Outcome of Charnley total hip replacement across a single health region in England

THE RESULTS AT TEN YEARS FROM A REGIONAL ARTHROPLASTY REGISTER

M. K. Allami,
D. Fender,
F. M. Khaw,
D. R. Sandher,
C. Esler,
W. M. Harper,
P. J. Gregg

From the James Cook University Hospital, Middlesbrough, England

■ M. K. Allami, FRCS(Trauma and Orth), Specialist Orthopaedic Registrar
Leeds Teaching Hospitals NHS Trust, Beckett Street, Leeds, LS9 7TF, UK.

■ D. Fender, FRCS (Trauma and Orth), Consultant Orthopaedic Surgeon
Freeman Hospital, Freeman Road, High Heaton, Newcastle upon Tyne, Tyne and Wear, NE7 7DN, UK.

■ F. M. Khaw, FRCS, Specialist Registrar and Honorary Clinical Lecturer in Public Health Medicine
University of Newcastle upon Tyne, The Medical School, Framlington Place, Newcastle upon Tyne, NE2 4HH, UK.

■ D. R. Sandher, FRCS(Trauma and Orth), Specialist Orthopaedic Registrar
Stepping Hill Hospital, Poplar Grove, Stockport, Cheshire, SK2 7JE, UK.

■ C. Esler, FRCS(Trauma and Orth), Consultant Orthopaedic Surgeon

■ W. M. Harper, FRCS(Ed), MD, Professor of Orthopaedic and Trauma Surgery
Glenfield Hospital, Groby Road, Leicester, Leicestershire, LE3 9QP, UK.

■ P. J. Gregg, FRCS, MD, Professor, Consultant Orthopaedic Surgeon of Orthopaedic Surgical Science
The James Cook University Hospital, Marton Road, Middlesbrough, Cleveland, TS4 3BW, UK.

Correspondence should be sent to Mr M. K. Allami at 7 Allerton Grange Crescent, Leeds LS17 6LN, UK; e-mail: mklami@yahoo.com

©2006 British Editorial Society of Bone and Joint Surgery
doi:10.1302/0301-620X.88B10.17933 \$2.00

J Bone Joint Surg [Br]
2006;88-B:1293-8. Received 22 March 2006; Accepted 30 May 2006

Using the Trent regional arthroplasty register, we analysed the survival at ten years of 1198 consecutive Charnley total hip replacements carried out across a single health region of the United Kingdom in 1990. At ten years, information regarding outcome was available for 1001 hips (83.6%). The crude revision rate was 6.2% (62 of 1001) and the cumulative survival rate with revision of the components as an end-point was 93.1%. At five years, a review of this series of patients identified gross radiological failure in 25 total hip replacements which had previously been unrecognised. At ten years the outcome was known for 18 of these 25 patients (72%), of whom 13 had not undergone revision.

This is the first study to assess the survival at ten years for the primary Charnley total hip replacement performed in a broad cross-section of hospitals in the United Kingdom, as opposed to specialist centres. Our results highlight the importance of the arthroplasty register in identifying the long-term outcome of hip prostheses.

Following the success of the Norwegian¹ and Swedish² joint registries, the Trent regional arthroplasty register was established in 1990 and was the first of its kind in the United Kingdom. Since the beginning of 1990, and with the agreement of all the consultant orthopaedic surgeons in the region, all primary total hip and knee replacements performed throughout the Trent region have been recorded prospectively. The region has a population of 4.7 million (1990 census), served by 18 National Health Service (NHS) hospitals (11 district general hospitals and seven teaching hospitals), and six private hospitals. The database allows analysis to be made of the objective and subjective outcomes of the hip and knee prostheses used most commonly in the NHS.

The Charnley total hip replacement (THR) has a long and established record³⁻⁵ with long-term survival of more than 90% in patients over 60 years of age.⁵⁻¹³ However, most studies have been carried out in a single centre or by an individual surgeon, often with a specialist interest in THR.⁵⁻¹³

We present the survival of the primary Charnley THR at ten years, with revision as the end-point, in patients documented in the Trent regional arthroplasty register.

