

COMPARISON OF SIMULTANEOUS BILATERAL WITH UNILATERAL TOTAL KNEE ARTHROPLASTY IN TERMS OF PERIOPERATIVE COMPLICATIONS

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Background: Previous studies have demonstrated an increased rate of perioperative complications and morbidity following simultaneous bilateral total knee arthroplasty compared with the rate following unilateral total knee arthroplasty. The purpose of this study was to compare the rate of perioperative complications and morbidity associated with simultaneous bilateral total knee arthroplasty with that associated with unilateral total knee arthroplasty.

Methods: The records on all bilateral total knee arthroplasties performed between January 1994 and June 2000 and unilateral total knee arthroplasties performed between January 1995 and June 2000 were retrospectively reviewed. The records on 514 unilateral total knee arthroplasties and 255 bilateral total knee arthroplasties were analyzed to determine demographic information, preoperative comorbidities, perioperative complications, and thirty-day and one-year mortality rates.

Results: The rates of some perioperative complications, including myocardial infarction, postoperative confusion, and the need for intensive monitoring, were greater after the bilateral arthroplasties. However, the thirty-day and one-year mortality rates and the risks of pulmonary embolism, infection, and deep venous thrombosis were similar for the two groups.

Conclusions: The risk of perioperative complications associated with bilateral simultaneous total knee arthroplasty was slightly increased compared with that associated with unilateral total knee arthroplasty, but the mortality rates were similar. Ultimately, the decision to proceed with simultaneous knee replacement should depend on patient preference through informed choice.

Level of Evidence: Therapeutic study, Level III-2 (retrospective cohort study). See Instructions to Authors for a complete description of levels of evidence.

Total knee arthroplasty can provide reliable pain relief and consistent correction of limb alignment in patients with moderate or severe arthritis. Currently, more than 315,000 total knee replacements are performed annually in the United States in the Medicare population alone¹. Many of these patients have bilateral gonarthrosis requiring operative intervention. The surgeon and patient are then faced with the decision of whether to proceed with a staged bilateral total knee replacement, done as two unilateral total knee arthroplasty procedures performed on different days, or a simultaneous bilateral total knee replacement.

Critics of simultaneous bilateral total knee replacement believe that the rate of perioperative complications is greater than that associated with staged bilateral arthroplasty². Several authors have reported an increased risk of cardiovascular and neurological complications in patients undergoing bilateral surgery³. However, proponents of simultaneous bilateral total knee arthroplasty have reported greater patient satisfaction, lower overall rehabilitation time, similar functional gains, and decreased costs for the patient and institution⁴⁻¹⁰. Several authors have also found no difference between unilateral and bilateral procedures in terms of long-term component survival or thirty-day and one-year mortality rates¹¹⁻¹³. We hypothesized that there would be no difference in the prevalence of perioperative complications between unilateral total knee arthroplasty and simultaneous bilateral



total knee arthroplasty performed with a standard surgical technique and postoperative protocol.

Materials and Methods

Patient Population

After institutional review board approval was obtained, the surgical database of a single tertiary care facility was searched to identify retrospectively all patients who had undergone simultaneous bilateral total knee arthroplasty between January 1994 and June 2000 or unilateral total knee arthroplasty between January 1995 and June 2000. Patients were excluded if an additional procedure had been performed under the same anesthesia, there was an additional complicating diagnosis, blood transfusions were refused, the procedure was a revision arthroplasty, component augmentation was required, a tourniquet was not used, or the arthroplasty was a two-stage procedure for septic arthritis. Five hundred and fourteen unilateral and 255 bilateral total knee arthroplasties met the criteria. Two patients were excluded from the thirty-day mortality analysis and fifty were excluded from the one-year mortality analysis because follow-up had not continued through those time-points (Fig. 1). All patients who had radiographic and clinical evidence of bilat-

eral gonarthrosis were offered simultaneous bilateral surgery during the inclusion time period.

Operative and Postoperative Procedures

The bilateral total knee arthroplasties were performed under a single anesthetic, either general or regional, and the two procedures were done simultaneously by two surgical teams. A tourniquet was utilized throughout each procedure, with a minimum of ten minutes between the releases on the two sides. An intramedullary alignment rod was utilized through an overreamed hole for femoral alignment, and an external tibial guide was used for tibial alignment. A cruciate-retaining, posterior stabilized, or rotating-platform prosthesis (Johnson and Johnson, Warsaw, Indiana) was used. All of the tibial components and the majority of the femoral components were fixed with polymethylmethacrylate. The same surgical technique was utilized in the unilateral total knee arthroplasties.

