Revision following cemented and uncemented primary total hip replacement
A SEVEN-YEAR ANALYSIS FROM THE NEW ZEALAND JOINT REGISTRY

We have reviewed the rate of revision of fully cemented, hybrid and uncemented primary total hip replacements (THRs) registered in the New Zealand Joint Registry between 1999 and December 2006 to determine whether there was any statistically significant difference in the early survival and reason for revision in these different types of fixation. The percentage rate of revision was calculated per 100 component years and compared with the reason for revision, the type of fixation and the age of the patients.

Of the 42,665 primary THRs registered, 920 (2.16%) underwent revision requiring change of at least one component. Fully-cemented THRs had a lower rate of revision when considering all causes for failure (p < 0.001), but below the age of 65 years uncemented THRs had a lower rate (p < 0.01). The rate of revision of the acetabular component for aseptic loosening was less in the uncemented and hybrid groups compared with that in the fully cemented group (p < 0.001), and the rate of revision of cemented and uncemented femoral components was similar, except in patients over 75 years of age in whom revision of cemented femoral components was significantly less frequent (p < 0.02). Revision for infection was more common in patients aged below 65 years and in cemented and hybrid THRs compared with cementless THRs (p < 0.001). Dislocation was the most common cause of revision for all types of fixation and was more frequent in both uncemented acetabular groups (p < 0.001). The experience of the surgeon did not affect the findings.

Although cemented THR had the lowest rate of revision for all causes in the short term (90 days), uncemented THR had the lowest rate of aseptic loosening in patients under 65 years of age and had rates comparable with international rates of aseptic loosening in those over 65 years.

Controversy remains regarding the best method of fixation in total hip replacement (THR). Advocates of fully-cemented THR state that it has been a durable procedure with excellent long-term survival and predictable outcome.1 The early advantage of cemented fixation was seen to be the formation of an immediate strong mechanical interlock with bone, resulting in reliable early fixation and relief from pain.2,3 However, longer term follow-up studies have shown a significant incidence of revision for both femoral and acetabular loosening.4-6 In addition, the long-term results of cemented THR in younger patients have been disappointing, with a significant early rate of failure due to polyethylene wear and aseptic loosening of the acetabulum.7-10

Over the last 20 years there has been a trend towards the use of cementless fixation in an attempt to improve survival. Several studies have shown that the long-term outcome is comparable, and in some cases superior to, that of cemented fixation.11-16 Cementless fixation has the potential to attain a permanent bond with bone by bony ingrowth, and once stable fixation has occurred, the outcome does not appear to deteriorate in the decade after implantation.11-15 Cementless fixation has also introduced greater surgical options with respect to the size and type of bearing surface used. The modularity of cementless acetabula has improved the ability of the surgeon to deal with the problems of dysplasia, acetabular deficiency and recurrent dislocation and has increased the ability of the surgeon to restore the anatomy, particularly in the difficult THR.

Hybrid THR was introduced to make use of the potential benefits of a cemented stem and uncemented acetabular component, particularly in younger patients.17,18 Acetabular wear and loosening were identified as the weak links of cemented THR in younger patients and early results showed that hybrid THR
performed well in these patients at medium-term follow-up with low rates of aseptic loosening. However, polyethylene wear and osteolysis remained a problem.

National joint registries have been set up in many countries. One of their primary aims was to identify early failure of prostheses and thereby modify surgical practice in order to reduce the early rate of revision of THR by analysing large numbers of procedures to produce reliable and relevant statistical information.

Recent analyses of joint registries have revealed that the early revision rates (within nine years) for primary THR have been higher for cementless than for cemented fixation. This has not been the perceived experience in New Zealand where there is widespread use of cementless fixation, and it was decided that analysis of the New Zealand data was timely.

We wished to confirm whether there was a significant difference in the rate of revision between fully cemented, hybrid and uncemented THR and to determine whether there were any factors predisposing to early revision in either group. Our hypothesis was that there would be no difference in the early revision rate between cemented and uncemented THR.

### Materials and Methods

Our study analysed the results of the 42,665 primary THRs entered into the New Zealand Joint Registry from its establishment in 1999 until December 2006. The THRs were divided into four groups based on the method of fixation of the femoral and acetabular components: cementless femoral and acetabular components (uncemented), cemented femoral and acetabular components (cemented), cemented femoral and cementless acetabular components (hybrid), and cementless femoral and cemented acetabular components (reverse hybrid).

