Acetabular revision in total hip replacement with a press-fit cup

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The need for supplementary screw fixation in acetabular revisions is still widely debated. We carried out 439 acetabular revisions over an eight-year period. In 171 hips with contained or small segmental defects, the Morscher press-fit cup was used. These revisions were followed prospectively. No screws were used for additional fixation.

A total of 123 hips with a mean follow-up of 7.4 years (5 to 10.5) were available for clinical and radiological review. There was no further revision of a press-fit cup for aseptic loosening. Radiological assessment revealed osteolysis in three hips. Of the original 171 hips there was cranial and medial migration of up to 6 mm at two years in 44 (26%). No further migration was seen after the second post-operative year. Acetabular revision without screws is possible with excellent medium-term results in well selected patients.

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For primary total hip replacement (THR), press-fit cups with physiological force transmission, by means of stress distribution to the periphery, have become the gold standard for primary acetabular replacement.¹⁻⁹ Cemented revisions for loose cups have shown high failure rates.^{2,10-14} Consequently, uncemented cup revisions with or without the use of allografts have become more popular, particularly in situations where a peripheral press-fit fixation can still be achieved.^{2-4,7,8,11,15-17}

The selected method of revision depends upon the type of acetabular deficiency.¹⁸ Deficiencies which allow for a

peripheral press-fit by an oversized uncemented hemispherical cup are those with contained defects according to the American Academy of Orthopaedic Surgery classification system.¹⁹ Acetabular reinforcement rings or oblong revision cups are recommended for deficiencies where a peripheral press-fit can no longer be achieved.²⁰⁻³⁰ Large cavities in the acetabular region need additional measures, especially when the posterior column is missing.

The Morscher press-fit cup was introduced into clinical practice in 1985. A follow-up of 280 cups inserted in primary operations revealed only one revision for aseptic loosening in a patient with rheumatoid arthritis after an observation period of five to eight years. The 6.3-year survival rate for aseptic loosening in primary arthroplasties was therefore, 99.6%.⁵ Encouraged by these excellent results in primary arthroplasties, the question was whether the press-fit cup, without additional screw fixation, would also yield good results in revision operations. This implant was becoming increasingly used in revision operations in which a situation comparable to a primary arthroplasty, such as contained, rim-supportive acetabular deficiencies (Fig. 1), could be created.

The goals of acetabular revision are the restoration of the centre of rotation in the original acetabulum, stable fixation of the new component and the replacement of lost bone stock, thereby restoring the anatomical situation as close as possible to that of a primary THR.³¹ We identified two situations: i) contained, rim-supportive defects, similar to that at primary arthroplasty and ii) segmental and rim non-supportive defects, where a press-fit between the uncemented cup and the acetabular bone can no longer be obtained and containment of the acetabulum must be achieved by bone grafts and/or reinforcement rings.³²

The aim of this study is to report the results of the specially designed press-fit cup in acetabular revisions with predominantly contained and rim-supportive defects and to establish whether additional screw fixation of a press-fit cup is necessary, even in revisions.

Patients and Methods

Based on clinical experience, both in primary and revision operations with cemented and uncemented acetabular cups, and on histological observations of retrieved cups and labo-

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Fig. 1a

Fig. 1b

Fig. 1c

Radiographs of a 79-year-old woman who underwent an acetabular revision with a press-fit cup. a) Pre-operatively, b) immediately after surgery and c) nine years after surgery.

Fig. 2

The Morscher press-fit cup.

Fig. 3

The biradial bicentricity of the Morscher press-fit cup.

ratory studies, the senior author (EWM) developed the Morscher uncemented press-fit cup (Protek, Sulzer Orthopaedics, Baar, Switzerland) (Fig. 2).^{5,6,31,33-36}

