Short-term survival of the trabecular metal cup is similar to that of standard cups used in acetabular revision surgery

Analysis of 2,460 first-time cup revisions in the Swedish Hip Arthroplasty Register

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Background and purpose — The use of trabecular metal (TM) cups in revision surgery has increased worldwide during the last decade. Since the introduction of the TM cup in Sweden in 2006, this design has gradually replaced other uncemented designs used in Sweden. According to data from the Swedish Hip Arthroplasty Register (SHAR) in 2012, one-third of all uncemented first-time cup revisions were performed using a TM cup. We compared the risk of reoperation and re-revision for TM cups and the 2 other most frequently used cup designs in acetabular revisions reported to the SHAR. The hypothesis was that the performance of TM cups is as good as that of established designs in the short term.

Patients and methods — The study population consisted of 2,384 patients who underwent 2,460 revisions during the period 2006 through 2012. The most commonly used cup designs were the press-fit porous-coated cup (n = 870), the trabecular metal cup (n = 805), and the cemented all-polyethylene cup (n = 785). 54% of the patients were female, and the median age at index revision was 72 (19–95) years. Reoperation was defined as a second surgical intervention, and re-revision—meaning exchange or removal of the cup—was used as endpoint. The mean follow-up time was 3.3 (0–7) years.

Results — There were 215 reoperations, 132 of which were re-revisions. The unadjusted and adjusted risk of reoperation or re-revision was not significantly different for the TM cup and the other 2 cup designs.

Interpretation — Our data support continued use of TM cups in acetabular revisions. Further follow-up is necessary to determine whether trabecular metal cups can reduce the re-revision rate in the long term, compared to the less costly porous press-fit and cemented designs.

According to several reports (Kurtz et al. 2007, Pabinger and Geissler 2014) an increase in revision hip arthroplasties is expected. During the past 2 decades, the number of hip revision surgeries reported to the Swedish Hip Arthroplasty Register (SHAR) has doubled (Mohaddes et al. 2013).

Cemented fixation was the method of choice in revision surgery until the mid-1980s (Pulido et al. 2011). A high rate of failure (16–48% at 5–12 years) for this technique in some reports (Kavanagh et al. 1985, Pellicci et al. 1985, Katz et al. 1997) and a belief that the cement itself had a destructive effect on bone tissue (Dahl et al. 1994) encouraged the use of uncemented fixation in hip revision surgery (Lachiewicz et al. 1998, Etienne et al. 2004, Della Valle et al. 2005). During the past 2 decades, uncemented titanium cups have been preferred for revision (Pulido et al. 2011). Titanium alloys and the majority of older designs of porous coatings have some inherent limitations such as low volumetric porosity, high modulus of elasticity, and low friction against the bone. In order to address these limitations, new, more porous materials have been developed. Today, many of these materials such as Tritanium (Stryker, Mahwah, NJ), Regenerex (Biomet, Warsaw, IN), and Stiktite (Smith and Nephew, Memphis, TN) are available. Only one of these highly porous designs, trabecular metal (TM; Zimmer, Warsaw, IN), has been used in Sweden during a sufficiently long period to permit reliable evaluation.

After the introduction of the TM cup in Sweden in 2006, it has been increasingly used in acetabular revision surgery (Figure 1). During 2012, the TM cup was the most common uncemented design used in acetabular revision surgery, accounting for 17% of all revisions performed.

We analyzed data from the SHAR on all reported first-time revisions performed with a TM cup. The Trilogy cup and

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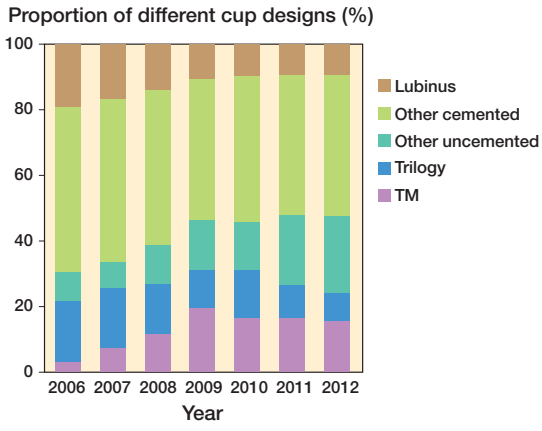

Figure 1. Distribution of different cup designs, used at first-time cup revisions, reported to the SHAR in the period 2006–2012. The proportion of TM and other uncemented cups increased during these 7 years.

