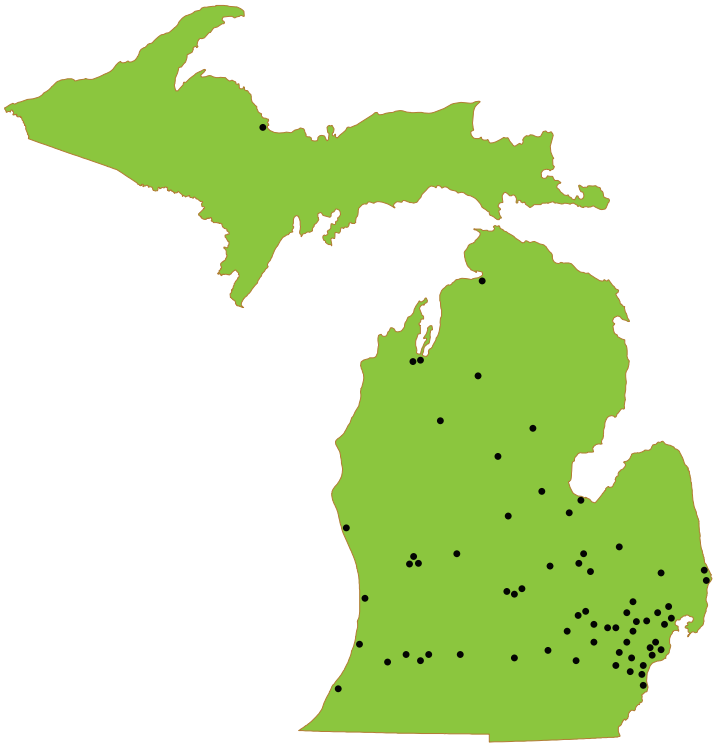
Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI) Report: 2012 - 2017



November 2018

MARCQI Sites



Ascension/Borgess, Kalamazoo
Ascension/Crittenton, Rochester
Ascension/Genesys, Grand Blanc
Ascension/Providence-Providence Park Hospitals, Southfield/Novi
Ascension/St. John, Detroit
Ascension/St. John Macomb/Oakland, Warren
Beaumont Hospital - Dearborn
Beaumont Hospital - Farmington Hills
Beaumont Hospital - Grosse Pointe
Beaumont Hospital - Royal Oak
Beaumont Hospital - Taylor
Beaumont Hospital - Trenton
Beaumont Hospital - Troy
Bronson Battle Creek Hospital, Battle Creek
Bronson Methodist Hospital, Kalamazoo
Covenant Medical Center, Saginaw
DMC - Harper University Hospital, Detroit
DMC - Huron Valley-Sinai, Commerce Township
DMC - Sinai Grace Hospital, Detroit
Garden City Hospital, Garden City
Henry Ford Allegiance, Jackson
Henry Ford Hospital, Detroit
Henry Ford Macomb, Clinton Township
Henry Ford, West Bloomfield
Henry Ford, Wyandotte
Holland Hospital, Holland
Hurley Medical Center, Flint
Lake Huron Medical Center, Port Huron
Lakeland Health, St. Joseph/Niles & Watervliet
McLaren Bay, Bay City
McLaren Flint
McLaren Greater Lansing
McLaren Lapeer Region, Lapeer
McLaren-Macomb, Mt. Clemens
McLaren-Northern Michigan, Petoskey
McLaren-Oakland, Pontiac
McLaren-Port Huron, Port Huron
Memorial Healthcare, Owosso
Mercy Health, Muskegon
Mercy Health, St. Mary's, Grand Rapids
MetroHealth Hospital, Wyoming
Michigan Medicine, Ann Arbor
MidMichigan Medical Center, Midland
MidMichigan Health, Clare
MidMichigan Health, Gratiot
MidMichigan Health, West Branch
Muskegon Surgery Center, Muskegon
Munson Medical Center, Traverse City
Munson Healthcare, Cadillac
Munson Healthcare, Grayling
OrthoMichigan, Flint
Sparrow Hospital, Lansing
Spectrum Health, Grand Rapids
St. Joseph Mercy Health, Ann Arbor
St. Joseph Mercy Health, Chelsea
St. Joseph Mercy Health-Livingston, Howell
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Suggested citation

Hughes, R.E., Zheng, H., and Hallstrom, B.R. (2018) Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI) Report: 2012-2017. University of Michigan, Ann Arbor.

Conflict of interest disclosure

None of the authors have financial relationships with the pharmaceutical or medical device industries.

Disclaimer

Although Blue Cross Blue Shield of Michigan and the Michigan Arthroplasty Registry Collaborative Quality Initiative work collaboratively, the opinions, beliefs and viewpoints expressed by the authors do not necessarily reflect the opinions, beliefs and viewpoints of BCBSM or any of its employees.

Acknowledgements

We would like to acknowledge and thank Mendenhall Associates, Inc./Curvo Labs for making their device library available to us and the Michigan Health & Hospital Association for providing access to the Michigan Inpatient Data Base. Within the University of Michigan, we thank Sharon Vaassen of the Department of Orthopaedic Surgery for her instrumental contributions to creating MARCQI.

We appreciate the assistance in producing this report provided by Colleen McClorey (legal review) and Mary Gumtow (proofreading).

Support for the Michigan Arthroplasty Registry Collaborative Quality Initiative is provided by Blue Cross and Blue Shield of Michigan and Blue Care Network (BCBSM/BCN) as part of their Value Partnerships program. We express our gratitude to BCBSM/BCN staff who have pioneered the CQI model in Michigan and supported MARCQI (Marc Cohen, Rozanne Darland, Tom Leyden, Tom Simmer, and Monica Whitted) and the University of Michigan-BCBSM/BCN liaisons (John Billi, Joanne Kimata, and Carrie Miller).

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Chapter 1

Quality improvement initiatives update

The Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI) continues in its efforts to improve the quality of care for all patients undergoing hip and knee replacement in Michigan. This effort succeeds because the surgeons, nurses, data abstractors, quality teams, and other participants continue to work together toward this end. Members of the Collaborative work with the Coordinating Center to transparently share data and ideas at regular, in-person Collaborative meetings. These meetings complete the quality improvement cycle and allow each project to be continually refined, which then drives further progress. This chapter summarizes the improvements made since the start of MARCQI in the continuing effort to make Michigan the best place in the world to have a joint replacement.

1.1 Transfusions and tranexamic acid

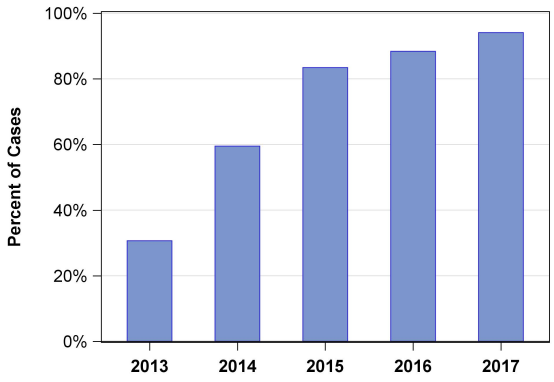

Figure 1: Frequency of using tranexamic acid in MARCQI.

Allogenic blood transfusions have long been used by orthopaedic surgeons after total joint arthroplasty. In 2001, a quarter of the patients undergoing joint replacements in the United States were given blood; 11.0% of those undergoing primary hip replacements received banked autologous blood, and 14% received allogenic transfusions (Helder *et al.*, 2017). As the use of autologous blood transfusions declined between 2001 and 2010, the rate of allogenic transfusion increased.

In our first annual report, we described our efforts to reduce the use of transfusions after arthroplasty (Hughes *et al.*, 2017). These efforts included treating preoperative anemia, adopting transfusion reduction guidelines, reassessing of the patient after each unit of blood was transfused, and administering tranexamic acid. This effort has resulted in continued reductions in blood transfusion for all primary arthroplasties across the state. In 2017, tranexamic acid was used in 94.4% of primary cases and in 86.4% of revisions in Michigan, up from less than 30% in 2013 (Figure 1). This MARCQI recommendation has recently been reinforced by the publication of a Clinical Practice Guideline endorsed by the American Association of Hip and Knee Surgeons, the American Academy of Orthopaedic Surgeons, the American Association of Regional Anesthesiology and Pain Management and the Hip and Knee Societies (Fillingham *et al.*, 2018).

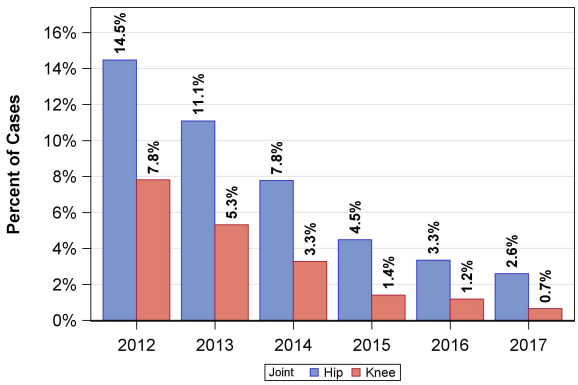

Figure 2: Frequency of transfusions after primary hip and knee arthroplasty in MARCQI.

More recent reports of nationwide transfusion rates show

that secular trends and influences have resulted in reductions in transfusions across the country. A 2015 analysis of a large national insurance database found transfusion rates of 4.4% after total knee arthroplasty (TKA) and 8.7% after total hip arthroplasty (THA). Corresponding rates for the Collaborative in 2015 were 1.4% for TKA and 4.5% for THA. This dramatic reduction in transfusion has continued. In 2017 the MARCQI transfusion rates for TKA and THA were 0.7% and 2.6%, respectively (Figure 2).

Overall, changes in blood management and transfusion practices in Michigan since the inception of the transfusion reduction program are estimated to have prevented 30,000 transfusions after primary hip and knee arthroplasty. This has saved patients the risks of allogenic blood and improved value by eliminating the cost of administering thousands these transfusions, estimated at $700-$900 per unit transfused.

1.2 Venous thromboembolism prevention

Preventing both symptomatic deep venous thrombosis (DVT) and pulmonary embolus (PE), collectively referred to as venous thromboembolism (VTE), is critical after THA and TKA. MARCQI has worked to understand the relationship between VTE prophylaxis and VTE events in patients after THA and TKA. Since the Collaborative began, aspirin has been increasingly included on the list of acceptable medications to prophylax against VTE. MARCQI has continued to monitor the association of VTE events, including death, with the prescribed prophylaxis and has not found an increased risk in patients treated with aspirin.

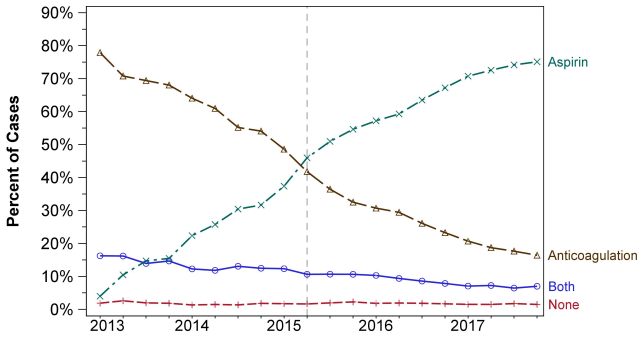

Figure 3: Frequency of VTE prophylaxis usage for venous thromboembolism over time in MARCQI.

The results of these analyses have been presented at MARCQI collaborative meetings over the past several years. During that time, aspirin was added to the acceptable list in the Surgical Care Improvement Project (SCIP) measures and to the American College of Chest Physicians guidelines for VTE prevention (Guyatt *et al.*, 2012). Subsequently, the use of aspirin as the sole pharmacologic prophylaxis has increased dramatically. Aspirin use as the sole pharmacologic prophylaxis has increased from 10.2% to 61.6% for TKA. For THA use has risen to 64.8% (Figure 3).

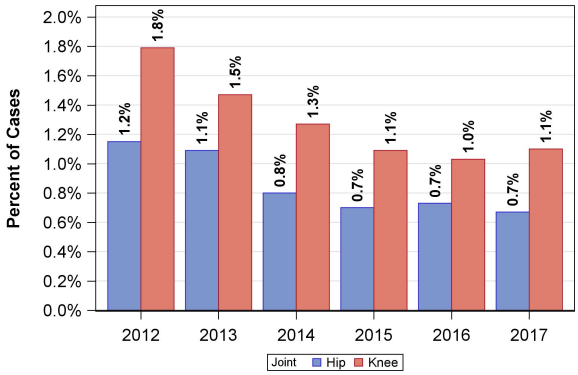

Figure 4: Frequency of VTE events (DVT and PE) after primary total hip and knee arthroplasty in MARCQI.

MARCQI has closely tracked the rate of VTE events within 90 days of surgery closely, specifically out of concern for a potential increase in these events as a result of this change in practice. Reassuringly, the rate of post-operative VTE events has not increased despite the sharp increase in the primary use of aspirin (Figure 4). Further analysis of TKA patients has shown aspirin to be non-inferior to other anticoagulants with regards to VTE events (Hood *et al.*, 2018). It is important to note that aspirin is not recommended for bilateral cases.

This shift to aspirin in appropriately selected patients has many benefits. The simple administration and low cost eases the burden on patients previously prescribed anticoagulants. Aspirin avoids the blood draws and monitoring associated with warfarin, high out-of-pocket expenses and self-injection with low molecular weight heparin, and the high cost of newer oral anticoagulants. In other words, aspirin greatly reduces costs while maintaining quality and safety.

1.3 Discharges to skilled nursing facilities

Across MARCQI sites, the large variation in the percentage of patients discharge to skilled nursing or extended care facilities after primary TKA or THA is not completely explained by variations in patient characteristics. Analysis showed a higher association between readmission and discharge to nursing facilities, an effect that persisted despite risk-stratification.

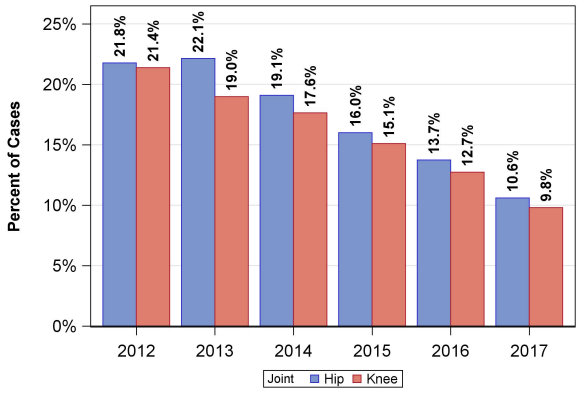

Figure 5: Frequency of discharge to nursing home after primary total hip and knee arthroplasty in MARCQI.

MARCQI focused quality improvement on efforts to reduce the number of discharges to skilled nursing facilities after elective primary arthroplasty. Collaborative sites were encouraged to implement programs to prepare patients for home discharge, arrange for home care or family support as needed and to shift patient expectations about the expected post-operative course. As a result, discharges to extended care facilities for all primaries in Michigan decreased from 21.8% to 10.6% of cases after THA and from 21.4% to 9.8% after TKA (Figure 5). Associated with this reduction was a significant drop in length of stay, in part because of the decreased need to keep patients in the hospital for three nights in order to qualify for discharge to a skilled nursing facility.

The reduction in discharges to a skilled nursing facility also reduced the costs of hip and knee arthroplasty. The Centers for Medicare and Medicaid Services has reported that discharges to such facilities increases the cost of an arthroplasty by about $7,300 (Lavernia *et al.*, 2006; Ellimoottil *et al.*, 2016). In 2017 alone, Michigan avoided an estimated 15,000 nursing home discharges with this change in practice.

1.4 Revisions

Patients expect total joint arthroplasty to be a durable operation that improves their function and reduces pain. Unfortunately, some of these procedures fail early and need to be revised soon after the primary procedure. This document reports that 1.57% (95% CI: 1.47, 1.68) of 63,093 hip cases required revision within the first year after surgery and that by three years 2.33% had already been revised (95% CI: 2.19, 2.47). Of all revisions completed within a year of the primary surgery, 78% were performed within six months of the original surgery. For knees, 0.91% (95% CI: 0.85, 0.97) of 108,486 primary TKAs were revised in the first year and 2.36% (95% CI: 2.24, 2.47) were revised by three years. MARCQI efforts have focused on the top three reasons for revision in the first year post-operatively. The top three reasons for THA were peri-prosthetic fracture (femur), instability/dislocation, and joint infection. The top three reasons for TKA were joint infection, instability, and pain. Quality improvement efforts are now targeted at identifying factors associated with these early complications and improving survivorship by reducing early revision.

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Chapter 2

Total hip arthroplasty statistics, devices, and revisions

Selection of the most suitable implant is a critical component of providing high quality hip arthroplasty care. Since revision is an undesirable outcome and is widely reported across arthroplasty registries, chapters on revision risk have been included. Chapter 2 reports on hips; chapter 3 on knees. These data are based on primary cases performed from 2/15/2012 to 12/31/2017. The first section of this chapter provides an overview of THA, primary and revision procedures combined. All revision risk in sections 2.2 through 2.4 are for primary conventional THA only. For detailed information on each figure and table (date ranges and inclusion/exclusion criteria), see the online supplement *MARCQI Six-Year Report Specifications* available at MARCQI annual reports web page.

2.1 Descriptive statistics

This section presents data on all THA cases, including primary and revision cases.

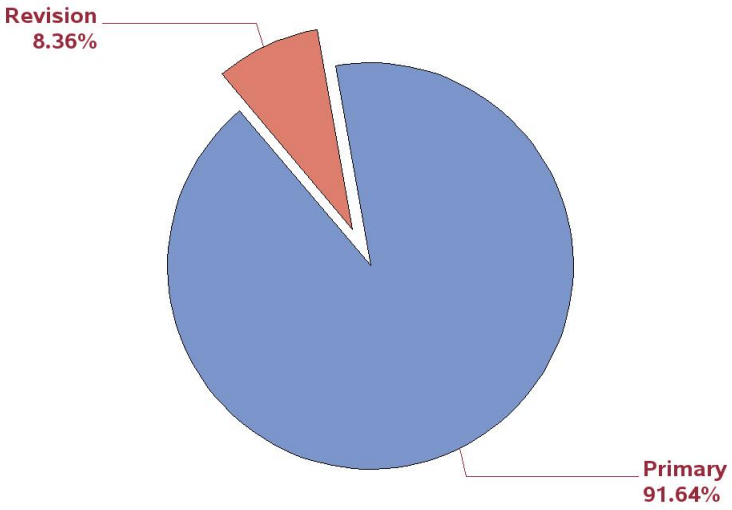

Figure 7: Percent of THA arthroplasty cases by primary or revision.