The principles and rationale of this monoblock cup. Primary intrinsic stability by press-fit is achieved by an oversized cup (+1.5 mm). The transmission of force is as in the natural hip joint, to the periphery, and is achieved by flattening the cup's dome area.³⁷ Close implant-bone contact in the periphery, the main region for force transmission, is generated by a hemispherical design of biradial bicentricity. Therefore, the radius of the outer surface corresponds to that of the acetabular reaming. Oversize is achieved by 1.5 mm eccentricity of the mid-points of the radii (Fig. 3).^{5,6,36} Rotational and tilting stability is enhanced by an eccentrically located peg. There is no additional screw fixation. A porous surface facilitates bony ingrowth (osseointegration)

by means of a mesh of four orderly orientated layers of chemically pure titanium (Sulmesh, Centerpulse Orthopaedics Ltd, Winterthur, Switzerland). The bevel of the cup avoids impingement of the neck of the femoral stem at the inferior circumference of the cup and reduces the risk of dislocation and loosening and there is no separate metal-backing. The direct fixation of the titanium wire mesh coating in the polyethylene prevents stress shielding by preserving the elasticity of the cup, and avoids polyethylene wear from the liner's back and disassociation of the liner.^{5,34,38,39}

Plain radiographs do not allow accurate assessment of the type of deficiency so a final decision about treatment must be made intra-operatively. In most patients the key issue is the stability of the posterior wall. The final decision to use the press-fit cup, or a different method, was based upon a modified grading system proposed by Moskal,

Fig. 4

The trial 'Swiss cheese' cup with holes to allow the surgeon to check the implant-bone contact.

Danisa and Shaffrey.⁴⁰ In Grade 1, there is complete peripheral prosthetic host bone contact. No bone graft is required and the press-fit cup may be used. In Grade 2, there is incomplete prosthetic host bone contact but the component is stable on host bone. Filler grafts may be added. The press-fit cup may be used if a reliable press-fit can be achieved. In Grade 3, there is incomplete host bone contact with an acetabular component that is unstable in host bone. Bone grafting is required in order to restore the acetabulum. Acetabular reinforcement rings are used to protect the graft.¹⁸

Operative technique. The revisions were carried out by six surgeons. Through the pre-existing approach (usually lateral) the joint was opened, the newly formed capsule excised and the failed socket and stem removed. After debridement of the acetabulum with sharp curettes, forceps and hemispherical reamers, a new bed for the hemispherical acetabular component was formed by careful reaming towards the medial wall, and slightly cephalad. With a trial cup of the same size as the final reamer (Fig. 4), the rim of the acetabulum was checked for its ability to take load and to determine whether the implant/bone contact exceeded 50%.

In patients where it was not possible to enlarge the acetabulum without damaging the anteroposterior containment, a higher hip centre was accepted. In these patients a smaller cup than the original was chosen.^{26,41,42} Any associated leg shortening was compensated by a long femoral neck. Abductor muscle length was restored by distal displacement of the greater trochanter.^{18,43-45} Lateralisation of the hip centre was avoided.

Patients. Between 1 January 1988 and 31 December 1995, 439 acetabular revisions were carried out. We revised 171 hips (39%) in 167 patients (four bilateral) with the Morscher press-fit cup. In 39 hips the uncemented all polyethylene RM cup was used and in eight a cemented polyethylene

Fig. 5

The number and type of devices used for acetabular revision between 1988 and 1995

cup. In 221 acetabular revisions undertaken during the same period, Burch-Schneider or Ganz acetabular reinforcement rings were used (Centerpulse Orthopedics Ltd; Mathys Medical Ltd, Bettlach, Switzerland) (Fig. 5). Of the 171 acetabular revisions with the Morscher press-fit cup, 59 hips (35%) had an acetabular revision only, four (2%) had an acetabular re-revision, 106 (62%) had both components revised and two (1%) had both components re-revised.

At a minimum follow-up of five years, 119 patients with 123 hips were available for clinical and radiological review. Ten patients could only be interviewed by phone (none was revised or scheduled for revision), 37 patients had died (until death none had to be revised or was scheduled for a revision) and one patient was lost to follow-up. The mean follow-up was 7.4 years (5.0 to 10.5). The clinical situation was rated by using the Merle d'Aubigné and Postel score.⁴⁶

The pre-operative diagnosis for the 123 hips with complete clinical and radiological follow-up was aseptic loosening of a cup in 49 (39.8%), of both components in 51 (41.5%), conversion of an endoprosthesis into a THR in two (1.7%), infected THR in seven (5.7%) malposition of the cup in five (4.1%) and other diagnosis in nine (7.3%). The left hip was affected in 43 patients (35.0%), the right hip in 74 (60.2%) and both hips in three (4.8%).

