FLANGED ACETABULAR COMPONENTS IN CEMENTED CHARNLEY HIP ARTHROPLASTY

TEN-YEAR FOLLOW-UP OF 350 PATIENTS

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A flanged socket was introduced by Sir John Charnley for use in his low-friction hip arthroplasty in 1976. Experimental evidence has suggested that the flange offers an advantage in terms of cement pressurisation at the time of implantation. We have reviewed 302 primary Charnley arthroplasties followed for 9 to 11 years to determine the effect of the flanged socket on the radiological appearance.

The incidence of radiological demarcation at the cement-bone interface is significantly reduced in early radiographs after the use of a flanged socket, and the advantage is maintained in the long-term results.

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The low-friction arthroplasty developed by Sir John Charnley has set the 'gold standard' by which other hip arthroplasties have been evaluated. He considered, however, that aseptic loosening of the acetabular component might become an increasing problem with time, and continued his own research and development programme using the results from his first 500 cases as a reference series. This led to several modifications in the design of the acetabular component with a view to improving the long-term outcome.

The first change was the addition of a scalloped rim and an improvement in the anchorage grooves. In 1976, he introduced a flange to improve pressure injection and later, in 1981, modified the shape of the flange to an ogee pattern. The aims of the addition of the flange were to reduce socket movement during implantation, to prevent the socket from 'bottoming out', and to improve cement pressurisation (Charnley 1979).

Recent experimental work has shown that a flanged socket can exert a much higher pressure on setting bone cement than its unflanged equivalent, and that this pressure is maintained throughout polymerisation. In contrast, even the lower pressure under an unflanged socket is lost when its apex makes contact with the acetabular floor (Shelley and Wroblewski 1988).

We have studied matched series to determine whether these design concepts were associated with improvements in the radiological appearance of the cement-bone interface in short-term and long-term follow-up.

PATIENTS AND METHODS

The flanged socket was progressively introduced at the Centre for Hip Surgery, Wrightington from 1976 onwards. We compared the results of the first 168 arthroplasties using the flanged socket with those of a randomly selected group of 182 arthroplasties with unflanged sockets also performed from 1976 to 1978 by the same group of surgeons. Apart from the type of

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socket, all operations used the standard technique described by Charnley.

Our method of analysing the radiological demarcation of the acetabular component has been previously described (Hodgkinson, Shelley and Wroblewski 1988). It uses standardised anteroposterior radiographs of the pelvis to determine the extent and width of any radiolucent line at the cement-bone interface. The extent is recorded in four grades (Fig. 1).

Table I. Details of the patients in two groups of hip arthroplasties

	Unflanged (n = 152)	Flanged (n = 150)
Mean age (yr)	58.2	60.6
Females	82 (53.9%)	67 (44.7%)
Males	70 (46.1%)	83 (55.3%)
Mean weight (kg)	69.2	70.3
Osteoarthritis	105 (69.1%)	108 (72.0%)
Rheumatoid arthritis	14 (9.2%)	9 (6.0%)
CDH	16 (10.5%)	13 (8.7%)
Trauma	6 (3.9%)	3 (2.0%)
Other	11 (7.3%)	17 (11.3%)
Mean pain score	3.13	3.11
Mean function score	2.76	2.81
Mean movement score	2.65	2.58
Small socket	31 (20.4%)	15 (10.0%)
Standard socket	114 (75.0%)	135 (90.0%)
Other sockets	7 (4.6%)	0

Data for each case were collected from the records and radiographs at the time of operation, and from the 1-year and the 9- to 11-year reviews. Non-parametrical statistical analysis was used throughout. The chi-squared test was used for grouped data and the Mann-Whitney rank-sum test for linear data.

RESULTS

Of the 350 arthroplasties reviewed, 302 (152 unflanged, 150 flanged) had accurate follow-up data available at 9 to 11 years from the date of surgery (Table I). The 48 exclusions were 11 hips which had required revision before ten years (3.1%), 23 hips lost to follow-up by the death of the patient (6.6%), and 12 hips lost to follow-up for other reasons (3.4%). The remaining two were unflanged cases followed up for 13 years but were excluded because the follow-up data at ten years was incomplete.

In all, 15 arthroplasties (4.3%) had some form of revision surgery, four at ten years or later (Table II). Nine of these hips showed radiological evidence of socket loosening with demarcation grades 2 to 4, but in only five of these was the loose acetabular component considered to be the main cause of symptoms.

Statistical analysis confirmed that the two groups of patients receiving either unflanged or flanged sockets

Fig. 1

Diagrams to show grades of demarcation at the cement-bone interface.

were well matched for age, weight, sex, type of disease and preoperative symptoms, performance scores and radiological appearance. We found no significant influence of the patient's age, weight or gender on the short-term or long-term results.

The demarcation grades for the initial postoperative radiographs and at one and ten years are given in Table III. On the postoperative radiograph the most significant finding was the difference in incidence of grade 0 and grade 1 demarcation lines between the unflanged and flanged sockets. There was no radiographic demarcation (grade 0) in 82% of the flanged group as against only 60% of the unflanged group, while grade 1 demarcation was seen in 14.7% and 36.8% respectively. These differences are statistically significant at $p < 0.0001$. In both groups five cases (3.3%) showed grade 2 or grade 3 demarcation.

At both one and ten years more flanged than unflanged sockets still showed no radiographic demarcation. These differences remained statistically significant.

