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Resurfacing hip prostheses revisited

Failure analysis during a 16-year follow-up

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Abstract We conducted a prospective study of the clinical and radiographic variables related to the survival of 114 cementless resurfacing double-cup hip replacements (RHR) with a mean follow-up of 9 (range: 1–16) years. Three patients died, and 22 were unavailable for the final review in 2003. Sixty-one RHRs had to be revised to a total hip replacement. Failure analysis of these revised RHRs showed femoral head and neck resorption under the prosthesis in 33, acetabular protrusion in seven, both femoral and acetabular resorption in 14 and a femoral-neck fracture in three. One hip had dislocated, and there were three hips with unexplained pain. The Kaplan–Meier 5-year mean survival was 92%, the 10-year survival was 47% (95% CI 37–57%) and the 15-year survival was 30% (95% CI 20–40%). Pre-operative joint destruction (grade 1), a high degree of radiological osteoporosis, a body mass index >25 and prosthesis mismatch were significantly related to failure of the RHR. We believe that in young, non-obese patients with pre-operative radiological central destruction but without severe proximal femoral osteoporosis, a resurfacing arthroplasty may have some value. Our failures were mainly due to femoral resorption under the prosthetic femoral component.

Résumé Nous avons conduit une évaluation rétrospective des variables cliniques et radiographiques qui déterminent la survie de 114 resurfaçages de la hanche par une double cupule sans ciment (RHR) avec un suivi moyen de 9 (1–16) ans. Trois malades sont morts et 22 étaient perdus de vue au dernier examen en 2003. Soixante et un RHR ont été révisés pour faire une prothèse totale. L'analyse des échecs montre une résorption de la tête et du col dans 33 cas; une protrusion acétabulaire dans 7 cas; une résorption fémorale et acétabulaire dans 14 cas; une fracture du col fémoral dans 3 cas. Il y avait une hanche avec luxation et trois hanches avec des douleurs inexpliquées. La survie moyenne (Kaplan–Meier) à 5 ans était 92%; la survie à 10 ans était 47% (95% CI 37–57%), la survie à 15 ans 30% (95% CI 20–40%). La destruction articulaire préopératoire de grade 1, le haut degré d'ostéoporose radiologique, l'index de masse corporelle >25, et la disparité de la prothèse avec le col fémoral sont des facteurs significatifs de l'échec du RHR. Chez des jeunes patients non-obèses, avec destruction centrale radiologique et sans sévère ostéoporose fémorale proximale, le resurfaçage peut avoir de la valeur. La mode d'échec était principalement la résorption fémorale en dessous du composant fémoral prothétique.

Introduction

The average 10–15 year survival of a total hip replacement (THR) in patients younger than 55 years is only 70%, and this relatively poor figure suggests the need for another method for replacing degenerative hips in this group of patients. This is especially necessary as in the last 10 years, the mean age of a patient requiring a prosthesis has steadily decreased [16]. In 1940, the principle of a resurfacing hip replacement (RHR) was introduced [14, 17], and recently, its use is again becoming popular [1, 7], with both short- and medium-term reviews showing favourable results. However, long-term results are still awaited. The advantages of the RHR technique are the preservation of bone stock, a short rehabilitation period due to the less extensive surgery and the possibility of revision to a regular total hip prosthesis [1–4, 7, 11, 12, 15]. However, other authors dispute these favourable results [6, 17, 18] pointing out that bone is not preserved and that both femoral head resorption [17] and acetabular defects [17] lead to subsequent early failure.

Of considerable relevance to this controversy is information on both the long-term performance and failure of RHR. Prosthetic failure mechanisms are related to patient characteristics, bone stock of the femoral neck and acetabulum (both pre-operative and at follow-up), and implant

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position. Our study is an analysis of the causes of failure associated with RHR design.

Materials and methods

One hundred and fourteen patients who were treated with resurfacing hip prostheses between 1984 and 1988 at our medical centre were included in this prospective study. The indication for operation was a patient younger than 50 years suitable for a THR. A Gerard prosthesis inserted via an antero-lateral approach was used in 54 women and 38 men (mean age 47 years; SD 11), and in 22 patients, a bilateral procedure was performed. The pre-operative diagnosis was osteoarthritis (50 patients), osteonecrosis (13 patients), ankylosing spondylitis (eight patients) and rheumatoid arthritis (21 patients). The mean follow-up was 9 (range: 1–16) years.

