Primary Total Knee Arthroplasty in Patients Aged 45 Years or Younger: 162 Total Knee Arthroplasties With a Mean Follow-up Duration of 7 Years

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Abstract
Background: There are few large studies evaluating total knee arthroplasty (TKA) in young patients. Therefore, we sought to evaluate patients aged 45 years or younger undergoing a primary TKA.

Methods: This was a retrospective, single-institution study, from 2003 to 2018, evaluating primary TKA in patients aged 45 years or younger. We identified 162 TKAs with a minimum follow-up duration of 2 years. Common surgical indications were degenerative joint disease (50%), post-traumatic arthritis (21%), and inflammatory arthritis (20%). Forty-nine knees had a prior significant knee surgery. We evaluated survivorship free of revision for any reason and aseptic revision. In addition, we characterized complication rates and risk factors for failure.

Results: The mean age was 39 years, 70% were female, and the mean clinical follow-up duration was 7 years. At 8 years, survivorship free of revision for any reason was 82%, and survivorship free of aseptic revision was 87%. Fifty-five knees experienced at least 1 complication, with an overall complication rate of 34%. There were 6 (4%) periprosthetic joint infections (PJIs), and 24 (15%) knees of patients underwent manipulation under anesthesia with or without arthroscopic lysis of adhesions. There were no specific risk factors for revisions identified. Age less than 40 years was associated with PJI (P = .031), and marital status at the time of TKA was associated with arthrofibrosis requiring an intervention (P = .045).

Conclusions: TKAs in patients aged 45 years or younger are associated with acceptable survivorship at a mean follow-up duration of 7 years. Patients should be counseled about the elevated risk of complications, specifically PJI and arthrofibrosis.

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Introduction

Total knee arthroplasty (TKA) provides good survivorship free of revision [1–3]. With these successful results, TKA has been performed increasingly in younger patients. Kurtz et al. [4] found that in 2006, the percentage of patients younger than 65 years undergoing a primary TKA had increased to 40% of the total TKAs performed. There have been multiple studies evaluating the use of TKA in younger patients with variable results [5–19].

TKA has been performed with satisfactory results in young patients with inflammatory arthritis [6,19]. Further studies have shown TKA to be a reasonable option in young patients, but many of these studies have small sample sizes or do not involve the use of contemporary implants [10,11,15,17,18]. Although some studies evaluating TKAs in younger patients have had satisfactory results, other studies have reported less promising results [5,12,16]. The Australian National Joint Replacement Registry found that patients younger than 55 years undergoing a primary TKA had increased risk of revision compared to some older age groups [20]. The National Joint Registry found that patients aged 65 years or greater had a 3-year revision rate of 1.9% compared to 4.2% in those younger than 65 years undergoing a primary TKA [21]. Many of the larger studies used to evaluate the impact of age on primary TKAs are from registries and thus, lack some of the specific clinical details that can
be elucidated from an institutional study. Furthermore, the defi-
nition of a “young TKA patient” varies from study to study, with
some studies including patients in their fifties.

Therefore, we hoped to evaluate a larger group of young patients
(aged 45 years or younger) undergoing a primary TKA from a single
institution and evaluate the survivorship free of revision and
aseptic revision, the type and frequency of complications, and risk
factors for periprosthetic joint infection (PJI) and arthrofibrosis. We
hypothesized that patients younger than 45 years would have
increased rates of PJI and arthrofibrosis requiring an intervention.

Material and methods

After institutional review board approval, a retrospective review
was completed from December of 2003 to March of 2018 for pri-
mary TKAs in patients aged 45 years or younger at an academic
institution. During this time, we identified 245 TKAs. Patients with
less than 2 years of clinical follow-up were excluded, resulting in
162 TKAs in 136 patients. A manual chart review was then per-
formed to confirm patient demographics, indication for the surgery,
presence of a revision surgery, complications, and latest follow-up.
The American Society of Anesthesiologist (ASA) Physical Status
Classification was used to assess overall health and to evaluate each
case. The mean age was 39 years (range 16-45), 113 (70%) were
female, and the mean follow-up duration was 7 years (2 to 16.5).
Ninety-six (59%) had an ASA score of 1-2, and 65 (40%) had an ASA
score of 3-4.