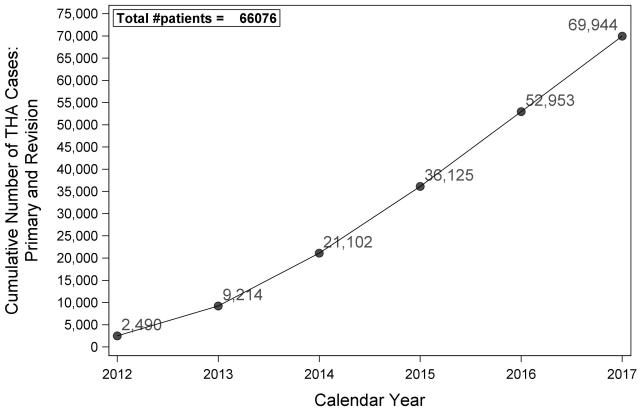

Figure 6: THA cases over time.

Table 1: Descriptive statistics of patients in THA cases.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	34999	54.6	
Age (yrs)	64097	64.7(11.3)	65(15)
Height (cm)	64086	169.4(10.4)	170(15)
Weight (kg)	64086	87.8(21.1)	86(28)
BMI(kg/m^2)	64083	30.5(6.3)	29.7(8.1)
Smoking - never (%)	30184	47.1	
Smoking - previous (%)	24786	38.7	
Smoking - current (%)	8794	13.7	
Smoking - unknown (%)	333	0.5	

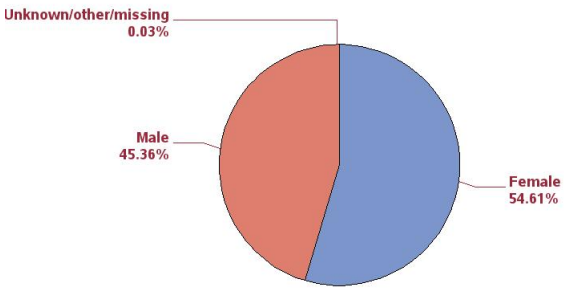

Figure 8: Percent of primary THA cases by sex.

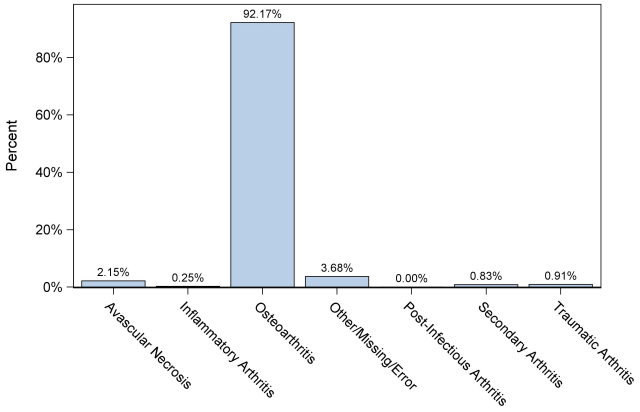

Figure 11: Percent of primary THA cases by diagnosis.

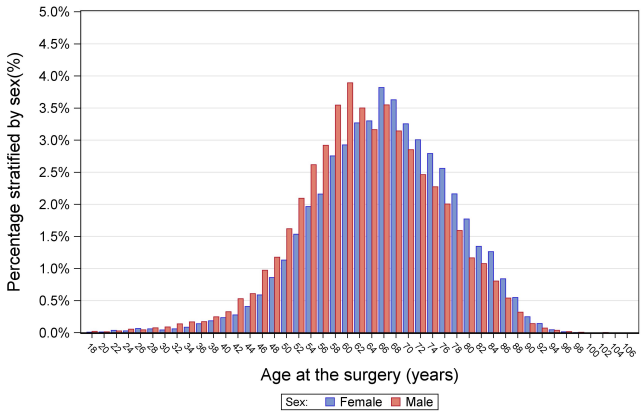

Figure 9: Age distribution of primary THA cases by sex.

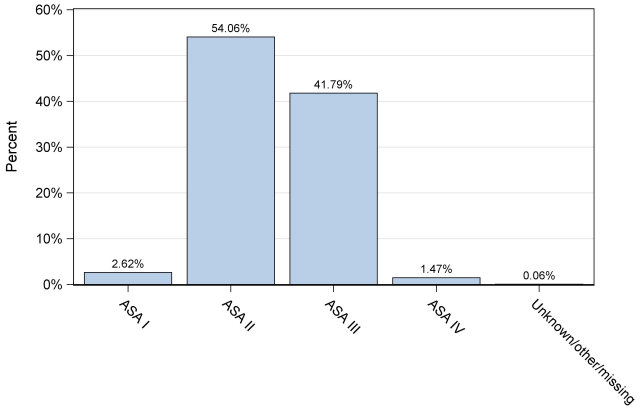

Figure 12: Percent of primary THA cases by ASA class.

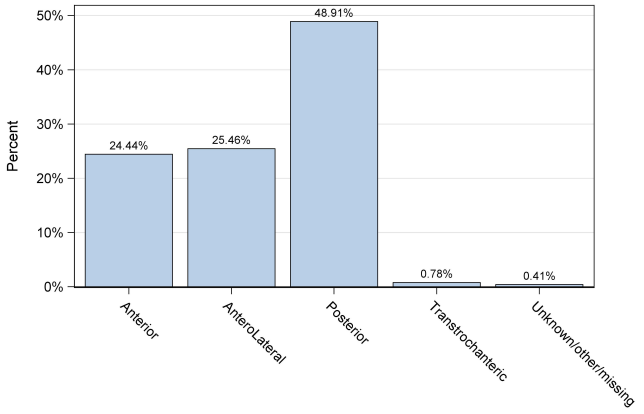

Figure 10: Percent of primary THA cases by approach.

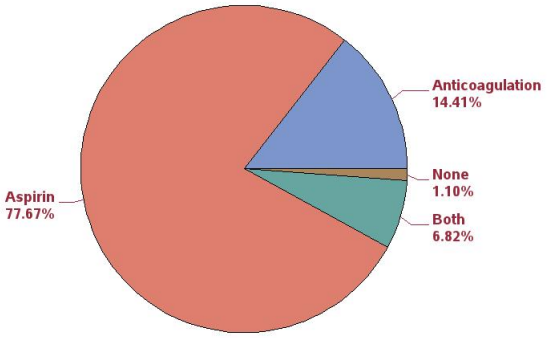

Figure 13: Percent of primary THA patients (first case) by thrombosis prophylaxis between 10/1/2017 and 12/31/2017 (this time window is shorter than rest of figures because of significant change over time).

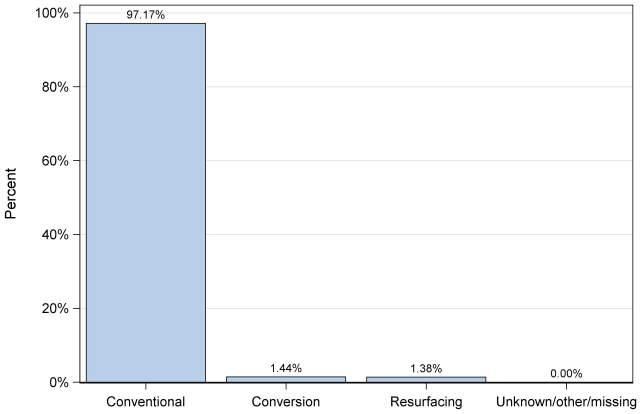

Figure 14: Percent of primary THA cases by procedure.

Note the data element for procedure, which was used to create the figure above, was changed in January of 2015 to include conversion.

2.2 Most commonly used implants

The following three tables provide utilization data of implants used in primary THA.

Table 2: Ten most commonly used femoral components in primary total conventional THA.

Rank	Stem	N	Percent
1	Accolade II	14970	23.7
2	M/L Taper	8676	13.7
3	Taperloc 133	6765	10.7
4	Summit	4693	7.4
5	Fitmore	3258	5.2
6	Anthology	2205	3.5
7	Secur-Fit Max	1995	3.2
8	Tri-Lock BPS	1943	3.1
9	Secur-Fit Plus Max	1915	3.0
10	Corail	1805	2.9
11	Others	14985	23.7

Table 3: Ten most commonly used acetabular components in primary total conventional THA.

Rank	Cup	N	Percent
1	Trident	21342	33.8
2	Continuum	11110	17.6
3	Pinnacle	9890	15.7
4	G7	6299	10.0
5	Reflection 3	3805	6.0
6	RingLoc+	1740	2.8
7	Trilogy	1551	2.5
8	Trabecular Metal	1395	2.2
9	Regenerex RingLoc+	990	1.6
10	Converge	534	0.8
11	Others	4554	7.2

Table 4: Ten most commonly used femoral/acetabular component combinations used in primary total conventional THA.

Rank	Stem/cup combination	N	Percent
1	Accolade II / Trident	14230	22.5
2	M/L Taper / Continuum	5685	9.0
3	Summit / Pinnacle	4636	7.3
4	Taperloc 133 / G7	3344	5.3
5	Fitmore / Continuum	2401	3.8
6	Secur-Fit Max / Trident	1988	3.1
7	Secur-Fit Plus Max / Trident	1909	3.0
8	Anthology / Reflection 3	1875	3.0
9	Corail / Pinnacle	1799	2.9
10	Tri-Lock BPS / Pinnacle	1623	2.6
11	Others	23720	37.2

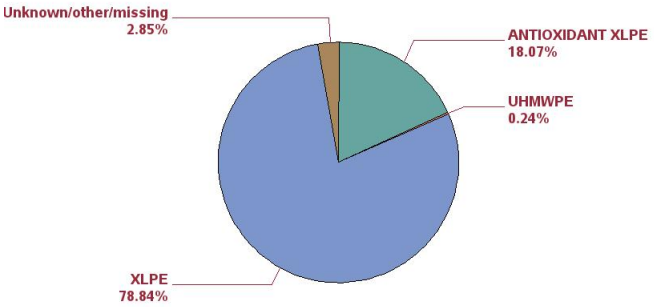

Figure 15: Percentage of polyethylene liners by type of polyethylene for primary conventional THA.

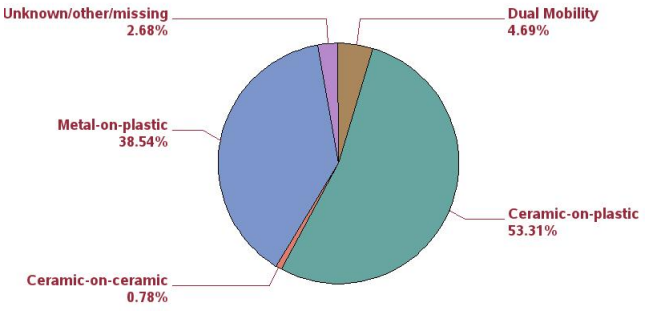

Figure 16: Percentage by bearing surface couple for primary conventional THA.

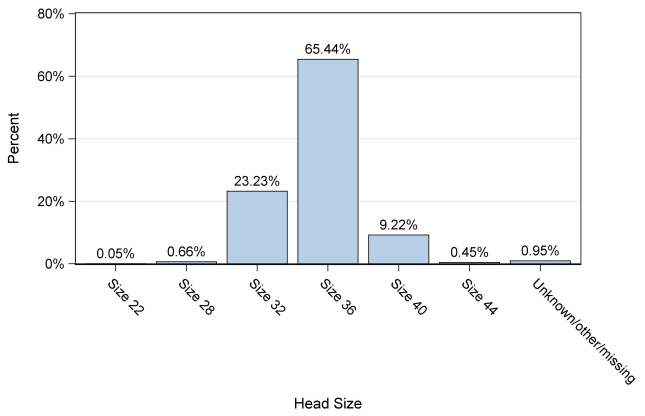

Figure 17: Distribution of head sizes for primary conventional THA, excluding dual mobility cases.

2.3 THA Revision risk summary

The reason for revision is of central importance to quality improvement because it helps focus attention on specific causes that may be addressed. Therefore, the data are presented in two formats below: tabular and Pareto chart. The tabular format is consistent with how other arthroplasty registries report cause of revision. The Pareto chart figure presents the same data in a format commonly used in quality improvement. The Pareto chart sorts the reasons for revision by frequency (bar chart on bottom, from left to right) and presents a cumulative percent using a line graph above. The causes corresponding to each bar are numbered and a key at the bottom links the numbers to text descriptions

In addition to an overall summary of reason for revision, tables showing reason for revision for the first, second, and third year post-operatively are provided because the reasons change over this time horizon. It is important to note that the time window for the cases reported in reasons for revision tables and figures differ from the time window used for other figures because reason for revision was added to the database on 1/1/2015. While these data capture revisions for primaries performed back to 2/15/2012, only revisions occurring on or after 1/1/2015 are included in the reasons for revision figure and tables.

Table 5: Reasons for revision following primary conventional THA.

Rank	Reason for revision	N	Percent
1	Peri-prosthetic fracture (Femur)	255	24.9
2	Instability/Dislocation	248	24.2
3	Joint Infection	174	17.0
4	Aseptic loosening	159	15.5
5	Pain	93	9.1
6	Component fracture/failure	38	3.7
7	Peri-prosthetic fracture (Acetabulum)	24	2.3
8	Malalignment	22	2.1
9	Metal reaction/Metallosis	8	0.8
10	Poly liner wear	1	0.1
11	Unknown/other/missing	2	0.2

Table 6: Reasons for revision following primary conventional THA in first year post-operatively.

Rank	Reason for revision	N	Percent
1	Peri-prosthetic fracture (Femur)	235	32.1
2	Instability/Dislocation	187	25.6
3	Joint Infection	127	17.4
4	Aseptic loosening	70	9.6
5	Pain	46	6.3
6	Component fracture/failure	30	4.1
7	Peri-prosthetic fracture (Acetabulum)	18	2.5
8	Malalignment	15	2.0
9	Poly liner wear	1	0.1
10	Unknown/other/missing	2	0.3

Table 7: Reasons for revision following primary conventional THA in second year post-operatively.

Rank	Reason for revision	N	Percent
1	Aseptic loosening	54	33.3
2	Instability/Dislocation	32	19.8
3	Pain	30	18.5
4	Joint Infection	29	17.9
5	Peri-prosthetic fracture (Femur)	5	3.1
6	Component fracture/failure	4	2.5
7	Peri-prosthetic fracture (Acetabulum)	3	1.9
8	Malalignment	3	1.9
9	Metal reaction/Metallosis	2	1.2

Table 8: Reasons for revision following primary conventional THA in third year post-operatively.

Rank	Reason for revision	N	Percent
1	Aseptic loosening	24	32.9
2	Pain	14	19.2
3	Instability/Dislocation	13	17.8
4	Joint Infection	9	12.3
5	Peri-prosthetic fracture (Femur)	8	11.0
6	Component fracture/failure	2	2.7
7	Peri-prosthetic fracture (Acetabulum)	1	1.4
8	Metal reaction/Metallosis	1	1.4
9	Malalignment	1	1.4

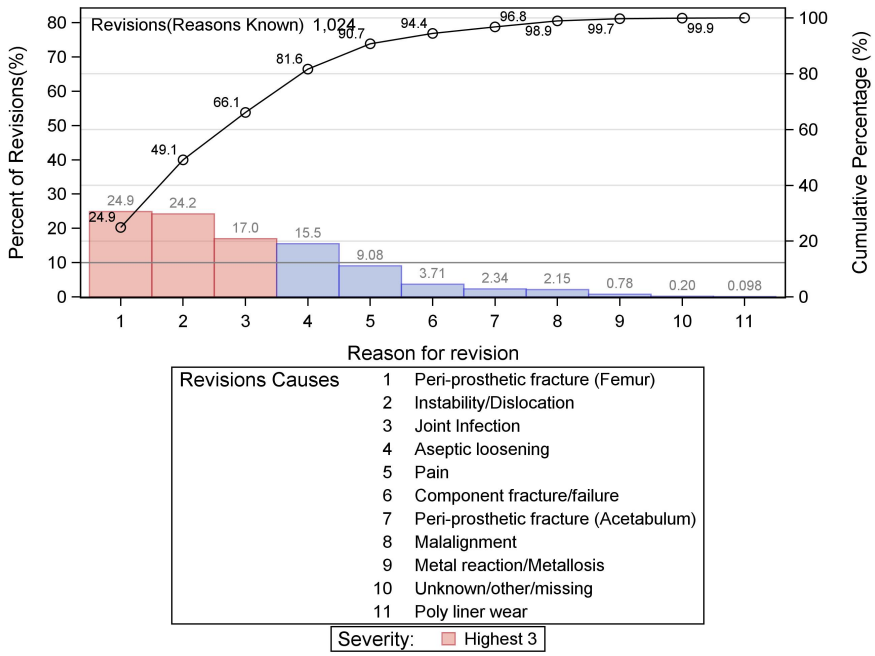

Figure 18: Reasons for revision following primary conventional THA (Pareto chart).

