Radiostereometric analysis in hip revision surgery– optimal time for index examination

6 patients revised with impacted allografts and cement followed weekly for 6 weeks

Ewald Ornstein[1], Herbert Franzén[2], Ragnar Johnsson[3] and Martin Sundberg[1]

Departments of Orthopedics, [1]Hässleholm-Kristianstad County Hospital, SE-281 25 Hässleholm, Sweden. Tel +46 451 864 72. E-mail: ewald.ornstein@skane.se; [2]Ängelholm County Hospital, SE-262 81 Ängelholm, [3]Lund University Hospital, SE-221 85 Lund, Sweden
Submitted 99-10-10. Accepted 00-04-16

ABSTRACT – We revised the hip (6 stems and 5 sockets) with impacted morselized allografts and cement in 6 patients. We followed prosthetic migration by roentgen radiostereometric analysis (RSA) every 7th day for 6 weeks after the first (index) examination performed on the first postoperative day before mobilization. Most of the migration occurred during the first 2 weeks. In most cases more than half of the distal stem migration was seen between the 1st and 14th days. In all cases, the stem and socket migrations slowed down gradually and several prosthetic components had become stable after 5 weeks. We conclude that it is essential to perform the index RSA examination on the 1st or 2nd day after surgery and to state when and how weight bearing should be permitted. Otherwise it will be difficult to compare prosthetic migration in various studies and define normative values for migration predicting survival.

■

Although radiostereometric analysis (RSA) (Selvik 1989) has become the golden standard for measuring skeletal kinematics in arthroplastic surgery, the optimal time for the first postoperative RSA examination (index examination) has not been determined. In the literature, the time between surgery and the index examination varies between 1 day and 2 months (Table 1) with differences in mobilization and weight bearing prior to the index examination.

We assessed the migration pattern by RSA of the prosthetic components during the initial 6 weeks following surgery with the index examination on the 1st postoperative day before mobilization.

Patients and methods

Patients

6 patients underwent a hip revision (6 stems and 5 sockets) with impacted morselized allografts and cement (Gie et al. 1993, Slooff, Schimmel and Buma 1993). We used the standard Exeter stem and the low profile socket (Howmedica International, Stains Middlesex, England). The 6 patients (4 men) were aged 68 (47–76) years and were revised for the first time. The preoperative diagnosis was aseptic loosening in all hips, however, routine multiple tissue cultures at surgery, according to Kamme and Lindberg (1981), revealed a low virulent infection in 2 of the cases (Propioni-bacterium acnes and Staphylococcus epidermidis, respectively). No postoperative mobilization was allowed prior to the index RSA examination, which was followed by weight bearing as soon as possible. Preoperative bone stock deficiency was classified according to Gustilo and Pasternak (1988) (Table 2).

Radiostereometric analysis (RSA)

RSA is the standard radiographic follow-up method for all hip revisions at our department. For this study, the patients were asked if they agreed to

Table 1. RSA reports dealing with hip arthroplasties

Year	Author	Index examination	Components studied	Primary/ revisions
1999a	Ornstein et al.	"2–3 days postoperatively and before mobilization"	Both	Both
1999b	Ornstein et al	"before mobilization"	Sockets	Revisions
1999	Alfaro-Adrián et al.	"at 1–2 weeks"	Stems	Primary
1999	Kärrholm et al.	" 5–10 days"	Stems	Revisions
1997	Nivbrant and Kärrholm	"within the first week"	Sockets	Revisions
1996	Nivbrant et al.	"within the first 11 days"	Sockets	Revisions
1996	Önsten et al.	"at about 1 week"	Stems	Primary
1995	Malchau et al.	"at 4–6 days"	Stems	Primary
1995a	Önsten et al.	"at 1 week"	Stems	Primary
1995b	Önsten et al.	"within 10 days"	Stems	Revisions
1995	Franzén et al.	"1 week"	Stems	Revisions
1994	Kärrholm et al.	"1 day to 2 months"	Stems	Primary
1994	Önsten et al.	"usually within 2 weeks"	Sockets	Primary
1994	Önsten and Carlsson	"within 1 week"	Sockets	Primary
1993	Franzén et al.	"1 week"	Sockets	Revisions
1992	Franzén et al.	"at 1 week"	Stems	Revisions
1991	Nistor et al.	"as soon as practical (6–11 days postoperatively)"	Stems	Primary
1990	Snorrason and Kärrholm	"1–3 weeks (all patients)"	Both	Revisions
1990	Mjöberg et al.	"1 week"	Both	Primary
1988	Wykman et al.	"1 week"	Stems	Primary
1986	Mjöberg et al.	"soon after operation"	Both	Primary
1979	Baldursson et al.	"5–15 days"	Sockets	Primary

