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# Revision total knee arthroplasty in the young patient: is there trouble on the horizon?

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# Revision Total Knee Arthroplasty in the Young Patient: Is There Trouble on the Horizon?

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**Background:** The volume of total knee arthroplasties, including revisions, in young patients is expected to rise. The objective of this study was to compare the reasons for revision and re-revision total knee arthroplasties between younger and older patients, to determine the survivorship of revision total knee arthroplasties, and to identify risk factors associated with failure of revision in patients fifty years of age or younger.

**Methods:** Perioperative data were collected for all total knee arthroplasty revisions performed from August 1999 to December 2009. A cohort of eighty-four patients who were fifty years of age or younger and a cohort of eighty-four patients who were sixty to seventy years of age were matched for the date of surgery, sex, and body mass index (BMI). The etiology of failure of the index total knee arthroplasty and all subsequent revision total knee arthroplasties was determined. Kaplan-Meier survival curves were used to evaluate the timing of the primary failure and the survivorship of revision knee procedures. Finally, multivariate Cox regression was used to calculate risk ratios for the influence of age, sex, BMI, and the reason for the initial revision on survival of the revision total knee arthroplasty.

**Results:** The most common reason for the initial revision was aseptic loosening (27%; 95% confidence interval [CI] = 19% to 38%) in the younger cohort and infection (30%; 95% CI = 21% to 40%) in the older cohort. Of the twenty-five second revisions in younger patients, 32% (95% CI = 17% to 52%) were for infection, whereas 50% (95% CI = 32% to 68%) of the twenty-six second revisions in the older cohort were for infection. Cumulative six-year survival rates were 71.0% (95% CI = 60.7% to 83.0%) and 66.1% (95% CI = 54.5% to 80.2%) for revisions in the younger and older cohorts, respectively. Infection and a BMI of  $\geq 40$  kg/m<sup>2</sup> posed the greatest risk of failure of revision procedures, with risk ratios of 2.731 ( $p = 0.006$ ) and 2.934 ( $p = 0.009$ ), respectively.

**Conclusions:** The survivorship of knee revisions in younger patients is a cause of concern, and the higher rates of aseptic failure in these patients may be related to unique demands that they place on the reconstruction. Improvement in implant fixation and treatment of infection when these patients undergo revision total knee arthroplasty is needed.

**Level of Evidence:** Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

**Peer Review:** This article was reviewed by the Editor-in-Chief and one Deputy Editor, and it underwent blinded review by two or more outside experts. It was also reviewed by an expert in methodology and statistics. The Deputy Editor reviewed each revision of the article, and it underwent a final review by the Editor-in-Chief prior to publication. Final corrections and clarifications occurred during one or more exchanges between the author(s) and copyeditors.

Total knee arthroplasty is a safe and effective procedure that is the surgical treatment of choice for advanced degenerative knee arthritis<sup>1</sup>. The volume of primary and

revision total knee arthroplasties has increased by up to 200% over the past decade<sup>2-4</sup>. It is projected that, by the year 2030, the number of total knee revisions in the United States will

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A commentary by Kelly G. Vince, MD, is linked to the online version of this article at [jbjs.org](http://jbjs.org).

TABLE I Demographic Variables of Younger and Older Patient Cohorts

Demographic Variable	Younger Cohort	Older Cohort	P Value
Age* (yr)			
At primary op.	41 (16-48)	62 (46-69)	<0.0001
At revision	44 (19-50)	67 (62-70)	<0.0001
Male (% of patients)	45	45	1.000
BMI* (kg/m <sup>2</sup> )	32.1 (19.7-57.6)	32.4 (21.5-54.2)	0.808
Osteoarthritis (% of patients)	85	95	0.674
Follow-up time* (mo)	69 (24-140)	66 (24-161)	0.642

\*The values are given as the mean, with the range in parentheses.

grow approximately 600%, to 268,200 cases per year<sup>3,5</sup>. Patients younger than sixty-five years of age are projected to contribute to the majority of this growth, accounting for >55% of all total knee arthroplasties by the year 2030<sup>6</sup>. Specifically, demand from patients in the forty-five to fifty-four-year age group is expected to grow the fastest, reaching nearly one million total knee arthroplasties per year over the next twenty years<sup>6</sup>.

