We reviewed the rate of revision of unicompartmental knee replacements (UKR) from the New Zealand Joint Registry between 1999 and 2008. There were 4284 UKRs, of which 236 required revision, 205 to a total knee replacement (U2T) and 31 to a further unicompartmental knee replacement (U2U). We used these data to establish whether the survival and functional outcome for revised UKRs were comparable with those of primary total knee replacement (TKR). The rate of revision for the U2T cohort was four times higher than that for a primary TKR (1.97 vs 0.48; p < 0.05). The mean Oxford Knee Score was also significantly worse in the U2T group than that of the primary TKR group (30.02 vs 37.16; p < 0.01). The rate of revision for conversion of a failed UKR to a further UKR (U2U cohort) was 13 times higher than that for a primary TKR.

The poor outcome of a UKR converted to a primary TKR compared with a primary TKR should contra-indicate the use of a UKR as a more conservative procedure in the younger patient.

The long-term results of unicompartmental knee replacement (UKR) have been encouraging, and recent reports suggesting that the revision of a failed UKR to a total knee replacement (TKR) is successful further support their use. Johnson, Jones and Newman showed that < 10% of revised UKRs needed an augmented prosthesis, implying that the revision procedure was predictable, with results similar to those of primary TKR. Others have published similar results. However, an earlier publication by Padgett, Stern and Insall which evaluated the results of revising a UKR, was less encouraging. At revision, 76% had ‘major osseous defects’, and their final functional scores were less than satisfactory, suggesting that revising a UKR was a more complicated procedure than a primary TKR.

Most joint registries have noted a rise in the number of UKRs implanted over the last ten years, although some have seen a fall over the last five years. Younger patients with single-compartment arthritis are now being treated in this way, rather than with a more traditional osteotomy, in the expectation that they will not be at a disadvantage when they need revision to a TKR.

The New Zealand joint registry has recorded 98% of all joint replacements carried out in our country since 1999. This includes all UKRs and any subsequent revision procedures. As well as collecting survival data, using revision as the endpoint, the registry has collected Oxford Knee Scores (OKS) on these patients six months after operation.

We used the registry to review the survival, functional outcome and difficulty of revision of UKR. Our hypothesis was that the survival and function of a primary TKR would be superior to that of a TKR carried out to revise a UKR.

Patients and Methods

We began by reviewing all primary TKRs (n = 34 369) and primary UKRs (n = 4284) entered into the registry since 1999. These data were used to calculate the rates of revision and functional outcomes for these two groups.

We then identified all UKRs that required revision to a further joint replacement (n = 236) and analysed the rate of re-revision and the outcome scores for this subgroup. We used the OKS to assess functional outcome after revision to either a UKR (U2U) or a TKR (U2T), and then compared these results with those of patients who had undergone a primary TKR or UKR.

Survival was assessed as the rate of revision per 100 component years. This is equivalent to the yearly rate of revision expressed as a percentage, and is calculated by dividing the number of protheses revised by the observed component years multiplied by 100. Rates are
usually very low, and so are expressed per 100 component years rather than per component year.

The functional outcome was assessed using the OKS at six-months. Until July 2002, all patients on the registry were sent an OKS questionnaire six months after their operation. However, in 2002, because of increasing numbers of patients, combined with financial constraints, it was decided to randomly select 20% of the TKR patients to complete a questionnaire. However, every patient who had a UKR or a revision receives an OKS questionnaire six months after their operation.

The OKS was recorded according to the recommendations of the original authors, and we categorised the results into four groups (excellent, good, fair, poor) as suggested by Kalairajah et al. (Table I).

The operative records of revisions from a UKR were reviewed, and those that required anything other than a primary prosthesis were noted. The reason for revision was also recorded. Revisions that needed primary components were compared with these.

### Table I. Oxford Knee Scores

<table>
<thead>
<tr>
<th>Category</th>
<th>Oxford Knee Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>42 to 48</td>
</tr>
<tr>
<td>Good</td>
<td>34 to 41</td>
</tr>
<tr>
<td>Fair</td>
<td>27 to 33</td>
</tr>
<tr>
<td>Poor</td>
<td>&lt; 27</td>
</tr>
</tbody>
</table>

Statistical analysis. Rates of revision were calculated as number of revisions per 100 component years; 95% confidence intervals (CI) were calculated using a chi-squared approach. Comparisons of revision-free survival were made using log-rank tests. The mean age and the OKS scores were compared between pairs of groups using independent t-tests, and early rate of revision were compared between classes of the OKS using chi-squared tests. Statistical significance was assumed with a two-tailed p-value < 0.05.

### Results

Revision and mortality data were available for all patients, and the Oxford Knee Score was available for 13,257 (38.6%) patients with an unrevised primary TKR, 3,024 (70.6%) patients with an unrevised primary UKR, and 122 (59.5%) patients who had a failed UKR revised to total knee replacement (U2T).

