Surgeon Learning Curve With Selection of New Total Knee Arthroplasty Implants and Risk of Revision: A Registry-Based Cohort Study

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Abstract

INTRODUCTION: Prior studies have reported learning curves as surgeons adopt new technology/techniques. The authors sought to evaluate revision risk following primary total knee arthroplasty (TKA) to assess whether a learning curve was observed as surgeons transitioned to 1) a new implant from the same manufacturer and 2) a new implant from a new manufacturer.

METHODS: Patients ≥ 18 years of age who underwent primary fixed bearing, posterior stabilized, fully cemented TKA with patella resurfacing were identified using a US integrated health care system's total joint replacement registry (2009–2023). The exposure groups were categorized in these groups: baseline implant (reference), first 50 TKA with new implant (≤ 50), second 50 (51–100), third 50 (101–150), and the remainder (> 150). A multiple Cox proportional hazard regression was used to evaluate revision risk with adjustment for confounders.

RESULTS: The intra-manufacturer cohort comprised 42,743 TKA. A higher revision risk was observed for the ≤ 50 group compared to the baseline group (hazard ratio [HR], 1.37; 95% confidence interval [CI], 1.01–1.86); no other differences were observed after the first 50 TKA (51–100: HR, 0.98; 95% CI, 0.71–1.34; 101–150: HR, 0.95; 95% CI, 0.69–1.32; > 150: HR, 0.99; 95% CI, 0.79–1.34). However, the association was no longer significant after excluding the TKA performed with the Attune fixed bearing tray, which has been associated with a higher risk of revision in the total joint replacement registry. The inter-manufacturer cohort comprised 19,817 TKA. No differences were observed when comparing a new manufacturer to the baseline manufacturer.

DISCUSSION: Surgeons should be cautious for the first several TKA when transitioning to a new implant given the relationship between surgeon and implant on revision risk.

LEVEL OF EVIDENCE: Level III.

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Introduction

Despite the availability of many joint arthroplasty implants with excellent clinical track records, new implants and models are continuously introduced to the market with the proposed benefit of increased performance and improved outcome.[1-3] Generally, total knee arthroplasty (TKA) is one of the most successful procedures in orthopedics,[4] with excellent long-term prosthesis survivorship[2,5] and high patient satisfaction.[6] However, TKA is not without complications that lead to revision surgery.[7] The most frequent reasons for revision after primary TKA are infection (10%–87%), aseptic loosening (3%–41%), instability (3%–29%), patellofemoral or extensor mechanism problems (1%–25%), malalignment (1%–25%), and periprosthetic fracture (2%–14%) at < 2 years follow-up.[8] To address the related complications, insufficiencies, or problems of older implant designs/models, manufacturers have continuously designed and introduced successive generations of implants/models into the market over the last couple of decades.[9,10]

When a new joint arthroplasty model replaces an older model, manufacturers, surgeons, and patients should expect better survivorship and/or improved functional performance.[2,11] However, not all new models are beneficial,[2] and the expectation of improvements offered by the new implant models compared to the older established ones can sometimes be challenged by unwanted effects on implant survival[12,13] or patient-perceived outcomes.[14] Although older TKA implants were designed to mimic the geometry and improve stability of the knee joint, new designs were developed to improve biomechanics and wear rates of the implant by further closely mimicking the kinematics and movement of the knee joint to recreate a knee joint that functions and feels more similar to a native knee.[15-17] However, this raises the question of whether technological improvements are really reflected in TKA implant failures/survivorship, patient-perceived outcomes, and surgeons' learning curves.[18] Further, new models are generally priced higher than the older implants.[19] Thus, implementation of new technology should be done with the exercise of caution across the surgical community.[20] For instance, surgeons should thoroughly train themselves with the new knee implant models before use.[21] As new surgical technology is adopted and surgeons transition to its use, it is unclear whether patients who are within a surgeon's early learning curve may be at a higher risk for adverse events, including revision surgery.[22] In addition to worse outcomes for the patient, such an adverse outcome has a potential cost burden to the health care system.

Therefore, the aim of the study was to evaluate revision risk following primary TKA to assess whether a learning curve was observed as surgeons transitioned from one implant model to 1) a new model from the same manufacturer and/or 2) a new model from a new manufacturer. The authors hypothesized that there would be a difference in revision risk when surgeons used a new implant model relative to an older implant model.

Methods

STUDY DESIGN AND DATA SOURCE

The Strengthening the Reporting of Observational Studies in Epidemiology guidelines for reporting cohort studies were followed.[23] Approval was completed by Kaiser Permanente Southern California/Hawaii institutional review board prior to study commencement. The authors conducted a cohort study using data from Kaiser Permanente's Total Joint Replacement Registry (TJRR). This US-based integrated health care system includes over 12 million members in 8 regions of the United States. Membership in this health care plan is representative of the geographical areas served.[24] Information regarding data collection procedures, coverage, and participation rates for the TJRR has been published previously.[25-27] Outcomes collected by the registry, such as revisions, are prospectively monitored using electronic screening algorithms.