Patients and Methods

All patients undergoing primary Charnley THR during 1990 were prospectively regis-

tered with the Trent regional arthroplasty study. Registration was carried out by the surgeon undertaking the operation, who completed a standard form at the time of the procedure and returned it to the study centre. The form recorded the clinical and operative details which were entered into a computerised database. The data were validated by a peripatetic clerk, who checked theatre and consultant records and the patient administration system of each hospital to ensure that no information had been lost and that the data were accurate.¹⁴

During 1990, 1198 Charnley THRs were carried out on 1152 patients, under the care of 56 consultants. There were 449 men (39%) and 703 women (61%) with a mean age of 69.1 years (21 to 103) at the time of operation; 19% (227) of the patients were less than 60 years of age. The procedures were undertaken on the right side in 690 (57.6%) hips and on the left in 508 (42.4%). No simultaneous bilateral cases were performed.

Consultants performed 49% (587) of the operations, senior trainees assisted by a consultant 10% (120), senior trainees without the assistance of a consultant 34% (407), and other grades of surgeons 7% (84). The operations were performed in the teaching hospitals in 46.5% (557) of cases, district general hospitals in 42.2% (506) and in private hospitals in the remaining 11.3% (135).

Fig. 1

The breakdown of the series and the outcome data available.

The pre-operative diagnosis was osteoarthritis (OA) in 87% (1042) of cases, rheumatoid arthritis (RA) in 7% (84) and miscellaneous in the remaining 6% (72). In 82% (982) of the procedures a laminar-air-flow theatre was used, in 11% (132) a standard general theatre and in the remaining 7% (84) no information was available about the theatre. All patients received prophylactic antibiotics.

In 1996, Fender, Harper and Gregg¹⁵ reviewed this series of patients and the results regarding the outcome at five years were published in 1999. At ten years we contacted the Office for National Statistics to obtain a list of those patients who had died. We sent a questionnaire to patients who were still alive to determine the current status of their prosthesis and whether or not it had been revised. The questionnaire also asked whether the patients were pleased with the outcome of their THR, the type and date of any complications, the date of their most recent clinical and radiological follow-up and the outcome of their THR. For patients who did not respond to the questionnaire, the status of their implant was determined by contacting their general practitioner (GP). In patients who had died and in whom the outcome of their THR was not known, its status was determined either from their GP or from the medical records held by the relevant hospital at the time of death.

Statistical analysis. Survival analysis was performed using life-table analysis as detailed by Armitage, Berry and Matthews,¹⁶ using SPSS version 11 (SPSS Inc., Chicago, Illinois). Asymmetrical binomial confidence limits as described by Rothman¹⁷ were calculated using the effective number at risk, as indicated by Murray, Carr and Bulstrode.¹⁸ The end-point was defined as a revision to remove the original components. Additionally, revisions were subdivided into four groups depending on whether the procedure was undertaken for aseptic loosening, infection, recurrent dislocation or peri-prosthetic fracture.

Cox's proportional hazard model¹⁹ was used to determine whether the risk of requiring revision surgery was related to age, gender, diagnosis (OA and RA only) or the side of operation. The null hypothesis was that these co-variables were not related to revision. Deaths without revision were treated as censored data (with censoring the date of death). Hazard ratios and the corresponding 95% confidence intervals (CI) were reported. Binomial logistic regression was used to determine whether patients lost to follow-up were different from those who had a revision and from those who were not lost to follow-up in terms of age, gender, indication for surgery and the side of operation. Statistical significance was set at a p-value ≤ 0.05 .

Table I. Indications for revision at ten years

Indication for revision	Number of revisions (%)
Aseptic loosening	33 (53.2)
Infection	14 (22.6)
Recurrent dislocation	9 (14.5)
Peri-prosthetic fracture	3 (4.8)
Unknown	3 (4.8)
Total	62 (100.0)

Results

Response rate and patient's assessment (Fig. 1). At ten years, the outcome was known for 1001 (83.5%) THRs and unknown for 197 (16.5%). For those patients in whom the outcome was known, 586 were alive and 415 had died. Of the THRs in whom the outcome was unknown, 42 had died, 57 had moved from their primary residence at the time of their surgery, four were in nursing homes and too unwell to respond to the questionnaire, four expressed their wish not to be contacted and 90 did not reply. Of the 586 alive at ten years, 485 responded to the questionnaire.

Patient satisfaction. At ten years, 439 of 485 (90.5%) respondents to the questionnaire indicated that they were pleased with the outcome of their THR. Nine (1.9%) were dissatisfied, mostly due to persistent pain, five (1%) were not sure and 32 (6.6%) did not respond to the question.

