The Oxford medial unicompartmental knee replacement using a minimally-invasive approach

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This prospective study describes the complications and survival of the first 688 Phase 3 Oxford medial unicompartmental knee replacements implanted using a minimally-invasive technique by two surgeons and followed up independently. None was lost to follow-up. We had carried out 132 of the procedures more than five years ago. The clinical assessment of 101 of these which were available for review at five years is also presented.

Nine of the 688 knees were revised: four for infection, three for dislocation of the bearing and two for unexplained pain. A further seven knees (1%) required other procedures: four had a manipulation under anaesthesia, two an arthroscopy and one a debridement for superficial infection. The survival rate at seven years was 97.3% (95% confidence interval 5.3). At five years, 96% of the patients had a good or excellent American Knee Society score, the mean Oxford knee score was 39 and the mean flexion was 133˚. This study demonstrates that the minimally-invasive Oxford unicompartmental knee replacement is a reliable and effective procedure.

The Oxford knee (Biomet, Bridgend, UK) is a unicompartmental replacement with a fully congruous mobile bearing (Fig. 1). Initially it was implanted through a standard approach as used for total knee replacement (TKR). The long-term results when used in the medial compartment have been good with survival rates at ten years of between 94% and 100%. Svard and Price described a 95% survival of the implant at 15 years. Although not all centres have achieved such good results, the Swedish Knee Arthroplasty Register has shown that those undertaking at least two replacements per month achieved a survival of about 93% at nine years. These long-term studies have shown that if failures occur, they tend to occur early. This is, in part, because the fully congruous mobile bearing has greatly reduced the problem of long-term failure because of wear.

In June 1998, the minimally-invasive Oxford Knee Phase 3 was introduced. There were minor modifications to the components, including an increased range of sizes, but the articular surfaces were not changed. The instrumentation was simplified and made smaller. We have previously shown that the recovery is much quicker with the smaller incision and that the components can be implanted as reliably. It is important to know if the minimally-invasive approach has compromised the clinical results and therefore the purpose of this study was to determine the complication rate, the clinical outcome and the midterm survival following this procedure.

Patients and Methods
Since June 1998, the Phase 3 Oxford unicompartmental knee replacements performed by
two surgeons (DWM and CAFD) have been followed up prospectively. Almost all the clinical assessments have been made by two independent observers (HP, CJ) in a dedicated clinic. The cut-off date for recruitment into this study was 1 July 2005. By then a reliable assessment of the rate of complication could be made on more than 500 knees, more than 100 knees were available for clinical appraisal at five years and more than 25 had been ‘at risk’ for seven years.8

We recruited 688 knees, 667 with anteromedial osteoarthritis and 21 with medial avascular necrosis. Of these, 132 unicompartmental replacements had been implanted more than five years previously including 129 for anteromedial osteoarthritis and three for medial avascular necrosis. There were 308 men and 287 women. The mean age of the patients at the time of the operation was 66.4 years (33 to 89). There were 502 unilateral, 11 simultaneous bilateral and 82 staged bilateral procedures. In this study, we report first the complications and survival of all 688 knees, of which none was lost to follow up, and secondly, the outcome of those knees that were available for clinical review at five years.

During the recruitment period, in addition to the consecutive 688 procedures described above, 15 Phase 3 unicompartmental replacements were implanted in combination with anterior cruciate ligament (ACL) reconstruction at a mean age of 48 years (36 to 63); one was implanted in an ACL-deficient knee without ACL reconstruction at 84 years of age; two were implanted after a high tibial osteotomy; two in patients with Von Willebrand’s disease; one in a patient with medial osteochondritis dissecans and one in a patient with carbon fibre rods implanted in the femoral condyle. These 22 patients were excluded from the study, however, their results are presented separately. In addition, during this recruitment phase, 78 lateral Oxford unicompartmental knee replacements were implanted. In this study, we report first the complications and survival of all 688 knees, of which none was lost to follow up, and secondly, the outcome of those knees that were available for clinical review at five years.

