STEMMED REVISION ARTHROPLASTY FOR ASEPTIC LOOSENING
OF TOTAL KNEE REPLACEMENT


From The London Hospital Medical College, London

Fifty-three failed knee replacements were revised using minimally constrained implants with smooth uncemented intramedullary stems and metal-backed tibial components. Polymethylmethacrylate was used only to replace lost bone near the surface of the implant. Excluding four knees which had serious postoperative complications, 91% had successful relief of pain, 84% had over 90° of movement and 80% could walk for more than 30 minutes.

Review of the radiographs showed that there were no progressive lucencies at the interface between bone and cement, and no subsidence of components or changes in alignment. At the uncemented stem-to-bone interface, thin white lines developed near the metal, and their significance is discussed.

This revision technique is an effective treatment for aseptic failure of primary total knee arthroplasty.

Component loosening occurs after total knee arthroplasty as a result of migration of the components into the bone ends, with resorption at the bone-cement interface. This resorption, together with bone removed at the initial implantation, may result in substantial bone defects by the time revision operation is needed. These defects are often so great that surface fixation of new components is inappropriate; and, if this mode of fixation is used, it will often fail later.

Since 1978, tibial and, more recently, femoral components with intramedullary stems have been used increasingly for revision arthroplasty at The London Hospital. A major hazard of revision arthroplasty is infection. For this reason the senior author was reluctant to surround the long intramedullary stems with cement, fearing that, if the arthroplasty became infected, the removal of cement and the cure of extensive osteomyelitis would be difficult. Nevertheless, cement was used in the early cases, because we assumed that fixation of the stem would not be satisfactory without it. Later it was noted, when using a trial stem during operation, that secure fixation could be obtained without cement. At the same time increasing confidence was being gained in the cementless fixation used for surface replacement in primary arthroplasties (Blaha et al. 1982).

In June 1978, at a revision arthroplasty, the stem of the component shown in Figure 1 was placed without

![Fig. 1](image-url)

The first tibial component to have a metal intramedullary stem and backing, with anteroposterior radiographs showing its use in salvaging a failed arthroplasty.

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cement. This stem had a smooth surface so that ingrowth of bone was impossible, and cement was used only to fill any space between the under surface of the metal and polyethylene plateau of the prosthesis and the floor of the bony defect. The end of the tibia was left intact except where the polyethylene pegs of the prosthesis may have penetrated it, so that there was no possibility of cement interlocking with open cancellous bone. The cement simply rested upon the sclerotic floor of the defect so as to transmit compressive loads and obliterate dead space. Some chance gross interlock between the cement and the floor of the defect may have contributed to fixation against rotation, but gave little resistance to valgus/varus or anterior/posterior tilt: these displacements were resisted by the stem alone.

This paper reports the clinical and radiological results in 53 knees revised by this technique since June 1978.

MATERIAL

We have reviewed all cases of total knee revision for aseptic loosening in which an uncemented stem was used for one or two components; all have been followed-up for at least six months. In all, 50 patients had 53 revision arthroplasties (three were bilateral). There were 17 men and 33 women; the ages at operation are set out in Table I. Of the 53 knees, 27 were originally affected by osteoarthritis, 25 by rheumatoid arthritis and one by pigmented villonodular synovitis. Table II lists the types of failed arthroplasty which were revised. The components implanted at the revision operation included both femoral and tibial stems in 31 knees. In 14 knees the tibial component only was stemmed and in 8 only the femoral prosthesis had a stem. The patella was replaced in 33 knees, was not replaced in 17, and had already been removed from three knees.

Bone cement containing gentamicin (Palacos R) was used in 35 knees; in 18 there was no antibiotic in the cement. Stemmed ICLH prostheses were used in the 26 knees operated upon up to 1982. In the later 27 cases a Freeman–Samuelson prosthesis was used.