Revisions. By ten years, the recipients of 62 Charnley THRs (6.2%) had documented revision surgery. In 23, both components had been revised, in nine only the acetabular component, in 13 only the femoral component, in 12 an excision arthroplasty had been performed and in five the outcome was unknown. Aseptic loosening was the most common indication for revision followed by infection and recurrent dislocation (Table I).

Survival analysis. The survival rate at ten years for the Charnley THRs entered on the Trent regional arthroplasty

Fig. 2

Ten-year survival curve including 95% confidence intervals with revision for all causes as the end-point.

register in 1990 was 93.1% (95% CI, 91.2 to 94.6), using revision for all causes of failure as the end-point (Table II, Fig. 2). The survival rates at ten years for specific indications for revision were: 95.8% (95% CI, 94.2 to 97.0) for aseptic loosening (Table III); 98.7% (95% CI, 97.6 to 99.3) for infection; 99.1% (95% CI, 98.2 to 99.6) for recurrent dislocation; and 99.7% (95% CI, 99.0 to 99.9) for peri-prosthetic fracture.

Predictive factors for revision. Using Cox's regression analysis patients known to have had a revision were compared with those who had not. There was a significant difference between the gender of the patients (hazard ratio 2.21, 95% CI 1.28 to 3.84, $p < 0.01$). Male patients were more likely to have had a revision. However, the likelihood of revision was not influenced by age (hazard ratio 1.00, 95% CI 0.97

Table II. Life-table for survival of the Charnley total hip replacement (THR), Trent regional arthroplasty register 1990 with revision for all causes as the end-point

Years since operation	Number at start	Number revised	Withdrawn	Lost to follow-up*	Number at risk	Effective number at risk	Annual failure rate (%)	Annual success rate (%)	Survival rate (%)	95% confidence interval
0 to 1	1198	11	49	11	1173.5	1173.5	0.9	99.1	99.1	98.3 to 99.5
1 to 2	1138	5	42	8	1117.0	1144.6	0.4	99.6	98.6	97.8 to 99.2
2 to 3	1091	7	29	2	1076.5	1120.9	0.7	99.3	98.0	97.0 to 98.7
3 to 4	1055	8	37	6	1036.5	1098.6	0.8	99.2	97.2	96.1 to 98.0
4 to 5	1010	3	96	43	962.0	1068.2	0.3	99.7	96.9	95.7 to 97.8
5 to 6	911	5	174	113†	824.0	1017.9	0.6	99.4	96.3	95.0 to 97.3
6 to 7	732	4	53	13	705.5	957.4	0.6	99.4	95.8	94.3 to 96.9
7 to 8	675	1	33	0	658.5	906.0	0.2	99.8	95.6	94.1 to 96.8
8 to 9	641	8	37	0	622.5	862.3	1.3	98.7	94.4	92.7 to 95.8
9 to 10	596	8	28	1	582.0	822.7	1.4	98.6	93.1	91.2 to 94.6
10 to 11	560	2	272	0	424.0	757.9	0.5	99.5	92.7	90.6 to 94.3
11 to 12	286	0	286	0	143.0	558.0	0.0	100.0	92.7	90.2 to 94.6

* patients lost to follow-up in the year of their surgery. The number of patients lost to follow-up in each interval is included in the 'withdrawn' column

† this large number at five to six years relates to the withdrawal of all patients who died and those who were still alive between five and ten years for whom the status of the THR was not known at ten years

Table III. Life-table for survival of the Charnley total hip replacement (THR), Trent regional arthroplasty register 1990 with revision for aseptic loosening as the end-point

