EARLY RADIOLOGICAL OBSERVATIONS MAY PREDICT THE LONG-TERM SURVIVAL OF FEMORAL HIP PROSTHESES

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We reviewed a consecutive series of 527 uninfected hip replacements in patients resident in the UK which had been implanted from 1981 to 1993. All had the same basic design of femoral prosthesis, but four fixation techniques had been used: two press-fit, one HA-coated and one cemented. Review and radiography were planned prospectively. For assessment the components were retrospectively placed into two groups: those which had failed from two years onwards by aseptic femoral loosening and those in which the femoral component had survived without revision or recommendation for revision.

All available radiographs in both groups were measured to determine vertical migration and examined by two observers to agree the presence of radiolucent lines (RLLs), lytic lesions, resorption of the neck, proximal osteopenia and distal intramedullary and distal subperiosteal formation of new bone. We then related the presence or absence of these features and the rate of migration at two years to the outcome with regard to aseptic loosening and determined the predictive value of each of these variables.

Migration of $\geq 2$ mm at two years, the presence of an RLL of 2 mm occupying one-third of any one zone, and subperiosteal formation of new bone at the tip of the stem were predictors of aseptic loosening after two years. There were too few lytic lesions to assess at two years, but at five years a lytic lesion $\geq 2$ mm also predicted failure. We discuss the use of these variables as predictors of femoral aseptic loosening for groups of hips and for individual hips.

We conclude that if a group of about 50 total hip replacements, perhaps with a new design of femoral stem, were studied in this way at two years, a mean migration of $<0.4$ mm and an incidence of $<10\%$ of RLLs of 2 mm in any one zone would predict 95% survival at ten years.

For an individual prosthesis, migration of $<2$ mm and the absence of an RLL of $\pm 2$ mm at two years predict a 6% chance of revision over approximately ten years. If either 2 mm of migration or an RLL of 2 mm is present, the chances of revision rise to 27%, and if both radiological signs are present they are 50%. If at five years a lytic lesion has developed, whatever the situation at two years, there is approximately a 50% chance of failure in the following five years.

Our findings suggest that replacements using a limited number of any new design of femoral prosthesis should be screened radiologically at two years before they are generally introduced. We also suggest that radiographs of individual patients at two years and perhaps at five years should be studied to help to decide whether or not the patient should remain under close review or be discharged from specialist follow-up.

Received 29 August 1996; Accepted after revision 5 March 1997

A recent consensus statement proposed that a femoral stem should be regarded as satisfactory if its cumulative aseptic loosening rate at ten years was not greater than 5%. This may be a useful guide to the ultimate success or failure of a prosthesis of a particular type, implanted in a particular manner, but cannot be a useful basis for the introduction of new prostheses or new methods of fixation. To obtain a ten-year failure rate with reasonable confidence a large number of patients would have to be followed up. In addition to the practical difficulties, delay and cost, the ethics of a large number of ‘experimental’ operations must be considered. All surgeons who consider modifying femoral components or their fixation must seek a method of predicting ten-year outcomes on the basis of a relatively
with retention of the femoral neck. From August 1981 to July 1993, we performed a total of 575 primary THRs using the Freeman femoral prosthesis.

PATIENTS AND METHODS

From August 1981 to July 1993, we performed a total of 575 primary THRs using the Freeman femoral prosthesis with retention of the femoral neck. Four different methods of fixation were used:

1) a macroscopically smooth shot-blasted prosthesis as a press-fit (SPF);
2) as 1) but proximally ridged (RPF);
3) the ridged prosthesis with proximal hydroxyapatite coating (RPF+HA); and
4) a cemented smooth prosthesis (S+C).

We included 25 patients who lived overseas because of lack of follow-up, and 12 with infected hips since they could not be assessed for aseptic loosening.

All patients were enrolled in a prospective evaluation protocol, and standard radiographs were taken at 6 months and at 1, 2, 3, 5, 7 and 10 years after operation. Some patients failed to attend at various time intervals, but they were interviewed by telephone to determine if their hip had been revised. When possible radiographs were taken locally and sent to us. Failure of a THR was defined as revision or death, or aseptic loosening of the femoral component, and survival rates were calculated by the life-table method. This gave two groups at ten years; failed and surviving.