STUDY SAMPLE

Patients ≥ 18 years of age who underwent primary elective fully cemented (including femoral component, tray, and patella) TKA with patella resurfacing for osteoarthritis from 2009 to 2023 were identified. To minimize confounding due to implant factors, the study sample was restricted to the 4 highest-volume TKA implant systems within the TJRR: the DePuy Attune, DePuy Press Fit Condylar (PFC) Sigma, Zimmer–Biomet Persona, and Zimmer–Biomet NexGen. Procedures with mixed cement viscosity (eg, both high- and low-viscosity cement used) or unknown viscosity were excluded. Further, only fixed bearing (FB), posterior stabilized implant designs were included; constrained and cruciate retaining implants were excluded. The authors restricted the cohort based on these attributes, as they were the most commonly used in the TJRR, as well as a way to address potential confounding from implant characteristics. To investigate outcomes as surgeons transitioned from one implant system to another, data from surgeons who completed < 100

TKA (where a clear pattern could not be delineated), those who used only one implant system, or those who used multiple systems interchangeably (without a clear transition from one implant to the next) were excluded. Figure 1 presents a flow chart for how the final study sample was obtained.

The final study sample included 60,923 TKA performed by 71 surgeons at 41 hospitals. The average patient age and body mass index (BMI) were 68.5 years and 30.9 kg/m^2. Most patients were women (61.5%), White (68.5%), and had an American Society of Anesthesiologists' (ASA) classification of 1–2 (62.8%). Bilateral procedures accounted for 7.9% of the TKA, and high-viscosity cement was used in 72.1% of procedures.

TREATMENT GROUPS

Two types of surgeon implant transition pathways were evaluated: 1) intra-manufacturer (transition within the same manufacturer) and 2) inter-manufacturer transition (transition from one manufacturer to another manufacturer). Details on the 2 pathways are presented in Table 1. To compare outcomes as surgeons transitioned to a new implant, the initial implant used by the surgeon was the baseline implant. The new implant used was partitioned into the following groups that were then compared to the baseline implant group: 1) the first 50 TKA with the new implant (≤ 50), 2) the second 50 TKA with the new implant (51–100), 3) the third 50 TKA with the new implant (101–150), and 4) all remaining TKA with the new implant after the first 150 (> 150).

For each pathway, characteristics of the cohort by baseline implant and new implant study groups are presented in Table 2. Supplemental Appendix 2 provides characteristics stratified by baseline manufacturer (DePuy or Zimmer–Biomet).

OUTCOME OF INTEREST

The primary outcome of interest was aseptic revision surgery. This was defined as any reoperation following the index TKA where an implant was removed and replaced for noninfectious reasons. Revisions are longitudinally monitored within the health care system following the index TKA until either membership termination (leaving the authors' institution's health care plan) or death. All identified revisions were manually validated by registry research associated through chart review.

Median follow-up for the study cohort was 5.9 years (interquartile range = 3.2–8.9). Of the 60,923 patients included in the study sample, 9.9% were lost to follow-up through membership termination at a median time of 3.6 years (interquartile range = 1.6–6.0).

COVARIATES

Covariates included age, BMI, self-reported gender, race and ethnicity (Asian, Black, Hispanic, other, and White), ASA classification (1–2 and ≥ 3), bilateral procedures, cement viscosity (high and low/medium), average annual surgeon volume, and operative time.

STATISTICAL ANALYSIS

Means, standard deviations (SDs), frequencies, and percentages were used to describe the study sample. The standardized mean difference (SMD), which provides information on the distribution of a covariate between comparison groups, was determined. A SMD > 0.2 implied an imbalance in the covariate between study groups. Missing values for categorical covariates were modeled as a separate group, while the missing values for continuous covariates were imputed with the mean, and a missing indicator was included. Revisions were modeled as time-to-event using survival analysis techniques. Follow-up time was defined as the time from index TKA to aseptic revision surgery for those who had the outcome of interest. For those who did not have the outcome of interest, follow-up time was defined as the time from the index TKA to the date of the septic revision surgery, health care membership termination, death, or study end date (December 31, 2023), whichever came first; these patients were censored in analysis. Crude cumulative aseptic revision incidence was calculated as 1 minus the Kaplan–Meier estimate at 8 years follow-up, as this was the follow-up time where there were at least 50 TKA in each study group for a more reliable estimate. A multiple Cox proportional hazard regression was used to evaluate the risk of aseptic revision during follow-up. The regression model adjusted for covariates mentioned previously, as well as a cluster term to account for TKA performed by the same surgeon; this allowed for adjustment for surgeon difference and experience. Hazard ratios (HRs) and 95% confidence intervals (CIs) were reported. The baseline implant was used as the reference group in all models. The proportional hazards assumption for the treatment variable was checked by a proportionality test, and time-stratified results were presented when the proportional hazards assumption was not met. A