Additionally, we reviewed the cohort of excluded TKAs with less
than 2 years of follow-up for complications including PJI and
intervention for arthrofibrosis. This comprised 83 TKAs in 73
patients.

We reported survivorship free of aseptic revision and survivor-
ship free of revision for any reason for the cohort of patients with a
follow-up duration >2 years. Complications reported were in-
tructions for arthrofibrosis, PJI requiring revision, emergency
department (ED) visits and admissions in the 90-day postoperative
period, aseptic revisions, other reoperations, and medical
complications.

We reported hazard ratios (HRs) to determine if an association
existed between revision surgery and the following factors: a major
prior knee surgery, any prior knee surgery, surgical indication,
history of tobacco use, and ASA score. An additional risk factor
analysis was performed to evaluate the association of arthrofibrosis
requiring an intervention or PJI with specific risk factors such as a
major prior knee surgery, any prior knee surgery, age less than 40
years, marital status, male sex, and history of tobacco use. We
utilized EPIC MaestroCare SlicerDicer (Verona, WI) to estimate rates
of PJI and manipulation under anesthesia (MUA), with or without
lysis of adhesions from 2003 through 2018 at our institution. Dur-
ing this timeframe, there were 7201 primary TKAs performed in our
institution, 271 patients (4%) who underwent MUA of the knee, and
143 patients who developed PJI (2%).

The major indications for a primary TKA were degenerative joint
disease in 82 knees (51%), post-traumatic arthritis in 32 (20%),
inflammatory arthritis in 32 (20%), or other indications in 16 (10%).
Other indications included avascular necrosis in 6 knees, hemo-
philic arthropathy in 3, dysplasia in 2, synovial chondromatosis in
2, post-septic knee in 2, and neuropathic arthropathy in 1. Ninety
knees (56%) underwent at least 1 operation prior to their TKA.
Forty-nine knees (30%) had a significant prior knee surgery such as
ligament reconstruction, osteotomy, patellar realignment, or open
reduction internal fixation for fractures. Forty-one (25%) knees had
1 or more arthroscopic debridement procedures.

The primary TKA implant was posterior stabilized in 73 knees
(45%), ultracongruent in 59 (36%), cruciate retaining in 23 (14%),
and constrained in 7 (4%). The patella was resurfaced in 134 (83%).
All but 3 TKAs were cemented. A fixed bearing design was used in
152 (94%), and a mobile bearing design was used in 10 (6%). Post-
operatively, patients were made weight-bearing as tolerated and
underwent inpatient physical therapy. Outpatient physical therapy
was left to the discretion of the individual surgeon.

Statistical analysis

Kaplan-Meier survivorship analysis was used to calculate the
survivorship free of revision for any reason and survivorship free of
aseptic revision. HRs were used to evaluate the association between
specific variables and revision for any reason. A Fisher’s exact test,
2-tailed, was used to evaluate the association between risk factors
and PJI or arthrofibrosis requiring an intervention. A P value <0.05
was considered statistically significant. Statistical analysis was
completed using JMP (Version 14; SAS Institute Inc., Cary, NC).

Results

Survivorship analysis

The survivorship free of aseptic revision was 93% (95% confi-
dence interval [CI], 89-97) and 87% (95% CI, 80-94) at 4 and 8 years,
respectively. (Fig. 1). Twenty knees (12%) underwent revision for
aseptic etiology. Seven knees required revision for arthrofibrosis, 7
for aseptic loosening, 3 for instability, 2 for wear, and 1 for persist-
ten soft tissue pain. The survivorship free of revision for any reason
was 91% (95% CI, 86-96) and 82% (95% CI, 74-90) at 4 and 8 years,
respectively. (Fig. 2).