Fear of early failure and the need for subsequent revision surgery after primary total knee arthroplasty has led surgeons to consider a variety of non-arthroplasty surgical alternatives. These options, including realignment osteotomies, arthrodesis, and arthroscopic debridement, have been reported to have mixed results that tend to deteriorate with time<sup>7-9</sup>. There is literature suggesting that delaying total knee arthroplasty in younger patients with substantial pain and dysfunction can lead to inferior outcomes<sup>10</sup>. There have been conflicting reports with regard to survivorship of primary total knee arthroplasties in younger patients. Some authors have noted comparable implant survivorship between younger patients and their older counterparts<sup>11-17</sup>. Other investigators have reported that younger individuals may have higher cumulative revision rates<sup>3,18-21</sup>.

In order to improve prosthetic survivorship in young patients after primary and revision surgery, the reasons for revision and failure of revisions must be clearly established. Several investigators have implicated both infection and aseptic loosening as the most frequent modes of failure among both older and younger patients<sup>18,22-26</sup>. Patients less than sixty years of age appear to be at increased risk for aseptic loosening, presumably because of their more active lifestyles<sup>20,23,27,28</sup>. Several studies have examined outcomes and survivorship following primary total knee arthroplasty in young patients, but few have assessed survival and reasons for failure of revision arthroplasties in young patients<sup>22,29</sup>.

The objectives of this study were to define the reasons for total knee arthroplasty in patients fifty years of age or less and to define the reasons for failure of the revision arthroplasty, determine the survivorship of revision total knee arthroplasty, and identify risk factors for failure of revision total knee arthroplasty in that population.

## Materials and Methods

We retrospectively reviewed the results of revision total knee arthroplasties performed by six surgeons specializing in adult reconstruction at one institution over a ten-year time period (August 1999 to December 2009). Patients were identified for the study with use of our institutional prospective electronic database. A detailed chart review was performed for each patient. The date of and indication for the primary total knee arthroplasty, the etiology of the failure of the index arthroplasty, and the reason for and timing of all subsequent knee revision surgical procedures were noted. Details of all non-revision reoperations were also collected. Details of each operative procedure, including component specifics, were recorded and all complications were noted.

TABLE II Reasons for All Revisions

	Younger Cohort	Older Cohort	P Value
1st revision			
Aseptic loosening	23 (27%)	23 (27%)	0.853
Infection	19 (23%)	25 (30%)	0.375
Arthrofibrosis (stiffness)	12 (14%)	5 (6%)	0.121
Polyethylene wear	9 (11%)	12 (14%)	0.637
Instability of joint	8 (10%)	12 (14%)	0.470
Extensor mechanism failure	6 (7%)	—	—
Other	7 (8%)	7 (8%)	—
Total	84	84	—
2nd revision (re-revision)			
Infection	8 (32%)	13 (50%)	0.307
Aseptic loosening	7 (28%)	4 (15%)	0.451
Arthrofibrosis	4 (16%)	—	—
Other	6 (24%)	9 (35%)	—
Total	25	26	—
3rd, 4th, and 5th revisions			
Infection	5 (63%)	3 (50%)	—
Aseptic failure	3 (38%)	3 (50%)	—
Total	8	6	—

**TABLE III Cumulative Six-Year Survivorship with 95% Confidence Intervals in Younger and Older Cohorts**

	Overall	Septic Failure	Aseptic Failure
Older cohort (%)	66.1 (54.5-80.2)	59.1 (38.0-91.9)	69.1 (56.1-85.1)
Younger cohort (%)	71.0 (60.7-83.0)	57.4 (38.8-84.9)	75.6 (64.5-88.7)

A younger patient study cohort and an older matched-patient control cohort were formed. Patients were included in the younger patient cohort if they had undergone their first revision of a total knee arthroplasty when they were fifty years of age or younger. Patients who were sixty to seventy years of age were identified from the database for the older cohort; they were then matched one-to-one for sex, body mass index (BMI), and date of surgery (year, month, and day were matched as closely as possible). The patients were matched for the date of surgery to approximately equalize the follow-up times, perioperative practices, and arthroplasty techniques and technology available at the time of surgery. All index procedures were primary total knee arthroplasties.

