The Oxford medial unicompartmental arthroplasty
A TEN-YEAR SURVIVAL STUDY
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Retrieval studies have shown that the use of fully congruent meniscal bearings reduces wear in knee replacements. We report the outcome of 143 knees with anteromedial osteoarthritis and normal anterior cruciate ligaments treated by unicompartmental arthroplasty using fully congruous mobile polyethylene bearings. At review, 34 knees were in patients who had died and 109 were in those who were still living. The mean elapsed time since operation was 7.6 years (maximum 13.8). We established the status of all but one knee.

There had been five revision operations giving a cumulative prosthetic survival rate at ten years (33 knees at risk) of 98% (95% CI 93% to 100%). Considering the knee lost to follow-up as a failure, the ‘worst-case’ survival rate was 97%. No failures were due to polyethylene wear or aseptic loosening of the tibial component. One bearing which dislocated at four years was reduced by closed manipulation.

The ten-year survival rate is the best of those reported for unicompartmental arthroplasty and not significantly different from the best rates for total knee replacement.

Unicompartmental arthroplasty for selected cases of osteoarthritis of the knee is less invasive than total knee replacement, preserving the cruciate ligaments and giving better range of movement and more physiological function. The operation has a lower morbidity, blood transfusion is not required and the implant is cheaper. The results of knee arthroplasty, however, are usually assessed by survival analysis. This has shown that unicompartmental arthroplasty often has a higher failure rate than modern total replacement, commonly due to the effects of polyethylene wear, which some authors regard as inevitable. To reduce wear in knee prostheses Goodfellow and O’Connor introduced fully congruent arthroplasty with mobile bearings. The first unicompartmental replacement with the ‘Oxford’ prosthesis was performed in 1982. By 1985, the criteria for this arthroplasty had been determined; the presence of an intact anterior cruciate ligament (ACL) was found to be essential. In 1991, the detailed pathological morphology of ‘anteromedial osteoarthritis of the knee’ was described and considered to be suitable for treatment by unicompartmental replacement.

We report the ten-year survival of knees with anteromedial osteoarthritis and normal ACLs treated by unicompartmental replacement with the Oxford prosthesis.

Patients and Methods

From 1982 to 1992, details of all patients treated by one of the authors (JWG) with unicompartmental arthroplasty were recorded and updated annually. Early outcomes were reported in 1987, 1988 and 1993, and in 1996, the two- to ten-year results of 53 lateral compartment arthroplasties were published. We now report the results only of medial-sided replacements.

Patients who were still alive were sent a questionnaire and for those who had died, we established the state of the implant at the time of death from hospital records, the general practitioner or the patient’s family. We required positive evidence that there had been no further surgical procedure on the knee before recording the survival of the prosthesis. A life table was used to determine survival rates with the 95% confidence interval (CI) calculated by various methods including that of Peto et al. Our study was approved by the local Ethical Committee.

Inclusions. All were primary operations performed by, or under the direct supervision of one surgeon (JWG), for idiopathic osteoarthritis with full-thickness loss of articular cartilage, with or without bone loss, in the medial compartment (Ahlbäck’s radiological grades 2 or 3).

Preoperative radiographs were taken with valgus stress to confirm the presence of full thickness of articular cartilage in the lateral compartment. Fibrillation of the surface...
of the cartilage in the lateral compartment seen at operation was not a contraindication and even frank erosions, if they were limited to the medial margin of the lateral femoral condyle, were accepted. Osteophytes around the margins of the lateral condyle were often seen and were not a contraindication. The possibility of full correction of the varus deformity to neutral had been shown by routine preoperative anteroposterior radiographs taken in valgus stress.

All the knees had normal anterior and posterior cruciate ligaments, and the final decision for unicompartmental or total replacement was made at operation after inspection of the ACL. We defined a ‘normal’ ligament as one which retained its synovial covering and had no longitudinal splits.

The pathological anatomy associated with these criteria was defined as ‘anteromedial osteoarthritis of the knee’ by White et al in 1991 because the cartilage and bone erosions are at first only in the anterior articular surfaces of the medial tibiofemoral joint. The preserved surfaces in the posterior part of the joint, plus an intact ACL, were considered to protect the knee from the development of a fixed varus deformity and from involvement of the lateral compartment.

