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Definition of endoprosthetic loosening

Comparison of arthrography, scintigraphy and roentgen stereophotogrammetry in prosthetic hips

Contrast arthrography, radionuclide arthography, scintigraphy and roentgen stereophotogrammetric analysis (RSA) were used to detect mechanical loosening in 14 painful total hip replacements. All prosthetic components unstable by RSA, or with abnormal arthrogram, or with increased scintigraphic activity, or loose at revision were migrating, but no non-migrating components demonstrated any of these signs of loosening. Our findings indicate that mechanical loosening should be defined as migration.

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Contrast arthrography (Murray & Rodrigo 1975, O'Neill & Harris 1984), radionuclide arthrography (Abdel-Dayem et al. 1982, Uri et al. 1984) and scintigraphy (Sjöstrand 1974, Häckel et al. 1978, Weiss et al. 1979, Rushton et al. 1982) have been used to detect mechanical loosening of total hip prostheses (THP). The results have been conflicting, mainly because of disagreement about the diagnostic criteria.

We evaluated these indirect techniques by comparison with roentgen stereophothogrammetric analysis (RSA), which reveals both instability and migration by direct measurement (Mjöberg et al. 1984 a,b).

Patients and methods

Fourteen patients with 14 THP for arthrosis, all painful on weight-bearing, were investigated. There were seven Lubinus, three Brunswik and four Charnley prostheses. Twelve were primary and two were revision arthoplasties. In three acetabular and five femoral components there was a radiolucent zone between the cement and bone of 2 mm or more, a zone between the prosthetic component and the cement, or a fracture of the cement. There were no signs of infection.

RSA was performed after percutaneous implantation of tantalum balls into the os ilium and into the trochanter major. A detailed description of the RSA technique has been given by Selvik (1974), Baldursson et al. (1979, 1980) and Mogensen et al. (1982). The term *instability* is used for prosthetic component displacement in relation to bone at distraction-compression and at rotation (Mjöberg et al. 1984 b). The term *migration* is used for displacement with time – in this investigation during mean 19(8–42) months. In an earlier report (Mjöberg et al. 1984a), the lower limit of significant ($p < 0,01$) translations was found to be 1.0, 0.5 and 2.0 mm for the acetabular component and 0.4, 0.4 and 1.6 mm for the femoral component along the x-(transversal), y-(frontal = longitudinal) and z-(sagittal) axis, respectively.

Contrast and radionuclide arthrography was performed under fluoroscopic control with a mixture of 10 ml water- soluble iodine contrast (Iohexol 240 mg J/ml) and 15 MBq ^{99m}Tc- sulphur colloid diluted in 1 ml saline (Abdel-Dayem et al. 1982, Uri et al. 1984). Following the intra-articular injection the patient walked around for some minutes, before anterior and lateral radiographs were taken. The patient then walked for a few more minutes and scintigraphic registrations in anterior and lateral projections were then made on transparent films with a large field-of-view gamma camera. Information was also stored in a 128 × 128 matrix on a dedicated minicomputer. Penetration of contrast medium and/or radionuclides into bone-cement or prosthesis-cement interfaces was considered abnormal.

Scintigraphy was performed 3–5 h after intravenous administration of 370 MBq ^{99m}Tc-MDP. Visually increased activity around the acetabular component

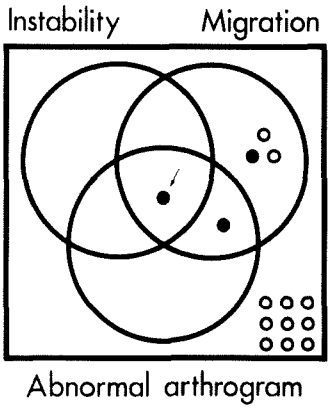
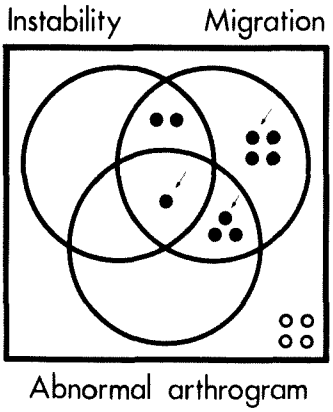


Figure 1. Relation between instability and migration revealed by RSA, abnormal arthrogram, and Tc-MDP-scintigraphy of the acetabular component in 14 hips. ● = increased activity by Tc-MDP-scan. ○ = no increased activity. Arrow indicates revised acetabular component.

Figure 2. Relation between instability and migration revealed by RSA, abnormal arthrogram, and Tc-MDP-scintigraphy of the femoral component in 14 hips. ● = increased activity at the tip by Tc-MDP-scan. ○ = no increased activity. Arrows indicate revised femoral components.



or at the tip of the femoral component was considered an indication of loosening (Häckel et al. 1978, Weiss et al. 1979). In ten cases, after completion of the ^{99m}Tc-MDP-study, 195 MBq ^{67}Ga-citrate was given intravenously and scintigraphy perfomed 2 days later. The scintigraphies were done on average 61(19–119) months after surgery.

