Acta orthop. scand. *53,* 929–936, 1982

SURFACE REPLACEMENT OF THE HIP IN CHRONIC ARTHRITIS

A Clinical, Radiographic and Roentgen Stereophotogrammetric Evaluation

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Surface replacement of the hip was performed on nine patients (11 hips) with chronic arthritis. The results were evaluated twice clinically, as well as by radiography and roentgen stereophotogrammetry, an average of 15 and 23 months postoperatively. The early clinical results were promising.
One or both of the components were loose in five hips and the acetabular socket had migrated in one hip, as revealed by the radiograms. Roentgen stereophotogrammetry revealed loosening in one hip and migration of one or both of the components in eight hips altogether. The radiograms gave the information needed in the daily routine but roentgen stereophotogrammetry gave more accurate information about early migration.
At the third clinical follow-up, an average of 35 months postoperatively, two hips had been reoperated on and two had developed pain.

Key words: hip; juvenile chronic arthritis; roentgen stereophotogrammetry; surface replacement

Accepted 11.iv.82

Surface replacement of the hip has been increasingly used during the past decade as an alternative total hip replacement (THR) especially in younger patients with hip disabilities (Freeman 1978). Chronic atrophic arthritis has been considered as only a relative indication for surface replacement due to the poor quality of the bone tissue (Wagner 1978). The same problems are encountered with THR in patients with juvenile chronic arthritis (JCA), and the long-term results indicate that several revisions may be necessary (Mogensen et al., to be published).

Well aware of the risks involved but in the hope of gaining time, the present authors started to perform surface replacement of the hip for patients with JCA in 1978. The early clinical results have already been presented (Lidgren et al. 1981, Mogensen et al. 1981). It is therefore of great interest to evaluate how surface replacement prosthesis components behave in patients with poor bone quality such as in JCA.

Conventional radiograms are convenient to use but may not be able to reveal early changes in the position of prosthetic components. Roentgen stereophotogrammetry offers very high accuracy for the determination of the three-dimensional position of implants in the bone (Selvik 1974). This method has been used in Lund for the determination of migration and wear in THR (Baldursson et al. 1979, 1980). It can also be used in surface replacement of the hip.

This study is a comparison of clinical, radiographic and roentgen stereophotogrammetric findings in surface replacement of the hip in young patients with chronic arthritis.

Supported by the Swedish Medical Research Council (Project No. B82-17X-D4776-08) and Stiftelsen för bidrag åt vanföra i Skåne, Helsingborg.

0001-6470/82/060929-08 $02.50/0

PATIENTS AND METHODS

Surface replacement of the hip was performed on 13 patients (17 hips) with chronic arthritis from April 1978 to October 1979. Nine of the patients (11 hips) were evaluated by roentgen stereophotogrammetry and the results compared with the radiographic changes and the clinical results. The average age at the time of surface replacement was 23 years (range 14–43 years). There were six female and three male patients. Six of the patients had JCA (Wood 1978) and three had rheumatoid arthritis. The duration of the disease was from 2 to 13 years and duration of hip symptoms from 2 to 12 years.

Clinical and radiographic evaluation

The patients were evaluated twice clinically, as well as radiographically and by roentgen stereophotogrammetry. The radiograms were obtained in all cases within 3 months of the clinical and roentgen stereophotogrammetric examination. The scoring system used by Merle d'Aubigné & Postel (1954) and modified by Charnley (1972) was used for clinical evaluation. The first evaluation was carried out, on average, at 15 months (range 9–24 months) and the second at 23 months (range 12–33 months). A third clinical evaluation was performed for the non-reoperated patients an average of 35 months (range 27–44 months) after surface replacement. Conventional A–P and lateral radiograms were used for radiographic evaluation. The acetabular socket was considered loose if a radiolucent zone of more than 2 mm was seen locally or all around the socket. The femoral cup was considered loose if there had been a change in the original position.