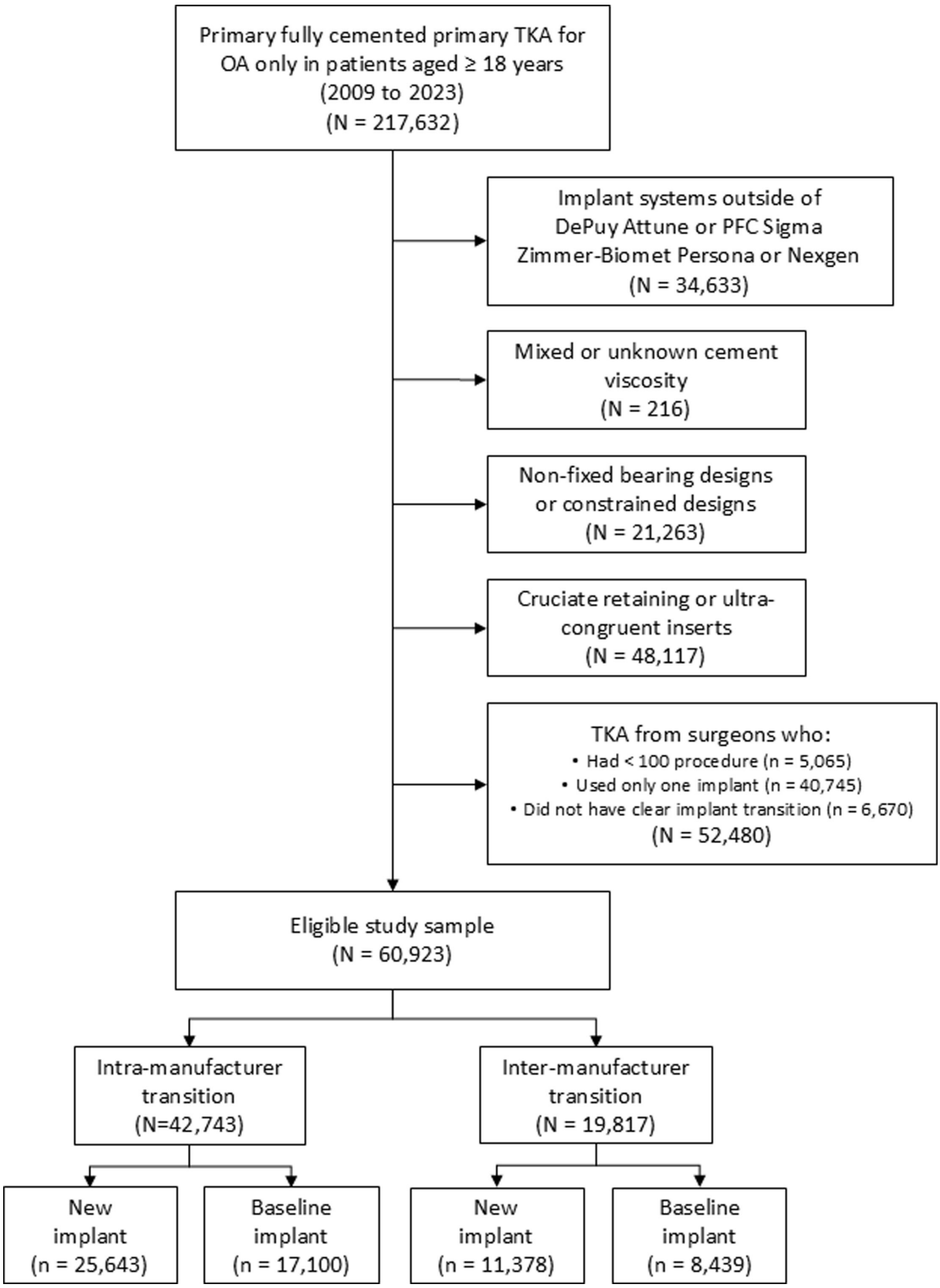

Figure 1: Study sample flowchart. There were 1637 TKA involved in both transition pathways as the surgeon transitioned to 2 new implant systems over time. OA = osteoarthritis; PFC = Press Fit Condylar; TKA = total knee arthroplasty.

Type of transition	Manufacturer	Pathway observed
Intra-manufacturer	DePuy to DePuy	PFC Sigma to Attune
	Zimmer to Zimmer	NexGen to Persona
Inter-manufacturer	DePuy to Zimmer	PFC Sigma to NexGen
	DePuy to Zimmer	PFC Sigma to Persona
	DePuy to Zimmer	Attune to Persona
	Zimmer to DePuy	NexGen to PFC Sigma
	Zimmer to DePuy	NexGen to Attune
	Zimmer to DePuy	Persona to Attune

Table 1: Transition pathways of baseline implant system to new implant system used by surgeons for primary total knee arthroplasty for the comparison groups of interest

PFC = Press Fit Condylar.

$P < .05$ was the statistical significance threshold; all tests were 2-sided. Analyses were performed using R version 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria).

SUBGROUP ANALYSIS

The previous analysis was repeated after stratifying by baseline implant manufacturer (DePuy or Zimmer–Biomet).