A standardized postoperative total knee arthroplasty clinical pathway was utilized for all patients. This consisted of immediate postoperative continuous passive motion; use of a patient-controlled morphine or meperidine intravenous anesthesia pump, which was discontinued on the first postoperative day; and removal of drains on the first postoperative day. Sup-

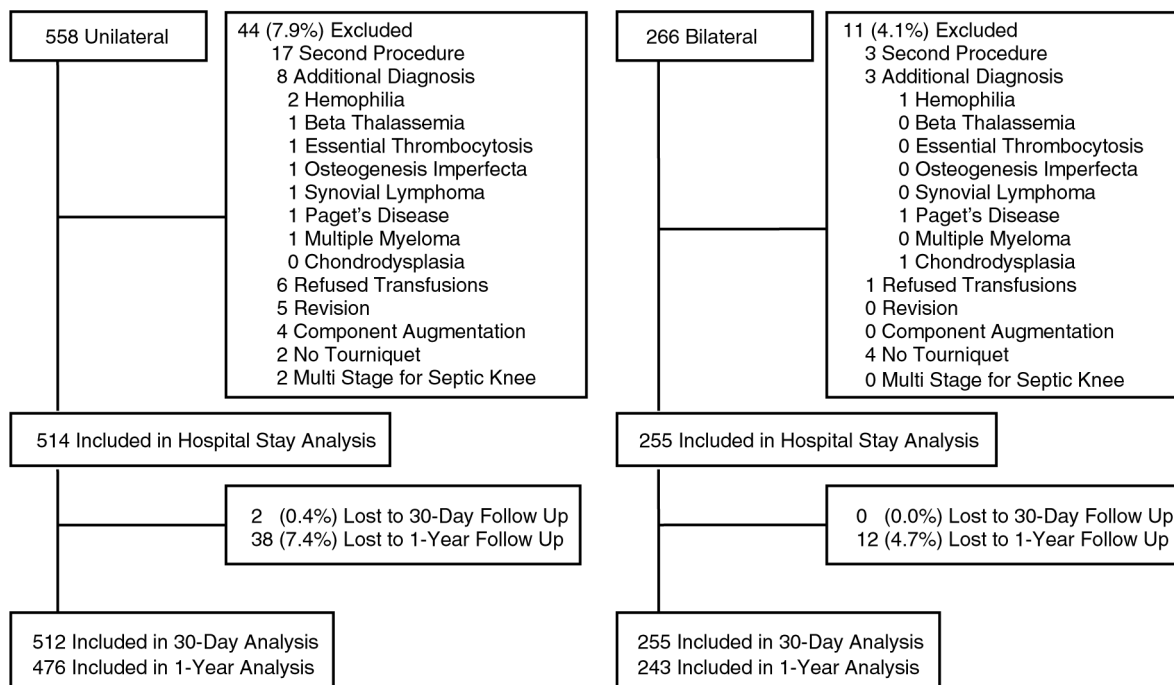


Fig. 1

The total patient population, with the number of patients excluded from each group. Data for 514 patients treated with unilateral arthroplasty and 255 treated with bilateral arthroplasty were analyzed. The numbers of patients lost to the thirty-day and one-year follow-up are shown. Data for 512 unilateral and 255 bilateral procedures were analyzed at thirty days, and data for 476 unilateral and 243 bilateral procedures were analyzed at one year. Paget disease = osteitis deformans.

plemental oxygen was supplied by a nasal cannula to all patients through the second postoperative day and was discontinued when the oxygen saturation was maintained at or above 92% on room air. Antibiotic therapy was continued for twenty-four hours postoperatively. All patients were started on either warfarin on the night before the surgery or a low-molecular-weight heparin on the day of the surgery. Patients were mobilized on the first postoperative day and were generally discharged to home or a rehabilitation facility by the fourth postoperative day.