Roentgen stereophotogrammetric investigation

Tantalum balls, 0.8 mm in diameter, were inserted under local anaesthesia, using a special instrument (Aronson et al. 1974) and guided by fluoroscopy. This was done 3 months to 2 years after the surface replacement. Four balls were inserted percutaneously through four punctures (about 1 cm apart) into the crista iliaca and four balls through one puncture into the trochanter major. The roentgen stereophotogrammetric examination was performed using the following technique: simultaneous exposures of the hip were made with two roentgen tubes 65 cm apart, and the operated leg hanging freely (Figure 1), and another examination was performed with the patient standing on the operated leg. At the first investigation one examination was also performed with the leg in abduction.

Before examination of the patient the stereo roentgen apparatus was calibrated using a glass-plexiglass test object with known three-dimensional positions of tantalum markers. A reference plate with tantalum markers in front of the film was exposed at this calibration and in the patient examinations the relation between the roentgen foci and these reference markers, exposed on the patient films, was unchanged.

The first roentgen stereophotogrammetric examination was performed at times varying from the same day and up to 65 days after the insertion of the tantalum balls (in ten cases within 1 month). The second investigation was performed from 1 to 13 months after the first one.

The films were evaluated by the method described by Baldursson et al. (1979), with the modification that the metal ring in the acetabular socket was also evaluated as there were no tantalum markers in the socket. By this method the position of the centre of the sphere (of which the femoral cup represents a part) and of the centre of the acetabular indicator ring were calculated.

Instability (displacement from unloaded examination in the same day) and migration of both the acetabular socket and the femoral cup were determined in relation to the tantalum indicators in the crista and the trochanter, respectively. The laxity of the hip joint, which was taken as the vertical movement between the femoral cup and ring centre, was also assessed.

RESULTS

Clinical results

Initially the patients experienced very satisfactory pain relief after surface replacement. The score for hip pain averaged 2.6 points before the arthroplasty and 5.6 and 5.3 points, respectively, at the first two follow-ups (at 15 and 23 months). At the third clinical follow-up two hips (nos. 3 and 7) had been reoperated on and two others had developed hip pain (nos. 6 and 11) (Table 1).

One of the reoperated hips (no. 7) was pain-free for 7 months but then developed pain. The radiograms taken 3 months later revealed that the femoral cup, which was in a position of 10 degrees of varus from the beginning, had slipped into a greater degree of varus and later became grossly displaced. THR was performed after 13 months and has so far given good results. The other reoperated patient (no. 3) had JCA, and bilateral surface replacement (nos. 3 and 4) was performed in spite of acetabular protrusion on the right side. During the operation on the right side (no. 3) the patient sustained a fracture of the central part of the acetabular floor, which eventually healed. The patient was pain-free in the beginning but developed severe hip pain 25 months later and the acetabular cup was replaced because of loosening.

