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The Risk of Subsequent Joint Arthroplasty after Primary Unilateral Total Knee Arthroplasty, a 10-Year Study

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Abstract: The purposes of this study were to determine the probabilities of subsequent lower extremity arthroplasty after index knee arthroplasty for osteoarthritis and to evaluate the demographic as well as radiographic factors that may predict progression to arthroplasty in the contralateral knee. Between 1984 and 1994, 646 patients, aged 40 to 75 years, with a primary cruciate-retaining knee were identified. The 10-year probability of having a contralateral knee after index knee was 36%. When grade 4 radiographic changes were present, the probability increased to 70%. Demographic factors played no role in the risk of future contralateral knee. The radiographic grade of the contralateral knee at the time of index surgery was found to correlate strongly with the future risk of contralateral total knee. **Keywords:** total knee arthroplasty, unilateral.

Osteoarthritis (OA) is reported as the most common indication for performing a total knee or hip arthroplasty [1]. In the United States, approximately 9 million adults have a diagnosis of knee OA [1]. Most of the patients with knee OA are older than 65 years [1]. Radiographically, bilateral knee OA has been reported in nearly two thirds of patients presenting for evaluation of knee pain [1]. Given the high number of patients affected by this disease, the number of arthroplasties per year is increasing. More than 400 000 total knee arthroplasties are being performed each year in the United States [2]. These numbers have been projected to increase markedly over the next decade [2].

To date, there is a wealth of information regarding the long-term survivorship of total knee arthroplasties [3-6]. The 10-year probability of prosthesis survival for cruciate-retaining total knee designs has been reported to be from 96% to 100% [3,4]. However, there are very little data concerning the natural history of the contralateral knee after primary unilateral total knee arthroplasty (TKA) for OA [7,8]. In addition, there is very little information on the demographic and radiographic risk factors that may predict progression to contralateral TKA after primary unilateral knee arthroplasty [7,8].

The purpose of the present study was to evaluate the probability of subsequent lower extremity arthroplasty after primary unilateral TKA for OA using a single implant design, as well as to evaluate the demographic and radiographic risk factors that may predict progression to contralateral knee arthroplasty.

Materials and Methods

A retrospective review of the prospectively collected total joints database was performed to identify those patients who underwent a unilateral primary TKA with a minimum of 10 years follow-up. Patients who underwent bilateral TKA were excluded in this study population. Bilateral TKA was defined as having a contralateral TKA within 3 months of the index TKA. Six hundred forty-six consecutive patients were identified meeting the above criteria, with a mean age of 62 years (range, 40-75 years), having a primary cruciate-retaining TKA performed using a single implant design for a diagnosis of OA between 1984 and 1994. The mean follow-up for all patients was 11 years (range, 10-18 years). No patients were lost to follow-up; however, 146 patients died after the minimum 10-year follow-up period. All patients who were alive at the time of data review (500 patients), or direct family in the case the

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Table 1. Demographic Variables

Total number of patients (n)	646
Men/women	294/352
Follow-up, y, mean (range)	11.2 (10.1-17.9)
Age, y, mean (range)	61.6 (40.3-75.2)
BMI (kg/m^2), mean (range)	30.3 (17.4-40.2)
Kellgren-Lawrence radiographic grade, contralateral knee (n)	
Grade 0	16
Grade 1	46
Grade 2	113
Grade 3	226
Grade 4	226

Table 2. Overall Patient Population 5- and 10-Year Probabilities of Having a Contralateral Total Knee, Ipsilateral Knee Revision, Ipsilateral Total Hip, Contralateral Total Hip, or Death

	5-y Estimates			10-y Estimates		
	P (Event)	95% CI		*P* (Event)	95% CI	
Contralateral total knee	26.0%	22.4%	29.4%	36.2%	32.1%	40.2%
Ipsilateral knee revision	3.0%	1.5%	4.4%	7.4%	4.8%	10.1%
Ipsilateral total hip	1.3%	0.3%	2.2%	3.4%	1.6%	5.2%
Contralateral total hip	1.6%	0.5%	2.7%	2.4%	1.0%	4.0%
Death	7.3%	4.9%	9.6%	21.2%	17.1%	25.2%

CI indicates confidence interval.

patient was deceased (146 patients), were called to confirm that no second procedure was performed at another facility. Institutional review board approval was obtained for the study of these patients. Table 1 outlines the demographics of the patient population.

