Survivorship of rough-surfaced threaded acetabular cups

382 consecutive primary Zweymüller cups followed for 0.2–12 years

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We studied prospectively 382 cementless (Zweymüller stem) and hybrid (cemented stem) primary total hip replacements and used a cementless grit-blasted titanium alloy threaded cup. After a median 5 (0.2–12)-year follow-up, 1 cup was exchanged, 2 cups were removed for deep sepsis, and 3 cups showed definite loosening; of these, 2 subsequently required revision. Actuarial calculation methods indicated a 10-year survivorship of 99% with cup retrieval for any cause (clinical failure), definite cup-loosening (radiographic failure), and revision for aseptic cup-loosening as endpoints. These intermediate results exceed those from smooth-surfaced screw rings and compare favorably with those from cemented cups and cementless, press-fit, metal-backed cups.

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The use of smooth-surfaced threaded acetabular cups has been unanimously condemned (Apel et al. 1989, Snorrason and Kärrholm 1990, Duparc and Massin 1991, Tallroth et al. 1993, Witvoet et al. 1993, Fox et al. 1994, Bruijn et al. 1995, Decoulx et al. 1995, Weill and Scarlat 1995).

In the mid-1980s, rough-surfaced threaded cups were introduced, mainly on the European market, using various surface treatments. Among them was the Zweymüller grit-blasted titanium threaded cup, introduced in 1985. We have prospectively studied these cups in primary total hip arthroplasty (THA) since January 1986. The early and mid-term clinical and radiographic results have been encouraging (Delaunay and Kapandji 1994, 1997). We now report survivorship analysis in a consecutive series of 382 Zweymüller threaded cups used in primary acetabular replacement.

Patients and methods

The Zweymüller threaded cups

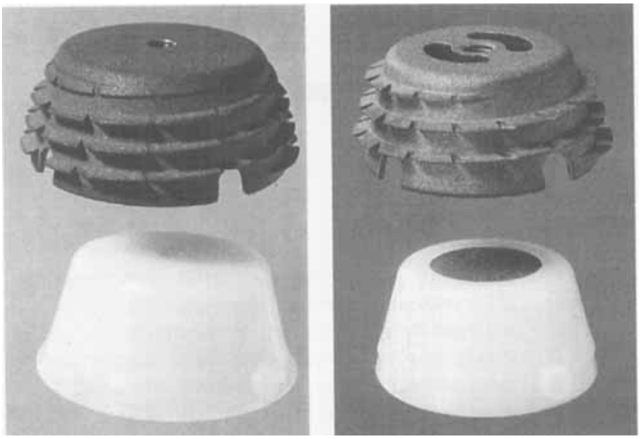
The first generation Zweymüller threaded cup (ZMTC), forged from pure titanium (Protasul-Ti®, Sulzer, Winterthur, Switzerland), had a truncated shape and a flat closed dome. An average roughness of 3–5 microns was created by blasting the outer surface with corundum particles. The deep broad self-tapping thread, double-pitch in its first configuration, was changed to a single one for easier penetration. In 1989, the flat dome was open to allow bone-grafting, if necessary, thus achieving the configuration of the Conical Self-tapping Cement-Free (CSF) second-generation ZMTC, currently used (Figure 1). In all designs, the 1.5 mm metal wall thickness allows insertion of thick, truncated and prestrained ultra-high-density polyethylene liners (Chirulen®, Ruhrchemie AG, Oberhausen, Germany). 32 or 28 mm alumina-ceramic heads (Biolox®, CeramTec, Plochingen, Germany) with 3 neck-lengths were impacted on a 12–14 mm titanium Morse taper. With the smallest cup size, the minimum polyethylene thickness is 5.5 mm.

