811 Charnley hips followed for 3–17 years

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10–12 year survivorship analysis of 811 primary or conversion Charnley arthroplasties showed 89 percent probability of mechanical survival (revision excluding sepsis). The mechanical failure rate was 7 percent, and more stems required revision than sockets. The antero-posterior radiographs of 630 unrevised hips, with a minimum 3-year follow-up, were evaluated using the CART system of terminology. Cement-bone radiolucency was present in 50 percent of sockets and 18 percent of stems. Substantial loosening was present in 6 percent with 94 percent probability of survival at 10–12 years.

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If cemented total hip arthroplasty is to be the yardstick for the success and longevity of uncemented total hip replacement, it is essential that reports contain sufficient detail to avoid ambiguity. This problem was addressed by Galante (1990), and representatives from The Hip Society, Société Internationale de Chirurgie Orthopédique et de Traumatologie (SICOT), and The American Academy of Orthopedic Surgeons, have proposed the adoption of a uniform clinical and radiographic terminology (CART; Johnston et al. 1990).

We report a retrospective study of 811 Charnley hips with clinical grading and antero-posterior radiographic findings, evaluated using the CART nomenclature. Lateral radiographs were not routinely available.

Patients and methods

1224 primary or conversion Charnley low-friction arthroplasties were performed at the Princess Alice Orthopedic and Leeuwendahl Hospitals in Cape Town between 1970 and 1985. 413 hips were lost to follow-up or deceased. Kaplan-Meier cumulative survivorship analysis was performed on all 811 hips available for follow-up (maximum 17 years). Failure requiring revision surgery, occurred in 68 hips. This paper reports the detailed clinical and radiological evaluation of 630 of the remaining 743 unrevised hips that had a minimum 3-year follow-up.

The male/female ratio was 2/3 and the mean age was 60 years (Table 1). The principal diagnosis was arthrosis, accounting for 72 percent of hips (Table 2). 93 percent were primary procedures, and 7 percent were conversions for failed previous surgery other than total hip replacements. A trochanteric osteotomy was performed in the majority of cases. Complications occurring in the first 6 months postoperatively are shown in Table 3.

The clinical results were evaluated according to the method of Merle d'Aubigné and Postel, as modified by Charnley (1979): (A) unilateral hip disease (36 percent); (B) bilateral hip disease (38 percent); (C) unilat-

Table 1. Age-distribution of patients

Age	Percent
0–20	0.4
21–30	3
31–40	5
41–50	12
51–60	21
61–70	34
71–80	23
81–90	2
90+	0.0

Table 2. Preoperative diagnosis

	Percent
Arthrosis	72
Rheumatoid arthritis	9
Ankylosing spondylitis	2
Congenital dislocation	2
Protrusio	1
Osteonecrosis	5
Bone disease	1
Other	2
Failed surgery	7

eral or bilateral hip disease, but complicated by systemic disease or other conditions in the lower extremities, which would limit function, even if the hip arthroplasties were satisfactory (26 percent).

All patients reviewed had sequential antero-posterior radiographs taken postoperatively through to the latest radiograph. The radiographic evaluation is presented using the standard system of terminology for reporting results (CART) as proposed by Johnston et al. (1990). We used our own scoring system to determine the incidence of radiographic loosening and impending failure based on the following criteria (Learmonth et al. 1990, Dall et al. 1992). Loosening of the socket was thought to be present in Type 3 demarcation with a 3+ millimeter width, or if 3+ millimeters of migration was present. Loosening of the femoral stems was thought to be present when 3 or more zones of 3+ millimeter width were present together with any one of the following: subsidence at bone/cement interface of 3+ millimeters; subsidence at stem/cement interface of 5+ millimeters (Bannister 1988), or cortical thinning in 3 or more zones. A detailed proforma was completed on each patient, and a dBase III Plus software program (Ashton-Tate, 20101 Hamilton Avenue, Torrance, CA 90502, U.S.A.) was used to analyze the results. All results are presented as hips rather than as patients.

Results

Survivorship Analysis. There was an 87 percent probability of survival at 10–12 years (Figure 1). Apart from sepsis, the survival was 89 percent.

Failures. For the following reasons revision of 1 or both components was required in 68 hips (8 percent), all but 2 within 10 years: 12 for sepsis, 3 for recurrent dislocation, 6 for loose sockets, 20 for loose stems, 12 for both components loose, and 15 for stem fracture.

Unrevised hips. For the remaining 630 unrevised hips the average grade for pain was 5.2, function 5.0 (excluding Category C hips), and motion 5.2 (Table 4).

Sockets (Table 5). Cement-bone radiolucency was present in 50 percent of sockets. However, the majority of these changes were Type 1 with a width of 1 millimeter. Only 7 percent had Type 3 cement-bone radiolucency, and substantial migration (3+ millimeters) was present in 2 percent. Wear was noted in 16 percent of sockets.