One author (SAS) reviewed standard bilateral weight-bearing preoperative A/P knee radiographs before the index procedure. Of 646 patients, 627 had radiographs available for review. The Kellgren-Lawrence grading scale was used to classify knee OA in the contralateral knee [9]. The reviewer was blinded as to the side of index knee arthroplasty and the subsequent surgery that patients underwent.

Statistical Analysis

The end points evaluated were performance of a contralateral total knee, ipsilateral knee revision, ipsilateral total hip, contralateral total hip, no second procedure, and death. Kaplan-Meier survival methods were used to estimate the cumulative incidence for each event type and results stratified according to age and sex. The predictive values of sex and body mass index (BMI) as potential risk factors for eventual contralateral total knee were assessed using the multivariate Cox proportional hazards model. In addition, Kaplan-Meier survival methods were used to estimate the cumulative incidence for contralateral knee arthroplasty as related to the Kellgren-Lawrence grading scale. The predictive value of the Kellgren-Lawrence radiographic grade as a potential risk factor for eventual contralateral total knee was assessed using the multivariate Cox proportional hazards model.

Results

For the entire patient population, the 5- and 10-year probabilities of having a contralateral total knee, ipsilateral knee revision, ipsilateral total hip, contralateral total hip, or death are given in Table 2. At 10 years, the probability of having a contralateral total knee is

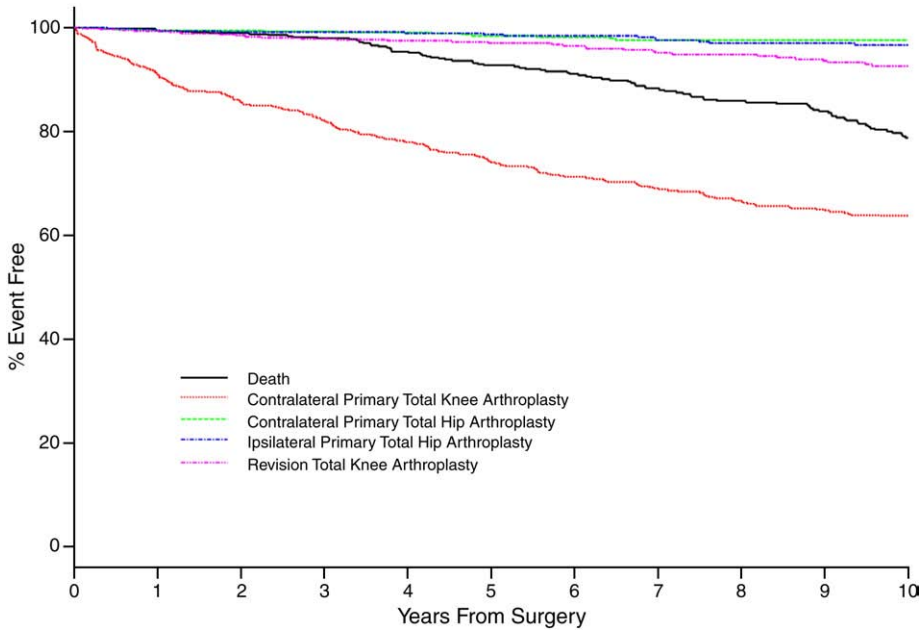

Fig. 1. Kaplan-Meier survival curves depicting probabilities of subsequent joint arthroplasty after index TKA.

Table 3. Age-Stratified 10-Year Probabilities of Having a Contralateral Total Knee, Ipsilateral Knee Revision, Ipsilateral Total Hip, Contralateral Total Hip, or Death