The range of hip movement increased from an

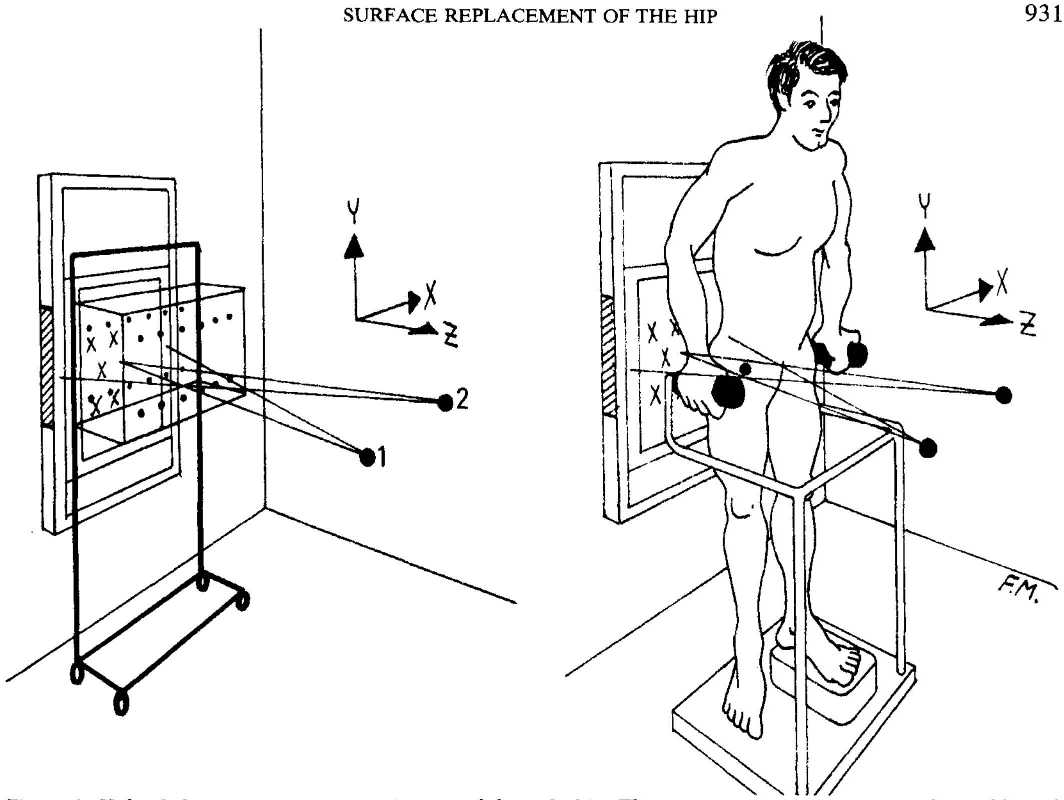

Figure 1. Unloaded stereo roentgen examination of the right hip. The stereo roentgen apparatus is first calibrated, using a test object with tantalum markers in two planes. In front of the film a reference plate with tantalum markers (shown for focus 2) is fixed and these markers are used to relate film coordinates in patient examinations to the laboratory coordinate system.

Table 1. Numerical classification of pain, range of movement and walking capacity for 11 surface replacements in nine patients*

Number of hip	Follow-up (months)			Pain				Range of movement				Walking			
				Before operation	Follow-up			Before operation	Follow-up			Before operation	Follow-up		
	1	2	3		1	2	3		1	2	3		1	2	3
1	24	33	44	3	6	6	5	1	6	5	5	2	5	5	5
2	20	28	40	2	6	6	6	2	5	5	5	2	3	3	3
3	17	26	**	2	6	2	**	2	5	5	**	2	4	2	**
4	17	31	37	2	6	6	5	3	5	5	5	2	4	3	3
5	17	25	36	2	6	6	5	3	5	5	5	2	3	3	3
6	15	23	34	2	6	6	3	4	5	6	6	2	5	5	2
7	11	12	**	3	2	2	**	3	4	4	**	3	2	2	**
8	11	20	31	3	6	6	6	1	4	4	3	2	6	6	5
9	11	20	31	3	6	6	6	4	5	5	5	3	5	5	6
10	11	20	31	3	6	6	6	1	4	4	4	2	6	6	5
11	9	16	27	3	6	6	4	1	5	5	4	2	6	6	3
Average	15	23	35	2.6	5.6	5.3	5.1	2.3	4.8	4.8	4.7	2.2	4.3	4.0	3.9

* The classification of Merle d'Aubigné & Postel as modified by Charnley, see text.
** Reoperation, see text.