The state of the patellofemoral joint was not a selection criterion. No knee was excluded, even with extensive fibrillation or the erosions commonly seen on the medial facet of the patella and the medial flange of the patellar groove of the femur. Neither excessive weight nor the presence of chondrocalcinosis was a contraindication.

Exclusions. The early medial unicompartmental replacements were performed without regard to the state of the ACL. Poor results have been reported in 28 knees with an absent or damaged ACL. These joints are not included in this review. After 1985 an absent ACL was a contraindication for unicompartmental replacement, but review of the operative records showed that 13 knees had shown longitudinal splits in this ligament with absence of synovial covering. These cases were also excluded; two of the knees have required revision for loosening of the tibial component, at 6 months and 6.7 years, respectively.

Nine knees had a medial unicompartmental arthroplasty after a failed high tibial osteotomy and were excluded. One required revision at 5.7 years. Two other cases were excluded because of preoperative diagnoses of post-traumatic arthritis in one and avascular necrosis in the other. Neither has yet needed revision.

From November 1982 to February 1992, 144 medial compartment replacements were performed on 114 patients whose knees strictly fulfilled the criteria given above. Their mean age at operation was 70.7 years (34.6 to 90.6) and the male to female ratio was 1 to 1.2. At review in October 1996, 29 patients (34 knees) had died and the fate of 143 prostheses was determined. One patient had been lost to follow-up one year after her operation. The mean follow-up was 7.6 years (maximum 13.8).

Prosthesis. The Oxford Meniscal prosthesis (Biomet Ltd, Bridgend, UK) consists of a cobalt-chrome femoral component with a spherical articular surface and a cobalt-chrome tibial component, with a flat articular surface. The polyethylene ‘meniscal’ bearing conforms with the metal components. It is unconstrained and is retained by its shape and soft-tissue tension. Only one size of femoral component was used (24 mm radius), with five sizes of tibial component and nine thicknesses of meniscal bearing, ranging from 3.5 mm to 11.5 mm in 1 mm steps at their thinnest points. All the metal components were cemented to bone.

These features remained unchanged, but the original femoral component with three flat internal facets fitted to angled saw cuts on the femur (Fig. 1) was changed in 1987 to a design with one flat and one spherically concave facet (Fig. 2) to fit a convex surface prepared with a shaped bone-mill. The mill removes bone in measured amounts from the inferior aspect of the femoral condyle to allow accurate matching of the extension and flexion gaps. At the same time an intramedullary jig was introduced to align the femoral component, and the anterior lip of the meniscal bearing was lowered by 1.5 mm to reduce the risk of its impingement against the femur in full extension.

The operative technique has been described in detail; osteophytes were removed from the margins of the medial tibiofemoral and patellofemoral joints but no soft-tissue release was ever performed.

Results

There had been five revision operations, detailed in Table I. One other patient had anterior dislocation of the meniscal bearing at four years which was replaced by closed manipulation under general anaesthesia; the knee has functioned
normally for another six years. It is recorded as a success in
the survival table.

Table II shows the number of knees at risk for each year,
the number revised and the cumulative survival, which at
ten years was 98% (95% CI 93% to 100%). The ‘worst-
case’ ten-year survival including the knee lost to follow-up
as a failure is 97% (CI 91% to 100%).

Discussion

Survival analysis is considered to be the best record of the
results of prosthetic replacement,\textsuperscript{15-17} but the predictive
reliability depends on several factors,\textsuperscript{18} especially the num-
ber of patients at risk and those lost to follow-up.\textsuperscript{19} The use
of the 95% confidence interval quantifies the influence of
small numbers, and the possible effect of loss to follow-up
is shown by a ‘worst-case scenario’ recording all such
losses as failures. Table III summarises the few ten-year
survival studies for unicompartmental arthroplasty of the
knee with available information on their reliability.

In the series which we report, 33 knees were at risk at ten
years, and the cumulative ‘worst-case’ survival was 97% (CI 91% to 100%), the best yet recorded for unicompartmental
knee arthroplasty.