Vertical migration of the stem was measured on standard anteroposterior radiographs using a digitising table (Orthographics Inc, Salt Lake City, Utah) and suitable software (Researchmetrics, Orthographics Inc, Salt Lake City, Utah). The methods and the calculation of migration rates have previously been described.

We analysed the differences between the mean calculated migration at each time period for the surviving as against the failed group using an unpaired t-test with an F-test and Welch’s test if necessary. The difference between mean migration rates for both groups was examined by the same method. Correlations between measured migration rates (see Fig. 4) and the cumulative failure rates were analysed by Pearson’s correlation coefficient. The observed figures for migration rather than the calculated mean migration rates were used to develop predictors for individual hips.

Each radiograph was examined for the presence of RLLs of 2 mm or more, lytic lesions of 2 mm diameter or more, proximal osteopenia, intramedullary formation of new bone, and we therefore based our study on standard anteroposterior views taken with the beam centred on the prosthesis at the level of the greater trochanter and covering the whole prosthesis. The patient is positioned with the patella facing forward and knee and buttock contacting the table. On such films we have measured: changes in component position such as vertical migration of the stem, and we therefore recorded only those greater than 2 mm in width. Each of the variables was related to outcome defined as survival or failure up to ten years. Group outcome was assessed by survival rates.

Table I. Details of the four fixation groups, and of the hips which failed because of femoral aseptic loosening and of those surviving

<table>
<thead>
<tr>
<th>Group*</th>
<th>Period of use</th>
<th>N*</th>
<th>Mean age ± SD (yr)</th>
<th>Male (%)</th>
<th>OA:RA:PT‡</th>
<th>Mean follow-up (yr)</th>
<th>OA:RA:PT‡</th>
<th>Missing data</th>
<th>Failure by femoral ASL§</th>
<th>Lost to follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPF</td>
<td>8/81 to 11/87</td>
<td>134</td>
<td>54.2 ± 14.4</td>
<td>37</td>
<td>82:8:10:0</td>
<td>8.3</td>
<td>12</td>
<td>10</td>
<td>19</td>
<td>27</td>
</tr>
<tr>
<td>SPF</td>
<td>1/86 to 11/89</td>
<td>55</td>
<td>54.2 ± 9.7</td>
<td>31</td>
<td>80:7:11:2</td>
<td>6.5</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>SPF</td>
<td>1/89 to 6/93</td>
<td>115</td>
<td>52.0 ± 11.9</td>
<td>56</td>
<td>69:7:13:11</td>
<td>3.7</td>
<td>16</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>SPF</td>
<td>6/83 to 6/93</td>
<td>223</td>
<td>68.8 ± 6.7</td>
<td>33</td>
<td>88:7:3:2</td>
<td>5.4</td>
<td>35</td>
<td>19</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Failed</td>
<td>41</td>
<td>49.6 ± 10.8</td>
<td>49</td>
<td>88:2:10:0</td>
<td>6.3</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>37</td>
<td>4</td>
</tr>
<tr>
<td>Surviving</td>
<td>486</td>
<td>60.2 ± 13.2</td>
<td>38</td>
<td>81:8:7:4</td>
<td>5.8</td>
<td>63</td>
<td>39</td>
<td>56</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* see text
† post-traumatic
‡ subincision
§ aseptic loosening

This leaves the possibility of studying routine radiographs. Lateral views of femoral components are difficult to interpret and to standardise, and we have therefore based our study on standard anteroposterior views taken with the beam centred on the prosthesis at the level of the greater trochanter and covering the whole prosthesis. The patient is positioned with the patella facing forward and knee and buttock contacting the table. On such films we have measured: changes in component position such as vertical migration of the stem, and the calculated mean migration at each time period for the surviving as against the failed group using an unpaired t-test with an F-test and Welch’s test if necessary. The difference between mean migration rates for both groups was examined by the same method. Correlations between measured migration rates (see Fig. 4) and the cumulative failure rates were analysed by Pearson’s correlation coefficient. The observed figures for migration rather than the calculated mean migration rates were used to develop predictors for individual hips.