Table 2. Roentgen stereophotogrammetric and radiographic analysis

Number of hip	Follow-up (months) First Second	Acetabular socket: Roentgen stereophotogrammetry* Instability	Acetabular socket: Roentgen stereophotogrammetry* Migration	Acetabular socket: Radiographic changes Radiolucent zones in mm	Femoral cup: Roentgen stereophotogrammetry* Instability	Femoral cup: Roentgen stereophotogrammetry* Migration	Femoral cup: Radiographic changes
1	24	N.S.	N.S.	1 all around	N.S.	N.S.	None
	33	N.S.		1 all around	N.S.		
2	20	N.S.	N.S.	1 laterally 3 medially	N.S.	−1.1	None
	28	N.S.		1 laterally 5 medially	N.S.		
3	17	N.S.	1.3	1 laterally 4 medially	N.S.	−1.2	None
	26	N.S.		1 laterally 5 medially	N.S.		
4	17	N.S.	1.3	1 all around	N.S.	−1.3	None
	31	N.S.		1 all around	N.S.		
5	17	N.S.	N.S.	1 all around	N.S.	−1.7	None
	25	N.S.		1 all around	N.S.		
6	15	N.S.	1.0	1 laterally 2 medially	N.S.	N.S.	None
	23	N.S.		1 laterally 2 medially	N.S.		
7	11	N.S.	1.2	1 all around	−0.7	−6.6	Initially in 10° varus and subsided
	12	N.S.		1 all around	***		
8	11	0.6	2.7	1 all around	N.S.	−2.2	0° into 10° varus and subsided
	20	N.S.		2 all around	N.S.		
9	11	**	**	1 all around	N.S.	N.S.	None
	20	**		1 all around	N.S.		
10	11	**	**	1 laterally 3 medially	N.S.	−2.0	0° into 10° varus and subsided
	20	**		1 laterally 6 medially	N.S.		
11	9	N.S.	N.S.	1 all around	N.S.	N.S.	None
	16	N.S.		1 all around	N.S.		

* Translations along vertical (Y) axis in mm. Only values higher than 0.5 mm are considered significant; see text. N.S. = not significant.

** Could not be evaluated; see text.

*** Only examination in abduction on this occasion; see text.

average of 2.3 points before operation to 4.7 points at the most recent follow-up. All but one hip were in class 4 or better after the arthroplasty but six were in class 1 (four hips) or class 2 (two hips) before operation (Table 1). There was a small increase in the walking capacity, from 2.2 points before the operation to 3.9 points at the most recent follow-up, mainly because of involvement of other joints in the lower extremities. This improvement was, however, considered to be most important by the patients.

Radiographic results

At the first radiographic follow-up (15 months) there was a radiolucent zone around all 11 acetabular sockets (Table 2). Around seven sockets the zone was a mm or less, in one socket 2 mm medially and 1 mm laterally, in two sockets 3 mm medially and 1 mm laterally, and in one socket 4 mm medially and 1 mm laterally.

At the second follow-up (23 months) there were complete radiolucent zones around all the acetabular sockets. Around six of the sockets the zones were still 1 mm or less; one socket had 2 mm medially and 1 mm laterally. In one socket (no. 3) the zone had progressed from 4 mm medially and 1 mm laterally to 5 mm medially, and the socket was replaced because of hip pain 26 months postoperatively. In another hip (no. 2) there was a progression from 3 to 5 mm medially but the 1 mm lateral zone remained unchanged and the socket had rotated into a more vertical position. One socket (no. 4) with a 1 mm zone all around had also migrated 5 mm upwards and slightly medially as compared with the initial films (Figure 2).

Figure 2. Hip no. 4. The tantalum balls are relatively well spaced. Migration can be observed as indicated by a gap between the lower part of the cement and the lower part of the acetabulum.

A 15-year-old boy with severe JCA, bilaterally operated, had a 3 mm zone medially and 1 mm laterally in the right socket (no. 10) and 1 mm in the left (no. 8) at the first follow-up. At the second follow-up he had a 6 mm zone medially and 1 mm laterally; the socket had rotated into a more vertical position on the right side and on the left side there was a 2 mm zone. Both the femoral cups had been in a neutral position from the beginning but had moved into 5 degrees varus at the first follow-up. At the second follow-up the cups were in 10 degrees varus, both had migrated a few millimetres and there was resorption of the femoral neck on both sides. This patient had been able to walk short distances with two crutches before operation. He had started jogging about 5 kilometres twice a week after operation but mentioned this too late. He was, however, still painfree and used no walking aids at the third follow-up 31 months later. In one more hip (no. 7) the femoral cup tilted into varus and total hip replacement was performed after 13 months.