Table II. Type and number of the original knee arthroplasty

<table>
<thead>
<tr>
<th>Arthroplasty</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICLH</td>
<td>24</td>
</tr>
<tr>
<td>Freeman–Swanson</td>
<td>17</td>
</tr>
<tr>
<td>Total condylar</td>
<td>4</td>
</tr>
<tr>
<td>Unicompartmental ICLH</td>
<td>2</td>
</tr>
<tr>
<td>Guepar</td>
<td>1</td>
</tr>
<tr>
<td>Charnley</td>
<td>1</td>
</tr>
<tr>
<td>Townley</td>
<td>1</td>
</tr>
<tr>
<td>MacIntosh</td>
<td>1</td>
</tr>
<tr>
<td>Multi-radius</td>
<td>1</td>
</tr>
<tr>
<td>Freeman–Samuelson (polymeric femoral component)</td>
<td>1</td>
</tr>
</tbody>
</table>

METHOD

Operation. A full description of the technique of revision is provided by the manufacturers of the implant and will not be repeated in detail. In brief, all foreign material was removed and holes were made to enter either the tibial or the femoral canal, or both. The decision to use a stemmed prosthesis on either or both sides depended on the amount of bone loss. The medullary canals were reamed to size with Charnley-type straight medullary reamers. Although the reamers have virtually the same taper as the stems, the match is not precise, so perfect contact between bone and stem was not always achieved. The diameter of the stem was such that little or no cortical reaming was required. The proximal to distal depth of the components was adjusted to provide stability in both flexion and extension and they were then implanted on cement placed between the floor of the bony defect and the prosthesis, but never within the intramedullary canal (Fig. 2). The wound was closed with drainage and the knee immobilised in plaster.

Prophylactic antibiotic therapy was the same as that used for primary knee arthroplasty, and was continued until swabs taken at the time of operation were reported to be sterile. The postoperative management in general was the same as that for a primary arthroplasty.

Review. Patients were reviewed at six months, at one year and then annually. Pre-operative and all postoperative findings were recorded on standard data sheets. Radiographs were taken before operation and at each post-operative review.

RESULTS

Complications and loss from follow-up. Of the 53 arthroplasties, four we were unable to follow-up and they have been excluded from the clinical review, though they were included in the peri-operative complications which were seen in 19 knees: 9 required manipulation, 5 had

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delayed healing and 4 had a substantial haematoma. There was one case each of cardiac ischaemia, superficial infection and deep staphylococcal infection. Three patients had patellar dislocation. Some patients had more than one complication. All except the case of deep infection have resolved with the appropriate treatment.

Four patients (4 knees) had complications which severely affected the final result and were excluded from the clinical review. One patient who had a deep wound infection is still being treated. Three knees which had stemmed ICLH prostheses developed lateral patellar dislocation; these knees were painful and unstable, and limited the patients’ walking distance. Two of these patients await revision, and the third is so disabled by pneumoconiosis and generalised rheumatoid arthritis that revision is inappropriate. The complication of patellar dislocation is peculiar to the ICLH prosthesis because no lateral stability is provided at the patello-femoral joint. This complication has not been seen since the provision of a patellar groove in the Freeman-Samuelson modification of the ICLH prosthesis (Freeman, Samuelson and Bertin 1985).

Clinical review

The remaining 45 revision arthroplasties have been reviewed at 6 to 48 months after operation; the average follow-up was 18 months. The findings before and after operation with respect to pain, walking ability and range of movement are given in Figures 3, 4 and 5.

Pain (Fig. 3). Twenty-five of the 45 patients (56%) had no pain at review. Sixteen patients (35%) reported occasional pain requiring no analgesics and not affecting their daily activities. Thus 41 patients (91%) had satisfactory relief of pain.

Three patients had moderate pain which required, but was controlled by, simple analgesics; one patient had severe pain. These four patients all had rheumatoid arthritis but the exact cause of their pain could not be determined. The patient with severe pain had had many previous and unsuccessful procedures for the pain. Radiographs of these knees were no different from those of patients whose knees were painless.

Walking ability (Fig. 4). Thirty-nine knee replacements were in patients who were able to walk for longer periods after revision than they could before. The patients with the other six revised knee replacements could walk either the same distance or less than pre-operatively; five of these were severely limited both before and after operation.

Thirty-six revised knee replacements (80%) were in patients who were able to walk for at least 30 minutes. Seven of the nine patients who could walk for less than 30 minutes had rheumatoid arthritis, and had undergone a number of other operations for multiple joint involvement. Three of the four patients who had unsatisfactory pain relief were in this group. Two patients with osteoarthritis were able to walk for less than 30 minutes; but both were over 75 years old, and their replaced knee was not the main limiting factor, one having had a cerebrovascular accident and the other extensive degenerative arthritis.

Range of movement (Fig. 5). The range of movement was improved in 31 knees, though many knees had a good range before operation. The postoperative arc was more than 90° in 38 knees (84%). Of the other seven knees, three had less movement than before operation, three were unchanged and one had an improved range.

