Revision Rates Following Staged and Simultaneous Bilateral Knee Replacement

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Objective: To compare rates of revision knee replacement (KR) surgery for patients who had 2 knees replaced simultaneously with rates for those who had staged surgery.

Design: Retrospective database study covering the period January 1985 through December 1990.

Participants: 11,771 Medicare recipients in the United States.

Main outcome measure: Rates of revision following primary bilateral KR surgery.

Results: Revision rates were lower for patients who underwent simultaneous surgery relative to patients who underwent staged surgery. After adjusting for risk factors previously determined to affect likelihood of revision, patients who underwent simultaneous KR had an approximately 20% lower risk of subsequent revision surgery compared with patients who had staged surgery (risk ratio, 0.79; 95% confidence interval, 0.64–0.98).

Conclusion: The lower revision rates associated with simultaneous bilateral KR is a factor that physicians and patients can consider when making treatment decisions for bilateral disease.

Arthritis of the knee is common, particularly among the elderly [1]. Bilateral knee arthritis is associated with obesity, and the proportion of subjects with knee osteoarthritis who have bilateral disease increases with age [2]. Total knee replacement (KR) surgery, either unilateral or bilateral, is frequently used to alleviate pain and improve function in patients with severe knee arthritis [3–5]. A major concern associated with KR is the likelihood of subsequent major revision of the primary knee arthroplasty. According to a 1994 meta-analysis of the medical literature, the rate of revision after tricompartmental KR is approximately 1.1% per year [6]. Based on data from more than 200,000 Medicare patients who underwent KR surgery, we found revision rates were between 0.2% and 1.2% at 1 year and between 1.0% and 4.2% at 4 years [7]. Higher rates of revision surgery at 2 years were associated with younger age, male gender, more comorbidities, longer length of stay, surgical complications, and surgery in an urban hospital for the primary KR. Lower rates were seen for those with rheumatoid arthritis as opposed to osteoarthritis or traumatic or unspecified arthritis.

For patients with severe arthritis in both knees, the advantages and disadvantages of simultaneous bilateral surgery (ie, both knees replaced in a single procedure) versus bilateral surgery performed in 2 staged procedures have not been investigated fully. Among Medicare patients, simultaneous KR has been shown to have lower surgical complication rates, shorter total hospital stay, and less total cost than staged procedures [8]. However, patients treated with simultaneous KR have twice the average number of days in intensive care than those who undergo staged procedures. These same patients have higher mortality rates through 1 year, but mortality rates become equivalent thereafter. In this study, we examined data for 11,771 Medicare recipients who underwent bilateral KR between 1985 and 1988 to compare rates of revision for those who underwent simultaneous KR with rates for those who underwent staged KR.

Methods

Data Set

Data were extracted from the Health Care Financing Administration (HCFA) Medicare Provider Analysis and Review (MEDPAR) files, which contain all Medicare-reimbursed hospitalizations. Inpatient (Part A) data from 1985 through 1990 were compiled and subsetted for hospitalizations during which a KR procedure was performed. Exclusion criteria were applied to the data set to eliminate patients enrolled in health maintenance organizations (HMOs) and those residing abroad (because both groups would be expected to have incomplete data), patients who qualified for Medicare for reasons other than age, and patients with data...
that indicated that a KR was unlikely to have been performed. The latter category included patients who had diagnoses suggesting that the KR procedure was miscoded, were discharged home and had an inpatient stay less than 3 days or had costs totaling less than $5000 (in 1989 dollars), and any case in which the procedure was performed in a psychiatric, rehabilitation, or drug treatment facility. Additional details of these exclusion criteria have been published previously [4]. All patients who had bilateral surgery were included in the calculation of cumulative mortality rates; information on deaths was obtained from the Medicare files.

**Identifying Revision KR**

Since October 1989, separate ICD-9-CM codes have been used for primary (81.54) and revision (81.55) KR; prior to this date, coding for KR did not distinguish between primary and revision surgeries. In order to identify revision surgeries performed prior to October 1989, we developed an algorithm using post–October 1989 data. To determine its validity, the algorithm was tested using data from the 15-month period of October 1989 through December 1990. Our method yielded a sensitivity of 87.2% and a specificity of 99.0% [7].

**Linking Revision with Primary KR**

Because ICD-9-CM coding does not indicate laterality (left versus right) for KR surgeries, a second issue that needed to be addressed was how to link each revision with a specific primary KR. We enumerated all primary/revision patterns in the data set and then linked all possible primary/revision pairs. We defined 2 algorithms to link revisions with primary procedures: 1 algorithm resulted in a data set representing the shortest time to revision (ST) and the other produced a data set representing the longest time to revision (LT). Details of this linking procedure have also been published previously [7]. Revision rates based on the ST data set agreed more closely with the revision rate produced by a meta-analysis of published studies [6]. Parallel analyses were performed on both data sets to assess the sensitivity of our results to the linking algorithm.