Characteristic	Intra-manufacturer			Inter-manufacturer		
	New	Baseline	SMD[a]	New	Baseline	SMD[a]
Total N	25,643	17,100		11,378	8439	
Patient factors						
Age, y, mean (SD)	68.5 (8.5)	68.3 (8.7)	0.020	68.5 (8.4)	68.6 (8.6)	0.008
BMI, in kg/m^2, mean (SD)	30.7 (5.2)	31.0 (5.6)	0.440	30.9 (5.3)	31.0 (5.5)	0.015
Men, n (%)	9889 (38.6)	6449 (37.7)	0.018	4459 (39.2)	3285 (38.9)	0.005
Race and ethnicity, n (%)			0.132			0.113
Asian	2097 (8.2)	1049 (6.1)		936 (8.2)	532 (6.3)	
Black	2027 (7.9)	1375 (8.0)		656 (5.8)	648 (7.7)	
Hispanic	4500 (17.5)	2425 (14.2)		1842 (16.2)	1226 (14.5)	
Other	176 (0.7)	107 (0.6)		77 (0.7)	54 (0.6)	
White	16,843 (65.7)	12,144 (71.0)		7867 (69.1)	5979 (70.8)	
ASA classification, n (%)			0.102			0.190
1–2	16,115 (62.8)	10,884 (63.6)		7120 (62.6)	5242 (62.1)	
≥ 3	93,64 (36.5)	5928 (34.7)		4217 (37.1)	2974 (35.2)	
Missing	164 (0.6)	288 (1.7)		41 (0.4)	223 (2.6)	
Surgical factors						
Bilateral, n (%)	1804 (7.0)	962 (5.6)	0.058	1206 (10.6)	949 (11.2)	0.021
Cement viscosity, n (%)			0.090			0.516
High	19,105 (74.5)	13,393 (78.3)		8652 (76.0)	4395 (52.1)	
Low/medium	6538 (25.5)	3707 (21.7)		2726 (24.0)	4044 (47.9)	
Yearly surgeon volume, mean (SD)	98.2 (44.2)	94.2 (40.9)	0.094	111.6 (39.5)	117.5 (44.0)	0.141
Operative time, mean (SD)	85.0 (29.7)	92.2 (29.1)	0.237	75.3 (25.4)	77.6 (28.1)	0.079

Table 2: Characteristics of 60,923 primary total knee arthroplasties performed within a US-based health care system (2009–2023). Stratified by transitioning from one implant system (baseline) to a new implant system from the same manufacturer (intra-manufacturer) and across manufacturers (inter-manufacturer)

Missing: operative time = 3901 (6.4%)

[a] A SMD > 0.2 indicates imbalance in the covariate between study groups.

ASA = American Society of Anesthesiologists; BMI = body mass index; SD = standard deviation; SMD = standardized mean difference.

SENSITIVITY ANALYSIS

Recent studies have reported concerns regarding loosening occurring with the early Attune tibial tray.[28–32] Evaluation of the authors' own data has found a higher revision risk with the Attune FB tibial tray specifically.[33] To try to tease out potential confounding due to the use of this tibial tray, the previous analysis was repeated after excluding TKA where the Attune FB tibial tray was used (N = 3373).

Results

TRANSITION TO A NEW IMPLANT FROM THE SAME MANUFACTURER

Cumulative aseptic revision incidence during follow-up is presented in Figure 2. At 8 years follow-up, revision incidence was 1.9% for the baseline implant group; incidence for the new implant group was 2.8% for the first 50 TKA (≤ 50), 2.0% for the second 50 (51–100), 1.6% for the third 50 (101–150), and 1.8% for TKA after the first 150 with the new implant (> 150). In adjusted analysis, a higher revision risk was observed for the ≤ 50 new implant group compared to the baseline group (HR, 1.37; 95% CI, 1.01–1.86). No other differences were observed after the first 50 TKA (51–100: HR, 0.98; 95% CI, 0.71–1.34; 101–150: HR, 0.95; 95%CI, 0.69–1.32; > 150: HR, 0.99; 95% CI, 0.79–1.34; Table 3).

Manufacturer-specific cumulative aseptic revision incidence during follow-up is presented in Supplemental Appendix 1. When considering specific manufacturers, a higher revision risk was observed only after 3.5 years follow-up for the first 50 DePuy Attune implants when shifting from PFC Sigma (within 3.5 years follow-up: HR, 0.82; 95% CI, 0.51–1.31; after 3.5 years follow-up: HR, 2.14; 95% CI, 1.13–4.04), and a lower revision risk was observed after 150 Attune implants when compared to the PFC Sigma baseline (HR, 0.73; 95% CI, 0.57–0.93). The direction of the