Each radiograph was examined for the presence of RLLs of 2 mm or more, lytic lesions of 2 mm diameter or more, proximal osteopenia, intramedullary formation of new bone, and we therefore based our study on standard anteroposterior views taken with the beam centred on the prosthesis at the level of the greater trochanter and covering the whole prosthesis. The patient is positioned with the patella facing forward and knee and buttock contacting the table. On such films we have measured: changes in component position such as vertical migration of the stem, and the calculated mean migration at each time period for the surviving as against the failed group using an unpaired t-test with an F-test and Welch’s test if necessary. The difference between mean migration rates for both groups was examined by the same method. Correlations between measured migration rates (see Fig. 4) and the cumulative failure rates were analysed by Pearson’s correlation coefficient. The observed figures for migration rather than the calculated mean migration rates were used to develop predictors for individual hips.

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Each radiograph was examined for the presence of RLLs of 2 mm or more, lytic lesions of 2 mm diameter or more, proximal osteopenia, intramedullary formation of new bone.
around the tip of the stem, subperiosteal formation of new bone and femoral neck resorption. Radiological evaluation was performed by two orthopaedic surgeons blinded to the patient’s eventual clinical outcome. The differences of the frequency of these radiological observations between the surviving group and the failed group were then analysed using the chi-squared test or Fisher’s exact test as appropriate.

To examine the predictive values of these radiological observations we calculated the following:

\[
\text{Sensitivity} = \frac{\text{true-positive (TP)}}{\text{TP} + \text{false-negative (FN)}}
\]

\[
\text{Specificity} = \frac{\text{true-negative (TN)}}{\text{false positive (FP)} + \text{TN}}
\]

\[
\text{Positive predictive value (PPV)} = \frac{\text{TP}}{\text{TP} + \text{FP}}
\]

\[
\text{Negative predictive value (NPV)} = \frac{\text{TN}}{\text{FN} + \text{TN}}
\]

We used the SPSS program (SPSS Inc, Chicago, Illinois) and StatView 4.51 (Abacus Concepts Inc, Berkeley, California) for the statistical analyses.

RESULTS

Single radiological parameters as predictors of outcome

Migration

Groups. The mean observed and calculated migration rates for the surviving and failed groups at time intervals up to ten years are shown in Figure 1. Migration differed significantly between the two groups from one year onwards. The mean calculated migration rate of the surviving group (0.36 mm/yr) was significantly less than that of the failed group (1.43 mm/yr) (p < 0.0001).

Individuals. The predictive value of migration for individuals was based on the observed (rather than the calculated) migration at two years after operation since the observed value can be determined in the clinical situation for an individual patient. Various threshold values of the observed migration were chosen and the relevant prediction indices were calculated (Table II). As a predictor of aseptic loosening, an observed migration of 2.0 mm at two years was found to give a specificity of 85%, a sensitivity of 58%, a PPV of 26% and an NPV of 96%. In other words, 85% of surviving prostheses, as against 42% of failed prostheses, had migrated less than 2.0 mm at two years. Of stems which had migrated 2.0 mm or more at two years 26% had failed, as against 4% of stems which had migrated less than 2.0 mm.

Table II. The prediction of aseptic loosening in an individual hip at any time between two and ten years related to observed migration at two years (TP = true positive; FN = false negative; FP = false positive; TN = true negative; PPV = positive predictive value; NPV = negative predictive value; Sens = sensitivity; and Spec = specificity)

<table>
<thead>
<tr>
<th>Observed migration at two years (mm)</th>
<th>TP</th>
<th>FN</th>
<th>FP</th>
<th>TN</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
<th>Sens (%)</th>
<th>Spec (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥3.0</td>
<td>13</td>
<td>18</td>
<td>22</td>
<td>309</td>
<td>37</td>
<td>42</td>
<td>94</td>
<td>42</td>
</tr>
<tr>
<td>≥2.5</td>
<td>16</td>
<td>15</td>
<td>33</td>
<td>298</td>
<td>33</td>
<td>95</td>
<td>52</td>
<td>90</td>
</tr>
<tr>
<td>≥2.0</td>
<td>18</td>
<td>13</td>
<td>50</td>
<td>281</td>
<td>26</td>
<td>96</td>
<td>58</td>
<td>85</td>
</tr>
<tr>
<td>≥1.5</td>
<td>20</td>
<td>11</td>
<td>77</td>
<td>254</td>
<td>21</td>
<td>96</td>
<td>65</td>
<td>77</td>
</tr>
</tbody>
</table>
Radiolucent lines

Groups. The incidence of hips showing an RLL of 2 mm or greater in any zone at six months and at two and five years is shown in Figure 2. The incidence of RLLs was significantly higher in the failed group than in the surviving group at two years (p < 0.002).