Patients who underwent unicompartmental knee arthroplasty as the index arthroplasty were excluded. We defined revision as removal or exchange of any prosthetic component for any reason in a patient with an existing total knee replacement. All patients had a minimum of twenty-four months of follow-up. In infected cases, the revision procedures consisted of irrigation and debridement with polyethylene exchange (four of twenty-five cases in the younger group and six of twenty-six in the older group), one-stage exchange arthroplasty (one of twenty-five cases in the younger group and one of twenty-six in the older group), or two-stage exchange arthroplasty (twenty of twenty-five cases in the younger group and nineteen of twenty-six in the older group). Antibiotic-impregnated cement was utilized in all revisions when a nonmodular component was replaced. Although we did not know the cement type used in each primary total knee arthroplasty, Simplex-P cement (Stryker, Mahwah, New Jersey) was used in >75% of the revisions in which cement was employed. To ensure accuracy of survivorship data and minimize losses to follow-up, we contacted all patients by telephone in

December 2011 to complete data collection and to specifically inquire about revision surgery performed outside our institution. We contacted the families of patients who had died to assess the outcome of surgery at the time of death.

During the time period identified more than 1500 total knee arthroplasty revisions were performed at our institution. Of these, 113 were done in patients fifty years of age or younger at the time of the revision. After exclusion of patients because of insufficient availability of data or lack of adequate follow-up, eighty-four knee revisions remained in the younger patient cohort. Eighty-four older patients were then matched as a control cohort (Table I).

Descriptive analysis was performed with use of the mean and frequency for continuous and categorical variables, respectively. Cumulative survival rates and associated 95% confidence intervals (CIs) were calculated with use of a Kaplan-Meier survival curve. The log-rank test was used to compare differences in cumulative survival rates between groups. The cumulative survival rate describes the risk of re-revision of a revision implant at a given time and was used instead of a crude revision rate (proportion of re-revisions to total number of revision knees included in the study). Cox proportional hazard regression was used to calculate the risk of re-revision. Age group (younger versus older), sex, BMI, and reason for the initial revision (infection versus aseptic reasons) were all considered for their potential effect on cumulative survival rates and risk of revision failure in the study population. These factors were established as categorical variables with one category defined as a reference (relative risk of 1.0) and the other category compared with the reference by using Cox regression models.

#### Source of Funding

There was no external source of funding for this study.