The cementless double-cup Gerard prosthesis (Howmedica) consists of a femoral component, a Luck cup—the cylinder of which has a collar—and an acetabular component (Fig. 1). The latter has a polyethylene-coated liner that articulates with the femoral cup and has a polished acetabular bone surface. Both parts are made of chromium–cobalt alloy, and five sizes were available.

Indications for and date of revision of the resurfacing hip prosthesis were recorded. All patients were called for review regularly or when indicated, by telephone or by letter. Three patients died during the follow-up period, and 22 did not attend for their appointment in 2003. They were therefore considered lost to follow-up. However, their clinical and radiological data were available and ranged from 1 to 10 years. This last clinical and radiological follow-up appointment was then censored (worst case scenario) for survival analysis.

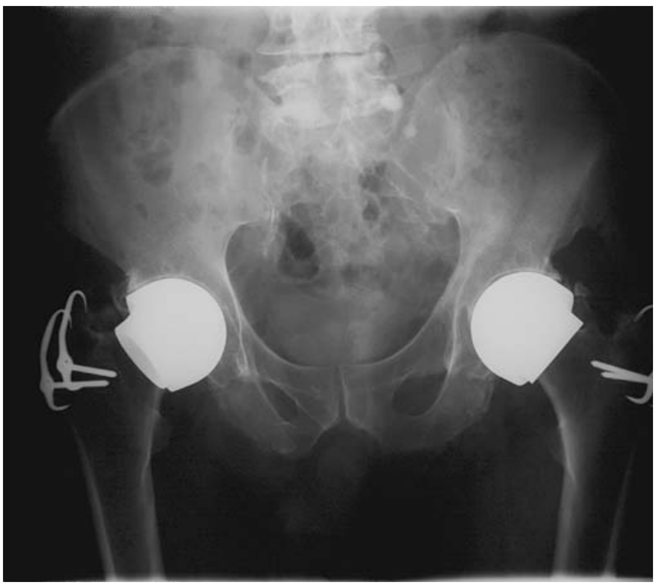

Fig. 1 Bilateral Gerard prosthesis: 16-year follow-up in patient with rheumatoid arthritis.

Possible pre-operative confounding factors influencing prosthesis survival were scored, i.e. body mass index (BMI), steroid usage and pre-operative radiological variables. The latter included the stage of radiological osteoporosis (mean modified Singh index 1.6; SD 0.6 [8]), hip dysplasia (centre-edge angle), protrusio acetabuli, number and size of cysts >3 mm in femoral head and acetabulum and the degree of radiological joint destruction. The latter was classified for osteoarthritis [20] (mean 2; SD1.1), osteonecrosis (mean 3.3; SD 0.5) [9] and rheumatoid arthritis (mean 3.3; SD 1.1) [13].

For the radiological assessment, an AP-pelvis and a lateral hip radiograph were taken. During follow-up, the prosthesis position was compared with the first post-operative and the last radiograph. On the post-operative radiographs, variables that might interfere with prosthesis survival were measured with a radiographic measurement package (Ortho-CMS, Medis, Leiden, the Netherlands). These included prosthesis position (valgus/varus), progression of acetabular protrusion (difference between the first and last post-operative radiographs) and a qualitative score for adequate size matching of the prosthesis with the bone (i.e. prosthesis–bone size match.). A 'good fit' indicated that the collar surface of the femoral component was in line with the femoral neck, and "too big" indicated a gap of 3 mm or more between the femoral component and the femoral neck. Repeated measurements were used to test for intra- and inter-observer variability of these radiographic measurements. The inter-observer variability of these radiographic measurements for CE angles were mean 0.1°; SD 1.95° (95% CI: 0–4°) and for translation (acetabular protrusion) mean 0.2 mm; SD 1.68 mm (95% CI: 0–4 mm). The inter-observer variability for radiographic measurements of the CE angle was mean 0.25°; SD 2.4° (95% CI: 0–5°) and for translation mean 0.06 mm SD; 1.0 mm (95% CI: 0–3 mm).

Reasons for revision were pain with no radiological abnormalities or pain with radiological evidence of femoral-head resorption or acetabular protrusion. For the revised cases, all pre-operative radiographs, surgical reports and pathology reports for the resected heads were assessed for any resorption of the femoral head and neck and for any acetabular defects. At revision, the 'shape' of the femoral head was classified either as a stump (extensive resorption of the proximal aspect, candle appearance) or as a cylinder. The histology of ten femoral stumps and five cylindrical femurs of revised RHR was also assessed. Indications for revision were substantiated using the radiological and intra-operative evidence of prosthesis mismatch between the prosthesis and the femur and/or the acetabulum. During the revision surgery, no problems arose from the femur, but bone grafting of the acetabulum was necessary in 21 hips.