The number of revisions for each group was obtained from the registry and used to calculate the overall rate of revision. This was expressed as the rate per 100 component years and was equivalent to the yearly rate of revision expressed as a percentage. It was derived by dividing the number of prostheses revised by the observed component years multiplied by 100, and therefore allowed for the number of years of post-operative follow-up in calculating the rates for comparison. These rates were usually very low hence it was expressed per 100 component years (equivalent to a percentage) rather than per component year. This was considered to be a more accurate way of deriving revision rates for comparison when analysing data with widely varying follow-up times.

Revision was defined as re-operation for any reason with the change of at least one component. These revision rates were compared among the four groups and survival curves constructed with the endpoint being revision for any reason with the change of at least one component. These revision rates were compared among the four groups and survival curves constructed with the endpoint being revision for any reason.

The reasons for revision of the primary THR were documented at the time of the operation, and recorded in the registry. The options available to the surgeon were: 1, loosening of the acetabular component; 2, loosening of the femoral component; 3, dislocation; 4, pain; 5, deep infection; 6, a fractured femur and 7, ‘other’ (with a space to elaborate on the reason). Since more than one reason for revision could be selected this was represented as a percentage of the total number within each group. The reasons for revision in each group were determined and evaluated before and after 90 days following surgery. We chose 90 days as an arbitrary time for early complications which were most likely to be due to the surgical procedure itself, such as femoral fracture and malposition of the component. The age of the patient

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**Table I.** The number of primary total hip replacements (THRs) revised according to the type of fixation

<table>
<thead>
<tr>
<th>Type of THR</th>
<th>Number registered</th>
<th>Number revised</th>
<th>Revision rate per 100 component years (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cemented</td>
<td>16 005</td>
<td>302</td>
<td>0.49 (0.44 to 0.55)†</td>
</tr>
<tr>
<td>Uncemented</td>
<td>10 898</td>
<td>273</td>
<td>0.84 (0.74 to 0.95)‡</td>
</tr>
<tr>
<td>Hybrid</td>
<td>15 189</td>
<td>334</td>
<td>0.66 (0.59 to 0.73)§</td>
</tr>
<tr>
<td>Reverse hybrid</td>
<td>573</td>
<td>11</td>
<td>0.50 (0.25 to 0.89)</td>
</tr>
</tbody>
</table>

* 95% CI, 95% confidence interval
† uncemented compared with cemented (z-test, p < 0.001)
‡ hybrid compared with cemented (z-test, p < 0.001)
§ hybrid compared with uncemented (z-test, p < 0.01)
be censored in the construction of the Kaplan-Meier who died during the follow-up period were considered to show cumulative rates of revision over time. Patients using the z-test. Kaplan-Meier curves were generated to of these rates among patient groups were undertaken as the number of revisions per 100 component years. The rate of revision for the cemented group (Fig. 1).

Finally, the experience of the surgeon was linked to the rate of revision by comparing the yearly work-load with the revisions undertaken.

**Statistical analysis.** The rates of revision were calculated as the number of revisions per 100 component years. The 95% confidence intervals for these rates were calculated using the standard Poisson approximation. Comparisons of these rates among patient groups were undertaken using the z-test. Kaplan-Meier curves were generated to show cumulative rates of revision over time. Patients who died during the follow-up period were considered to be censored in the construction of the Kaplan-Meier curves. A two-tailed p-value ≤ 0.05 was taken to indicate statistical significance.

**Results**

The numbers of each type of fixation are presented in Table I. Most uncemented THRs were performed in patients under 65 years of age (8378 of 10 898, 77%) whereas 13 715 of the 16 005 cemented THRs (86%) were in patients 65 years of age or older. Hybrid fixation was most common in the age range between 55 and 75 years (10 207 of 15 189 67%).

The revision rates for each fixation group are shown in Table I. The number of reverse hybrid THRs was small compared with the other three groups and therefore this group was not considered for further analysis. There were significant differences (z-test, p < 0.001) between the overall revision rates for the uncemented and hybrid groups compared with the cemented group, and there was a significant difference between the uncemented and the hybrid group (z-test, p < 0.01). Kaplan-Meier estimates of the rate of revision over time indicated a lower rate of revision for the cemented group (Fig. 1).