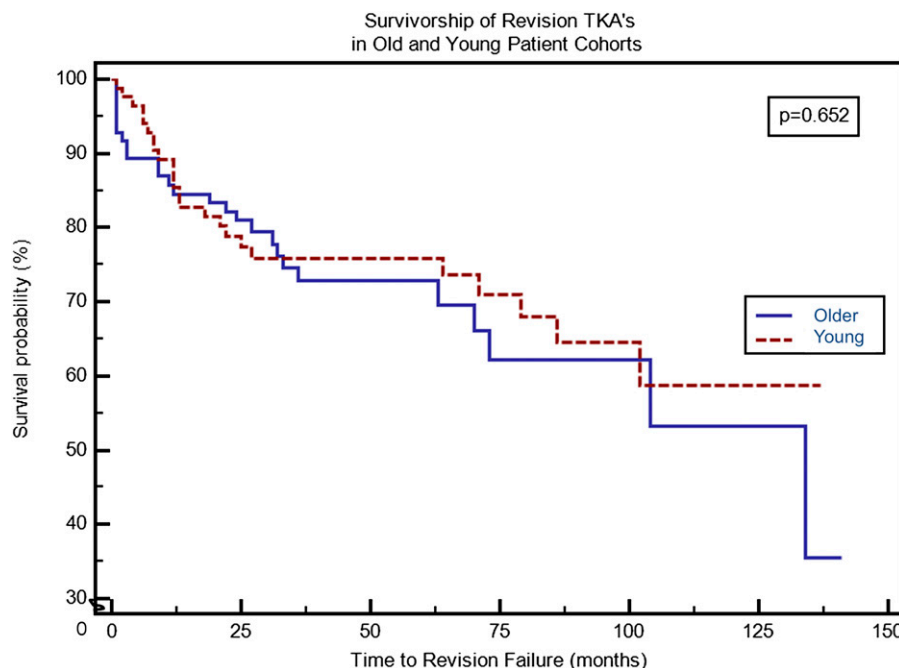


Fig. 1

No significant difference in implant survivorship was observed between older and younger patients after revision total knee arthroplasty (TKA).

**TABLE IV Results of Cox Regression Analysis for Factors Affecting Risk of Re-Revision**

Variable	Risk Ratio	95% Confidence Interval	P Value
Age group (younger)	1.068	0.602-1.894	0.823
Sex (male)	0.998	0.553-1.800	0.995
BMI*			
30.0-34.9	1.867	0.901-3.870	0.093
35.0-39.9	2.213	0.924-5.300	0.075
≥40.0	2.934	1.302-6.609	0.009
Infection	2.731	1.264-4.644	0.006

\*Compared with reference of BMI <30.0 kg/m<sup>2</sup>.

## Results

The reasons for all revision surgical procedures are shown in Table II. There was an overall higher trend toward aseptic failures of both primary and revision total knee arthroplasties in the younger cohort; however, no significant difference between the older and younger groups was noted. Causes of primary and revision failures listed in the table as “Other” include delayed wound-healing, periprosthetic fracture, and extensor mechanism failure. The mean time from the index arthroplasty to the first revision in the younger cohort was thirty-six months (range, one to 210 months) compared with fifty-nine months (range, one to 230 months) in the older

cohort ( $p = 0.0028$ ). The mean time from the first revision surgery to re-revision in the younger cohort was twenty-seven months (range, one to 102 months) compared with twenty-eight months (range, one to 134 months) in the older cohort ( $p = 0.7481$ ).

The overall six-year cumulative survival rate for revision knee arthroplasties was 71.0% (95% CI = 60.7% to 83.0%) in the younger cohort and 66.1% (95% CI = 54.5% to 80.2%) in the older cohort (Table III). However, there was no significant difference in survivorship of revision total knee arthroplasty based on age group ( $p = 0.652$ ) (Fig. 1). In addition, patients with infection as the diagnosis at the initial revision procedure had a significantly lower cumulative survival rate after revision when compared with patients who had the initial revision surgery for reasons other than infection ( $p = 0.0392$ ) (Fig. 2). No other factors that were evaluated (sex, age, or further breakdown of the reasons for revision) significantly influenced the cumulative survival rate.

Cox regression analysis showed that patients with infection as the reason for the first revision were 2.7 times more likely to undergo re-revision than patients with aseptic causes ( $p = 0.006$ ). Furthermore, a BMI of  $\geq 40.0$  kg/m<sup>2</sup> was associated with a 2.9 times increased risk of re-revision ( $p = 0.009$ ). When age group, sex, and BMI groups of 30.0 to 34.9 and 35.0 to 39.9 kg/m<sup>2</sup> were considered, none were found to significantly increase the risk of re-revision (Table IV).