Chart Review

A total of 514 unilateral total knee arthroplasties and 255 bilateral total knee arthroplasties met the inclusion criteria. The preoperative history and findings of the physical examination were assessed to obtain demographic information, the medical history, and the indication for the total knee arthroplasty. Surgical parameters were recorded from the anesthesiology record, nurse's operative note, and/or surgeon's operative note. The record of the hospital stay was reviewed to obtain information concerning complications, the hemoglobin nadir, transfusions, the duration of the hospital stay, and the location to which the patient was discharged. Admission records and physicians' records of follow-up visits through the first postoperative year were reviewed to determine mortality rates and any additional postoperative complications.

Statistical Methods

Lynch et al., in a study of the results of unilateral and bilateral total knee arthroplasties in patients eighty years of age or older, found one-year mortality rates of 0.00% and 4.08%, respectively³. Because unilateral total knee arthroplasty is performed more frequently than simultaneous bilateral total knee arthroplasty, we expected to identify twice as many unilaterally treated patients as bilaterally treated patients over a given time period. Therefore, to achieve 80% power, with a two-sided type-I error of 0.05, estimated one-year mortality rates of 0.3% for the unilaterally treated patients and 3.3% for the bilaterally treated patients, and a study population with twice as many unilaterally treated patients as bilaterally treated patients, 500 patients treated with unilateral arthroplasty and 250 treated with bilateral arthroplasty were required.

Continuous variables were analyzed for significance with the Student t test with use of Microsoft Excel software (Redmond, Washington). Dichotomous variables were analyzed for significance with a Yates corrected chi-square analysis or the Fisher exact test. A tourniquet time of eight minutes during one of the bilateral operations was not included in the analysis since this outlier value was secondary to a tourniquet failure. A patient was excluded from a given category if the data field for that category was incomplete for that patient. Most categories had no more than five missing data points.

Results

Baseline Characteristics

The indications for total knee arthroplasty were similar between the groups, which had comparable percentages

with degenerative joint disease, rheumatoid or psoriatic or lupus arthritis, and traumatic injury ($p > 0.25$). With only two exceptions, all baseline demographic parameters and preoperative conditions were similar between the two groups ($p > 0.25$). There was a significant, but not clinically important, difference in body mass index ($p < 0.0001$), which averaged 30.00 kg/cm² in the unilateral group and 32.26 kg/cm² in the bilateral group, and in the rates of smoking within one year before the operation, which were 10.9% and 5.9%, respectively ($p < 0.05$). The difference in smoking rates suggested a minimally increased predisposition to morbidity and mortality at baseline in the unilateral group (see Appendix).

Surgical Parameters

The percentages of posterior stabilized, cruciate-retaining, and rotating-platform components implanted did not differ significantly between the groups ($p > 0.50$, $p > 0.95$, and $p > 0.10$, respectively). There was also no difference in the use of general or regional anesthesia between the two groups ($p > 0.25$) (see Appendix).

Duration of Follow-up

We compared the groups with regard to the percentages of patients who were followed for thirty days and for one year to assess bias created by incomplete data. There was no significant difference between the unilateral and bilateral groups with regard to the percentages lost to follow-up before thirty days (0.39% and 0.0%, respectively; $p = 1.0000$) or between the percentages lost before one year (7.4% and 4.7%; $p > 0.10$) (see Appendix).

Primary Outcomes (Table I)

There was no significant difference between the unilateral and bilateral groups with regard to the thirty-day mortality rate (0.0% and 0.78%, respectively; $p = 0.1102$) or the one-year mortality rate (0.63% and 2.1%; $p = 0.1277$). The number of patients requiring readmission within thirty days was also similar for the unilateral and bilateral groups (2.3% and 3.6%; $p > 0.25$).

Within the thirty-day postoperative period, the rates of pulmonary embolism and symptoms suggestive of gastrointestinal bleeding were not significantly different between the two groups ($p = 0.3333$ and 0.5469). The rates of knee infection and deep venous thrombosis within one year also did not differ between the groups ($p = 1.0000$ and 0.0557).

The only primary outcome that was significantly different between the groups was myocardial infarction within thirty days: 0.39% of the patients in the unilateral group and 2.0% in the bilateral group had myocardial infarction, with an absolute difference of 1.61% and a relative risk of 5.13 ($p = 0.0445$). Analysis of the rates of myocardial infarction in specific age groups revealed no significant difference between treatment groups. However, of the patients who were eighty years of age or older, those treated with the bilateral procedure showed a sizable trend toward an increased risk of myocardial infarction.

