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Original Research

Performing Revision Arthroplasty Increases Surgeon and Practice Volumes Through the Generation of Subsequent Cases: A Retrospective Study

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ABSTRACT

Background: Revision total knee (TKR) and hip (THR) arthroplasty surgeries are disincentivized due to unfavorable reimbursement rates, surgical times, and complication rates. Our study investigates secondary benefits of performing these surgeries by generating subsequent cases for surgeons and practices.
Methods: Patients undergoing TKR and THR between April 1, 2011, and January 1, 2019, at our tertiary academic institution were analyzed. Patients were identified with Current Procedural Terminology codes for TKR and THR. We calculated a subsequent surgery rate on the same or different joint by the initial surgeon or another surgeon within the practice to determine the procedure yield after initial revision arthroplasty.
Results: One thousand six hundred twenty-five patients met inclusion criteria. Six hundred forty-nine (39.9%) patients received at least one subsequent procedure on any joint by any orthopaedic surgeon in the practice. Four hundred five patients (24.9%) underwent another procedure on any joint by the same surgeon. Two hundred sixty patients (16.0%) underwent another procedure on the same joint by the same surgeon, with 109 cases (41.9%) being a planned second stage of a 2-stage revision for infection. Two hundred eighty-five patients (17.5%) underwent another procedure on a different joint by the same surgeon, with 122 of these patients (42.8%) undergoing at least one primary total hip or knee arthroplasty.
Conclusions: TKRs and THRs can increase surgeon and practice volumes through the generation of future cases, which are primarily the second stage of a 2-stage revision or primary joint arthroplasties on other joints.

Introduction

Arthritic disease of the hip and knee are some of the leading causes of long-term disability and time missed from work [1,2]. The societal burden of this condition is substantial. Total joint arthroplasty (TJA) is the treatment option for end-stage osteoarthritis once conservative management fails and is one of the most commonly performed surgeries [3]. Unfortunately, there are multiple modes of failure after TJA, which may require further surgery. The incidence of revision total knee and hip revision arthroplasties (TKR/THR) is expected to increase significantly. TKRs are projected to grow by 142 percent to 72,000 procedures and THRs by 190 percent to 120,000 procedures by 2030 [4]. Due to the projected increase in demand for revision arthroplasties, there is a need for competent and experienced surgeons to care for these patients with complex arthroplasty needs.

Common causes for revision arthroplasty include aseptic loosening, wear, fracture, instability, or infection [5-10]. Compared to primary arthroplasties, revision arthroplasties are higher-cost

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procedures due to longer procedure times, more expensive implants, longer hospital stays, greater infection rates, and a higher frequency of complication [3,11-15]. Additionally, one study shows that the referral pattern for revision arthroplasty places a large portion of the burden of these cases on tertiary care centers [16]. Indeed, the management of revision arthroplasty represents a complex challenge in orthopaedic surgery, yet the aforementioned increased costs, longer surgical times, and complications may make these procedures less desirable for surgeons and hospitals to perform.

Despite the challenges associated with revision arthroplasty, it does not appear that driving financial incentives are in line with the demand or added complexity of these cases. In the current fee-for-service model, revision arthroplasties are reimbursed at a lower rate per minute of work compared to primary joint arthroplasty. Several studies determined the relative value units per minute of primary TJA to be significantly higher than that of revision total arthroplasty, creating a financial disincentive to perform these procedures [17-20]. This, combined with the added surgical complexity of these cases, the longer length of stay, higher complication rate, and added clinical burden on the provider, makes access to care for these patients more limited.

Nevertheless, there is potentially an underappreciated benefit to performing revision arthroplasty surgery beyond the satisfaction derived from caring for these patients. It is understood that patients who undergo primary arthroplasty are at risk for subsequent arthroplasty on the ipsilateral or contralateral side [21-24]. We hypothesize that patients who are referred for and undergo revision surgery may consider the same surgeon or group practice when considering subsequent procedures. Therefore, we suspect a surgeon who performs revision surgery may generate future surgical volume from this patient cohort. To date, no study has explored this indirect opportunity of performing revision arthroplasty. Our study aims to demonstrate and quantify the generation of subsequent case volumes for surgeons performing revision arthroplasty.