Individuals. To test the predictive value of RLLs for an individual prosthesis, we calculated the predictive significance at two years of the presence of an RLL of 2 mm or greater occupying 30% of any zone (Table III). Prostheses which had an RLL of 2 mm or more in one or more zones at two years after operation were found to have a 29% chance of failure, whereas the absence of an RLL of 2 mm at two years, gave a chance of failure of 4%.

Lytic lesions

Two few lytic lesions were seen at two years for them to be useful predictors at this time. In view of their known importance, we studied their predictive value at five years.

Groups. At five years the frequency of lytic lesions was significantly higher (p = 0.004) in the failed group than in the surviving group at two years.

Individuals. The predictive value of subperiosteal formation of new bone around the tip of the stem was significantly higher (p = 0.004) in the failed group than in the surviving group at two years.

Other radiological findings

Subperiosteal new bone at the tip

Groups. The frequency of subperiosteal formation of new bone around the distal stem was significantly higher (p = 0.004) in the failed group than in the surviving group at two years.

Individuals. The predictive value of subperiosteal formation of new bone around the tip of the stem for an individual prosthesis is shown in Table III. Of prostheses with subperiosteal formation of new bone 71% survived as against 93% of those without formation of new bone.

Other radiological findings

We found no predictive significance for proximal osteopenia, the formation of intramedullary new bone (pedestal), or femoral neck resorption at two years.

The use of a combination of predictors. Our findings show that at two years, prostheses destined to fail tended to have (as a group) more rapid migration, a higher incidence of RLLs of 2 mm in one or more zones, and more frequent subperiosteal new bone around the distal stem. By five years, the presence of lytic lesions could be added to these predictors. At two years the mean migration rates in each of the four fixation groups were strongly correlated with the presence of RLLs (Fig. 3) and with the formation of subperiosteal bone at the tip of the stem, presumably because they all reflect the stability of the interface and thus the quality of the fixation.

No single factor provided a reliable basis for the prediction of the outcome of a single hip. We therefore calculated the predictive power for the outcome of a single hip of two or more of those variables in combination (Table IV). To simplify this calculation we omitted the formation of subperiosteal new bone because it is a weak predictor for individual hips and is hard to quantify. We therefore combined migration and RLLs. Although it may appear inappropriate to combine predictors which correlate with each other, this is not so: each predictor is imperfect, but they may complement each other as would two imperfect photographs of the same face. Because of the predictive power of lytic lesions seen at five years (Table III) we extended our analysis of these beyond the second year to include all the 155 hips radiographed at two and five years and followed to a maximum of ten years.

Groups. The correlations between survival at six years and the mean migration rate over the first two years, measured on all hips with two or more measurements between 6 and 24 months, were combined with the percentage of hips...
displaying an RLL of at least 2 mm in one or more zones at two years (Figs 4 and 5). These show that a 3% cumulative failure rate at six years (which would become a 5% cumulative failure rate at ten years if the rate of onset is constant) could be expected if the migration rate over the first two years was not greater than 0.4 mm/year (strictly 0.38 mm/year) and if there were not more than 10% (strictly 11%) of hips showing an RLL of 2 mm.

The relevant values for each of our four separate groups of prostheses (from which the values were calculated) are shown in Table IV which illustrates the application of this combined predictor. This shows that the two groups of press-fit prostheses (SPF and RPF) fail both the migration and the RLL tests by a wide margin (migration 0.7 and 0.6 mm/year and had 37% and 29% incidences of RLLs, respectively). By contrast, the HA-coated and cemented prostheses pass both tests (migration 0.3 mm/year for both; 1% and 4% incidence of RLLs, respectively).

### Table IV. Prediction of outcome for four groups of hips at two years: the results in the four fixation groups in this study vs proposed threshold values.