Table I. Details of the nine revised replacements

<table>
<thead>
<tr>
<th>Case</th>
<th>Time to revision (yrs)</th>
<th>Reason for revision</th>
<th>Operative findings*</th>
<th>Revision and outcome†</th>
</tr>
</thead>
<tbody>
<tr>
<td>1‡</td>
<td>0.75</td>
<td>Bearing dislocation</td>
<td>Dislocated bearing</td>
<td>Femoral component revised and bearing changed. Good result at 5 yrs</td>
</tr>
<tr>
<td>2*</td>
<td>2.5</td>
<td>Unexplained pain</td>
<td>No abnormality, components well fixed</td>
<td>Revision to TKR, continues to have pain at 5 yrs</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>Infection (coagulase negative staphylococcus)</td>
<td>Infected knee, both components loose</td>
<td>Two-staged revision with antibiotics, good result at 4 yrs</td>
</tr>
<tr>
<td>4</td>
<td>1.1</td>
<td>Unexplained pain</td>
<td>No problem</td>
<td>Two-staged revision with antibiotics, good result at 3 yrs</td>
</tr>
<tr>
<td>5A</td>
<td>1.9</td>
<td>Infection (no organisms grown)</td>
<td>Synovitis, destruction of the lateral and P-F joint</td>
<td>Two-staged revision with antibiotics, good result at 3 yrs</td>
</tr>
<tr>
<td>5B</td>
<td>1.6</td>
<td>Infection (no organisms grown)</td>
<td>Synovitis, destruction of the lateral and P-F joint</td>
<td>Two-staged revision with antibiotics, good result at 3 yrs</td>
</tr>
<tr>
<td>6</td>
<td>0.75</td>
<td>Infection (coagulase negative staphylococcus)</td>
<td>Infected knee, both components loose</td>
<td>Two-staged revision with antibiotics, good result at 3 yrs</td>
</tr>
<tr>
<td>7</td>
<td>0.75</td>
<td>Bearing dislocation</td>
<td>Dislocated bearing</td>
<td>Bearing changed, patient died from disseminated carcinoma of the bladder</td>
</tr>
<tr>
<td>8</td>
<td>5.75</td>
<td>Bearing dislocation</td>
<td>Dislocated bearing</td>
<td>Bearing changed. Good result at 1 yr since revision</td>
</tr>
</tbody>
</table>

* cases included in the first 121 (clinically assessed at five years)
† TKR, total knee replacement
‡ PFJ, patellofemoral joint

Table II. Details of cases with re-operation (not listed as revision)

<table>
<thead>
<tr>
<th>Time to re-operation</th>
<th>Reasons for revision</th>
<th>Procedure</th>
<th>Findings</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 yrs</td>
<td>Persistent pain</td>
<td>Arthroscopy</td>
<td>Partial thickness damage to PFJ cartilage</td>
<td>Pain persisted, possibly caused by neuroma at 5 yrs</td>
</tr>
<tr>
<td>5.5 yrs</td>
<td>Pain and swelling</td>
<td>Arthroscopy and synovial biopsy</td>
<td>Chronic inflammation</td>
<td>No change at 1 yr</td>
</tr>
<tr>
<td>6 weeks</td>
<td>MRSA† infection</td>
<td>Wound debridement</td>
<td>Superficial infection</td>
<td>Good at 3 yrs</td>
</tr>
</tbody>
</table>