**Statistical Analysis**

The analysis for this paper was performed on patients who had a second primary KR within 3.5 months of the first primary KR and for whom there were at least 2 years of follow-up beyond the second primary KR. Therefore, patients whose second primary KR occurred after 1 January 1989 were excluded, as were those who died within 2 years of the second primary KR. All revisions performed through December 1990 were included as endpoints. The final data set included 11,771 patients (23,542 primary KR surgeries). Revision rates were calculated separately for staged and simultaneous procedures using product-limit survival curves.

To model the time to revision of bilateral primary KR surgery, we used 7 factors significantly associated with the probability of a revision in our previous analysis of all primary KR surgeries [7]: age, gender, type of arthritis (osteoarthritis, rheumatoid arthritis, post-traumatic arthritis, or other), number of clinical diagnoses (as a measure of comorbidity), surgical complications, length of hospital stay, and urban versus rural hospital location. In addition, each surgery was coded as to whether it took place on the same day as the surgery for the contralateral knee. Surgical complications were identified using Patient Management Categories software (Pittsburgh Research Institute, Pittsburgh, PA) and included wound dehiscence, postoperative wound infection, postoperative hemorrhage, and mechanical complications of orthopedic devices. The number of diagnoses was included because we have found that this measure performs better than other measures of comorbidity and severity for outcomes as diverse as mortality and health care utilization [9].

Since each patient contributed 2 primary KR surgeries to the data set, the surgeries for each patient were not independent. Therefore, usual methods for analyzing time-to-event (survival) data, such as the Cox proportional hazards model [10], were not appropriate. Instead, we used a modification of the Cox regression model that accounts for the correlation structure of the data [11]. The method is analogous to the generalized estimating equations used in the analysis of longitudinal data [12] and was shown to perform well in a recent simulation study [13]. We developed a full model using all 7 previously identified characteristics plus the indicator variable differentiating simultaneous and staged procedures. This allowed us to compare the effect of simultaneous versus staged bilateral surgery after adjustment for all of the factors that were previously associated with the probability of revision. The current study is based on a relatively small subset of the data used in the previous study; the 7 prespecified factors are more generalizable to all KR procedures than factors that might be obtained from the smaller data set. In addition, the factors do not suffer from bias due to overfitting in the current data set. Therefore, the full models will provide the fairest comparison of revision rates between staged and simultaneous bilateral KR.

**Results**

Of the 11,771 patients included for analysis, simultaneous surgeries were performed for 5211 (44.3%). Women accounted for about 61% of the patients in each group (Table 1). The overall racial distribution of the patients was 91.4% white, 4.5% African American, and 4.1% other or unknown. Average age was 73 years, and average stay for each hospitalization was 14.5 days in both groups. As expected, the vast majority (86.9%) of patients who underwent bilateral KR had osteoarthritis, although the proportion of patients with
rheumatoid arthritis was higher among those with staged surgeries. Surgical complications occurred in only 2.4% of the procedures. There were no major demographic differences between patients who underwent either staged or simultaneous bilateral procedures. Since those who underwent staged procedures had 2 hospital admissions, their total length of stay was almost twice that of those who underwent both primary KR procedures on the same day. Surgical complication rates were slightly lower among the simultaneous KR patients as has been noted elsewhere [8]. These complications included wound dehiscence, postoperative wound infection, postoperative hemorrhage, and mechanical complications of orthopedic devices.

Modeling Results
The risk ratios (RR) obtained from the final models and 95% confidence intervals (CIs) based on the standard errors that account for the within-person correlation are presented in Table 3. Of the 7 characteristics and simultaneous surgery included in the proportional hazards model, only age, the presence of rheumatoid arthritis, and whether the surgery occurred on the same day were statistically significant (P < 0.05). The above results are consistent for both the ST and LT data sets. Specifically, for the ST data set, at 1 year the revision rate is 33% less for simultaneous surgery, although the rates are low (less than 1%) for both groups. At 2 and 3 years, the relative difference is still about 30%, with the absolute revision rate of staged surgery still below 2%. By 5 years, the relative difference is 21%, while the absolute revision rates differ by 0.7% (2.57% versus 3.27%).
Table 3. Risk Ratios from Cox Regression Models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Shortest Time to Revision Risk Ratio (95% CI)</th>
<th>Longest Time to Revision Risk Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age*</td>
<td>0.95 (0.93–0.97)</td>
<td>0.95 (0.93–0.97)</td>
</tr>
<tr>
<td>Female gender</td>
<td>0.86 (0.71–1.04)</td>
<td>0.83 (0.68–1.01)</td>
</tr>
<tr>
<td>Rheumatoid arthritis*</td>
<td>0.39 (0.25–0.61)</td>
<td>0.41 (0.26–0.65)</td>
</tr>
<tr>
<td>Other arthritis</td>
<td>1.41 (0.91–2.19)</td>
<td>1.26 (0.77–2.05)</td>
</tr>
<tr>
<td>Number of diagnoses</td>
<td>0.99 (0.93–1.06)</td>
<td>1.01 (0.94–1.08)</td>
</tr>
<tr>
<td>Length of stay</td>
<td>1.00 (0.98–1.01)</td>
<td>1.01 (0.99–1.02)</td>
</tr>
<tr>
<td>Urban hospital</td>
<td>1.13 (0.93–1.37)</td>
<td>1.06 (0.87–1.30)</td>
</tr>
<tr>
<td>Surgical complication</td>
<td>1.60 (0.96–2.68)</td>
<td>1.33 (0.75–2.33)</td>
</tr>
<tr>
<td>Simultaneous surgery*</td>
<td>0.78 (0.64–0.95)</td>
<td>0.79 (0.64–0.98)</td>
</tr>
</tbody>
</table>