Complications

Out of the 162 TKAs, there were 55 TKAs (34%) that experienced
a total of 82 complications, with some knees having multiple
complications (range, 1-4). Six knees (4%) developed PJI that un-
derwent reoperation, 24 knees (15%) underwent an intervention for
arthrofibrosis, 15 knees (12%) had ED visits, 3 (2%) had medical
complications, 7 (5%) underwent other reoperations, and 20 (12%)
underwent aseptic revision (Table 1).

Of the 6 knees that developed PJI, some had multiple reopera-
tions. Two knees were treated with debridement antibiotics and
implant retention (DAIR) with polyethylene exchange alone. One
patient with bilateral TKAs underwent a 2-stage exchange protocol
(each side about 1 year apart). One patient was an intravenous drug
user who developed PJI and underwent a DAIR. He had PJI reoc-
currence treated with resection arthroplasty, had persistent

![Figure 1. Survivorship free of aseptic revision: Survivorship was 93% (95% CI, 89-97) at 4 years and 87% (95% CI, 80-94) at 8 years.](image-url)
infection, and fell, sustaining a periosteal fracture. He elected to have an above-knee amputation. Another patient on chronic opioids developed PJI and underwent resection and had a static spacer placed. This patient was lost to follow-up for over 7 years. She presented to the ED with a draining sinus tract and osteomyelitis about her knee. She elected to undergo an above-knee amputation.

Risk factor analysis

Age less than 40 years was associated with PJI, as 83% of PJIs were in knees of patients younger than 40 years, and 17% were in knees of patients aged 40 to 45 years \( (P = .031) \). Marital status at the time of TKA was associated with arthrofibrosis requiring an intervention as 29% of interventions were in those married and 71% of interventions were in those not married \( (P = .045) \) (Table 2). There were no significant risk factors associated with revision TKAs (Table 3).

Patients excluded for insufficient follow-up

Eighty-three TKAs (73 patients) were excluded for follow-up of less than 2 years. The mean follow-up was 0.6 years (0, 1.8 years). In this cohort, 9 out of 83 (11%) underwent MUA, and 1 patient underwent 2 MUAs. There were 2 prosthetic joint infections treated with DAIR (2%) (1 occurring at 1 year postoperatively, and the other at 3 months). There was 1 revision (1%) for loosening at 6 months.

Discussion

While TKA has been a successful operation, the results are variable in younger patients. We therefore evaluated the results of primary TKAs in patients aged 45 years or less. We found the survivorship free of aseptic revision (87% at 8 years) and the survivorship free of revision for any reason (82% at 10 years) to be acceptable given this challenging cohort. There was a high rate of PJI and MUA for arthrofibrosis compared to the overall rates at our institution for TKA patients of any age. Age less than 40 years was associated with PJI as 83% of PJIs were in knees of patients younger than age 40 years and 17% were in knees of patients aged 40 to 45 years \( (P = .031) \), and marital status at the time of TKA was associated with arthrofibrosis requiring an intervention as 29% of interventions were in those married and 71% were in those not married \( (P = .045) \).

This information is valuable to the surgeon when counseling young patients who have failed other treatment options and are considering TKA.

This study had several limitations. This represents the work of an academic institution, and the results may differ if multiple institutions or a larger database were used. However, by using data from 1 academic institution, we were able to detail surgical complications and specific risk factors. We included a minimum clinical follow-up of 2 years, so patients may have had further complications that were unaccounted for. With a mean clinical follow-up duration of 7 years, we believe our study allows for a reasonable survivorship analysis and reporting of surgical complications in a cohort that is infrequently reported on in the literature. The retrospective nature of this study limits the ability to truly determine the extent of various risk factors, and we could only determine associations but not causality. Furthermore, there may have been risk factors present that were not measured but would have had an impact on various outcomes such as revision, PJI, and arthrofibrosis requiring an intervention. A significant number of patients with a follow-up duration less than 2 years were excluded from our main analysis. Complications that were identified within the electronic medical record in the timeframe of less than 2 years revealed an incidence of MUA that was comparable to that in our cohort of patients with a follow-up duration greater than 2 years (11% vs 15%, respectively) and low rates of PJI (2% vs 4%).