participate in the investigation before any additional examinations were done. To permit RSA (Selvik 1989) evaluation of the prosthetic migration, 0.8 mm tantalum balls were implanted on the stem (shoulder and distal tip) and in the greater and lesser trochanters as well as in the socket, the acetabular roof and tuber ischii at surgery. The index RSA examination was performed with the patient supine before postoperative mobilization on the 1st day after surgery followed by similar RSA at 1, 2, 3, 4, 5 and 6 weeks postoperatively. The technical accuracy of the RSA set-up has previously been calculated by repeat examinations for both the stem (Ornstein et al. 1998) and socket (Ornstein et al. 1999b). Stem migration less than 0.3 mm in the distal/proximal direction, 0.5 mm in the medio/lateral and 0.6 mm in the posterior/anterior direction was not considered significant. Socket migration less than 0.2 mm in the proximal/distal direction, 0.3 mm in the medio/lateral and 0.3 mm in the posterior/anterior direction was not considered significant.

Results

Weight bearing

After the RSA index examination was performed, the patients were mobilized with 2 crutches and were instructed that there were no restrictions in weight bearing. All patients were able to climb stairs before discharge from the hospital 6–13 (median 7) days after surgery. They gradually stopped using 1 of the crutches, first inside their home then outside. 4 of the patients used either a crutch or a stick 4 weeks after surgery. 2 patients used a crutch between 4 and 6 weeks after surgery. Most patients reported that the main reason for using the crutch was that it gave a feeling of safety. None of them reported any pain from the operated hip, related to weight bearing at any time.

Migration

All prosthetic components migrated in at least 1 direction (Table 2). All 6 stems migrated distally (Figure 1), the median was 1.8 (1.3–4.8) mm and 4 of the 5 sockets migrated proximally (Figure 2), the median was 0.5 (0.4–1.8) mm. In all cases, the

Table 2. RSA migration of 6 stems and 5 sockets in revisions with impacted morselized allografts and cement

				Femoral component																	
A	B	C	D	Distal migration (mm) Accuracy 0.3 mm						Medial migration (mm) Accuracy 0.5 mm						Posterior migration (mm) Accuracy 0.6 mm					
Days after surgery				7	14	21	28	35	42	7	14	21	28	35	42	7	14	21	28	35	42
1	m	l	II	0.7	0.9	1.2	1.4	1.5	1.5	–	–	–	–	–	–	0.9	1.4	1.8	2.0	2.1	2.3
2	f	l	II	2.1	2.6	2.9	3.4 [c]	3.5	3.7	0.7	0.7	0.8	0.8 [c]	0.8	0.6	2.9	3.5	4.0	4.2 [c]	4.6	4.7
3 [a]	m	r	II	0.6	2.5	3.6	4.1	4.6	4.8	0.9	3.0	3.6	3.9	3.9	4.0	1.3	5.2	7.1	8.1	8.4	9.0
4 [a]	m	l	II	0.6	0.6	0.8	1.0	1.2	1.3	–	–	–	–	–	–	0.5	–	1.1	–	0.8	–
5 [b]	m	l	II	0.4	0.9	1.1	1.4	1.4	1.7	–	0.5	–	–	0.6	0.5	0.7	1.0	1.4	0.8	1.4	1.3
6	f	r	II	0.4	1.0	1.3	1.5	1.6	1.8	–	–	–	–	–	–	1.2	2.1	2.4	2.4	2.6	2.6