In our younger cohort, fifty-nine knees underwent one revision surgery, seventeen knees underwent two revisions, four underwent three, three underwent four, and one underwent five. Of the eight knees with three or more revisions, three

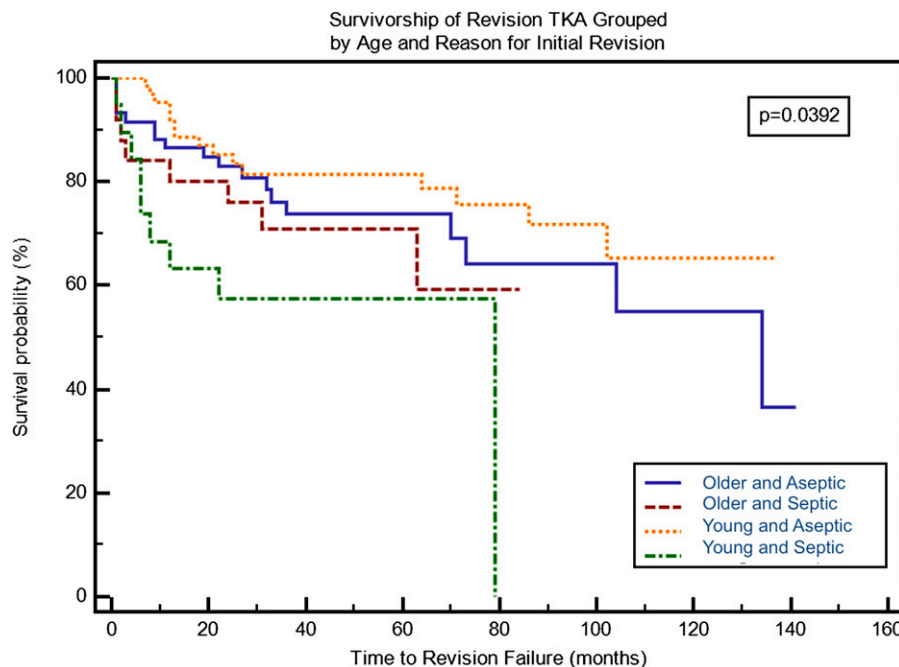


Fig. 2

Survivorship of revision total knee arthroplasty (TKA) grouped by age and reason for the initial revision. Infection led to worse survivorship of revision total knee arthroplasty in both age groups, with younger patients showing a greater difference between septic and aseptic failures.