Stems (Table 6). Evidence of cement-bone radiolucency was present in only 18 percent of stems. Zone 7 was the major zone affected. The majority of these changes were present in 1 or 2 zones only. Migration of the stem of 3+ millimeters was present in 7 percent. Medial neck changes were present in 68 percent, in the

Table 3. Early complications (occurring in the first 6 months of surgery)

	Percent
Hematoma	2.0
Superficial infection	2.8
Deep sepsis	0.1
Venous thrombosis	2.3
Pulmonary embolism	0.7
Dislocation	
Once	0.6
Recurrent (conservative management)	0.3
Recurrent (revision required)	0.4
Total	1.3

Table 4. Clinical results in the unrevised hips expressed as percentages with grades of 1–6 (n 630)

Grade	Pain	Function	Motion
1	0.5	2	0.2
2	2	3	1
3	7	9	5
4	7	11	15
5	25	23	34
6	59	53	45
Average	5.3	5.0	5.2

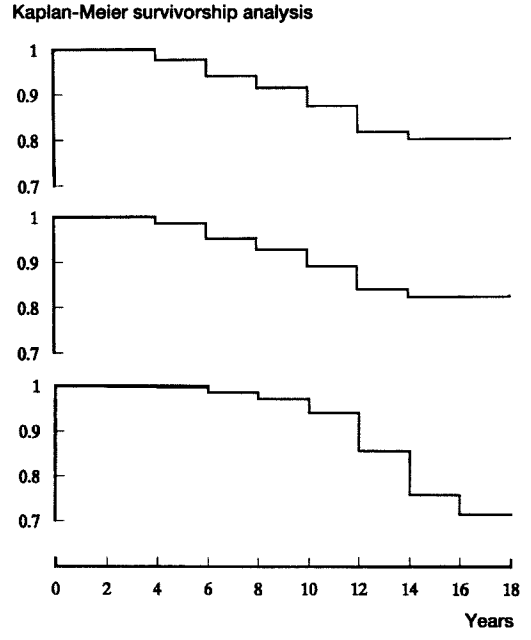

Figure 1. Kaplan-Meier survivorship analysis. Top—all revisions, including sepsis; middle—mechanical failure (revisions, excluding sepsis); and bottom—radiological changes in unrevised hips, indicative of impending failure.

Table 5. Radiographic features of the sockets of unrevised hips, expressed as percentages (n 630)

Cement–bone radiolucency (Charnley–De lee)		
	NIL	50
Type	1	34
	2	9.0
	3	7.3
Maximum width	1 mm	40
	2	7.2
	3	2.1
	4+	1.2
Migration		
	NIL	96
1–2 mm	Medial	1.9
	Superior	0.2
	Combined	0.3
	Total	2.4
3+ mm	Medial	0.3
	Superior	0.3
	Combined	1.5
	Total	2
Change in orientation (degrees)		
	NIL	97
	< 10	1.6
	> 10	1.0
Wear		
	NIL	84
	1–2 mm	13
	3–4 mm	2.9
	5 + mm	0.0

majority due to trabecularization. Endosteal cavitation greater than 5 millimeters was present in 4 percent, while resorption of the shaft involving more than 2 zones was present in 1 percent. Hypertrophy of the shaft was present in 17 percent and ectopic ossification in 14 percent. After trochanteric osteotomy, non-union occurred in 5 percent, half of which displaced.

Radiographic loosening indicating impending failure of components occurred in 38 hips (Table 7). The average clinical grading of the 38 hips with radiographic loosening was pain 4.2, function 4.4 and motion 4.5. In fact 22 of the 38 hips had persistent good/excellent clinical results, and only 16 actually had fair/poor clinical results. Of the 592 hips with satisfactory radiographs, 14 (2 percent) had unsatisfactory clinical results for a variety of reasons usually not attributable to their arthroplasty.

Discussion

What determines failure of a total hip arthroplasty? Most authors agree that the most tangible evidence of failure is the necessity for revision. In addition, we believe that all cases with substantial evidence of radiographic loosening of components or with poor clinical results should be regarded as pending failures.

Radiographic loosening

The definition of radiographic loosening remains contentious. Some authors use very strict criteria while others, such as ourselves, use criteria which they believe indicate the strong likelihood that revision is pending. Since consensus is unlikely: it is imperative that the carefully prepared CART guidelines be encouraged. By using this system in our series, we found that although some degree of cement-bone radiolucency was present in half of the unrevised sockets, the majority of socket changes were low-grade. We could not demonstrate a relationship between cup-wear and loosening in our series.

The majority of unrevised hips had no evidence of femoral cement bone radiolucency. However, we noted that the incidence of marked stem changes was similar to that encountered in the socket. We regard endosteal cavitation and resorption of the shaft (cortical thinning) as the most serious changes in the femur. Small diffuse and large (local or diffuse) areas of endosteal cavitation were present in 6 percent. The total incidence of endosteal cavitation (9 percent) was similar to the incidence of endosteal erosions (8 percent) reported in the Exeter stem in the 11–16-year review (Fowler et al. 1988). Resorption of the shaft was present in 5 percent.

Table 7 indicates that radiological loosening, indicative of impending failure, was present in 2.8 percent of sockets and 3.3 percent of stems. The total incidence of radiographic loosening (6 percent) in our series contrasts strikingly with the progressive loosening rate of the self-locking autophor cementless hip reported by Mahoney and Dimon (1990), 15/42 hips or one third.