Certainly, the long-term outcomes of these patients are unknown, and it is difficult to make conclusions based on this cohort. It is possible that younger patients may be more likely to move away due to changes in life circumstances, resulting in a lack of follow-up; alternatively, patients may be temporarily seeking care at our tertiary referral center.

We reported a survivorship free of aseptic revision of 87% at 8 years; these results are lower than some reports. Kim et al. \[22\] evaluated 108 patients who were younger than 51 years with osteoarthritis and found a survivorship free of revision of 93% in fixed-bearing TKAs and 97% in rotating-platform mobile-bearing TKAs at 16.8 years. Duffy et al. \[10\] examined 74 TKAs (the most common preoperative diagnosis being rheumatoid arthritis) in

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**Table 1**

| Complication                               | Number of TKAs affected (%) |
|--------------------------------------------|-----------------------------|
| ED visitor admission\(^a\)                 | 1 (1)                       |
| PICC related                               | 2 (1)                       |
| Wound Drainage                             | 6 (4)                       |
| Cellulitis                                 | 1 (1)                       |
| Hypotension                                | 1 (1)                       |
| Shortness of breath                        | 2 (1)                       |
| Vomiting/diarrhea\(^b\)                    | 2 (1)                       |
| Medical complication                       |                             |
| Ileus                                      | 2 (1)                       |
| Pulmonary embolism                         | 1 (1)                       |
| Aseptic surgical procedure (excluding revision) |                             |
| Manipulation under anesthesia              | 21 (13)                     |
| Lysis of adhesions                         | 3 (2)                       |
| Debridement for patellar clunk             | 1 (1)                       |
| Peroneal neurolysis                        | 1 (1)                       |
| Wound revision for dehiscence              | 2 (1)                       |
| Irrigation and debridement for hematoma     | 3 (2)                       |
| PJI\(^b\)                                  |                             |
| Debridement, antibiotics, implant retention| 2 (1)                       |
| Stage                                      | 2 (1)                       |
| Above knee amputation                      | 2 (1)                       |
| Aseptic revisions                          |                             |
| Aseptic loosening                          | 7 (4)                       |
| Wear                                       | 2 (1)                       |
| Arthrofibrosis                             | 7 (4)                       |
| Pain                                       | 1 (1)                       |
| Instability                                | 3 (2)                       |

\(^a\) One patient was admitted for nausea/vomiting and found to have acute renal failure.

\(^b\) Definitive treatment of PJI is shown in the table.
patients aged 55 years or younger and found a survivorship free of revision of 99% at 10 years. Others have reported less-favorable survivorship in young patients or survivorship that is lower than that of older-age cohorts. Castagnini et al. [5] evaluated 238 TKAs in patients aged 45 years or less in an Italian regional registry and found that the cumulative survival of TKA was 83.5% at 10 years. Julin et al. [12] utilized the Finnish Arthroplasty Registry and found that patients aged 55 years or younger had a 5-year survivorship free of revision of 92% compared to 97% in those over the age of 65 years. Similarly, Meehan et al. [16], using the California Patient Discharge Database, found that patients younger than 50 years were at an increased risk of aseptic mechanical failure compared to patients aged 65 years or older. We believe our cohort demonstrated an acceptable survivorship free of aseptic revision, but it was lower than that in some reports. This difference may be related to the fact that we had a complex cohort (50% with a diagnosis other than degenerative joint disease) that was young at the time of index arthroplasty (mean age of 39 years), with a relatively long follow-up (mean, 7 years). Importantly, 56% of the cohort had a prior surgical procedure, and 30% of the cohort had a significant prior surgical procedure, which is known to be associated with revision [23,24]. Given the unique findings and the limited literature on these patients, we believe these findings are important for the clinician counseling young patients considering primary TKA.