Early revision, within 90 days, was performed most often in the uncemented group (89 revisions) compared with the hybrid group (84 revisions) and the cemented group (49 revisions). The rates per 100 component years were 0.77, 0.57 and 0.32, respectively, during this early time period (Table II).

The rate of revision for each group was then compared within four age groups (Table III): less than 55 years, 55 to 64 years, 65 to 74 years and > 74 years. Above the age of 65 years cemented fixation showed a statistically significantly lower rate of revision than either cementless or hybrid fixation. However, in the youngest age group uncemented (z-test, p < 0.01) and hybrid fixation (z-test, p < 0.012) both had statistically significantly lower revision rates than cemented components, but without any statistically significant difference between the hybrid or cementless fixation (z-test, p < 0.65). In the age range 55 to 64 years again hybrid fixation gave the lowest rate, but statistical analysis of the differences in revision in this age range only identified a significant difference between the uncemented and hybrid fixation in favour of the hybrid implants (Tables III and IV). The overall rate of revision per 100 component years was higher in the < 55 and 55 to 65 year groups (0.82 and 0.70) compared with the 65 to 74 year group and > 74 year group (0.55 and 0.53).

The revision rate for the four groups remained unchanged over time with the patients aged under 55 years having the highest rate (Fig. 2).

**Reason for revision** (Table V). The most common reason for revision in all groups was dislocation, but it was more common for an uncemented or hybrid THR to be revised within the first 90 days. This difference continued after 90 days with the hybrid group having a significantly higher revision rate than the cemented groups (z-test, p = 0.007) and a higher, but not statistically significant (p = 0.18), rate compared with the uncemented group. The posterior approach was associated with greater early revision for dislocation, but at seven years this difference remained unchanged (Fig. 3). There was no apparent difference in dislocation rates when compared with patient age at the time of surgery, and the rates within each group remained similar with the hybrid group having the highest rate within all age groups.
Revision for infection was significantly greater (p < 0.001) in both cemented and hybrid THRs compared with the uncemented group. Of the 117 cemented or hybrid THRs revised for infection only 42 used cement combined with antibiotic for implantation.

Failure of ingrowth of the acetabular component (revision within 90 days) was more common in the hybrid group, but after 90 days the cemented acetabular component had a significantly higher (z-test, p < 0.001) rate of revision for loosening. This rate was higher in patients under 65 years, but remained high in the older age groups. The rate of revision of uncemented acetabular components did not increase with time. The incidence of femoral loosening was similar in all the age groups except for the poorer results of the cemented femoral component in patients under 55 years.

Femoral fracture was much more common as the reason for early revision of uncemented components, but the rate of femoral fracture increased with time in the cemented components and by seven years there was no apparent difference among all three groups.

Revision in the ‘other’ category had several causes including leg-length discrepancy, malposition of the component, breakage of the implant, mis-match of the component and a variety of other reasons. Implants with polyethylene wear and osteolysis formed the largest single group within this category. Polyethylene wear and osteolysis were recorded as causes of revision after implantation for five years and were more commonly associated with an uncemented acetabular component (n = 25) compared with the cemented implant (n = 3).
**Table V.** The percentage revision rate for the four most common causes for revision according to age and type of fixation

