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Loosening After Acetabular Revision: Comparison of Trabecular Metal and Reinforcement Rings. A Systematic Review

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ABSTRACT

The best method of revision acetabular arthroplasty remains unclear. Consequently, we reviewed the literature on the treatment of revision acetabular arthroplasty using revision rings (1541 cases; mean follow-up (FU) 5.7 years) and Trabecular Metal, or TM, implants (1959 cases; mean FU 3.7 years) to determine if a difference with regard to revision failure could be determined. Failure rates of the respective implants were compared statistically using a logistic regression model with adjustment for discrepancies in FU time. In our study, TM shows statistically significant decreased loosening rates relative to revision rings for all grades including severe acetabular defects and pelvic discontinuity. The severe defects appear to benefit the most from TM.

Total hip arthroplasties are regarded as one of the most successful operations performed in orthopedic surgery [1]. It is predicted that in the USA that the demand for total hip arthroplasties (THA) will grow by 174% to 572,000 procedures per year by 2030 [2]. Concurrently, it is estimated that the number of revision surgeries will increase by 137% by 2030 [2]. The most common indication for acetabular revisions is symptomatic aseptic loosening due to failure of fixation and osteolysis, and less commonly infection and instability [3].

A large retrospective study underscores this. Lie et al [4] evaluated 78,534 THA reported to the Norwegian Arthroplasty Register and found an overall failure rate of 11.4% during a 10-year follow-up period. Five thousand one hundred thirty-seven revisions were performed and reported to the Register, and of these 375 were necessitated by infection. Of the 4762 revisions that had no infection, 2751 (57.8%) involved the acetabular components. The authors described the 10-year risk of aseptic failure for revision operations as 25.6%.

Acetabular revision is the most difficult procedure in hip surgery primarily because of the loss of acetabular bone stock and the condition of the soft tissue in these patients [3]. Typically, the greater the bone loss the more complex are the reconstruction methods required for acetabular revision procedures. These utilize the use of oblong cups, reinforcement rings and antiprotrusio cages, posterior column plating, structural grafting and combinations of the above. Recently new porous metal cups, shells and augments such as the most commonly used Trabecular Metal (Zimmer, Warsaw, IN, USA) components have been developed [3]. The goal of all of these modifications is to promote firm fixation of the acetabular component to the bony pelvis and to prevent future loosening of the acetabular component.

The purpose of this study is to determine if the use of newer porous implants show improved loosening rates compared to revision rings. We therefore reviewed the literature on the results of THA revisions and specifically looked at the rate of loosening of the acetabular component from the bony pelvis after revision surgery for failed THA in cases utilizing reinforcement rings (Ganz, Mueller, Burch-Schneider) and compared these numbers to those of the newer Trabecular Metal (TM) cups, shells and augments.

Materials and Methods

Search Strategy

A search of the Medline and EMBASE databases was conducted using defined search phrases and citation tracking. This initial search included single-arm and controlled studies published between

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January 1992 and May 2012 that evaluated the failure rate of THA revisions with TM constructs and the Mueller, Ganz and Burch-Schneider reinforcement rings. TM components and the Ganz, Mueller, Burch-Schneider reinforcement rings were selected for comparison because they were the most widely used and published. The medical subject headings used were “Cementless Acetabular Revision,” “Acetabular revisions and Trabecular Metal” and “Acetabular revisions and reinforcement rings.”

Studies were included if the revisions were cementless (between construct and host bone), utilized either TM constructs or Mueller, Ganz or Burch-Schneider reinforcement rings and had both clinical and radiographic follow-up. Excluded were single case reports, review articles and failures due to infection. Data extracted included authors, study type, year of publication, type of revision, mean patient age at time of revision surgery, mean duration of follow-up, radiographic follow-up and revision rate.

In a second analysis we further narrowed our selection criteria. Many of these patients had significant loss of bone stock requiring complex reconstruction. We therefore only compared results with similar indications and involving more severe bone defects corresponding to Paprosky III or AAOS 3 and 4 grades. AAOS 3 defects are combined segmental defects (complete loss of bone in the supporting hemisphere of the acetabulum including the medial wall) and cavitary defects (volumetric loss in bony substance of the acetabular cavity). AAOS 4 defects represent pelvic discontinuity. Paprosky III defects are classified as those with major destruction of the acetabular rim and supporting structures. Publications that did not use these classification systems and that did not correlate revision failures to a particular grade were excluded from this second analysis. In addition we looked at cases with pelvic discontinuities following revision THA and compared the incidence of radiographic loosening after the use of TM cups, shells and augments with the incidence after the use of metallic reinforcement rings.

