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High Survivorship of Cemented Sockets with Roof Graft for Severe Acetabular Dysplasia

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Abstract

Background Socket fixation in patients with acetabular dysplasia can be technically demanding but the use of structural grafts can help to reconstruct the original center of hip rotation. Because reported survival rates differ, construct survival seems to depend on the technique of graft preparation and fixation.

Questions/purposes What is the survivorship of cemented sockets with acetabular roof graft in patients with severe acetabular dysplasia? Do clinical scores equal those of patients without acetabular grafting?

Methods We retrospectively reviewed 62 patients (74 hips) who had undergone cemented THA with acetabular roof graft. Mean age at surgery was 45 years (range,

19–71 years). Revisions and radiographic failures were determined and clinical scores (Oxford, SF-12) were obtained and matched to a control group. Kaplan-Meier analysis was used to determine survivorship at a minimum followup of 5 years (mean, 10.4 years; range, 5–16 years).

Results Survivorship for all-cause revision was 98% (95% CI, 92.5%–100.0%) at 10 years followup. Two hips were revised for aseptic acetabular loosening and one hip for polyethylene wear. All grafts incorporated and no additional radiographic loosening was seen. Patients with grafting had higher Oxford scores compared with the control group but other scores were equal.

Conclusions In contrast to reported series and the common use of cementless cups in patients with developmental dysplasia of the hip, we found high survivorship of cemented sockets with roof graft in severe acetabular dysplasia at a mean followup of more than 10 years. These patients showed higher Oxford scores than patients in a control group. This technique that restores bone stock is a reasonable solution for often young patients with dysplasia.

Level of Evidence Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent was obtained.

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Introduction

Restoration of the center of hip rotation in patients with developmental dysplasia of the hip (DDH) is advocated by most authors [35, 40, 50, 54] and this can be achieved in most patients using a standard hip implant without reconstruction of the deficient acetabulum. In more severe dysplastic cases, however, a deficient acetabulum may appear inadequate to support a standard implant. Several

options are available to reconstruct the deficient acetabulum. The technique of impaction bone grafting was introduced by Slooff et al. [47] and evaluation of this technique applied in young patients shows acceptable long-term survival rates of 77% at 25 years with revision for aseptic loosening as the end point [7]. In a series of 84 patients younger than 40 years at the time of surgery, 10-year survival of acetabular reconstruction using impaction bone grafting was 95% with revision for aseptic loosening [13]. In 28 acetabular reconstructions in 22 patients with primary diagnosis DDH [48], survivorship of 84% was reported at 15 years with revision for any reason as the end point. Impaction bone grafting of acetabular defects has developed as a proven technique with high long-term survival rates, but other options like the use of solid grafts are also available. Cementless cups are the preferred technique today by most surgeons and several studies evaluated the survival of acetabular bulk grafting with cementless THA [2, 14, 19, 22, 24, 31, 38, 43, 46, 49]. However, few studies are available with a mean followup of 10 years or longer [23, 31, 44]. Hendrich and Mehling [23] presented a series of patients with DDH (56 hips) with a survival rate of 91.6% at 11 years but substantial socket migration was observed in 19 hips. Kim and Kadowaki [31] showed 94% survival at 10 years in a series of 83 hips. Shetty et al. [44] reported in a series of 15 cases that no revisions were necessary at 10 years of followup but observed resorption of the graft in five of 15 cases. Solid grafts with a cemented socket are less widely used and some early reports showed increase of failure rates at longer followup [34, 39, 45]. Mulroy and Harris [39] reported a decline of survival in time with failure of 46% at 11.8 years. Shinar and Harris [45] presented a total rate of loosened or revised cups of 60% after a followup of more than 16 years in a series of 81 cases of bulk grafts with cemented THA. Despite these discouraging results, long-term studies with a mean followup of 10 years or longer and high survival of bulk grafts and cemented THA have been reported [1, 4, 12, 27, 28, 33, 50]. Kobayashi et al. [33] presented a series of 37 reconstructions using bulk grafts and cemented THA without any reoperations at a mean followup of 19 years. Survival of acetabular bulk grafts seems to depend on the technique applied and younger age is related to lower survival of THA [32, 42].

To address the controversy in choice of treatment for patients with DDH, we therefore (1) determined the survival of roof grafts with a cemented THA; (2) evaluated survivorship of roof grafts in patients younger versus older than 50 years at the time of surgery; (3) determined radiographic failures and complications; and (4) compared the clinical scores of patients with roof grafting with those of a matched control group of patients with nondysplastic hips and, if possible, identify predictors of the scores.