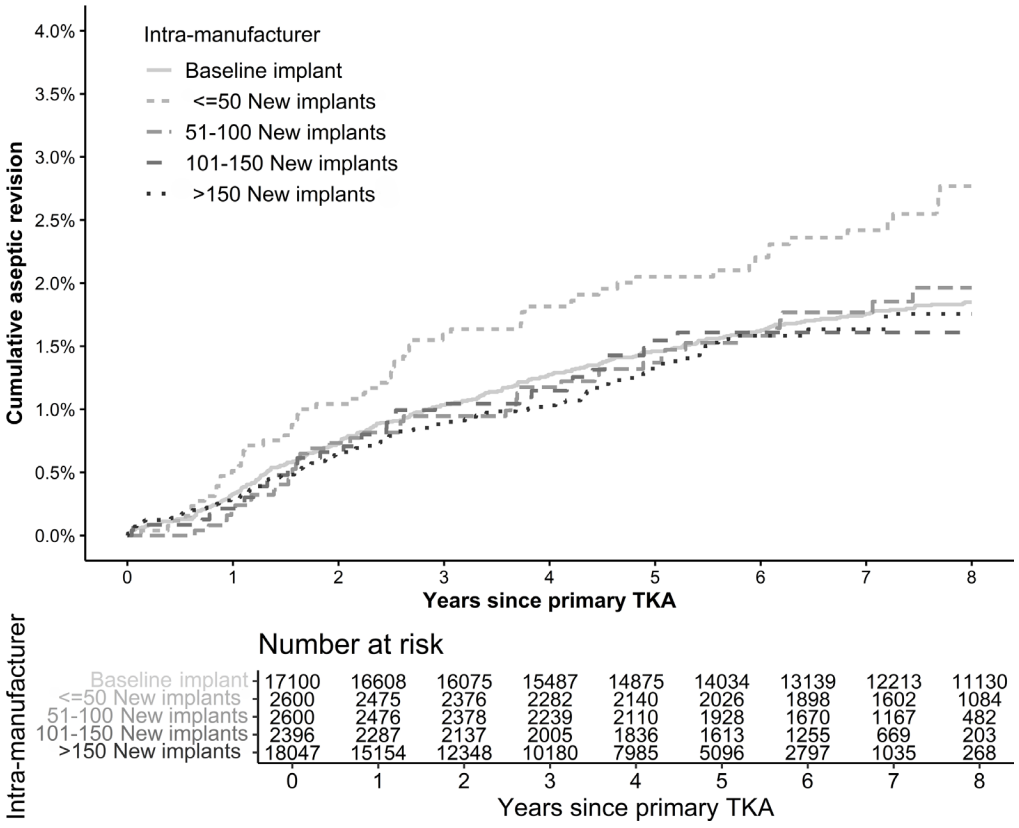

Figure 2: Crude cumulative aseptic revision incidence following primary total knee arthroplasty when transitioning from one implant system (baseline) to a new implant system from the same manufacturer (intra-manufacturer). Table along the x-axis presents the number of patients still at risk at each year of follow-up. TKA = total knee arthroplasty.

Comparison (by group)	Crude incidence, n (%)[a]	Adjusted HR (95% CI)[b]	*P* value
Intra-manufacturer (N = 42,743)			
Baseline implant (n = 17,100)	285 (1.9)	Ref	—
≤ 50 new implant (n = 2600)	61 (2.8)	1.37 (1.01–1.86)	.045[c]
51–100 new implant (n = 2600)	41 (2.0)	0.98 (0.71–1.34)	.878
101–150 new implant (n = 2396)	33 (1.6)	0.95 (0.69–1.32)	.763
> 150 new implant (n = 18,047)	171 (1.8)	0.99 (0.79–1.34)	.935
Inter-manufacturer (N = 19,817)			
Baseline manufacturer (n = 8439)	159 (2.2)	Ref	—
≤ 50 new manufacturer (n = 1200)	29 (2.9)	1.16 (0.76–1.77)	.492
51–100 new manufacturer (n = 1200)	23 (2.6)	0.94 (0.63–1.39)	.747
101–150 new manufacturer (n = 1147)	18 (2.4)	0.81 (0.54–1.20)	.286
> 150 new manufacturer (n = 7831)	102 (2.3)	0.98 (0.76–1.26)	.856

Table 3: Crude 8-year aseptic revision incidence and adjusted association for primary total knee arthroplasty when transitioning from one implant system (baseline) to a new implant system within the same manufacturer (intra-manufacturer) and across manufacturers (inter-manufacturer)

[a] Calculated as the crude incidence at 8 years follow-up using 1 minus the Kaplan–Meier estimate.

[b] Cox proportional hazard regression model adjusted for age, body mass index, gender, race and ethnicity, American Society of Anesthesiologists' classification, bilateral procedure, cement viscosity, average annual surgeon volume, operative time, and operating surgeon.

[c] Statistically significant at $P < .05$.

CI = confidence interval; HR = hazard ratio; Ref = reference.

association for the first 50 implants was toward a higher risk for shifting from Zimmer–Biomet NexGen to Persona, but the association was not statistically significant (HR, 1.29; 95% CI, 0.82–2.06; Table 4).

TRANSITION TO A NEW IMPLANT FROM A NEW MANUFACTURER

Cumulative aseptic revision incidence during follow-up is presented in Figure 3. At 8 years follow-up, revision incidence was 2.2% for the baseline manufacturer group; incidence for the new manufacturer group was 2.9% for the first 50 TKA (≤ 50), 2.6% for the second 50 (51–100), 2.4% for the third 50 (101–150), and 2.3% for TKA after the first 150 with the new implant (> 150). No significant differences were observed in adjusted analysis when comparing the new implant manufacturer groups to the baseline manufacturer group (Table 3).

Supplemental Appendix 1 presents the cumulative aseptic revision incidence during follow-up by specific manufacturer. Results stratified by specific manufacturer are presented in Table 4. Although the direction of the association was toward a higher risk for the first 50 TKA with going from DePuy to Zimmer (HR, 1.32; 95% CI, 0.78–2.21), no significant associations were observed when transitioning from a DePuy to a Zimmer–Biomet implant, nor from a Zimmer–Biomet to a DePuy implant.

SENSITIVITY ANALYSIS

Table 5 presents the updated results when excluding the Attune FB tray. No differences were observed for any of the comparisons. There were too few events for the DePuy intra-manufacturer analysis.

