Age at hip or knee joint replacement surgery predicts likelihood of revision surgery

We compared revision and mortality rates of 4668 patients undergoing primary total hip and knee replacement between 1989 and 2007 at a University Hospital in New Zealand. The mean age at the time of surgery was 69 years (16 to 100). A total of 1175 patients (25%) had died at follow-up at a mean of ten years post-operatively. The mean age of those who died within ten years of surgery was 74.4 years (29 to 97) at time of surgery. No change in comorbidity score or age of the patients receiving joint replacement was noted during the study period. No association of revision or death could be proven with higher comorbidity scoring, grade of surgeon, or patient gender.

We found that patients younger than 50 years at the time of surgery have a greater chance of requiring a revision than of dying, those around 58 years of age have a 50:50 chance of needing a revision, and in those older than 62 years the prosthesis will normally outlast the patient. Patients over 77 years old have a greater than 90% chance of dying than requiring a revision whereas those around 47 years are on average twice as likely to require a revision than die. This information can be used to rationalise the need for long-term surveillance and during the informed consent process.

The New Zealand Joint Registry shows that the number of primary hip and knee replacements increased by 50% and 100%, respectively, between 2000 and 2008. Patients are living longer as a result of improved medical management, so it is to be anticipated that the demand for joint replacement will continue to rise. During the same period, although the overall rate of joint replacement rose by 73%, the population over the age of 50 increased by only 7.5%. This contrasts with a predicted increase in the population of people over 50 years of age by 50% in the next 30 years. This is likely to place an increasing demand on a health system where resources are already scarce. In order to estimate the scale of the additional resources required, the survival rates of both patients and implants have to be identified.

Patients who are at a higher risk of dying before a revision is needed may not require follow-up and so we need to know whether age or comorbidity can be used as a predictor of survival. The question of patient survival following arthroplasty of the lower limb had been recently looked at by Ramiah et al, but the measure of comorbidity was not included in their calculations, and they provided ranges of age rather than the actual ages at which revision arthroplasty or the patient dying became more likely. We feel that a more detailed analysis is required.

Combining the figures of life expectancy and revision burden would allow us to predict future demand on health-care resources and refine follow-up practices to save both time and expense. The current practice at our hospital is to review, as a minimum, all patients who have had a lower-limb joint replacement at six weeks, one year, five and ten years then annually subsequently. This costs the orthopaedic department NZ$131 760 per annum. This cost would rise to around NZ$1 million over the next 30 years, if the predictions on population increase and intervention rate hold true.

The primary aim of our study was, therefore, to determine the life expectancy of our joint replacement population and whether survival can be predicted using age or comorbidity. We also looked at whether our patient population was changing, what impact this would have on our future primary and revision load, and therefore how best to follow-up our patients.

Patients and Methods
Our cohort included all patients who had a total hip or knee replacement (THR or TKR) in our hospital between 1989 and 2007. Data
for primary THR and TKR were collected from the District Health Board Hospital Coding System and from our Departmental Audit Data Base.

As a first step, a method of ‘cleaning’ the data was devised. Data were removed in the following circumstances: code/text descriptor mismatches (e.g. code for THR matched with text for compression hip screw or hemiarthroplasty); revision could not be matched to primary (e.g. no side given or primary performed outside the region); and duplicate entries.

Revision surgery data were obtained from both the Operating Theatre Electronic Records and from the New Zealand National Joint Registry. It should be noted that the National Joint Registry only has data from 1999 and does not include a record of comorbidities.

Once a final list of patients had been collated, it was resubmitted to our coding department to add any comorbidities. Only those comorbidities recorded at the time of surgery were included as they were relevant to the patient at that time.

There are currently no comorbidity scoring systems that are widely accepted for retrospective use with large administrative databases that encompass all comorbidities. Of the various scoring systems which have been described, the International Classification of Diseases (ICD)-based Injury Severity Score (ICISS) is the only system validated in New Zealand which uses simple comorbidity data and can be retrospectively calculated. It is derived from the product of a patient’s Survival Risk Ratios (SRR) i.e. the difference in survival ratio for any given disease classified according to the codes of the ninth (ICD-9) or tenth (ICD-10) edition of the ICD. For example, the SRR of Alzheimer’s disease is 1.13 times more likely to die during an admission than a patient without. If they have hypertension (ICD-9 code 401.1) with an SRR of 1.02 they are 1.02 times more likely to die, and if they have both conditions the individual SRRs are multiplied (in this instance 1.02 x 1.13), therefore they are 1.15 times more likely to die. The final product of all related SRRs is the ICISS score, so this patient’s ICISS would be 1.15.