Patients and Methods

We performed a retrospective, observational study by identifying all 62 patients (74 hips) with DDH from the prospective database at our institute who underwent a cemented THA in combination with an acetabular autogenous bulk roof graft from 1995 to 2006. During that time we performed more than 900 primary THAs each year. The indication for THA with a roof graft was painful secondary osteoarthritis of the hip with a deficient acetabular roof of 20% or more. The contraindication was acetabular roof deficiencies of less than 20%. We excluded all patients who had no acetabular augmentation or required acetabular reconstruction using additional impaction bone grafting. Twenty-four hips had previous hip surgery. The study group consisted of 57 female patients (67 hips) and five male patients (seven hips) with a mean age at surgery of 45 years (range, 19–71 years). Three patients were lost to followup, leaving 59 patients for study. Three patients (three hips) died 1, 6, and 12 years after surgery of causes unrelated to the surgery but their data were included in the survival analyses. The minimum followup was 5 years (mean, 10.4 years; range, 5–16 years). No patients were recalled specifically for this study; all data were obtained from medical records, radiographs, and questionnaires.

The study cohort was younger with a predominance when compared with the control group (Table 1). The control group, however, had a greater level of comorbidity (Table 1).

Preoperative radiographic documentation was complete for 50 hips and was reviewed by two of the authors separately (VB, SJB). DDH was graded in a blinded fashion according to the Crowe classification [10], the system of Hartofilakidis et al. [22], and the Edinburgh classification [19] (Table 2), which additionally identifies problems the surgeon might encounter during reconstruction (eg, retained hardware) and distinguishes concerns on the acetabular and femoral sides.

A posterolateral approach without trochanteric osteotomy was used in all cases. If, based on preoperative radiographs, the original center of hip rotation needed to be restored or in case of a deficient roof of more than 20% during surgery, an anterosuperior solid graft was used for reconstruction. A wedge of the femoral head was taken and fixed with two cancellous screws with its sclerotic concave side toward the defect as an inlay graft (Fig. 1). Further reaming of the inferior part of the graft was performed to create the optimal space for insertion of a standard cemented Contemporary or Exeter low-profile, all-polyethylene cup (Stryker, Newbury, UK) (Fig. 2). This technique creates a relatively small acetabular bulk autograft, which is supported by host bone. A femoral shortening osteotomy was necessary in 14 cases (Crowe III

Table 1. Details and clinical scores of study group and control group

Case-mix variables	Study group (n = 30)	Control group (n = 1312)	p value
Age (mean years, SD)	45.6 (10.9)	69.2 (9.7)	< 0.0001*
Sex (male/female)	1/29	553/759	< 0.0001†
Mean number comorbidities (SD)	0.8 (1.2)	1.9 (1.7)	0.002‡
Preoperative (SD)			
SF-12 PCS	Not available	31.1 (13.6)	
SF-12 MCS	Not available	50.8 (14.4)	
OHS	Not available	41.9 (8.2)	
Outcome measures			
Postoperative (SD)			
SF-12 PCS	48.2 (10.5)	44.8 (15.9)	0.09*
SF-12 MCS	52.5 (9.7)	54.0 (13.8)	0.39*
OHS	16.9 (5.3)	21.3 (9.2)	0.009‡
Satisfied (number, %)	30 (100)	1198 (91.3)	0.10

* Student's t-test; †chi square; ‡Mann Whitney U-test; PCS = physical component score; MCS = mental component score; OHS = Oxford hip score.

Table 2. Distribution of developmental dysplasia of the hip classifications according to Crowe, Hartofilakidis, and the Edinburgh classification systems

Crowe	Percent	Hartofilakidis	Percent	Edinburgh system			
				A	Percent	F	Percent
1	16	A	14	A1	14	F1	16
2	56	B	72	A2	70	F2	54
3	22	C	14	A3	16	F3	30
4	6						

and IV) to facilitate restoration of the original center of hip rotation. An Exeter stem (Stryker) was inserted using modern cementing techniques. All patients received systemic prophylactic antibiotics (1.5 g cefuroxime) before surgery.

Postoperatively, all patients had chemical thromboembolism prophylaxis for 6 weeks or 3 months after surgery. Patients were mobilized routinely and were allowed 50% weightbearing for 6 weeks after surgery and then mobilized full weightbearing. Our standard postoperative protocol includes clinical and radiographic review at 6 weeks, 3 months, and 1 year after surgery. After the first year, review took place on a regular base or on indication decided by the consultant.