Discussion

The expectation of improvements offered by the introduction of new technology/implant models in joint arthroplasty can be challenged by adverse outcomes. Outcomes of joint arthroplasty are multifactorial and can also be due to a surgeon's experience and volume. In this study, the authors evaluated whether a learning curve was observed as surgeons transitioned to a new implant from the same manufacturer and/or a risk of early aseptic revision was observed with a new implant from a new manufacturer. Although a trend toward a learning curve was found as surgeons transitioned to a new implant from the same manufacturer, no significant associations were observed as surgeons transitioned from one implant to one from a new one manufacturer. It should be noted that regardless of the transition pathway, the crude cumulative revision rate for the

Comparison (by group)	Crude incidence, n (%)[a]	Adjusted HR (95% CI)[b]	*P* value
DePuy baseline			
Intra-manufacturer (N = 20,133)			
DePuy PFC baseline (n = 7773)	134 (2.0)	Ref	—
≤ 50 Attune (n = 1200)			
Within 3.5 y[c]	27 (2.9)	0.82 (0.51–1.31)	.402
After 3.5 y[c]		2.14 (1.13–4.04)	.019[d]
51–100 Attune (n = 1200)	18 (2.1)	1.00 (0.66–1.54)	.986
101–150 Attune (n = 1131)	12 (1.3)	0.71 (0.47–1.07)	.098
> 150 Attune (n = 8829)	70 (1.5)	0.73 (0.57–0.93)	.012[d]
Inter-manufacturer (N = 12,616)			
DePuy baseline (n = 5595)	105 (2.2)	Ref	—
≤ 50 Zimmer (n = 750)	20 (3.2)	1.32 (0.78–2.21)	.300
50–99 Zimmer (n = 750)	16 (2.8)	1.09 (0.70–1.69)	.714
101–150 Zimmer (n = 708)	13 (2.7)	0.97 (0.61–1.53)	.885
> 150 Zimmer (n = 4813)	68 (2.4)	1.08 (0.81–1.45)	.587
Zimmer baseline			
Intra-manufacturer (N = 22,610)			
Zimmer NexGen baseline (n = 9327)	151 (1.8)	Ref	—
≤ 50 Persona (n = 1400)	34 (2.7)	1.29 (0.82–2.06)	.274
51–100 Persona (n = 1400)	23 (1.9)	0.93 (0.58–1.48)	.759
101–150 Persona (n = 1265)	21 (1.8)	1.10 (0.75–1.62)	.617
> 150 Persona (n = 9218)	101 (2.0)	1.10 (0.79–1.53)	.557
Inter-manufacturer (N = 7201)			
Zimmer baseline (n = 2844)	54 (2.2)	Ref	—
≤ 50 DePuy (n = 450)	9 (2.2)	0.94 (0.44–2.00)	.876
51–100 DePuy (n = 450)	7 (2.0)	0.74 (0.31–1.78)	.499
101–150 DePuy (n = 439)	5 (2.0)	0.57 (0.27–1.19)	.132
> 150 DePuy (n = 3018)	34 (2.1)	0.84 (0.58–1.21)	.349

Table 4: Crude 8-year aseptic revision incidence and adjusted association for primary total knee arthroplasty when transitioning from one implant system (baseline) to a new implant system from the same manufacturer (intra-manufacturer) and across manufacturers (inter-manufacturer); stratified by baseline manufacturer, DePuy or Zimmer–Biomet

[a] Calculated as the crude incidence at 8 years follow-up using 1 minus the Kaplan–Meier estimate.

[b] Cox proportional hazard regression model adjusted for age, body mass index, gender, race and ethnicity, American Society of Anesthesiologists' classification, bilateral procedure, cement viscosity, average annual surgeon volume, operative time, and operating surgeon.

[c] Time-stratified regression results presented due to the proportional hazards assumption not being met.

[d] Statisically significant at $P < .05$.

CI = confidence interval; HR = hazard ratio; PFC = Press Fit Condylar; Ref = reference.

implant systems included was low, ranging from 1.6% to 3.2% at the 8-year follow-up.

Earlier studies have investigated whether the introduction of a new TKA implant plays a role in early outcome.[3,13,18,21,34,35] A Danish study reported longer surgical time and more intraoperative blood loss immediately after the introduction of the new TKA implant. However, the association was diminished 1 year after the introduction of a new implant.[3] Similarly, Whittaker et al,[35] in their multicenter study examining the learning curve after the introduction of a new TKA implant, reported no difference in intraoperative outcome and patient-reported outcome measures, but they did report a slight increase in operation time.