Years since operation	Number at start	Number revised	Withdrawn	Lost to follow-up*	Number at risk	Effective number at risk	Annual failure rate (%)	Annual success rate (%)	Survival rate (%)	95% confidence interval
0 to 1	1198	2	58	11	1169	1169.0	0.2	99.8	99.8	99.4 to 100.0
1 to 2	1138	1	46	8	1115	1141.4	0.1	99.9	99.7	99.2 to 99.9
2 to 3	1091	3	33	2	1074.5	1118.2	0.3	99.7	99.5	98.8 to 99.8
3 to 4	1055	4	41	6	1034.5	1096.0	0.4	99.6	99.1	98.2 to 99.5
4 to 5	1010	1	98	43	961.0	1066.1	0.1	99.9	99.0	98.2 to 99.4
5 to 6	911	4	175	113†	823.5	1016.2	0.5	99.5	98.5	97.5 to 99.1
6 to 7	732	4	53	13	705.5	956.0	0.6	99.4	97.9	96.8 to 98.7
7 to 8	675	1	33	0	658.5	904.9	0.2	99.8	97.8	96.6 to 98.6
8 to 9	641	5	40	0	621.0	861.2	0.8	99.2	97.0	95.6 to 97.9
9 to 10	596	7	29	1	581.5	821.7	1.2	98.8	95.8	94.2 to 97.0
10 to 11	560	1	273	0	423.5	757.0	0.2	99.8	95.6	93.9 to 96.8
11 to 12	286	0	286	0	143.0	557.5	0.0	100.0	95.6	93.6 to 97.0

* patients lost to follow-up in the year of their surgery. The number of patients lost to follow-up in each interval is included in the 'withdrawn' column

† this large number at five to six years relates to the withdrawal of all patients who died and those who were still alive between five and ten years for whom the status of the THR was not known at ten years

Fig. 3

The breakdown of the series and the outcome data available for gross radiological failure at five years.

to 1.03, $p = 0.93$), the indication for the initial surgery (hazard ratio 3.33, 95% CI 0.45 to 24.5, $p = 0.24$) or the side of operation (hazard ratio 1.04, 95% CI 0.60 to 1.80, $p = 0.88$).

Loss to follow-up. There were 197 (16.5%) hips lost to follow-up at ten years. Using binomial logistic regression analysis, there was no statistically significant difference between those lost to follow-up and those not lost in relation to age (odds ratio (OR) 1.0, $p = 0.06$), gender (OR 0.8, $p = 0.14$), the indications for initial surgery (OR 0.8 to 1.6, $p = 0.5$ to 0.6) and the side of operation (OR 1.1, $p = 0.47$).

Patients who were lost to follow-up were also compared with those who had revision surgery (62). Using binomial logistic regression analysis, there were significantly more women in those lost to follow-up (67%) compared with those who had revision surgery (40%); OR 0.37, $p = 0.001$. There was also a significant difference between these groups in relation to age (OR 1.0, $p = 0.04$). However, there was no significant difference with respect to the indications for initial surgery (OR 1.1 to 3.7, $p = 0.31$ to 0.95) or the side of operation (OR 0.96, $p = 0.90$).

Radiological failure at five years. Fender et al,¹⁵ during their clinical review of this series of patients at five years, highlighted the finding of gross radiological failure which had been previously unrecognised in 25 of 480 (5.2%) THRs which had clinical and radiological reviews. This group comprised 12 women and 13 men with a mean age of 68.4 years (22 to 82) at the time of surgery. At ten years, 23 were still alive. The outcome was unknown in seven (28%) (Fig. 3). Of the nine of these 25 patients who had not had revision and who responded to the questionnaire (four women and five men with a mean age of 78 years (58 to 79) at the time of surgery), six confirmed that they were satisfied with the outcome and three said that they were not. This series of 25 patients is the subject of a current review to assess the relationship between the causes of failure, the characteristics of the patient, the radiological features of failure at five years and the clinical outcome at ten years.

Discussion

The Charnley cemented THR is one of the most commonly-used hip prostheses. It is considered by many as the implant

of choice, especially for older patients but most long-term reports have emanated from specialist units.^{3,7,13,20} Our revision rate of 6.2%, cumulative survival rate for revision (all causes) of 93.1%, and cumulative survival rate for revision for aseptic loosening of 95.8% at ten years, are comparable to these findings and also those from the Swedish and Norwegian joint registries.^{1,21} However, our study reflects a cross-section of orthopaedic practice in the United Kingdom.

Aseptic loosening is a major complication and a frequent indication for revision. Certain aspects of the surgical technique are thought to contribute to its incidence.²²⁻²⁴ Numerous reports have attempted to identify and to quantify the predictive parameters for aseptic loosening,²⁵⁻²⁷ but there are few studies on the long-term outcome of this complication, especially in those patients in whom THR failed but who did not undergo revision.