Postoperative radiographic documentation was complete of 49 surviving hips in living patients at followup times ranging from 2.5 to 15.3 years. One of us (VB) assessed structural quality and consolidation of the roof graft, interface radiolucencies and osteolysis, prosthesis migration, socket tilting, heterotopic ossification, and wear. Graft incorporation was defined as the manifestation of a regular

Fig. 1A–C Schematic overview of graft insertion and reaming. (A) Graft is fixated with two cancellous lag screws with its sclerotic concave side toward the defect as an inlay graft. (B) Reaming of the graft to prepare for a cemented socket. (C) Final situation before cementation and insertion of the acetabular component.

radiodensity and trabecular bone structure throughout the graft and host bone with a continuous trabecular pattern according to Conn et al. [9]. Radiolucent lines more than 2 mm wide were described and were defined as stable or

Fig. 2 Situation after cementation of the acetabular component with supporting graft and restoration of original center of hip rotation.

progressive in time. Acetabular zones were identified using the criteria of DeLee and Charnley [14] and radiographic failure was defined as radiolucent lines in all three zones and/or migration of 5 mm or more in any direction on the AP pelvic view relative to the interteardrop line. Linear wear was measured as described by Livermore et al. [36]. Radiolucent zones on the femoral side were evaluated using the method of Gruen et al. [20]. Loosening of the femoral component was defined using the criteria of Harris et al. [21]. Definite loosening of the stem was defined as the appearance of a radiolucent line in all Gruen zones that did not exist on the immediate postoperative radiographs, a crack in the cement, or fracture of the stem. Femoral prosthetic subsidence was considered abnormal if it was more than 2 mm [37].

For the purpose of this study, patients were sent a questionnaire and were asked to complete the Oxford hip score [11], the SF-12 [52], the EQ5-D [5], and visual analog scale scores for pain [26]. The obtained information was combined with data available from the records. Complications were recorded according to the classification of Dindo et al. [16].

Kaplan-Meier survivorship analysis [30] was performed for the entire study cohort and additionally for patients who were 50 years or younger at the time of surgery versus patients who were older than 50 years. End points used were revision of one or both components for any reason and revision for aseptic loosening. A radiographic worst case scenario was included, in which the assumption was

made that the patients without a recent radiograph (16 hips) and the three patients (three hips) lost to followup had failed at least radiographically (total of 26%). Conventional worst case scenario survivorship was calculated comprising all known failures and those lost to clinical followup. Log-rank testing was used to compare survival rates of patients younger and older than 50 years.

The SF-12 and the Oxford hip scores for the study cohort were compared with a control group (Table 1). The control group consisted of patients undergoing a THA for primary osteoarthritis using conventional acetabular cementing techniques from a previously published study reporting the 1-year outcome according to the patient's socioeconomic status [8]. The prior study also included bilateral THA; for the purposes of this study, only the first THA was included for comparative analysis. Parametric and nonparametric tests were used as appropriate to assess continuous variables for significant differences between groups. An unpaired Student's *t*-test or a Mann-Whitney *U*-test was used to compare linear variables between groups. Dichotomous variables were assessed using a chi square test. All case-mix variables (age, sex, number of comorbidities, preoperative SF-12 mental component scores [MCS] and physical component scores [PCS], and the Oxford hip score) were entered into a multivariable linear regression model, using enter methodology, to assess the independent effect of the groups on outcome (SF-12 MCS and PCS and the Oxford hip score). All case-mix variables and postoperative SF-12 MCS and PCS and the Oxford hip score were entered into a multivariable binary logistic regression model using enter methodology to assess the independent effect of the groups on satisfaction. We presumed an improvement greater than 3 points in the Oxford hip score would be clinically important. Statistical analysis was performed using Statistical Package for Social Sciences Version 17.0 (SPSS Inc, Chicago, IL, USA).

Results

All-cause survivorship was 98% (95% CI, 93%–100%) at 10 years (Fig. 3). Thirty-seven hips were still at risk at 10 years of followup and all patients with a minimal followup of 5 years were included in the study. The conventional worst case scenario, assuming that all patients lost to followup were revised, showed a 10-year survival rate of 93% (95% CI, 91%–96%). Radiographic worst case scenario analysis (assuming all patients with no radiographic followup as a radiographic failure) predicted a survivorship of 83% (95% CI, 69%–97%) at 10 years followup. Three hips had been revised, two hips for aseptic loosening of the cup at 7.9 and 17.4 years after the index operation. One hip was revised after 12.4 years because of

Fig. 3 A Kaplan-Meier curve showing survivorship with revision for all reasons as the end point.

