PRIMARY MIGRATION OF FULLY-THREADED ACETABULAR PROSTHESES

A ROENTGEN STEREOPHOTOGRAMMETRIC ANALYSIS

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We investigated the fixation of fully-threaded cementless acetabular prostheses in 20 patients with osteoarthritis, measuring the migration of the cup using roentgen stereophotogrammetric analysis (RSA).

All the cups migrated proximally, 13 moved laterally or medially, and nine moved anteriorly or posteriorly in the first two postoperative years, the average migration being 1.1 to 1.4 mm in either direction. Rotatory movements of up to 5.7° were found in nine of the 13 hips where this analysis could be performed. Movements of cobalt-chrome (12) and titanium alloy (8) cups did not differ significantly. Seventeen of the 20 patients had some pain two years after the operation.

The migration of the prostheses indicates that 'osseointegration' had not occurred. The combination of this with persistent pain suggests that the long-term results will be unfavourable.

The limited durability of cemented hip prostheses has led to the development of numerous cementless designs. Most attention has been focused on the fixation of the femoral component, perhaps because symptoms and signs appear earlier for this than the acetabular component (Stauffer 1982; Sutherland et al 1982; Morscher 1983).

Primary fixation of cementless implants is essential to provide stability and avoid movements which result in the formation of a connective tissue layer between prosthesis and bone (Uthoff 1973; Schatzker, Horne and Sumner-Smith 1975; Ducheyne, De Meester and Aernoudt 1977; Albrektsson et al 1981; Perren 1984; Pilliar, Lee and Maniopoulos 1986). For cementless acetabular components, two main principles are used: porous coating to obtain initial stability by press fit, sometimes with the addition of cancellous screws, and the use of a threaded component which can be screwed into the bone.

We have used roentgen stereophotogrammetric analysis (RSA) (Selvik 1989) to investigate the stability

of fixation of a fully-threaded cementless acetabular prosthesis (Link V-type).

PATIENTS AND METHODS

We investigated unilateral hip replacement in 12 women and eight men aged 35 to 65 years (mean 50.7) with osteoarthritis of the hip. The threaded acetabular prostheses were of cobalt-chrome alloy (12) or Tilastan, Ti-A16-V4 (8) (Table I). The choice of prosthesis was partly determined by the diameter of the acetabulum, because at the time of the operation the Tilastan cups were not available in all sizes. The femoral prostheses were either cemented (Lubinus SP; cobalt-chrome) or uncemented (Rippen; Tilastan, ceramic head).

Operative technique. Operations were performed as advised by the manufacturers, using a posterolateral approach. The acetabulum was reamed, the cortical layer being removed from the outer acetabulum until the spongiosa was visible. Medially, the cone shape of the prostheses required removal of a rim of subcortical bone. The diameter of the cup inserted was 4 mm larger than the largest reamer used. The cup was screwed into the acetabulum without prior tapping until the outer rim of the cup rested on the edge of the acetabulum. No peroperative fractures of the acetabulum, postoperative dislocations or infections were observed.

The patients were mobilised on the first postoperative day, and allowed to place the forefoot on the floor during walking with two crutches, but without further

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weight-bearing until six weeks later, when free weight-bearing was allowed.

Radiographic evaluation. On the pre-operative radiographs, the hips were classified according to the quality of the bone of the acetabulum (Saito et al 1987). Four hips were hypertrophic, 10 normotrophic and six of the atrophic type. Postoperative radiographs revealed a mean inclination of the cups of 54° (range 42° to 70°). The oblique position of the prosthesis prevented a reliable evaluation of radiolucent zones on conventional anteroposterior, lateral, and pelvic radiographs (Linder and Strid 1987; Bobyn, Engh and Glassman 1988).

Roentgen stereophotogrammetry. At the operation, from five to seven tantalum balls (diameter 0.8 mm) were inserted into the edge of each polyethylene cup; six to nine were placed into the innominate bone. RSA examinations were performed at one to three weeks (all patients), six weeks (6 patients), three months (4), six and 12 months (all), and at 24 months (19). Two tubes were used for simultaneous exposures with uniplanar techniques (Baldursson et al 1979; Mogensen et al 1982; Mjöberg 1986; Selvik 1989).

movements between this and other spheres in the polyethylene cup.

To visualise the movements in the frontal plane, nine definable landmarks were plotted on the two views of the initial investigation in one of the patients (Fig. 1, case 17). The three-dimensional positions of these points were calculated and transformed to the subsequent examination two years later by using the rigid body identified by four tantalum markers in the acetabular cup (van Dijk, Huiskes and Selvik 1979; Kärrholm et al 1988). The precision of the measurements (Table II) was assessed by 26 double examinations (Mjöberg 1986).

Clinical evaluation. The patients were asked about the presence and sites of pain at the two-year follow-up.

Statistical method. The Mann-Whitney U-test was used for the statistical calculations.