* PFJ, patellofemoral joint
† MRSA, methicillin resistant staphylococcus aureus

Table III. Life table of all 688 knees

<table>
<thead>
<tr>
<th>Follow-up (yrs)</th>
<th>Number at start</th>
<th>Withdrawn</th>
<th>Failures</th>
<th>At risk</th>
<th>Failure rate (%)</th>
<th>Success rate (%)</th>
<th>Survival (%)</th>
<th>Confidence interval (Peto et al)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1</td>
<td>688</td>
<td>157</td>
<td>4</td>
<td>609.5</td>
<td>0.7</td>
<td>99.3</td>
<td>99.3</td>
<td>0.6</td>
</tr>
<tr>
<td>1 to 2</td>
<td>527</td>
<td>108</td>
<td>3</td>
<td>473</td>
<td>0.6</td>
<td>99.4</td>
<td>98.7</td>
<td>1.0</td>
</tr>
<tr>
<td>2 to 5</td>
<td>416</td>
<td>283</td>
<td>1</td>
<td>274.5</td>
<td>0.4</td>
<td>99.6</td>
<td>98.4</td>
<td>1.5</td>
</tr>
<tr>
<td>5 to 6</td>
<td>132</td>
<td>71</td>
<td>1</td>
<td>96.5</td>
<td>1.0</td>
<td>99.0</td>
<td>97.3</td>
<td>3.2</td>
</tr>
<tr>
<td>6 to 7</td>
<td>60</td>
<td>51</td>
<td>0</td>
<td>34.5</td>
<td>0.0</td>
<td>100.0</td>
<td>97.3</td>
<td>5.3</td>
</tr>
<tr>
<td>7 to 8</td>
<td>9</td>
<td>9</td>
<td>0</td>
<td>4.5</td>
<td>0.0</td>
<td>100.0</td>
<td>97.3</td>
<td>14.6</td>
</tr>
</tbody>
</table>

VOL. 88-B, No. 1, JANUARY 2006


Selection criteria. The recommended indications for the Oxford knee are medial compartment osteoarthritis or avascular necrosis.9,10 In the arthritic patient there should be full thickness cartilage loss with bone-eburnation in the medial compartment. The ACL should be intact. The varus deformity should be correctable at 20˚ flexion indicating that the medial collateral ligament is functionally normal. There should be full thickness cartilage in the lateral compartment, but a chondral ulcer on the medial side of the lateral femoral condyle can be ignored. These last two criteria are best assessed on valgus stress radiographs. The patient’s age, activity, weight and the presence of chondrocalcinosis11 and patellofemoral arthritis are not considered contraindications to the operation. Of the 688 knees included in this study, 673 fulfilled these recommended indications. Although the 15 remaining knees had partial thickness cartilage loss and thus did not fully meet the recommended indications they have been included in the study.

Operative technique. All the procedures were carried out through an incision from the medial pole of the patella to the medial side of the tibial tuberosity. The details of the operative technique are given in the operative manual.12 Care was taken to ensure that accurate ligament balance was achieved and that the bearing did not impinge on retained bone or cement. Patients were allowed to mobilise and fully weight-bear as tolerated. They were given low-dose aspirin and graduated compression stockings as in patients for thromboembolic prophylaxis.

Clinical assessment. Patients were clinically assessed pre-operatively and at one, two, five and seven years after surgery. They were also contacted at six years to assess the state of the knee. The clinical outcome was assessed using the Oxford knee score (OKS), a validated patient-based questionnaire.13 We used this score with a minimum of 0 (worst outcome) and maximum of 48 (best outcome). The American Knee Society Score (AKSS) was also used.14 Each patient’s level of activity was recorded with the Tegner score.15 If for any reason (social, geographic or medical) the patients were unable to attend for follow-up, they were contacted by telephone or by post and relevant clinical information obtained. For patients who had died, information was gathered from hospital and general practitioners’ records to establish whether the patient had undergone any further surgery on the knee under investigation. Operative data was collected using a standard form, which recorded surgical findings including the status of the ACL and the status of the cartilage in the involved as well as the retained compartments.

Using revision of the prosthesis or of any component (including the mobile bearing) as failure, a life table was constructed for all the 688 cases. The 95% confidence intervals (CI) were calculated using the method of Peto et al.16

Radiological assessment. Precise post-operative radiographs were taken using an image intensifier. The anteroposterior film was aligned so that the tibial component appeared end on. The lateral view was aligned with the femoral condyles.