Four hips were revised after these investigations, and specimens for bacteriological cultures were obtained at surgery (Kamme & Lindberg 1981).

Results

RSA

Of the 14 acetabular components five migrated (1.3–2.8 mm in varying directions along the x-axis in four cases, 0.6–6.5 mm cranially along the y-axis in all five cases, and 3.4 mm dorsally along the z-axis in one case), but instability was revealed in only one of these (2.8 mm along the y-axis) and in none of the nine non-migrating acetabular components (Figure 1).

Of the 14 femoral components ten migrated (0.4–2.7 mm medially along the x-axis in six cases, 0.4–4.5 mm distally along the y-axis in all ten cases, and 2.0–3.0 mm in varying directions along the z-axis in two cases), but instability was revealed in only three of these (0.5–1.1 mm along the x-axis in all three cases, 0.5–0.8 mm along the y-axis in all three cases, and 2.5 mm along the z-axis in one case) and in none of the four non-migrating femoral components (Figure 2).

In two of the 14 hips none of the prosthetic components migrated.

Arthrography

Contrast arthrography was abnormal in two of the five migrating acetabular components (Figure 1); radionuclide arthrography was abnormal in none.

Both contrast and radionuclide arthrography were abnormal in one of the ten migrating femoral components (Figure 3); radionuclide arthrography alone was abnormal in three of them (Figure 2).

Neither contrast nor radionuclide arthrography was abnormal in any of the non-migrating prosthetic components.

Scintigraphy

Of the five migrating acetabular components three had increased activity by Tc-MDP-scan (Figure 1) and none by Ga-scan. None of the nine non-migrating acetabular components showed increased activity.

All ten migrating femoral components showed increased activity by Tc-MDP-scan, at least at the tip of the stem (Figures 2 and 4); one migrating femoral component also showed increased activity by Ga-scan at the trochanter minor, where there was no increased activity on Tc-MDP-scan. None of the four non-migrating femoral components showed increased activity at the tip (Figure 2).

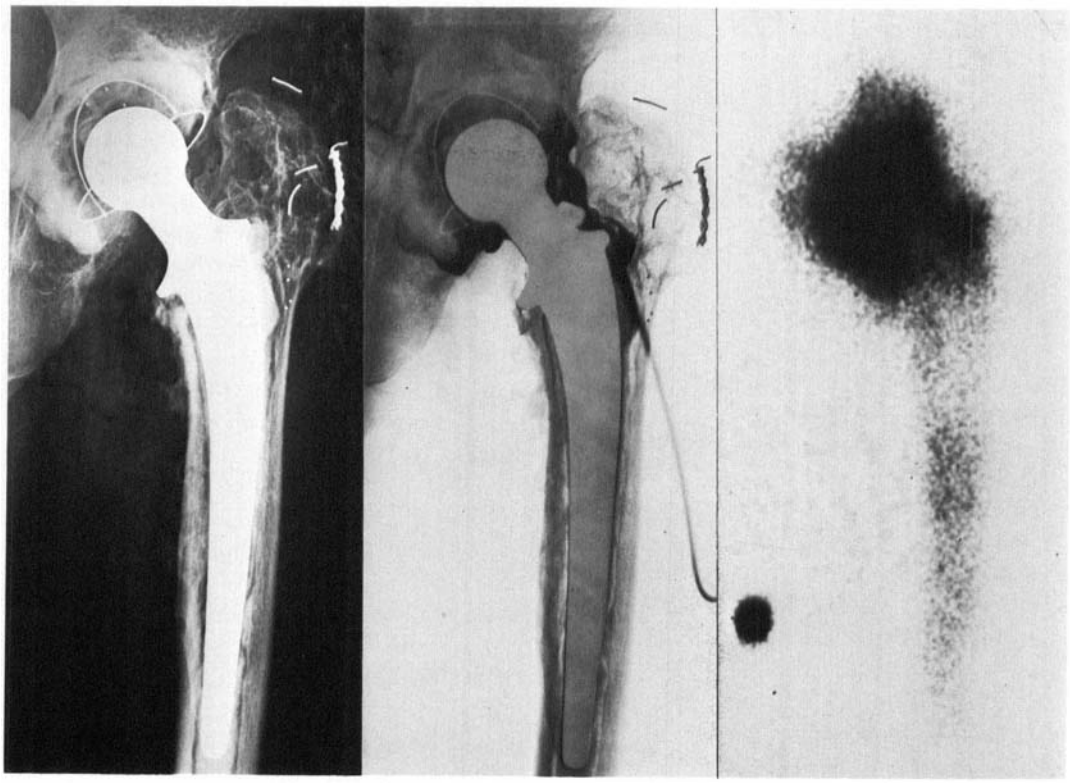


Figure 3. Radiograph (a), contrast arthrogram with subtraction technique (b) and radionuclide arthrogram (c). Radionuclide penetration along the femoral component is more easily assessed than contrast medium penetration.