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean migration rate at two years (mm/yr)</th>
<th>RLL in any zone at two years (%)</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (SPF)</td>
<td>0.7</td>
<td>37</td>
<td>72 (at 10 years)</td>
</tr>
<tr>
<td>2 (RPF)</td>
<td>0.6</td>
<td>29</td>
<td>79 (at 8 years)</td>
</tr>
<tr>
<td>3 (RPF+HA)</td>
<td>0.3</td>
<td>1</td>
<td>100 (at 6 years)</td>
</tr>
<tr>
<td>4 (S+C)</td>
<td>0.3</td>
<td>4</td>
<td>97 (at 10 years)</td>
</tr>
<tr>
<td>Proposed threshold values</td>
<td>0.4</td>
<td>11</td>
<td>95 (calculated as at 10 years)</td>
</tr>
</tbody>
</table>

### Table V. The prediction of individual stem loosening at any time between five and ten years by combined radiological observations at two years and lytic lesions at five years in 155 hips.

<table>
<thead>
<tr>
<th>Observation at:</th>
<th>Predictive values†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines*</td>
<td>TP</td>
</tr>
<tr>
<td>2 years (2.0 mm migration, 2.0 mm RLL)</td>
<td>5 years (lytic lesion)</td>
</tr>
<tr>
<td>1.1 NEITHER present</td>
<td>All hips as assessed at 2 years’ follow-up</td>
</tr>
<tr>
<td>1.2 Absent</td>
<td>4</td>
</tr>
<tr>
<td>1.3 Present</td>
<td>3</td>
</tr>
<tr>
<td>2.1 ONE present</td>
<td>All hips as assessed at 2 years’ follow-up</td>
</tr>
<tr>
<td>2.2 Absent</td>
<td>7</td>
</tr>
<tr>
<td>2.3 Present</td>
<td>5</td>
</tr>
<tr>
<td>3.1 BOTH present</td>
<td>All hips as assessed at 2 years’ follow-up</td>
</tr>
<tr>
<td>3.2 Absent</td>
<td>3</td>
</tr>
<tr>
<td>3.3 Present</td>
<td>2</td>
</tr>
</tbody>
</table>

* see text
† see Table II for definition
Individuals. Our findings are shown in Table V and may be expressed as follows. If at two years an annual hip has neither 2 mm migration nor an RLL of 2 mm, the chance of failure at five to ten years after operation is 6% (PPV, line 1.1 in Table V = 6). If either 2 mm migration or an RLL of 2 mm is present the chance of failure is 27% (PPV, line 2.1 in Table V = 27). Finally, if both 2 mm of migration and an RLL of 2 mm are present at two years, there is a 50% chance of failure (PPV, line 3.1 in Table V = 50). Thus, of the 155 patients in Table V reviewed at two years, 111 without either 2 mm migration or an RLL could be discharged with the knowledge that only 6% would fail. The other 41 would have a 27% chance of failure, and among them a subgroup of ten hips with both rapid migration and an RLL would have a 50% chance of failure, and require very close supervision at follow-up.

If all 155 hips without warning signs had radiographs at five years, a lytic lesion would have been detected in our series in 15 cases. Seven of these would not have been under review by our suggestion above (an incidence of 7/111, 6%), but would now have a chance of failure of 43% (line 1.3, Table V). Eight hips would have been under review (an incidence of 8/44, 18%) and would now have a chance of failure increased to 62% (line 2.3, Table V). This is much the same chance statistically as the 43% in those who had not been under review. The two hips which had migrated showing an RLL and then a lytic lesion, and would both be certain to fail (line 3.3, Table V). Of the hips which do not develop a lytic lesion, the chance of failure in those not under review would fall to 4% (line 1.2, Table V) and the chance for the remainder would fall to 19% (line 2.2, Table V).

Thus the development of a lytic lesion at five years (presumably due to wear debris gaining access to the interface) makes an important change to the prognosis at two years based on migration and RLLs (which presumably reflect the quality of initial fixation). Hips which develop a lytic lesion at five years have about a 50% chance of failure regardless of the findings at two years. Those with no lytic lesion at five years have about a 20% chance of failure if they have either 2 mm of migration or an RLL at two years (poor initial fixation) and a 4% chance of failure if they neither migrate nor have an RLL at two years.

DISCUSSION

Both for research and for day-to-day clinical care, there is a need to predict the late outcome, at say ten years, on the basis of early findings which can be obtained on a routine clinical basis, at say two years. We know of no previous study which has tried to find a quantitative basis for such a prediction on routine radiographs. We have tried to show how such predictions may be achieved but do not claim that the particular values which we have suggested are generally applicable, since these are based solely on one particular type of prosthesis and most of the failures occurred in our two press-fit groups. Despite this reservation, we believe that the data which we report at two years provide a hope that useful predictions of late outcome can be made for both groups of prostheses and for individual prostheses and that they may be supplemented by a further radiograph at five years.