RESULTS

Migration. Seven acetabular prostheses had migrated medially from 0.3 to 2.5 mm (mean 1.1) and six laterally from 0.6 to 1.4 mm (mean 1.1) (Fig. 2). All the cups had

Table I. Clinical details and maximum migration in any direction in 20 fully-threaded porous-coated acetabular cups in osteoarthritic patients

Case	Side	Age at operation	Sex	Type of arthritis*	Type of prosthesis†	Maximum migration (mm)			Pain
						6 mth	12 mth	24 mth	
1	R	35	F	H	C	0.6	1.5	1.9	None
2	R	36	F	N	C	0.7	1.9	2.0	Mild
3	R	39	F	N	C	0.8	1.2	1.4	Mild
4	R	42	F	N	T	0.5	0.3	0.3	Mild
5	L	45	F	A	C	0.6	1.3		Mild
6	R	47	M	H	T	1.3	0.3	0.8	Severe
7	R	50	F	N	C	1.3	1.8	2.2	None
8	R	50	F	N	C	0.8	1.1	2.4	Mild
9	L	51	F	A	C	0.8	1.2	1.4	Mild
10	L	52	M	A	T	0.4	0.4	0.7	Mild
11	L	52	M	A	T	0.3	1.4	2.0	Moderate
12	R	52	M	N	T	0.9	0.9	1.3	Mild
13	L	54	F	N	C	0.3	0.9	2.1	None
14	R	54	F	A	C	1.0	1.6	1.7	Mild
15	R	54	M	N	T	0.7	0.5	0.6	Mild
16	L	55	F	A	C	1.0	1.2	1.9	Moderate
17	R	56	M	H	T	1.6	2.3	2.6	Mild
18	R	61	M	H	C	1.4	1.7	2.4	Mild
19	R	65	F	N	T	1.2	2.0	2.5	Mild
20	R	65	M	N	C	0.3	0.4	0.7	Mild

* H, hypertrophic; N, normotrophic; A, atrophic (Saito et al 1987)

† C, cobalt-chrome; T, titanium alloy

In 13 patients the configuration of the markers in the polyethylene cup allowed evaluation of rotatory movements, but in seven the metallic part of the implants concealed some of the tantalum balls leaving an insufficient number of markers or a configuration close to a straight line. A further 10 patients were excluded because the stability of the only tantalum ball available for measurements could not be confirmed by the absence of

Table II. The smallest movements in each axis which were significant at $p < 0.01$

	Cardinal axis		
	Transverse X	Longitudinal Y	Sagittal Z
Migration (mm)	0.30	0.25	0.50
Rotation (degrees)	1.3	1.5	0.8

Fig. 1a

Fig. 1b

Fig. 1c

Figure 1a – The right hip of a 56-year-old man (case 17) after insertion of a Lubinus SP femoral component and a threaded cobalt-chrome acetabular cup. One year after the operation the patient had no pain. At two years (Fig. 1b) he had mild pain in the groin when starting to walk. Radiographically there was no obvious migration. Figure 1c – Reconstruction of the metallic part of the acetabular prosthesis in the frontal plane (only 4 of the 9 points used are illustrated). The medial part of the prosthesis migrated most: points 1 and 2 having displaced proximally by 4.9 and 6.1 mm, and medially by 3.4 and 1.1 mm to points 1' and 2'. Points 3 and 4 also displaced proximally and laterally by smaller amounts. The prosthesis had rotated about the sagittal axis by 5.7° (decreased inclination).

Fig. 2

Average medial or lateral migration ($\pm$ range) of the threaded acetabular cups. The number of cups which showed significant migration is indicated.

migrated proximally (Fig. 3). In six patients this was by 0.5 to 1.0 mm and in 12 over 1.0 mm. The greatest movement was in case 17 (Table I, Fig. 1). In the six patients studied at six weeks, before full weight-bearing, there was continuous proximal migration, levelling off after six to 12 months (Fig. 4). The rate of migration, shown by the slope of the graphs, tended to slow down with time during the first postoperative year, but in two cases it increased again during the following year.

Nine prostheses showed an anterior or posterior movement from 0.5 to 2.4 mm (Fig. 5). In two this was in an anterior direction; in seven it was posterior. There was no significant difference between cups made of cobalt-chrome or titanium alloy as regards the magnitude of migration.

Rotation. Rotatory movements were recorded in nine of the 13 cups for which this type of analysis could be performed. In eight cups there was rotation of up to 5.7° (range 0.8° to 5.7°) about the sagittal axis (change of

inclination); five showing a decrease and three an increase in inclination. Five cups showed rotation about the transverse axis (1.3° to 4.1°) and five rotation into increased anteversion about the longitudinal axis (1.7° to 2.2°).