Comparisons of survival rates of total and unicompartmental
knee replacements are biased for many reasons. On
the one hand, knees suitable for unicompartmental replace-
ment have less severe disease and are likely to have a
better outcome. On the other hand, unicompartmental
replacements are usually easier to revise than total replace-
ments,\textsuperscript{20} and thus the indications for this procedure are
likely to be less stringent. Table III also shows some ten-
year survival results for four total knee replacements,
which show that our unicompartmental prostheses had a
similar outcome.

Patient selection. Patient selection must affect survival
rates and our strict criteria have probably contributed to our
low failure rate. We studied only one specific disorder of
the knee, anteromedial osteoarthritis with an intact ACL.\textsuperscript{7}
Absence of the ACL was first recognised as a risk factor in
bicompartmental meniscal arthroplasty.\textsuperscript{21,22} A significant
association (Fisher’s test, p<0.019) was later reported
between failure and an “absent or damaged” ligament in 75
medial unicompartmental replacements.\textsuperscript{6} The 28 knees
without a functioning ACL failed ten times more often than
the rest, usually from loosening of the tibial component.

Deschamps and Lapeyre\textsuperscript{23} had previously reported an asso-

\begin{table}[h]
\centering
\begin{tabular}{|l|l|l|l|}
\hline
Case & Time after primary operation (yr) & Reason for revision & Operative findings & Revision and outcome \\
\hline
1 & 2.2 & Pain since operation Clinical evidence of infection & Infected knee, both components loose & 1) Revision to TKR + antibiotics. Infection persisted 2) Two-stage revision; outcome uncertain \\
\hline
2 & 3.9 & Increasing pain and valgus deformity. Leg spasticity due to cervical myelopathy & Erosion of cartilage and bone in lateral compartment & Revision to TKR Pain relieved \\
\hline
3 & 4.3 & Increasing pain and lateral compartment arthritis & Erosion of cartilage in lateral compartment. Both components well fixed & Revision to TKR Good result \\
\hline
4 & 10.0 & Gradually increasing pain & Loose femoral component Tibial implant well fixed but large subchondral cyst before operation* & Revision to TKR Good result \\
\hline
5 & 12.5 & Long-standing pain in whole leg; radiograph normal. Arthroscopy showed no abnormality, ACL intact & No abnormality, components well fixed & Revision to TKR Unexplained pain continues \\
\hline
\end{tabular}
\caption{Details of the five revised arthroplasties \textsuperscript{* reported in detail by Crawford et al.\textsuperscript{50}}}
\end{table}
Association between ACL laxity and failure of non-meniscal unicompartmental replacements.

As explained above our criteria for the condition of the ACL changed with experience. There were no revisions for tibial loosening in the 144 knees in which the ACL was normal as defined above, but in the 13 knees in which the ligament showed longitudinal splits and absence of synovial covering there were two failures, both because of tibial loosening. A biomechanical explanation for this association between non-function of the ACL and tibial loosening was provided by O’Connor et al.

In excluding from our analysis all knees with other pathologies, we attempted to enhance the predictive power of our survival study for anteromedial osteoarthritis. It does not follow that all the knees excluded were necessarily inappropriate for unicompartmental replacement, only that our numbers are too small to provide evidence.

**Surgical expertise.** Unicompartmental replacement is more difficult than total replacement with a smaller margin for error, and the use of an unconstrained bearing introduces the additional hazard of dislocation. The series which we report was all performed by, or under the supervision of, one surgeon already experienced with meniscal bearings before starting unicompartmental replacement. There were few failures in the early years due to technical errors and no revision was for dislocation of the bearing. Others have reported more problems: Lewold et al. found a survival of only 90% at five years in 699 Oxford unicompartmental medial or lateral arthroplasties at several centres in Sweden from 1983 to 1992, with the commonest cause of early failure being dislocation of the meniscal bearing. These results reflect the learning curves of surgeons at 19 hospitals, who “applied their own indications for arthroplasty”. How wide these indications may have been is shown by the results of Larsson, Larsson and Lundkvist who used unicompartmental replacement in 71%, and Christensen who used a relatively thin implant or to sacrifice additional bone. Thin polyethylene cannot withstand the high pressures which result from small contact areas and it is now widely agreed that incongruous surfaces require polyethylene at least 8 mm thick, although even thick layers of polyethylene almost always show wear. Metal backing of the tibial component was introduced to avoid distortion and facilitate fixation, but has tended to worsen the effects of wear. Excessive wear is often cited as a cause of failure. Bartley et al. reported 147 unicompartmental knee replacements using three different designs; at a mean of three years, 23% had been revised and polyethylene wear was seen in 83% of the retrieved implants. Witvoet et al. considered that polyethylene wear was the probable cause of loosening of the tibial component in 10 of 16 failures, and found radiologically measurable wear of 1 to 7 mm in 32 functioning implants. Cartier, Sanouiller and Greisamer reported neither polyethylene wear nor tibial loosening in a series with incomplete follow-up (Table III). Heck et al. found that 11 of 16 failures were due to aseptic loosening, attributing only two of these to polyethylene failure, but providing no measurements of penetration. The probable association between polyethylene wear and aseptic loosening was suggested in 1986 by Marmor who reported that loosening was the eventual mode of failure of most of the 6 mm thick polyethylene components which he had used. Christensen observed, that at revision operations, “whenever the components were firmly fixed, there was no wear of the tibial components while in the case of even slight looseness there was a considerable amount of wear”.

