Radiological changes five years after unicompartmental knee replacement

A. E. Weale, D. W. Murray, J. Baines, J. H. Newman
From the Nuffield Orthopaedic Centre, Oxford, and Avon Orthopaedic Centre, Bristol, England

Failure of a unicompartmental knee replacement (UKR) may be caused by progressive osteoarthritis of the knee and/or failure of the prosthesis. Limb alignment can influence both of these factors. We have examined the fate of the other compartments and measured changes in leg alignment after UKR.

A total of 50 UKRs was carried out on 45 carefully selected patients between 1989 and 1992. At operation, deliberate attempts were made to avoid overcorrection of the deformity. Four patients died, one patient was lost to follow-up and two knees were revised before review which was at a minimum of five years. Standard long-leg weight-bearing anteroposterior views of the knee and skyline views of the patellofemoral joint were taken before and at eight months and five years after operation. The radiographs of the remaining 43 knees were reviewed twice by blind and randomised assessment to measure the progression of osteoarthritis within the joints. Overcorrection of the deformity in the coronal plane was avoided in all but two knees. Only one showed evidence of progression of osteoarthritis within the patellofemoral joint, and this was only identified in one of the four assessments. Deterioration in the state of the opposite tibiofemoral compartment was not seen. Varus deformity tended to recur. Recurrent varus of 2° was observed between eight months and five years after operation. There was no correlation between the postoperative tibiofemoral angle and the extent of recurrent varus recorded at five years. Changes in alignment may be indicative of minor polyethylene wear or of subsidence of the tibial component.

The incidence of progressive osteoarthritis within the knee was very low after UKR. Patients should be carefully selected and overcorrection of the deformity be avoided.

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The causes of failure of unicompartmental knee replacement (UKR) and total knee replacement (TKR) are similar, but UKR carries the additional potential hazard of progressive osteoarthritis (OA) within the remaining parts of the joint.

Early reports of failure after UKR were associated with progression of the arthritis, the design of the prosthesis or the surgical technique. Progressive OA was reported to be the cause of failure in 25% to 34% of failures and often occurred within the first five years after insertion. The design of prostheses has improved and the indications for UKR have become better defined, but only recently has the importance of mechanical alignment and functioning cruciate ligaments been established.

We have examined the fate of the remainder of the joint after implantation of one design of UKR, in which strict criteria for the selection of patients were applied, and the mechanical axis was deliberately undercorrected.

Patients and Methods

Between 1989 and 1992, we performed 50 UKRs in 45 patients as part of a prospective randomised controlled comparison of UKR and TKR. There were 17 men and 28 women with a mean age of 69.6 years (53 to 89). In all cases the prosthesis used was the St Georg Sled (Waldemar Link, Hamburg, Germany), which has a metal femoral component rounded in both the anteroposterior (AP) and lateral planes and a flat polyethylene tibial prosthesis.

Inclusion criteria. All operations were carried out for tibiofemoral OA. All joints had full-thickness loss of articular cartilage in the affected compartment (Ahlbäck grade O to IV) identified during surgery (Table I). Fibrillation of the cartilage in the opposite compartment and the presence of osteophytes were not considered contraindications if limited to the margins of the femoral condyle. All knees...
had intact anterior and posterior cruciate ligaments (ACL, PCL). The decision to include the patient in the trial was made after exposing the joint, when the exact state of the ligaments and articular cartilage could be determined. A number of cases were excluded after arthrotomy.

The deformity in the coronal plane was 15° or less, and the fixed flexion deformity was less than 15° in all cases. Fibrillation and discoloration of the articular cartilage in the patellofemoral compartment were accepted but ulceration was a contraindication.

Four patients died from causes unrelated to surgery before review at a minimum of five years. One UKR had been revised because of aseptic loosening of the tibial component and another was revised to a TKR because of recurrent haemarthroses. One patient was lost to follow-up. The radiographs of all the remaining 43 knees were reviewed. There were 39 medial and four lateral compartment replacements.

**Operative technique.** A full description of the technique has been published.\(^8\) The manufacturer’s guidelines regarding the use of implants and instruments were followed. A deliberate attempt was always made to avoid overcorrection of the varus or valgus deformity so that there was no overloading of the contralateral compartment.\(^9\)

**Radiological assessment.** All knees were assessed before operation, and at eight months and five years after. Standard radiographs included long-leg weight-bearing AP views of the fully extended knee and skyline views of the patellofemoral joint taken with the knee flexed to 40° and the limb rotated to centralise the patella over the femur. The film was supported on the anterior aspect of the thigh, at right angles to the central ray, and centred to the posterior aspect of the patella. Fluoroscopic control was not used, but radiography was repeated if initially unsatisfactory.