Alignment and stability. The standing alignment of the knees before operation ranged from 20° valgus to 30° varus, and 62% of the 45 knees had an alignment outside the range of 2° to 14° valgus. Postoperatively the standing alignment measured from radiographs ranged from 2° varus to 15° valgus, with all except two in the range from 4° to 12° valgus. The mean alignment of the group as a whole after operation was 8° valgus. All knees were subjectively and objectively stable in extension.

Progress after operation. Patients who had been followed for one year or more were further investigated to determine whether they had reached a plateau of improvement, were continuing to improve, or were deteriorating with time. Of 30 patients evaluated in this way, 15 had remained constant, 11 had shown slight improvement, and four had deteriorated slightly with time. The four patients with lower scores after one year included one with progressive systemic rheumatoid arthritis, one stroke victim, one senile patient and one with osteoarthritis in other joints which limited activity.
Radiological review

Radiographs of all stemmed implants were reviewed, excluding the case of deep infection; the three patients with dislocating patellae were also excluded, although the radiographic appearances of their tibial and femoral interfaces were no different from the others.

Bone-cement interface. Sclerotic bone was left at this interface in every case, so postoperative sclerosis could not be evaluated. The only change possible was therefore the development of a radiolucent line.

One femoral component was inserted without cement and thus had no bone-cement interface for evaluation. At the other cemented femoral interfaces, there was no radiolucent zone in eight (24%), and one of less than 2 mm in 26 (76%). Six of these 26 knees had complete radiolucent zones and the other 20 had lucent zones involving only part of the interface. The tibial bone-cement interface showed no lucency in eight knees (21%) and a lucency of less than 2 mm in 31 knees (79%). Eight of these 31 knees had a complete radiolucent zone; the other 23 had lucency involving only part of the interface. In no patient was fracture of cement or migration of the components demonstrable. The width of the radiolucent zone was not progressive in any knee.

Stem interface. A metal–bone interface was present around each uncemented stem, and this region was studied to determine any change from the earliest postoperative radiograph. The only changes seen were the appearance of white lines next to most stems, and some cortical hypertrophy adjacent to the tips of five of the stems.

**Table III.** Radiographic appearances near 74 uncemented intramedullary stems

<table>
<thead>
<tr>
<th>Bone changes</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within canal</td>
<td></td>
</tr>
<tr>
<td>No line</td>
<td>9</td>
</tr>
<tr>
<td>Parallel line</td>
<td>40</td>
</tr>
<tr>
<td>Tightly apposed line</td>
<td>18</td>
</tr>
<tr>
<td>Wedge line</td>
<td>6</td>
</tr>
<tr>
<td>Hour-glass line</td>
<td>1</td>
</tr>
<tr>
<td>Cortical hypertrophy</td>
<td>5</td>
</tr>
</tbody>
</table>

White lines. A thin white line commonly developed parallel to the stem. It was never present in the immediate postoperative radiograph but appeared as early as six weeks after operation. The line was eventually seen in relation to all but four of the femoral and five of the tibial stems, that is near 65 of the 74 stems (Table III, Figs 6 and 7). The line was usually near the tip of the stem and ran parallel to its sides for a variable distance, which usually increased with time. The line completely encircled 15 of the stems in 11 knees in either the anteroposterior or the lateral radiograph, and six stems had a
complete line in both radiographs. No correlation was found between postoperative pain and the presence of a white line. Of the 15 stems which had a complete white line around them, 14 had a space of 2 mm or less between the stem and the line and one had a space of 3 mm. The lucency at the bone-cement interface in these knees was confluent with and similar in appearance to the space between stem and white line in eight cases. None of these knees demonstrated any further changes at the bone-cement interface with increasing time. 

*Lines parallel to the stem.* Eighteen stems (8 femoral and 10 tibial) had a white line tightly apposed to the metal with no radiolucent interval (Fig. 7). The sclerotic line was separated from the metal and was parallel to the stem in 40 components (Fig. 8). The maximal interval between line and stem was 2 mm or less for 20 femoral and 18 tibial components. One femoral stem and one tibial stem lay 3 mm from their white line. The interval between the line parallel to the stem and the stem itself was measured on successive follow-up radiographs. It increased in width near only one femoral component, in which the increase was from 1 to 2 mm. This increase occurred between radiographs taken at 12 and 25 months; no later radiograph is available. 