In our study we identified that a significant number of patients in whom there was gross radiological failure at five years did not undergo revision. Most of those who responded to the questionnaire and did not have a revision were still satisfied with the outcome at ten years. It is worth emphasising that not all radiologically loose implants require urgent revision. Patients may remain asymptomatic, thus making it difficult to convince them to have major surgery when they do not perceive that they have a problem. Reliance on a register alone may lead to a delay in identifying radiological failure and any implants with inferior performance. Therefore, regular clinical and radiological review is of paramount importance and should remain standard practice.

Our study had a rate of loss to follow-up of 16.5%. Of these patients, 78.7% (155 of 197) were still alive at the time of the study. They did not participate either because they had moved, were too ill to respond, or did not wish to be contacted or to participate in the study. In 42 patients (21.3%) who had died at ten years and were lost to follow-up, failure was due to lack of cooperation of the 13 health authorities, the related hospitals and their GPs. No significant difference was found between those lost to follow-up and the study group with respect to age, gender, the indication for initial surgery and the side of operation. These findings also held true for patients who had undergone revision, whether they were lost to follow-up or continued in the study group.

There is no evidence to suggest that the outcome of the patients who were lost to follow-up should be any different from those enrolled in the study. This assumption is supported by the findings of other reports.^{18,28,29} The percentage who were lost to follow-up is comparable to that of other studies.^{20,30,31}

Our study lacked objective clinical and radiological assessment but our main aim was to assess the survival of the Charnley THR at ten years with revision as the end-point. To conduct an extensive clinical and radiological assessment of this series of patients would require large

resources of manpower and finance which are unavailable. When the Trent regional arthroplasty register was first established in 1990 a validated hip scoring system was not in use, making a current functional outcome assessment of the corresponding patients invalid. Similarly, the body mass index was not calculated when the study commenced.

This is the first study in the United Kingdom to assess independently the outcome of the primary Charnley THR across a single health region at ten years. The study concerns more than 1000 consecutive patients who had undergone THR over a period of one year. No patients were concealed in this study since the Trent registry employed a clerk who visited all the hospitals and personally checked theatre logbooks for all THRs carried out during 1990. The patients were unselected and the operations were performed by a wide spectrum of orthopaedic surgeons. The finding of a survival rate of 93.1% between nine and ten years with a narrow 95% CI (91.2 to 94.6) and the outcome data on 596 hip replacements at this ten-year interval makes this a viable study.

Supplementary Material

A further opinion by Mr Alistair Ross is available with the electronic version of this article on our website at www.jbjs.org.uk

The authors acknowledge the procedural support of Mrs. E. James, Orthopaedic Principal Clerk at Glenfield Hospital, Leicester.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

1. Havelin LI, Engesaeter LB, Espehaug B, et al. The Norwegian Arthroplasty Register: 11 years and 73,000 arthroplasties. *Acta Orthop Scand* 2000;71:337-53.
2. Herberts P, Malchau H. Long-term registration has improved the quality of hip replacement: a review of the Swedish THR Register comparing 160,000 cases. *Acta Orthop Scand* 2000;71:111-21.
3. Aamodt A, Nordsletten L, Havelin LI, et al. Documentation of hip prostheses used in Norway: a critical review of the literature from 1996-2000. *Acta Orthop Scand* 2004;75:663-76.
4. Bulstrode CJ. Keeping up with orthopaedic epidemics. *Br Med J (Clin Res Ed)* 1987;295:514.
5. Wroblewski BM, Siney PD. Charnley low-friction arthroplasty of the hip: long term results. *Clin Orthop* 1993;292:191-201.
6. Brady LP, McCutchen JW. A ten-year follow-up study of 170 Charnley total hip arthroplasties. *Clin Orthop* 1986;211:51-4.
7. Older J. Low-friction arthroplasty of the hip: a 10-12 year follow-up study. *Clin Orthop* 1986;211:36-42.
8. Effekhar NS. Long-term results of cemented total hip arthroplasty. *Clin Orthop* 1987;225:207-17.
9. Garellick G, Herberts P, Stromberg C, Malchau H. Long-term results of Charnley arthroplasty: a 12-16 year follow-up study. *J Arthroplasty* 1994;9:333-40.
10. Salvati EA, Wilson PD Jr, Jolley MN, et al. A ten-year follow-up study of our first one hundred consecutive Charnley total hip replacements. *J Bone Joint Surg [Am]* 1981;63-A:753-67.
11. Schulte KR, Callaghan JJ, Kelley SS, Johnston RC. The outcome of Charnley total hip arthroplasty with cement after a minimum twenty-year follow-up: the results of one surgeon. *J Bone Joint Surg [Am]* 1993;75-A:961-75.
12. Wroblewski BM. 15-21 year results of the Charnley low friction arthroplasty. *Clin Orthop* 1986;211:30-5.
13. Lehtimäki MY, Lehto MU, Kautiainen H, et al. Survivorship of the Charnley total hip arthroplasty in juvenile chronic arthritis: a follow-up of 186 cases for 22 years. *J Bone Joint Surg [Br]* 1997;79-B:792-5.