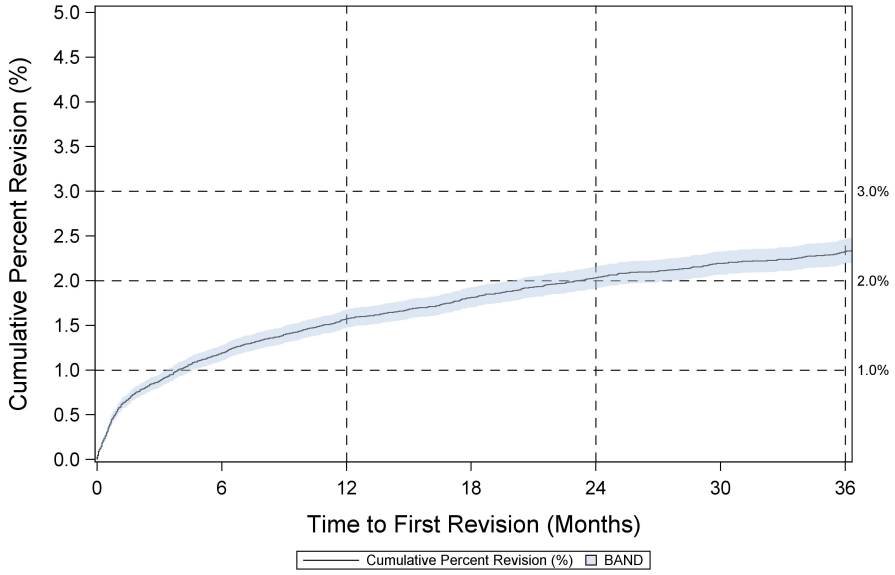

Figure 19: Cumulative percent revision for primary conventional THA.

Table 9: Cumulative percent revision for primary conventional THA (numerical values).

N	1 year	2 years	3 years
63093	1.57 (1.47,1.68)	2.03 (1.91,2.15)	2.33 (2.19,2.47)

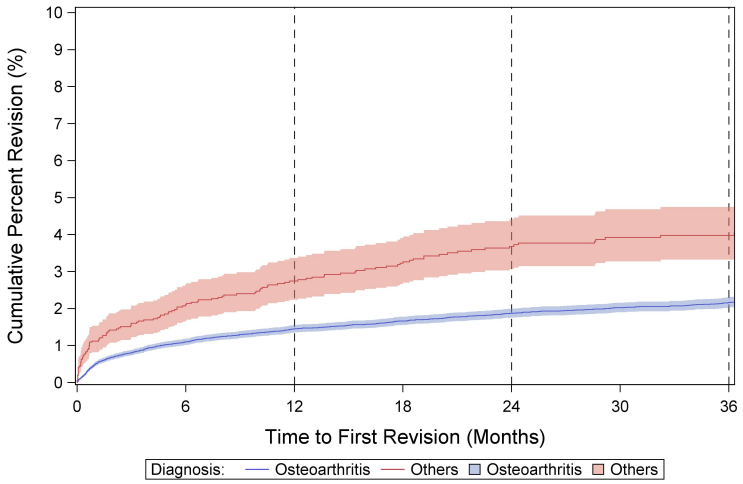

Figure 20: Cumulative percent revision for primary conventional THA by diagnosis.

Table 10: Cumulative percent revision for primary conventional THA by diagnosis (numerical values).

Diagnosis	N	1 year	2 years	3 years
Osteoarthritis	58149	1.45 (1.35,1.55)	1.87 (1.75,1.99)	2.17 (2.03,2.31)
Others	3497	2.74 (2.24,3.36)	3.68 (3.07,4.41)	3.98 (3.33,4.75)
Unknown/Missing	1447			

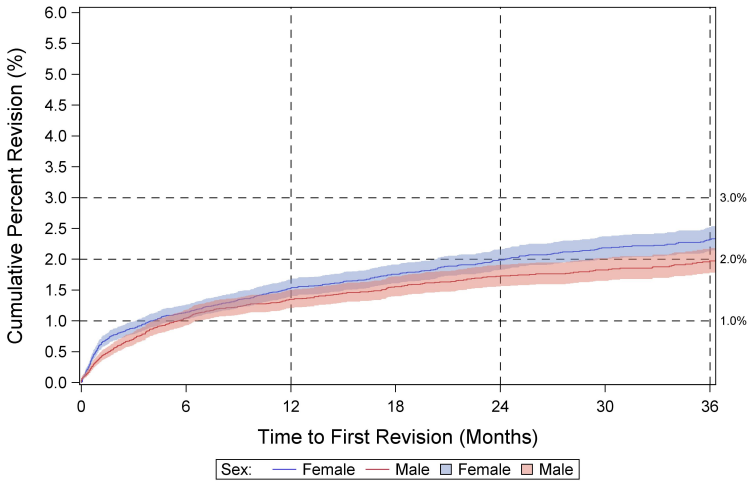

Figure 21: Cumulative percent revision for primary conventional THA by sex for osteoarthritis diagnosis.

Table 11: Cumulative percent revision for primary conventional THA by sex for osteoarthritis diagnosis (numerical values).

Sex	N	1 year	2 years	3 years
Female	32282	1.53 (1.40,1.68)	1.99 (1.83,2.16)	2.32 (2.14,2.52)
Male	25847	1.35 (1.21,1.50)	1.72 (1.56,1.91)	1.97 (1.78,2.18)
Missing	20			

2.4 Revision risk for implant combinations

There is variation in revision risk across implants. The following section of this chapter provides revision risk data by stem/cup implant combination. The reader should be cautious in interpreting implant cumulative percent revision (CPR) data because there are many other factors that can affect CPR such as the characteristics of the patients who receive the implants, the volume of procedures done by the surgeons using the implant, and the volume of procedures done using that specific implant. Both mean and median volume numbers are provided for surgeons and hospitals because the distributions are skewed. Bearing surface couple, head size, and approach can also vary across implant combinations and affect CPR. Text and tables have been included to provide this information for each implant combination so the reader can make decisions based on a comprehensive view of how the implant combination is used. Note that sample size differs for CPR reporting and descriptive statistics provided in tables: the difference is due to excluding death from the CPR calculations. All implant combinations have a minimum follow up of at least three years. Therefore, if the red line and shaded confidence interval end prior to three years, this does not mean the longest follow up was less than three years. Instead, it means that no additional revisions occurred after the end of the red line and confidence interval band.

The numbers in the implant-specific tables may appear to be inconsistent, but they can be understood by studying the online supplement *MARCQI Six-Year Report Specifications* that describes inclusion and exclusion criteria for each table. For example, the number of cases listed in demographic tables often are greater than the total number of implants listed in the CPR table. The explanation for this is that the CPR estimates exclude patients who died.

While the reader is encouraged to read the details of each stem/cup implant combination, the following table summarizes the three-year CPR values.

Table 12: Summary of cumulative percent revision for stem/cup combinations having at least 500 cases, sorted alphabetically.

Stem/cup combination	N*	1 year	2 years	3 years
Accolade II / Trident	14212	1.18 (1.01,1.38)	1.68 (1.45,1.94)	2.11 (1.81,2.44)
Accolade TMZF / Trident	901	1.11 (0.60,2.06)	1.73 (1.04,2.85)	2.17 (1.37,3.44)
Anthology / Reflection 3	1868	2.56 (1.91,3.42)	3.19 (2.44,4.19)	3.54 (2.68,4.67)
Corail / Pinnacle	1792	1.12 (0.71,1.79)	*1.35 (0.86,2.11)*	*1.35 (0.86,2.11)*
Echo Bi-Metric / G7	721	2.23 (1.35,3.68)	2.23 (1.35,3.68)	*5.38 (1.69,16.48)*
Fitmore / Continuum	2400	1.26 (0.87,1.82)	1.61 (1.15,2.26)	*1.90 (1.36,2.64)*
M/L Taper** / Continuum	5679	1.76 (1.44,2.14)	2.08 (1.73,2.50)	2.52 (2.11,3.00)
M/L Taper** / G7	978	1.44 (0.84,2.46)	*2.67 (1.56,4.57)*	*2.67 (1.56,4.57)*
M/L Taper** / Trabecular Metal	616	1.01 (0.46,2.24)	1.30 (0.61,2.76)	2.08 (1.03,4.18)
M/L Taper** / Trilogy	1290	1.20 (0.73,1.99)	1.95 (1.30,2.93)	*2.35 (1.60,3.46)*
Polarstem / Reflection 3	629	1.88 (1.00,3.53)	*2.37 (1.25,4.49)*	*2.37 (1.25,4.49)*
SROM / Pinnacle	898	0.93 (0.46,1.84)	1.62 (0.94,2.78)	1.84 (1.08,3.13)
Secur-Fit / Trident	908	3.22 (2.23,4.63)	4.15 (2.97,5.78)	4.39 (3.15,6.12)
Secur-Fit Max / Trident	1986	2.11 (1.55,2.87)	2.72 (2.03,3.63)	2.81 (2.11,3.75)
Secur-Fit Plus Max / Trident	1902	1.67 (1.18,2.37)	1.88 (1.35,2.63)	2.09 (1.50,2.90)
Summit / Pinnacle	4631	1.40 (1.09,1.80)	1.65 (1.30,2.09)	1.73 (1.37,2.19)
Synergy / Reflection 3	724	1.76 (1.00,3.09)	2.47 (1.52,4.01)	2.71 (1.68,4.35)
Taperloc 133 / G7	3338	1.94 (1.50,2.52)	*2.61 (2.00,3.39)*	*2.61 (2.00,3.39)*
Taperloc 133 / Regenerex RingLoc+	526	2.06 (1.11,3.81)	2.32 (1.29,4.17)	2.32 (1.29,4.17)
Taperloc 133 / RingLoc+	1405	1.90 (1.30,2.79)	2.49 (1.78,3.49)	*2.59 (1.85,3.61)*
Trabecular Metal / Continuum	597	2.74 (1.68,4.43)	2.94 (1.84,4.69)	3.63 (2.28,5.76)
Tri-Lock BPS / Pinnacle	1619	0.47 (0.22,0.99)	0.58 (0.29,1.16)	0.58 (0.29,1.16)

Notes:

* Number of patients that contribute to survival analysis used to compute cumulative percent revision.

* *M/L Taper does not include M/L Taper Kinectiv.

A revision risk in *italics* indicates it is the same as it was at the time of the last revision.

Accolade II/Trident
N=14230

104 surgeons across 42 sites use this implant combination.

Table 13: Volume of cases by surgeon and site for Accolade II/Trident.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	136.8 (223.9)	27 (171)
Cases per site	338.8 (546.6)	117.5 (437)

Table 14: Descriptive statistics of patients receiving Accolade II/Trident.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	7777	54.65	
Age (yrs)	14230	64.15(11.11)	64.00(15.00)
Height (cm)	14229	169.63(10.22)	170.00(15.00)
Weight (kg)	14230	87.47(20.78)	86.00(28.00)
BMI(kg/m^2)	14229	30.29(6.20)	29.57(8.08)
Smoking - never (%)	6831	48	
Smoking - previous (%)	5422	38.1	
Smoking - current (%)	1891	13.29	
Smoking - unknown (%)	86	0.6	

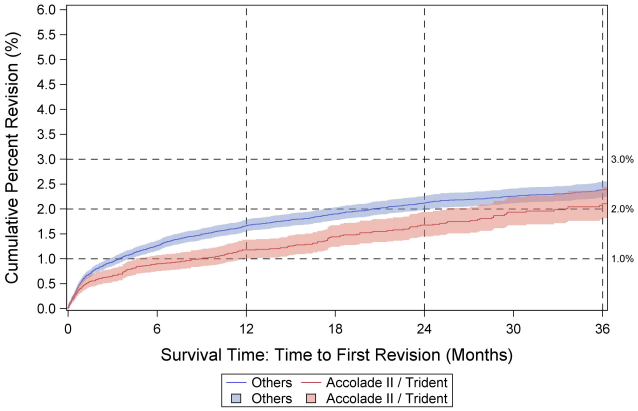

Figure 22: Cumulative percent revision curve for Accolade II/Trident compared to all other conventional THA implants.

Table 15: Cumulative percent revision for Accolade II/Trident compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
14212	1.18 (1.01,1.38)	1.68 (1.45,1.94)	2.11 (1.81,2.44)

Table 16: Distribution of approach used for Accolade II/Trident.

Approach	N	Percent
Anterior	4496	31.6
Anterolateral	2055	14.4
Posterior	7626	53.6
Transtrochanteric	18	0.1
Missing/unknown/other	35	0.3

Table 17: Distribution of head size for Accolade II/Trident.

Size (mm)	N	Percent
22	8	0.1
28	28	0.2
32	2640	20.4
36	9421	72.8
40	762	5.9
44	55	0.4
Missing/unknown/other	34	0.3

Table 18: Distribution of bearing surface for Accolade II/Trident.

Bearing	N	Percent
Metal-on-plastic	3000	21.1
Ceramic-on-plastic	9901	69.6
Ceramic-on-ceramic	11	0.1
Metal-on-metal	0	0.0
Dual mobility	1245	8.8
Missing/unknown/other	73	0.5

Table 19: Distribution of polyethylene used for Accolade II/Trident cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	14166	100.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 20: Reasons for revision for Accolade II/Trident.

Rank	Reason for revision	N	Percent
1	Peri-prosthetic fracture (Femur)	60	30.2
2	Aseptic loosening	39	19.6
3	Joint Infection	34	17.1
4	Instability/Dislocation	28	14.1
5	Pain	21	10.6
6	Component fracture/failure	7	3.5
7	Peri-prosthetic fracture (Acetabulum)	6	3.0
8	Metal reaction/Metallosis	3	1.5
9	Malalignment	1	0.5

Accolade TMZF/Trident
N=903

14 surgeons across 11 sites use this implant combination.

Table 21: Volume of cases by surgeon and site for Accolade TMZF/Trident.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	64.5 (140.6)	8 (14)
Cases per site	82.1 (108.2)	22 (203)

Table 22: Descriptive statistics of patients receiving Accolade TMZF/Trident.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	501	55.48	
Age (yrs)	903	63.32(11.22)	63.00(15.00)
Height (cm)	903	169.64(10.58)	170.00(15.00)
Weight (kg)	903	89.86(21.31)	89.00(29.00)
BMI(kg/m^2)	903	31.09(6.18)	30.47(8.30)
Smoking - never (%)	411	45.51	
Smoking - previous (%)	348	38.54	
Smoking - current (%)	127	14.06	
Smoking - unknown (%)	17	1.88	

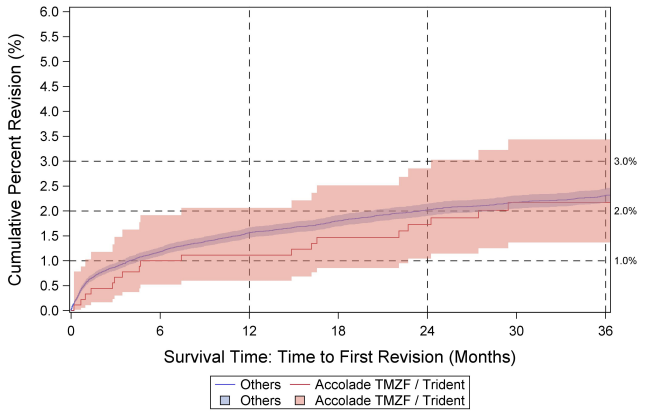

Figure 23: Cumulative percent revision curve for Accolade TMZF/Trident compared to all other conventional THA implants.

Table 23: Cumulative percent revision for Accolade TMZF/Trident compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
901	1.11 (0.60,2.06)	1.73 (1.04,2.85)	2.17 (1.37,3.44)

Table 24: Distribution of approach used for Accolade TMZF/Trident.

Approach	N	Percent
Anterior	8	0.9
Anterolateral	138	15.3
Posterior	747	82.7
Transtrochanteric	3	0.3
Missing/unknown/other	7	0.8

Table 25: Distribution of head size for Accolade TMZF/Trident.

Size (mm)	N	Percent
28	1	0.1
32	96	10.9
36	683	77.4
40	95	10.8
Missing/unknown/other	7	0.8

Table 26: Distribution of bearing surface for Accolade TMZF/Trident.

Bearing	N	Percent
Metal-on-plastic	489	54.1
Ceramic-on-plastic	383	42.4
Ceramic-on-ceramic	2	0.2
Metal-on-metal	0	0.0
Dual mobility	18	2.0
Missing/unknown/other	11	1.2

Table 27: Distribution of polyethylene used for Accolade TMZF/Trident cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	894	100.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 28: Reasons for revision for Accolade TMZF/Trident.

Rank	Reason for revision	N	Percent
1	Aseptic loosening	6	46.2
2	Instability/Dislocation	2	15.4
3	Joint Infection	2	15.4
4	Peri-prosthetic fracture (Femur)	2	15.4
5	Metal reaction/Metallosis	1	7.7

Anthology/Reflection 3
N=1875

43 surgeons across 30 sites use this implant combination.

Table 29: Volume of cases by surgeon and site for Anthology/Reflection 3.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	43.6 (71.6)	13 (51)
Cases per site	62.5 (84.5)	20 (79)

Table 30: Descriptive statistics of patients receiving Anthology/Reflection 3.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1019	54.35	
Age (yrs)	1875	64.47(11.40)	65.00(16.00)
Height (cm)	1875	169.00(10.43)	168.00(15.00)
Weight (kg)	1875	90.46(23.26)	88.00(30.00)
BMI(kg/m^2)	1875	31.56(7.08)	30.49(8.91)
Smoking - never (%)	884	47.15	
Smoking - previous (%)	681	36.32	
Smoking - current (%)	306	16.32	
Smoking - unknown (%)	4	0.21	

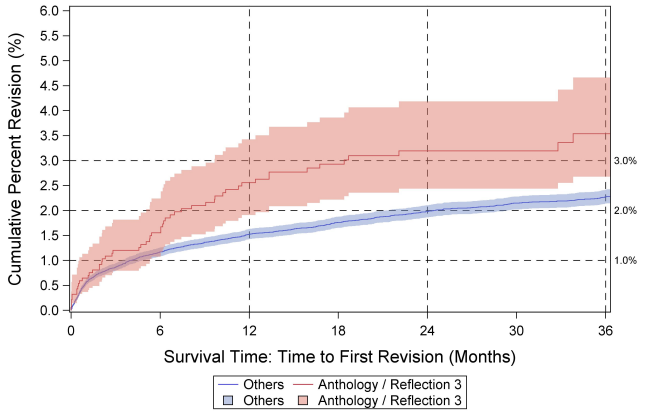

Figure 24: Cumulative percent revision curve for Anthology/Reflection 3 compared to all other conventional THA implants.