Assessment. For the radiological assessment we used an anteroposterior radiograph taken at six weeks post-operatively as the baseline. The assessment of the quality of fixation of the acetabular component depended upon an analysis of any periacetabular radiolucencies and osteolysis. Any radiolucency, regardless of width and extension, indicated non-osseointegration. A cup which was completely surrounded by radiolucency was regarded as radiologically loose.⁴⁷ Osteolysis was defined as a newly developed expansile scalloping radiolucency extending away from the cup which had not been seen on the immediate post-operative radiograph.⁴⁷ The location of the radiolucencies and osteolysis were classified according to the zones (I to III) of DeLee and Charnley.⁴⁸

For measurement of cup migration we used a Müller template according to the method of Sutherland et al.⁴⁹ Lateral and medial migration were measured as the distance

between two vertical lines passed through the centre of the femoral head and the inner border of the teardrop. The cup was considered to have migrated if there was a change in its angle of $>5^\circ$, or a change in its horizontal or vertical position of the cup by >3 mm.⁴ The cup angle (inclination) was measured as the angle subtended between the horizontal and a line drawn from the caudad to the cephalad edge of the cup. Anteversion was measured as described by Dorr et al.,⁵⁰ and heterotopic bone formation was classified according to the criteria of Brooker et al.⁵¹

Results

Clinical outcome. Of the 119 patients with 123 acetabular revisions, 100 patients with 103 revisions (84%) were without pain and the hip joint could be flexed beyond 90° . The mean pre-operative Merle d'Aubigné and Postel score⁴⁶ of 9.5 (6 to 12) improved to 15.8 (13 to 18) points. For the 17 patients with 18 revisions (15%) who complained of slight intermittent pain, the mean pre-operative score increased from 8.2 (5 to 10) to 10.5 (9 to 12) points. Two patients with two hip revisions (1.6%) complained of continuous, but not disabling pain. Both patients used two crutches for walking. Flexion of the hip joint for these two patients was 70° to 90° , their mean pre-operative score was 5.7 (3 to 8) and their post-operative score was 6.4 (5 to 8) points. With the exception of seven patients who had a leg-length discrepancy of about 1 cm prior to revision surgery, leg-lengths were equalised to within 1 cm.

Radiological. The mean inclination angle was 37° (29 to 48°) and the mean anteversion was 7° (3 to 15°). Three cups had osteolysis, two in zone I and one in zone III. Radiolucencies could be seen in 18 hips, three in zone I, six in zone II and four in zone III. Four radiolucencies were bizonal, two in zones I to II and two in zones II to III. One radiolucent line extended from zone I into zone III. This cup must, therefore, be regarded as radiologically loose.

Within the first two post-operative years 44 of the original 171 cups (26%) had migrated mediolaterally and cranially by 2 to 6 mm. One-third were in hips with an uncontained acetabular defect. All had stabilised after the second post-operative year and none had loosened or been revised.

Brooker III and IV ectopic ossification was seen in four hips, two of which had insignificant restriction of movement. With the exception of one Wagner revision stem, which had to be revised due to a valgus position of 10° and a subsidence of 15 mm, no stem had a varus or valgus position of $>3^\circ$.

Complications. In seven of the 123 hips (5.7%), the greater trochanter became unstable during revision and had to be fixed with cerclage wires in four operations. Three patients (2.4%) developed a superficial wound infection and 13 (10.5%) an haematoma, while 9 (7.3%) dislocated. There were no pulmonary emboli and no patient died during the early post-operative period.

Further revision. No further revision of a press-fit cup was needed for aseptic loosening. There were, however, 16 (13%) re-interventions during the observation period. Three (2.4%) were for dislocation, which was treated by closed reduction and remained stable thereafter. In six hips (4.8%) a further revision operation was necessary due to recurrent dislocation. Four of these hips were treated by fixing a segmental augment to the cup. Two further revisions of both components were undertaken due to a combination of factors, borderline cup position, steep neck-shaft angle of the femoral component (Wagner revision stem) and anteversion of the stem. Nine stems had to be revised, six (4.9%) for aseptic loosening, one (0.8%) for septic loosening and two (1.6%) for periprosthetic fractures. Of the nine revised stems, seven were Müller straight stems, one a PCA stem and one a Wagner revision stem. Heterotopic ossification had to be removed on two occasions (1.6%).