Radiography. We found no significant correlation between the type of the osteoarthritis and the magnitude of migration. The average proximal migration was 1.9 mm (range 0.8 to 2.6), 1.2 mm (range 0.3 to 2.5) and 1.3 mm (range 0.7 to 2.0) respectively in hypertrophic, normotrophic and atrophic types.

Pain. Sixteen patients complained of mild to moderate pain in the groin or the gluteal region (Table I), most commonly when they were starting to walk. One also had severe gluteal pain at rest and required a revision operation a few months after the two-year follow-up (case 6). At the operation, the screw cup was surrounded by fibrous tissue and was easily extracted. Multiple peroperative cultures were negative. After the revision the patient became pain free but has only been followed for a few months.

DISCUSSION

Fully-threaded cementless acetabular prostheses have been recommended for use in primary hip arthroplasty and in revision surgery (Lord and Bancel 1983). Morscher (1987) claimed that bone cement is no longer needed for fixation of the acetabular component and there have been several reports of promising clinical results (Lord and Bancel 1983; Bertin et al 1985; Engh 1987; Gibson et al 1988; von Thabe and Miehke 1988). However, some recent studies with follow-up of three to four years have reported a high incidence of failure (Herberts and Malchau 1987; Ayerza et al 1988; Kennedy 1988; More et al 1988), but no long-term results with these prostheses are available. Clinical loosening of the acetabular component in cemented hip arthroplasty is rare during the first four years after surgery (Morscher 1983) and this is probably also true for some types of cementless arthroplasty, depending on the design of the implant.

Pilliar et al (1986) demonstrated that bone ingrowth into porous surfaces can occur only in the presence of an initially stable fixation, concluding that movement exceeding 0.15 mm will result in the formation of fibrous tissue between the implants and bone and prevent 'osseointegration' (Albrektsson and Albrektsson 1987). In our study all but one of the prostheses had moved 0.3 mm or more during the first six postoperative months; this indicates that the cups are probably surrounded by fibrous tissue (Bobyn et al 1988).

The Link V-type threaded cup has relatively deep and widely spaced threads. It should therefore offer strong initial fixation compared with many other types of threaded cup (Kody et al 1988). The density of the bone varies in the arthritic acetabulum; it is usually most sclerotic in the proximal and lateral parts, while medially

Fig. 3

Average proximal migration ($\pm$ range) of 20 threaded acetabular cups, with the number migrating. One patient did not attend for RSA at two years but showed proximal migration at one year.

Fig. 4

Proximal migration in the six patients who were examined at six weeks and at three (4 patients), six, 12, and 24 months postoperatively. Case numbers are given.

and distally it is usually softer. When the cup is screwed into the acetabulum the threads do not sufficiently penetrate the roof and the cup therefore tends to move distally resulting in poor fixation (Fig. 6).

It has been shown experimentally in dogs that threaded cups have less primary stability than porous-coated press-fit cups (Tooke et al 1988), and offer a poor contact between prostheses and bone (Schimmel and Huiskes 1988). Finite element analysis (Huiskes 1987)

Fig. 5

Average anterior or posterior migration ($\pm$ range) of the threaded acetabular prostheses. The number of migrating cups is indicated.

Fig. 6

Postoperative radiograph of the left hip of a 45-year-old woman (case 5) after the insertion of a threaded cobalt-chrome acetabular prosthesis. Proximally, at the acetabular roof, there is minimal penetration of the threads into the bone.

has indicated that load transfer to the bone is mainly concentrated at the first and last threads, producing stress peaks in these areas. By contrast, the use of bone cement enlarges the contact area and provides a more favourable load transfer (Charnley 1965; McKee 1970). We found a higher frequency and rate of migration in threaded cups than those recorded for cemented acetabular prostheses

(Mjöberg et al 1986), presumably as a result of these differences.

The biocompatibility of Tilastan has not been as well documented as that of pure titanium (Albrektsson et al 1981; Linder et al 1988), but close contact between bone and metal has been demonstrated after using both Ti-Al-V (Lintner, Zweymüller and Brand 1986) and cobalt-chrome alloy (Engh, Bobyn and Glassman 1987). In an experimental study of osseointegration of bulk implants in rabbits, Linder found no differences in bone-implant contact when comparing pure titanium with titanium alloy, cobalt-chrome alloy and stainless steel (Linder 1989). We believe that in our study the mechanical factors discussed above were most important for the outcome. A threaded ring is a rigid construction; this reduces the effect on shock-absorbing properties of changing from cobalt-chrome to titanium with its lower elastic modulus (Huiskes 1987).

Migration is a sensitive measurement of clinical loosening in patients who have delayed pain after a total hip arthroplasty (Mjöberg et al 1985), but the clinical implications of decelerating migration after operation remain to be established. We are concerned about the result in cases with high and continuing rates of migration, in combination with persisting pain. Until the results of controlled long-term studies of threaded cups are available we think it is advisable to use other methods of primary fixation.

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