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Number of implants</th>
<th>Type of fixation</th>
<th>Loosening acetabular component</th>
<th>Loosening femoral component</th>
<th>Dislocation</th>
<th>Deep infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 55</td>
<td>500</td>
<td>Cemented</td>
<td>3.20</td>
<td>1.00</td>
<td>0.80</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td>4024</td>
<td>Uncemented</td>
<td>0.47</td>
<td>0.35</td>
<td>0.94</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>1906</td>
<td>Hybrid</td>
<td>0.32</td>
<td>0.63</td>
<td>1.10</td>
<td>0.53</td>
</tr>
<tr>
<td>55 to 64</td>
<td>1790</td>
<td>Cemented</td>
<td>1.17</td>
<td>0.34</td>
<td>0.67</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>4364</td>
<td>Uncemented</td>
<td>0.32</td>
<td>0.49</td>
<td>1.01</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>4323</td>
<td>Hybrid</td>
<td>0.28</td>
<td>0.28</td>
<td>0.86</td>
<td>0.28</td>
</tr>
<tr>
<td>65 to 74</td>
<td>6068</td>
<td>Cemented</td>
<td>0.57</td>
<td>0.26</td>
<td>0.64</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>2021</td>
<td>Uncemented</td>
<td>0.12</td>
<td>0.25</td>
<td>0.74</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>5884</td>
<td>Hybrid</td>
<td>0.26</td>
<td>0.31</td>
<td>1.00</td>
<td>0.43</td>
</tr>
<tr>
<td>&gt; 74</td>
<td>7647</td>
<td>Cemented</td>
<td>0.30</td>
<td>0.13</td>
<td>0.68</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>499</td>
<td>Uncemented</td>
<td>0.00</td>
<td>0.40</td>
<td>0.80</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>3076</td>
<td>Hybrid</td>
<td>0.23</td>
<td>0.26</td>
<td>1.43</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Surgeon experience (Table VI). A higher rate of revision was associated with a performance rate of less than ten THRs per year. However, there was very little difference in the overall revision rate. Surgeons performing > 100 THRs per year did not have a lower rate of revision.

**Discussion**

Joint registries were introduced in order to provide valuable audit information from their large databases to help to improve orthopaedic practice and to monitor the survival of various implants. Registries can be criticised if they fail to achieve high rates of data collection. The New Zealand Joint Registry has been in operation since 1999 and all orthopaedic surgeons working within New Zealand are required to provide data for the registry as part of their mandatory requirements of continuing professional development. Annual auditing of the registry consistently confirms a nationwide compliance rate of 95% to 98%.

A criticism of registries has been that the orthopaedic practice within the catchment area may be skewed towards one particular procedure. The Swedish Joint Registry has produced valuable data for several years and has had a considerable role in modifying the use of implants throughout the world. However, a valid criticism has been the relatively few uncemented compared with cemented procedures within this registry. Other registries such as those of Canada and Australia are skewed in the other direction with a predominance of uncemented replacements. Although there has been a steady increase in the number of uncemented THRs performed in New Zealand over the last seven years, the distribution has remained relatively uniform with a similar number of cemented, uncemented and hybrid procedures (Table VII). We believe that this uniform use of prostheses and the high capture rate provides us with powerful data which strengthens the statistical results of our study.

Although the rate of revision of THRs registered in the New Zealand registry was low (0.63 per 100 component years) and comparable with that of other registries, the analyses clearly show that, throughout the whole group, the overall revision rate for all causes in uncemented THR was higher than in cemented THR. This result confirms the findings of some recent registry studies and contradicts the results of other studies and does not support our initial hypothesis.

One of the reasons for introducing the uncemented THR was to eliminate the cement layer in order to reduce the number of potential interfaces which could fail and thereby...
decrease the rate of aseptic loosening. The incidence of femoral aseptic loosening in the uncemented group in our study was low with revision-free survival of about 98% which compares favourably with other studies which have shown femoral survival of almost 100% at ten years. These studies indicate that the stability of the femoral component does not deteriorate with time, suggesting that the biological bond formed between the prosthesis and bone may indeed be permanent. The rate of revision for femoral loosening in the uncemented group in our study was comparable with that of cemented components, except in the group aged over 74 years in which the numbers were small, resulting in wide confidence intervals. These data are in agreement with the low incidence of aseptic loosening of uncemented femoral components recently reported by the Norwegian arthroplasty register.

Aseptic loosening of the uncemented acetabulum was low (0.31%) and once ingrown they performed better than the cemented acetabulum in the medium term (nine years, 0.28% compared with 0.58%). The poorer results for the cemented acetabular component were present across all age groups. Poor results of cemented metal-backed acetabular components have been recorded previously but none of the cemented acetabular components registered in our study was metal-backed. We applied the arbitrary separation of revision before or after 90 days to try to delineate between revision for failure of ingrowth and that due to aseptic loosening. Early aseptic loosening of the uncemented acetabulum is multifactorial, but emphasises that failure of ingrowth may rarely occur and further studies are required to isolate host, surgical and implant factors which may be responsible. As with the femoral component, once the acetabulum had ingrown there was no deterioration with time suggesting that the ingrowth of bone may be permanent.