TABLE I Clinical Outcomes of the Study Group*

Characteristics	Unilateral*	Bilateral*	Statistical Test	P Value†	Relative Risk or Difference Between Means‡
30-day mortality rate	0/512 (0.0%)	2/255 (0.78%)	Fisher	0.1102	∞
<60 yr old	0/105 (0.0%)	0/50			
60-69 yr old	0/140 (0.0%)	1/82 (1.2%)	Fisher	0.3694	∞
70-79 yr old	0/208 (0.0%)	0/97			
≥80 yr old	0/59 (0.0%)	1/26 (3.8%)	Fisher	0.3059	∞
1-yr mortality rate	3/476 (0.63%)	5/243 (2.1%)	Fisher	0.1277	3.33
<60 yr old	0/101 (0.0%)	0/49			
60-69 yr old	0/129 (0.0%)	1/81 (1.3%)	Fisher	0.3857	∞
70-79 yr old	1/193 (0.52%)	2/88 (2.3%)	Fisher	0.2319	4.42
≥80 yr old	2/53 (3.8%)	2/25 (8.0%)	Fisher	0.5894	2.11
Readmission within 30 days	12/512 (2.3%)	9/253 (3.6%)	$\chi^2 = 0.5348$	>0.25	1.57 (0.65, 3.55)
Tourniquet time (min)	72.04 ± 17.42	79.22 ± 18.90		<0.0001	7.18 (5.30, 9.06)
Blood loss (mL)	211 ± 111	356 ± 169		<0.0001	145 (129, 162)
Length of hospital stay (days)	4.42 ± 2.18	5.11 ± 3.68		0.0012	0.69 (0.34, 1.04)
Hemoglobin nadir (g/dL [g/L])	9.47 ± 1.26 (94.7 ± 12.6)	8.62 ± 1.06 (86.2 ± 10.6)		<0.0001	-0.85 (-0.70, -1.00) 8.5 (-7.0, -10.0)
No. of units given to patients requiring transfusion	1.99 ± 0.684	2.65 ± 1.46		<0.0001	0.66 (0.49, 0.84)
Discharged to extended care facility	161/511 (31.5%)	167/252 (66.3%)	$\chi^2 = 81.8056$	<0.001	2.10 (1.80, 2.46)
O ₂ beyond 2nd postop. day	50/507 (9.9%)	50/255 (19.6%)	$\chi^2 = 13.2929$	<0.001	1.98 (1.38, 2.86)
Confusion	75/509 (14.7%)	54/255 (21.2%)	$\chi^2 = 4.5748$	<0.05	1.44 (1.05, 1.97)
Required transfusion	238/511 (46.6%)	194/255 (76.1%)	$\chi^2 = 59.0198$	<0.001	1.63 (1.46, 1.83)
Pulmonary embolism within 30 days	0/510 (0.0%)	1/255 (0.39%)	Fisher	0.3333	∞
Gastrointest. bleeding within 30 days	7/510 (1.4%)	5/255 (2.0%)	Fisher	0.5469	1.43
Infection within 1 yr	3/474 (0.63%)	1/243 (0.41%)	Fisher	1.0000	0.65
Deep venous thrombosis within 1 yr	21/474 (4.4%)	4/243 (1.6%)	Fisher	0.0557	0.37
Myocardial infarction within 30 days	2/510 (0.39%)	5/255 (2.0%)	Fisher	0.0445	5.13
<60 yr old	0/105 (0.0%)	0/50			
60-69 yr old	0/138 (0.0%)	0/82			
70-79 yr old	1/208 (0.48%)	2/97 (2.1%)	Fisher	0.2383	4.38
≥80 yr old	1/59 (1.7%)	3/26 (11.5%)	Fisher	0.0831	6.76
Admission to intensive care unit	3/512 (0.59%)	10/255 (3.9%)	Fisher	0.0014	6.61
<60 yr old	0/105 (0.0%)	0/50			
60-69 yr old	0/139 (0.0%)	2/82 (2.4%)	Fisher	0.1366	∞
70-79 yr old	2/209 (0.96%)	5/97 (5.2%)	Fisher	0.0348	5.42
≥80 yr old	1/59 (1.7%)	3/26 (11.5%)	Fisher	0.0831	6.76
Cardiac monitoring	17/512 (3.3%)	22/255 (8.6%)	$\chi^2 = 8.8649$	<0.005	2.60 (1.41, 4.81)
<60 yr old	1/105 (0.95%)	1/50 (2.0%)	Fisher	0.5425	2.11
60-69 yr old	3/139 (2.2%)	2/82 (2.4%)	Fisher	1.0000	1.09
70-79 yr old	8/209 (3.8%)	12/97 (12.4%)	$\chi^2 = 6.5792$	<0.025	3.26 (1.37, 7.65)
≥80 yr old	5/59 (8.5%)	7/26 (26.9%)	Fisher	0.0398	3.16