The series

Between January 1986 and January 1996, we performed 386 primary cementless or hybrid THAs. An anterolateral approach was used by one of us in 195 hips and a posterolateral approach by the other (191 hips). The femoral component was a cementless Zweymüller tapered stem (Sulzer Orthopedics Ltd., Baar, Switzerland) in 354 hips, or a cemented titanium collarless stem of various designs in 32 hips with poor bone stock (Table 1). In all but 4, the Zweymüller cup was used. Thus, this ZMTC series represents 99% of all the acetabular components used for primary THA in our department during the study period.

The studied group included 382 ZMTC, 167 (44%) of the first design and 215 (56%) of the CSF-

Figures 1. The Zweymüller truncated grit-blasted titanium threaded cups and corresponding polyethylene liners.



A. The first generation double-threaded ring, with a closed dome.

B. The second generation Conical Self-tapping Cement-Free (CSF) ring, single-threaded, with an open dome.

design, implanted in 344 patients (38 bilaterally) (Table 2).

Outcome and survival analysis

Postoperative clinical and radiographic examinations took place at 2, 6, and 12 months, then once annually. Complete clinical and radiographic data were available for the 29 patients (34 hips) who died of causes unrelated to their hip surgery, as well as 258 patients (286 hips) who are still evaluated annually (Table 3). Thus, a complete follow-up was achieved for 320 hips (84% of the index series). 49 hips (13%) in 44 patients contacted by phone remain up-dated in the clinical survival analysis. For some of them, radiographs sent by mail allowed an up-dated radiographic survival analysis. Only 9 patients (9 hips) were lost to follow-up within the first 2 years.

Statistical survivorship analysis was performed for the 382 THAs by construction of life tables and calculation of annual cumulative rates. 95% confidence intervals were calculated with the Wilson quadratic method (Dorey et al. 1993). Clinical endpoints included pain levels below 40 points in the Harris hip score (Harris 1969, Brittton et al. 1997), cup revision for any cause (clinical failure, including recurrent dislocation, deep sepsis and pelvic osteolysis), and revision for aseptic loosening alone. The radiographic endpoint was cup loosening, defined as either progressive lucency at the bone-implant interface or migration of the component by more than 2° or 2 mm. For each end-point, we established a "worst case survival curve" where all 9 patients who were lost to follow-up before the 2-year postoperative period were considered as failures (Murray et al. 1997).

Table 1. Breakdown of the 386 total hip replacements, according to the components used (ZMTC: Zweymüller threaded cup)

Stem:	Cemented	Hochgezogen	Alloclassic	Total
Socket				
Cemented	2	1	–	3
Press-fit	–	–	1	1
ZMTC-closed	–	72	95	167
ZMTC-CSF	30	–	185	215
Total	32	73	281	386

Table 2. Breakdown of patients, hips, diagnosis and follow-up periods (in months), according to the type of total hip replacement

Type of replacement	Cementless	Hybrid [a]	Entire series
Patients	315	29	344
female	154	22	176
male	161	7	168
mean age	64	77	65
age range	19–91	63–90	19–91
Hips	352	30	382
female	167	23	190
male	185	7	192
age > 65 years	151	27	178
age < 65 years	201	3	204
Diagnosis			
Primary arthrosis	239	25	254
Hip dysplasia	55	1	56
Osteonecrosis	38	–	38
Posttrauma	18	2	20
Rheumatoid arthritis	2	–	2
Pagetic arthritis	–	2	2
Months follow-up	59	35	57
range	2–146	2–78	2–146

[a] A patient with a cementless and a contralateral hybrid hip was included in the hybrid group

Table 3. Breakdown of patients/hips, according to femoral fixation and outcome during the study period

Patient outcome	Cementless	Hybrid	Total
Postoperative death	3/3	1/1	4/4
Lost to follow-up < 2 years	7/7	2/2	9/9
Death unrelated to hip surgery	26/31	3/3	29/34
Contacted by phone and mail	32/37	12/12	44/49
Reaching the end of follow-up	247/274	11/12	258/286
Total	315/352	29/30	344/382