Operative findings and clinical remarks

In the four revised hips all migrating components (one acetabular and three femoral, all with the mentioned radiographic changes) were loose, i.e. visible movement could be induced at surgery. However, RSA revealed instability in only two of them (Figures 1 and 2). All, including the one with a focally increased activity at the trochanter minor on Ga-scan, had negative cultures.

One of the two patients with non-migrating components had a later diagnosed lumbar root syndrome, and the other became asymptomatic after extraction of a piece of loose bone cement close to the joint.

Discussion

Contrast arthrography (Murray & Rodrigo 1975, O'Neill & Harris 1984), radionuclide arthrography (Abdel-Dayem et al. 1982, Uri et al. 1984) and provocational investigation with RSA (Mjöberg et al. 1984b) are to some extent complementary in the detection of *instability;* in our series none of these methods revealed all the unstable prosthetic components: two femoral components proved unstable by RSA and one femoral component found loose at revision had normal arthrograms (Figure 2); fibrous tissue may prevent the arthrographic medium penetrating the interfaces (Schneider et al. 1982). On the other hand, in four prosthetic components (one acetabular and three femoral) with abnormal arthrogram, an indirect sign of instability (O'Neill & Harris, 1984), and in another femoral component found loose at revision, RSA did not reveal instability (Figures 1 and 2). This indicates the existence of instability not detectable by RSA with the present significance limits, not even with rotational provocation (Mjöberg et al. 1984b).

The definition of mechanical loosening of

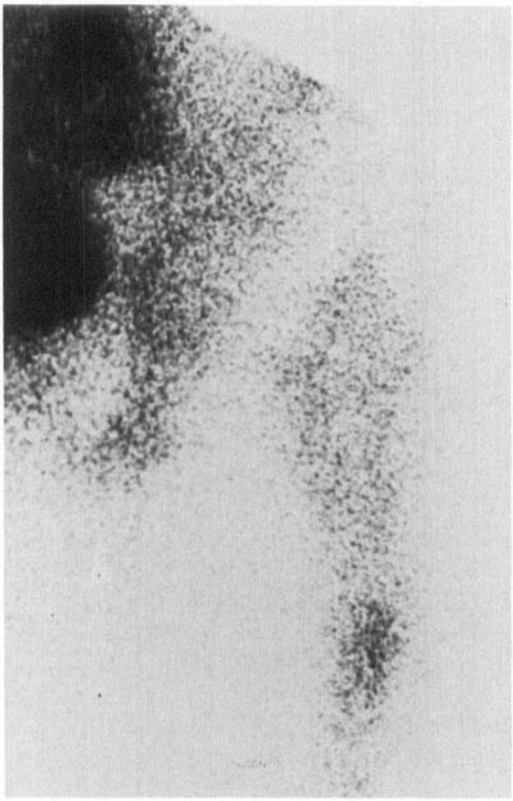


Figure 4. Focally increased activity at the tip of the femoral component at Tc-MDP scan.

THP is controversial (Murray & Rodrigo 1975, Weber & Charnley 1975, Häckel et al. 1978, Weiss et al. 1979, Carlsson & Gentz 1980, Dobbs 1980, Hendrix & Andersson 1981, Schneider et al. 1982, O'Neill & Harris 1984). Our findings indicate that loosening should be defined as *migration*. The reason is evident from Figures 1 and 2: all prosthetic components unstable by RSA (one acetabular and three femoral), or with an abnormal arthrogram (two acetabular and four femoral), or with increased scintigraphic activity (three acetabular and ten femoral), or loose at revision (one acetabular and three femoral) were migrating, but no non-migrating components (nine acetabular and four femoral) demonstrated any of these signs of loosening.

In an earlier study (Mjöberg et al. 1984a) four unstable but non-migrating prosthetic components were reported. The instability of the two femoral components was, however, at the statistical limits for significance, and later RSA including rotational provocations (Mjöberg et al. 1984b) have not demonstrated instability; we therefore consider these as false positive results. The two unstable acetabular components were both found to migrate at a later investigation; thus in these cases the first follow-up period (6–8 months) was too short in relation to the present significance limits.

Contrast arthrography, radionuclide arthrography and provocational investigation with RSA had a low sensitivity in detecting loosening defined as migration (Figures 1 and 2). Increased activity at the tip of the femoral component by Tc-MDP-scan (Häckel et al. 1978, Weiss et al. 1979), however, had high sensitivity and specificity (Figure 2), but increased activity around the acetabular component was more difficult to evaluate visually due to its deep position and to bladder activity.

One case of increased activity by Ga-scan with incongruent spatial distribution compared to Tc-MDP-scan confirmed the observation of Rosenthall et al. (1979) that this pattern is not specific for septic conditions.

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