*Values are given as the mean and standard deviation for continuous variables and as the number of patients with the percentage in parentheses for dichotomous variables. †P values for continuous variables were generated by the Student t test, and p values for dichotomous variables were generated by chi-square analysis when all prevalences were >5 and by the Fisher exact test when at least one prevalence was ≤5. ‡For dichotomous variables, the value is the relative risk (95% confidence interval) for the event occurring in the bilateral group compared with the event occurring in the unilateral group. For continuous variables, the value is the difference between the means (95% confidence interval) of the two groups.

Secondary Outcomes (Table I)

The rate of transfusion was significantly greater in the bilateral group ($p < 0.001$). The patients who had a transfusion in the bilateral group received an average of 2.65 units, and those who had a transfusion in the unilateral group received an average of 1.99 units ($p < 0.0001$). In the bilateral group 66.3% of the patients were discharged to an extended care facility, whereas in the unilateral group this discharge arrangement was required for only 31.5% of the patients ($p < 0.001$). However, the average length of stay in the hospital averaged only 0.69 day longer in the bilateral group than in the unilateral group ($p = 0.0012$).

The patient was noted to be confused after 14.7% and 21.2% of the unilateral and bilateral arthroplasties, respectively, for a relative risk of 1.44 ($p < 0.05$). The rate of oxygen use after the second postoperative day was 9.9% in the unilateral group and 19.6% in the bilateral group, for a relative risk of 1.98 ($p < 0.001$). The rate of admission to the intensive care unit was 0.59% in the unilateral group and 3.9% in the bilateral group, with a relative risk of 6.61 ($p = 0.0014$), and the rates of cardiac monitoring were 3.3% and 8.6%, with a relative risk of 2.60 ($p < 0.005$).

Discussion

Surgical intervention for bilateral gonarthrosis can be performed either with a same-day bilateral procedure or with a staged bilateral procedure requiring two separate unilateral procedures performed on different days. Initially, the patient and surgeon choose between a same-day bilateral arthroplasty and a single unilateral arthroplasty. Inevitably, the decision to proceed with the second unilateral procedure is reevaluated after the patient recovers from the first. Therefore, it is important to evaluate the outcomes of the choices regarding unilateral or simultaneous bilateral arthroplasty. Our results suggest that, compared with unilateral total knee arthroplasty, simultaneous bilateral total knee arthroplasty is a safe approach with few perioperative complications.

In our series of 514 unilateral and 255 bilateral knee replacements, the thirty-day mortality rates were 0.0% and 0.78%, respectively, and the one-year mortality rates were 0.63% and 2.1%. The average age of the patients in this study was sixty-eight years old. Although the relative risk of one-year mortality in the bilateral cohort compared with that in the unilateral cohort was 3.33, the one-year mortality rate of 2.1% after the bilateral arthroplasties is favorable compared with an expected risk of mortality of 2.3% over a one-year period for the average sixty-eight-year-old person¹⁴. Therefore, patients undergoing bilateral total knee arthroplasty are in general at no more risk of dying than are individuals of similar age dying of natural causes. Additionally, it is estimated that a second arthroplasty would, at a minimum, double the mortality rate associated with the unilateral procedures in this patient cohort.

The rate of perioperative complications and the average convalescence period were slightly greater in the bilateral group than in the unilateral group. The higher rate of postoperative confusion in the bilateral group could be partly explained by the

lower hemoglobin nadirs in that group. However, confusion, together with the increased demand for nasal oxygen, could be attributed to increased systemic dissemination of fat during the surgical procedure. Several authors have shown that bilateral procedures result in an increased prevalence of fat emboli with resulting pulmonary and neurological effects¹⁵⁻¹⁷.