14. **Fender D, Harper WM, Gregg PJ.** The Trent regional arthroplasty study: experiences with a hip register. *J Bone Joint Surg [Br]* 2000;82-B:944-7.
15. **Fender D, Harper WM, Gregg PJ.** Outcome of Charnley total hip replacement across a single health region in England: the results at five years from a regional hip register. *J Bone Joint Surg [Br]* 1999;81-B:577-81.
16. **Armitage P, Berry G, Matthews JNS.** *Statistical methods in medical research.* Fourth ed. Oxford: Blackwell Science, 2002.
17. **Rothman K.** Estimation of confidence limits for the cumulative probability of survival in life table analysis. *J Chron Dis* 1978;31:557-60.
18. **Murray DW, Carr AJ, Bulstrode C.** Survival analysis of joint replacements. *J Bone Joint Surg [Br]* 1993;75-B:697-704.
19. **Cox DR, Oakes D.** *Analysis of survival data.* London: Chapman & Hall, 1984.
20. **Wroblewski BM, Siney PD, Fleming PA.** Charnley low-frictional torque arthroplasty in patients under the age of 51 years: follow-up to 33 years. *J Bone Joint Surg [Br]* 2002;84-B:540-3.
21. **Garellick G, Malchau H, Herberts P.** Survival of hip replacements: a comparison of a randomized trial and a registry. *Clin Orthop* 2000;375:157-67.
22. **Barrack RL, Mulroy RD Jr, Harris WH.** Improved cementing techniques and femoral component loosening in young patients with hip arthroplasties: a 12-year radiographic review. *J Bone Joint Surg [Br]* 1992;74-B:385-9.
23. **Ebrahimzadeh E, Sarmiento A, McKellop HA, Llinas A, Gogan W.** The cement mantle in total hip arthroplasty: analysis of long-term radiographic results. *J Bone Joint Surg [Am]* 1994;76-A:77-87.
24. **Beckenaugh RD, Ilstrup DM.** Total hip arthroplasty. *J Bone Joint Surg [Am]* 1978;60-A:306-13.
25. **Chambers IR, Fender D, McCaskie AW, Reeves BC, Gregg PJ.** Radiological features predictive of aseptic loosening in cemented Charnley femoral stems. *J Bone Joint Surg [Br]* 2001;83-B:838-42.
26. **Ritter MA, Zhou H, Keating CM, et al.** Radiological factors influencing femoral and acetabular failure in cemented Charnley total hip arthroplasties. *J Bone Joint Surg [Br]* 1999;81-B:982-6.
27. **Star MJ, Colwell CW Jr, Kelman GJ, Ballock RT, Walker RH.** Suboptimal (thin) distal cement mantle thickness as a contributory factor in total hip arthroplasty femoral component failure: a retrospective radiographic analysis favoring distal stem centralization. *J Arthroplasty* 1994;2:143-9.
28. **Dorey F, Amstutz HC.** The validity of survivorship analysis in total joint arthroplasty. *J Bone Joint Surg [Am]* 1989;71-A:544-8.
29. **Austin MA, Berreysesa S, Elliott JL, et al.** Methods for determining long-term survival in a population based study. *Am J Epidemiol* 1979;110:747-52.
30. **Callaghan JJ, Albright JC, Goetz DD, Olejniczak JP, Johnston RC.** Charnley total hip arthroplasty with cement: minimum twenty-five-year follow-up. *J Bone Joint Surg [Am]* 2000;82-A:487-97.
31. **Soto MO, Rodriguez JA, Ranawat CS.** Clinical and radiographic evaluation of the Harris-Galante cup: incidence of wear and osteolysis at 7 to 9 years follow-up. *J Arthroplasty* 2000;15:139-45.