Table IV. Pre-operative and five-year clinical data

<table>
<thead>
<tr>
<th>Score definition</th>
<th>Pre-operative (n = 132)</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Oxford Knee score (SD)</td>
<td>18 (5.9)</td>
<td>39.2 (9.1)</td>
</tr>
<tr>
<td>Mean Knee Society score – objective (SD)</td>
<td>35.3 (8.6)</td>
<td>91.2 (11)</td>
</tr>
<tr>
<td>Mean Knee Society score – function (SD)</td>
<td>49.6 (11.1)</td>
<td>78.6 (20.8)</td>
</tr>
<tr>
<td>Mean Tegner activity score (SD)</td>
<td>1.0 (0.6)</td>
<td>2.6 (0.9)</td>
</tr>
</tbody>
</table>
Five-year follow-up radiographs were assessed and compared with the one-year follow-up radiographs, looking for progression of osteoarthritis in the lateral compartment and patellofemoral joint, the presence and extent of radiolucency and evidence of component subsidence. The method described by Weale et al\textsuperscript{17} was used for assessing the progression of arthritis. In this, each radiograph was assessed twice by the same observer and the severity of arthritis was graded using the Ahlback\textsuperscript{18} and Altman et al\textsuperscript{19} classifications. Intra-observer reproducibility was found to be good for Ahlback classification system (\(k = 0.71\)) and moderate for the Altman grading system (\(k = 0.58\)). On repeated examination of the same radiograph, the maximum difference recorded was one grade using the Ahlback classification and two grades using the Altman. These differences were taken to be the errors of measurement. Greater differences than these between sequential films were recorded as evidence of definite progression or improvement in the severity of osteoarthritis. Differences of the same order or less were taken as evidence of possible change.

Results

Survival and complications of all patients. Revision operations had been performed on nine knees (eight patients), for infection in four, dislocation of the bearing in three, and for unexplained pain in two (Table I).

Table II presents details of further interventions in seven patients which were not counted as revisions. In none of these was the prosthesis removed and all functioned well after the last intervention.

Table III is the life table and Figure 2 is the survival curve, with the point of failure defined as revision of the prosthesis or any component part. The seven-year cumulative survival, when there were 35 knees at risk, was 97.3% (95% CI 5.3).

The most common cause for revision was infection. The patients with infection presented with pain and effusion. Their early radiographs showed loss of lateral joint space with the presence of subchondral erosions (Fig. 3). One patient with bilateral unicompartmental knee replacement was presumed to have bilateral infections, although no organisms were grown. The other two infections, confirmed by culture, occurred in unilateral patients. The infections were treated with two-stage revision and in all cases a primary cruciate retaining TKR without stems (anatomic graduated components) was used. The mean time from index procedure to revision was 14 months.

Three replacements were complicated by a dislocated bearing. The first case, which occurred in the first year, was a posterior dislocation (Fig. 4). The bearing and femoral component were removed through the old incision and a new femoral component and bearing were implanted. This became infected and, after debridement, the patient did well. At the last follow-up, five years after the dislocation, he has an excellent clinical outcome (AKSS - 100 and 100). The second dislocation also occurred in the first year. The patient, however, died soon after the dislocation from disseminated bladder cancer with bony metastasis. The third dislocation occurred in the sixth year. The bearing which had evidence of anterior impingement was replaced with a thicker bearing. This patient had an excellent outcome.

Two unicompartmental knee replacements were revised to TKRs for unexplained pain. No cause for the pain was identified in either knee. The first patient was revised at 1.1 years and has a good outcome (OKS 38, AKSS 84 - objective). In the second case, revised at 2.5 years, the pain persists and its cause remains unclear. This patient has been off work for the last six years and is on sickness benefit.

