STANMORE COMPARED WITH CHARNLEY TOTAL HIP REPLACEMENT

A PROSPECTIVE STUDY OF 413 ARTHROPLASTIES

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From 1982 to 1987, we randomised prospectively 413 patients requiring primary total hip replacements to receive either a Stanmore or Charnley prosthesis. They were reviewed by an independent observer in an attempt to correlate a number of factors including femoral head size with longevity. There were 213 Stanmore hips and 200 Charnley prostheses. At five to ten years (mean 6.5) 76 patients had died and 16 arthroplasties had required revision. Seven were radiologically loose in asymptomatic patients. There was only one case of deep infection.

We found no difference statistically in the clinical outcome or in the revision rate of 4% in the two types of prosthesis. The revision rate was greater for trainees than for senior operating surgeons, and there were recognisable technical errors in seven of the nine Stanmore, and four of the seven Charnley replacements which required revision. Retrospective radiological analysis of a random subset of 51 Charnley and 57 Stanmore femoral components showed no difference in femoral subsidence, but in 14 patients who had had bilateral replacements with one femoral component of each type, there was greater early subsidence of the Stanmore prosthesis.

Our results confirm that conventional cemented total hip replacements give acceptable results in a general teaching unit, and we found no evidence of any effect of the size of the femoral head on wear or loosening at five to ten years.

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The Charnley and Stanmore hip prostheses are both cemented, but have different head sizes and different femoral-stem profiles. The former was first introduced in November 1961 and its 22.25 mm head was designed to reduce friction and diminish the torque at the cement-bone interface. Problems of posterior dislocation led to the introduction of the long posterior-wall cup and the femoral stem was later increased in cross-section to reduce the incidence of stem fracture. The Stanmore hip was introduced in 1969, with head sizes of 25, 29 and 32 mm. The 29 mm head was selected for use in our trial. The Charnley femoral component has a more bulky cross-section than the Stanmore component, but the latter is designed to be placed centrally in the femoral canal when the neck cut is correct to facilitate a symmetrical cement mantle (Fig. 1).

There have been three previous reports which have attempted to correlate femoral-head size with the longevity of metal-on-plastic arthroplasties (Ritter et al 1983; Morrey and Ilstrup 1989; Frankel et al 1990) but none of these was

Fig. 1

Photograph showing the Charnley (left) and Stanmore (right) prostheses.

prospective or randomised. Despite the extensive use of both prostheses, both in the UK and worldwide, we are aware of no other controlled clinical trial comparing the Stanmore and the Charnley replacements.

Recent enthusiasm for the use of uncemented prostheses has been tempered by reports of the high incidence of persistent thigh pain (Duncan et al 1992), femoral loosening and osteolysis. It is therefore important that accurate information be made available on the performance of these basic and relatively cheap cemented designs.

PATIENTS AND METHODS

Between June 1982 and June 1987, all patients requiring a primary total hip arthroplasty (THA) at the Professorial Unit of the Royal National Orthopaedic Hospital were randomised to have either a Stanmore Tivaloy prosthesis with a 29 mm head (Biomet, Bridgend, UK) or a Charnley prosthesis with a 22.25 mm head (Thackray, Leeds, UK). All patients gave informed consent. The method of randomisation was from random number tables, the allocation for each hip being kept in a sealed envelope until the morning of operation. For bilateral replacements the second hip was also randomised. A total of 413 primary arthroplasties were performed on 360 patients of mean age 67 years. There were 126 men with a mean age of 66 years (18 to 91) and 234 women with a mean age of 69 years (30 to 87). A total of 200 Charnley and 213 Stanmore prostheses were implanted.

The preoperative diagnoses are shown in Table I, over 85% of patients having primary osteoarthritis. The exact type of Charnley or Stanmore prosthesis was determined by the 'best-fit' at operation. The largest possible acetabular component was used in each case, with the standard Stan-

more stem and either the 40 or 45 mm offset Charnley femoral component according to fit. Our aim was to achieve good filling of the femur with a cement mantle of at least 2 mm. In the early cases, cementing was by digital pressure, without the use of a femoral cement restrictor. In all later cases a cement gun was used with a cement restrictor in the femoral canal. Acetabular pressurisation was not used.

