal™ (TM) system by Zimmer [22].

Although recent literature suggests higher Paprosky bone defect scores are associated with higher risk for implant failure our study found no significant difference in revision rates when considering Paprosky bone defect classification [1,23,24].

Cumulative survival of the Delta One TT and Revision TT cups as found in this study are in line with recent literature on use of trabecular metal cups and are therefore regarded by the authors

-
9. Bertollo N, Da Assuncao R, Hancock NJ, Lau A, Walsh WR. Influence of electron beam melting manufactured implants on ingrowth and shear strength in an ovine model. *J Arthroplasty*. 2012; 27: 1429-1436.
 10. Parthasarathy J, Starly B, Raman S, Christensen A. Mechanical evaluation of porous titanium (Ti6Al4V) structures with electron beam melting (EBM). *J Mech Behav Biomed Mater*. 2010; 3: 249-259.
 11. De Meo F, Cacciola G, Bellotti V, Bruschetta A, Cavaliere P. Trabecular Titanium acetabular cups in hip revision surgery: mid-term clinical and radiological outcomes. *Hip Int*. 2018; 28: 61-65.
 12. Cuthbert R, Wong J, Mitchell P, Kumar Jaiswal P. Dual mobility in primary total hip arthroplasty: current concepts. *EFORT Open Rev*. 2019; 4: 640-646.
 13. Schmidt A, Batailler C, Fary C, Servien E, Lustig S. Dual Mobility Cups in Revision Total Hip Arthroplasty: Efficient Strategy to Decrease Dislocation Risk. *J Arthroplasty*. 2020; 35: 500-507.
 14. Batailler C, Fary C, Verdier R, Aslanian T, Caton J, Lustig S. The evolution of outcomes and indications for the dual-mobility cup: a systematic review. *Int Orthop*. 2017; 41: 645-659.
 15. Wolters U, Wolf T, Stutzer H, Schroder T. ASA classification and perioperative variables as predictors of postoperative outcome. *Br J Anaesth*. 1996; 77: 217-222.
 16. Hardinge K. The direct lateral approach to the hip. *J Bone Joint Surg Br*. 1982; 64: 17-19.
 17. Smith-Petersen MN. Approach to and exposure of the hip joint for mold arthroplasty. *J Bone Joint Surg Am*. 1949; 31A: 40-46.
 18. Paprosky WG, Perona PG, Lawrence JM. Acetabular defect classification and surgical reconstruction in revision arthroplasty. A 6-year follow-up evaluation. *J Arthroplasty*. 1994; 9: 33-44.
 19. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004; 240: 205-213.
 20. Munegato D, Bigoni M, Sotiri R, Bruschetta A, Omeljaniuk RJ, Turati M, et al. Clinical and radiological outcomes of acetabular revision with the Delta Revision TT cup. *Hip Int*. 2018; 28: 54-60.
 21. Perticarini L, Rossi SMP, Medetti M, Benazzo F. Clinical and radiological outcomes of acetabular revision surgery with trabecular titanium cups in Paprosky type II and III bone defects. *J Orthop Traumatol*. 2021; 22: 9.
 22. Jain S, Grogan RJ, Giannoudis PV. Options for managing severe acetabular bone loss in revision hip arthroplasty. A systematic review. *Hip Int*. 2014; 24: 109-122.
 23. Garcia-Cimbrelo E, Cruz-Pardos A, Garcia-Rey E, Ortega-Chamarro J. The survival and fate of acetabular reconstruction with impaction grafting for large defects. *Clin Orthop Relat Res*. 2010; 468: 3304-3313.
 24. Theil C, Schmidt-Braekling T, Gosheger G, Moellenbeck B, Schwarze J, Dieckmann R. A single centre study of 41 cases on the use of porous tantalum metal implants in acetabular revision surgery. *BMC Musculoskelet Disord*. 2019; 20: 238.