Discussion

Cementless acetabular fixation is of value in revision hip surgery, although most published data are based upon cup designs which are used with supplementary screw fixation.⁵² Mechanical tests show that the addition of screws gives only a modest improvement to the fixation of an oversized hemispherical cup and that peg fixation is superior.^{53,54} With the RM (Mathys Medical Ltd) cup which is an uncemented, hemispherical, uncoated polyethylene cup, we observed a higher rate of aseptic loosening when screws were used than when they were not. In an earlier series of 545 hips, the loosening rate was 9% with screws and 5.6% without.³⁴ The short-term results with this uncemented cup were excellent.⁵⁵ Unfortunately, abrasive wear of the outer surface led to periacetabular osteolysis and loosening.

Our study, with no further revisions for aseptic loosening, confirms that excellent results can be achieved with uncemented press-fit cups, even in revisions.^{2-4,7,8,56-58} Furthermore, it demonstrates that the use of screws, in addition to an intrinsic press-fit fixation to the peripheral acetabular rim, is unnecessary. The absence of screws also eliminates complications such as screw-hole osteolysis, screw loosening and fracture, aseptic loosening and operative damage to vascular, neural and other intrapelvic structures.^{26,34,59,60} In mechanical tests of adult cadaver pelvises, Won, Hearn and Tile⁶¹ found that, although the use of screws in an acetabular component decreased micromovement at the site of the screw, it sometimes increased micromovement on the opposite side of the cup. A press-fit cup showed less micromovement than a non-press-fit cup with screw fixation. The use of screws did not necessarily increase the initial stability.

In 26% of the original 171 hips, migration of the cup by 2 to 6 mm was observed during the first two years without subsequent loosening. In the absence of screws, a press-fit cup with a flattened dome appears to find a new intrinsic stability during the settling process which would otherwise be

disturbed. Screws would act as a fulcrum and lead to rocking of the socket, which combined with micromovement, is the main mechanism of bone resorption and eventually leads to loosening of the implant. The press-fit concept is, by definition, a wedge in an undersized body. Therefore, screws are not only unnecessary but can be as problematic as a collar on a tapered cemented stem.⁶² Rocking is minimised in the design of the press-fit cup. The flattened dome area and the biradial eccentricity avoid gaps between the cup and the underlying bone bed (tripod stability).³⁷

Migration in cemented and uncemented cups which do not use the press-fit concept appears to be an indicator of subsequent aseptic loosening.¹² Similar conclusions from radiological assessments of migration with Radio-Stereometric analysis or EBRA (Einzell-Bild-Röntgen-Analyse)⁶³ do not apply to press-fit implants which are fixed without screws. In these hips, migration must not only be accepted, but is the second line of defence. A primary press-fit with primary stability gives way due to bone remodelling or to resorption of any bone graft which was introduced at the time of the revision. This is often seen in revisions, where containment may be compromised or bone quality is reduced.

These observations are supported by our study where acetabular deficiencies with segmental defects have also been treated with the press-fit cup. Even cups with significant migration did not become loose in the long term. The same observation has been made by Hubble et al⁵⁶ who found significant migration without loosening of the implant in 9% of acetabular revisions where morsellised allograft and the Harris-Galante cup had been used. All these hips had uncontained, segmental or combined, defects. No case with a contained defect has, as yet, failed. For the final osseointegration of a press-fit cup in revision hips, at least 50% of the cup's periphery must be in contact with autogenous, vascularised acetabular bone.¹⁸ This has been demonstrated by the poor results of acetabular revisions with uncemented cups against structural or morsellised allografts.^{11,64-66} If too much of a cup's surface is in contact with dead bone, osseointegration is compromised and the use of an acetabular reinforcement ring is recommended.

The observation that there was no further revision of a press-fit cup due to loosening supports our experience with this cup in primary arthroplasties, and shows that screw fixation of such a cup is also unnecessary in revisions. Migration of an acetabular component which is designed according to the press-fit concept must be accepted as part of the settling process of this device, and should not be considered as a sign of loosening. The definition of radiological loosening, must therefore, be reconsidered. Migration may not represent radiological loosening. Screws, however, may interfere with the settling process and can propagate the loosening process.

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