Fig. 4 A Kaplan-Meier curve showing survivorship for patients 50 years or younger (blue) compared with those older than 50 years old (green) with revision for all reasons as the end point.

wear and instability. No stem revisions were performed. At the time of subsequent revision, the grafts had integrated into the acetabular roof in all hips, as suggested by bleeding bone within the graft; the graft fixation screws were removed at the time of revision.

Separate analysis of patients 50 years old or younger demonstrated a survivorship rate of 93% at 10 years (Fig. 4), which was similar to ($p = 0.56$) the survival of patients older than 50 years.

Of the 47 surviving hips in living patients with complete radiographic followup, all grafts showed bony incorporation (Fig. 5A–C). Acetabular radiolucent lines were seen in 14 hips (30%), all in Zone 3. Osteoporosis was present in seven hips around the screws not adjacent to the acetabular

Fig. 5A–C (A) Preoperative radiograph of a 55-year-old woman with bilateral DDH, classified as a Crowe III, Hartofilakidis C, and Edinburgh system A2 F3. (B) Postoperative radiograph showing bilateral reconstruction using roof grafts and a cemented Exeter THA after femoral shortening osteotomy. (C) Radiograph 15 years after the reconstruction showing incorporation of the roof grafts without evidence of loosening or resorption of the graft but signs of wear.

component and was nonprogressive. Two hips showed osteolysis in Zone 1. None of the hips showed migration. The mean linear wear measured 0.07 mm per year

Table 3. Results of multivariable binary logistic regression model

Outcome	B	95% CI	p value	R ²
SF-12 PCS	−0.47	−4.2 to 3.3	0.81	0.15*
SF-12 MCS	−2.30	−9.1 to 4.5	0.51	0.10*
OHS	−1.3	−7.3 to 4.7	0.67	0.04*
Satisfaction	0.00005	–	0.99	0.38†

* Linear regression analysis; †binary logistic regression analysis; PCS = physical component score; MCS = mental component score; OHS = Oxford hip score.

(range, 0–0.27 mm). None of the femoral components migrated more than 2 mm. A progressive radiolucent line was seen in one hip in Gruen Zone 1; none of the femoral components had evidence of radiographic loosening. One femur had delayed union after shortening osteotomy but clinical symptoms were absent (Grade I according to Dindo et al). One patient sustained incomplete femoral nerve palsy but had a full recovery (Grade I). Two patients were diagnosed with a pulmonary embolism and one patient with postoperative deep vein thrombosis (Grade II). All were treated successfully with warfarin. One patient had three dislocations 2 years after surgery and closed reduction was successful without damage to the acetabular reconstruction (Grade IIIB). Revision was not necessary.

Patients who had reconstruction using a roof graft had better ($p = 0.009$) Oxford hip scores. SF-12 PCS and SF-12 MCS were similar ($p = 0.09$ and $p = 0.39$, respectively). Adjusting for confounding case-mix variables, roof grafting was not an independent predictor of outcome, although there was a trend toward a better outcome and greater satisfaction in the study cohort (Table 3). The median postoperative EQ-5D score was 89.5 for the study group. The EQ-5D score was not available for the control group.

Discussion

Structural grafts have been used in patients with more severe dysplasia to reconstruct the original center of hip rotation. However, the reported survival rates differ considerably. We presume construct survival depends in part on the techniques used for graft preparation and fixation. To address the conflicting survival rates, we (1) determined the survival of roof grafts with a cemented THA; (2) evaluated survivorship of roof grafts in patients younger versus older than 50 years at the time of surgery; (3) determined radiographic failures and complications; and (4) compared the clinical scores of patients with roof grafts with those of a matched control group of patients with nondysplastic hips and if possible identified predictors of the scores.

Our study was associated with a number of limitations. First, 19 of the 74 hips did not have radiographs at final review. However, they were included in a worst case scenario analysis with a potential radiographic failure rate of 17% at a mean followup of 10 years. Second, only one of us observed the postoperative radiographs at final review so we cannot provide any data on interobserver variability. Definite radiographic loosening however is expected to cause problems in young patients and the radiographic data do not jeopardize the presented data on revisions and survival rates. Third, we have not measured the level of activity of our patients, which might have influenced the survivorship and clinical scores. Because survivorship of THA seems to be related to activity of patients by means of accelerated wear and osteolysis [42], it would be worthwhile including an activity score in our questionnaire in the future. Fourth, the present study has a retrospective design with a limited number of patients. However, this is the best evidence available at the moment and we have included all patients available with a minimal followup of 5 years or longer at our institute.

