EARLY LOOSENING OF FEMORAL COMPONENTS
AFTER CEMENTED REVISION
A ROENTGEN STEREOPHOTOGRAMMETRIC STUDY

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Roentgen stereophotogrammetric analysis was used to measure the migration of 24 cemented femoral components implanted during revision for mechanical loosening. All hips were examined one week, four months and one year after surgery; 14 hips were also examined after two years. Twenty-one components subsided 0.2 to 5.5 mm during the observation period; in 17 of these, subsidence occurred within four months of surgery. In 16 hips the prosthetic head was displaced 0.7 to 11.2 mm posteriorly.

The fixation of the femoral components was less secure than after primary arthroplasty, especially in cases of femoral canal enlargement, when a standard-sized rather than a thick-stemmed prosthesis had been used, and in cases of inadequate cement filling.

Loosening of the femoral component is considerably more common after revision than after primary arthroplasty (Amstutz et al 1982; Kavanagh, Illstrup and Fitzgerald 1985; Pellicci et al 1985; Marti et al 1990). Radiographs may fail to detect prosthetic loosening at an early stage, because of the difficulty of determining the presence and the degree of radiolucency (Brand, Yoder and Pedersen 1985; Jacobs et al 1989). Roentgen stereophotogrammetric analysis (RSA), however, reveals most cases of prosthetic migration within the first four to six months postoperatively (Mjöberg 1986; Wykman, Selvik and Goldie 1988; Mjöberg, Franzén and Selvik 1990; Snorras and Kårrholm 1990a,b; Nistor et al 1991).

We investigated the early migration of cemented femoral components after revision arthroplasty for loosening to determine the influence of pre-operative bone loss, stem design and cementing technique.

PATIENTS AND METHODS

We examined 24 hips, revised for loosening of the femoral component, by RSA one to two years after surgery. There were nine women and 15 men; their mean age was 70 years (45 to 87). Three cases were second revisions. The reason for the first arthroplasty was primary osteoarthritis in 17 patients, secondary osteoarthritis in four, ankylosing spondylitis in one, rheumatoid arthritis in one, and avascular necrosis of unknown aetiology in one. The pre-operative bone loss was quantified according to Gustilo and Pasternak (1988): nine hips had type I (minimal endosteal bone loss) and 15 type II (proximal canal enlargement and/or greater than 50% thinning of proximal cortices).

In two cases Charnley standard prostheses were used for the revision; in all the others a Scan hip prosthesis (MITAB, Sjöbo, Sweden) was implanted. Six of the Scan prostheses had thick stems with 50% more volume than the standard stem of the same length; the neck and shoulder of the prostheses were the same.

We performed the operations through a posterolateral incision without trochanteric osteotomy, except in one case. The operative technique included brushing, high-pressure lavage, plugging of the femoral canal, pressurisation of cement when possible, and the use of vacuum-mixed pre-chilled Palacos R bone cement with gentamicin.

Prophylactic antibiotic treatment was started during the operation after obtaining tissue cultures (Kamme and Lindberg 1981), except in one patient who had antibiotics before the operation and no culture specimens. The cultures were all negative.

At operation, tantalum balls, 0.8 mm in diameter, were implanted into the greater and lesser trochanters (Fig. 1). We performed RSA (Selvik 1989) in all the patients at one week, four months, and one year after the operation; 14 hips were also measured after two years.

Two X-ray tubes with an angle of 40° between the central rays were used to obtain simultaneous exposures.
A reference plate with tantalum balls was placed in front of the film plane. Before examination, a glass-plexiglass cage, with tantalum balls in known positions, was used as a calibration device. We performed the examinations without changing the positions of the X-ray tubes or the reference plate. The tantalum ball configuration in the femur represents a co-ordinate system fixed to it. By measuring the films using a photogrammetric instrument (Wild Autograph A8, Wild, Switzerland) equipped with television magnification and by data processing on a personal computer (IBM PC-AT), the displacement of the femoral component in relation to the tantalum balls was determined. In the subsequent examinations the femur was reoriented by the computer to its position in the earlier examination. Migration of the components along the longitudinal, transverse and sagittal axes was recorded.

The accuracy of the RSA measurements was evaluated by double examinations and the standard deviation of the displacement errors from zero was estimated (zero is the expected mean difference within pairs, as each individual difference is positive or negative at random).

