TOTAL HIP REPLACEMENT AFTER FAILED HEMIARTHROPLASTY OR MOULD ARTHROPLASTY

COMPARISON OF RESULTS WITH THOSE OF PRIMARY REPLACEMENTS

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We compared the radiographic results of secondary total hip replacements, 99 following failed uncemented hemiarthroplasties and 21 following failed mould arthroplasties, with those of 825 primary cemented total hip replacements. The probability of occurrence of a number of radiological changes over time was calculated using survival analysis. The mean follow-up was 7.6 years (range one month to 20 years).

The performance of the secondary total hip replacements varied with the preceding implant and was different for acetabular and femoral components. The incidence of radiological loosening was higher for femoral components implanted after failed hemiarthroplasties and for acetabular components after failed mould arthroplasties. However, the incidence of continuous radiolucent lines was lower for the acetabular components of converted hemiarthroplasties than for the primary replacements.

Mould arthroplasty and hemiarthroplasty are conservative operations in that only one side of the joint is replaced, preserving bone stock for future, more extensive procedures if necessary. These operations may buy time before a total hip replacement (THR) is indicated but the effect of these implants on the long-term performance of a subsequent cemented THR has not been clear.

The technical pitfalls at the revision of failed hemiarthroplasties and mould arthroplasties have been described (Dupont and Wrightington 1972; Coventry et al 1974; Sarmiento and Gerard 1978; Amstutz and Smith 1979; Stambough et al 1986), but there is little data on the clinical outcome of such revisions. However, some important differences have been shown in the performance of revised hemiarthroplasties and mould arthroplasties compared to primary THRs. For example, Amstutz and Smith (1979) reviewing 41 THRs implanted after failed hemiarthroplasties at a mean follow-up of three years, found the clinical results to be comparable to those of primary THRs but that 15% of the revisions had developed radiographic signs of progressive loosening. Similarly, Stambough et al (1986), comparing a series of 140 conversion THRs, which included 32 failed hemiarthroplasties, with a series of 433 primary THRs at a mean follow-up of six years, found no statistically significant differences in clinical performance, but the radiological failure rate was twice as great in the conversion group.

We have reviewed 954 patients with THRs, which included 106 with failed hemiarthroplasties and 23 with failed mould arthroplasties, all having been operated on by one surgeon (AS) in the last 20 years. It was our clinical impression that the secondary THRs were at higher risk of failure and that each component of the joint was affected differently depending on the type of the preceding arthroplasty. We have therefore used survivorship analysis to quantify the incidence of radiological loosening in THR after prior hemiarthroplasty or mould arthroplasty.

MATERIAL AND METHODS

Between 1970 and 1990, 106 failed hemiarthroplasties and 23 failed mould arthroplasties were converted to cemented total hip replacements. Following the termino-
logy of Stambough et al (1986), we refer to a cemented THR that was implanted after failure of a hemiarthroplasty or mould arthroplasty, as a converted failed hemiarthroplasty, or a converted failed mould arthroplasty, respectively. During the same period, 825 patients underwent primary cemented total hip replacement for osteoarthritis, rheumatoid arthritis or avascular necrosis.

Follow-up ranged from one month to 20 years, with a mean of 7.4 years for converted failed hemiarthroplasties, 7.8 years for converted failed mould arthroplasties and 7.6 years for primary THRs. Seven of the converted hemiarthroplasties and two of the converted mould arthroplasties were excluded because of incomplete records, leaving 99 converted hemiarthroplasties and 21 converted mould arthroplasties available for the study (Table I).

Table I. Number and type of THRs reviewed with patients’ age and sex

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of hips</th>
<th>Number of hips</th>
<th>Mean age (yr)</th>
<th>Male:Female (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Converted hemiarthroplasties</td>
<td>81</td>
<td>25</td>
<td>106</td>
<td>99</td>
</tr>
<tr>
<td>Converted mould arthroplasties</td>
<td>15</td>
<td>8</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>Primary cemented total hip replacements</td>
<td>369</td>
<td>456</td>
<td>825</td>
<td>825</td>
</tr>
</tbody>
</table>

1. Acetabular cement–bone radiolucent lines. Such lines are very common at the margins of the cup (Salvati et al 1976; Reckling, Asher and Dillon 1977; Beckenbaugh and Ilstrup 1978; Collis 1984), so only continuous radiolucent lines spanning all three zones were recorded. Migration of the component was not counted separately since, in our experience, it is always accompanied by a continuous radiolucent line.

2. Wear of the acetabular cup, defined as a reduction in the distance between the peripheral wire in the cup and the surface of the femoral ball. Due to the limited accuracy of such radiographic wear measurements (Clarke et al 1976), only wear of 1 mm or more was counted.