Table 31: Cumulative percent revision for Anthology/Reflection 3 compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
1868	2.56 (1.91,3.42)	3.19 (2.44,4.19)	3.54 (2.68,4.67)

Table 32: Distribution of approach used for Anthology/Reflection 3.

Approach	N	Percent
Anterior	747	39.8
Anterolateral	529	28.2
Posterior	582	31.0
Transtrochanteric	13	0.7
Missing/unknown/other	4	0.2

Table 33: Distribution of head size for Anthology/Reflection 3.

Size (mm)	N	Percent
22	1	0.1
28	17	0.9
32	510	27.2
36	1118	59.7
40	203	10.8
44	13	0.7
Missing/unknown/other	11	0.6

Table 34: Distribution of bearing surface for Anthology/Reflection 3.

Bearing	N	Percent
Metal-on-plastic	493	26.3
Ceramic-on-plastic	1368	73.0
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	14	0.8

Table 35: Distribution of polyethylene used for Anthology/Reflection 3 cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	1	0.1
XLPE	1871	100.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 36: Reasons for revision for Anthology/Reflection 3.

Rank	Reason for revision	N	Percent
1	Aseptic loosening	12	26.1
2	Instability/Dislocation	9	19.6
3	Joint Infection	9	19.6
4	Peri-prosthetic fracture (Femur)	6	13.0
5	Component fracture/failure	3	6.5
6	Pain	3	6.5
7	Peri-prosthetic fracture (Acetabulum)	2	4.3
8	Malalignment	2	4.3

Corail/Pinnacle
N=1799

33 surgeons across 22 sites use this implant combination.

Table 37: Volume of cases by surgeon and site for Corail/Pinnacle.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	54.5 (74.1)	19 (81)
Cases per site	81.8 (125.9)	26.5 (140)

Table 38: Descriptive statistics of patients receiving Corail/Pinnacle.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1073	59.64	
Age (yrs)	1799	65.97(10.54)	66.00(15.00)
Height (cm)	1799	168.70(10.21)	168.00(15.00)
Weight (kg)	1799	87.00(19.55)	85.00(26.00)
BMI(kg/m^2)	1799	30.50(5.94)	29.76(7.69)
Smoking - never (%)	819	45.53	
Smoking - previous (%)	685	38.08	
Smoking - current (%)	293	16.29	
Smoking - unknown (%)	2	0.11	

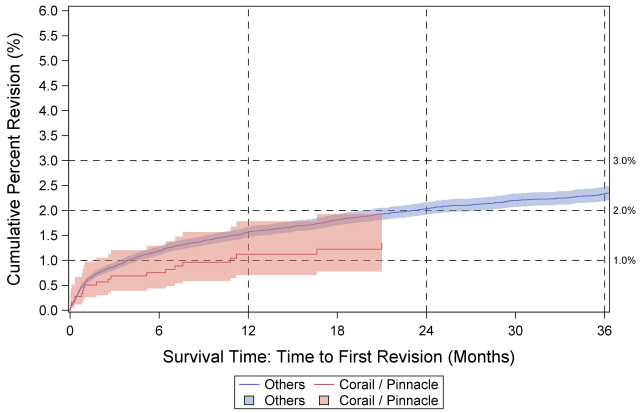

Figure 25: Cumulative percent revision curve for Corail/Pinnacle compared to all other conventional THA implants.

Table 39: Cumulative percent revision for Corail/Pinnacle compared to all other conventional THA implants (numerical values).

N	1 year	2 years*	3 years*
1792	1.12 (0.71,1.79)	1.35 (0.86,2.11)	1.35 (0.86,2.11)

* No revision occurred after the termination of the red curve in figure above; therefore, numerical revision risk at this time point is the same as it was at the time of the last revision.

Table 40: Distribution of approach used for Corail/Pinnacle.

Approach	N	Percent
Anterior	1280	71.2
Anterolateral	312	17.3
Posterior	201	11.2
Transtrochanteric	3	0.2
Missing/unknown/other	3	0.2

Table 41: Distribution of head size for Corail/Pinnacle.

Size (mm)	N	Percent
28	1	0.1
32	422	23.6
36	1203	67.3
40	141	7.9
44	15	0.8
Missing/unknown/other	6	0.3

Table 42: Distribution of bearing surface for Corail/Pinnacle.

Bearing	N	Percent
Metal-on-plastic	947	52.6
Ceramic-on-plastic	830	46.1
Ceramic-on-ceramic	6	0.3
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	16	0.9

Table 43: Distribution of polyethylene used for Corail/Pinnacle cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	1782	100.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 44: Reasons for revision for Corail/Pinnacle.

Rank	Reason for revision	N	Percent
1	Aseptic loosening	5	26.3
2	Instability/Dislocation	4	21.1
3	Joint Infection	4	21.1
4	Peri-prosthetic fracture (Femur)	3	15.8
5	Other	3	15.8

Echo Bi-Metric/G7
N=721

14 surgeons across 14 sites use this implant combination.

Table 45: Volume of cases by surgeon and site for Echo Bi-Metric/G7.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	51.5 (73.5)	20 (60)
Cases per site	51.5 (80.7)	10.5 (64)

Table 46: Descriptive statistics of patients receiving Echo Bi-Metric/G7.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	411	57	
Age (yrs)	721	65.26(10.59)	66.00(15.00)
Height (cm)	721	169.06(10.14)	167.00(15.00)
Weight (kg)	721	88.30(19.78)	88.00(26.00)
BMI(kg/m^2)	721	30.79(5.93)	30.19(8.19)
Smoking - never (%)	326	45.21	
Smoking - previous (%)	294	40.78	
Smoking - current (%)	101	14.01	
Smoking - unknown (%)	0	0.0	

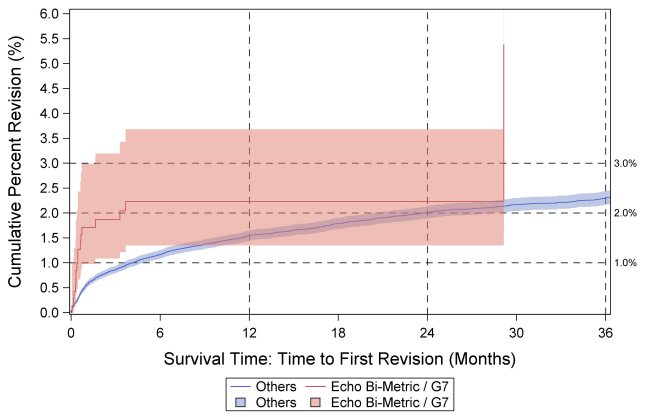

Figure 26: Cumulative percent revision curve for Echo Bi-Metric/G7 compared to all other conventional THA implants.

Table 47: Cumulative percent revision for Echo Bi-Metric/G7 compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years*
721	2.23 (1.35,3.68)	2.23 (1.35,3.68)	5.38 (1.69,16.48)

* No revision occurred after the termination of the red curve in figure above; therefore, numerical revision risk at this time point is the same as it was at the time of the last revision.

Table 48: Distribution of approach used for Echo Bi-Metric/G7.

Approach	N	Percent
Anterior	220	30.5
Anterolateral	34	4.7
Posterior	466	64.6
Transtrochanteric	1	0.1
Missing/unknown/other	0	0.0

Table 49: Distribution of head size for Echo Bi-Metric/G7.

Size (mm)	N	Percent
32	167	24.1
36	464	67.0
40	56	8.1
Missing/unknown/other	5	0.7

Table 50: Distribution of bearing surface for Echo Bi-Metric/G7.

Bearing	N	Percent
Metal-on-plastic	105	14.6
Ceramic-on-plastic	582	80.7
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	25	3.5
Missing/unknown/other	9	1.3

Table 51: Distribution of polyethylene used for Echo Bi-Metric/G7 cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	271	37.9
Antioxidant XLPE	445	62.1
Missing/unknown/other	0	0.0

Table 52: Reasons for revision for Echo Bi-Metric/G7.

Rank	Reason for revision	N	Percent
1	Peri-prosthetic fracture (Femur)	9	56.3
2	Instability/Dislocation	3	18.8
3	Aseptic loosening	1	6.3
4	Component fracture/failure	1	6.3
5	Other	2	12.5

Fitmore/Continuum
N=2401

37 surgeons across 16 sites use this implant combination.

Table 53: Volume of cases by surgeon and site for Fitmore/Continuum.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	64.9 (216.0)	5 (21)
Cases per site	150.1 (240)	31.5 (192)

Table 54: Descriptive statistics of patients receiving Fitmore/Continuum.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1109	46.19	
Age (yrs)	2401	63.81(10.18)	63.00(14.00)
Height (cm)	2401	171.13(10.09)	172.00(15.00)
Weight (kg)	2401	88.69(21.36)	87.00(28.00)
BMI(kg/m^2)	2401	30.13(6.10)	29.34(7.80)
Smoking - never (%)	1148	47.81	
Smoking - previous (%)	950	39.57	
Smoking - current (%)	299	12.45	
Smoking - unknown (%)	4	0.17	

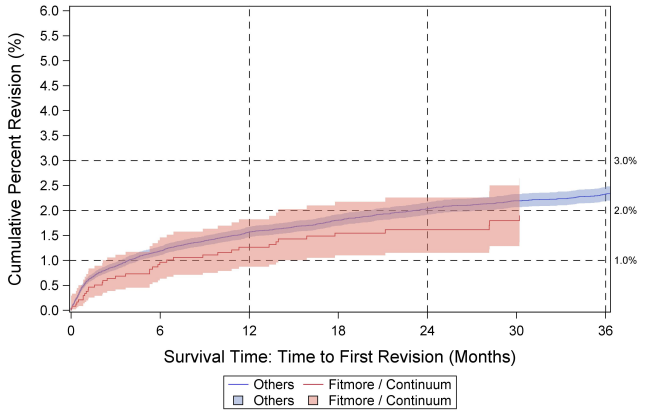

Figure 27: Cumulative percent revision curve for Fitmore/Continuum compared to all other conventional THA implants.

Table 55: Cumulative percent revision for Fitmore/Continuum compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years*
2400	1.26 (0.87,1.82)	1.61 (1.15,2.26)	1.90 (1.36,2.64)

* No revision occurred after the termination of the red curve in figure above; therefore, numerical revision risk at this time point is the same as it was at the time of the last revision.

Table 56: Distribution of approach used for Fitmore/Continuum.

Approach	N	Percent
Anterior	2039	84.9
Anterolateral	23	1.0
Posterior	339	14.1
Transtrochanteric	0	0.0
Missing/unknown/other	0	0.0

Table 57: Distribution of head size for Fitmore/Continuum.

Size (mm)	N	Percent
28	3	0.1
32	486	20.3
36	1698	71.0
40	190	7.9
Missing/unknown/other	16	0.7

Table 58: Distribution of bearing surface for Fitmore/Continuum.

Bearing	N	Percent
Metal-on-plastic	528	22.0
Ceramic-on-plastic	1849	77.0
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	24	1.0

Table 59: Distribution of polyethylene used for Fitmore/Continuum cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	900	37.6
Antioxidant XLPE	1492	62.4
Missing/unknown/other	1	0.0

Table 60: Reasons for revision for Fitmore/Continuum.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	9	25.7
2	Peri-prosthetic fracture (Femur)	9	25.7
3	Pain	7	20.0
4	Aseptic loosening	3	8.6
5	Other	7	20.0

M/L Taper/Continuum
N=5685

This analysis excludes M/L Taper Kinectiv. 66 surgeons across 29 sites use this implant combination.

Table 61: Volume of cases by surgeon and site for M/L Taper/Continuum.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	86.1 (181.7)	27.5 (87)
Cases per site	196.0 (428.2)	39 (162)

Table 62: Descriptive statistics of patients receiving M/L Taper/Continuum.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	3047	53.6	
Age (yrs)	5685	64.68(10.76)	65.00(14.00)
Height (cm)	5677	169.75(10.36)	170.00(15.00)
Weight (kg)	5676	86.66(20.13)	85.00(27.00)
BMI(kg/m^2)	5676	29.96(5.87)	29.29(7.55)
Smoking - never (%)	2835	49.87	
Smoking - previous (%)	2177	38.29	
Smoking - current (%)	655	11.52	
Smoking - unknown (%)	18	0.32	

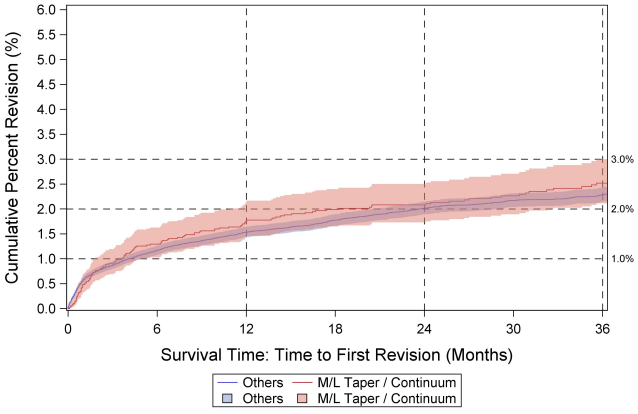

Figure 28: Cumulative percent revision curve for M/L Taper/Continuum compared to all other conventional THA implants.

Table 63: Cumulative percent revision for M/L Taper/Continuum compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
5679	1.76 (1.44,2.14)	2.08 (1.73,2.50)	2.52 (2.11,3.00)

Table 64: Distribution of approach used for M/L Taper/Continuum.

Approach	N	Percent
Anterior	1259	22.1
Anterolateral	1035	18.2
Posterior	3309	58.2
Transtrochanteric	45	0.8
Missing/unknown/other	37	0.7

Table 65: Distribution of head size for M/L Taper/Continuum.

Size (mm)	N	Percent
28	20	0.4
32	1304	23.1
36	3842	68.2
40	395	7.0
Missing/unknown/other	72	1.3

Table 66: Distribution of bearing surface for M/L Taper/Continuum.

Bearing	N	Percent
Metal-on-plastic	2270	39.9
Ceramic-on-plastic	3288	57.8
Ceramic-on-ceramic	3	0.1
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	124	2.2

Table 67: Distribution of polyethylene used for M/L Taper/Continuum cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	4100	72.8
Antioxidant XLPE	1530	27.2
Missing/unknown/other	0	0.0

Table 68: Reasons for revision for M/L Taper/Continuum.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	24	24.5
2	Peri-prosthetic fracture (Femur)	24	24.5
3	Joint Infection	16	16.3
4	Aseptic loosening	14	14.3
5	Pain	7	7.1
6	Component fracture/failure	5	5.1
7	Peri-prosthetic fracture (Acetabulum)	4	4.1
8	Metal reaction/Metallosis	2	2.0
9	Malalignment	2	2.0

M/L Taper/G7
N=978

This analysis excludes M/L Taper Kinectiv. 15 surgeons across 10 sites use this implant combination.

Table 69: Volume of cases by surgeon and site for M/L Taper/G7.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	65.2 (91.3)	26 (88)
Cases per site	97.8 (143.9)	39 (118)

Table 70: Descriptive statistics of patients receiving M/L Taper/G7.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	544	55.62	
Age (yrs)	978	65.13(10.40)	66.00(15.00)
Height (cm)	978	169.43(10.20)	170.00(15.00)
Weight (kg)	978	86.99(20.64)	84.00(28.00)
BMI(kg/m^2)	978	30.15(5.94)	29.21(8.22)
Smoking - never (%)	465	47.55	
Smoking - previous (%)	419	42.84	
Smoking - current (%)	94	9.61	
Smoking - unknown (%)	0	0.0	

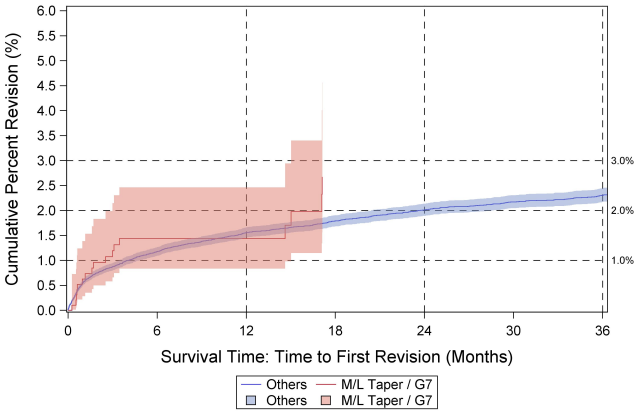

Figure 29: Cumulative percent revision curve for M/L Taper/G7 compared to all other conventional THA implants.

Table 71: Cumulative percent revision for M/L Taper/G7 compared to all other conventional THA implants (numerical values).

N	1 year	2 years*	3 years*
978	1.44 (0.84,2.46)	2.67 (1.56,4.57)	2.67 (1.56,4.57)

* No revision occurred after the termination of the red curve in figure above; therefore, numerical revision risk at this time point is the same as it was at the time of the last revision.

Table 72: Distribution of approach used for M/L Taper/G7.

Approach	N	Percent
Anterior	278	28.4
Anterolateral	28	2.9
Posterior	666	68.1
Transtrochanteric	6	0.6
Missing/unknown/other	0	0.0

Table 73: Distribution of head size for M/L Taper/G7.

Size (mm)	N	Percent
28	1	0.1
32	86	9.0
36	775	81.0
40	90	9.4
Missing/unknown/other	5	0.5

Table 74: Distribution of bearing surface for M/L Taper/G7.

Bearing	N	Percent
Metal-on-plastic	259	26.5
Ceramic-on-plastic	693	70.9
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	18	1.8
Missing/unknown/other	8	0.8

Table 75: Distribution of polyethylene used for M/L Taper/G7 cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	333	34.2
Antioxidant XLPE	640	65.8
Missing/unknown/other	0	0.0

Table 76: Reasons for revision for M/L Taper/G7.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	6	35.3
2	Peri-prosthetic fracture (Femur)	5	29.4
3	Aseptic loosening	2	11.8
4	Pain	2	11.8
5	Joint Infection	1	5.9
6	Malalignment	1	5.9

M/L Taper/Trabecular Metal
N=617

This analysis excludes M/L Taper Kinectiv. 18 surgeons across 14 sites use this implant combination.