Radiographs at eight months and five years after surgery were compared and assessed in a blinded, randomised fashion. The films were numbered and the names and dates obscured so that the observer could not recognise pairs or distinguish between the earlier films and those taken at the five-year review. A computer-generated random-number table was used to determine the order in which the films were examined. The radiographs were examined twice by the same observer. The severity of arthritis was graded using the classifications of Ahlbäck\(^10\) and Altman et al\(^11\) (Tables I and II). We compared the patellofemoral joint on skyline views using the same methods. In order to determine limb alignment the mechanical axis was marked on long-leg weight-bearing radiographs of the knee (Fig. 1). The normal mechanical axis passes from the centre of the hip through the centre of the knee to the centre of the ankle.\(^12\)

The distance of the mechanical axis in millimetres from the centre of the measured width of the tibial plateau on films taken eight months and five years after surgery was recorded, as was the zone of the knee through which the mechanical axis passed.\(^5,13\) (Fig. 1). The angle formed by the intersection at the knee of the long axes of the femur and tibia, the tibiofemoral angle, was measured on long-leg weight-bearing radiographs taken before and at eight months and five years after operation. The tibiofemoral angle was measured twice on each radiograph.

**Table I.** The Ahlbäck radiological scoring system for estimation of the severity of OA and the preoperative condition of the 50 knees

<table>
<thead>
<tr>
<th>Ahlbäck grade</th>
<th>Radiological characteristics</th>
<th>Medial compartment (knees)</th>
<th>Lateral compartment (knees)</th>
<th>Patellofemoral compartment (knees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal</td>
<td>4*</td>
<td>44</td>
<td>38</td>
</tr>
<tr>
<td>I</td>
<td>Joint narrowing</td>
<td>5</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>II</td>
<td>Joint obliteration</td>
<td>12</td>
<td>4*</td>
<td>0</td>
</tr>
<tr>
<td>III</td>
<td>Bone destruction &lt;5 mm</td>
<td>22</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>IV</td>
<td>Bone destruction &gt;5 mm</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>V</td>
<td>Subluxation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* lateral compartment replacements

**Table II.** The Altman radiological scoring system for the estimation of the severity of OA

<table>
<thead>
<tr>
<th>Altman score range</th>
<th>Radiological characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 3 (None, mild, moderate, severe)</td>
<td>Osteophytes</td>
</tr>
<tr>
<td>0 to 3</td>
<td>Joint narrowing</td>
</tr>
<tr>
<td>0 to 3</td>
<td>Subchondral sclerosis</td>
</tr>
<tr>
<td>Total (0 to 9)</td>
<td></td>
</tr>
</tbody>
</table>

**Statistical analysis.** Intraobserver variability for the assessment of the severity of OA in the retained compartments was assessed by means of the unweighted kappa (κ)
The Wilcoxon signed-rank test was used for ordinal data and Student’s t-test for continuous data. Linear regression analysis was used to explore the relationship between measurements of alignment.

Results

As each film was reviewed twice, it was possible to estimate the intraobserver error. Intraobserver reproducibility was good for the Ahlbäck classification system in the lateral and patellofemoral compartments (κ = 0.71 and κ = 0.82, respectively) and moderate for the Altman system (κ = 0.55 and κ = 0.41, respectively). On repeated examination of the same radiograph, the maximum difference recorded was one grade using the Ahlbäck and two grades using the Altman classification (Tables I and II). These differences were taken to be the errors of the measurement. Greater differences than this between 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 progression or improvement.

Table III indicates that no opposite compartment showed radiological evidence of progression of OA. One patellofemoral joint showed definite advance of OA, but only on one assessment (Table III). Analysis of all scores showed a slight trend towards improvement in the condition of the patellofemoral joint, but this was not statistically significant. Statistical analysis of the radiological scores revealed no significant deterioration with time (Table IV).

Table IV

<table>
<thead>
<tr>
<th>Compartment</th>
<th>Ahlbäck Reading 1</th>
<th>Ahlbäck Reading 2</th>
<th>Altman Reading 1</th>
<th>Altman Reading 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definite worse</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Possibly worse</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Same</td>
<td>39</td>
<td>40</td>
<td>26</td>
<td>24</td>
</tr>
<tr>
<td>Possibly better</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Definitely better</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The mean distance of the mechanical axis from the centre of the measured width of the tibial plateau was 8.7 mm (± 9.2) of varus. This increased to a mean of 11.0 mm (± 11.1) of varus five years after operation (p = 0.008). After lateral UKR, the mechanical axis passed through the replaced compartment in two knees and through the central zone in the other two. The mean difference on repeated measurement of the tibiofemoral angle on each of the three radiographs reviewed for all knees treated with medial UKR was 1.5°. The standard deviation of this measurement was 2.2°. The accuracy (2 SD) of the measurement was therefore taken to be 3.2°. The mean tibiofemoral angle before operation and at eight months and at five years after operation is given in Table V. Between eight months and five years, there was a mean recurrence of varus of 2° (± 2.4°, p < 0.001).