The radiological features which we examined can be applied to both cemented or cementless fixation. It seems possible that these could be further refined for cemented prostheses by grading the quality of the cement mantle, but this topic is outside the scope of the present paper.

Marking the prosthesis and the skeleton to allow RSA has been used to predict aseptic loosening of an individual prosthesis and of groups of prostheses but this cannot be used on a routine clinical basis. Another potentially valuable method of measuring migration with almost the accuracy of RSA has been developed by Walker et al. Unfortunately, it requires a digitiser and special computer software. It may be appropriate in the research context, but may not be convenient for individual clinical cases. Our method of measuring migration can be used on a routine clinical basis without special equipment, but does require a design of prosthesis which makes possible the accurate identification of points on the implant and the skeleton. Many prostheses do not have such features. The method which we describe has less accuracy than RSA (approx ± 1 mm as against ± 0.2 mm). It is therefore a less reliable predictor and requires reinforcement from the measurement of RLLs. It has been shown that RLL recording is subject to large intraobserver and interobserver errors and we therefore based our prediction solely on RLLs of 2 mm or more agreed by two observers.

Our findings suggest that the designer of a new femoral implant should initially insert only enough prostheses to provide sufficient numbers to allow for radiological evaluation, including migration, at two years. The number required for this would depend upon the reliability of the observations of migration and RLLs; we believe that about 50 hips would be sufficient. At the two-year follow-up an anteroposterior radiograph showing the whole of the interface would allow the measurement of vertical migration, and the calculation of a mean for the group. Radiolucent lines which are 2 mm or greater in width occupying up to one-third of any one zone can be reasonably reliably recorded – the detection and measurement of RLLs of less than 2 mm are not sufficiently reliable.

If the mean migration rate in 50 hips at two years is less than 0.4 mm/year and the incidence of hips having an RLL of 2 mm in any one zone is less than 10% in round figures it seems reasonable to anticipate 95% survival at ten years. Our findings indicate that if the incidence of RLLs or the extent of migration is greater than these values, it would not be appropriate to continue the clinical evaluation of the new implant: this would cause an unnecessary number of patients to require revision for aseptic loosening. No advance in prosthetic design would have been made.

We found that migration is approximately linear for the
ten years after operation, both for hips that survive and for those that fail (Fig. 1). This and the significant difference between mean migration rates for failed and surviving femoral components at one and two years confirm, over longer periods, the findings of Plante-Bordeneuve and Freeman reported for shorter periods of follow-up. The development of RLLs also appears to be progressive with time and, as for migration, their frequency is greater in hips destined to fail than in the remainder (Fig. 2).

To help in the management of individual patients, we suggest that at the two-year follow-up measurement should be made of distal migration since operation and record made of RLLs of 2 mm occupying 30% or more of any one zone. These can be assessed by what we call the 'rule of two'. For our population at two years, patients without an RLL of 2 mm and less than 2 mm of migration could be discharged from review with the knowledge that they have only a 6% chance of aseptic loosening within five to ten years. All other patients, those with either an RLL of 2 mm or 2 mm of migration or both, should remain under review. About 25% of patients with one sign would be expected to require revision within ten years. If both radiological signs are present the chance of revision rises to about 50%.

A radiograph at five years for all patients is advised to detect the consequences of wear in the form of lytic lesions. If these are present, the chance of failure at ten years rises to about 50% regardless of the initial quality of the interface. If the interface is initially sound, the chance of a lytic lesion developing is about 6% as against 18% if the interface is unsound. Patients with a lytic lesion should remain under regular review.

We do not have enough data to calculate the chances of survival if a lytic lesion develops in each of the subgroups defined at two years, but it seems obvious that the presence of an RLL of 2 mm and migration at two years, followed by a lytic lesion at five years, gives a very low chance of survival at ten years. If none of these three features is found, the chance of survival approaches 100%.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

The authors wish gratefully to acknowledge the financial support received for the review of the patients over the years of this study from the Arthritis and Rheumatism Council for Research and the Department of Health for England and Wales.

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