Routine antibiotic prophylaxis was by flucloxacillin 500 mg and ampicillin 500 mg intravenously at induction of anaesthesia, continued six-hourly for at least 48 hours postoperatively, but this treatment was prolonged if indicated clinically. A single deep suction drain was used in 94% of patients and a second drain was placed in the subcutaneous layer in 12%. They were removed routinely at 24 hours to reduce wound contamination (Willett, Simmons and Bentley 1988). Oral thromboprophylaxis with Warfarin was started on the first postoperative day, unless there were contraindications to its use, and continued until the patient had been discharged from hospital.

The operations were performed by surgeons of varying experience (Table I) but all those in training had been taught the technique by the consultant staff and were allowed to perform unsupervised arthroplasties only after they were considered to be fully competent. The anterolateral approach was used in 54% of patients and the McFarland-Osborne approach in 40% (Table I). No trochanteric osteotomies were performed. We used Simplex radio-opaque bone cement in all cases, with placement of a plastic cement restrictor or bone block in the femur 1 to 2 cm from the tip of the stem in 130 Stanmore (61%) and 116 Charnley (58%) procedures.

Routine annual review was undertaken in a hip clinic, except when distance from the hospital made this impos-

Table I. Clinical details of 360 patients (413 hips) having total hip arthroplasty

	Stanmore		Charnley	
	Number	Percentage	Number	Percentage
Preoperative diagnosis				
Primary osteoarthritis	189	88.7	179	89.5
Rheumatoid arthritis	6	2.8	7	3.5
Seronegative arthritis	7	3.3	5	2.5
Fractured neck of femur	5	2.3	5	2.5
(with primary treatment of open reduction and internal fixation)				
Osteoarthritis (previous femoral osteotomy)	6	2.8	4	2.0
Total	213		200	
Seniority of surgeon				
Professor	26	12.20	24	12.00
Consultant	67	31.5	64	32.00
Trainee	115	54.00	108	54.00
Junior trainee	5	2.35	4	2.00
Total	213		200	
Surgical approach				
Anterolateral	115	54.00	109	54.50
McFarland-Osborne	85	39.9	84	42.00
Posterior ('Southern')	13	6.1	7	3.50
Total	213		200

No. at risk:

Charnley:	200	181	171	168	164	159	147	126	84	46	16
Stanmore:	213	192	178	168	158	149	137	122	87	43	15

Fig. 2

Survival curves for both prostheses.

sible. We made a special clinical review of this series at five to ten years with an average follow-up of 6.5 years. The patients fell into four groups, each of which had an approximately equal distribution of prosthesis type.

Group I. There were 214 patients (248 hips) with detailed clinical and radiological assessment at five to ten years.

Group II. Fifty-one patients (59 hips) were unable to attend for late review because of infirmity or distance from the hospital. They were sent a questionnaire and 49 replied. The other two were interviewed by telephone.

Group III. Seventy-six patients (with 89 hips) had died and two others could not be traced. For these 78 cases clinical and radiological assessments were made from the records of the last clinic visit, using this date to give the length of follow-up.

Group IV. There were 14 patients (16 hips) who had revision arthroplasties and one who required revision but declined the operation.

Preoperative and follow-up Harris hip scores (Harris 1969) were obtained for all hips, and radiographs were assessed for signs of loosening, with special note of obvious migration or zones of lucency wider than 2 mm. The radiographs from a random sample of 51 Charnley and 57 Stanmore prostheses were analysed by computer digitisation (Walker et al 1995) to provide more accurate assessment of femoral subsidence. Fourteen of the 53 patients with bilateral replacement had a Stanmore prosthesis in one hip and a Charnley in the other.

RESULTS

The mean preoperative Harris score was 46.0 in each group. The mean postoperative Harris score for the hips

with Charnley prostheses was 91.2 and for those with Stanmore prostheses 91.4 ($p = 0.49$). Figure 2 shows survival curves calculated from survival tables by the method of Armitage (1971).

Revision. At the time of review 16 hips (nine Stanmore, seven Charnley) in 14 patients had been revised (3.9%). There were technical errors in ten of these cases (Table II). The indication for revision was persistent pain combined with radiological evidence of loosening, and at revision only loose components were replaced.