	Age = 40-49			Age = 50-59			Age = 60-69			Age = 70-75		
10-y Estimates	*P* (Event)	95% CI		*P* (Event)	95% CI		*P* (Event)	95% CI		*P* (Event)	95% CI	
Contralateral total knee	41.8%	0.0%	69.2%	34.3%	21.6%	45.1%	39.4%	33.4%	44.9%	31.9%	25.1%	38.4%
Ipsilateral knee revision	43.7%	0.0%	71.9%	17.7%	6.1%	27.9%	7.6%	3.8%	11.4%	1.7%	0.0%	3.9%
Ipsilateral total hip	0.0%	0.0%	0.0%	2.1%	0.0%	6.8%	4.2%	1.4%	7.1%	2.7%	0.0%	5.7%
Contralateral total hip	0.0%	0.0%	0.0%	1.4%	0.0%	5.3%	2.7%	0.5%	5.2%	2.3%	0.0%	5.2%
Death	0.0%	0.0%	0.0%	9.5%	1.1%	17.9%	17.3%	11.7%	22.7%	30.3%	22.7%	37.2%

36%, ipsilateral knee revision is 7%, ipsilateral hip arthroplasty is 3%, and contralateral hip arthroplasty is 2%. Fig. 1 depicts the Kaplan-Meier survival curve for the above end points.

Tables 3 and 4 describe the above given end points for age and sex at 10 years, respectively. The probability of having a contralateral TKA peaked in the 40- to 49-year-old age group at 42%, with men and women having a 10-year probability of progression to contralateral TKA of 37% and 36%, respectively. Contralateral disease progression leading to arthroplasty is highlighted in Tables 2, 3, and 4.

There was no difference in risk of contralateral total knee between men and women ($P = .25$). Body mass index was not found to be a significant risk factor associated with contralateral knee arthroplasty ($P = .38$).

Among the 627 patients with available radiographs, the Kellgren-Lawrence grade of the contralateral knee at the time of index knee arthroplasty was found to correlate strongly with future risk of contralateral total knee ($P < .0001$). The 10-year probabilities of progression to contralateral TKA are given in Table 5 as related to the radiographic degree of OA. Patients in our study with Kellgren-Lawrence grade 3 to 4 OA have a high likelihood of contralateral TKA at 10 years (30%-70%).

Discussion

In this study, we determined the probabilities of subsequent lower extremity arthroplasty after index knee arthroplasty for OA using a single implant design and evaluated the demographic, as well as, radiographic risk factors that may predict progression leading to arthroplasty in the contralateral knee. The results showed that in our population of patients, the most common second joint to be replaced was the contralateral total knee. The probability for the contralateral total knee to be replaced peaked in the 40- to 49-year-old age group. In addition, we found that the only significant predictor to contralateral TKA was the degree of OA in the contralateral knee at the time of the index procedure.

In the past, 2 studies were performed evaluating the probability of progression to contralateral TKA [7,8]. Our study differs from the above studies in the fact that age stratification was an essential part of the data analysis, radiographic and demographic risk factors leading to performance of a contralateral TKA were assessed, and determination of probabilities of progression to subsequent arthroplasty performance in other lower extremity joints was completed. In a recent study evaluating subsequent arthroplasty procedures in noncognate joints after Charnley total hip arthroplasty, it was shown that the age of the patient is associated with the probability of progression to a contralateral total hip when a unilateral total hip is performed for OA [10]. Our results mirror the above study to reveal an age predominance with younger patients progressing toward a contralateral TKA more commonly than the older patient population.

Historically, female sex and BMI have been correlated with the development of bilateral knee OA [11,12]. In addition, BMI greater than 30 kg/m^2 has been shown to be significantly associated with the need for TKA compared to an age-matched cohort of patients with a BMI less than 30 kg/m^2 [13]. However, there have been no studies to the author's knowledge evaluating if these demographic factors correlate to risk of progression to contralateral TKA after index TKA. In this cohort of patients, we found no association with these demographic factors and the risk of progression to contralateral TKA. The findings in our study are consistent with the findings in previous studies that suggest that BMI may predispose patients to knee OA; however, it does not contribute to progression of the disease once it is established [14,15].