Material and methods

Following institutional review board approval, patients undergoing THR and TKR between April 1, 2011, and January 1, 2019, at our tertiary academic referral institution in the Northeastern United States were identified in our institutional data repository based on Current Procedural Terminology (CPT) codes for revision arthroplasty. The CPT codes used to define the patient cohort were 27090, 27091, 27132, 27134, 27137, 27138, 27445, 27486, 27487, and 27488 without any previous orthopaedic operations at the institution. Informed consent was waived by the institutional review board, given the retrospective nature of the study.

After the initial patient cohort was established, any subsequent surgery performed on each individual patient was identified. These surgeries were classified by location (same joint, another joint), if they were performed by the initial operating surgeon or another orthopaedic surgeon in the practice, and what type of subsequent surgery was performed. A preliminary chart review was performed to determine indication for initial revision (aseptic loosening, septic, metal on metal, trunionosis, instability, wear, mechanical failure of implant, periprosthetic fracture). The total number of subsequent surgeries was recorded for each patient, and the procedure type was determined based on the CPT code and chart review.

Patient demographic data was acquired from the medical record and included age, gender, body mass index (BMI), Charlson comorbidity index (CCI), race, employment status, tobacco use, and diabetes.

Using descriptive unadjusted analysis, we calculated a subsequent surgery rate to determine the yield on future arthroplasty and orthopaedic procedures after a patient with revision needs establishes care. Univariate analysis for patients seeking subsequent surgeries and revision arthroplasty includes independent samples t-tests for continuous variables and chi-square tests for categorical variables. Statistical significance was set at $P < .05$.

Results

There were 1625 patients identified in our repository who underwent either THR or TKR. Of the patients who underwent THR or TKR, 649 (39.9%) patients had at least one subsequent orthopaedic procedure on any joint by any orthopaedic surgeon in our practice, whereas 993 (60.1%) patients did not undergo a subsequent procedure from our group. The cohort that received a subsequent orthopaedic procedure was younger (64.3 vs 67.1, $P < .001$) and had a higher BMI (32.7 vs 30.6, $P < .001$) than those that did not undergo a subsequent orthopaedic procedure (Table 1). The mean CCI scores (2.33 vs 1.98, $P = .007$) and percentage of diabetes (7.2% vs 4.3%, $P = .015$) were higher in patients undergoing a subsequent orthopaedic procedure as well. The race of the patients and tobacco use were similar between both groups.

Table 1
Patient demographic information stratified by cohorts that did or did not seek subsequent surgeries.

Demographic	No	Yes	*P*
Total (n)	993	649	
Age (mean [SD])	67.07 (13.19)	64.32 (12.19)	**<.001**
Gender = male (%)	471 (47.4)	290 (44.7)	.298
BMI (mean [SD])	30.58 (7.53)	32.69 (8.04)	**<.001**
BMI category (%)			**<.001**
Underweight (<18.5)	18 (1.9)	6 (0.9)	
Normal weight (18.5-24.9)	205 (21.2)	100 (15.7)	
Overweight (25.0-29.9)	286 (29.6)	164 (25.7)	
Class I obesity (30.0-34.9)	225 (23.3)	143 (22.4)	
Class II obesity (35.0-39.9)	129 (13.3)	119 (18.7)	
Class III obesity (≥40.0)	104 (10.8)	105 (16.5)	
CCI (mean [SD])	1.98 (2.59)	2.33 (2.61)	**.007**
CCI category (%)			**.008**
0	422 (42.5)	236 (36.4)	
1	103 (10.4)	56 (8.6)	
2+	468 (47.1)	357 (55.0)	
Race (%)			.556
American Indian or Alaska Native	1 (0.1)	2 (0.3)	
Asian	2 (0.2)	0 (0.0)	
Black or African American	10 (1.0)	4 (0.6)	
Native Hawaiian/Pacific Islander	1 (0.1)	0 (0.0)	
Unknown	14 (1.4)	6 (1.1)	
White	964 (97.2)	637 (98.0)	
Employment status (%)			**.001**
Currently working	56 (26.7)	39 (21.1)	
Disabled/retired because of ill health	34 (16.2)	62 (33.5)	
Homemaker	8 (3.8)	3 (1.6)	
On leave of absence	6 (2.9)	9 (4.9)	
Other	16 (7.6)	7 (3.8)	
Retired (not due to ill health)	75 (35.7)	50 (27.0)	
Returned to work since last visit	0 (0.0)	3 (1.6)	
Unemployed	15 (7.1)	12 (6.5)	
Tobacco use (%)			.683
Never	421 (43.0)	267 (42.0)	
Quit	447 (45.7)	291 (45.8)	
Passive	1 (0.1)	3 (0.5)	
Yes	103 (10.5)	69 (10.9)	
Not asked	7 (0.7)	5 (0.8)	
Diabetes = yes (%)	43 (4.3)	47 (7.2)	**.015**

Univariate tests across opioid misuse diagnosis include independent samples t-tests for continuous variables and chi-square tests for categorical variables.
Use of bold *P*-values denotes statistical significance ($P < .05$).