Of the seven patients requiring further interventions, which were not counted as revisions (Table II), four knees required manipulation under anaesthesia to improve flexion. The range of movement (ROM) improved from a mean of 76° to 125°. Arthroscopy was undertaken in two knees (two patients) for persistent pain and/or swelling. In one knee, the patellofemoral joint was debrided for a partial thickness chondral lesion. This did not help the pain, which is now thought to be caused by a neuroma. In the other knee, the arthroscopy revealed chronic inflammation but synovial biopsy was inconclusive. One patient (one knee) developed a superficial methicillin resistant \textit{Staphylococcus aureus} infection, needing debridement of the wound and a prolonged course of antibiotics. The patient has a good outcome.

No patients died as a result of their surgery. Eleven patients (12 knees) died because of unrelated causes and in each case the status of the knee prior to death was estab-
lished by contacting the family and/or the patients’ general practitioner.

One patient (two knees) had a pulmonary embolus, confirmed by VQ scan. This occurred four days after a simultaneous bilateral procedure in a patient who was slow to mobilise and was subsequently found to have a carcinoma of the caecum. Two other patients had a possible pulmonary embolus at about three weeks post-operatively. One patient had severe angina. There were no other major medical complications.

Clinical results of first 132 cases at five years. Out of 132 knees, 101 (90 patients) were assessed clinically and radiologically at five years, four had died prior to their five-year assessment, two had been revised and 25 knees could only be reviewed by telephone due to medical (6), geographic (14) or social (5) reasons. For these 25 knees, only OKS, the AKSS (functional) and Tegner score were obtained (Table IV).

Considering all patients at five years, the mean range of movement was 133˚ (pre-operative 115˚) (Fig. 5). The mean AKSS (objective) was 91.2 (pre-operative: 35.3) and the mean AKSS (functional) was 78.6 (pre-operative: 49.6). The mean OKS at five years was 39.2 (pre-operative: 18) and mean Tegner activity score was 2.6 (pre-operative: 1.9).

Of the 101 knees clinically reviewed, 87 (86%) had an excellent clinical outcome according to the AKSS criteria (85 to 100), ten had a good outcome (71 to 84), two had a fair outcome (51 to 60) and two had a poor outcome (score < 50).

The radiographic review demonstrated that at five years, two of 101 knees, had evidence of progression of arthritis in the lateral compartment (Table V). In one case, there was progression of arthritis in the patellofemoral joint but this was manifest on the Altman but not on the Ahlback score.

Radiolucent lines were seen in 70% (70) of the 101 knees. Of 70, 42 (60%) of the radiolucent lines were partial and in 28 (40%) were complete. In all cases, the radiolucency had a sclerotic margin. In no case, was there any evidence of either subsidence or loosening of either the femoral or tibial component.

Discussion

These clinical results are encouraging and indicate that, at least in the hands of experienced surgeons doing about one case per week, good results can be achieved with the minimally-invasive Oxford Phase 3 medial unicompartmental knee replacement.

Although a seven-year survival of 97% is good, there is concern that there may be a higher failure rate in the long-term. This study demonstrates that using the Oxford device the survival for unicompartmental knee replacement performed through a minimally-invasive approach can be as good as with an open approach. The previous long-term studies of the open Oxford unicompartmental knee replacement demonstrated that the failures tended to occur early rather than late.17 This pattern of failure seems to be peculiar to the mobile bearing Oxford knee. Technical errors tend to manifest themselves early and long-term problems are rare because of the resistance of the device to wear. The long-term studies of Oxford unicompartmental knee replacement have shown that if the survival is good at seven years, it is likely to be good in the long term.17 It is therefore likely that the minimally-invasive Oxford unicompartmental knee replacement will have good long-term rates of survival.
The most common cause of revision was infection (0.6%). Although distressing, this may be unavoidable and occurs in all joint replacements. Bearing dislocation occurred in 0.4% of cases and is a complication peculiar to mobile bearings. We however, believe that this is a small risk and justified by the minimal wear properties associated with the mobile bearing. There were no revisions for progression of arthritis in the lateral compartment or the patellofemoral joint. The radiographic review suggests that in the future, there may be revisions for progression of arthritis but the number is likely to be very low. The incidence of radiolucencies is similar to that after open Oxford unicompartmental knee replacement when assessed by fluoroscopy. None of the radiolucencies had an appearance suggestive of subsidence or component loosening.\textsuperscript{20} We therefore think that it is unlikely that there will be an appreciable number of revisions for loosening in the longer term.