Table 1. Demography of patients operated during the period 2006–2012 with Trilogy, TM, or Lubinus designs, reported to the Swedish Hip Arthroplasty Register

Demographic	Trilogy	TM	Lubinus
Total number of revisions	870	805	785
Sex			
Female	57%	52%	54%
Primary diagnosis			
Osteoarthritis	78%	73%	78%
Fixation method—primary cup			
Cemented	82%	78%	85%
Concomitant stem revision	48%	53%	58%
Bone grafting used at index revision	60%	45%	58%
Mean age at index revision, years (range)	72 (29–93)	70 (19–94)	73 (39–95)
Mean follow-up, years (range)	3.6 (0–7)	2.6 (0–7)	3.7 (0–7)

TM: trabecular metal.

the Lubinus cup, the most commonly used uncemented and cemented designs reported to the SHAR, were included as controls.

Patients and methods

All institutions that perform THA and revision arthroplasty in Sweden report to the Swedish Hip Arthroplasty Register (SHAR). This registry has a 100% compliance rate of reporting from hospitals in Sweden and a 90% rate of completeness regarding the number of revision surgeries performed in Sweden (Soderman et al. 2001). Revision cases have been reported in detail, including social security number, since the foundation of the SHAR in 1979. In 1999, the information submitted to the SHAR was extended with the article ID number of the components being used at revisions. Reports of revision/reoperation procedures are validated when each hospital sends a copy of the case records to the SHAR for data extraction into the database. The date of death can be retrieved through the SHAR because it is linked to the population register, which is administered by the Swedish Tax Agency. The end of this study was set to the end of December 2012.

Between 2006 and 2012, 9,478 first-time revisions in 7,613 patients had been reported to the SHAR. During this time period, the Trilogy design (Zimmer, Warsaw, IN) (n = 883), followed by the trabecular metal (TM) cup (Zimmer) (n = 828), and the Lubinus design (Link, Hamburg, Germany) (n = 805) were the most commonly used cups. The cup designs used in the TM group were TM modular (n = 407), TM revision (n = 418), and TM monoblock (n = 3). Information about age, sex, primary diagnosis, fixation method at the previous surgery, components revised during revision, use of bone graft during revision surgery, date and reason for a second surgical intervention, and date of death were extracted from the SHAR database. Cases with missing data (n = 33) and operations in which hip resurfacing had been used as a primary prosthesis (n = 23) were excluded. The follow-up was started on the day after the revision and continued until the occurrence of a new surgical intervention, death, or December 31, 2012, whichever came first. Since the aim of the study was to investigate whether a new surgical device is similar or superior to the established designs, we included all first-time cup revisions, including those with a follow-up shorter than 2 years. Reoperation was defined as any open surgical intervention related to the previous first-time cup revision (the index revision). Exchange or removal of the cup/liner following the index revision was defined as re-revision of the cup.

Study population

At the index revisions, there were 1,339 women (54%). Mean age at the time of the index revision was 72 (19–95) years. The most common primary diagnosis was primary osteoarthritis (76%), followed by inflammatory arthritis (8%) and status post-childhood disease (6%). The index revision was performed after a mean of 13 (0–34) years following the primary hip replacement. The mean follow-up time, with reoperation as endpoint, was 3.2 (0–7) years and the corresponding figure for re-revision was 3.3 (0–7) years. In the TM group, there were more men, the mean age at index revision was lower, the mean follow-up was almost 1 year shorter, the use of bone graft was less common, and concomitant stem revision was more frequent compared to the group in which the Trilogy cup had been used at the index revision (Table 1). In the Lubinus group, the cup revision was still more frequently associated with revision of the stem (Table 1).

Statistics

Mann-Whitney U-test was used for comparison of demo-

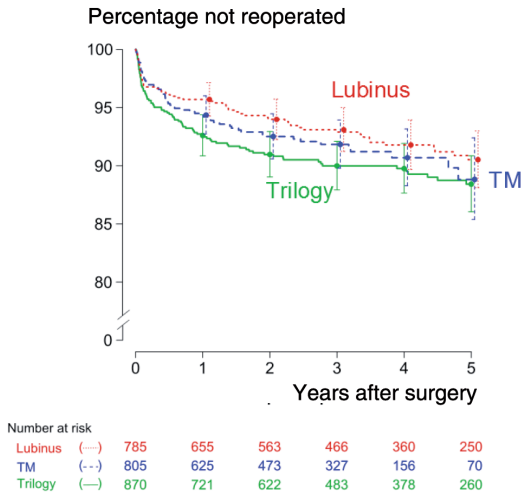

Figure 2. 5-year crude cumulative survival probability with reoperation as endpoint for Trilogy, TM, and Lubinus designs used in first-time cup revision.