All-cause survivorship was 98% at 10 years followup, which is comparable to other reported series on patients with DDH that show high survival of bulk acetabular grafts with a mean followup of 10 or more years (Table 4). Although high failure rates have been reported using bulk grafts with cemented THA [34, 39, 45], we would like to confirm previous studies [1, 4, 12, 18, 27, 28, 33, 50, 51] that high survival rates can be obtained using solid grafts with cemented THA. Comparison of grafting (32 cases) versus nongrafting (48 cases) of severe acetabular defects in a series of 64 patients showed higher survival rates of grafted cases [18]. Solid grafts to reconstruct acetabular defects of more than 20% is the philosophy at our institute. Bulk grafts in combination with uncemented THA remain controversial. Several early reports [2, 24, 29, 38, 43, 46, 49] show high survival rates but series with longer followup are scarce [23, 31, 44]. Shetty et al. [44] reported in a series of 15 cases that no revisions were necessary at 10 years of followup but observed resorption of the graft in five of 15 cases, a finding that was not present in our series.

Survival of THA in young patients is lower than survival of THA in older patients, presumably because of their higher demands on their prosthesis [32, 42], although we acknowledge the fact that age by itself should be interpreted cautiously in young patients because activity levels may differ between patients, also in time [17]. Unfortunately, we have not assessed activity in the present study so we made subgroups of patients younger and older than 50 years old at the time of surgery. We could not detect a difference in survival between these two groups, possibly because of the small number of revisions in the present series. Longer followup is needed to confirm this hypothesis.

Table 4. Overview of literature[‡] of acetabular bulk grafts in patients with DDH with a mean followup of 10 years or longer

Author	Number of hips	Number of patients	Mean age in years (range)	Type of fixation	Mean followup in years (range)	Survivorship revision for aseptic loosening/radiographic loosening
Akiyama et al. [1]	147	119	56 (38–76)	Cemented	11.8 (6–15)	96%/91% at 15 years
Bobak et al. [4]	45	41	46 (25–73)	Cemented	11 (10–15)	100%/88% at 11 years
Hendrich and Mehling [23]	56	47	50.4	Cementless	10.2	91.6%/88.9% at 11 years
Iida et al. [27]	133	112	53 (33–72)	Cemented	12.3 (8–24)	96%/83% at 15 years
Inao and Matsuno [28]	20	18	48 (20–66)	Cemented	12.9 (10–18)	100%/85% at 12.9 years
De Jong et al. [12]	116	102	64.4 (35–84)	Cemented	17.6 (11–26)	85%/82% at 15 years*
Lee et al. [34] [†]	102	95	51 (21–78)	Cemented	10.2 (4–18)	65%/62% at 12 years
Kim and Kadowaki [31]	83	70	57 (33–72)	Cementless	11 (9–14)	94%/97% at 10 years*
Kobayashi et al. [33]	37	30	57 (48–73)	Cemented	19 (10–26)	100%/100% at 19 years
Mulroy and Harris [39]	46	37	46.5 (14–69)	Cemented	11.8 (10–16)	80%/54% at 11.8 years
Rodriguez et al. [41]	29	23	49 (20–78)	Cemented	11 (7–17)	80% at 15 years/60% at 15 years
Shetty et al. [44]	15	15	59 (20–85)	Cementless	10 (8–11)	100%/100% at 10 years
Shinar and Harris [45]	81	73	45.2 (16–69)	Cemented	16.5 (14–21)	65%/40% at 16.5 years*
Stringa et al. [51]	21	19	51 (22–68)	Cemented	10 (5–14)	100%/85% at 10 years
Current study	74	48	45 (19–71)	Cemented	10.3 (5–16)	98%/98% at 10 years

* Survivorship with revision for any reason as the end point; [†]series of patients with different diagnosis; 57% had DDH; survival shown of primary THA in patients with DDH patients; [‡]literature reported until September 2011; DDH = developmental dysplasia of the hip.