Table 77: Volume of cases by surgeon and site for M/L Taper/Trabecular Metal.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	34.3 (76.0)	2 (7)
Cases per site	44.1 (84.1)	4 (50)

Table 78: Descriptive statistics of patients receiving M/L Taper/Trabecular Metal.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	336	54.46	
Age (yrs)	617	64.35(10.63)	64.00(13.00)
Height (cm)	617	169.04(11.32)	168.00(15.00)
Weight (kg)	616	89.29(21.54)	88.00(31.00)
BMI(kg/m^2)	616	31.43(9.32)	30.15(9.34)
Smoking - never (%)	220	35.66	
Smoking - previous (%)	235	38.09	
Smoking - current (%)	161	26.09	
Smoking - unknown (%)	1	0.16	

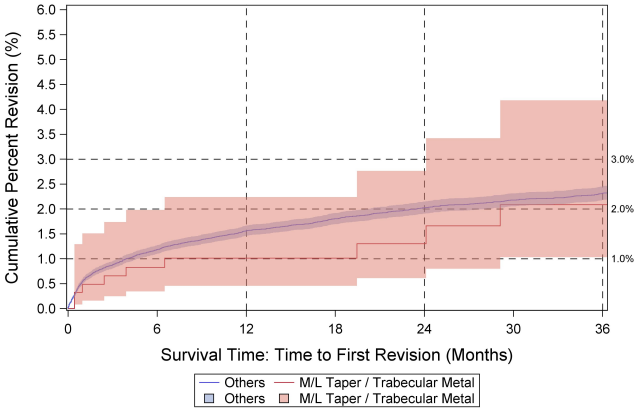

Figure 30: Cumulative percent revision curve for M/L Taper/Trabecular Metal compared to all other conventional THA implants.

Table 79: Cumulative percent revision for M/L Taper/Trabecular Metal compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
616	1.01 (0.46,2.24)	1.30 (0.61,2.76)	2.08 (1.03,4.18)

Table 80: Distribution of approach used for M/L Taper/Trabecular Metal.

Approach	N	Percent
Anterior	3	0.5
Anterolateral	367	59.5
Posterior	221	35.8
Transtrochanteric	23	3.7
Missing/unknown/other	3	0.5

Table 81: Distribution of head size for M/L Taper/Trabecular Metal.

Size (mm)	N	Percent
28	25	4.1
32	404	65.6
36	161	26.1
40	21	3.4
Missing/unknown/other	5	0.8

Table 82: Distribution of bearing surface for M/L Taper/Trabecular Metal.

Bearing	N	Percent
Metal-on-plastic	384	62.2
Ceramic-on-plastic	227	36.8
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	6	1.0

Table 83: Distribution of polyethylene used for M/L Taper/Trabecular Metal cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	615	99.8
Antioxidant XLPE	1	0.2
Missing/unknown/other	0	0.0

Table 84: Reasons for revision for M/L Taper/Trabecular Metal.

Rank	Reason for revision	N	Percent
1	Peri-prosthetic fracture (Femur)	4	40.0
2	Aseptic loosening	2	20.0
3	Instability/Dislocation	1	10.0
4	Joint Infection	1	10.0
5	Pain	1	10.0
6	Malalignment	1	10.0

M/L Taper/Trilogy
N=1293

This analysis excludes M/L Taper Kinectiv. 17 surgeons across 11 sites use this implant combination.

Table 85: Volume of cases by surgeon and site for M/L Taper/Trilogy.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	76.1 (108.5)	14 (109)
Cases per site	117.6 (196.3)	13 (274)

Table 86: Descriptive statistics of patients receiving M/L Taper/Trilogy.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	676	52.28	
Age (yrs)	1293	67.55(9.98)	67.00(15.00)
Height (cm)	1293	169.41(10.45)	169.00(15.00)
Weight (kg)	1293	86.69(19.74)	85.00(28.00)
BMI(kg/m^2)	1293	30.10(5.77)	29.58(7.48)
Smoking - never (%)	576	44.55	
Smoking - previous (%)	550	42.54	
Smoking - current (%)	166	12.84	
Smoking - unknown (%)	1	0.08	

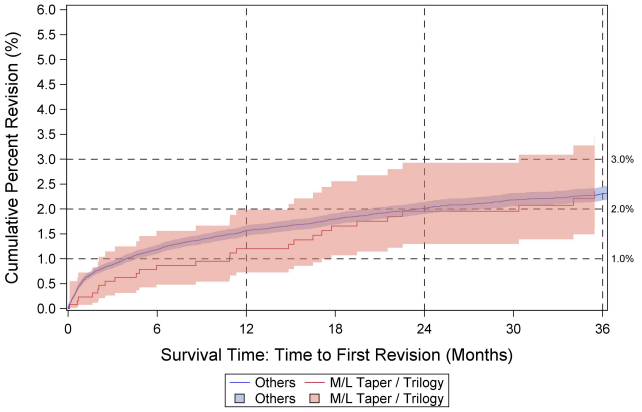

Figure 31: Cumulative percent revision curve for M/L Taper/Trilogy compared to all other conventional THA implants.

Table 87: Cumulative percent revision for M/L Taper/Trilogy compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years*
1290	1.20 (0.73,1.99)	1.95 (1.30,2.93)	2.35 (1.60,3.46)

* No revision occurred after the termination of the red curve in figure above; therefore, numerical revision risk at this time point is the same as it was at the time of the last revision.

Table 88: Distribution of approach used for M/L Taper/Trilogy.

Approach	N	Percent
Anterior	15	1.2
Anterolateral	792	61.3
Posterior	462	35.7
Transtrochanteric	24	1.9
Missing/unknown/other	0	0.0

Table 89: Distribution of head size for M/L Taper/Trilogy.

Size (mm)	N	Percent
28	37	2.9
32	821	63.7
36	406	31.5
40	15	1.2
Missing/unknown/other	10	0.8

Table 90: Distribution of bearing surface for M/L Taper/Trilogy.

Bearing	N	Percent
Metal-on-plastic	1073	83.0
Ceramic-on-plastic	206	15.9
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	14	1.1

Table 91: Distribution of polyethylene used for M/L Taper/Trilogy cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	1289	100.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 92: Reasons for revision for M/L Taper/Trilogy.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	9	45.0
2	Peri-prosthetic fracture (Femur)	5	25.0
3	Aseptic loosening	4	20.0
4	Pain	1	5.0
5	Malalignment	1	5.0

Polarstem/Reflection 3
N=631

24 surgeons across 15 sites use this implant combination.

Table 93: Volume of cases by surgeon and site for Polarstem/Reflection 3.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	26.3 (54.5)	5 (14.5)
Cases per site	42.1 (69.0)	11 (30)

Table 94: Descriptive statistics of patients receiving Polarstem/Reflection 3.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	260	41.2	
Age (yrs)	631	64.24(10.76)	64.00(15.00)
Height (cm)	631	171.84(10.53)	172.00(15.00)
Weight (kg)	631	90.18(21.50)	89.00(31.00)
BMI(kg/m^2)	631	30.39(6.15)	29.99(8.68)
Smoking - never (%)	271	42.95	
Smoking - previous (%)	239	37.88	
Smoking - current (%)	120	19.02	
Smoking - unknown (%)	1	0.16	

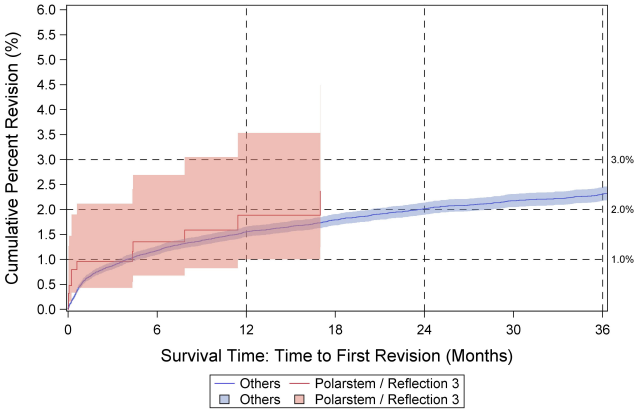

Figure 32: Cumulative percent revision curve for Polarstem/Reflection 3 compared to all other conventional THA implants.

Table 95: Cumulative percent revision for Polarstem/Reflection 3 compared to all other conventional THA implants (numerical values).

N	1 year	2 years*	3 years*
629	1.88 (1.00,3.53)	2.37 (1.25,4.49)	2.37 (1.25,4.49)

* No revision occurred after the termination of the red curve in figure above; therefore, numerical revision risk at this time point is the same as it was at the time of the last revision.

Table 96: Distribution of approach used for Polarstem/Reflection 3.

Approach	N	Percent
Anterior	518	82.1
Anterolateral	29	4.6
Posterior	83	13.2
Transtrochanteric	0	0.0
Missing/unknown/other	1	0.2

Table 97: Distribution of head size for Polarstem/Reflection 3.

Size (mm)	N	Percent
22	1	0.2
32	95	15.1
36	508	80.8
40	24	3.8
Missing/unknown/other	1	0.2

Table 98: Distribution of bearing surface for Polarstem/Reflection 3.

Bearing	N	Percent
Metal-on-plastic	47	7.5
Ceramic-on-plastic	581	92.1
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	3	0.5

Table 99: Distribution of polyethylene used for Polarstem/Reflection 3 cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	1	0.2
XLPE	628	99.8
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 100: Reasons for revision for Polarstem/Reflection 3.

Rank	Reason for revision	N	Percent
1	Peri-prosthetic fracture (Femur)	6	54.5
2	Instability/Dislocation	2	18.2
3	Joint Infection	2	18.2
4	Pain	1	9.1

SROM/Pinnacle
N=898

39 surgeons across 19 sites use this implant combination.

Table 101: Volume of cases by surgeon and site for SROM/Pinnacle.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	23.0 (42.5)	3 (26)
Cases per site	47.3 (124.3)	5 (19)

Table 102: Descriptive statistics of patients receiving SROM/Pinnacle.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	452	50.33	
Age (yrs)	898	61.30(11.80)	62.00(15.00)
Height (cm)	898	170.88(10.98)	170.00(18.00)
Weight (kg)	898	90.31(21.89)	89.00(29.00)
BMI(kg/m^2)	898	30.84(6.48)	30.30(8.52)
Smoking - never (%)	424	47.22	
Smoking - previous (%)	326	36.3	
Smoking - current (%)	146	16.26	
Smoking - unknown (%)	2	0.22	

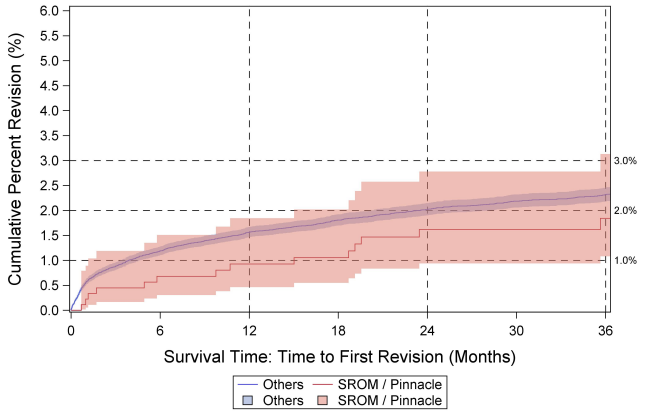

Figure 33: Cumulative percent revision curve for SROM/Pinnacle compared to all other conventional THA implants.

Table 103: Cumulative percent revision for SROM/Pinnacle compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
898	0.93 (0.46,1.84)	1.62 (0.94,2.78)	1.84 (1.08,3.13)

Table 104: Distribution of approach used for SROM/Pinnacle.

Approach	N	Percent
Anterior	9	1.0
Anterolateral	496	55.2
Posterior	377	42.0
Transtrochanteric	10	1.1
Missing/unknown/other	6	0.7

Table 105: Distribution of head size for SROM/Pinnacle.

Size (mm)	N	Percent
28	4	0.5
32	218	24.3
36	645	72.0
40	24	2.7
44	2	0.2
Missing/unknown/other	3	0.3

Table 106: Distribution of bearing surface for SROM/Pinnacle.

Bearing	N	Percent
Metal-on-plastic	293	32.6
Ceramic-on-plastic	599	66.7
Ceramic-on-ceramic	1	0.1
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	5	0.6

Table 107: Distribution of polyethylene used for SROM/Pinnacle cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	895	100.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 108: Reasons for revision for SROM/Pinnacle.

Rank	Reason for revision	N	Percent
1	Joint Infection	6	46.2
2	Aseptic loosening	3	23.1
3	Instability/Dislocation	2	15.4
4	Component fracture/failure	1	7.7
5	Pain	1	7.7

Secur-Fit/Trident
N=913

30 surgeons across 17 sites use this implant combination.

Table 109: Volume of cases by surgeon and site for Secur-Fit/Trident.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	30.4 (65.4)	4 (20)
Cases per site	53.7 (85.7)	13 (54)

Table 110: Descriptive statistics of patients receiving Secur-Fit/Trident.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	545	59.69	
Age (yrs)	913	64.72(10.48)	65.00(13.00)
Height (cm)	913	169.04(10.22)	169.00(16.00)
Weight (kg)	913	90.13(21.88)	88.00(29.00)
BMI(kg/m^2)	913	31.43(6.66)	30.73(9.22)
Smoking - never (%)	421	46.11	
Smoking - previous (%)	327	35.82	
Smoking - current (%)	157	17.2	
Smoking - unknown (%)	8	0.88	

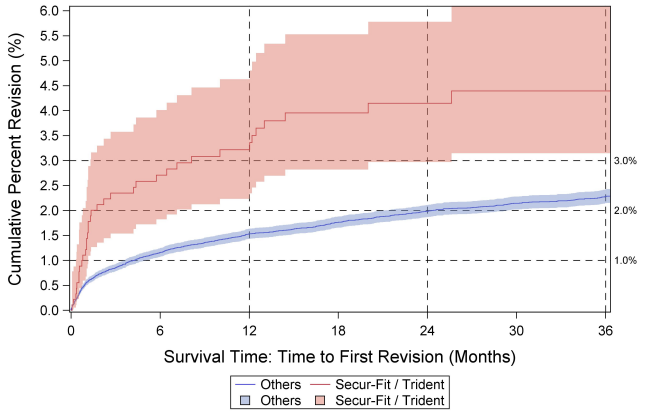

Figure 34: Cumulative percent revision curve for Secur-Fit/Trident compared to all other conventional THA implants.

Table 111: Cumulative percent revision for Secur-Fit/Trident compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
908	3.22 (2.23,4.63)	4.15 (2.97,5.78)	4.39 (3.15,6.12)

Table 112: Distribution of approach used for Secur-Fit/Trident.

Approach	N	Percent
Anterior	1	0.1
Anterolateral	455	49.8
Posterior	453	49.6
Transtrochanteric	1	0.1
Missing/unknown/other	3	0.3

Table 113: Distribution of head size for Secur-Fit/Trident.

Size (mm)	N	Percent
28	1	0.1
32	137	17.1
36	445	55.6
40	209	26.1
Missing/unknown/other	8	1.0

Table 114: Distribution of bearing surface for Secur-Fit/Trident.

Bearing	N	Percent
Metal-on-plastic	259	28.4
Ceramic-on-plastic	533	58.4
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	109	11.9
Missing/unknown/other	12	1.3

Table 115: Distribution of polyethylene used for Secur-Fit/Trident cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	909	100.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 116: Reasons for revision for Secur-Fit/Trident.

Rank	Reason for revision	N	Percent
1	Peri-prosthetic fracture (Femur)	10	30.3
2	Joint Infection	8	24.2
3	Instability/Dislocation	7	21.2
4	Aseptic loosening	6	18.2
5	Component fracture/failure	1	3.0
6	Peri-prosthetic fracture (Acetabulum)	1	3.0

Secur-Fit Max/Trident
N=1988

56 surgeons across 22 sites use this implant combination.

Table 117: Volume of cases by surgeon and site for Secur-Fit Max/Trident.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	35.5 (72.3)	8.5 (40.5)
Cases per site	90.4 (124.8)	22.5 (111)

Table 118: Descriptive statistics of patients receiving Secur-Fit Max/Trident.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1005	50.55	
Age (yrs)	1988	64.18(11.54)	65.00(15.00)
Height (cm)	1988	169.87(10.26)	170.00(15.00)
Weight (kg)	1988	90.63(21.23)	89.00(27.00)
BMI(kg/m^2)	1988	31.30(6.30)	30.72(8.37)
Smoking - never (%)	900	45.27	
Smoking - previous (%)	790	39.74	
Smoking - current (%)	290	14.59	
Smoking - unknown (%)	8	0.4	

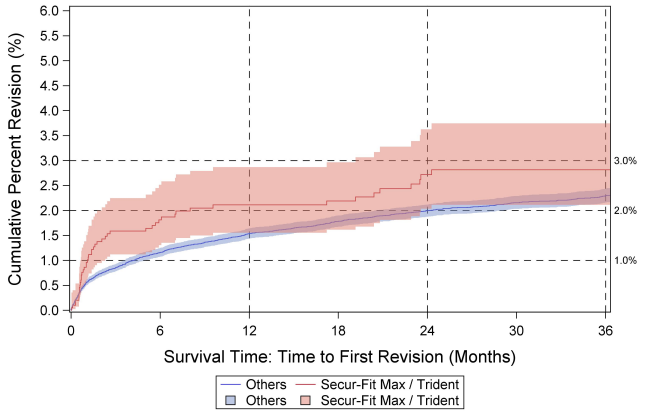

Figure 35: Cumulative percent revision curve for Secur-Fit Max/Trident compared to all other conventional THA implants.

Table 119: Cumulative percent revision for Secur-Fit Max/Trident compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
1986	2.11 (1.55,2.87)	2.72 (2.03,3.63)	2.81 (2.11,3.75)

Table 120: Distribution of approach used for Secur-Fit Max/Trident.