Charnley. Of the seven Charnley arthroplasties requiring revision five needed only replacement of the stem. One had both stem and acetabulum revised; the initial postoperative radiographs in this patient showed inadequate medialisation of the cup. One hip was revised elsewhere and details are not available.

Stanmore. Nine Stanmore arthroplasties were revised. One hip required only acetabular revision; the original postoperative radiograph showed inadequate medialisation. In two hips both acetabular and femoral components were revised, and in five only the femoral component was loose. One patient had an exploration for suspected aseptic loosening on clinical and radiological grounds but no evidence of loosening was found. The symptoms have persisted and the diagnosis is uncertain.

One 84-year-old patient developed a superficial *Staphylococcus epidermidis* infection within two weeks. This settled but deep infection due to the same organism was diagnosed 11 months after surgery; the patient declined further treatment.

Rates of revision. Of the 16 arthroplasties requiring revision, 14 had been performed through an anterolateral approach and only two by the McFarland-Osborne tech-

Table II. Primary arthroplasties requiring revision for aseptic loosening

Case	Age at initial surgery (yr)	Sex	Months to revision	Operative approach*	Acetabular component	Femoral component	Cement restrictor	Postoperative complications	Immediate postop radiograph	Loose component at revision
1	77	M	12	AL	Large Charnley	45 mm round back	No	No	Reverted femoral component	Femoral
2	71	F	42	AL	Small Charnley	40 mm round back	No	No	Satisfactory	Femoral
3	66	M	94	AL	Large Charnley	40 mm round back	No	No	Incomplete proximal femoral cement mantle	Femoral
			44	MO	Small Charnley	45 mm round back	Yes	Urinary infection	Satisfactory	Femoral
4	73	M	93	AL	Large Charnley	40 mm round back	Yes	Urinary infection	Satisfactory	Revision elsewhere
5	58	F	31	AL	Large Charnley	40 mm round back	No	No	Cup not medialised	Both
									Valgus stem	
6	66	M	92	AL	Large Charnley	40 mm flanged	No	Urinary retention	Varus stem	Femoral
7	70	F	68	MO	45 mm	Standard Stanmore	NE	No	Cup not medialised	Acetabulum
8	59	M	72	AL	50 mm	Standard Stanmore	NE	Deep vein	Valgus stem thrombosis	Both
9	70	M	42	AL	53 mm	Straight Stanmore	NE	No	Varus stem	Both
10	70	F	86	AL	45 mm	Standard Stanmore	Yes	No	Varus stem	Both
11	69	M	103	AL	53 mm	Standard Stanmore	Yes	<i>Pseudomonas</i> wound infection	Satisfactory	Femur
12	73	M	72	AL	53 mm	Standard Stanmore	Yes	No	Valgus stem	Femur
			57	AL	50 mm	Standard Stanmore	No	Urinary retention	Incomplete femoral cement mantle	Femur
13	65	M	87	AL	45 mm	Standard Stanmore	Yes	No	Satisfactory	Not loose
14	69	F	53	AL	45 mm	Standard Stanmore	No	Cardiac failure	Satisfactory	Femur

* MO = McFarland-Osborne; AL = Anterolateral

† NE = non-effective

nique. The difference is significant ($p = 0.002$) but the anterolateral approach was used largely by surgeons in training and this is also a factor. Fifteen of the 16 primary procedures which subsequently required revision were performed by surgeons in training; one was performed by a consultant. The difference in revision rates between experienced and trainee surgeons was also statistically significant ($p = 0.005$). The relative risk of requiring revision was 11.47 times greater for trainees (95% confidence interval (CI) 1.53 to 86.06).

We found no statistically significant difference in revision between the two types of prosthesis. The log-rank test gave a p value of 0.77; the odds ratio for revision was 0.82 for the Charnley design as compared with the Stanmore (95% CI 0.27 to 2.47).

Asymptomatic loosening. At the time of review, seven hips showed asymptomatic radiological loosening with radiolucent lines wider than 2 mm around the components. This applied to three Stanmore femoral stems and four Charnley stems, of which there were also radiologically loose acetabular components.

Complications. Perioperative complications were minimal. One fracture of the shaft of the femur was successfully treated by cerclage wiring. Four hips had penetration of the shaft of the femur; this was recognised at operation in three and cement extrusion avoided. In one Stanmore hip the femoral component was placed in a false passage. This was managed by removal of the protruding tip at another operation using a diamond-tipped saw; the patient has remained asymptomatic for six years.