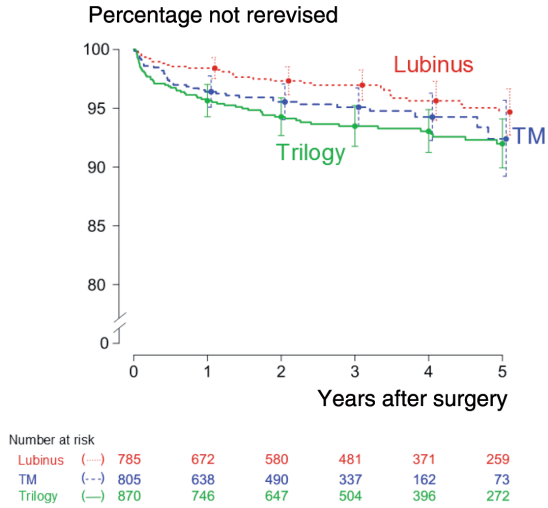

Figure 3. 5-year crude cumulative survival probability with re-revision as endpoint for Trilogy, TM, and Lubinus designs used in first-time cup revision.

graphic data between groups. Kaplan-Meier analysis was used to calculate the unadjusted survival rate for different cup designs. The unadjusted survival data is presented as mean with 95% confidence interval (CI).

Log rank test was used to compare the unadjusted survival at 5 years between the 3 cup designs. Due to differences in demographic data between groups, and to adjust for these covariates, we used Cox regression analysis adjusted for age at revision surgery (categorized into 3 groups: younger than 70 years; 70–79 years, and older than 79 years), sex, primary diagnosis (2 categories: primary and secondary osteoarthritis), concomitant stem revision (yes/no), and bone grafting (yes/no). The proportional hazards from the Cox regression model are presented with risk ratios (RRs), CIs, and p-values. The proportional hazards assumption (Fox 2011) was controlled for by computing and plotting Schoenfeld residuals from the Cox regression models, for each covariate.

Ethics

The study was approved by the SHAR and the local ethics committee (reference number 039-13).

Results

During the follow-up, there were 215 open surgical interventions (reoperations) (8.8%). 132 cases (5.4%) were re-revised, with the acetabular component being exchanged or extracted. The mean length of time from the index revision to reoperation was 1.1 (0–6.3) years and the corresponding time for re-revision was 1.4 (0–6.3) years. Reoperation was most often performed for dislocation (n = 62), followed by infection (n = 51) and aseptic loosening (n = 39). The most common causes of re-revision were dislocation (n = 48), infection (n = 35), and aseptic loosening (n = 29).

The unadjusted 5-year survival rates using reoperation as endpoint for the TM, the Trilogy, and the Lubinus cups were 89% (CI: 85–93), 88% (CI: 86–90), and 91% (CI: 89–93), respectively (Figure 2). The corresponding figures using re-revision as endpoint were 92% (CI: 88–96), 90% (CI: 86–94), and 93% (CI: 89–97) (Figure 3). There were no statistically significant differences when the TM design was compared to the Trilogy design (p = 0.31) or the Lubinus design (p = 0.09). The Lubinus cup was re-revised significantly less frequently than the Trilogy design (p = 0.01).

After adjustment for differences in the demographic data in the Cox regression analysis, the risk of re-revision was similar between the Trilogy cup and the TM cup (RR = 0.82, CI: 0.54–1.2). The Lubinus cup showed a slightly lower risk of being re-revised (RR = 0.63, CI: 0.41–0.97) than the Trilogy design, but not when compared to the TM cup designs (RR = 1.3, CI: 0.80–2.1). The stem not being revised at the index revision increased the risk of a second cup revision by 78% (RR = 1.8, CI: 1.2–2.6). Gender, age, primary diagnosis, method of fixation at primary hip arthroplasty, and use of bone graft or not had no statistically significant influence on the risk of reoperation or re-revision (Table 2).

Discussion

During the period 1979–2000, the majority of all first-time cup revisions in Sweden were cemented. The predominance of cemented fixation gradually changed, and in 2006, when the TM designs were introduced, about one-third of all first-time cup revisions were uncemented. In 2006, the Trilogy cup was

Table 2. Risk factors for reoperation and re-revision; comparison between the 3 most frequently used designs in the Swedish Hip Arthroplasty Register (Cox regression analysis)