Approach	N	Percent
Anterior	14	0.7
Anterolateral	800	40.2
Posterior	1135	57.1
Transtrochanteric	22	1.1
Missing/unknown/other	17	0.9

Table 121: Distribution of head size for Secur-Fit Max/Trident.

Size (mm)	N	Percent
22	3	0.2
28	21	1.2
32	379	20.9
36	1270	70.0
40	134	7.4
Missing/unknown/other	8	0.4

Table 122: Distribution of bearing surface for Secur-Fit Max/Trident.

Bearing	N	Percent
Metal-on-plastic	947	47.6
Ceramic-on-plastic	476	23.9
Ceramic-on-ceramic	376	18.9
Metal-on-metal	0	0.0
Dual mobility	138	6.9
Missing/unknown/other	51	2.6

Table 123: Distribution of polyethylene used for Secur-Fit Max/Trident cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	1562	100.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 124: Reasons for revision for Secur-Fit Max/Trident.

Rank	Reason for revision	N	Percent
1	Peri-prosthetic fracture (Femur)	20	44.4
2	Joint Infection	10	22.2
3	Aseptic loosening	7	15.6
4	Instability/Dislocation	4	8.9
5	Peri-prosthetic fracture (Acetabulum)	2	4.4
6	Pain	1	2.2
7	Malalignment	1	2.2

Secur-Fit Plus Max/Trident
N=1909

30 surgeons across 18 sites use this implant combination.

Table 125: Volume of cases by surgeon and site for Secur-Fit Plus Max/Trident.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	63.6 (195.6)	10 (53)
Cases per site	106.1 (270.8)	18.5 (97)

Table 126: Descriptive statistics of patients receiving Secur-Fit Plus Max/Trident.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	946	49.55	
Age (yrs)	1909	61.92(13.19)	63.00(16.00)
Height (cm)	1909	169.59(10.68)	170.00(15.00)
Weight (kg)	1909	86.91(19.78)	86.00(27.00)
BMI(kg/m^2)	1909	30.11(6.13)	29.52(7.12)
Smoking - never (%)	911	47.72	
Smoking - previous (%)	701	36.72	
Smoking - current (%)	255	13.36	
Smoking - unknown (%)	42	2.2	

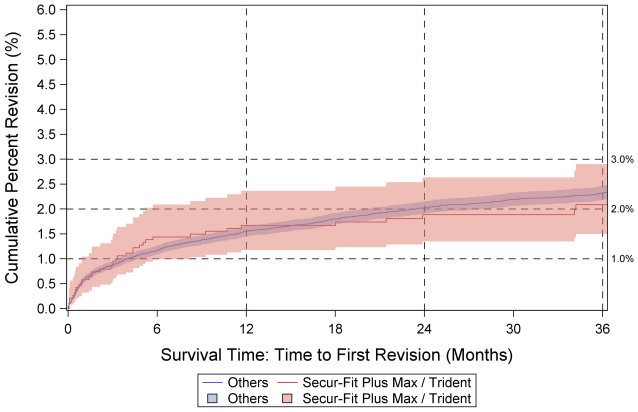

Figure 36: Cumulative percent revision curve for Secur-Fit Plus Max/Trident compared to all other conventional THA implants.

Table 127: Cumulative percent revision for Secur-Fit Plus Max/Trident compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
1902	1.67 (1.18,2.37)	1.88 (1.35,2.63)	2.09 (1.50,2.90)

Table 128: Distribution of approach used for Secur-Fit Plus Max/Trident.

Approach	N	Percent
Anterior	2	0.1
Anterolateral	90	4.7
Posterior	1808	94.7
Transtrochanteric	4	0.2
Missing/unknown/other	5	0.3

Table 129: Distribution of head size for Secur-Fit Plus Max/Trident.

Size (mm)	N	Percent
28	1	0.1
32	147	7.9
36	1404	75.8
40	259	14.0
44	38	2.0
Missing/unknown/other	4	0.2

Table 130: Distribution of bearing surface for Secur-Fit Plus Max/Trident.

Bearing	N	Percent
Metal-on-plastic	1141	59.8
Ceramic-on-plastic	708	37.1
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	47	2.5
Missing/unknown/other	13	0.7

Table 131: Distribution of polyethylene used for Secur-Fit Plus Max/Trident cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	1899	100.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 132: Reasons for revision for Secur-Fit Plus Max/Trident.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	8	30.8
2	Peri-prosthetic fracture (Femur)	8	30.8
3	Joint Infection	5	19.2
4	Aseptic loosening	3	11.5
5	Component fracture/failure	1	3.8
6	Pain	1	3.8

Summit/Pinnacle
N=4636

57 surgeons across 27 sites use this implant combination.

Table 133: Volume of cases by surgeon and site for Summit/Pinnacle.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	81.3 (163.8)	23 (116)
Cases per site	171.7 (256.1)	47 (254)

Table 134: Descriptive statistics of patients receiving Summit/Pinnacle.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	2626	56.64	
Age (yrs)	4636	65.36(11.15)	66.00(15.00)
Height (cm)	4635	169.19(10.32)	170.00(15.00)
Weight (kg)	4636	89.07(21.93)	87.00(30.00)
BMI(kg/m^2)	4635	30.99(6.57)	30.04(8.42)
Smoking - never (%)	2063	44.5	
Smoking - previous (%)	1883	40.62	
Smoking - current (%)	673	14.52	
Smoking - unknown (%)	17	0.37	

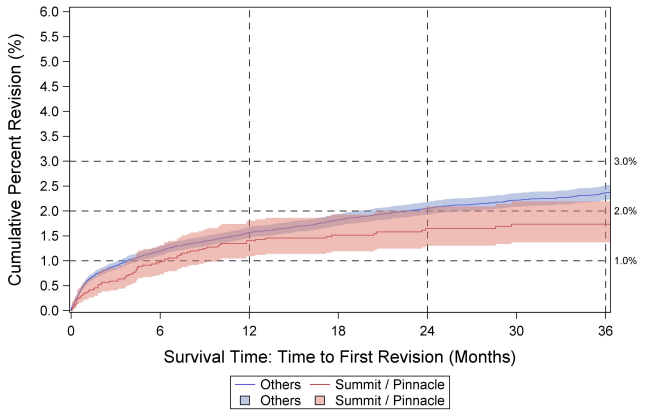

Figure 37: Cumulative percent revision curve for Summit/Pinnacle compared to all other conventional THA implants.

Table 135: Cumulative percent revision for Summit/Pinnacle compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
4631	1.40 (1.09,1.80)	1.65 (1.30,2.09)	1.73 (1.37,2.19)

Table 136: Distribution of approach used for Summit/Pinnacle.

Approach	N	Percent
Anterior	137	3.0
Anterolateral	1975	42.6
Posterior	2471	53.3
Transtrochanteric	30	0.7
Missing/unknown/other	23	0.5

Table 137: Distribution of head size for Summit/Pinnacle.

Size (mm)	N	Percent
28	12	0.3
32	1159	25.1
36	3162	68.5
40	238	5.2
44	24	0.5
Missing/unknown/other	23	0.5

Table 138: Distribution of bearing surface for Summit/Pinnacle.

Bearing	N	Percent
Metal-on-plastic	2389	51.5
Ceramic-on-plastic	2161	46.6
Ceramic-on-ceramic	46	1.0
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	40	0.9

Table 139: Distribution of polyethylene used for Summit/Pinnacle cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	4570	100.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 140: Reasons for revision for Summit/Pinnacle.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	15	27.8
2	Peri-prosthetic fracture (Femur)	11	20.4
3	Joint Infection	9	16.7
4	Pain	8	14.8
5	Aseptic loosening	6	11.1
6	Peri-prosthetic fracture (Acetabulum)	3	5.6
7	Unknown/missing	2	3.7

Synergy/Reflection 3
N=725

25 surgeons across 20 sites use this implant combination.

Table 141: Volume of cases by surgeon and site for Synergy/Reflection 3.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	29 (46.9)	6 (39)
Cases per site	36.3 (69.8)	7 (22)

Table 142: Descriptive statistics of patients receiving Synergy/Reflection 3.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	390	53.79	
Age (yrs)	725	67.81(10.59)	68.00(16.00)
Height (cm)	725	168.92(10.90)	168.00(17.00)
Weight (kg)	725	88.77(21.09)	88.00(30.00)
BMI(kg/m^2)	725	30.96(6.17)	30.37(8.49)
Smoking - never (%)	299	41.24	
Smoking - previous (%)	319	44	
Smoking - current (%)	104	14.34	
Smoking - unknown (%)	3	0.41	

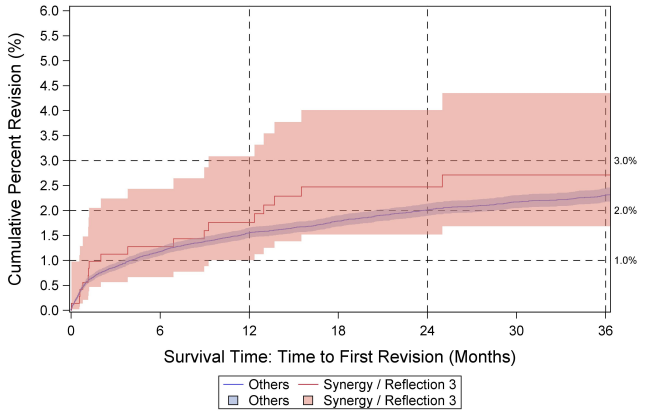

Figure 38: Cumulative percent revision curve for Synergy/Reflection 3 compared to all other conventional THA implants.

Table 143: Cumulative percent revision for Synergy/Reflection 3 compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
724	1.76 (1.00,3.09)	2.47 (1.52,4.01)	2.71 (1.68,4.35)

Table 144: Distribution of approach used for Synergy/Reflection 3.

Approach	N	Percent
Anterior	11	1.5
Anterolateral	218	30.1
Posterior	491	67.7
Transtrochanteric	3	0.4
Missing/unknown/other	2	0.3

Table 145: Distribution of head size for Synergy/Reflection 3.

Size (mm)	N	Percent
22	1	0.1
28	8	1.1
32	172	23.7
36	474	65.4
40	64	8.8
44	4	0.6
Missing/unknown/other	2	0.3

Table 146: Distribution of bearing surface for Synergy/Reflection 3.

Bearing	N	Percent
Metal-on-plastic	359	49.5
Ceramic-on-plastic	364	50.2
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	2	0.3

Table 147: Distribution of polyethylene used for Synergy/Reflection 3 cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	2	0.3
XLPE	723	99.7
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 148: Reasons for revision for Synergy/Reflection 3.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	7	63.6
2	Joint Infection	2	18.2
3	Pain	2	18.2

Taperloc 133/G7
N=3344

62 surgeons across 34 sites use this implant combination.

Table 149: Volume of cases by surgeon and site for Taperloc 133/G7.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	53.9 (93.7)	20.5 (50)
Cases per site	98.4 (128.7)	53.5 (123)

Table 150: Descriptive statistics of patients receiving Taperloc 133/G7.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1799	53.8	
Age (yrs)	3344	63.24(10.91)	63.00(14.00)
Height (cm)	3344	169.56(10.30)	170.00(15.00)
Weight (kg)	3344	89.34(20.49)	88.00(28.00)
BMI(kg/m^2)	3344	30.96(6.07)	30.46(8.14)
Smoking - never (%)	1558	46.59	
Smoking - previous (%)	1277	38.19	
Smoking - current (%)	492	14.71	
Smoking - unknown (%)	17	0.51	

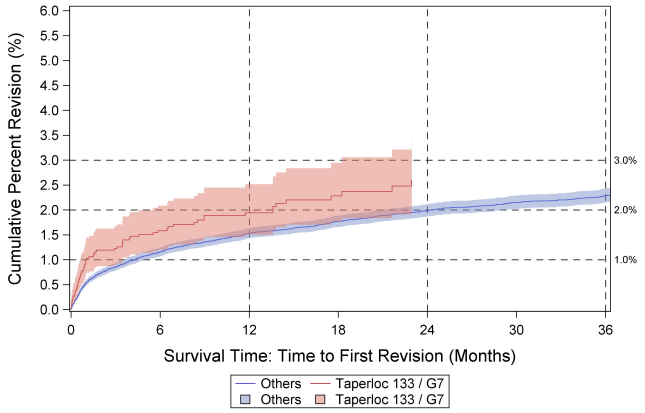

Figure 39: Cumulative percent revision curve for Taperloc 133/G7 compared to all other conventional THA implants.

Table 151: Cumulative percent revision for Taperloc 133/G7 compared to all other conventional THA implants (numerical values).

N	1 year	2 years*	3 years*
3338	1.94 (1.50,2.52)	2.61 (2.00,3.39)	2.61 (2.00,3.39)

* No revision occurred after the termination of the red curve in figure above; therefore, numerical revision risk at this time point is the same as it was at the time of the last revision.

Table 152: Distribution of approach used for Taperloc 133/G7.

Approach	N	Percent
Anterior	1062	31.8
Anterolateral	784	23.4
Posterior	1488	44.5
Transtrochanteric	3	0.1
Missing/unknown/other	7	0.2

Table 153: Distribution of head size for Taperloc 133/G7.

Size (mm)	N	Percent
28	4	0.1
32	306	9.3
36	2236	67.9
40	727	22.1
44	1	0.0
Missing/unknown/other	17	0.5

Table 154: Distribution of bearing surface for Taperloc 133/G7.

Bearing	N	Percent
Metal-on-plastic	994	29.7
Ceramic-on-plastic	2280	68.2
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	26	0.8
Missing/unknown/other	44	1.3

Table 155: Distribution of polyethylene used for Taperloc 133/G7 cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	1101	33.2
Antioxidant XLPE	2216	66.8
Missing/unknown/other	0	0.0

Table 156: Reasons for revision for Taperloc 133/G7.

Rank	Reason for revision	N	Percent
1	Peri-prosthetic fracture (Femur)	22	34.9
2	Instability/Dislocation	15	23.8
3	Joint Infection	9	14.3
4	Aseptic loosening	8	12.7
5	Component fracture/failure	4	6.3
6	Pain	4	6.3
7	Malalignment	1	1.6

Taperloc 133/Regenerex RingLoc+
N=529

21 surgeons across 17 sites use this implant combination.

Table 157: Volume of cases by surgeon and site for Taperloc 133/Regenerex RingLoc+.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	25.2 (49.5)	4 (11)
Cases per site	31.1 (58.5)	6 (16)

Table 158: Descriptive statistics of patients receiving Taperloc 133/Regenerex RingLoc+.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	290	54.82	
Age (yrs)	529	63.14(11.28)	63.00(14.00)
Height (cm)	529	169.61(10.24)	170.00(15.00)
Weight (kg)	529	90.75(22.77)	89.00(30.00)
BMI(kg/m^2)	529	31.43(7.09)	30.10(9.44)
Smoking - never (%)	230	43.48	
Smoking - previous (%)	168	31.76	
Smoking - current (%)	128	24.2	
Smoking - unknown (%)	3	0.57	

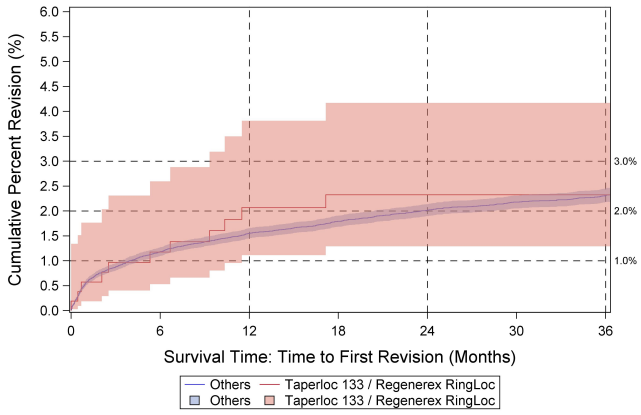

Figure 40: Cumulative percent revision curve for Taperloc 133/Regenerex RingLoc+ compared to all other conventional THA implants.

Table 159: Cumulative percent revision for Taperloc 133/Regenerex RingLoc+ compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
526	2.06 (1.11,3.81)	2.32 (1.29,4.17)	2.32 (1.29,4.17)

Table 160: Distribution of approach used for Taperloc 133/Regenerex RingLoc+.

Approach	N	Percent
Anterior	83	15.7
Anterolateral	337	63.7
Posterior	104	19.7
Transtrochanteric	2	0.4
Missing/unknown/other	3	0.6

Table 161: Distribution of head size for Taperloc 133/Regenerex RingLoc+.

Size (mm)	N	Percent
28	4	0.8
32	77	14.6
36	308	58.6
40	128	24.3
Missing/unknown/other	9	1.7

Table 162: Distribution of bearing surface for Taperloc 133/Regenerex RingLoc+.

Bearing	N	Percent
Metal-on-plastic	338	63.9
Ceramic-on-plastic	179	33.8
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	12	2.3

Table 163: Distribution of polyethylene used for Taperloc 133/Regenerex RingLoc+ cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	1	0.2
XLPE	190	36.1
Antioxidant XLPE	335	63.7
Missing/unknown/other	0	0.0

Table 164: Reasons for revision for Taperloc 133/Regenerex RingLoc+.

Rank	Reason for revision	N	Percent
1	Joint Infection	3	27.3
2	Aseptic loosening	2	18.2
3	Peri-prosthetic fracture (Femur)	2	18.2
4	Pain	2	18.2
5	Instability/Dislocation	1	9.1
6	Malalignment	1	9.1

Taperloc 133/RingLoc+
N=1410

23 surgeons across 17 sites use this implant combination.