3. Femoral cement–bone radiolucent lines, defined as any radiolucency at this interface.

The total hip replacement prostheses used were the Charnley, the STH and the STH-2 (all supplied by Zimmer, Warsaw, Indiana). The Charnley femoral component was of 316 LVM stainless steel with a 22 mm head, and the STH and STH-2 were of titanium alloy (ASTM F 136) with a 28 mm head. All the acetabular cups were of ultra high molecular weight (UHMW) polyethylene and were of similar shape, except that the inner diameters matched those of the respective femoral heads. None were metal-backed. The surgical approach was different for the two prostheses: Charnley prostheses were inserted through a lateral approach with trochanteric osteotomy; the STH components were inserted through a posterior approach without trochanteric osteotomy.

Anteroposterior and lateral radiographs of the hips were obtained immediately postoperatively, at three, six and 12 weeks, at six months and annually thereafter. The serial radiographs were evaluated by observers who had been thoroughly instructed in the pertinent criteria (Gruen, McNeice and Amstutz 1979; Sarmiento and Gruen 1985; Sarmiento et al 1988), and who were unaware of the clinical status of the patients. The circumference of the acetabulum was considered in three zones (DeLee and Charnley 1976), and the proximal femur in the seven zones described by Gruen et al (1979).

The radiographs were inspected for the presence of:

4. Femoral stem–cement radiolucent lines, defined as any radiolucency at this interface.

5. Femoral cement fractures, through the entire thickness of the cement mantle.

6. Progressive loosening of the femoral component, defined as a shift in the position of the stem relative to the femur accompanied by one or more of the following: changes in the width or length of stem–cement or cement–bone radiolucent lines, widening of a cement-fracture gap, fragmentation of the cement or fracture of the stem.

Isolated radiolucent lines or cement-fracture gaps less than 1 mm wide were not considered to indicate progressive loosening. However, stem–cement radiolucent lines ≥ 1 mm wide, cement–bone radiolucent lines ≥ 2 mm wide or cement-fracture lines ≥ 1 mm wide, that were not evident in the immediate postoperative radiograph, were considered to indicate progressive loosening of the components.

7. Calcar resorption, defined as a longitudinal loss of proximal-medial cortical bone stock.

8. Cortical hypertrophy, defined as thickening of the femoral cortex around the stem.

Survival analysis was used to calculate the probability of occurrence of each of these radiographic signs over time in converted hemiarthroplasties, converted mould arthroplasties and primary THRs, using Gehan’s life-table method (Gehan 1969). The statistical signifi-
cance of the differences between groups was determined using Mantel and Haenzel's modified chi-square test (Lee 1980). A probability level of $p < 0.05$ was used as the level of significance.

RESULTS

Converted hemiarthroplasties compared to primary THRs. The acetabular components of converted failed hemiarthroplasties were at lower risk of developing continuous radiolucent lines than those of primary THRs, although this was not statistically significant ($p < 0.08$, Fig. 1). In contrast, the femoral components in this group were at significantly higher risk of cement fracture ($p < 0.02$), cement–bone radiolucency ($p < 0.001$, Fig. 2) and progressive loosening ($p < 0.001$, Fig. 3) than primary THRs. No significant differences were found for acetabular wear, stem–cement radiolucency, calcar resorption or distal cortical hypertrophy ($p > 0.25$).

Second revisions. By the end of the study, 50 patients had required revision surgery. Of the patients with converted hemiarthroplasties, six (about 6\%) had had a second revision at an average of 87 months after the original conversion to total hip replacement. Two were for revision of the acetabular component, one for the femoral component and three for both components. Of the 21 patients with a converted mould arthroplasty, only one (about 4\%) required revision of the acetabular component 93 months after the original conversion.

Of the patients with primary THR, 43 (about 5\%) required revision at an average of 84 months after the primary procedure, 17 for revision of the acetabular component, 11 of the femoral component and 15 of both components. Because of the small numbers of patients with second revisions in the conversion groups, no meaningful comparisons could be made.

DISCUSSION

Hemiarthroplasty disrupts the femoral canal, but usually leaves the acetabular bone stock undisturbed (Moore 1952; Thompson 1954); by contrast, mould arthroplasty requires thorough reaming of the acetabular socket and femoral head, but preserves the proximal femur (Smith-Petersen 1948; Harris 1969; Bryan and Bickel 1971). Each procedure damages one side of the joint while preserving the opposite side for a future, more extensive procedure.

Converted mould arthroplasties compared to primary THRs. The acetabular components of converted failed mould arthroplasties had a significantly higher risk of developing continuous radiolucent lines than those of primary THRs ($p < 0.008$, Fig. 4). There were no significant differences in the other radiographic criteria between these groups.

Converted mould arthroplasties compared to converted hemiarthroplasties. Converted failed mould arthroplasties had a significantly lower incidence of femoral cement–bone radiolucency than converted failed hemiarthroplasties ($p < 0.05$), but a significantly higher incidence of acetabular radiolucency ($p < 0.001$, Fig. 5). There were no significant differences between any of the other radiographic criteria.

The survivorship analysis confirmed our clinical impression that the acetabular components of converted hemiarthroplasties and the femoral components of converted mould arthroplasties had equal or longer radiological survival rates than the corresponding components of primary THRs. In other words the component
on the side disturbed the least by the original procedure had equal or better performance than one implanted primarily.