At the last review, in 2003, the clinical and radiological assessment was combined with a questionnaire on the quality of life (SF-36) in order to reveal differences between patients with a 'survived' RHR and a 'revised' RHR. The SF-36 consists of 36 questions divided into eight areas: physical function, social function, role-emotional, role-physical, bodily pain, general health, mental health and vitality [5].

Statistics

Descriptive statistics (mean, standard deviation) and independent samples *t* tests (parametric) or chi-square (nonparametric) tests for comparison between groups were done ($p<0.05$ was considered to be a statistically significantly difference). A Kaplan–Meier survival curve was made with end-point revision of the prosthesis; 95% CIs were calculated at 10 and 15 years. The effect of confounding factors (e.g. osteoporosis index, BMI, diagnosis) on prosthesis survival was tested with a log-rank test. A BMI index of 25 was considered the threshold for being overweight.

Results

The mean 10-year survival was 47% (95% CI; 37–57%) and the mean 15-year survival 30% (95% CI; 20–40%, Fig. 2). During the 16-year follow-up (mean 9 years), 61 Gerard prostheses were converted to a total hip prosthesis. The reason for revision was pain, and on analysis of radiological, intra-operative and pathological data, the following causes were revealed: resorption of the femoral head and neck with mechanical loosening in 33, femoral-neck fracture in three, progressive acetabular resorption in seven, combined femoral and acetabular resorption in 14, a dislocated RHR in one and in three others, no cause for the hip pain was found.

In the cases with no femoral-head resorption, the head had a cylindrical form but was not fused to the polished metal cup. Histological review revealed extensive osteonecrosis in all ten femoral stumps examined, and normal bone trabeculae were seen in all five cylindrical femoral heads similarly examined. BMI (A BMI >25 led to more revisions) and the side of the prosthesis (the right side had more revisions) were significantly different between revision and the non-revision patients (respectively, p=0.03 and p=0.005). For obese patients, at long-term follow-up, the mean survival was lower (Fig. 3). Landmark testing between the BMI <25 and the BMI >25 groups after a median follow-up of 80 months showed a significant difference (log rank test) between the low and high BMI groups. After more than 80 months, obese patients had a lower prosthesis survival.

Age, corticosteroid usage and gender were not significantly different between revised and non-revised patients (p=0.6, p=0.71 and p=0.08, respectively). However, a tendency existed (p=0.08) for female patients to have more revisions compared with men. Although differences between patients with arthritis, osteonecrosis (ON), osteoarthritis (OA) and ankylosing spondylitis (AS) were not significant, a trend could be seen that those with AS seemed to have better results and those with ON worse results (log rank=0.07, Fig. 4).

The degree of pre-operative radiological osteoarthritis had a significant negative effect (little destruction resulting in more revisions) on the survival period of the prosthesis, and this was similar for the severity of radiological osteoporosis (p=0.03), with more severe osteoporosis showing a higher revision rate. The pre-operative medial-wall thickness (acetabular protrusion) had no influence on prosthetic survival (revision group: mean −3 mm, SD 5.6; non-revision: mean −3 mm, SD 4.6, p=0.3). There were no significant differences in respect to the pre-operative number of femoral-head cysts (revision group: mean three cysts, SD 3.2; non-revision: mean four cysts, SD 3.1, p=0.4), the pre-operative number of acetabular cysts (revision group: mean

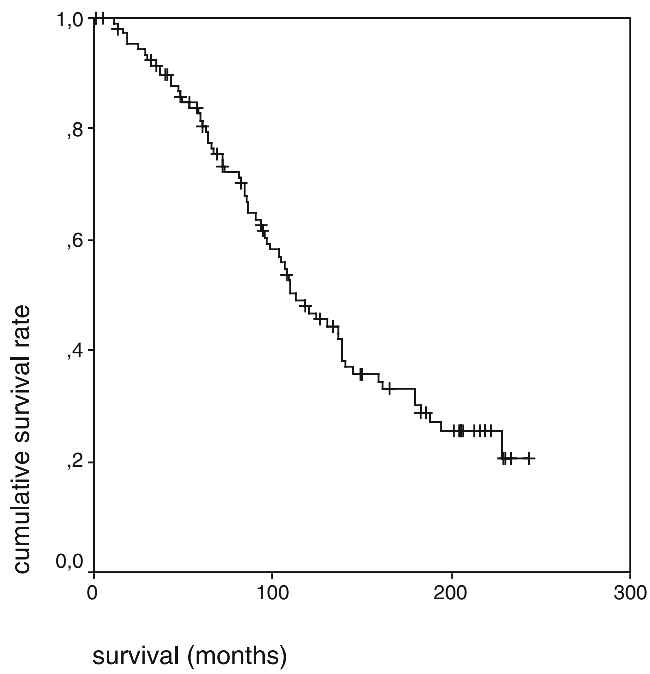

Fig. 2 Survival analysis of Gerard prosthesis (+) during follow-up.