*P < 0.05.

simultaneous bilateral KR is independent of age, gender, comorbidity, length of stay, hospital location, and surgical complications.

Discussion

Patients with bilateral knee arthritis who undergo simultaneous bilateral KR are similar to those who undergo staged surgery in terms of age, race, and gender. Rheumatoid arthritis is the underlying disease somewhat more often among those who have staged procedures. Estimated revision rates for those with bilateral KR (either simultaneous or staged) are very low: only about 1% at 2 years.

The major finding of the current study is that those patients who had simultaneous bilateral KR had consistently lower revision rates than those who underwent staged procedures. A previous study of a much smaller number of patients who underwent surgery at the Mayo Clinic found no statistically significant differences in revision rates for those with unilateral KR, simultaneous bilateral KR, or staged bilateral KR [14]. Many studies have also reported no differences in complications, a key predictor of revision surgery, between simultaneous and staged bilateral KR [14–18]. Our previous study using Medicare data found a decrease in surgical complications and wound infections among those who underwent simultaneous bilateral KR [8]. These results should be more generalizable than smaller studies performed at a single center.

Several factors may contribute to the lower rate of subsequent revision in patients who underwent simultaneous bilateral KR for bilateral knee arthritis. There may be a technology bias; those surgeons and institutions that perform simultaneous bilateral surgery may have incorporated more advanced surgical techniques that provide better durability in this patient group. Biomechanically, patients with bilateral knee arthritis may load their lower extremities more evenly following simultaneous bilateral KR, while patients who have had a staged procedure may overload the single replaced knee for a period of time. Unfortunately, no data are presently available to assess these or other possible explanations for our findings.

Early mortality was 0.5% higher among those with simultaneous surgery through 6 months but was approximately the same at 2 years [8]. Thus, it is unlikely that the lower revision rate observed for simultaneous surgery for those with at least 2 years of follow-up was the result of selective mortality. For this bias to occur over the long term, early deaths in the simultaneous surgery group would have to occur much more frequently among those at greatest risk for revision.

Our results are based on administrative claims data, which have both inherent strengths and weaknesses. These data are rich in many important elements and represent the general population better than smaller databases; however, their weaknesses limit the types of studies for which they can be used [19]. Such weaknesses include limited clinical and comorbidity information, lack of data concerning socioeconomic status, inability to identify similar individuals who do not receive care, and inconsistent coding [20]. For example, in the present study, we were unable to identify and compare patients with bilateral arthritis who did not have a KR or had only a single KR with our 2 bilateral surgery groups. Identification and linking of primary and revision surgeries were based on an algorithm that likely resulted in some misclassification. However, with no a priori reason to suspect this to be more common in either group, this limitation will bias our findings toward the null. Thus, the difference between the 2 groups may be greater than our analysis results suggest. In addition, the data lack much detail at both the patient and provider level, so we were unable to account for surgeon effects and effects of technical, procedure-specific issues, such as prosthesis type, surgical techniques, and perioperative care. This is of particular concern in a nonrandomized study, since the 2 patient groups can be compared only to assess possible selection bias on demographic and basic clinical variables like those listed in Table 1. The level of detail required to compare and adjust for other more specific factors is usually available only in relatively small, institution- or provider-specific studies. However, the Medicare database covers a broad spectrum of patients, institutions, and environments; therefore, it is more generalizable to the entire practicing community than the existing literature. For a patient and his or her physician, these results are indicative of outcomes more likely to occur in standard medical practice outside a major teaching center or orthopedic hospital.
BILATERAL KNEE REPLACEMENT

In summary, simultaneous bilateral KR procedures confer an approximately 20% lower risk of subsequent revision than staged bilateral KR. Such lower risk translates to a 0.25% to 0.3% absolute reduction in the cumulative revision rate at 2 years and a 0.5% to 0.7% absolute reduction by 5 years. Other studies have shown that simultaneous bilateral surgery also has a lower perioperative complication rate, lower total cost, and shorter total length of stay compared with staged bilateral knee procedures. However, simultaneous bilateral KR is also associated with higher early mortality (approximately 0.5%) through 6 months [8]. Patients and physicians need to balance a decrease in cost, revision, and complications with a slight increase in early mortality in deciding whether a patient with bilateral disease will have bilateral simultaneous or staged procedures or a unilateral procedure.

References

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