Roentgen stereophotogrammetric analysis

When the films were analysed it became evident that the dispersion of the tantalum balls in the crista and the trochanter major was not satisfactory. The balls in the crista iliaca were often almost in a straight line and the balls in the trochanter major were too close together. An overall accuracy of about 0.1 mm along the X, Y and Z coordinate axes could therefore not be obtained (Olsson 1975, Baldursson et al. 1979). For the definition of the coordinate axes and their positive directions see Figure 1. Control analysis, consisting of calculating movement between repeated unloaded investigations and re-evaluations of stereo films, revealed that movement of the components up to 0.5 mm along the vertical (Y-) axis was within the error of the method and only values exceeding 0.5 mm were considered to be representative of true movement. However, in some cases with better than average positioning of implants it was evident that the measurement quality was about five times as accurate. It might have been possible to calculate separate precision values for the different configurations of tantalum implants, but this was considered too laborious and the value of 0.5 mm in the loading direction, representing the less favourable but most common configuration, was used for the whole material. There was less precision in calculating translations along the transverse and sagittal axes because of the positioning of the indicators in the crista iliaca mainly along an anterior-caudal, often almost a vertical axis, and here the cases also varied to a greater extent.

Acetabular sockets

Only one acetabular socket (no. 8) showed movement, exceeding the error of the method (>0.5 mm), along the Y-axis at the stability test during the first examination. All the acetabular sockets were stable at the second examination (Table 2). Two hips were not evaluated, one (no. 9) because the wire around the cup was missing and in the second (no. 10) because one of the tantalum balls in the crista was not stable and the other three formed a straight line. The socket migrated cranially 1.1 mm to 2.7 mm in five hips (Table 2). The migration is the calculated movement occurring between the unloaded examinations at the two follow-ups.

An illustration of the accuracy of measurement and three-dimensional displacement when the tantalum balls are spaced in a better than average configuration is given by hip no. 4 (Figure 2). The displacement vector of the acetabular ring centre in relation to the pelvis implants was (0.0, –0.1, 0.2) mm between two unloaded examinations at the 17-month follow-up; for the stability test on that occasion it was (0.3, 0.1, 0.1) mm, and (0.0, 0.0, 0.1) mm for loading in abduction. For the stability test at the 31-month follow-up it was (–0.3, 0.0, 0.2) mm. The migration was (–1.0, 1.3, 0.0) mm. The migration vector corresponds well with the medial radiolucent zone (left side prosthesis, –X translation medially).

Femoral cups

The femoral cups were stable according to our criteria (vertical movement ≦0.5 mm) in all but one hip. In this hip (no. 7) there was at the two examinations a caudal displacement of 0.7 mm and 6.6 mm, respectively, but the second value is the migration between the unloaded examination on the first occasion and the only examination (in abduction) on the second. Six of the femoral cups subsided 1.1 mm to 2.2 mm between the follow-ups (Table 2) but none was symptomatic.

In one case, hip no. 8, there was a greater cranial movement, 1.4 mm of the acetabular socket, at the examination in abduction than during loading by standing, and in one case (no. 3) there was a limit value, –0.5 mm of the femoral cup during loading by standing but a movement of –1.0 mm during abduction.

Laxity

In one hip (no. 11) joint laxity was 0.9 mm at the first examination and in another hip (no. 8) it was 0.9 mm at the second evaluation. In a third hip (no. 9) with no wire around the cup, joint laxity and eventual instability of the socket measured 0.8 mm and 0.9 mm, respectively, at the two examinations.

DISCUSSION

The era of total hip prosthesis was started by Charnley in the early sixties and the results after 10 to 15 years are promising but not without problems (Charnley 1979, Salvati et al. 1981). Three-quarters of the metal-on-plastic prostheses will probably survive for 20 years but the annual reoperation rate tends to increase with time due to mechanical loosening (Dobbs 1980). In 50 THR in JCA with an average follow-up time of 77 months there were six reoperations, four because of mechanical loosening and two because of infection. Ten hips were radiographically loose and two of these are at present awaiting reoperation (Mogensen et al., to be published).

Surface replacement of the hip was developed during the seventies as an alternative to THR for younger patients with hip disability. The aim has been to preserve the femoral head. Revision to a total hip arthroplasty can therefore be performed later if required.