Risk factor	Reoperation			Re-revision		
	RR	95% CI	p-value	RR	95% CI	p-value
Sex						
Male	1.1	0.83–1.4	0.6	1.1	0.76–1.5	0.7
Female [a]	1			1		
Age, years						
< 70	1.1	0.79–1.5	0.6	1.3	0.84–1.9	0.3
70–79 [a]	1			1		
> 79	0.87	0.59–1.3	0.5	1.1	0.64–1.7	0.8
Primary diagnosis						
Secondary OA [b]	1.2	0.88–1.7	0.3	1.4	0.96–2.1	0.08
Primary OA [a,c]	1			1		
Primary cup						
Uncemented	0.98	0.68–1.4	0.9	1.1	0.73–1.8	0.6
Cemented [a]	1			1		
Acetabular bone grafting						
Yes	0.91	0.68–1.2	0.5	0.9	0.64–1.3	0.7
No [a]	1			1		
Components revised						
Cup	1.1	0.85–1.5	0.4	1.8	1.23–2.6	0.002
Cup + stem [a,d]	1			1		
Cup [d]						
TM [e]	0.85	0.61–1.2	0.3	0.8	0.54–1.2	0.3
Lubinus	0.78	0.57–1.1	0.1	0.6	0.41–0.97	0.04
Trilogy [a]	1			1		

RR: risk ratio; CI: 95% confidence interval.
[a] Reference.
[b] Inflammatory hip desease (8%), sequelae after childhood disease (6%), fracture (4%), avascular necrosis (3%), and other (2%).
[c] Primary ostheoarthritis (77%).
[d] Cup used at index revision.
[e] Trabecular metal.

the most frequently used uncemented cup in first-time revisions, and accounted for about two-thirds of all uncemented designs. During the last 7 years, uncemented fixation has increased further (Figure 1) and the TM cup has replaced the Trilogy as the most frequently used uncemented design in Sweden.

The high porosity of tantalum and this metal's excellent conditions for bone ingrowth (Bobyn et al. 2004, Levine et al. 2006) could be of benefit in cup revision surgery. These possible advantages and encouraging reports with favorable short-term survival of these designs in revision surgery (Table 3) have resulted in increasing use of TM designs, not least in acetabular revisions. We wanted to examine differences in re-revision and reoperation rates between the Trilogy, the TM, and the Lubinus designs by analyzing data on first-time cup revisions reported to the SHAR during the years 2006–2012.

Several authors have reported promising short-term results using different tantalum designs in acetabular revision surgery (Unger et al. 2005, Sporer et al. 2006, Flecher et al. 2008, Lakstein et al. 2009, Siegmeth et al. 2009, Van Kleunen et al. 2009, Davies et al. 2011) (Table 3). Skyttä et al. (2011) studied 827 TM revision cups in the Finnish Arthroplasty Register and reported a 3-year overall survivorship of 92%. There have been few published comparisons between porous tantalum and TM cups and other frequently used designs in cup revision surgery. Kremers et al. (2012) analyzed a retrospective series of 3,448 cup revisions performed with a tantalum cups (n = 642) or a titanium cups (n = 2,805), and found that the risk of a repeated revision was the same for the TM and titanium designs.

In our analysis, the crude survival of the TM cup was similar to that in previous reports (Unger et al. 2005, Sporer et al. 2006, Flecher et al. 2008, Lakstein et al. 2009, Siegmeth et al. 2009, Van Kleunen et al. 2009, Davies et al. 2011, Skyttä et al. 2011). The risk of a new surgical intervention for any reason after a first-time cup revision was not significantly different for the TM cup and for the 2 other most frequently used cup designs registered in the SHAR.

There have been several reports with discouraging results when cemented cups have been used in hip revision surgery (Pellicci et al. 1985, Van Haaren et al. 2007). However, Schreurs et al. (1998, 2004, 2009) have repeatedly reported favorable long-term results using impaction bone grafting with cemented technique. Using the same technique on 142 acetabular reconstructions, Comba et al. (2006) reported a survival rate of 96% at a mean follow-up time of 4.3 years. In a recently published study (Mohaddes et al. 2013) from the SHAR, we could not find any difference in risk of re-revision between cemented and uncemented first-time cup revisions. According to the current analysis, the risk of re-revision was lower for the

Table 3. Publications in revision surgery using porous tantalum cups

Study	No. of hips	Age (range)	Follow-up, years (range)	Reoperation due to aseptic loosening	dislocation	infection
Unger et al. 2005	60	64 (28–75)	3.5 (1–6)	2%	12%	0%
Sporer and Paprosky 2006	13	63 (47–88)	2.6 (1–3)	0%	0%	0%
Flecher et al. 2008	23	58 (34–84)	3 (2–4)	0%	4%	0%
Lakstein et al. 2009	53	63 (29–86)	4 (2–6)	4%	6%	0%
Siegmeth et al. 2009	34	64 (37–97)	3 (2–5)	6%	3%	0%
Van Kleunen et al. 2009	97	59 (27–87)	3.8 (2–7)	0%	1%	8%
Davies et al. 2011	46	67 (39–85)	4.2 (2–6)	0%	0%	2%
Skyttä et al. 2011	827	69 (16–94)	1.1 (0–3)	1%	3%	0.2%