With regard to radiographic findings, Hart and Spector [16] criticized the Kellgren-Lawrence grading scale

Table 4. Sex-Stratified 10-Year Probabilities of Having a Contralateral Total Knee, Ipsilateral Knee Revision, Ipsilateral Total Hip, Contralateral Total Hip, or Death

	Female			Male		
10-y Estimates	*P* (Event)	95% CI		*P* (Event)	95% CI	
Contralateral total knee	35.6%	30.0%	40.9%	36.9%	30.6%	42.7%
Ipsilateral knee revision	7.0%	3.6%	10.4%	8.0%	3.7%	12.1%
Ipsilateral total hip	4.2%	1.4%	7.0%	2.2%	0.3%	4.6%
Contralateral total hip	2.4%	0.5%	4.7%	2.3%	0.2%	4.7%
Death	18.5%	13.0%	23.6%	24.7%	18.1%	30.8%

Table 5. Kellgren-Lawrence Radiographic Grade–Stratified 10-Year Probabilities of Having a Contralateral Total Knee, Ipsilateral Knee Revision, Ipsilateral Total Hip, Contralateral Total Hip, or Death

	OA Stage 0, 1, 2,			OA Stage = 3			OA Stage = 4		
10-y Estimates	*P* (Event)	95% CI		*P* (Event)	95% CI		*P* (Event)	95% CI	
Contralateral total knee	3.2%	0.4%	6.2%	29.5%	22.5%	36.0%	69.5%	62.1%	75.9%
Ipsilateral knee revision	7.2%	3.0%	11.3%	9.5%	4.6%	14.2%	4.7%	0.0%	10.5%
Ipsilateral total hip	0.6%	0.0%	1.9%	4.4%	1.1%	8.1%	7.0%	0.6%	13.5%
Contralateral total hip	3.3%	0.4%	6.2%	1.7%	0.0%	4.0%	2.6%	0.0%	7.2%
Death	15.7%	9.7%	21.3%	22.4%	15.5%	28.8%	32.9%	20.4%	43.3%

because of its subjective nature and its overemphasis on osteophytes. However, the Kellgren-Lawrence radiographic criterion has been generally accepted as the standard for evaluating OA radiographically [17-19]. It has been accepted by the World Health Organization and the American Rheumatism Association in developing criteria for the classification of knee OA [17]. Kellgren and Lawrence [9] emphasized that effective control of the intraobserver and interobserver error rate requires one observer. This standard was adhered to during radiographic review as one observer (SAS) read all radiographs. The findings in this study with regard to radiographic degree of OA and progression to contralateral TKA are similar to the findings of Mont et al and Ritter et al [7,8]. Patients in our study with Kellgren-Lawrence grade 3 to 4 OA have a high likelihood of contralateral knee arthroplasty at 10 years (30%-70%).

It has been postulated that biomechanical factors may play a role in the evolution of end-stage OA of the lower extremities [20,21]. It has been shown that patients with medial compartment knee OA have a more rapid increase in the ground reaction force in the diseased knee and a more rapid shift of the body's weight to the support limb and a lateral shift of the trunk [21]. This increase in the ground reaction force with compensatory shift of the body weight has been theorized to initiate OA in the cognate and noncognate lower extremity joints [21]. Currently, it is unclear if the degree of OA in the index knee at the time of arthroplasty correlates to the risk of progression to contralateral total knee as this criterion was not included in the present study. Studies evaluating these biomechanical compensatory forces and the risk of progression to contralateral TKA are currently being performed by the primary author.

To the author's knowledge, the present study is the largest study performed to date, with the longest patient follow-up, evaluating probabilities of progression to subsequent lower extremity arthroplasty after index knee arthroplasty and studying risk factors leading to contralateral TKA. Although our study was a retrospective registry review, the large patient population and long-term follow-up add validity to the data.

Nevertheless, this study does have potential limitations. There is a propensity for selection bias in our patient population. This would occur if a patient had their index TKA performed at our institution and then went on to have a subsequent lower extremity arthroplasty performed at another institution without our knowledge. To minimize this form of bias, each patient or their direct family if the patient was deceased was contacted to confirm that they had no second lower extremity arthroplasty procedure performed at another institution.

In summary, our data suggest if a patient undergoes primary TKA, at 10 years, the patient has a risk of progression to contralateral total knee of 36%, ipsilateral knee revision of 7%, ipsilateral hip arthroplasty of 3%, and contralateral hip arthroplasty of 2%. If stage 4 OA is present, the 10-year risk of progression to contralateral total knee is 70%. As the need for total knee and hip arthroplasty procedures increase, the above data will allow orthopedic surgeons to better educate their patients regarding subsequent arthroplasty procedures and the risk factors predisposing toward contralateral TKA.

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