Statistical analysis. Data were collated in a custom-written database. We matched up the data on death, revision and comorbidity via the patient’s National Health Index and date of surgery. We calculated ICISS data for each admission. The data were then analysed using Microsoft Excel (Microsoft, Redmond, Washington), Medcalc (Mariakerke, Belgium) and SPSS software (SPSS Inc., Chicago, Illinois) under supervision of our local university statistician. Analysis and comparison of survival rates was by the Kaplan-Meier method. Analysis of variance (ANOVA) multivariate analysis for multiple variables was used for regression analysis where multiple variables may have had an effect such as comorbidity and delay to surgery. Student’s t-tests (using data corrected for skew and kurtosis) were used for comparison of specific subgroups (e.g. gender, hip versus knee). Regression analysis was performed for any changes over time such as the age of the patient at the time of surgery. Statistical significance was set at a p-value ≤ 0.05.

Results

A total of 6328 records were coded for primary THR or TKR. Of these 1660 (26.2%) were removed as ‘unclean’ leaving 4668 records for analysis. We verified our data by cross-referencing hospital theatre coding of primary joint replacements with independent departmental audit data and found that we lost only 314 patients due to patients not being present in both datasets. These were analysed for age, gender, and ICISS to ensure that potential bias was minimised. Those patients only present in one or other database were excluded from our study.

The mean age of the THR and TKR patients was 69 years (16 to 100). We found that the TKR patients were older than the THR patients. Other basic demographics can also be found in Table I. The patient survival curves (as opposed to joint replacement survival curves) showed no significant difference between hips and knees except for greater 95% CIs for knees. As both implant and patient survival for both hip and knee replacement patients showed no difference when corrected for age of patient, the data were combined as one cohort without risk of skewing the results.

An example of the hip survival is shown in Figure 1. There was also no difference between hip and knee ICISS values or implant survival when adjusted for age and as such only the survival curve for hips is shown here.

When the implant survival probability is broken down by age, there is a significant difference (Kaplan-Meier, p < 0.0001) between the likelihood of surviving in older and younger patients (Fig. 2). The comparison between the implant survival and patient survival in different age groups, according to ranges, as used in the Swedish Joint Registry, is shown in Table II.

We found that nearly all patients with joint replacements live longer than the standardised age-adjusted New Zealand population (Table III). Only those who have a joint replacement when < 50 years of age do worse than their

**Table I. Patient characteristics (mean (SD))**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Hips (n = 3130)</th>
<th>Knees (n = 1538)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at operation (years)</td>
<td>67.67 (12.35)</td>
<td>70.79 (9.77)</td>
</tr>
<tr>
<td>Patients dead at time of review (%)</td>
<td>805 (25.72)</td>
<td>370 (24.04)</td>
</tr>
<tr>
<td>Age at the time of surgery of deceased patients (years)</td>
<td>73.99 (8.78)</td>
<td>75.35 (7.9)</td>
</tr>
<tr>
<td>Age at death (years)</td>
<td>80.12 (9.18)</td>
<td>81.25 (8.29)</td>
</tr>
<tr>
<td>Number of comorbidities</td>
<td>4.03 (3.27)</td>
<td>4.23 (3.15)</td>
</tr>
<tr>
<td>ICISS score*</td>
<td>1.15 (0.32)</td>
<td>1.17 (0.28)</td>
</tr>
</tbody>
</table>

*ICISS, International Classification of Diseases 10th Edition-based Injury Severity Score*
age-matched general population counterparts: only 93% (survival probability 0.9292) will survive for ten years as opposed to 96% (survival probability 0.9626) for their age- and gender-matched counterparts in the un-operated population.

When comorbidity data are converted to ICISS values, there was a trend for a higher score (representing a ‘sicker’ patient) to have an increased risk of mortality (Fig. 3). It should be noted that even those patients with high ICISS values still have a > 1:3 chance of survival at 18 years.