Table 4. Indications for reoperation and re-revision in different groups [a]

Reason for a second intervention	Reoperation			Re-revision		
	Trilogy	TM	Lubinus	Trilogy	TM	Lubinus
Aseptic loosening	13 (1.5)	10 (1.2)	16 (2.0)	10 (1.1)	8 (1.0)	11 (1.4)
Infection	28 (3.2)	11 (1.4)	13 (1.7)	23 (2.6)	5 (0.6)	7 (0.9)
Fracture	15 (1.7)	8 (1.0)	11 (1.4)	2 (0.2)	1 (0.1)	5 (0.6)
Dislocation	20 (2.3)	25 (3.1)	17 (2.2)	19 (2.2)	21 (2.6)	8 (1.0)
Other	14 (1.6)	8 (1.0)	6 (0.8)	7 (0.8)	3 (0.4)	2 (0.3)
Total	90 (10.3)	62 (7.7)	63 (8.0)	61 (7.0)	38 (4.7)	33 (4.2)

[a] Data are given as n (%) reoperated or re-revised during the follow-up.

cemented Lubinus cup than for the Trilogy cup. This finding is surprising, but it may be due to higher risk of early re-revision in the Trilogy group, mainly due to infection (Table 4). Uncemented cups tend to be associated with more early revisions, due to dislocation, probably secondary to positioning problems, whereas cemented cups tend to suffer from more problems related to aseptic loosening (Mohaddes et al. 2013). Re-revision due to aseptic loosening occurs mainly after a longer time in situ than 5 years, emphasizing the importance of time to follow-up when the comparison between cemented and uncemented fixation is done. Thus, it may be that the difference in our analysis between the Trilogy and the Lubinus designs would level out with time. The number of re-revisions in the current study was low, thus not allowing a more detailed analysis of the different reasons for repeated revisions. This would have been of interest, not least regarding re-revision due to dislocation and infection.

In an earlier report comparing cemented and uncemented fixation in acetabular revisions (Mohaddes et al. 2013), we found that the stem not being revised increased the risk of a second revision. This finding has been confirmed in our current analysis. The discrepancy is still difficult to explain. One explanation may be that when both components are exchanged, it might increase the biomechanical stability. It should be considered that revision of a well-fixed stem can be associated with complications and morbidities. Our finding is therefore difficult to translate into a general clinical recommendation without taking all risk factors into consideration.

The present study had some limitations. The mean follow-up was short—only 3.3 years. TM cups and similar cups with newly developed porous surfaces have gained popularity and are becoming used more frequently, especially in revision surgery. Thus, we believe that it is important to determine at an early stage whether these designs are associated with any advantages or shortcomings. Clearly, further studies are needed—not least to evaluate whether these designs can facilitate fixation in the long term. Another limitation was that only first-time revisions were included. This selection would exclude the majority of revisions with severe bone defects. According to some reports (Weeden et al. 2007, Sternheim et al. 2012), the TM cup shows superior results when there are severe bone defects. This might influence the surgeons to choose the TM design in already re-revised cases with more pronounced acetabular bone loss. To remove this potential selection bias, we decided to include only the first-time revisions in our analysis, and to adjust for bone graft being used at the index revision. Finally, we used only reoperation and re-revision as endpoints in our evaluation, since patient-reported outcome measures are unavailable for revision cases in the SHAR. There has been criticism of using re-revision as a measure of failure (Goodfellow et al. 2010). However, data from the New Zeeland Joint Registry have indicated a clear relationship between revision rates and patient-reported outcome scores, both in primary and revision arthroplasties (Rothwell et al. 2010).

After analyzing a large number of patients from a national registry with a high degree of completeness, we can conclude that the short-term survival of the TM designs is about equal to that of the most commonly used cemented cup design and the second most commonly used uncemented cup design reported to the Swedish Hip Arthroplasty Register. The TM cup appears to be a safe option in first-time cup revisions. Further follow-up is needed to determine whether the more expensive trabecular metal cup—in the long term—is a more cost-effective choice than already established designs.

MM: data collection, analysis, statistics, and writing. OR: data collection and writing. JK: study design, data collection, analysis, statistics, and writing.

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No competing interests declared

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