				Acetabular component																	
A	B	C	E	Proximal migration (mm) Accuracy 0.2 mm						Lateral migration (mm) Accuracy 0.3 mm						Posterior migration (mm) Accuracy 0.3 mm					
Days after surgery				7	14	21	28	35	42	7	14	21	28	35	42	7	14	21	28	35	42
1	m	l	x																		
2	f	l	II	0.2	0.3	0.3	0.4 [c]	0.3	0.4	–	–	–	– [c]	–	–	–	–	–	– [c]	–	–
3 [a]	m	r	II	0.5	0.8	1.2	1.4	1.6	1.8	–		0.4	0.4	0.4	0.5	–	–	–	–	–	–
4 [a]	m	l	II	–	–	–	–	–	–	–	–	–	–	0.3	0.4	–	–	–	–	–	–
5 [b]	m	l	II	0.2	0.4	0.5	0.6	0.7	0.5	–	–	–	–	–	–	–	–	–	–	–	0.3
6	f	r	II	–	0.2	0.3	0.4	0.4	0.5	–	–	–	–	–	–	–	–	–	–	–	–

A Patient and hip number
B Gender
C Side
D Femoral bone stock deficiency according to Gustilo and Pasternak (1988)
E Acetabular bone stock deficiency according to Gustilo and Pasternak (1988)

– No migration
[a] Infected
[b] The patient who used 1 crutch between 4 and 6 weeks after surgery
x Not revised
[c] Examination at the 29th day

migration slowed down gradually and the prosthetic movements had ceased in most of the directions at 6 weeks. Between the 5- and 6-week follow-ups, 1 stem migrated 0.3 mm in the distal direction, 1 stem migrated 0.6 mm in the posterior, 1 stem migrated 0.8 mm in the anterior, 1 socket migrated 0.2 mm in the proximal direction and 1 socket migrated 0.3 mm in the posterior direction.

Discussion

RSA (Selvik 1989) has become the preferred method for migration studies of the prosthetic components in primary and revision hip arthroplasties (Table 1). It has been suggested that early migration of the stem and the socket above a certain level, increases the risk of revision in primary hip arthroplasties (Freeman and Bordeneuve 1994, Kärrholm et al. 1994, Walker et al. 1995, Krismer et al. 1996) and rerevision in revision hip arthroplasties (Snorrason and Kärrholm 1990, Kärrholm et al. 1997).

In our study, we found that most of the migration occurred during the first 2 weeks. In most cases, more than half of the distal stem migration was observed between the 1st and 14th days. In all cases, the stem and socket migrations slowed down gradually and several prosthetic components were stable between 5 and 6 weeks.

Revisions, especially when using grafts, are often associated with higher migration than primary hip arthroplasties. Differences in the degree of stem migration in the studies of revisions with impacted morselized allografts and cement by Ornstein et al. (1998, 1999b) and by Kärrholm et al. (1999) might, at least partly, be explained by varying times prior to the index RSA examination and associated differences in mobilization and weight bearing prior to the index examination. Varying

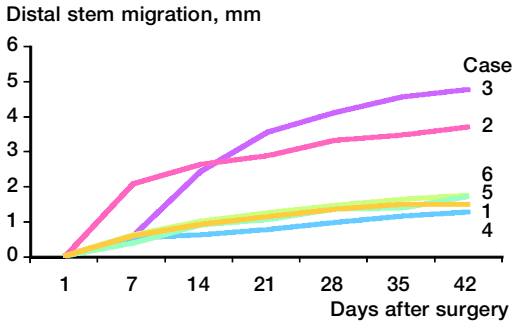

Figure 1. All 6 stems migrated distally.

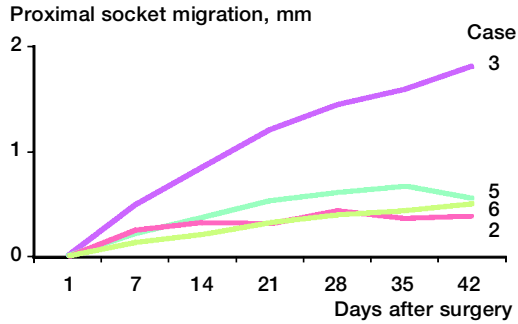

Figure 2. 4 of 5 sockets migrated proximally.

stem designs and graft impaction techniques should also be important (Kärrholm et al. 1997). The same may explain the varying degrees of socket migration reported (Snorrason and Kärrholm 1990, Franzén et al. 1993, Ornstein et al. 1999b). The magnitude of the prosthetic migration seen in our study cannot be explained by creep alone (Verdonshot and Huiskes 1996) or by bone resorption, which seems to be detectable at about 6 months (Kärrholm et al. 1999). Our interpretation is that migration was also due to compression of the grafts. If the purpose is to compare various surgical techniques, especially revisions with graft impaction, in which the size of the particles has been discussed as an important factor (Brewster et al. 1999), it seems necessary to examine the migration early. Whether this is valid for primary hip arthroplasties is not clear, although early index examination seems rational in the quest for information on early migration (Jasty et al. 1991).