In the series which we now report, there were no failures from polyethylene wear and no revisions for aseptic tibial loosening. We report was all performed by, or under the supervision of, one surgeon already experienced with meniscal bearings before starting unicompartmental replacement. There were no revisions for tibial loosening in the 144 knees in which the ACL was normal as defined above, but in the 13 knees in which the ligament showed longitudinal splits and absence of synovial covering there were two failures, both because of tibial loosening. A biomechanical explanation for this association between non-function of the ACL and tibial loosening was provided by O’Connor et al.

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**Design of the prosthesis.** The mobile congruous bearing is designed to reduce polyethylene wear while allowing unstrained tibiofemoral movement. All the non-meniscal implants used for unicompartmental replacement have incongruous articular surfaces giving small areas of contact for the transmission of load. In addition, “an inherent weakness of all unicompartmental implants is the need to use a relatively thin implant or to sacrifice additional bone”. Thin polyethylene cannot withstand the high pressures which result from small contact areas and it is now widely agreed that incongruous surfaces require polyethylene at least 8 mm thick, although even thick layers of polyethylene almost always show wear. Metal backing of the tibial component was introduced to avoid distortion and facilitate fixation, but has tended to worsen the effects of wear. Excessive wear is often cited as a cause of failure. Bartley et al. reported 147 unicompartmental knee replacements using three different designs; at a mean of three years, 23% had been revised and polyethylene wear was seen in 83% of the retrieved implants. Witvoet et al. considered that polyethylene wear was the probable cause of loosening of the tibial component in 10 of 16 failures, and found radiologically measurable wear of 1 to 7 mm in 32 functioning implants. Cartier, Sanouiller and Greisamer reported neither polyethylene wear nor tibial loosening in a series with incomplete follow-up (Table III). Heck et al. found that 11 of 16 failures were due to aseptic loosening, attributing only two of these to polyethylene failure, but providing no measurements of penetration. The probable association between polyethylene wear and aseptic loosening was suggested in 1986 by Marmor who reported that loosening was the eventual mode of failure of most of the 6 mm thick polyethylene components which he had used. Christensen observed, that at revision operations, “whenever the components were firmly fixed, there was no wear of the tibial components while in the case of even slight looseness there was a considerable amount of wear”.

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### Table III.