**Converted hemiarthroplasty**

*Acetabular side.* Although one might expect that a virgin acetabulum would be optimal for a primary cemented polyethylene cup, our results suggested that the previous exposure of the unreamed acetabulum to the articulating metallic femoral head of a hemiarthroplasty may have had a beneficial effect on the performance of the subsequent cemented polyethylene cup. It is possible that acetabular subchondral bone had adapted to the non-physiological load transfer by a structural modification, such as trabecular hypertrophy, to provide better support for the subsequent cemented cup.

**Fig. 3**

Probability of surviving without femoral cement–bone radiolucency, comparing primary THRs with converted hemiarthroplasties.

Such subchondral sclerosis is common in osteoarthritis, but not in other conditions such as rheumatoid arthritis (McDonough, Brandfass and Stinchfield 1967). Thompson (1954) described subchondral sclerosis induced by a hemiarthroplasty, primarily in zone I, by about one year after the surgery. This reaction was not observed in patients who maintained normal cartilage thickness following surgery, nor in those patients where the acetabulum had been reamed. Thompson concluded that “the real significance of acetabular sclerosis is not understood. It is not believed to be a beneficial finding.” However, our results suggest that the sclerotic bone may provide better support for a cemented cup than can a virgin acetabulum.

Acetabular sclerosis does not always occur: where the acetabulum was reamed during the initial procedure, a practice that used to be performed at the surgeon's discretion (McDonough et al 1967), erosion and supramedial migration of the prosthesis was more likely (Sarmiento 1972). Furthermore, rheumatoid arthritis (Sarmiento 1972) and a high patient activity level (Phillips 1989) have both been associated with gradual sinking of the prosthesis into the acetabulum.

**Femoral side.** The relatively poor performance of cemented femoral components inserted after removal of a non-cemented hemiarthroplasty stem may have several causes. Extensive resorption of the endosteal bone may have occurred while the stem was loose (Hofmann et al 1989); additional damage may be done during revision, particularly while removing the bone struts that fill fenestrated stems (Dupont and Wrightington 1972; Amstutz and Smith 1979; Grue et al 1979).

Furthermore, toggling of the prosthesis may produce
a thick fibrous membrane that is adherent to the surrounding bone and may not be completely removed at the time of revision (Dupont and Wrightington 1972; Sarmiento and Gerard 1978; Amstutz and Smith 1979). Remnants of such a membrane may compromise the fixation of the subsequent cemented prosthesis by decreasing the total area of bone available for cement interdigitation, preventing intimate contact between cement and bone, and also by increasing the rate of endosteal bone resorption. It has been suggested that fragments of such a fibrous membrane are very active metabolically, producing prostaglandin E₂, collagenase and interleukin 1 beta, all of which may contribute to resorption of the adjacent bone (Goldring et al 1983; Gowen et al 1983; Goodman, Fornasier and Kei 1988). Goodman et al (1988) reported that membranes retrieved from loose cemented and uncemented implants produced significantly higher levels of prostaglandin E₂ than membranes retrieved from stable implants.

** Converted mould arthroplasty

**Femoral side.** Mould arthroplasty has been regarded as a conservative procedure, since it allows preservation of the femoral neck with minimal damage to the surrounding bone. Some young patients that require joint replacements are offered this conservative alternative, so it is important to know how it will affect a subsequent cemented stem. We found no significant differences in performance between the femoral components of converted failed mould arthroplasties and those of primary THRPs. Furthermore, since the more recent surface replacement arthroplasties also tend to preserve the femoral bone stock (Amstutz et al 1978; Capello et al 1978; Freeman, Cameron and Brown 1978; Furuya, Tsuchiya and Kawachi 1978; Trentani and Vaccarino 1978; Wagner 1978), our results may also apply to these patients.

**Acetabular side.** After mould arthroplasty there was a higher probability of loosening of a subsequent cemented acetabulum, in contrast to the beneficial effect of a prior hemiarthroplasty. The poor results after mould arthroplasty may have been due to the techniques of acetabular preparation that were recommended by Smith-Petersen (1948) and others (Harris 1969; Johnston and Larson 1969; Urist and Marius 1969; Bryan and Bickel 1971), typically involving reaming to the inner wall of the pelvis and expansion to provide space for the metallic shell. The mould prosthesis was placed in contact with cancellous bone, whereas the metallic femoral head of a hemiarthroplasty was typically articulated against the acetabular cartilage.

**Conclusions.** In our series of patients the acetabular components of THRPs inserted following failed mould arthroplasty and the femoral components inserted after failed hemiarthroplasty showed earlier radiological loosening than those after primary THRPs. By contrast, acetabular cups implanted after a failed hemiarthroplasty had fewer radiographical signs of loosening than those cemented into virgin acetabula. These effects should be considered when the initial procedure is selected, so as to provide the patient with the maximum benefit at each stage.

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**REFERENCES**