We conclude that a considerable amount of the prosthetic migration occurs in the first 7 days after surgery in hip revisions with impacted morselized allografts and cement. It is therefore essential to perform the index RSA examination on the 1st or 2nd day after surgery and to specify when and how mobilization and weight bearing should be permitted. Otherwise, it will be difficult to compare prosthetic migration in different studies and define normative values for migration, predicting prosthetic survival.

This study was supported by Kristianstads läns landsting and the Swedish Medical Research Council (#17x-09509). We thank Agneta Nilsson for all the radiographs necessary for RSA, and Håkan Leijon for computerizing the RSA pictures.

Alfaro-Adrián J, Gill HS, Murray DW. Cement migration after THR. A comparison of Charnley Elite and Exeter femoral stems using RSA. J Bone Joint Surg (Br) 1999; 81: 130-4.

Baldursson H, Egund N, Hansson L I, Selvik G. Instability and wear of total hip prostheses determined with roentgen stereophotogrammetry. Arch Orthop Traumat Surg 1979; 95: 257-63.

Brewster N T, Gillespie W J, Howie C R, Madabhushi S P G, Usmani A S, Fairbairn D R. Mechanical considerations in impaction grafting. J Bone Joint Surg (Br) 1999; 81: 118-24.

Franzén H, Mjöberg B, Önnerfält R. Early loosening of femoral components after cemented revision. A roentgen stereophotogrammetric study. J Bone Joint Surg (Br) 1992; 74: 721-4.

Franzén H, Mjöberg B, Önnerfält R. Early migration of acetabular component revised with cement. Clin Orthop 1993; 287: 131-4.

Franzén H, Toksvig Larsen S, Lidgren L, Önnerfält R. Early migration of femoral components revised with impacted cancellous allografts and cement. A preliminary report of five patients. J Bone Joint Surg (Br) 1995; 77: 862-4.

Freeman M A R, Bordeneuve P. Early migration and late aseptic failure of proximal femoral prostheses. J Bone Joint Surg (Br) 1994; 76: 432-8.

Gie G A, Linder L, Ling R S, Simon J P, Slooff T J, Timperley A J. Impacted cancellous allografts and cement for revision total hip arthroplasty. J Bone Joint Surg (Br) 1993; 75: 14-21.

Gustilo R B, Pasternak H S. Revision total hip arthroplasty with titanium ingrowth prosthesis and bone grafting for failed cemented femoral component loosening. Clin Orthop 1988; 235: 111-9.

Jasty M, Maloney W J, Bragdon C R, O'Connor D O, Haire T, Harris W H. The initiation of failure in cemented femoral components of hip arthroplasties. J Bone Joint Surg (Br) 1991; 73: 551-8.

Kamme C, Lindberg L. Aerobic and anaerobic bacteria in deep infections after total hip arthroplasty : differential diagnosis between infectious and non-infectious loosening. Clin Orthop 1981; 154: 201-7.

Krismer M, Stockl B, Fischer M, Bauer R, Mayrhofer P, Ogon M. Early migration predicts late aseptic failure of hip sockets. J Bone Joint Surg (Br) 1996; 78: 422-6.

Kärrholm J, Borssén B, Löwenhielm G, Snorrason F. Does early micromotion of femoral stem prostheses matter? J Bone Joint Surg (Br) 1994; 76: 912-7.

Kärrholm J, Herberts P, Hultmark P, Malchau H, Nivbrant B, Thanner J. Radiostereometry of hip prostheses. Clin Orthop 1997; 344: 94-110.

Kärrholm J, Hultmark P, Carlsson L, Malchau H. Subsidence of a non-polished stem in revisions of the hip using impaction allograft. Evaluation with radiostereometry and dual-energy X-ray absorptiometry. J Bone Joint Surg (Br) 1999; 81: 135-42.

Malchau H, Kärrholm J, Wang Y X, Herberts P. Accuracy of migration analysis in hip arthroplasty. Digitized and conventional radiography, compared to radiostereometry in 51 patients. Acta Orthop Scand 1995; 66: 418-24.