Table 165: Volume of cases by surgeon and site for Taperloc 133/RingLoc+.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	61.3 (89)	9 (161)
Cases per site	82.9 (119.0)	16 (147)

Table 166: Descriptive statistics of patients receiving Taperloc 133/RingLoc+.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	744	52.77	
Age (yrs)	1410	65.16(10.35)	66.00(14.00)
Height (cm)	1410	169.63(10.48)	170.00(15.00)
Weight (kg)	1410	90.18(21.73)	88.00(28.00)
BMI(kg/m^2)	1410	31.22(6.42)	30.46(8.52)
Smoking - never (%)	632	44.82	
Smoking - previous (%)	565	40.07	
Smoking - current (%)	192	13.62	
Smoking - unknown (%)	21	1.49	

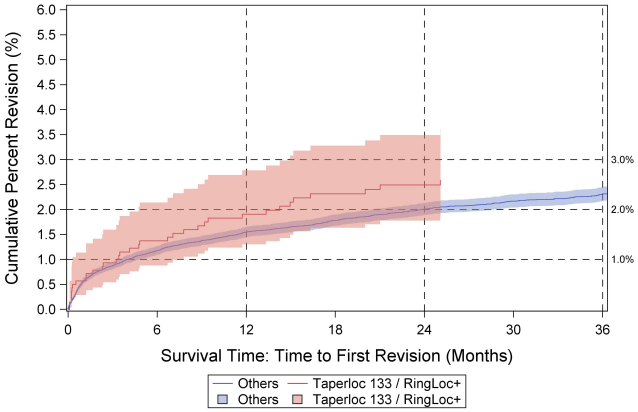

Figure 41: Cumulative percent revision curve for Taperloc 133/RingLoc+ compared to all other conventional THA implants.

Table 167: Cumulative percent revision for Taperloc 133/RingLoc+ compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years*
1405	1.90 (1.30,2.79)	2.49 (1.78,3.49)	2.59 (1.85,3.61)

* No revision occurred after the termination of the red curve in figure above; therefore, numerical revision risk at this time point is the same as it was at the time of the last revision.

Table 168: Distribution of approach used for Taperloc 133/RingLoc+.

Approach	N	Percent
Anterior	155	11.0
Anterolateral	640	45.4
Posterior	602	42.7
Transtrochanteric	7	0.5
Missing/unknown/other	6	0.4

Table 169: Distribution of head size for Taperloc 133/RingLoc+.

Size (mm)	N	Percent
32	79	5.6
36	832	59.2
40	411	29.2
44	66	4.7
Missing/unknown/other	18	1.3

Table 170: Distribution of bearing surface for Taperloc 133/RingLoc+.

Bearing	N	Percent
Metal-on-plastic	803	57.0
Ceramic-on-plastic	585	41.5
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	22	1.6

Table 171: Distribution of polyethylene used for Taperloc 133/RingLoc+ cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	3	0.2
XLPE	119	8.5
Antioxidant XLPE	1284	91.3
Missing/unknown/other	0	0.0

Table 172: Reasons for revision for Taperloc 133/RingLoc+.

Rank	Reason for revision	N	Percent
1	Peri-prosthetic fracture (Femur)	6	24.0
2	Instability/Dislocation	5	20.0
3	Joint Infection	5	20.0
4	Aseptic loosening	4	16.0
5	Other	5	20.0

Trabecular Metal/Continuum
N=598

13 surgeons across 12 sites use this implant combination.

Table 173: Volume of cases by surgeon and site for Trabecular Metal/Continuum.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	46 (65.7)	6 (66)
Cases per site	49.8 (73.0)	7.5 (80)

Table 174: Descriptive statistics of patients receiving Trabecular Metal/Continuum.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	323	54.01	
Age (yrs)	598	66.04(10.96)	66.00(16.00)
Height (cm)	598	169.39(10.80)	170.00(16.00)
Weight (kg)	598	89.54(21.92)	88.00(28.00)
BMI(kg/m^2)	598	31.04(6.39)	29.93(8.34)
Smoking - never (%)	250	41.81	
Smoking - previous (%)	254	42.47	
Smoking - current (%)	93	15.55	
Smoking - unknown (%)	1	0.17	

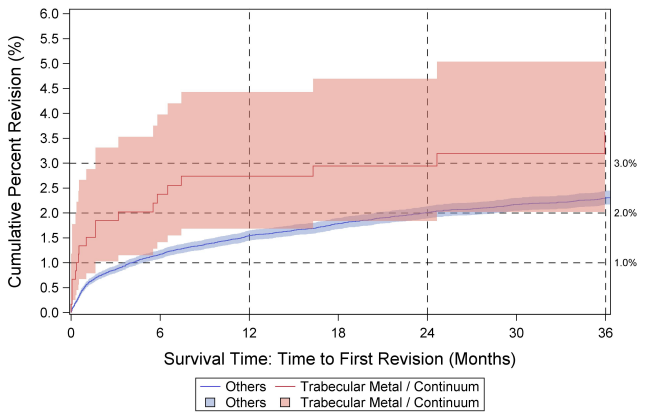

Figure 42: Cumulative percent revision curve for Trabecular Metal/Continuum compared to all other conventional THA implants.

Table 175: Cumulative percent revision for Trabecular Metal/Continuum compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
597	2.74 (1.68,4.43)	2.94 (1.84,4.69)	3.63 (2.28,5.76)

Table 176: Distribution of approach used for Trabecular Metal/Continuum.

Approach	N	Percent
Anterior	2	0.3
Anterolateral	512	85.6
Posterior	82	13.7
Transtrochanteric	1	0.2
Missing/unknown/other	1	0.2

Table 177: Distribution of head size for Trabecular Metal/Continuum.

Size (mm)	N	Percent
28	8	1.3
32	258	43.2
36	307	51.4
40	21	3.5
Missing/unknown/other	3	0.5

Table 178: Distribution of bearing surface for Trabecular Metal/Continuum.

Bearing	N	Percent
Metal-on-plastic	297	49.7
Ceramic-on-plastic	297	49.7
Ceramic-on-ceramic	0	0.0
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	4	0.7

Table 179: Distribution of polyethylene used for Trabecular Metal/Continuum cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	532	89.1
Antioxidant XLPE	65	10.9
Missing/unknown/other	0	0.0

Table 180: Reasons for revision for Trabecular Metal/Continuum.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	5	35.7
2	Pain	5	35.7
3	Aseptic loosening	2	14.3
4	Peri-prosthetic fracture (Femur)	2	14.3

Tri-Lock BPS/Pinnacle
N=1623

40 surgeons across 21 sites use this implant combination.

Table 181: Volume of cases by surgeon and site for Tri-Lock BPS/Pinnacle.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	40.6 (93.7)	8 (38)
Cases per site	77.3 (162.4)	14 (77)

Table 182: Descriptive statistics of patients receiving Tri-Lock BPS/Pinnacle.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	923	56.87	
Age (yrs)	1623	65.02(10.34)	65.00(14.00)
Height (cm)	1622	169.74(10.04)	170.00(16.00)
Weight (kg)	1623	86.02(19.20)	84.00(27.00)
BMI(kg/m^2)	1622	29.74(5.60)	29.15(7.73)
Smoking - never (%)	781	48.12	
Smoking - previous (%)	640	39.43	
Smoking - current (%)	191	11.77	
Smoking - unknown (%)	11	0.68	

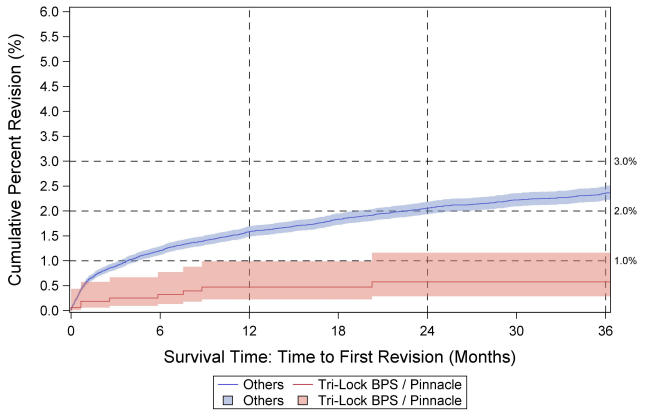

Figure 43: Cumulative percent revision curve for Tri-Lock BPS/Pinnacle compared to all other conventional THA implants.

Table 183: Cumulative percent revision for Tri-Lock BPS/Pinnacle compared to all other conventional THA implants (numerical values).

N	1 year	2 years	3 years
1619	0.47 (0.22,0.99)	0.58 (0.29,1.16)	0.58 (0.29,1.16)

Table 184: Distribution of approach used for Tri-Lock BPS/Pinnacle.

Approach	N	Percent
Anterior	889	54.8
Anterolateral	277	17.1
Posterior	454	28.0
Transtrochanteric	1	0.1
Missing/unknown/other	2	0.1

Table 185: Distribution of head size for Tri-Lock BPS/Pinnacle.

Size (mm)	N	Percent
28	5	0.3
32	659	40.8
36	904	55.9
40	42	2.6
Missing/unknown/other	7	0.4

Table 186: Distribution of bearing surface for Tri-Lock BPS/Pinnacle.

Bearing	N	Percent
Metal-on-plastic	898	55.3
Ceramic-on-plastic	667	41.1
Ceramic-on-ceramic	45	2.8
Metal-on-metal	0	0.0
Dual mobility	0	0.0
Missing/unknown/other	13	0.8

Table 187: Distribution of polyethylene used for Tri-Lock BPS/Pinnacle cases in which polyethylene liners were used.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	1572	100.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	0	0.0

Table 188: Reasons for revision for Tri-Lock BPS/Pinnacle.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	3	30.0
2	Joint Infection	3	30.0
3	Aseptic loosening	2	20.0
4	Peri-prosthetic fracture (Femur)	2	20.0

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Chapter 3

Total knee arthroplasty statistics, devices, and revisions

The data reported in this chapter is based on primary knee cases performed from 2/15/2012 to 12/31/2017. For detailed information on each figure and table (date ranges and inclusion/exclusion criteria), see the online supplement *MARCQI Six-Year Report Specifications* available at MARCQI annual reports web page.

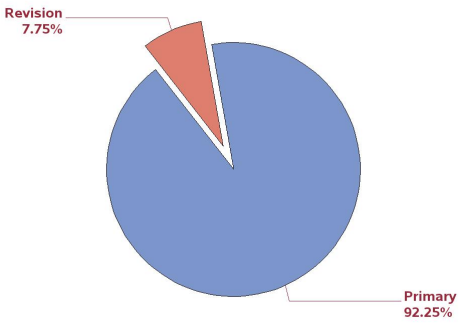

Figure 45: Percent of knee arthroplasty cases by primary or revision.

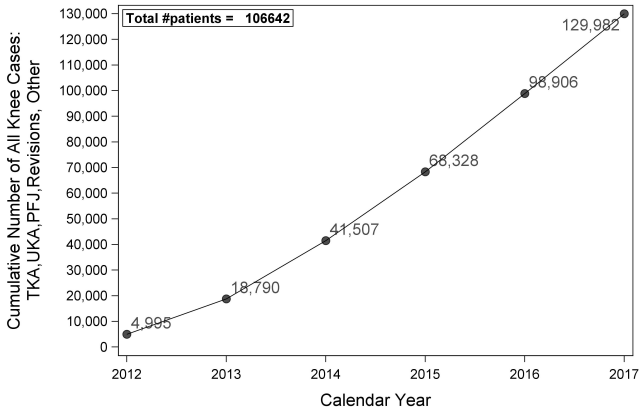

Figure 44: All knee cases over time.

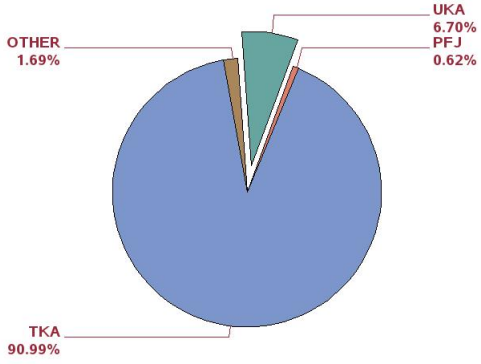

Figure 46: Percent of primary TKA cases performed as TKA, UKA, and PFJ.

3.1 TKA descriptive statistics

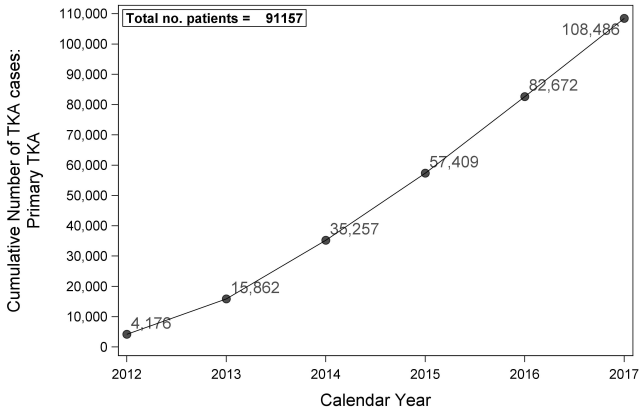

Figure 47: Primary TKA cases over time.

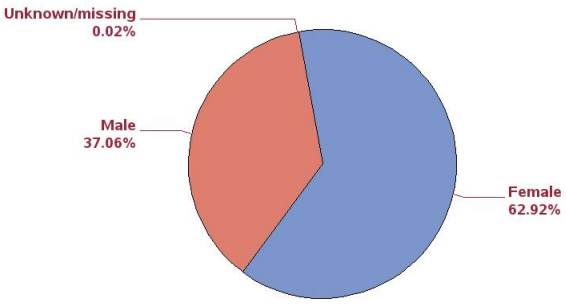

Figure 48: Percent of primary TKA cases by sex.

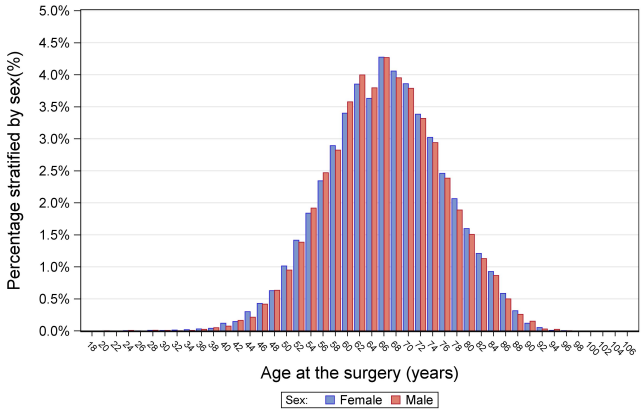

Figure 49: Age distribution of primary TKA cases by sex.

Table 189: Descriptive statistics of patients in TKA cases.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	68261	62.9	
Age (yrs)	108486	66.2(9.5)	66(13)
Height (cm)	108477	168(10.5)	167(15)
Weight (kg)	108477	94.3(21.8)	92(29)
BMI(kg/m^2)	108475	33.4(7)	32.5(9.3)
Smoking - never (%)	55854	51.5	
Smoking - previous (%)	42035	38.8	
Smoking - current (%)	9878	9.1	
Smoking - unknown (%)	719	0.7	

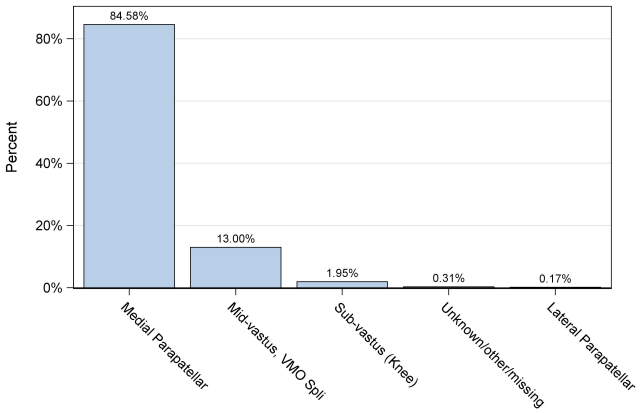

Figure 50: Percent of primary TKA cases by approach.

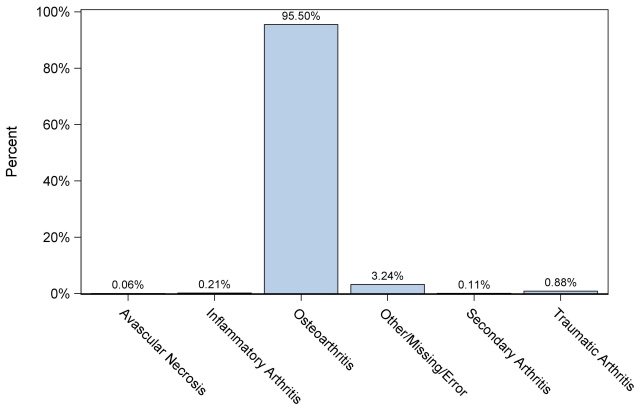

Figure 51: Percent of primary TKA cases by diagnosis.

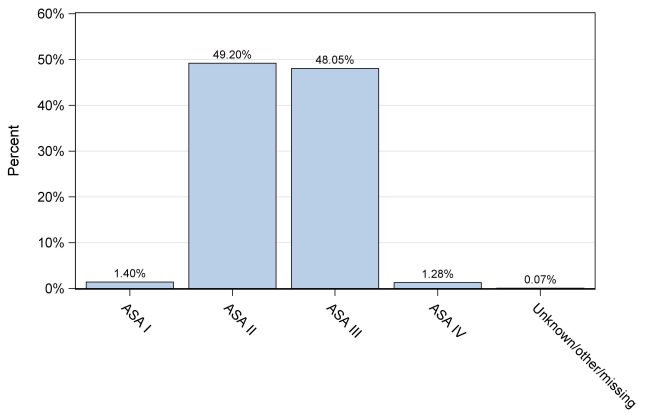

Figure 52: Percent of primary TKA cases by ASA class.

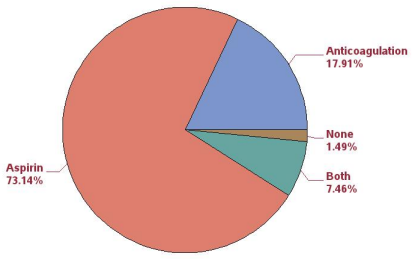

Figure 53: Percent of primary TKA patients (first case) by thrombosis pharmacoprophylaxis between 10/1/2017 and 12/31/2017 (this time window is shorter than rest of figures because of significant change over time).

3.2 Most commonly used TKA implants

The following three tables provide utilization data of implants used in primary TKA.