Discussion

Our study has shown that progression of OA is rarely seen in the retained compartments of the knee in the medium term, in carefully selected patients with UKR in whom overcorrection of the deformity in the coronal plane had been largely avoided and the ACL was intact. A tendency towards recurrent varus deformity was identified, indicative of minor subsidence of the tibial component or polyethylene wear, but after follow-up for five years this has not presented a clinical problem.

Previous studies in which attempts were made to assess the progression of OA after UKR may be criticised because radiological assessment was neither blind nor randomised. We used standardised weight-bearing AP and skyline views of the knee for assessment of the progression of OA. The techniques used in our study were those currently recom-
mended by the American Academy of Orthopaedic Surgeons and the World Health Organisation for the purpose of assessment of the progression of OA of the knee.\textsuperscript{14} We used both a global scoring system\textsuperscript{10} and assessment of individual radiological features\textsuperscript{11} to measure progression of OA, and reviewed each film twice. Joint narrowing reflects loss of articular cartilage and is considered to be the most reliable marker of progression of OA of the knee.\textsuperscript{15} The Ahlbäck system, which is primarily an assessment of the width of the articular cartilage, is a widely used, easily interpretable and reproducible method for assessing progression of disease but has the disadvantage that only one grade separates the normal joint (grade 0) from one in which the ‘joint space’ is obliterated (grade II). A change in Ahlbäck grade requires a reduction of joint space by 3 mm or more.\textsuperscript{16} This system may therefore have been insensitive to the detection of minor progression of OA if the rate of joint narrowing in the lateral compartment was less than 3 mm over the five-year period. Altman et al\textsuperscript{17} found that assessment of AP weight-bearing radiographs of the knee for narrowing of the joint, osteophytes, and subchondral sclerosis produced the greatest sensitivity for assessment of the progression of OA but we found that intraobserver reproducibility using the Altman system was only moderate.

Progression of OA within the retained compartments of the knee has been an important cause of failure in some series of UKR. In survivorship analyses, progressive OA has accounted for failure in 1\% to 10\% of knees treated with UKR.\textsuperscript{18-22} In series of UKR requiring revision, progressive OA was the cause of failure in 0\% to 57\%.\textsuperscript{2,24-27} While progressive OA in the patellofemoral joint is rare after medial UKR,\textsuperscript{3} overcorrection of pre-existing varus deformity is a significant cause of progressive OA of the lateral compartment.\textsuperscript{5,28} Failure from that cause usually occurred within the first two years following operation.\textsuperscript{4} In our patients, deliberate attempts were made to avoid overcorrection and we found no evidence of progressive OA after a minimum of five years.

If the ACL was not intact, survivorship of UKR declined because of progressive arthritis of the lateral compartment.\textsuperscript{13} Attrition rupture of the ACL may occur after UKR and lead to the development of symptomatic degenerative change within the retained compartments. Minimally constrained implants, such as that used in our series, may be associated with abnormally high loads on the ACL with the attendant risk of disruption, but we did not find clinical or radiological evidence of it.

A mean recurrence of the varus deformity of 2° over five years was identified in our study, but it was not associated with undercorrection of alignment in the coronal plane. A similar tendency with the same implant was seen in 102 knees with a mean follow-up of 8.1 years.\textsuperscript{29} Progressive changes in alignment were attributed to resorption of bone at the cement-bone interface and to polyethylene wear.\textsuperscript{29} ‘Minor’ progression of OA, in the remaining compartments, was observed in 4\% of cases in that series and almost half of the patients had a disrupted ACL.\textsuperscript{29} Polyethylene wear, subsidence of the tibial component or a combination of both were the most likely causes of recurrent varus in our patients. A change in alignment of 2° was equated to approximately 2 mm of wear or subsidence over five years. In theory, the prosthesis which we used carries a risk of accelerated polyethylene wear because of its incongruous design. In practice, the patients reported here have continued to function well clinically after a minimum five-year follow-up\textsuperscript{8} and the ten-year survivorship of the implant has been 87\% (confidence interval 81\% to 93\%).\textsuperscript{19} The mean linear rate of wear with this prosthesis has been shown to be 0.12 mm per annum in one retrieval study,\textsuperscript{30} but continued clinical and radiological review will be required.

Although progressive OA is a potential hazard of UKR the risk may be minimised by careful selection of patients and attention to detail during the operation. We have shown that the incidence of progressive OA within the retained compartments of the knee can be very low.

The correction of deformity achieved at operation did not remain constant and varus deformity tended to recur. Clinical failure was not associated with this phenomenon, but continued observation will be necessary.

Since progressive OA can be virtually eliminated as a cause of failure by careful selection and technique, it should be possible to improve the results of UKR further by enhancement of the design and instrumentation, allowing more precise insertion.

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References