The mean age for a primary TKR was 68.4 years (8 to 100), that for a primary UKR was 66.0 years (35 to 94), 64.2 (43 to 88) for a UKR revised to TKR (U2T) and 66.4 years (42 to 89) for a UKR revised to another UKR (U2U). The age difference between the TKR and both U2T and U2U groups was statistically significant (independent t-tests, p < 0.001 and p = 0.017).

#### Rate of revision for primary UKR.

Of the 4,284 UKRs recorded in the register, 236 (5.51%) required revision (rate of revision of 1.44 per 100 component years; 95% CI 1.26 to 1.64). Of these, 205 (86.9%) were revised to a TKR (U2T) and the other 31 (13.1%) to a further UKR (U2U). The age difference between the TKR and both U2T and U2U groups was statistically significant (independent t-tests, p < 0.001 and p = 0.017).

Figure 1 shows the survival curve for primary UKRs. At six years, the survival rate is 92.03%; there are insufficient data for accurate analysis after this. The mean follow-up of revised UKRs was 2.81 years (0.085 to 7.83): ten patients had died.

#### Re-revision rates for failed U2T and U2U.

In the U2T group there were 11 further revisions, giving a rate of 1.97 per 100 component years (95% CI 1.26 to 3.52). In the U2U group (31 patients), there were seven further revisions, giving a rate of 6.67 per 100 component years (95% CI 2.68 to 13.7). The rate for primary TKR during this period was 0.484 per 100
component years (95% CI 0.428 to 0.522). The differences in the rates between primary TKR and U2T (log-rank, p < 0.001) and primary TKR and U2U (log-rank, p < 0.001) were both significant (Fig. 2). The indications for revision are listed in Table II. The revision procedures ranged from full replacement of both components to simple bearing exchanges (Table III). The mean age at the time of further revision for the failed U2T patients was 61.7 years (45 to 76), which is, on average, five and seven years younger than for the primary UKR and TKR groups, respectively. The mean time to a further revision from their first was 1.38 years (7 months to 3 years). Of these 11 patients who underwent a further procedure, two had a patellar resurfacing, four a two-stage revision for deep infection (one for persistent infection from the index UKR), and the others for pain with or without loosening of the components. Of the seven patients in the U2U group requiring further revision, three had a dislocated mobile bearing and one each deep infection, pain, loose femoral and tibial components, and another a loose femoral component. The mean time between the first and second revision in the U2U group was 1.74 years (4 months to 4.2 years).

Revision prostheses, including femoral or tibial stems and metal augments, were used in 28.3% of the U2T procedures (Table IV).

**Table II. Indications for revision (frequency). Note that some patients were recorded as having more than one indication for revision, hence the total is greater than 236**

<table>
<thead>
<tr>
<th>Indications for revision</th>
<th>U2T* Percentage of U2T</th>
<th>U2U† Percentage of U2U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>100 48.8</td>
<td>9 29.0</td>
</tr>
<tr>
<td>Loose tibial component</td>
<td>45 22.0</td>
<td>9 29.0</td>
</tr>
<tr>
<td>Loose femoral component</td>
<td>30 14.6</td>
<td>5 16.1</td>
</tr>
<tr>
<td>Infection</td>
<td>11 5.38</td>
<td>2 6.45</td>
</tr>
<tr>
<td>Disease progression</td>
<td>16 7.8</td>
<td>2 6.45</td>
</tr>
<tr>
<td>Bearing dislocation (mobile bearing)</td>
<td>9 4.39</td>
<td>9 29.0</td>
</tr>
</tbody>
</table>

* U2T, unicompartment knee replacements converted to total knee replacement;
† U2U, unicompartmental knee replacements converted to further unicompartmental replacements

**Table III. Revision procedures for U2U***

<table>
<thead>
<tr>
<th>Revision procedure</th>
<th>Number of patients</th>
<th>Percentage of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing only</td>
<td>18</td>
<td>58.1</td>
</tr>
<tr>
<td>Femur and bearing only</td>
<td>5</td>
<td>16.1</td>
</tr>
<tr>
<td>Tibia and bearing only</td>
<td>4</td>
<td>12.9</td>
</tr>
<tr>
<td>All implants</td>
<td>4</td>
<td>12.9</td>
</tr>
</tbody>
</table>

* U2U, unicompartmental knee replacement converted to further unicompartmental replacements

**Table IV. Use of revision prostheses in the U2T* cohort (n = 58 of 205)**

<table>
<thead>
<tr>
<th>Revision implant</th>
<th>Number of patients</th>
<th>Percentage of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any</td>
<td>58</td>
<td>28.3</td>
</tr>
<tr>
<td>Stems</td>
<td>45</td>
<td>22.0</td>
</tr>
<tr>
<td>Wedges</td>
<td>29</td>
<td>14.1</td>
</tr>
<tr>
<td>Both</td>
<td>21</td>
<td>10.2</td>
</tr>
</tbody>
</table>

* U2T, unicompartmental knee replacement converted to a total knee replacement

and second revision in the U2U group was 1.74 years (4 months to 4.2 years).

Revision prostheses, including femoral or tibial stems and metal augments, were used in 28.3% of the U2T procedures (Table IV).