Mechanical failure

Survivorship analysis (containing all revisions, including sepsis) showed an 87 percent probability of survival at 10–12 years, similar to the estimate of 87 percent at 10 years by Hozack et al. (1990) while Kavanagh et al. (1989) reported only 8 percent revision at 10 years. Although our sample size may be reduced at longer intervals, it is interesting to compare our 17 year survival of 79 percent with Ranawat et al.'s (1989) 72 percent at 17 years. In our series, certain parameters were found to have a higher incidence in cases requiring revision surgery, notably male, protrusio, osteonecrosis, medial cup position, and valgus stem position (Table 8).

In reports of the long-term results of the Charnley arthroplasty done by surgeons outside the Hip Center at Wrightington, the mean incidence of failure was 7.2 (3.5–14) percent. The mechanical failure rate of 6.9

Table 6. Radiographic features of the stems of unrevised hips, expressed as percentages (n 630)

Cement–bone radiolucency	NIL	82
Major zone affected	1	1.8
	2	1.8
	3	2.1
	4	1.0
	5	2.1
	6	1.1
	7	7.7
Maximum width	1 mm	7.4
	2	6.0
	3	2.3
	4	0.8
	5 +	1.1
Number of zones	1	8.1
	2	3.4
	3	3.2
	4	1.5
	5	0.5
	6	0.6
	7	0.3
Migration of stem	NIL	88
	Varus	3.0
	Valgus	2.4
	Distal	7.4
Subsidence	1 mm	1.1
	2	3.4
	3	2.1
	4	0.5
	5	1.1
	6	0.6
	7	0.0
	8	0.2
	9	2.7
	10 +	0.0
Broken cement	NIL	94
	Present	6.4
Medial neck changes	NIL	32
Resorption	1 mm	0.5
	2	3.4
	3	7.1
	4	2.7
	5	3.7
	6+	2.8
	Total	20
Trabecularization	Slight	39
	Severe	9.2
	Total	48
Endosteal cavitation	NIL	91
Small (1–5 mm)	Localized (1 zone)	3.2
	Diffuse (2+ zone)	2.7
	Total	5.7
Large (6+ mm)	Localized (1 zone)	2.4
	Diffuse (2+ zone)	1.1
	Total	3.5
Resorption of shaft		
Number of zones	1–2	4.0
	3–4	0.6
	5–6	0.3
	7	0.2
	Total	5.1
Hypertrophy of shaft	NIL	83
	Slight	10.9
	Moderate	3.9
	Severe	2.2
	Total	17
Ectopic ossification (Brooker)	I None	86
	II Mild	9.7
	III Moderate	3.6
	IV Severe	0.5
	Total	14
Greater trochanter		
Not osteotomized		12
Osteotomized		88
	Healed	95
	Non-healed	5.1
	Displaced	2.5
	Non-displaced	2.6

Table 7. Incidence of radiographic loosening in unrevised hips (n 630)

	Hips	Percent
Socket	15	2.2
Stem	19	2.7
Socket and stem	4	0.6
Total	38	5.5

Table 8. The occurrence of certain parameters, expressed as percentages in the whole series, compared with their occurrence in revisions (whole series n 811, revisions n 68)

Parameter	Whole series	Revisions
Sex		
Male	40	63
Pathology		
Protrusio	1.2	4.9
Avascular necrosis	4.6	7.3
Cup position		
Medial	4.4	7.3
Stem position		
Valgus	15	24

percent in our series was consistent with most reliable reports (Table 9).

8 hips with acetabular protrusion were not grafted, resulting in excessive medial placement of the socket. 2 of these required revision and 3 had evidence of radiographic loosening and pending failure. Current techniques with medial grafting may well have prevented socket problems in these cases. In spite of this, fewer sockets required revision than stems. This finding is at variance with current perceptions, and challenges the protagonists of a hybrid system (cementless socket and cemented stem). Furthermore, cemented all-polyethy-

Table 9. Incidence of revision for mechanical failure reported in other published series

Author	Year published	No.of hips	Follow-up years	Percentage revision for mechanical failure
Salvati et al.	1981	67	10	6
Stauffer	1982	231	10	8.2
Dall et al.	1986	98	10–14	14
Dall et al.	1988	73	10–14	11
Wejkner	1988	248	5–10	14
McCoy et al.	1988	40	15	10
Sarmiento et al.	1988	367	12–17	7.4
Hartofilakidis et al.	1989	93	10–14	12
Kavanagh et al.	1989	333	15	9.9
Hozack et al.	1990	1,041	Ave. 7	3.5
Jacobsson et al.	1990	41	10–13.5	8
This series	1991	811	3–17	6.9
Total		3,443		7.2

lene sockets have a lower failure rate than cemented metalbacked sockets (Harris and Penenberg 1987, Ritter et al. 1990). If these differences are due to stress-shielding produced by the metalbacking, concern must exist about the long-term fate of metalbacked uncemented sockets.

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