We found that the mean age of the patients having a joint replacement remained static during this 18-year period (standard correlation co-efficient $r = 0.00001$ with 95% CI -0.06 to 0.07, indicating an almost flat line trend with CI centred around zero). We confirmed a greater spread of ages, meaning that both older and younger patients are receiving operations than would have been considered in the past. By comparing the positive difference from the mean age over time in our cohort (standard correlation coefficient $r = 0.001$, 95% CI 0.004 to 0.08, $p = 0.033$) we found an increase in operating on the very old and very young over this time, although with such a small slope, this is unlikely to be clinically significant. The ICISS values for all our patients also increased during this time (standard
correlation co-efficient $r = 0.001$, 95% CI 0.004 to 0.008, $p < 0.001$) although again with such a small slope this is unlikely to be clinically significant.

In contrast to the general population we found no gender difference in patient survival. The seniority of the surgeon, consultant or a registrar under supervision, did not influence implant survival (Student’s $t$-test, all $p < 0.001$).

As the largest available data on implant survival, we looked at implant survival (probability) from the Swedish Joint Registry with 95% CIs plotted against our patient survival. Ages in the Swedish Registry were therefore assumed to be similar\(^7\) in keeping with standard epidemiological practice. The relative survival probabilities of implant and patient can be plotted as a ratio (Fig. 4). The $y$-axis indicates the relative risk for ten year survival of either patient (from our data) or implant (taken from Swedish registry\(^7\)) and the $x$-axis the age of the patient at surgery (from our data).

Discussion

Our findings suggest that over the 18 years of our study period, the population of patients selected (by self-selection, general practitioners and surgeons) has remained remarkably static with only an extremely modest increase in ICISS score and variation in age during this time with mean age remaining the same. If we look at national census data as compared to joint registry data, between 2001 and 2006 (census years) our population increased by 6% whereas our number of hip and knee replacements increased by 47%, a factor of 8:1. This exponential increase should eventually plateau, as in the short term (relative to population change) it is likely to represent a rise in demand from a more informed and active older population than a true increase in the occurrence of diseases necessitating hip or knee replacement.

As stated previously, our patients over 62 years of age are more likely to die than require revision and those only five years younger have a 50:50 chance. This information is useful when discussing the prognosis and obtaining consent. Informed consent relies on the basic tenet of accurate information and we now feel we have the evidence to encourage patients to follow conservative steps as much as possible until at least the age of 62. It is then up to the patient and surgeon as part of the informed consent process to decide on a relative probability of implant versus patient survival that is acceptable to both parties.

Population trends would suggest a 10% increase in our catchment population in the next ten years. The trend over the past few years indicates that the number of joint replacements in New Zealand is also likely to increase two-fold in the next ten years.\(^1\)

There are several comorbidity scoring systems available including the Charlson Comorbidity Index,\(^8\) the Multi-
purpose Australian Scoring System,9 the American Society of Anesthesiologists (ASA) physical status classification system,10 the Acute Physiology and Chronic Health Evaluation I and II,11 the Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM)12 and the ICISS,4,13 but POSSUM is the only one to have been validated in orthopaedic patients.14 It relies on physiological data that were unavailable to us as it would have required physical review of all 4668 sets of notes. We, therefore, elected to use the ICISS system. Our findings indicate that comorbidities measured using a simple scoring system cannot be reliably used to differentiate between patients likely to survive and those who will not. Patients with the worst comorbidity scores, that is above the 90th percentile (ICISS > 1.25), still have a 37% chance of surviving 18 years.

The same is true of age at time of surgery. Although age has a proven effect on chance of survival we have shown that a patient who is between 70 and 80 years of age (in the older half of our patient population) still has a 25% chance of surviving 18 years.

The limitation of our study, as is often the case with population studies, is trends can be easy to see and prove but do not necessarily apply to the individual patient.

We cannot reliably discharge patients based solely on their comorbidities but we can inform patients that those around an age of 58 years have a 50:50 chance of surviving to revision, those over 62 years of age are more likely to die than to require revision (and thus could be reasonably discharged after short-term follow-up) and those under 50 years of age are likely to require revision in their lifetime.

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References