Table 4. Breakdown of acetabular surgical procedures, according to hip replacement complications (in 378 cups [a])

	n hips (%)	Complication: Cup repositioning	Complication: PE liner exchange	Revision
Dislocation				
Early postop. (<3 m)	16 (4)	1	–	–
Recurrent	12 (3)	1	3 (2 elevated rim)	–
Late (>3 m)	7 (2)	–	5 elevated rim-liners	–
Infection	4	1 (2d stage)	1	2 (cement+AB)
Unexplained groin pain	1	–	1	–
Femoral revision	4	–	–	1 (well fixed)
Cup aseptic loosening	3	–	–	2
Acetabular osteolysis	1	–	1 (+ grafting)	–
Total (%)	378 (100)	3 (1)	11 (3)	5 (1.3)

[a] After exclusion of 4 hips in 4 patients who died in the early recovery period

Results

Complications

4 patients (4 hips) died in the early postoperative period. 21 hips (5.5%) required a reoperation (Table 4). 16 THAs (4.2%) dislocated before the end of the third postoperative month, with no recurrence after closed reduction in 4 hips. The other 12 THAs dislocated twice and 7 more dislocated later than the third postoperative month. All these 19 hips were successfully stabilized after a surgical procedure, 12 of them involving the socket side of the arthroplasty. Acetabular osteolysis was noted in 1 hip in Charnley and DeLee zone I, 4.8 years after the index surgery was performed in a 17-year-old girl for Gaucher bilateral femoral head osteonecrosis. At reoperation, the impingement between the stem neck and the inner PE wedge was evident, but the cup was perfectly stable; the granuloma was curetted and allografted and the bearing surfaces were exchanged for a metal-on-metal combination, with an increased off-set. Only 5

Table 5. 10-year cumulative annual survival rate (%) of the 382 Zweymüller threaded cups with clinical and radiographic endpoints

Endpoint	Cups [a]	10-year survival	95% CI
Clinical failure			
Hip pain < 40 points			
Worst case	29	90	NA[b]
Observed	20	92	75–98
Revision/any cause			
Worst case	14	96	NA
Observed	5	99	85–100
Revision/aseptic loosening			
Worst case	11	97	NA
Observed	2	99	86–100
Radiographic failure			
Aseptic loosening			
Worst case	12	96	NA
Observed	3	99	85–100

[a] Number of "failures" of 378 cups after exclusion of 4 hips in 4 patients who died in the early recovery period.
[b] NA not applicable.

Table 6. Life table according to Dobbs with revision for aseptic loosening of the Zweymüller threaded cup in primary total hip arthroplasty as endpoint

Annual Interval	n cups at start	Withdrawn hips	Dead patients	n cups at risk	Revision for loosening	Survival %	95% CI	Lost to FU hips	% Survival "worst case"
0–1	382	6	5	376.5	1	100	99–100	5	98
1–2	370	23	7	355	0	100	98–100	4	97
2–3	340	37	6	318.5	0	100	98–100	0	97
3–4	297	47	9	269	0	100	98–100	0	97
4–5	241	39	2	220.5	1	99	97–100	0	97
5–6	199	47	3	174	0	99	97–100	0	97
6–7	149	41	4	126.5	0	99	96–100	0	97
7–8	104	33	1	87	0	99	95–100	0	97
8–9	70	35	0	52.5	0	99	92–100	0	97
9–10	35	16	0	27	0	99	86–100	0	97
(sum)			(37)		(2)			(9)	

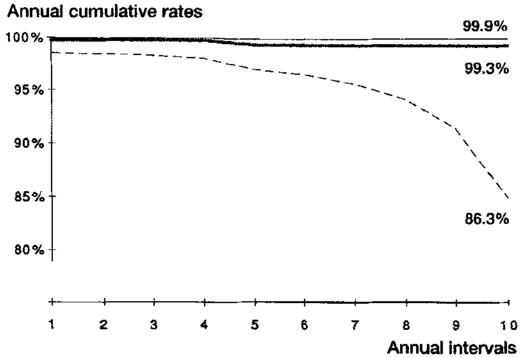


Figure 2. Survival curve and 95% confidence intervals of the Zweymüller rough-surfaced threaded cups, with revision for aseptic loosening as endpoint.