RESULTS

Accuracy of RSA. To determine the experimental error, we performed 20 double examinations. The standard deviations for errors of measurement along the longitudinal, transverse and sagittal axes were 0.08, 0.18 and 0.29 mm respectively. Using Student's t-distribution the smallest translation to achieve significance (p < 0.05) was found to be 0.2 mm along the longitudinal axis, 0.4 mm along the transverse, and 0.7 mm along the sagittal axis.

Migration measured by RSA. Significant migration was seen in 21 of the 24 femoral components during the observation period. They subsided 0.2 to 5.5 mm into the femoral canal. The prosthesis head migrated 0.4 to 5.3 mm medially in seven hips and 0.7 to 2.2 mm laterally in six. The head was displaced 0.7 to 11.2 mm posteriorly in 16 hips, but there were no cases of anterior displacement. Within four months of surgery, subsidence was seen in 17 hips (Fig. 2) transverse migration in ten, and posterior displacement in nine.

There were no significant differences between the three second revisions and the primary revisions except that the former group migrated more along the transverse axis (average 3.0 mm compared with 0.6 mm after one year, p = 0.01, Mann-Whitney U test).

There was a tendency for greater migration in hips with the most pre-operative bone loss. After one year the mean subsidence, the mean transverse migration, and the mean posterior displacement were 0.6, 0.4 and 0.7 mm, respectively, in the nine patients with type I loosening. The equivalent measurements were 1.5, 1.2 and 2.4 mm in the 15 patients with type II loosening.
(p = 0.02, 0.04, and 0.02, respectively, Mann-Whitney U test). The subsidence was less pronounced in hips with a thick stem than in those with a standard-sized stem: at one year the mean subsidence was 0.4 mm for the six thick stems compared with 1.4 mm for the 18 standard stems (p = 0.03, Mann-Whitney U test).

**Radiographic observations.** Eight hips had adequate filling of the proximal femoral canal. This implies the presence of a distal cement stopper, no cement leakage through any cortical perforation, and narrow postoperative radiolucent lines in no more than three of the seven zones. During the first postoperative year, six of the eight prostheses subsided an average of 0.6 mm whereas 15 of the 16 prostheses with inadequate cement filling subsided an average of 1.4 mm (p = 0.06, Mann-Whitney U test).

**DISCUSSION**

By using RSA, Mjöberg et al (1986) found that in a series of primary hip replacements, three of 20 femoral components had migrated two years after surgery. In another similar series four of 14 femoral components had subsided by three years (Mjöberg et al 1990). All but one of these migrations were obvious four months postoperatively, and the authors concluded that loosening starts at an early stage. The timing of femoral component migration in our study was the same as that observed for cemented primary hip replacements (Mjöberg et al 1986, 1990) and for cemented acetabular revisions (Snorrason and Kårrholm 1990a; Franzén, Mjöberg and Önnerfält 1992). In all, migration was rapid during the initial four months and then, in most cases, slowed down.

The proportion of femoral components which migrated, and the rate of their migration, were both greater one year after a revision than after a primary replacement (Mjöberg et al 1986, 1990). A similar difference in subsidence rates has been observed between revision and primary acetabular components (Franzén et al 1992). Snorrason and Kårrholm (1990a) found migration in 14 of 15 femoral components within one year of cemented revision arthroplasty.

Thus, fixation of the femoral component after revision is poor compared with that after primary arthroplasty. 'Lack of initial fixation' may be due to residual tissue debris (Halawa et al 1978; Krause et al 1982), insufficient filling with cement (Carlsson and Gentz 1980; Kristiansen and Jensen 1985; Paterson, Fulford and Denham 1986; Mulroy and Harris 1990), or an inadequate cement–bone interlock on the smooth sclerotic bone bed (Dohmae et al 1988). 'Loss of fixation' may be due to resorption of a layer of heat-injured bone in a hip with a wide femoral canal (Fig. 1) (Mjöberg 1986).

Although the fixation of the femoral components after revision with cement is poor compared with that after primary arthroplasty, the use of modern cementing techniques seems to improve the results (Rubash and Harris 1988). Furthermore, RSA studies of uncemented femoral components have shown that fixation is seldom achieved, even in primary arthroplasty (Wykman et al 1988; Kårrholm and Snorrason 1990; Nistor et al 1991). Thus, the use of cement still seems justified (Mjöberg 1991). Revision is best undertaken before severe bone loss and femoral canal enlargement have occurred. Adequate cement-filling and the use of a thick-stemmed component seem to offer the best chance of success.

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