The PJI rate of 4% is higher than that in other reported cohorts and our own institutional PJI rate [25,26]. Kurtz et al. [25] evaluated the incidence of infection in Medicare patients undergoing TKAs and found it to be 1.55% within 2 years. Tsaras et al. [26] found the cumulative incidence of PJI to be 1.4% at 10 years after arthroplasty. Meehan et al. [16] found an increased rate of revision due to PJI in patients younger than 50 years compared to patients aged 65 years or older. In addition to being young, the cohort had other known risk factors for PJI such as post-traumatic arthritis, inflammatory arthritis, and prior ligamentous reconstruction [23,24,27]. Of the 6 knees that developed PJI, 3 had post-traumatic arthritis with a prior surgery, and 2 had inflammatory arthritis. Fifteen percent of the TKAs underwent either MUA or arthroscopic lysis of adhesions with MUA, which is higher than our institutional rate of 4%. In a systematic review, Gu et al. reported an MUA rate of 5.8% in primary TKAs [28]. While studies have also shown that younger age is associated with a higher risk of MUA, there is scant literature evaluating the rate of MUA in an exclusively young cohort [29–31]. Young patients undergoing TKAs should be aware of this risk and should consider close communication with their surgical team in the early postoperative period to achieve an appropriate range of motion.

We identified risk factors associated with PJI and interventions for arthrofibrosis, but we did not identify any risk factors associated with revision. Interestingly, we found that those who were married at the time of TKA had a lower risk of undergoing an intervention for arthrofibrosis (P = .045). While others have found that mental health may be related to TKA outcomes, marital status and social factors are also associated with TKA outcomes—including a longer length of stay for divorced patients and better patient-reported outcomes in married patients [32–35]. While not directly connected to arthrofibrosis, it could be reasoned that patients with more normal, painless range of motion have decreased pain and increased function. Patients should consider building a “support” team to help them in the postoperative period. Furthermore, we found that age less than 40 years was associated with an increased risk of PJI (P = .031). While young age itself is a known risk factor for PJI, it may be that increasingly young patients have an even greater risk of PJI [16]. The HRs for a prior knee surgery (HR 1.6; 95% CI, 0.7–4.0; P = .2) and a significant prior knee surgery (HR 1.4; 95% CI, 0.6–3.2; P = .4) were not statistically significant but trended toward a higher risk of revision. Others have found that post-traumatic arthritis and prior ligamentous surgeries were associated with an increased risk of revision [23,24]. The association between inflammatory arthritis and revision was not statistically significant, but there was a trend toward lower revision in those with this diagnosis (HR 0.5; 95% CI, 0.1–1.4; P = .2). The Australian National Joint Replacement Registry found patients younger than 55 years with rheumatoid arthritis and undergoing a TKA were at a decreased risk of revision compared to those with osteoarthritis (HR 0.42; P < .001), but when they compared other types of inflammatory arthritis to osteoarthritis, this did not reach significance (HR 0.85; P = .405) [20]. Surgeons may consider this information when counseling young patients with disabling inflammatory arthritis.