**Functional results. Primary UKR vs primary TKR.** Unrevised primary UKRs had a significantly higher Oxford score (mean six-month OKS 37.16 (SD 8.18) than primary TKRs (mean 37.16 (0 to 48)) (independent t-tests, p < 0.001), although the difference was only two units on the Oxford scale.

**Revision UKR (U2T) vs primary TKR.** The functional results at six months were significantly worse in the U2T group than in both primary TKR and UKR groups (independent t-tests, p < 0.001). In the U2T group, 51.6% had a good or excellent result with a mean OKS of 30.02 (10 to 48), compared with a mean OKS of 37.16 (SD 8.18) for the primary TKR group (Fig. 3). The mean score for the U2T group was similar to the mean functional score for the group of patients who had undergone revision TKR (29.37, 4 to 48).

**Discussion**

Over the past decade, UKR has been used more frequently in younger patients. The introduction of minimally-invasive
surgery, the improvement in implant design, the reliable relief of pain achieved and a good early functional outcome have promoted the use of UKR over high tibial osteotomy. It was expected that UKR would be a satisfactory initial procedure for these patients, and that the subsequent conversion to a TKR would give an acceptable result comparable with that of primary TKR and better than that achieved by converting a high tibial osteotomy to a TKR. A recent randomised controlled trial has suggested that the 15-year results of UKR are better than those of a TKR, in terms of both survival and the Bristol Knee Score. However, it is worth noting that the mean age of the patients in this study in the former and the latter groups was 69.6 years and 69.8 years, respectively. By contrast, if we look at a younger cohort from the New Zealand Joint Registry’s nine-year report, the rate of revision for primary UKR was 1.85 per 100 component years (95% CI 1.51 to 2.25) compared with 0.66 (95% CI 0.57 to 0.75) for primary TKR in the 55- to 64-year age group. This suggests that age at the time of surgery has a significant impact on the survival of the implant. The mean OKS for the 55- to 64-year age group for primary UKR and primary TKR was 38.5 (3 to 48) and 36.9 (3 to 48) respectively, which, although significant (independent t-tests, p < 0.001), is only 1.6 points on the scale. The comparison of rate of revision and functional outcome in the younger age group make it difficult to justify a slightly improved OKS for a significantly higher rate of revision when choosing UKR over TKR.

A further study has suggested that the results of TKR for a failed UKR are as good as those of a primary TKR, in terms of both survival and functional outcome. However, the results of our current study have shown that the U2T is not as successful as primary TKR, and has a fourfold increase in the early rate of revision at 2.81 years of follow-up. The functional outcome is also significantly worse (p < 0.01) than that of primary TKR. The mean six-month Oxford score of U2T was similar to that of a revision TKR (30.02 vs 29.37).

We have previously shown a strong correlation between a poor (< 27) six-month OKS and early revision of a primary knee replacement. This is especially true for those with a primary UKR, who have a 24.3% risk of revision within two years. One possible explanation for this could be that the revision of a UKR was perceived as technically less demanding than revising a TKR, thereby resulting in a lower surgical threshold to offer early revision surgery to patients who complained of ongoing problems with a UKR. In addition, a higher proportion of patients with a UKR were younger, which has been shown to lead to higher rates of revision because the younger group are likely to demand more of their prostheses, resulting in early wear and failure. The result is that the mean age of patients who have had their UKR revised is significantly less than that of those with a primary TKR. The relatively high rate of re-revision in the U2T group is of concern: 11 required a further procedure within a mean of 1.38 years (7 months to 3 years) of the initial revision. The mean age of this group was only 61.7 years (39 to 74).

Of the revised UKRs, 58.1% required exchange of a bearing exchange following dislocation. The disproportionate number in the U2U group suggests that a simple exchange of bearing did not address the fundamental cause of failure. This could have been due to an inexperienced surgeon not recognising other problems, such as malalignment or unequal flexion and extension gaps. Our study shows that salvage of a failed UKR with a further UKR results in an unacceptably high rate of failure. This conclusion is supported by data previously reported from the Swedish Knee Arthroplasty Register, in which survival was expressed as a cumulative rate of re-revision. This was 7% for the U2T group and 26% for U2U.

The use of revision prostheses and augments (28.3%) in this series was comparable with those reported in others and lower than the published rates of revision for primary TKR, suggesting that it is easier to revise a UKR than a TKR. This could potentially reduce the cost of the procedure. However, other national registry studies have concluded that the increased rate of failure of a UKR over a TKR negates any economic saving in the long term.

This study shows that converting a failed UKR to a TKR gives a less reliable result than a primary TKR in the short term, and that the functional results are not significantly better than a standard revision from a primary TKR. These results are independent of surgical experience. The question of how to manage the younger patient with unicompartmental osteoarthritis remains unanswered. The place of UKR needs to be clearly defined: it should not be used as a ‘conservative’ procedure to delay TKR.

Supplementary material
A further opinion by Mr D. Deehan is available with the electronic version of this article on our website at www.bjs.org.uk

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References