Hybrid THR was introduced to improve the results of cemented THR in younger patients in whom acetabular failure was the main cause of early revision. However, in our study, hybrid THR only performed better in the 55- to 64-year age group when compared with the uncemented THR and did not out-perform cemented THR in any age group. Although the hybrid THR had similar rates of aseptic loosening, there was a marked increase in revision secondary to infection and dislocation compared with the uncemented THR, particularly in those patients under 55 years of age. This would suggest that there was no advantage in using a hybrid THR in this age group.

Younger patients across all three groups had a higher rate of revision compared with those over 65 years of age. Patients under 55 years of age at the time of THR had a lower rate of revision if an uncemented prosthesis was used, confirming other studies showing a higher incidence of early failure in this more active age group if they had a cemented replacement.

The number of revisions in the first 90 days in the cementless group was disproportionately high compared with the total number of revisions performed in this group. Dislocation was the predominant reason for revision in all groups, but early revision in the uncemented acetabular group was almost double that of cemented THR. There may be many reasons for this. However, changing an uncemented liner to a lipped liner or repositioning a malpositioned liner is a procedure with a relatively low morbidity. It is likely to be associated with a lower patient and surgeon threshold to proceed compared with cemented acetabular revision which is a more extensive intervention with a potentially higher risk of complications and patient morbidity.

Our study again confirmed the higher rate of revision surgery for dislocation with a posterior approach. However, the rate did not change with time suggesting that a stable THR, performed through the posterior approach, did not become unstable later. This also suggests that increasing age and diminishing mental function may not increase the risk...
of revision for dislocation. Most femoral heads during this period were 28 mm in diameter. The influence of the contemporary use of components of larger diameter to avoid dislocation can be monitored by the registry.

A large proportion of early revisions in the cementless group was for femoral fracture (2.5%). This is a recognised complication of inserting an uncemented femoral component and is dependent on surgical technique. It was anticipated that those surgeons who perform a low number of THRs each year would be likely to have a higher incidence of this type of technical complication. This was not confirmed. Only those surgeons who performed fewer than ten THRs annually had a higher revision rate with no significant increase in the rate of fracture. Those surgeons undertaking more than 100 THRs annually in fact had a slightly higher rate of revision than the other groups. This may be explained on the basis that these high-volume surgeons all work in tertiary referral units with a varied case load of more complicated problems.

There was a significant number of patients in the cemented group who underwent revision for infection. A large proportion of these (70%) did not receive antibiotic-impregnated cement for fixation of the components. There is evidence that the infection rate is markedly reduced by the use of antibiotic-impregnated cement and matches that of uncemented components. This finding suggests that all primary cemented THRs should be performed with antibiotic cement although it could be argued that an uncemented THR which was well fixed may have been more likely to survive in the presence of infection and therefore not require revision. Our study only looked at revision as defined by component exchange and there were no data collected on those THRs which might have had a deep infection, but did not require revision.

Polyethylene wear and osteolysis accounted for a large number of revisions within the ‘other’ category and there was a greater number of uncemented acetabular components within this group. Again, it is possible that revision of a liner, which radiologically shows signs of wear, is more likely to occur than that of a cemented acetabular component showing the same signs because of the relative ease of the procedure with lower complications. However, these results raise questions about the uncemented acetabular component and the rate of articular and back-side wear occurring in these components.

Uncemented replacements, in general, tend to be more expensive than cemented devices and funding agencies have a particular interest in the cost-effectiveness of these more expensive procedures. Surgeons must continue to be aware of these costs and exercise restraint in performing procedures which have not been shown to be cost-effective. The use of implants must be based on the evidence of successful patient outcome. We believe that our study has confirmed that the uncemented THR, at least in the younger age group (< 65 years), has a lower early rate of revision than that of cemented THR, and as such should be considered in these patients. Cemented THR continues to provide the best results in older patients with lower rates of revision. However, the changing nature of THR with the use of heads of larger diameter, increased modularity and different articulating surfaces may result in a wider indication for the use of uncemented THR in this age group, particularly with respect to the acetabular component.

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References