An increased frequency of radiolucent zones and migration of the THR acetabular socket has been reported in patients with rheumatoid arthritis (DeLee & Charnley 1976, Charnley 1979), and severe chronic arthritis has been considered only a relative indication (Wagner 1978) or even a total contraindication (Scott & Sledge 1981) for surface replacement due to poor bone quality. However, all types of THR, cemented or uncemented, have the same basic anchorage problems in this patient group.

Surface replacement of the hip is technically more demanding, especially in JCA, often because of contractures, increased valgus angulation and anteversion which cannot be corrected by this procedure. Because of the small skeletal size an extra small prosthesis has had to be developed for our patients (Lidgren et al. 1981, Mogensen et al. 1981). Our early clinical results were promising, with relief of pain in 16 out of 17 hips (Mogensen et al. 1981). At the third follow-up two patients had been reoperated on and two had developed hip pain. The degree of pain relief was lower than the previous rating but still satisfactory and appreciated by the patients (Table 1).

Concerning the acetabular sockets only one out of 11 (no. 8) showed signs of instability (vertical movement >0.5 mm). However, this instability was found only at the first examination. Furthermore the acetabular socket in hip no. 3 showed no instability, either at the first or the second examination but the migration between examinations was 1.3 mm. On both occasions the radiograms revealed a radiolucent zone measuring about 4 and 5 mm medially. The acetabular socket was found to be loose at reoperation. The reason that the roentgen stereophotogrammetric stability test did not give this information is probably that the pain-induced muscle contracture was stronger than the difference in the compressive force between "unloading" and weight-bearing of the hip. Five acetabular sockets migrated 1.0 to 2.7 mm. In three hips there was a radiolucent zone of more than 2 mm and two of these had also rotated into a more vertical position. One acetabular socket had migrated radiographically about 5 mm compared to the initial films.

In one patient (no. 7), later reoperated, the femoral cup had moved 0.7 mm at the first examination and 6.6 mm between the first and second examinations, but the radiograms also revealed changes in the position of the femoral cup at both examinations. All other patients had stable femoral cups. There was a 1.1 to 2.2 mm subsidence of the femoral cups in six hips but the radiograms revealed changes in only two of these hips.

To achieve precise results by roentgen stereophotogrammetry the skeletal indicators must be widely spread in the bone (Olsson 1975, Baldursson et al. 1980). Probst (1980) has developed a qualified method for roentgen stereophotogrammetry of prosthetic components and has also encountered the problem of skeletal indicators being too close to a straight line. The roentgen technique used in this study, with simultaneous exposures, is more convenient than that of Probst (1980) especially if films of hips under load are required.

Conventional radiograms were found to be satisfactory for the daily routine in this study and gave the information needed. However, for more precise analysis the roentgen stereophotogrammetric method is superior in the evaluation of early migration. Stereophotogrammetric and radiographic examination revealed changes in more than half of both components and this, together with the decreasing pain score and the reoperations, is alarming.

In the thin acetabular socket the maximum stressing forces are 1.4 times higher but are distributed over only about one half of the area of bone cement interface compared with the thicker socket (Charnley 1979). These increased forces may be too great for the soft bone in some of the JCA patients. It is likely that fixation of the acetabular socket can be increased by multiple small burr holes and a pressurizer (Eftekhar & Pawluk 1980, Ling 1980), but a disadvantage of the method is that the true subchondral bone can not be preserved. A minimal increase in the thickness of the acetabular socket with the use of a metal backing could reduce the stress forces and distribute them more evenly over the bone cement interface (Harris 1982).

It is a minimum demand that surface replacement prostheses survive without clinical problems for at least 5 years in JCA patients. The present patients were the first to be operated on with the surface replacement prosthesis at our department. With careful selection of the patients and a change in operation technique and prosthesis design it should be easier to achieve this goal.

Patients with JCA and severe protrusion, fixed flexion contracture of more than 45 degrees, severe valgus deformity and/or increased anteversion are today treated with total hip prosthesis in our department.

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