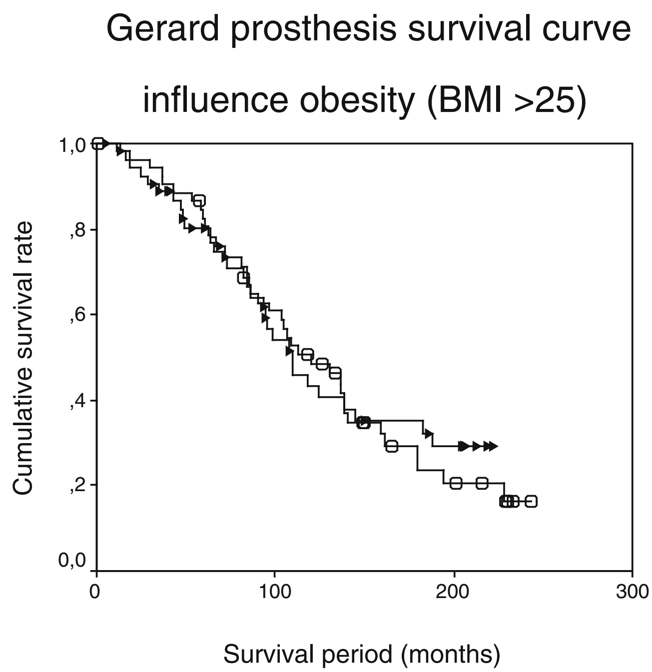

Fig. 3 Influence of Body Mass Index (BMI >25 (○) and BMI <25 (‣) on survival analysis of Gerard prosthesis during follow-up.

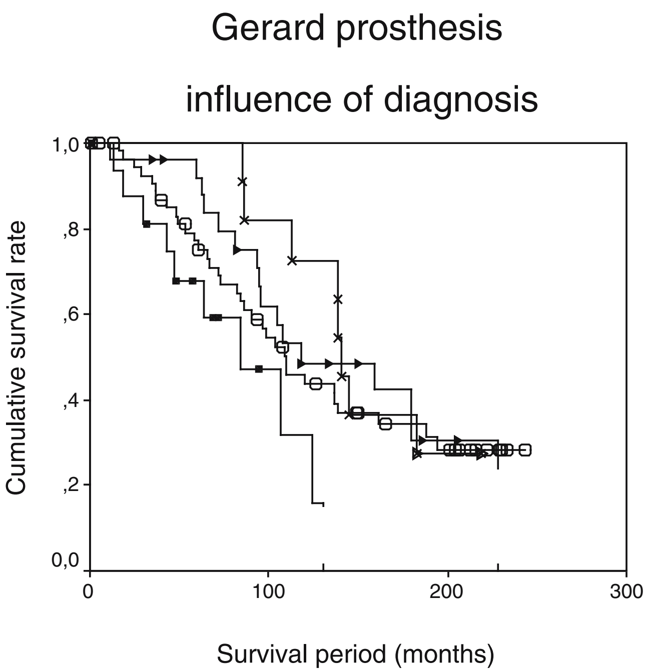

Fig. 4 Influence of diagnosis on survival analysis of Gerard prosthesis during follow-up. Diagnoses: *x* ankylosing spondylitis, ▪ osteonecrosis; ‣ rheumatoid arthritis, ○ osteoarthritis.

Table 1 Radiological position Gerard prosthesis (n=113)

	Varus mean (SD)	Valgus mean (SD[a])	Good-fitting prostheses* (%)
Gerard in situ	8.5 (5.9) n=24*	9.0 (6.8) n=8	63
Gerard revision	14.5 (11.8) n=35*	13.3 (7.7) n=24	31

[a]SD: standard deviation, difference between revised and non-revised RHR are significantly different (p=0.03)
*Good fit: within 4°. Differences between revised and non-revised RHR are significant (p=0.007)

one, SD 2.4; non-revision: mean one, SD 2.0, p=0.7), the pre-operative diameter of the cysts (revision group: mean 7 mm; SD 5.4; non-revision group: 9 mm, SD 6.0; p=0.14) and the pre-operative CE angle (revision group: mean 33°, SD 14.3; non-revision group: mean 36, SD 14.1, p=0.9).