Of the 649 patients who underwent subsequent procedures after their initial revision surgery, 284 underwent THR and 365 underwent TKR as the initial revision surgery. The mean age was similar in the THR and TKR groups at 64.5 and 64.2 years, respectively (Table 2). The mean BMI was larger in patients undergoing TKR than in those undergoing THR (34.4 vs 30.6, $P < .001$). Patients undergoing TKR also had higher mean CCI scores (2.60 vs 1.99, $P = .003$) as well as percentage of diabetes (9.9% vs 3.9%, $P = .006$) compared to those undergoing THR. The race of the patients and tobacco use were similar between both groups.

Of the total 1625 patients who underwent initial revision surgery, 405 patients (24.9%) received a subsequent procedure on any joint by the same surgeon (190 THR, 215 TKR) (Table 3). Additionally, 260 patients (16.0%) received a subsequent procedure on the same joint by the same surgeon (113 THR, 147 TKR), and 285 patients (17.5%) received a subsequent procedure on a different joint by the same surgeon (142 THR, 143 TKR). Finally, of the total patients who underwent initial revision surgery, 380 patients (23.4%) received a subsequent procedure by a different surgeon from the same practice.

Of all the patients undergoing initial revision surgery, 16.3% had one additional procedure by the same surgeon, 4.9% had 2 additional procedures, and 3.7% had 3 or more additional procedures (Table 4). Of the patients who underwent THR as their initial revision surgery, 13.1% had only one additional procedure by the same surgeon, 4.9% had 2 additional procedures, and 4.2% had 3 or more additional procedures. Of the patients who underwent TKR as their initial revision surgery, 19.9% had only one additional procedure by the same surgeon, 4.8% had 2 additional procedures, and 1.0% had 3 additional procedures.

The most common subsequent procedure performed by the same surgeon (Table 5) is associated with CPT code 27487, revision of total knee arthroplasty (TKA) (24.5%). This was closely followed by the procedure associated with CPT code 27134: revision of total hip arthroplasty (THA) (22%). Of these revisions performed on the same joint, 41.9% (45 THR, 64 TKR) were the planned second stage of a 2-stage revision for periprosthetic joint infection (Table 3). Notably, following these revision procedures, the next most common subsequent procedures were CPT code 27130, primary THA (7.8%), and CPT code 27477, primary TKA (7%).

Table 2
Patient demographic information stratified by revision joint.

Demographic	Total	Hip	Knee	*P*
n	649	284	365	
Age (mean [SD])	64.32 (12.19)	64.48 (13.68)	64.19 (10.90)	.768
Gender = male (%)	290 (44.7)	121 (42.6)	169 (46.3)	.39
BMI (mean [SD])	32.69 (8.04)	30.56 (7.52)	34.35 (8.06)	**<.001**
BMI category (%)				**<.001**
Underweight (<18.5)	6 (0.9)	6 (2.1)	0 (0.0)	
Normal weight (18.5-24.9)	100 (15.7)	63 (22.5)	37 (10.4)	
Overweight (25.0-29.9)	164 (25.7)	82 (29.3)	82 (23.0)	
Class I obesity (30.0-34.9)	143 (22.4)	62 (22.1)	81 (22.7)	
Class II obesity (35.0-39.9)	119 (18.7)	37 (13.2)	82 (23.0)	
Class III obesity (≥40.0)	105 (16.5)	30 (10.7)	75 (21.0)	
CCI (mean [SD])	2.33 (2.61)	1.99 (2.42)	2.60 (2.72)	**.003**
CCI category (%)				**.009**
0	236 (36.4)	122 (43.0)	114 (31.2)	
1	56 (8.6)	22 (7.7)	34 (9.3)	
2+	357 (55.0)	140 (49.3)	217 (59.5)	
Race (%)				.355
American Indian or Alaska Native	2 (0.3)	1 (0.4)	1 (0.3)	
Black or African American	4 (0.6)	0 (0.0)	4 (1.1)	
Unknown	6 (0.9)	3 (1.1)	3 (0.8)	
White	637 (98.2)	280 (98.6)	357 (97.8)	
Employment status (%)				.875
Currently working	39 (21.1)	16 (21.3)	23 (20.9)	
Disabled and/or retired because of ill health	62 (33.5)	23 (30.7)	39 (35.5)	
Homemaker	3 (1.6)	2 (2.7)	1 (0.9)	
On leave of absence	9 (4.9)	3 (4.0)	6 (5.5)	
Other	7 (3.8)	2 (2.7)	5 (4.5)	
Retired (not due to ill health)	50 (27.0)	21 (28.0)	29 (26.4)	
Returned to work since last visit	3 (1.6)	2 (2.7)	1 (0.9)	
Unemployed	12 (6.5)	6 (8.0)	6 (5.5)	
Tobacco use (%)				.092
Never	267 (42.0)	114 (41.3)	153 (42.6)	
Quit	291 (45.8)	123 (44.6)	168 (46.8)	
Passive	3 (0.5)	1 (0.4)	2 (0.6)	
Yes	69 (10.9)	38 (13.8)	31 (8.6)	
Not asked	5 (0.8)	0 (0.0)	5 (1.4)	
Diabetes = yes (%)	47 (7.2)	11 (3.9)	36 (9.9)	**.006**