Mjöberg B, Selvik G, Hansson L I, Rosenqvist R, Önnerfält R. Mechanical loosening of total hip prostheses. A radiographic and roentgen stereophotogrammetric study. J Bone Joint Surg (Br) 1986; 68: 770-4.

Mjöberg B, Franzén H, Selvik G. Early detection of prosthetic-hip loosening. Comparison of low- and high-viscosity cement. Acta Orthop Scand 1990; 61: 273-4.

Nistor L, Blaha J D, Kjellström U K, Selvik G. In vivo measurement of relative motion between an uncemented total hip component and the femur by roentgen stereophotogrammetric analysis. Clin Orthop 1991; 269: 220-7.

Nivbrant B, Kärrholm J. Migration and wear of hydroxyapatite-coated press-fit cups in revision hip arthroplasty. J Arthroplasty 1997; 12: 904-12.

Nivbrant B, Kärrholm J, Önsten I, Carlsson Å, Snorrason F. Migration of porous press-fit cups in hip revision arthroplasty. J Arthroplasty 1996; 11: 390-6.

Önsten I, Carlsson A S. Cemented versus uncemented socket in hip arthroplasty. A radiostereometric study of 60 randomized hips followed for 2 years. Acta Orthop Scand 1994; 65: 517-21.

Önsten I, Carlsson A S, Ohlin A, Nilsson J-Å. Migration of acetabular components, inserted with and without cement, in one-stage bilateral hip arthroplasty. J Bone Joint Surg (Am) 1994; 76: 185-94.

Önsten I, Åkesson K, Besjakov J, Obrant K L. Migration of the Charnley stem in rheumatoid arthritis and osteoarthritis. A roentgen stereophotogrammetric study. J Bone Joint Surg (Br) 1995a; 77: 18-22.

Önsten I, Carlsson Å, Sanzén L, Besjakov J. Migration of uncemented, long-stem femoral components in revision hip arthroplasty. A 2-8 year clinical follow-up of 45 cases and radiostereometric analysis of 13 cases. Acta Orthop Scand 1995b; 66: 220-4.

Önsten I, Carlsson Å S, Sanzén L, Besjakov J. Migration and wear of a hydroxyapatite-coated hip prosthesis. J Bone Joint Surg (Br) 1996; 78: 85-91.

Ornstein E, Johnsson R, Franzén H, Sandquist P, Sundberg M. Prosthetic migration during 2 years after hip revision with impacted morselized allograft evaluated by RSA. Trans Comb Orthop Res Soc 1998; 3: 65.

Ornstein E, Franzén H, Johnsson R, Löfqvist T, Stefánsdóttir A, Sundberg M. Early subsidence of the Exeter femoral stem within the cement mantle in primary arthroplasies and in revisions using impacted allografts and cement: a roentgen stereophogrammetric analysis. Hip International 1999a; 9: 139-43

Ornstein E, Franzén H, Johnsson R, Sandquist P, Stefánsdóttir A, Sundberg M. Migration of the acetabular component during 2 years after revision with impacted morselized allografts. A roentgen radiostereometric analysis. Acta Orthop Scand 1999b; 70: 338-42.

Selvik G. Roentgen stereophotogrammetry. A method for the study of the kinematics of the skeletal system. Acta Orthop Scand (Suppl 232) 1989: 1-51.

Snorrason F, Kärrholm J. Early loosening of revision hip arthroplasty. A roentgen stereophotogrammetric analysis. J Arthroplasty 1990; 5: 217-29.

Slooff T J, Schimmel J W, Buma P. Cemented fixation with bone grafts. Orthop Clin North Am 1993; 24: 667-77.

Verdonschot N, Huiskes R. Subsidence of THA stems due to acrylic cement creep is extremely sensitive to interface friction. J Biomech 1996; 29: 1569-75.

Walker P S, Mai S F, Cobb A G, Bentley G, Hua J. Prediction of clinical outcome of THR from migration measurements on standard radiographs. J Bone Joint Surg (Br) 1995; 77: 705-14.

Wykman A, Selvik G, Goldie I. Subsidence of the femoral component in the noncemented total hip: a roentgen stereophotogrammetric analysis. Acta Orthop Scand 1988; 59: 635-7.