The progression of demarcation lines was almost identical in the two groups. Ninety-two (60.5%) of the unflanged sockets and 89 (59.3%) of the flanged sockets

showed no increase in demarcation grade in the first year. After follow-up of 9 to 11 years, 72 (47.4%) of the unflanged sockets and 78 (52.0%) of the flanged sockets showed no progressive demarcation.

Of the 118 sockets which showed an increase in demarcation in the first year, 44 (37.3%) had developed evidence of radiological loosening with demarcation grade 2 to 4 at ten years. Of the 15 sockets which had a demarcation grade of 3 at one year, eight had migrated by ten years.

At ten years, 66 (21.9%) of all acetabular components (38 unflanged and 28 flanged) had demarcation grades of 2 or more, and were considered to be radiologically loose. In all cases there was a very close correlation between the maximum width and the extent of the cement-bone demarcation lines ($p < 0.0001$).

DISCUSSION

The long-term survival of the acetabular components of total hip arthroplasties is receiving increasing attention, although it is recognised that a loose femoral component causes clinical symptoms more often than a loose socket, even when there is complete radiological demarcation or migration of the cup (Carlsson, Gentz and Stenport 1977; Charnley 1979). It is uncertain whether socket loosening will become an increasing clinical problem as more arthroplasties survive beyond 10 to 15 years, but it has been shown that improved cementing techniques for the acetabular component will improve long-term results (Andersson, Freeman and Swanson 1972; Wroblewski et al 1987; McCoy et al 1988; Ranawat, Rawlins and Harju 1988; Wroblewski 1988).

Charnley addressed this problem by designing an acetabular component which had a peripheral flange. This could be cut by the surgeon to approximate closely to the shape of the acetabular margin, and experimental work suggests that the goals of improved cement pressurisation and prevention of 'bottoming-out' have been realised (Oh, Sander and Trehan 1985; Shelley and Wroblewski 1988). The importance of avoiding direct contact between a plastic socket and the underlying bone is recognised (Wroblewski et al 1987; Bullough et al 1988). It follows that the addition of pegs or pods to

Table II. Indications for revision arthroplasty and socket demarcation in 15 of the reported arthroplasties

	Length of follow-up (yr)	Socket demarcation (grade)
Recurrent dislocation	3	1
	6	2
	8	1
Femoral stem loosening	8	1
Femoral stem fracture	6	0
	6	1
	8	1
	11	3
Stem fracture with loose socket	13	3
Loose socket	8	3
	10	4
	11	4
Infected loose socket	7	3
Infection	5	4
	7	4

Table III. Demarcation grades on immediate postoperative and one- and 10-year radiographs in the two groups (number, percentage)

Demarcation grade	Unflanged sockets (n = 152)			Flanged sockets (n = 150)		
	Postoperative	One-year	10-year	Postoperative	One-year	10-year
0	91 (59.9)	45 (29.6)	46 (30.3)	123 (82.0)	67 (44.7)	64 (42.7)
1	56 (36.8)	87 (57.2)	68 (44.7)	22 (14.7)	68 (45.3)	58 (38.7)
2	3 (2.0)	8 (5.3)	12 (7.9)	5 (3.3)	11 (7.3)	17 (11.3)
3	2 (1.3)	11 (7.2)	18 (11.8)	0	4 (2.7)	5 (3.3)
4	0	1 (0.7)	8 (5.3)	0	0	6 (4.0)

the exterior surface of a socket to control the thickness of the cement mantle may have adverse effects on both cement pressurisation and the production of polyethylene wear debris from the socket-bone interface, implicated as a possible cause of component loosening (Oh, Sander and Treharne 1984).

We aimed to evaluate the benefits of a flange in improving the quality of cement-bone bonding at the time of socket implantation, since we consider that the early appearance of demarcation lines at the cement-bone interface of the acetabular component may not be as benign as has previously been suggested (Reckling, Asher and Dillon 1977). The appearance of any demarcation line on the immediate postoperative radiograph must be considered to be due to poor surgical technique. This may be failure to remove all the articular cartilage, especially at the periphery of the acetabulum, or loss of cement-bone apposition during cement polymerisation (Andersson et al 1972; Eftekhari and Nercissian 1988; Shelley and Wroblewski 1988). It has been shown that the appearance of even minor demarcations in the first year after surgery leads to 35% to 40% radiological loosening by ten years (Carlsson and Gentz 1984; Hodgkinson et al 1988). Our present study supports these figures.

We have shown that a flange has a beneficial effect on the radiological appearance of the cement-bone interface at the time of implantation, especially in zone I. This advantage is maintained at ten years, when 42.7% of flanged sockets still showed no evidence of radiological demarcation, as against 30.3% of the unflanged group.

Once the cement has fully cured the flange can no longer confer any structural or mechanical advantage which might prevent or delay the progression of radiological demarcation. This explains the similar rates of appearance of new demarcation in unflanged and flanged sockets in subsequent years. We conclude, therefore, that the improved long-term radiological results are due to the superior cement-bone interface created at the time of implantation.

Conclusions. We believe that a satisfactory cement-bone interface at the time of implantation is a critical factor in long-term results, and that the use of a flanged socket

gives an advantage. The development and progression of radiolucent demarcation lines are associated with aseptic socket loosening, and an increase in demarcation in the first year after surgery is a useful prognostic indicator of late socket failure.

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