Radiographic results of the present series compare favorably with reported series (Table 4) and we have included a worst case scenario showing 83% survival at 10 years assuming that all hips without a recent radiograph had failed. We did not observe extensive acetabular osteolysis with cemented socket fixation, which is a well-reported observation around cementless cups [6, 15]. The use of an all-polyethylene cup enables the use of thicker polyethylene in these patients who all have small acetabula; this may further reduce the incidence of polyethylene wear. Wear-induced osteolysis increases the risk of failure and compromises bone stock for future revision surgery.

The improvement in patient-reported scores in the study group of patients with dysplastic hips and roof graft reconstruction compares favorably with our control group of patients with primary cemented THA with a difference in Oxford scores. An explanation might be that the amount of improvement is higher in reconstructed patients. Unfortunately, preoperative scores are not available because of the retrospective design of this study.

The treatment protocol at the Royal Infirmary in Edinburgh for dysplastic hips consists of reconstruction of a deficient acetabular roof of more than 20% using a solid graft from the femoral head with a cemented THA. Our data suggest this is a biologically reasonable approach, resulting in restoration of bone stock in these relatively young patients. Although some authors recommend avoiding structural bone graft if possible [29], bulk grafts for reconstruction of acetabular defects provide additional

value for future revisions [3]. The technique was originally described by Wolfgang [53], has been further described by Iida et al. [27], and has been performed in the same way throughout this study. In the early years, three cancellous screws were used for fixation but we believe two screws are sufficient. A femoral shortening osteotomy was necessary to restore the center of hip rotation in almost 20% of cases. Except for one delayed union of the femoral osteotomy in a patient without symptoms in the present series, the results of femoral osteotomy are good as reported previously [25]. We recommend the use of roof grafts with cemented THA in patients with DDH.

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References

1. Akiyama H, Kawanabe K, Iida H, Haile P, Goto K, Nakamura T. Long-term results of cemented total hip arthroplasty in developmental dysplasia with acetabular bulk bone grafts after improving operative techniques. *J Arthroplasty*. 2010;25:716–720.
2. Anderson MJ, Harris WH. Total hip arthroplasty with insertion of the acetabular component without cement in hips with total congenital dislocation or marked congenital dysplasia. *J Bone Joint Surg Am*. 1999;81:347–354.
3. Bal BS, Maurer T, Harris WH. Revision of the acetabular component without cement after a previous acetabular reconstruction with use of a bulk femoral head graft in patients who had congenital dislocation or dysplasia. A follow-up note. *J Bone Joint Surg Am*. 1999;81:1703–1706.