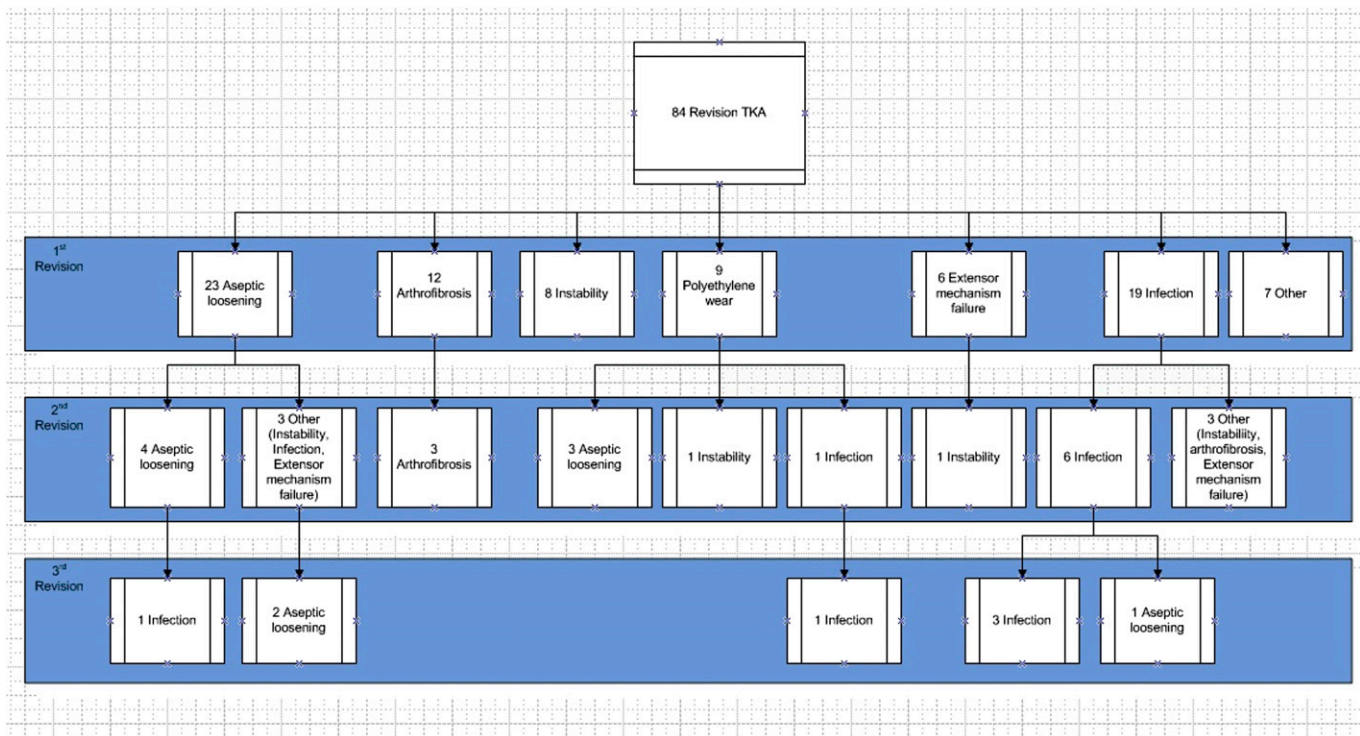


Fig. 3

Flowchart for the reasons for all revisions in the younger patient cohort. TKA = total knee arthroplasty.

had the third revision because of aseptic loosening and five had it because of infection; one of the five had amputation secondary to infection (Fig. 3).

Seventy-six patients in the younger cohort had data on the constraint level of the first revision prosthesis: 41% of the prostheses were posterior stabilized, 58% were condylar constrained, and 1% were hinged. Seventy patients in the older cohort had data on the constraint level of the first revision prosthesis: 1% were cruciate-retaining, 20% were posterior stabilized, 74% were condylar constrained, and 4% were hinged (see Appendix). In the younger patient group, of the sixty-four revisions with femoral component replacement, sixty-three had sufficient information on implant design and fifty-four had sufficient information on fixation methods. Of the sixty-two revisions with tibial replacement, sixty-one had sufficient information on implant design and fifty-three had sufficient information on fixation methods. In the older patient group, of the seventy revisions with femoral component replacement, sixty-six had sufficient information on implant design and on fixation methods. Of the sixty-nine revisions with tibial replacement, sixty-five had sufficient information on implant design and on fixation methods.

## Discussion

The incidence of total knee arthroplasty in young patients is increasing<sup>6</sup>. In order to improve the durability of the procedure, the failure mechanisms of primary and revision total knee arthroplasty in this population must be identified<sup>6</sup>. While authors of papers in the existing literature drew con-

clusions about the failure modes of revision knee arthroplasty in all age groups, we believe that this young population may have unique revision failure modes that surgeons must take into account when considering surgical risks and fixation methods<sup>30-32</sup>. The purpose of this study was to define the reasons for total knee arthroplasty revision and re-revision in patients fifty years of age or younger and determine the survivorship of revision total knee arthroplasty and isolate risk factors for failure of revision total knee arthroplasty in that population.

Our study is limited by its retrospective nature and by being based on the experience at a single institution. Based on the numbers of patients available for our study cohort, we are unable to draw any conclusions regarding survivorship of specific implant designs or knee fixation techniques used in younger patients—topics that undoubtedly warrant further investigation. Whereas prior studies have focused on only one particular subset of patients, our cohort comprised patients who underwent knee replacement in a tertiary referral center for an assortment of joint conditions, making the results more generalizable<sup>21</sup>.