Univariate tests across opioid misuse diagnosis include independent samples t-tests for continuous variables and chi-square tests for categorical variables.
Use of bold *P*-values denotes statistical significance ($P < .05$).

Table 3
Subsequent procedure by subsequent joint, surgeon, and index joint.

General	Total (n)	%
Total initial revisions	1625	
Hip	856	52.7%
Knee	769	47.3%
Patients who received subsequent procedures	**Total (n)**	**%**
On any joint by the same surgeon	405	24.9%
Hip	190	22.2%
Knee	215	28.0%
On the same joint by the same surgeon	260	16.0%
Hip	113	13.2%
Knee	147	19.1%
Two-stage hip revision	45	5.3%
Two-stage knee revision	64	8.3%
Revisions due to periprosthetic joint infection	109	41.9%
On a different joint by the same surgeon	285	17.5%
Hip	142	16.6%
Knee	143	18.6%
By a different orthopaedic surgeon	380	23.4%

Discussion

This study aimed to understand the generation of subsequent case volume after performing revision arthroplasty once a patient establishes a relationship with a surgeon. This analysis uncovered several key findings. First, in our population of patients referred to a tertiary academic medical center who underwent initial revision surgery, 39.9% of patients underwent THR and/or TKR procedure(s) within the same practice, with either the same surgeon or a different surgeon within the practice. This is in line with other studies that suggest the need for additional procedures after primary TKA and THA. Lamplot et al. demonstrated that 23.6% of their patient population necessitated subsequent orthopaedic procedures in a contralateral or different joint [21]. The higher rate of subsequent surgery in our study is likely due to our focus on revision procedures and the associated complexity of these cases compared to primary TKA and THA. Additionally, our study

Table 4
Number of subsequent procedures of any kind by the same surgeon.

# Of additional procedures	Overall frequency (%)	Hip frequency (%)	Knee frequency (%)
Total (n)	1625	856	769
0	1220 (75.1)	666 (77.8)	554 (72.0)
1	265 (16.3)	112 (13.1)	153 (19.9)
2	79 (4.9)	42 (4.9)	37 (4.8)
3	27 (1.7)	19 (2.2)	8 (1.0)
4	116 (0.9)	7 (0.8)	7 (0.9)
5	5 (0.3)	3 (0.4)	2 (0.3)
6	8 (0.4)	4 (0.5)	4 (0.5)
7	1 (<0.1)	1 (0.1)	0 (0.0)
8	3 (0.2)	1 (0.1)	2 (0.3)
9	1 (<0.1)	1 (0.1)	0 (0.0)
10	0 (0.0)	0 (0.0)	0 (0.0)
11	0 (0.0)	0 (0.0)	0 (0.0)
12	0 (0.0)	0 (0.0)	0 (0.0)
13	1 (<0.1)	0 (0.0)	1 (0.1)

included all subsequent surgeries, regardless of joint location or surgeon. When looking solely at those patients who had surgery on a different joint by the original surgeon, 17.5% of our cohort met this criterion.