In the present study, although the authors found switching to a new TKA implant system from the same manufacturer was associated with aseptic revision risk for the first 50 TKA using the new system, this association was no longer observed after excluding an implant that had itself been identified with more loosenings leading to revision. A

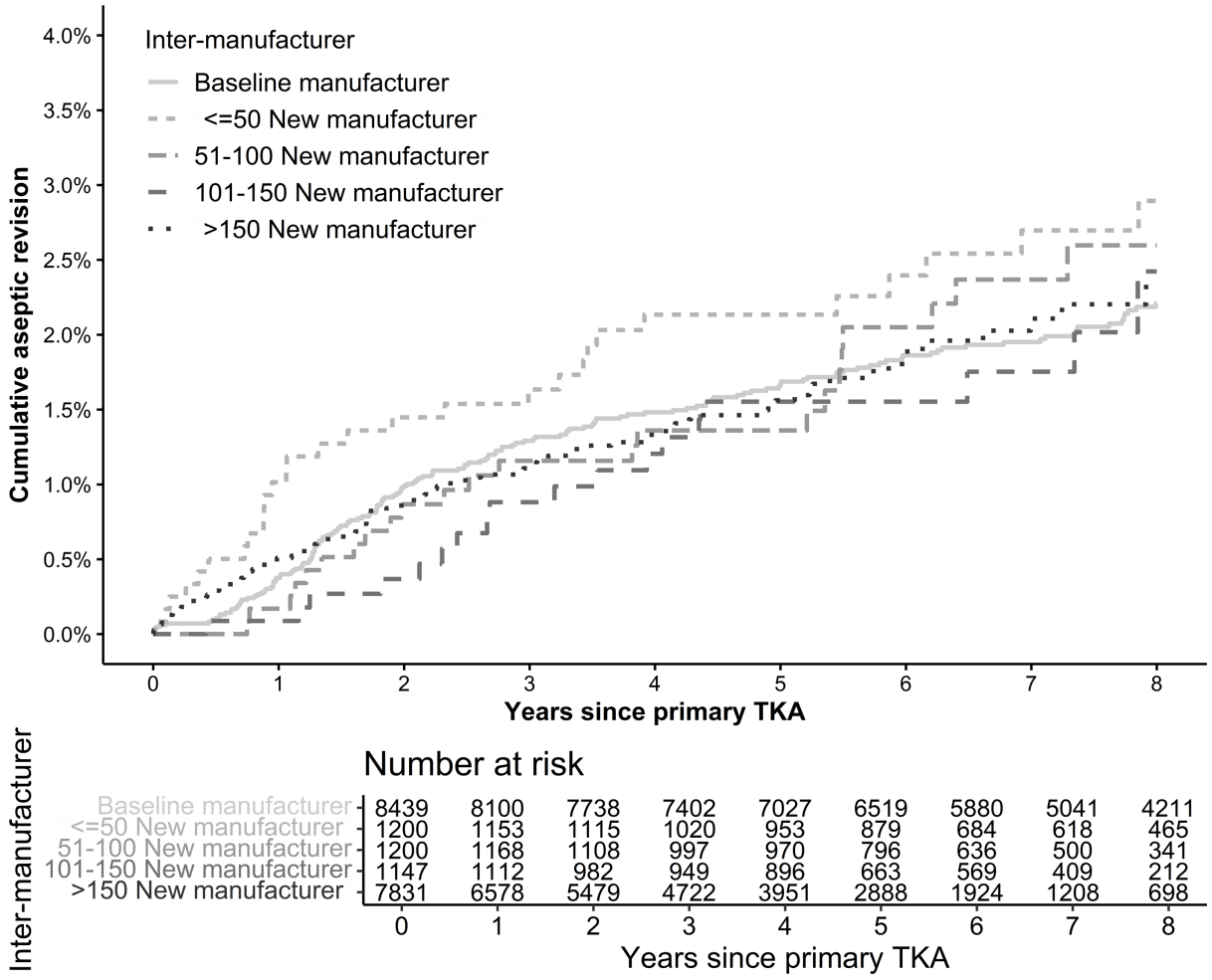

Figure 3: Crude cumulative aseptic revision incidence following primary total knee arthroplasty when transitioning from one implant system (baseline) to a new implant system across manufacturers (inter-manufacturer). The table along the x-axis presents the number of patients still at risk at each year of follow-up. TKA = total knee arthroplasty.

register-based Finnish study found large differences in risk of revision in 4 of the 10 TKA implants examined at their introduction.[21] The study found a clear surgeon learning curve with a higher risk for early revision. However, model-specific learning curves for new TKA implant systems may vary, with some implants being associated with a learning curve with an increase in early revisions.[21]

The authors observed no significant associations when switching between a new manufacturer and the baseline manufacturer (from a DePuy to a Zimmer–Biomet implant and vice versa). Like the present study, Sheridan et al[36] reported no negative association on early implant revisions, complications, or reintervention rates in their retrospective cohort study comparing shifting from NexGen (Zimmer, Warsaw, IN) to Triathlon (Stryker, Mahwah, NJ) TKA. Similarly, in their high-volume institution-based study, Olson et al[18] reported that adoption of newer TKA designs had not led to clinically important changes in the 10-year survivorship or patient-reported outcomes compared to older implants from the same manufacturers. However, both these studies were based on data from a high-volume single center, potentially limiting generalizability.