The postoperative complications are listed in Table III; 342 of the 413 hips had no such problems. There were no perioperative deaths and no cases of fatal pulmonary emboli. This supports the findings of a previous study from this unit which indicated the efficacy of Warfarin in the prevention of fatal pulmonary emboli (Muckle, Forney and Bentley 1974; Barber et al 1977). Two patients had gastrointestinal bleeding requiring blood transfusion and 12 had wound haematomas severe enough to delay discharge from hospital, but not requiring surgical intervention.

Table III. Complications in 413 hip arthroplasties

	Stanmore	Charnley
Local		
Superficial infection	6	14
Haematoma	4	8
Dislocation	1	4
Neurapraxia	1	3
Deep infection	1	0
General		
Urinary retention	10	12
Respiratory infection	8	7
Urinary tract infection	5	4
Non-fatal pulmonary embolus	3	5
Deep-vein thrombosis	1	6
Peptic ulceration	0	3
Cerebrovascular accident	1	1
Myocardial infarction	1	0

There were four postoperative dislocations, one of a Stanmore and three of Charnley prostheses. Three patients had partial nerve palsy, two femoral and one sciatic; all resolved completely.

There were 20 superficial wound infections with clinical symptoms and signs of infection associated with a positive wound swab culture, despite routine antibiotic prophylaxis. All but one settled with continued antibiotic treatment.

The average recorded blood loss during 219 arthroplasties performed by the anterolateral approach was 615 ml, as compared with 677.5 ml for the 165 by the McFarland-Osborne approach. Sixteen patients (3.9%) developed a persistent Trendelenburg gait due to abductor weakness; in eight operation had been performed by the anterolateral approach, in seven by the McFarland-Osborne approach and in one by the posterior approach.

Heterotopic ossification was rare, being noted on antero-posterior radiographs in 16 hips (3.9%); the surgical approach was McFarland-Osborne in three and anterolateral in 13. The presence of heterotopic ossification did not appear to affect the clinical outcome as judged by the Harris score.

Radiological review. A sample of the sequential antero-posterior radiographs including 51 Charnley and 57 Stanmore stems randomly selected on the basis of time from operation was digitised to determine stem-to-bone migration by the method of Walker et al (1995), which compensates for rotation, flexion/extension of the limb and magnification of the radiograph. Both types of prosthesis showed some subsidence during the first year, with less migration thereafter. The average subsidence for the 51 Charnley stems was 1.4 mm at one year and 2.6 mm at seven years, and for the Stanmore 1.3 mm at one year and 2.8 mm at seven years. This difference is not statistically significant.

In the 14 patients who had both a Charnley and a Stanmore prosthesis, the subsidence of the Stanmore stem in the first six months was significantly greater than that of the Charnley for the same period ($p = 0.003$).

DISCUSSION

In recent years, interest in cementless total hip replacement has been stimulated by the increasing need to revise cemented arthroplasties, not only in relatively young patients but also in the elderly with their increasing lifespan. Even before the use of modern cementing techniques, however, the survival figures for cemented implants were reassuring. Older and Butorac (1992) report 89% survival at 20 years for the Charnley prosthesis and there have been other similar results which call into question the trend towards cementless procedures (Hozack et al 1990). Revision surgery has also become easier with the use of ultrasonic extraction of cement.

Harris et al (1992) concluded that research in the 1980s had shown that failure of fixation of femoral components

was usually mechanical, not biological, and that new cementing techniques were much superior to digital pressurisation with no restrictor and using a high-viscosity cement. They considered that modern cementing techniques should be used for most patients, of whatever age, for both primary and revision arthroplasties.

The advantages of both the Charnley and Stanmore prostheses over more modern designs include their simplicity, the reproducibility of known clinical results and low cost. We could find no other report of a prospective, randomised comparison which used standard preoperative and postoperative assessment and operative techniques. Both of these prostheses are still in common use; their differences in design include head size, femoral cross-section and the presence of a collar on the Stanmore prosthesis. It is of interest that the collar did not prevent sinkage of the Stanmore stem, and that we found no apparent failures of the cement mantle related to the different cross-sections.