In our study, the most frequent failure mode of primary total knee arthroplasty leading to the initial revision in the younger cohort was aseptic loosening (27%), followed by infection (23%) and arthrofibrosis (14%). While some previous findings are in agreement with these results, several other studies, of patients with an older average age including that of the older patient cohort in our study, have shown infection to be the most common mode of failure of primary total knee

arthroplasty<sup>18,23,26,30,32,33</sup>. Hossain et al., who reviewed 349 cases of revision total knee arthroplasty in patients with an average age of 67.8 years, reported periprosthetic infection as the cause of revision in >30% of cases<sup>32</sup>. In perhaps the largest series of revision knee arthroplasties to date (60,355 in patients with an average age of 65.8 years), Bozic et al. found infection to be the reason for revision in 25.2% of cases<sup>33</sup>. Younger patients often have fewer comorbidities and higher activity levels compared with their older counterparts, possibly accounting for the higher proportion of aseptic loosening. There is little prior literature with which to compare the causes of revision failure and need for re-revision with those in our younger patient cohort. Although the finding was not significant, our younger cohort did show a higher proportion of aseptic failures of revision total knee arthroplasty compared with the older cohort, in which 50% of the revisions failed due to infection. Suarez et al. and Hossain et al. both found that infection led to a majority of revision failures (46% and 31%, respectively), especially those failures that occurred earlier after surgery<sup>31,32</sup>. This likely affirms many surgeons' qualms about performing multiple surgical procedures on the same joint, as the risk of infection is greater with each subsequent procedure<sup>34,35</sup>.


Overall, our study showed a relatively poor six-year cumulative survivorship of revision total knee arthroplasties in the younger (71%) and older (66%) groups. This is substantially lower than the survivorship reported in previous studies of failure of revision knee arthroplasty in the overall community population. Hossain et al. reported a ten-year survivorship of 90.6%, Suarez et al. reported a nine-year survivorship of 85%, and Sheng et al. reported a ten-year survivorship from the Finnish arthroplasty registry of 79%<sup>30-32</sup>. The mean ages in these three studies were sixty-six to sixty-nine years<sup>30-32</sup>. One of the possible reasons that our study did not show revision survivorship to differ significantly on the basis of age may have been the selection of a matched older cohort that was not old enough. It is plausible that only in elderly patient populations of more than seventy years of age does activity level decline enough to beneficially affect revision survivorship. This was shown by Sheng et al., who reported that patients who were more than seventy years old had significantly better revision survivorship than patients who were less than fifty-five years old and those who were fifty-five to seventy years old<sup>30</sup>.

Infection as the reason for the initial revision surgery was a significant predictor of poor implant survival in both groups, supporting the fact that current methods to treat and

eradicate periprosthetic joint infection are inadequate and contribute to substantial morbidity years after an infection diagnosis. While it is out of the scope of this study to compare infection treatment techniques, including irrigation and debridement, one-stage exchange arthroplasty, and two-stage exchange arthroplasty, several reports in the literature suggest that two-stage exchange may be favored in place of simple single-stage procedures for infection<sup>36-38</sup>. No other reason for revision significantly impacted cumulative survival after knee revision.

With the growth in the rates of younger patients undergoing total knee arthroplasty, improving the relatively poor survivorship associated with primary and revision procedures will be vital. As we examined patients who had undergone revision over a decade through the year 2009, our cohort had a mix of patients with knee revisions performed with modern implant technology and fixation methods. While improving treatment for infection remains a focus, some surgeons are turning to use of porous-coated metaphyseal sleeves, trabecular metal cones, and traditional stems and augments to improve revision survivorship in these younger active patients<sup>39</sup>. With future studies specifically examining long-term outcomes after use of these relatively novel techniques, orthopaedic joint replacement surgeons must continue to be aware of the unique reasons for failure, including aseptic loosening, in patients under the age of fifty years.

## Appendix

 A table showing implant constraint level, implant design, and methods of fixation is available with the online version of this article as a data supplement at [jbjs.org](http://jbjs.org). ■

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