STRENGTHS AND LIMITATIONS

Study strengths include the cohort size and the fact that data were obtained from Kaiser Permanente's TJRR, where information on all TKA performed within the health care system is prospectively collected and validated. Members of the

Comparison	Crude incidence, n (%)[a]	Adjusted HR (95% CI)[b]	*P* value
Overall			
Intra-manufacturer (N = 38,970)			
Baseline implant (n = 17,100)	285 (1.9)	Ref	—
≤ 50 new implant (n = 1615)	36 (2.6)	1.29 (0.85–1.96)	.228
51–100 new implant (n = 1784)	26 (1.8)	0.91 (0.60–1.37)	.637
101–150 new implant (n = 1780)	24 (1.6)	0.97 (0.67–1.40)	.856
> 150 new implant (n = 16,691)	151 (1.8)	0.96 (0.76–1.21)	.715
Inter-manufacturer (N = 19,244)			
Baseline manufacturer (n = 8274)	157 (2.2)	Ref	—
≤ 50 new manufacturer (n = 1074)	26 (2.9)	1.15 (0.75–1.77)	.528
51–100 new manufacturer (n = 1101)	22 (2.7)	0.96 (0.64–1.45)	.864
101–150 new manufacturer (n = 1047)	16 (2.4)	0.78 (0.50–1.20)	.256
> 150 new manufacturer (n = 7748)	102 (2.4)	0.98 (0.76–1.25)	.853
DePuy baseline			
Intra-manufacturer (N = 16,360)			
DePuy PFC baseline (n = 7773)	134 (2.0)	Ref	—
≤ 50 Attune (n = 215)	2 (1.3)	—	—
51–100 Attune (n = 384)	3 (2.0)	—	—
101–150 Attune (n = 515)	3 (1.0)	—	—
> 150 Attune (n = 7473)	50 (1.2)	0.76 (0.55–1.07)	.120
Inter-manufacturer (N = 12,451)			
DePuy baseline (n = 5430)	103 (2.2)	Ref	—
≤ 50 Zimmer (n = 750)	20 (3.2)	1.29 (0.77–2.17)	.336
50–99 Zimmer (n = 750)	16 (2.8)	1.07 (0.69–1.67)	.762
101–150 Zimmer (n = 708)	13 (2.7)	0.95 (0.60–1.52)	.838
> 150 Zimmer (n = 4813)	68 (2.4)	1.07 (0.80–1.42)	.650
Zimmer baseline			
Inter-manufacturer (N = 6793)			
Zimmer baseline (n = 2844)	54 (2.2)	Ref	—
≤ 50 DePuy (n = 324)	6 (1.9)	0.88 (0.42–1.83)	.731
51–100 DePuy (n = 351)	6 (1.8)	0.79 (0.29–2.13)	.639
101–150 DePuy (n = 339)	3 (1.9)	—	—
> 150 DePuy (n = 2935)	34 (2.2)	1.18 (0.59–1.22)	.374

Table 5: Crude 8-year aseptic revision incidence and adjusted association for primary total knee arthroplasty when transitioning from one implant system (baseline) to a new implant system from the same manufacturer (intra-manufacturer) and across manufacturers (inter-manufacturer); after excluding the Attune fixed bearing tibial tray

[a] Calculated as the crude incidence at 8 years follow-up using 1 minus the Kaplan–Meier estimate.

[b] Cox proportional hazard regression model adjusted for age, body mass index, gender, race and ethnicity, American Society of Anesthesiologists' classification, bilateral procedure, cement viscosity, average annual surgeon volume, operative time, and operating surgeon.

— = Too few events for analysis; CI = confidence interval; HR = hazard ratio; PFC = Press Fit Condylar; Ref = reference.

community-based health care system are representative of the geographic area served, increasing generalizability. Procedures included were performed by 70 high-volume, fellowship-trained surgeons, representing community-based practice.

There are limitations to the study. As the study was observational, only associations are reported, not causality. The authors restricted the cohort based on certain implant systems and characteristics (ie, cemented fixation, FB, posterior stabilized) to minimize confounding due to implant differences and tease out the association between surgeons transitioning to new implant systems and revision risk. These were the predominant implant attributes in the registry used in this study; however, results may not be generalizable across all implant systems available to surgeons. Further, the implant systems included in

the cohort were the predominant ones used over the study period. Revision risk is multifactorial, and the present study even observed differences based on the inclusion or exclusion of a specific tibial tray. Furthermore, all implant systems may not have equal baseline survivorship, so that may have impacted results. Additional study evaluating surgeon experience with other implant systems or other implant attributes, including component positioning, surgical time, and factors affecting those attributes[37] not currently considered, may be of interest. Finally, this study's primary outcome was aseptic revision surgery; other outcomes that may be of interest to the surgeon, including radiographic findings and patient-reported outcome measures, were not collected by the registry and, therefore, could not be evaluated.

Conclusion

In this registry-based study considering surgeons who transitioned to a new TKA implant system, although the authors observed a trend toward a learning curve with higher revision rates for the first 50 TKA with a new system, no significant differences were observed in adjusted analyses when utilizing the high-performing implant systems evaluated. When there is a sound clinical basis for a surgeon to change implants, surgeons should use caution for the first several TKA when transitioning to a new implant, given the interconnected relationship between surgeon and implant on revision risk. However, in this study, the authors did not identify a higher revision risk when transitioning to a new implant. Further studies are needed to determine whether the present findings persist across an international perspective, as well as with other surgical outcomes and patient-reported outcomes.

Data-Sharing Statement

Underlying data are not available.

Supplementary Materials

Supplemental material is available at: https://www.thepermanentejournal.org/doi/suppl/10.7812/TPP/25.017#supplementary-materials.

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