Data from previous ten-year survival studies of unicompartmental and total knee replacements. Survival rates are unreliable if the number at risk is low or the loss to follow-up is high. The loss to follow-up quotient is the number lost divided by the number of failures and is low when the data are reliable.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Number of knees</th>
<th>Type of Implant</th>
<th>Definition of failure</th>
<th>Number at start</th>
<th>Type of Operation</th>
<th>At risk at 10 years</th>
<th>Survival confidence limits (%)</th>
<th>Lost/Total at 10 years</th>
<th>Lost to follow-up quotient *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scott et al</td>
<td>40</td>
<td>M &amp; L Brigham</td>
<td>All revision operations</td>
<td>85.0</td>
<td>67.0</td>
<td>99.0</td>
<td>44/13</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Nieder</td>
<td>41</td>
<td>M UNI St Georg</td>
<td>All revision operations</td>
<td>80.0</td>
<td>93.0</td>
<td>97.0</td>
<td>44/13</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Capra &amp; Marmor</td>
<td>52</td>
<td>M Zimmer II</td>
<td>All revision operations</td>
<td>93.7</td>
<td>86.0</td>
<td>97.0</td>
<td>44/13</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Fehring</td>
<td>42</td>
<td>M Zimmer II</td>
<td>All revision operations</td>
<td>93.7</td>
<td>86.0</td>
<td>97.0</td>
<td>44/13</td>
<td>0.3</td>
<td></td>
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<tr>
<td>Heck et al.</td>
<td>120</td>
<td>M UNI</td>
<td>All revision operations</td>
<td>87.0</td>
<td>90.0</td>
<td>92.0</td>
<td>44/13</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Capra &amp; Marmor</td>
<td>52</td>
<td>M Zimmer II</td>
<td>All revision operations</td>
<td>93.7</td>
<td>86.0</td>
<td>97.0</td>
<td>44/13</td>
<td>0.3</td>
<td></td>
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<tr>
<td>Murray et al</td>
<td>144</td>
<td>M UNI Oxford</td>
<td>All revision operations</td>
<td>97.7</td>
<td>92.7</td>
<td>100.0</td>
<td>44/13</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Beuchel &amp; Pappas</td>
<td>21</td>
<td>TKR LCS</td>
<td>Revision or a 'poor' Meniscal knee score</td>
<td>90.9</td>
<td>87.0</td>
<td>93.0</td>
<td>44/13</td>
<td>0.3</td>
<td></td>
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<tr>
<td>Ritter et al</td>
<td>2001</td>
<td>TKR AGC</td>
<td>Revisions for loose femoral or tibial components. 15 infections and 27 failed patellar implants not included</td>
<td>98.0</td>
<td>96.0</td>
<td>100.0</td>
<td>44/13</td>
<td>0.3</td>
<td></td>
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<tr>
<td>Malkani et al</td>
<td>168</td>
<td>TKR Kinematic</td>
<td>All revision operations</td>
<td>96.0</td>
<td>93.0</td>
<td>99.0</td>
<td>44/13</td>
<td>0.3</td>
<td></td>
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<tr>
<td>Colizza, Insall &amp; Scuderi</td>
<td>165</td>
<td>TKR Posterior Stabilised (1 removal of patellar condylar total implant not included)</td>
<td>98.7</td>
<td>95.0</td>
<td>100.0</td>
<td>44/13</td>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weir, Moran &amp; Pinder</td>
<td>208</td>
<td>TKR Kinematic</td>
<td>All revised or recommended</td>
<td>92.0</td>
<td>87.0</td>
<td>95.0</td>
<td>44/13</td>
<td>0.3</td>
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</tbody>
</table>
loosening. The Oxford Knee uniquely provides congruous articular surfaces with areas of contact of about 6 cm² in all positions. In bearings retrieved from bicompartamental replacements the mean annual rate of penetration was 0.026 mm, and in those retrieved from medial unicompartmental replacements, with no evidence of impingement of the bearing against bone or cement, the mean penetration was 0.01 mm per annum. In both these studies, the mean rate of penetration was independent of the thickness of the bearing, down to 3.5 mm. If the generation of debris is important in causing implant loosening, the congruous mobile bearing, even when only 3.5 mm thick, may have contributed to the low rate of aseptic component loosening.

There were two failures due to progression of arthritis in the lateral compartment, both in the first five years, and it seems possible that they were due to slight overcorrection into valgus. Overcorrection seems unlikely when the medial collateral ligament is not released, as in our cases, but Emerson, Mead and Peters when measuring postoperative alignment in 27 knees with the Oxford implant and 42 with a fixed-bearing design, found occasional overcorrection in both groups (2/27 and 1/42, respectively).

**Conclusions.** In unicompartmental arthroplasty, a properly inserted congruous mobile polyethylene bearing can survive for at least ten years without failure from wear.

Given careful patient selection and appropriate surgical expertise a mobile meniscal bearing can be used in medial unicompartmental arthroplasty with little risk of postoperative dislocation.

Patients with anteromedial osteoarthritis, with an intact ACL, can be treated by unicompartmental rather than by total replacement without incurring any increase in the risk of failure in the first ten years.

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**References**