4. Bobak P, Wroblewski BM, Siney PD, Fleming PA, Hall R. Charnley low-friction arthroplasty with an autograft of the femoral head for developmental dysplasia of the hip. The 10- to 15-year results. *J Bone Joint Surg Br.* 2000;82:508–511.
5. Brooks R. EuroQol: the current stage of play. *Health Policy.* 1996;37:53–72.
6. Bruzzone M, La Russa M, Garzaro G, Ferro A, Rossi P, Castoldi F, Rossi R. Long-term results of cementless anatomic total hip replacement in dysplastic hips. *Chir Organi Mov.* 2009;93:131–136.
7. Busch VJ, Gardeniers JW, Verdonchot N, Slooff TJ, Schreurs BW. Acetabular reconstruction with impaction bone-grafting and a cemented cup in patients younger than fifty years old: a concise follow-up, at twenty to twenty-eight years, of a previous report. *J Bone Joint Surg Am.* 2011;93:367–371.
8. Clement ND, Muzammil A, MacDonald D, Howie CR, Biant LC. Socioeconomic status affects the early outcome of total hip replacement. *J Bone Joint Surg Br.* 2011;93:464–469.
9. Conn RA, Peterson LFA, Stuafter RN, Ilstrup D. Management of acetabular deficiency; long-term results of bone-grafting the acetabulum in total hip arthroplasty. *Orthop Trans.* 1985;9:451–452.
10. Crowe JF, Mani VJ, Ranawat CS. Total hip replacement in congenital dislocation and dysplasia of the hip. *J Bone Joint Surg Am.* 1979;61:15–23.
11. Dawson J, Fitzpatrick R, Carr A, Murray D. Questionnaire on the perceptions of patients about total hip replacement. *J Bone Joint Surg Br.* 1996;78:185–190.
12. De Jong de PT, Haverkamp D, van der Vis HM, Marti RK. Total hip replacement with a superolateral bone graft for osteoarthritis secondary to dysplasia: a long-term follow-up. *J Bone Joint Surg Br.* 2006;88:173–178.
13. De Kam DC, Gardeniers JW, Hendriks JC, Veth RP, Schreurs BW. Cemented polyethylene cups in patients younger than 40 years. *Clin Orthop Relat Res.* 2009;467:1753–1764.
14. DeLee JG, Charnley J. Radiological demarcation of cemented sockets in total hip replacement. *Clin Orthop Relat Res.* 1976; 121:20–32.
15. Della Valle CJ, Mesko NW, Quigley L, Rosenberg AG, Jacobs JJ, Galante JO. Primary total hip arthroplasty with a porous-coated acetabular component. A concise follow-up, at a minimum of twenty years, of previous reports. *J Bone Joint Surg Am.* 2009;91: 1130–1135.
16. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg.* 2004;240: 205–213.
17. Dorey FJ. Survivorship analysis of surgical treatment of the hip in young patients. *Clin Orthop Relat Res.* 2004;418:23–28.
18. García-Cimbrelo E, Munuera L. Low-friction arthroplasty in severe acetabular dysplasia. *J Arthroplasty.* 1993;8:459–469.
19. Gaston MS, Gaston P, Donaldson P, Howie CR. A new classification system for the adult dysplastic hip requiring total hip arthroplasty: a reliability study. *Hip Int.* 2009;19:96–101.
20. Gruen TA, McNeice GM, Amstutz HC. 'Modes of failure' of cemented stem-type femoral components: a radiographic analysis of loosening. *Clin Orthop Relat Res.* 1979;141:17–27.
21. Harris WH, McCarthy JC Jr, O'Neill DA. Femoral component loosening using contemporary techniques of femoral cement fixation. *J Bone Joint Surg Am.* 1982;64:1063–1067.
22. Hartofilakidis G, Stamos K, Karachalios T, Ioannidis TT, Zacharakis N. Congenital hip disease in adults. Classification of acetabular deficiencies and operative treatment with acetabuloplasty combined with total hip arthroplasty. *J Bone Joint Surg Am.* 1996;78:683–692.
23. Hendrich C, Mehling I. Cementless acetabular reconstruction and structural bone-grafting in dysplastic hips. *J Bone Joint Surg Am.* 2006;88:387–394.
24. Hintermann B, Morscher EW. Total hip replacement with solid autologous femoral head graft for hip dysplasia. *Arch Orthop Trauma Surg.* 1995;114:137–144.
25. Howie CR, Ohly NE, Miller B. Cemented total hip arthroplasty with subtrochanteric osteotomy in dysplastic hips. *Clin Orthop Relat Res.* 2010;468:3240–3247.
26. Huskisson EC. Measurement of pain. *Lancet.* 1974;9:1127–1131.
27. Iida H, Matsue Y, Kawanabe K, Okumura H, Yamamuro T, Nakamura T. Cemented total hip arthroplasty with acetabular bone graft for developmental dysplasia. Long-term results and survivorship analysis. *J Bone Joint Surg Br.* 2000;82:176–184.
28. Inao S, Matsuno T. Cemented total hip arthroplasty with autogenous acetabular bone grafting for hips with developmental dysplasia in adults: the results at a minimum of ten years. *J Bone Joint Surg Br.* 2000;82:375–377.
29. Ito H, Matsuno T, Minami A, Aoki Y. Intermediate-term results after hybrid total hip arthroplasty for the treatment of dysplastic hips. *J Bone Joint Surg Am.* 2003;85:1725–1732.
30. Kaplan EL, Meier P. Nonparametric estimation from incomplete observations. *J Am Stat Assoc.* 1958;53:457–481.
31. Kim M, Kadowaki T. High long-term survival of bulk femoral head autograft for acetabular reconstruction in cementless THA for developmental hip dysplasia. *Clin Orthop Relat Res.* 2010; 468:1611–1620.
32. Kobayashi S, Eftekhari NS, Terayama K, Joshi RP. Comparative study of total hip arthroplasty between younger and older patients. *Clin Orthop Relat Res.* 1997;339:140–151.
33. Kobayashi S, Saito N, Nawata M, Horiuchi H, Iorio R, Takaoka K. Total hip arthroplasty with bulk femoral head autograft for acetabular reconstruction in developmental dysplasia of the hip. *J Bone Joint Surg Am.* 2003;85:615–621.
34. Lee BP, Cabanela ME, Wallrichs SL, Ilstrup DM. Bone-graft augmentation for acetabular deficiencies in total hip arthroplasty: results of long-term follow-up evaluation. *J Arthroplasty.* 1997; 12:503–510.
35. Linde F, Jensen J, Pilgaard S. Charnley arthroplasty in osteoarthritis secondary to congenital dislocation or subluxation. *Clin Orthop Relat Res.* 1988;227:164–171.
36. Livermore J, Ilstrup D, Morrey B. Effect of femoral head size on wear of polyethylene acetabular component. *J Bone Joint Surg Am.* 1990;72:518–528.
37. Loudon JR, Older MW. Subsidence of the femoral component related to long-term outcome of hip replacement. *J Bone Joint Surg Br.* 1989;71:624–628.
38. Morsi E, Gabuz D, Gross AE. Total hip arthroplasty with shelf grafts using uncemented cups: a long term follow up study. *J Arthroplasty.* 1996;11:81–85.
39. Mulroy RD Jr, Harris WH. Failure of acetabular autogenous grafts in total hip arthroplasty. Increasing incidence: a follow-up note. *J Bone Joint Surg Am.* 1990;72:1536–1540.
40. Pagnano MW, Hanssen AD, Lewallen DG, Shaughnessy WJ. The effect of superior placement of the acetabular component on the rate of loosening after total hip arthroplasty: long-term results of patients who have Crowe type II congenital dysplasia of the hip. *J Bone Joint Surg Am.* 1996;78:1004–1014.
41. Rodriguez JA, Huk OL, Pellicci PM, Wilson PD Jr. Autogenous bone grafts from the femoral head for the treatment of acetabular deficiency in primary total hip arthroplasty with cement: long-term results. *J Bone Joint Surg Am.* 1995;77: 1227–1233.
42. Schmalzried TP, Huk OL. Patient factors and wear in total hip arthroplasty. *Clin Orthop Relat Res.* 2004;418:94–97.
43. Schofer MD, Pressel T, Schmitt J, Heyse TJ, Boudriot U. Reconstruction of the acetabulum in THA using femoral head autografts in developmental dysplasia of the hip. *J Orthop Surg Res.* 2011;22:6–32.