The relative risk of myocardial infarction in our study was 5.13 for the bilateral cohort compared with the unilateral cohort during the first thirty postoperative days. This perioperative complication resulted in a relative risk of intensive care monitoring of 6.61 and a relative risk of cardiac monitoring of 2.60 in the bilateral group. Previous authors have also found an increased prevalence of cardiovascular complications after bilateral total knee arthroplasty. Lynch et al. compared ninety-eight matched patients over the age of eighty who had had either unilateral or simultaneous bilateral total knee arthroplasty³. Cardiovascular complications were seen after 22% of the bilateral procedures compared with 6% of the unilateral procedures. The authors concluded: "Elderly patients may not have the reserve to manage the fluid shifts that occur after a bilateral procedure." Ritter et al. reported similar findings in a study of Health Care Financing Administration data on 339,152 patients treated with total knee arthroplasty¹⁸. Patients treated with a bilateral total knee arthroplasty during a single operation spent twice the number of days in the intensive care unit as did those treated with staged bilateral total knee arthroplasty.

In our series, patients who were more than seventy years old when they underwent a bilateral procedure appeared to have an increased risk of cardiac complications compared with patients in the same age group who underwent a unilateral procedure. No myocardial infarctions occurred in patients who were younger than seventy. Although it was not significant, the relative risk of myocardial infarction in the bilateral group, compared with that in the unilateral group, was 4.38 for patients between seventy and seventy-nine years old and 6.76 for those who were eighty years old or more. In addition, in the bilateral group, patients in the seventy to seventy-nine-year age group and those who were eighty or older had a significant increase in the need for cardiac monitoring compared with the patients treated with unilateral arthroplasty ($p < 0.025$ and $p = 0.0398$). This confirms the previous findings that elderly patients undergoing bilateral total knee arthroplasty are at a slightly higher risk for perioperative cardiac complications despite similar preoperative comorbidities.

Previous authors have expressed concerns about an increased risk of deep venous thrombosis, infection, or gastrointestinal bleeding in association with bilateral total knee arthroplasty^{6,19}. Our results showed no difference in these outcome measures between the unilateral and bilateral groups. In fact, our results suggest a trend toward a decreased prevalence of deep venous thrombosis in patients treated with bilateral total knee arthroplasty. These findings are similar to those of Soudry et al., who evaluated 304 patients and reported a two-fold increased relative risk of deep venous thrombosis in the cohort treated with unilateral arthroplasty¹³. One hypothesis for the decreased rate of deep venous thrombosis in association

with the bilateral arthroplasties is that the larger intraoperative blood loss and surgical insult may consume many of the patients' clotting factors, resulting in a less coagulable state.


Individuals undergoing staged bilateral total knee arthroplasty require two separate procedures to achieve the same knee-replacement outcome as patients undergoing simultaneous bilateral total knee arthroplasty. While the patients treated with the bilateral procedure stayed in the hospital for an additional 0.69 day on the average, this could be interpreted as an avoidance of 3.73 days of hospitalization compared with the stay for two consecutive unilateral procedures ($[4.42 + 4.42] - 5.11 = 3.73$).

Potential weaknesses of this study include the inherent problems with a retrospective review such as information bias and lack of a control group. However, the current cohort consisted of consecutive, nonselected patients. During this period, patients with bilateral disease were given the option of proceeding with either simultaneous or staged total knee arthroplasty. The two cohorts of patients did not differ significantly with regard to their baseline demographic information or their medical comorbidities, with the exception of body mass index and smoking history. A prestudy power analysis was performed to determine the number of patients required to identify what we believed would be a clinically relevant difference in mortality rates and perioperative complications.

Our results suggest that patients undergoing simultaneous bilateral total knee arthroplasty are at a slightly increased risk for perioperative cardiovascular, pulmonary, and neurological complications compared with those undergoing unilateral total knee arthroplasty. Previous studies have shown that patients are willing to accept greater surgical risks in order to receive their surgical care locally²⁰. It can be assumed that patients will also be willing to accept a slightly increased surgical risk in

order to minimize their recovery period, ultimate hospitalization time, and time until pain relief. We believe that simultaneous bilateral total knee replacement does not subject patients to an unacceptable level of risk and that ultimately the decision regarding whether to undergo simultaneous surgery should depend on patient preference through informed choice. We continue to perform simultaneous bilateral total knee arthroplasty at our institution, but we caution older patients (those more than seventy years old) and those with cardiac comorbidities about their slightly increased perioperative risk.

Appendix

 Tables comparing the groups with regard to baseline demographic data, surgical parameters, and loss to follow-up are available in the electronic versions of this article, on our web site at www.jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

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