**Table 2** Risk factor analysis for PJI and arthrofibrosis requiring an intervention.

| Variable | PJI | % | P value | Arthrofibrosis requiring an intervention | % | P value |
|----------|-----|---|---------|----------------------------------------|---|---------|
| Significant prior knee surgery | Yes (6 knees) | 3 | 50 | 46 | 29 | .368 | 4 | 17 | 45 | 33 | 0.151 |
| Any prior knee surgery | Yes (156 knees) | 3 | 50 | 87 | 56 | 1.000 | 9 | 38 | 78 | 57 | 0.660 |
| Age less than 40 y | Yes (24 knees) | 5 | 83 | 57 | 37 | .031 | 8 | 33 | 54 | 39 | 0.655 |
| Married | Yes (156 knees) | 3 | 50 | 77 | 49 | 1.000 | 7 | 29 | 73 | 53 | 0.045 |
| Male sex | Yes (138 knees) | 3 | 50 | 46 | 29 | .151 | 4 | 17 | 45 | 33 | 0.368 |
| History of tobacco use | Yes (138 knees) | 3 | 50 | 55 | 35 | .688 | 11 | 46 | 47 | 34 | 0.356 |
| Preoperative diagnosis of degenerative joint disease | Yes (138 knees) | 1 | 17 | 81 | 52 | .115 | 14 | 58 | 68 | 49 | 0.510 |
| Preoperative diagnosis of post-traumatic arthritis | Yes (138 knees) | 3 | 50 | 29 | 19 | .092 | 3 | 13 | 29 | 21 | 0.462 |
| Preoperative diagnosis of inflammatory arthritis | Yes (138 knees) | 2 | 33 | 30 | 19 | .339 | 4 | 17 | 28 | 20 | 0.788 |

**Table 3** Risk factor analysis for revision total knee arthroplasty.

| Variable | Hazard ratio | 95% confidence interval | P value |
|----------|--------------|-------------------------|---------|
| Significant prior knee surgery | 1.4 | 0.6–3.2 | .4 |
| Any prior knee surgery | 1.6 | 0.7–4.0 | .2 |
| Degenerative joint disease | 1.3 | 0.6–3.0 | .5 |
| Post-traumatic arthritis | 2 | 0.8–4.6 | .1 |
| Inflammatory arthritis | 0.5 | 0.1–1.4 | .2 |
| History of tobacco use | 1.2 | 0.5–2.7 | .7 |
| ASA score of 1-2 | 1.3 | 0.6–3.2 | .5 |

**Conclusion**

At a mean follow-up duration of 7 years, we found a satisfactory rate of survivorship free of revision in patients aged 45 years or younger. Although we believe this rate was acceptable, it was lower than that in some studies and may be related to the challenging cohort. As surgeons and young patients face the dilemma of...
whether to pursue such a major procedure, these survivorship data can be shared and potentially aide in this process. Furthermore, specific complications such as arthrofibrosis and PJI were more common than reported in other non-age-restricted series on primary TKAs; this too can be discussed during shared decision-making with young patients considering TKA. Given the limited number of young TKA series, often including patients in their fifties, we believe this study adds valuable information that can help educate young patients as they consider primary TKA.

Conflicts of interest

Dr. M. P. Bolognesi receives royalties from Zimmer Biomet and Total Joint Orthopedics; is a paid consultant for Zimmer Biomet and Total Joint Orthopedics; has stock or stock options in Total Joint Orthopedics and Medica; receives research support from DePuy Synthes, Exactech, and PCORI; receives other financial or material support from Zimmer Biomet, DePuy, Stryker, Total Joint Orthopedics, Smith & Nephew, DJO, and Exactech; is on the editorial or governing board of Arthroplasty Today; and is a board member in Eastern Orthopaedic Association, American Association of Hip and Knee Surgeons, American Academy of Orthopaedic Surgeons, Journal of Arthroplasty, and Journal of Surgical Orthopaedic Advances. Dr. T. M. Seyler receives royalties from Total Joint Orthopedics, Pattern Health, MiCare Path, and Restor3d; is a paid consultant for Total Joint Orthopedics, Smith & Nephew, Restor3d, and Heraeus Medical; receives research support from Zimmer Biomet; receives financial or material support from Wolters Kluwer Health Division; and is a board member in the American Association of Hip and Knee Surgeons and Board of Specialties. The other authors declare no potential conflicts of interest.

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