The mean knee flexion at five years was 133\degree, which is 18\degree more than the pre-operative flexion of 115\degree. This is better than the results with the open procedure.\textsuperscript{21} With the open procedure, the mean post-operative flexion was similar to the pre-operative flexion (105\degree and 104\degree, respectively). The reason for improved flexion with the minimally-invasive procedure, is probably that there is less damage to the extensor mechanism and the suprapatellar pouch.

The patients do, in general, achieve excellent function and gain good relief of their symptoms. A five-year clinical outcome of 96% good or excellent knee scores is similar to the best results achieved by other devices. Unfortunately, the AKSS is not reliable for comparing implants as it is open to bias and has poor repeatability.\textsuperscript{22} It is particularly poor at discriminating between devices achieving good function as it gives a maximum score for 125\degree flexion.\textsuperscript{13} In this series 80% of patients achieved more than 125\degree flexion and 43% more than > 135\degree. In addition, the aim of the Oxford knee is to restore the alignment of the leg to the predisease state rather than to alter the alignment so that the mechanical axis of the leg is straight. Therefore, a patient with tibia vara and medial osteoarthritis, who has a perfect result from unicompartmental knee replacement will have correction of the intra-articular deformity but not the tibia vara. This patient will therefore only score 90 points rather than 100, because of the tibia vara, yet will have normal function.

The outcome of unicompartmental knee replacement is dependent on the indications. The main indication is anteromedial osteoarthritis and medial avascular necrosis. In this study, we have only included patients with these diagnoses. Therefore if surgeons use appropriate techniques to implant the device in patients with these diagnoses, they should expect similar results. In general, one in three patients needing a knee replacement have these diagnoses and are appropriate for the Oxford unicompartmental knee replacement. Of our patients 2% had partial thickness cartilage loss. We do not generally recommend these patients for unicompartmental knee replacement as it is difficult to be certain that this is the source of their pain, and therefore that the procedure will be effective. We also implanted 22 medial Oxford unicompartmental knee replacements in patients with other diagnoses (ACL deficient knee, Von Willebrand's disease, osteochondritis dissecans and failed high tibial osteotomy). As the number is small compared to the overall series, the inclusion of these cases would have made little difference to the overall results. The seven-year survival would have been 97.2\% (95\% CI 5.4). We, however, believe it is misleading to include these patients in the main study as they probably will not do as well in the long-term as those with anteromedial osteoarthritis. We, therefore, do not generally recommend the use of the device in patients with these diagnoses and will not do so unless good outcome data becomes available in these subgroups.

There is currently a vogue for minimally-invasive total knee and hip replacement. This surgery is usually difficult, and although the faster recovery is encouraging, there may be an increase in the complication rate. The minimally-invasive Oxford unicompartmental knee replacement is very different. We find the operation is easier than the open procedure. The recovery is much more rapid and early morbidity lower. We have now shown that the risk of revision is no higher, the incidence of complications is lower and the clinical results are better.

There is considerable evidence in the literature that unicompartmental knee replacement gives better results than TKR, particularly in terms of kinematics, function, range of movement and speed of recovery.\textsuperscript{7,21} The Oxford Knee Phase 3 gives the additional advantage of sophisticated instrumentation for a reliable minimally-invasive approach and a mobile bearing which gives excellent long-term survival even in the young. We, therefore, believe that it is a good treatment for medial osteoarthritis providing the indications are satisfied and the appropriate surgical expertise is available.

The authors wish to thank Mrs Barbara Marks, Research Administrator; Mrs Sarah Poulter, Research Assistant; Dr Richie (H. S)-Gill, University Research Lecturer; Dr David Beard, University Research Lecturer and the radiographers at the Nuffield Orthopaedic Centre.

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References