This study illustrates the high reoperation rate after revision surgery. In our study, of the 1625 patients who underwent initial revision surgery, 16%, or 260, required subsequent surgery on the same joint by the same surgeon. Specifically, the reoperation rate is 13.2% in those undergoing an initial revision THA and 19.1% in those undergoing an initial revision TKA. These rates are in line with reoperation rates after revision arthroplasty noted in several other studies [25-31]. Namely, a study by Mortazavi et al reported a reoperation rate after revision TKA of 18%, while a study by Springer et al reported a reoperation rate of 13% following revision THA. Thus, the reoperation rate for revision knee and hip arthroplasty in our study reaffirms that initial revision surgery for THA and TKA is likely to lead to further surgery in the future. In addition, 41.9% of patients undergoing further surgery on the same joint were part of a planned second stage of a 2-stage revision for infection. We recognize that our focus was on revision THA and TKA, but we felt including hip conversion in this cohort was appropriate. Surgeons who commonly care for patients requiring revision will also care for patients with complex situations requiring hip conversion. CPT code 27132 (hip conversion) bears many similarities to performing revision hip or knee arthroplasty in that both operations require removal, implantation, and/or modification of in vivo implants with more challenging anatomy and technical demands in comparison to performing primary total joint arthroplasties in native hips. Given the abundance of literature reiterating the technical complexity (ie, longer average operative times, hospital lengths of stay, and surgical blood loss volumes) and lower relative reimbursement rates associated with conversion hip and knee arthroplasties, we feel that including CPT code 27132 only strengthened our conclusions. [17-19].

Furthermore, our study demonstrates the potential for subsequent case generation to the surgeon and practice after the initial revision surgery. The subsequent procedure rate for patients who underwent initial revision surgery and necessitated an additional procedure on any joint by the same surgeon was 24.9%. Thus, a significant catalyst of subsequent procedures with the same surgeon in this study was the management of periprosthetic joint infection. Other common indications for revisions performed by the same surgeon are presented in Table 5.

When looking at the subsequent procedure rate on any joint, 23.4% of patients underwent another procedure by a different orthopaedic surgeon in the same practice. Thus, about a quarter of the time, there were volume benefits for the practice after care was established for a revision arthroplasty. Additionally, the subsequent surgery rate on the same joint performed by the same surgeon was

Table 5
Types of subsequent procedures offered by same surgeon (frequency greater than 3).

CPT code	Frequency	% (n = 600)	CPT code description
27487	147	24.5	Revision of total knee arthroplasty, with or without allograft
27134	132	22.0	Revision of total hip arthroplasty
27130	47	7.8	Repair, revision, and/or reconstruction procedures on the pelvis and hip joint
27447	42	7.0	Arthroplasty, knee, condyle, and plateau
27488	25	4.2	Repair, revision, and/or reconstruction procedures on the femur (thigh region) and knee joint
27486	24	4.0	Revision of total knee arthroplasty, with or without allograft
11044	23	3.8	Debridement, bone (includes epidermis, dermis, subcutaneous tissue, muscle, and/or fascia, if performed)
73503	22	3.7	Radiologic examination, hip, unilateral
27570	15	2.5	Manipulation procedures on the femur (thigh region) and knee joint
11042	11	1.8	Debridement, subcutaneous tissue (includes epidermis and dermis, if performed)
20680	11	1.8	Removal of implant
27091	10	1.7	Removal of hip prosthesis
27132	10	1.7	Repair, revision, and/or reconstruction procedures on the pelvis and hip joint
13160	9	1.5	Repair-complex procedures on the integumentary system
27248	8	1.3	Fracture and/or dislocation procedures on the pelvis and hip joint
11043	7	1.2	Debridement, muscle, and/or fascia (includes epidermis, dermis, and subcutaneous tissue, if performed)
27580	7	1.2	Arthrodesis procedures on the femur (thigh region) and knee joint
27090	6	1.0	Removal of hip prosthesis
20610	5	0.8	Arthrocentesis, aspiration, and/or injection
26990	5	0.8	Incision and drainage, pelvis or hip joint area
27385	5	0.8	Suture of quadriceps or hamstring muscle rupture
27507	5	0.8	Fracture and/or dislocation procedures on the femur (thigh region) and knee joint
10061	4	0.7	Incision and drainage of abscess (eg, carbuncle, suppurative hidradenitis, cutaneous or subcutaneous abscess, cyst, furuncle, or paronychia)
27335	4	0.7	Arthrotomy, with synovectomy, knee
27470	4	0.7	Repair, nonunion or malunion, femur, distal to head and neck
27511	4	0.7	Fracture and/or dislocation procedures on the femur (thigh region) and knee joint
27590	4	0.7	Amputation, thigh, through femur, any level
97606	4	0.7	Negative pressure wound therapy (eg, vacuum assisted drainage collection), including topical application(s), wound assessment, and instruction(s) for ongoing care per session