ZMTC (1.3%) were not in situ at the end of our follow-up: 2 were removed for deep infection; 1 during revision of a loose cemented stem in another department (that cup was stable, as reported by the surgeon who performed the revision); and 2 for aseptic loosening (including 1 cup that was revised 2 weeks after the index procedure, due to an intra-operative fracture of a weak acetabular wall).

Survivorship data

Table 5 shows the 10-year annual cumulative survival rates for the clinical and radiographic endpoints previously described. In all categories, the "worst case" survivorship was clearly above the lower value of the 95% confidence interval. With cup revision for aseptic loosening as the endpoint, the 10-year survival rate is 99% (Table 6, Figure 2).

Discussion

The osseointegrative capacity of threaded titanium implants has been demonstrated in dentistry since the early 1980s (Albrektsson et al. 1981). The use of grit-blasted titanium implants in orthopedics was supported by mechanical testing (Semlitsch 1987) and autopsy specimen studies of Zweymüller stems (Lintner et al. 1986).

Several characteristics seem to be important for the success of the Zweymüller cup, when compared to smooth-surfaced designs: 1) primary stability must be high—superior strength of initial mechanical fixation was consistently observed with truncated threaded cups, as compared to hemispherical ones (Kody et al. 1990); 2) a single, large and sharp thread allows easier penetration and larger surface contact with the bone bed; 3) the corundum-blasting technology eliminates the risk of a porous coating (porocoat, plasma-sprayed titanium, hydroxyapatite layer) peeling off; 4) the reduction in the metal-back thickness (1.5 mm for the Zweymüller threaded cups) allows, together with 28 mm heads, insertion of thick polyethylene liners, even in small cup sizes; 5) the low modulus of elasticity of a thin metal-backed shell is thought to allow, with time, a reduction of the unphysiologic prestress load generated by screw rings during implantation (Dalstra and Huiskes 1994).

Table 7 lists the loosening and revision rates of smooth metal-backed threaded cups versus grit-blasted cups reported with at least 5-year mean follow-up times. The general trend indicates that the addition of the rough surface has dramatically improved intermediate outcome of this type of cup.

Table 7. Minimum 5-year results of smooth-surfaced and grit-blasted titanium threaded cups in primary total hip arthroplasty (in order of length of follow-up)

	Authors	n hips	Mean FU years	Loosening %	Revision %
Smooth					
Lord	Malchau et al. 1996	107	10	56	37
Weill-CLW	Weill and Scarlat 1995	312	(7–10.5)	11	–
	Decoulx et al. 1995	90	6.6	26	12
T-tap	Fox et al. 1994	52	5.2	31	–
Bichat III	Duparc and Massín 1991	198	5	11	–
Mecring + Weill	Simank et al. 1997	715	5	10	3.5
Grit-blasted-Ti					
Weill-CLW	Weill and Scarlat 1995	244	(7–10.5)	0.5	–
	Decoulx et al. 1995	751	(6–7)	0	0.1
Zweymüller	Delaunay and Kapandji 1997	126	7	2	1
	Effenberger et al. 1995	116	6.3	2	–
	Schuster et al. 1995	101	6	1	–
	Kutschera et al. 1993	96	5.4	1	–

With radiographic loosening as the endpoint, the prospective survivorship of the Zweymüller threaded cups is 99% at 10 years in our series. To our knowledge, only 2 other acetabular components have a 10-year survival rate above 95% for the same endpoint: the cemented original Charnley cup (Thackray, Leeds, U.K.), with a 96% survivorship in the series by Garcia-Cimbrelo and Munuera (1992), and the cementless Harris-Galante I cup (Zimmer, Warsaw, Indiana, USA), with a 99% survivorship in the study reported by Tompkins et al. (1997). Therefore, we propose that a minimum radiographic survival rate of 95% at 10 years should be considered the "gold standard" in primary acetabular replacement.

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