In view of the general trend in the 1970s for metal-to-plastic head sizes to move towards a smaller range (25, 28 and 32 mm), Charnley (1979) considered that it was unlikely to be profitable to study the effect of small differences in head diameter. We found only three papers which purport to study the effect of the size of femoral head on outcome.

Frankel et al (1990) reviewed retrospectively 84 patients with 32 mm head sizes and 98 patients with 22 mm heads up to 24 months. They found a 56% incidence of complete demarcation of the acetabulum on radiological examination in patients with a 32 mm head as compared with a 5% incidence in the group with a 22 mm head, but there was no difference in the mean Harris scores. The review was not prospective and the 32 mm femoral components were actually cementless. Morrey and Ilstrup (1989) studied 59 revisions for aseptic acetabular loosening from a series of 6128 total hip arthroplasties. There was a 1% acetabular revision rate in hips with a 22 mm head and a 2.6% revision rate after the use of a 32 mm head. Ritter et al (1983) reviewed 67 Müller (32 mm head) and 87 Charnley (22 mm head) total hip arthroplasties. The Müller hips showed significantly greater loosening of the acetabulum as defined by migration and progressive radiolucency at seven years, and also showed a significantly greater incidence of pain at five and seven years. Again, this study was retrospective and the choice of prosthesis depended mainly on availability at the time of surgery.

The small 22 mm head was designed to limit the torque transmitted from the prosthetic joint to the acetabular cement-bone interface, and to maintain the thickness of high-density polyethylene in order to distribute load uniformly and provide a good margin for wear (Charnley 1961). Theoretically, this would reduce both early acetabular loosening and the volume of polyethylene which may influence aseptic loosening. This claim was argued against by Andersson, Freeman and Swanson (1972) who

showed experimentally that the torsional force required to cause acetabular loosening was 4 to 20 times greater than the frictional moment which could be transmitted through the femoral head.

At the relatively short follow-up of ten years, we found no hip with wear greater than 2 mm. Wroblewski (1990) reported a relation between the rate of socket migration and the depth of wear of about 1 mm after ten years. Older studies on the wear of acetabular components showed that wear was not random but that the head bored itself a new cylindrical channel, the diameter of which was determined by the size of the femoral head (Charnley, Kamangar and Longfield 1969). The volume of worn plastic rises with the depth of penetration which is inversely proportional to the diameter of the head. The theoretical advantage of the smaller head size may therefore be lost. Another consideration is that a larger head is more stable and reduces the incidence of dislocation. In our series dislocation was infrequent with one in a Stanmore prosthesis and three in Charnley prostheses; this difference is not statistically significant.

Our results to date fail to support the case for the smaller 22 mm femoral head size, but on theoretical grounds we agree that the use of as great a depth of high-density polyethylene as possible is desirable.

We found no statistically significant difference in stem subsidence between the randomly selected series of Stanmore and Charnley hips examined by computer digitisation of sequential radiographs. In the small series of 14 bilaterally different types, however, the Stanmore prostheses always sank further than the Charnley prostheses in the first six months ($p < 0.003$). This may be due to the different profile and sharper taper of the Stanmore stem; it may also indicate that the collar on the Stanmore prosthesis is redundant.

Our overall revision rate was 4.1%. Our radiological failures included only those with a lucency of >2 mm in all zones of the femoral stem or the superolateral or inferomedial zones of the acetabular component. We considered this to be justified since radiological loosening is known to have a poor correlation with clinical outcome (Wroblewski, Taylor and Siney 1992), and the signs of radiological loosening are not always confirmed at a revision operation (Carlsson and Gentz 1984; O'Neill and Harris 1984).

Our revision rate is relatively high for the short period of follow-up, but most long-term series report the outcome of Stanmore or Charnley arthroplasties performed by only one or possibly two experienced senior surgeons. We found a higher revision rate after arthroplasties performed by a surgeon in training; this suggests that experience may have an effect on survivorship, contrary to the findings of Skeie et al (1991). Our results may be a more accurate reflection of overall revision rates in the United Kingdom.

We found no significant difference in clinical outcome between the two groups of hip replacements at five to ten years. This tends to confirm Charnley's impression that,

within a certain range, small differences in head size are not important. We shall continue to review these patients but at present there seems to be no indication that future failure is likely with either of the prostheses.

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