16.0%, while the subsequent surgery rate on a different joint performed by the same surgeon was 17.5%. Of note, some patients in the study received subsequent procedures from both the same surgeon and other surgeon(s) within the practice. In one such case, a patient received 13 subsequent procedures by the same surgeon after their initial revision demonstrating the complexities associated with some of these surgeries. The 16% reoperation rate on the same joint also reinforces this assumption and takes into consideration those patients undergoing treatment for periprosthetic joint infection. Nevertheless, these findings suggest that patients often choose the same surgeon to perform subsequent surgery after an initial revision surgery.

Our study also illustrated that the most common subsequent surgery performed by the same surgeon after the initial revision is further revision surgery (46.5%). However, and most notably, the next most common procedures performed are primary total knee and total hip arthroplasties (19%). Performing revision surgery thus appears to create future patient care opportunities once a relationship is established, which can lead to further care of joints with primary osteoarthritis. A subset of patients demonstrated a willingness to use the same physician to treat end-stage osteoarthritis in another joint.

Furthermore, our study findings suggest that younger patients are more likely to require subsequent orthopaedic procedures after their initial THR or TKR. These findings are consistent with other studies suggesting that younger people have higher revision rates due to infection after THA [31-33]. Younger patients will also be more likely to outlive the lifespan of a prosthetic joint. Therefore, younger patients may require more careful consideration for management of preoperative risk factors and comorbidities, as they are more likely to require additional revisions in the future [31-34]. Nevertheless, our study demonstrates that performing these complex revisions in younger patients may generate future additional case volume.

This is the first study of its kind that aimed to provide a rate of subsequent procedures after initial revision surgery, both on the same joint and other joints, and by an orthopaedic practice. Several studies [21-24] have demonstrated the need for subsequent arthroplasty procedures after primary arthroplasty, but to our knowledge, this is the only study to date that assessed subsequent surgery rates in the revision surgery patient population.

We acknowledge the limitations of our study. First, the conclusions of the study are drawn from data from a single tertiary care center in the northeast and thus represent only a subset of revisions in our specific geographical region. It is possible that the results of our study may not be applicable to surgeons and departments in their specific practice environments and geographic locations. We also recognize that the surgical outcome, interpersonal relationship between a patient and provider, and a multitude of other factors may influence a patient's desire to pursue further surgery with the same provider or orthopaedic practice. Finally, since the data only contained information from providers within the same institution, we are unable to determine a subsequent surgery rate for patients who sought care outside the institution. Despite these limitations, we believe our findings are encouraging for those surgeons who perform revision TJA and may encourage younger surgeons to take on some of these challenging cases as they begin to develop a practice.

The incidence of revision arthroplasty is increasing in parallel to the rising prevalence of THA and TKA, and most studies agree that TKA incidence will increase more than THA incidence [35,36]. Although the direct per minute of work reimbursement of THA and TKA is greater than that of THR and TKR, our study, combined with future projections for TJA incidence, demonstrates that there is a benefit in subsequent case volume generation for surgeons and practices that care for patients who need complex revision surgery. Surgeons interested in building their clinical practice may benefit from taking on these complex revision cases.

Conclusions

Although there are potential disincentives to performing TKR and THR, there appears to be a benefit for both surgeon and practice by increasing subsequent case volumes, which in this series were primary joint arthroplasties in approximately 19% of patients.

Conflicts of interest

W. Moschetti is a speaker for Depuy and Hereaus, is a paid consultant for Depuy and Smith and Nephew, receives research support from Depuy and OREF, receives other financial/material support from Microgen Dx, and is a board/committee member of PJI CPG committee, AAOS. All other authors declare no potential conflicts of interest.

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CRediT authorship contribution statement

Ikechukwu C. Amakiri: Data curation, Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Zachary A. Panton:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Paul Werth:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Wayne E. Moschetti:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

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