*Lines diverging from the stem.* Five tibial components developed white lines which were further from the metal stem near the tip of the component than they were from the proximal portion (Fig. 9). One femoral component had its line further from the stem distally than proximally. Three of these six "wedge-shaped" intervals had not increased in width since they had appeared. The other three wedge-shaped intervals increased during the year between radiographs. One increased from 1 to 2 mm between 36 and 48 months and the second from 2.5 to 4 mm between 12 and 24 months. The third had a line adjacent to the tip of the tibial stem at 6 months, and after one year the interval was 1 mm; by two years the interval had increased to 2 mm near the tip and was 1 mm proximally. This knee had an incomplete lucent zone at the bone-cement interface 1 mm in width.

One femoral stem had an interval shaped like an hourglass, with more space at either end than in the middle. The maximum separation of this line from its stem also increased from 1 to 2 mm between 6 and 30 months after operation but remained static during the next 12 months. No correlation was found between postoperative pain and the presence of a wedge or hourglass-shaped interval. Stress radiographs taken of one patient failed to show any movement of the stem relative to the line (Fig. 10).

*Cortical hypertrophy.* There was hypertrophy of the cortex in an area near the tip of five of the stems, an appearance suggestive of stress transfer (Fig. 11). This was seen twice in the femur and three times in the tibia, but there was no relationship between its presence and the subjective result.

**DISCUSSION**

It can be difficult to salvage a failed total knee arthroplasty. Arthrodesis, resection arthroplasty and amputation have all been used (Hagemann, Woods and Tullos 1978; Brodersen et al. 1979; Vahvanen 1979; Kaufert and Matthews 1981; Stulberg 1982). Surprisingly, there are few reports in the literature of the results of revisions of total knee replacement. Insall and Dethmers (1982) reported 89% success with revision arthroplasty, and Bryan and Rand (1982) reported 67% satisfactory results and also found that 22% of 227 revision arthroplasties had to be revised a second or even a third time.

The present series shows the feasibility of revising a failed total knee replacement with a minimally constrained implant. After the exclusion of the three patients with ICLH prostheses who had dislocating patellae, a
complication which is peculiar to this prosthesis, and of the patient with persistent deep sepsis, 91% of our patients had mild or no postoperative pain, 80% could walk for more than 30 minutes and 84% had over 90° of movement. There were no radiographic failures as defined by fracture of cement, progressive bone–cement lucent zones, or subsidence of components. No further operations have been necessary.

The number of peri-operative complications, 19 in 53 knees, illustrates that not only are these patients in an age group which is prone to general operative complications, but also that revision arthroplasty is inherently corrected without the use of a hinge, and one failed Guepar hinge was successfully converted to an unlinked Freeman–Samuelson replacement.

Metal backing of the tibial component serves three important functions (Walker et al. 1981; Bartel et al. 1982; Lewis, Askew and Jaycox 1982). First, part of the bone lost when the first prosthesis loosens is replaced by an inert, durable substance. Secondly, the metal distributes forces evenly across the interface and eliminates high peak stress in the cement. Thirdly, it serves as a strong platform for the attachment of an intramedullary stem. It is imperative in revision surgery (as in primary surgery) that correct soft-tissue tension and leg alignment is obtained so that forces are properly directed through the implant. In the context of alignment, tibial and femoral components with intramedullary stems are of assistance.

Severe bone defects after previous operations often make stabilisation of a revision prosthesis impossible without the use of a stem. Such defects impose two changes in prosthetic design: a tibial plate to help fill the defect, and tibial and femoral stems to stabilise the implant. The defects may be so large that they cannot be filled even with an augmented prosthesis and we have therefore used cement as a supplementary "filler" as well as a "fixative". More recently we have used bone grafts in place of cement but it is too early to comment on the results.

The useful contribution made by the uncemented stems is suggested by the radiographic findings that the bone–cement interface at the bone ends appeared to be stable, with no progressive radiolucent lines, and that no subsidence, cement fracture or change of alignment was seen. We also believe that the thin white lines which were
seen alongside 65 stems, and the cortical hypertrophy seen near the tip of five stems, suggest that stress was being transferred through the stems, showing that they make a useful mechanical contribution. Our observations do not suggest that the white lines imply loosening, since they were usually incomplete and symptomless, but clearly this possibility can only be finally resolved by long-term follow-up and eventual histological examination. We feel that the patchy sclerosis seen adjacent to implants in cancellous bone is probably the result of union of the many individual cancellous fractures produced by the insertion of the component and by stress absorption and transfer. The layers eventually in contact with the established implant may include variable thicknesses of fibrous and of osseous tissue (Pilliar et al. 1981; Freeman, Bradley and Revell 1982).

REFERENCES