The radiological fitting of the prosthesis on the proximal femur (i.e. the size of the prosthesis matched the femoral neck within 3 mm) was related to prosthesis survival (p= 0.007, Table 1). The immediate post-operative position of the RHR in the non-revised group showed significantly less varus or valgus when compared with the revised RHR (Table 1).

The quality of life (SF-36) between the non-revised and the revision group showed no significant differences for the eight dimensions that comprise the SF-36. These were recorded as: physical function p=0.97, social function p=0.62, role-emotional p=0.85, role-physical p=0.37, bodily pain p=0.68, general health p=0.5, mental health p=0.25 and vitality p=0.85.

Discussion

Although the 5-year results showed a mean survival of 92%, which is comparable with other recently published data [1, 7], the 10-year and 15-year results in our study of resurfacing prostheses showed poorer results when compared with primary total hip replacement in this age group. Although modern RHR techniques [7] give more predictable positioning of the cup, which, incidentally, is related to a higher RHR survival (Table 2), the principal reason for failure in our study was resorption of the femoral head and neck. Osteonecrosis of the femoral head and neck was probably responsible for this in the majority of patients, possibly enhanced by 'stress shielding' of the bone underneath the metal RHR, and this was even greater in osteopenic bone. Our results confirmed that radiological osteopenia in the proximal femur (modified Singh index 3) had a negative effect on prosthesis survival.

When revision was required, the same technique for primary THR was used; however, the acetabular defects in some patients required reconstruction with bone impaction grafting. Obesity (i.e. BMI >25) was another pre-operative factor that had a negative effect on prosthesis survival. Pre-operative radiological joint destruction (i.e. grade 1destruction) also had a significant effect on prosthesis survival. However, grade 4 pre-operative OA (i.e. circumferential and medial wall destruction) had a better prosthesis sur-

Table 2 Overview literature resurfacing hip prostheses (minimum 5 years)

Author	N	Type of Prosthesis (cemented/cementless)	Max Follow up (mean)	Mean Age	Results* Survival (mean %)
1988 Willems [19]	107	Gerard (cementless)	6 years	47 years	82%
1990 Howie [11]	100	Wagner (cemented)	8 years	63 years	40%
1995 Van Raaij [17]	183	Gerard (cementless)	11 years	47 years	33-63%[a]
1994 Amstutz [2]	170	THARIES (cemented)	12 years		49%
1998 Hungerford [12]	33	Resurfacing (cemented)	11 years (5 years)	41 years	62%
2001 Mont [15]	60	hemiresurfacing (cemented)	(7 years)	35 years	90%
2001 Beaulé [4]	37	hemiresurfacing (cemented)	15 years	34 years	45%
2004 Amstutz [1]	400	Conserve, Cemented femoral shell/ cementless acetabulum	6 years (4 years)	48 years	91-98%[a]
2004 Daniel [7]	446	Cemented femoral shell/cementless acetabulum	8 years (3.3 yrs)	48 years	99.8%

*Results: Kaplan Meier survival analysis, mean or, if available[a], 95% confidence interval vival, while grade 1 (only lateral joint space narrowing with normal medial wall appearance) had worse RHR survival results. In the latter group, symptoms would have been present for only a short period, suggesting that the patient probably had not adapted his or her daily activities to the degenerated joint and would therefore have overused the artificial joint. The presence of radiological cysts decreased RHR survival, and the presence of multiple, large, femoral cysts (>10 mm diameter) probably results in inadequate initial 'cementless' cup fixation and early collapse of the femoral neck with subsequent loosening of the prosthesis.

Inadequate prosthesis–bone size match is also important. This factor is largely dependent on the availability of different sizes of the prosthesis, particularly with respect to 'anatomical' variations of the femoral neck, and, in fact, only five sizes were available for our patients.

There may be four factors resulting in proximal femoral resorption: stress shielding underneath the cup, progressive resorption due to an initial mismatch between bone and prosthesis leading to subsequent bone resorption [10] and compromised vascularity of the femoral head with subsequent osteonecrosis.

Mid-term 'survival' results of this RHR are good, but long-term results are poor. Failure is related to three factors. Firstly, patient characteristics: obesity (BMI >25), the presence of little pre-operative radiological destruction, the presence of large femoral cysts and osteopenia in the proximal femur. Secondly, intra-operative factors: prosthesis alignment and prosthesis–bone match. Thirdly, biological factors: causing femoral-neck and head resorption. The first two factors should be remediable in a young population and also avoided by careful surgery.

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