44. Shetty AA, Sharma P, Singh S, Tindall A, Kumar SV, Rand C. Bulk femoral-head autografting in uncemented total hip arthroplasty for acetabular dysplasia: results at 8 to 11 years follow-up. *J Arthroplasty*. 2004;19:706–713.
45. Shinar AA, Harris WH. Bulk structural autogenous grafts and allografts for reconstruction of the acetabulum in total hip arthroplasty. Sixteen-year-average follow-up. *J Bone Joint Surg Am*. 1997;79:159–168.
46. Silber DA, Engh CA. Cementless total hip arthroplasty with femoral head bone grafting for hip dysplasia. *J Arthroplasty*. 1990;5:231–240.
47. Slooff TJ, Huiskes R, van Horn J, Lemmens AJ. Bone grafting in total hip replacement for acetabular protrusion. *Acta Orthop Scand*. 1984;55:593–596.
48. Somford MP, Bolder SB, Gardeniers JW, Slooff TJ, Schreurs BW. Favorable survival of acetabular reconstruction with bone impaction grafting in dysplastic hips. *Clin Orthop Relat Res*. 2008;466:359–365.
49. Spangehl MJ, Berry DJ, Trousdale RT, Cabanela ME. Uncemented acetabular components with bulk femoral head autograft for acetabular reconstruction in developmental dysplasia of the hip: results at five to twelve years. *J Bone Joint Surg Am*. 2001;83:1484–1489.
50. Stans AA, Pagnano MW, Shaughnessy WJ, Hanssen AD. Results of total hip arthroplasty for Crowe Type III developmental hip dysplasia. *Clin Orthop Relat Res*. 1998;348:149–157.
51. Stringa G, Pitto RP, Di Muria GV, Marcucci M. Total hip replacement with bone grafting using the removed femoral head in severe acetabular dysplasia. *Int Orthop*. 1995;19:72–76.
52. Ware J Jr, Kosinski M, Keller SD. A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. *Med Care*. 1996;34:220–233.
53. Wolfgang GL. Femoral head autografting with total hip arthroplasty for lateral acetabular dysplasia. A 12-year experience. *Clin Orthop Relat Res*. 1990;225:173–185.
54. Yoder SA, Brand RA, Pederson DR, O’Gorman TW. Total hip acetabular component position affects acetabular loosening rates. *Clin Orthop Relat Res*. 1988;228:79–87.