The criteria for radiographic loosening included breaking of screws fixing the acetabular cup or reinforcement ring to the bony pelvis, breaking of the reinforcement ring, radiographic lucency of 2 mm or more on follow-up radiographs especially if increasing over time, and the movement of the cup during follow-up. In general, revision was performed based upon clinical symptoms (i.e. pain) and not as a result of the radiological findings described above.

Statistical Analysis

Primary outcome was a binary, patient-level variable, namely success or failure (i.e., acetabular loosening) within the study-specific follow up (FU) period. Logistic regression was used to estimate the failure rates for the different surgical techniques (TM, Reinforcement rings: Mueller ring, Ganz ring, Burch-Schneider ring). The average failure rates *P*, along with their 95% confidence intervals (CIs), were determined from the baseline odds of intercept-only logistic regression models, $\log[p/(1-p)] \sim \beta_0$. The failure odds ratio between the two techniques and its CI were obtained from a logistic regression model with a single two-level factor technique, $\log[p/(1-p)] \sim \beta_0 + \beta_T T$. Possible heterogeneity of the studies (i.e., over-dispersion) was accounted for by means of the robust Huber-White sandwich estimator for the covariance matrix and standard errors of the parameter estimates. The analysis was adjusted for different FU by using the logarithm of the study-specific average FU time as an offset variable in the model (see Appx. 4 in [5]). Failure rates and rate differences in the subgroup of severe defects (AAOS 3 and 4, Paprosky III) were analyzed in the same way.

Results

After excluding duplicates, there were a total of 216 articles and abstracts. Forty-four of these publications dealt with cementless acetabular revision and Trabecular Metal. Fourteen of these papers were review articles and experimental studies. Of the remaining, 20 papers fulfilled the inclusion criteria (Table 1) with the first clinical paper appearing in 2004. The search on cementless acetabular revision and reinforcement rings yielded 71 articles with abstracts; 26 of these articles fulfilled the inclusion criteria (Tables 2–4). In all these patients the preoperative indications for revision were heterogeneous and not restricted to any grade in the AAOS or Paprosky classification.

For the second comparison of severe defects (AAOS 3 and 4, Paprosky III grades) only 16 papers on TM fulfilled the inclusion criteria, and in the reinforcement ring group only 13 publications fulfilled these criteria.

All Cases (All Grades)

The published articles consist of case series describing use of TM and reinforcement rings in revision THA; randomized controlled trials are not available. The results of the present review should, therefore, not be considered as conclusive but rather as hypothesis generating. In general, revision was performed based upon clinical symptoms (i.e., pain) – not as a result of the radiological findings described above.

We found a total of 20 articles (Table 1) published between 2005 and 2010 that reported on the use of the new TM porous metal systems. The review of 1959 revision THA described in these articles has a mean follow-up period of 3.7 years and a rate of loosening of the acetabular cup of 1.9% (95% CI within [1.3%, 3.0%]). Assuming a constant rate of loosening over time, this corresponds to a loosening rate of 0.5% per year (CI [0.3%, 0.9%]).

Reinforcement rings (Table 2) have been used over a much longer period of time and therefore longer follow-up periods are available. There were a total of 1541 patients who had acetabular revision surgery with one of the three most commonly used reinforcement rings. Four hundred seventy-nine patients (Table 2) evaluated in 14

Table 1
Porous Metal Trabecular Metal (Zimmer).

Author	Year	# Hips	Mean Age	FU Year	Aseptic Clin/ Radiol. Loose	Reason for Revision	
						Septic Loosening	Aseptic Loosening
Unger [18]	2005	60	64.2	3.5	0	0	1
Sporer [19]	2006	13	63	2.5	1	0	0
Sporer [20]	2006	28	64	3.3	0	0	0
Weeden [21]	2007	43	65.4	2.8	0	1	0
Siegmeth [22]	2009	34	64	2.9	2	0	2
Kim [23]	2008	46	64	3.8	1	0	1
Lingaray [24]	2009	23	67	3.5	1	0	0
Simon [25]	2009	53	67.4	2.3	1		1
van Kleunen [26]	2009	97	59	3.7	0	2	0
Malkani [27]	2009	25	72	3.3	0	0	0
Lakstein [28]	2009	53	63	3.7	4	0	2
Flecher [29]	2010	72	60	4.0	0	0	0
Fernandez [30]	2010	263	69.5	6.1	0	0	0
Lachiewicz [31]	2010	39	65.1	3.3	1	x	1
Jafari [12]	2010	81	66	2.95	5	x	3
Skyttae [32]	2011	827	69.1	3.0	16	x	16
Pierannunzii [33]	2011	21	71	1.7	1	0	1
Davies [34]	2011	42	66.7	4.2	0	1	0
Del Gaizo [35]	2012	37	60	5.0	1	0	x
Sternheim [36]	2012	102	62.4	6	4	0	2
TOTAL		1959	66.8	3.7	38 (1.9%)	4 (0.25%)	30 (1.5%)