Table 190: Ten most commonly used femoral components in primary TKA.

Rank	Femoral component	N	Percent
1	Triathlon	28556	26.3
2	Persona	25569	23.6
3	Vanguard	16266	15.0
4	Attune	6613	6.1
5	Genesis II	6428	5.9
6	Sigma PFC	3509	3.2
7	Journey II	2596	2.4
8	NK II GS	2089	1.9
9	Sigma	2080	1.9
10	NexGen LPS Option	2079	1.9
11	Others	12701	11.7

Table 191: Ten most commonly used tibial components in primary TKA

Rank	Tibial component	N	Percent
1	Persona	25258	23.3
2	Maxim	15215	14.0
3	Triathlon	14845	13.7
4	Triathlon TS	13851	12.8
5	Genesis II	7497	6.9
6	Attune	6363	5.9
7	Sigma	4111	3.8
8	NK II	3032	2.8
9	NexGen Precoat	2588	2.4
10	Journey	2521	2.3
11	Others	13205	12.2

Table 192: Ten most commonly used femoral/tibial component combinations in primary TKA.

Rank	Femural/tibial component combination	N	Percent
1	Persona / Persona	25251	23.3
2	Vanguard / Maxim	15195	14.0
3	Triathlon / Triathlon	14829	13.7
4	Triathlon / Triathlon TS	13667	12.6
5	Attune / Attune	6363	5.9
6	Genesis II / Genesis II	6356	5.9
7	Sigma PFC / Sigma	2734	2.5
8	Journey II / Journey	2507	2.3
9	NK II GS / NK II	2071	1.9
10	Sigma / Sigma	1366	1.3
11	Others	18147	16.6

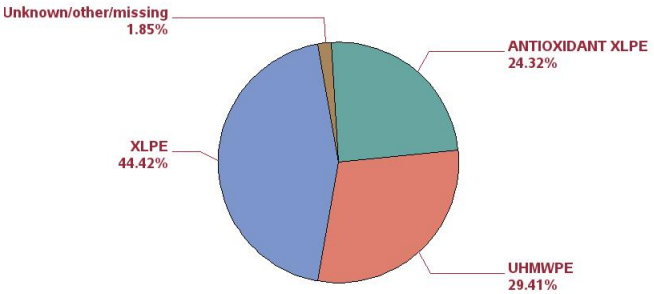

Figure 54: Percent of polyethylene inserts by type of polyethylene in primary TKA.

3.3 TKA revision risk summary

Reason for revision is of central importance to quality improvement because it helps focus attention on specific causes that may be addressed. Therefore, the data are presented in two formats below: tabular and Pareto chart.

The tabular format is consistent with how other arthroplasty registries report cause of revision. The Pareto chart figure presents the same data in a format commonly used in quality improvement. The Pareto chart sorts the reasons for revision by frequency (bar chart on bottom, from left to right) and presents a cumulative percent using a line graph above. The causes corresponding to each bar are numbered and a key at the bottom links the numbers to text descriptions. In addition to an overall summary of reason for revision, tables showing reason for revision for the first, second, and third year post-operatively are provided because the reasons change over this time horizon. It is important to note that the time window for the cases reported in reasons for revision tables and figures differ from the time window used for other figures because reason for revision was added to the database on 1/1/2015. While these data capture revisions for primaries performed back to 2/15/2012, only revisions occurring on or after 1/1/2015 are included in the reasons for revision figure and tables. Also note that for knees instability/dislocation should be interpreted as instability.

Table 193: Reasons for first revision following TKA.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	446	28.0
2	Joint Infection	363	22.8
3	Pain	254	16.0
4	Aseptic loosening	242	15.2
5	Arthrofibrosis	110	6.9
6	Component fracture/failure	57	3.6
7	Malalignment	30	1.9
8	Peri-prosthetic fracture (Femur)	28	1.8
9	Metal reaction/Metallosis	18	1.1
10	Extensor mechanism failure	14	0.9
11	Peri-prosthetic fracture (Tibia)	11	0.7
12	Poly liner wear	9	0.6
13	Patellofemoral joint	3	0.2
14	Osteolysis	1	0.1
15	Missing/unknown/other	6	0.4

Table 194: Reasons for first revision following primary TKA in first year post-operatively.

Rank	Reason for revision	N	Percent
1	Joint Infection	182	27.8
2	Instability/Dislocation	175	26.8
3	Pain	94	14.4
4	Arthrofibrosis	66	10.1
5	Aseptic loosening	47	7.2
6	Peri-prosthetic fracture (Femur)	22	3.4
7	Component fracture/failure	19	2.9
8	Malalignment	17	2.6
9	Extensor mechanism failure	10	1.5
10	Peri-prosthetic fracture (Tibia)	8	1.2
11	Metal reaction/Metallosis	5	0.8
12	Poly liner wear	3	0.5
13	Patellofemoral joint	1	0.2
14	Missing/unknown/other	5	0.8

Table 195: Reasons for first revision following primary TKA in second year post-operatively.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	159	29.2
2	Joint Infection	109	20.0
3	Pain	106	19.4
4	Aseptic loosening	95	17.4
5	Arthrofibrosis	25	4.6
6	Component fracture/failure	22	4.0
7	Metal reaction/Metallosis	7	1.3
8	Malalignment	7	1.3
9	Poly liner wear	4	0.7
10	Peri-prosthetic fracture (Femur)	4	0.7
11	Extensor mechanism failure	4	0.7
12	Peri-prosthetic fracture (Tibia)	1	0.2
13	Patellofemoral joint	1	0.2
14	Unknown/other/missing	1	0.2

Table 196: Reasons for first revision following primary TKA in third year post-operatively.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	75	28.8
2	Aseptic loosening	62	23.8
3	Joint Infection	51	19.6
4	Pain	43	16.5
5	Arthrofibrosis	10	3.8
6	Component fracture/failure	9	3.5
7	Metal reaction/Metallosis	4	1.5
8	Malalignment	4	1.5
9	Poly liner wear	1	0.4
10	Patellofemoral joint	1	0.4

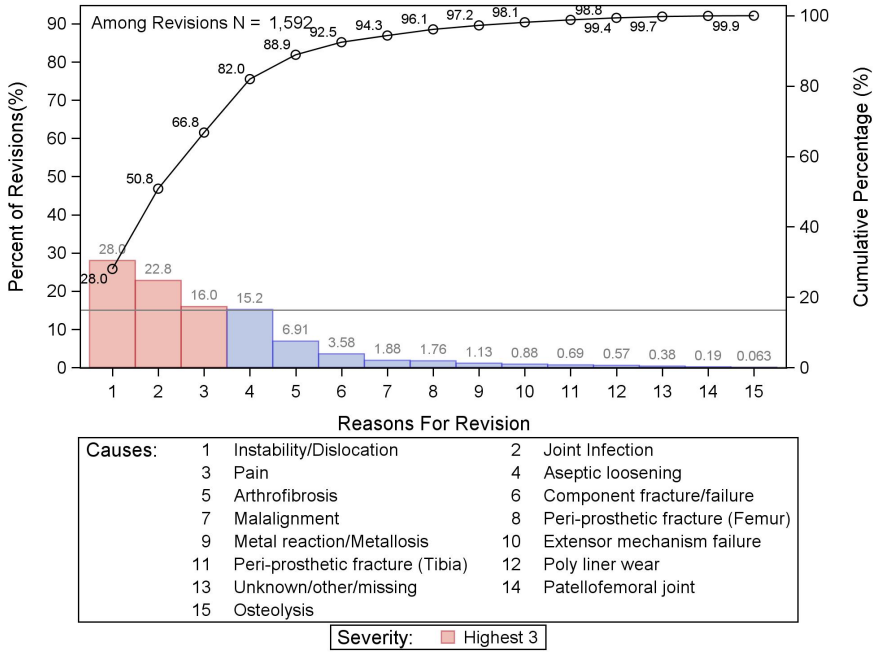

Figure 55: Most common reasons for first revision following primary TKA (Pareto chart).

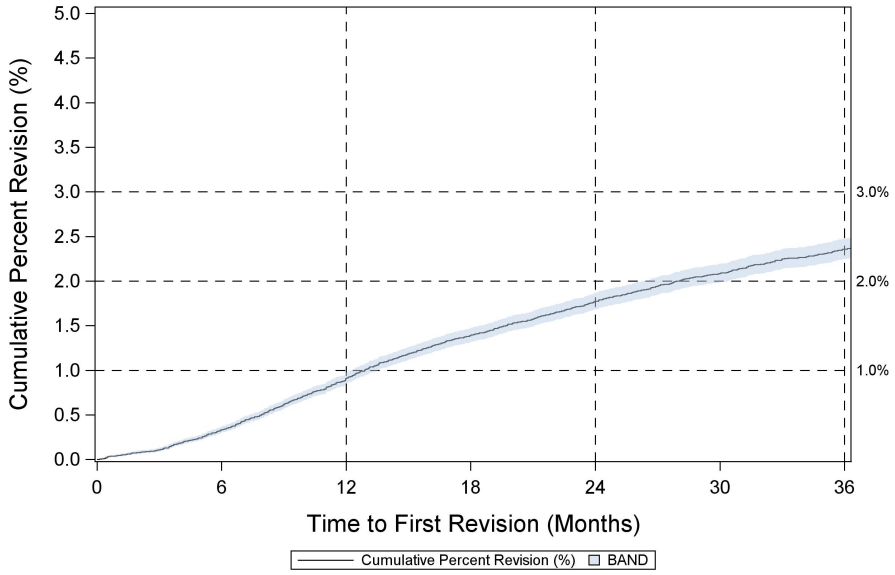

Figure 56: Cumulative percent revision for primary TKA.

Table 197: Cumulative percent revision for primary TKA (numerical values).

N	1 year	2 years	3 years
108486	0.91 (0.85,0.97)	1.77 (1.68,1.86)	2.36 (2.24,2.47)

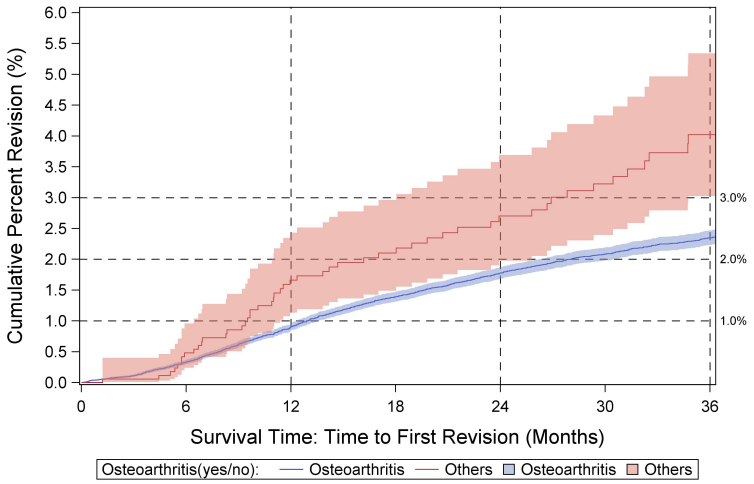

Figure 57: Cumulative percent revision for primary TKA by diagnosis.

Table 198: Cumulative percent revision for primary TKA by diagnosis (numerical values).

Diagnosis	N	1 year	2 years	3 years
Osteoarthritis	103464	0.90 (0.84,0.97)	1.77 (1.68,1.87)	2.35 (2.23,2.47)
Others	1809	1.66 (1.13,2.43)	2.70 (1.98,3.69)	4.02 (3.02,5.34)
Unknown/Missing	3067			

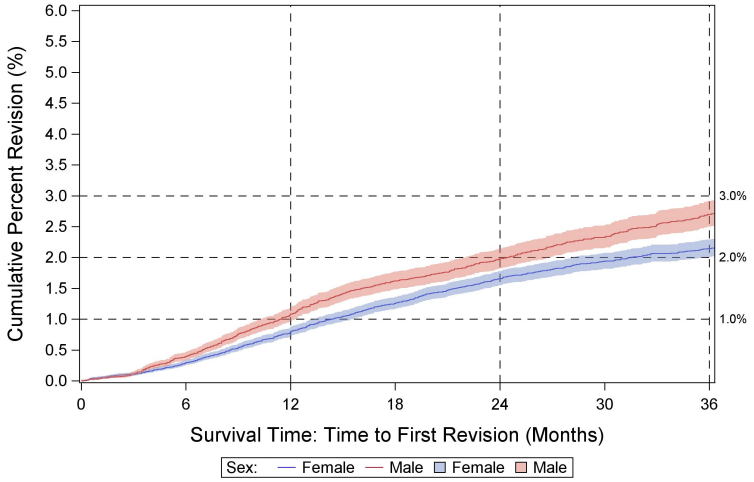

Figure 58: Cumulative percent revision for primary TKA by sex for osteoarthritis diagnosis.

Table 199: Cumulative percent revision for primary TKA by sex for osteoarthritis diagnosis (numerical values).

Sex	N	1 year	2 years	3 years
Female	65497	0.80 (0.73,0.88)	1.66 (1.55,1.78)	2.14 (2.01,2.29)
Male	37944	1.08 (0.98,1.20)	1.98 (1.82,2.15)	2.70 (2.50,2.92)
Unknown/Missing	23			

3.4 Revision risk for TKA implant combinations

As with hip implants, there is substantial variation in revision risk across TKA implants. The same caveats about interpreting CPR data provided in chapter 2 also apply to the interpretation of CPR data for knees. Specifically, note that all implant combinations have a minimum follow up of at least three years. Therefore, if the red line and shaded confidence interval end prior to three years, this does not mean the longest follow up was less than three years. Instead, it means that no additional revisions occurred after the end of the red line and confidence interval band.

As with the section on hip implants, the reader should go to the online supplement describing each table and figure to understand inclusion and exclusion criteria.

While the reader is encouraged to read the details of each femur/tibia implant combination, the following table summarizes the three-year CPR values.

Table 200: Cumulative percent revision risk for femoral/tibial combinations having at least 500 primary cases, sorted alphabetically.

Femur/Tibia combination	N*	1 year	2 years	3 years
Attune / Attune	6356	0.74 (0.55,1.01)	1.61 (1.28,2.02)	2.50 (1.99,3.15)
Evolution MP / Evolution MP	891	0.44 (0.14,1.38)	1.33 (0.62,2.83)	2.28 (1.20,4.33)
Genesis II / Genesis II	6338	1.27 (1.01,1.60)	2.57 (2.15,3.06)	3.39 (2.87,4.00)
Genesis II (Oxinium)/ Genesis II	4043	1.39 (1.05,1.84)	2.93 (2.38,3.60)	3.92 (3.22,4.77)
Genesis II (CoCr)/ Genesis II	2295	1.07 (0.70,1.62)	1.95 (1.41,2.71)	2.52 (1.85,3.43)
Journey II / Journey	2502	1.93 (1.39,2.66)	3.38 (2.55,4.48)	4.33 (3.27,5.73)
Journey II (Oxinium)/ Journey	2406	1.98 (1.44,2.73)	3.45 (2.60,4.57)	4.40 (3.33,5.81)
LCS Complete / M.B.T.	934	1.14 (0.59,2.19)	3.19 (2.07,4.89)	4.41 (2.92,6.63)
Legion / Genesis II	1138	1.00 (0.52,1.93)	*2.14 (1.27,3.61)*	*2.14 (1.27,3.61)*
NexGen GS / NexGen Pegged	575	1.18 (0.53,2.61)	1.18 (0.53,2.61)	1.49 (0.70,3.15)
NexGen LPS GS / NexGen Precoat	513	0.39 (0.10,1.57)	1.41 (0.67,2.93)	2.02 (1.09,3.73)
NexGen LPS Option / NexGen Precoat	640	0.50 (0.16,1.55)	1.23 (0.59,2.57)	1.44 (0.72,2.88)
NexGen LPS Option / NexGen TM	1046	0.40 (0.15,1.05)	0.50 (0.21,1.20)	0.84 (0.42,1.68)
NexGen Option / NexGen Option	993	0.44 (0.16,1.16)	0.85 (0.40,1.79)	*1.02 (0.51,2.05)*
NexGen Option / NexGen Pegged	602	0.88 (0.37,2.11)	1.70 (0.89,3.26)	2.21 (1.22,3.98)
NK II / NK II	960	0.21 (0.05,0.85)	0.56 (0.23,1.35)	0.98 (0.49,1.96)
NK II GS / NK II	2067	0.55 (0.29,1.02)	0.84 (0.49,1.42)	1.27 (0.78,2.06)
Persona / Persona	25220	0.77 (0.66,0.90)	1.80 (1.61,2.01)	2.42 (2.18,2.69)
Scorpio / Series 7000	572	0.82 (0.31,2.18)	2.65 (1.46,4.77)	4.06 (2.43,6.72)
Sigma / M.B.T.	688	1.92 (1.10,3.36)	3.06 (1.94,4.83)	3.48 (2.25,5.36)
Sigma / Sigma	1364	1.85 (1.24,2.75)	2.89 (2.09,3.99)	3.11 (2.27,4.25)
Sigma PFC / Sigma	2730	0.44 (0.24,0.79)	0.97 (0.65,1.46)	1.51 (1.07,2.12)
Triathlon / Triathlon	14802	0.93 (0.77,1.11)	1.46 (1.25,1.71)	1.98 (1.70,2.31)
Triathlon / Triathlon TS	13659	0.91 (0.75,1.10)	1.67 (1.44,1.94)	2.10 (1.82,2.43)
Vanguard / Maxim	15184	0.90 (0.75,1.08)	1.66 (1.44,1.90)	2.26 (1.98,2.57)
Vanguard / Maxim Mono-Lock	756	0.57 (0.22,1.52)	1.88 (1.04,3.39)	2.38 (1.37,4.10)

Notes:

* Number of patients that contribute to survival analysis used to compute cumulative percent revision.

A revision risk in *italics* indicates it is the same as it was at the time of the last revision.

Attune/Attune
N=6363

68 surgeons across 30 sites use this implant.

Table 201: Volume of cases by surgeon and site for Attune/Attune.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	93.6 (138.0)	19.5 (169)
Cases per site	212.1 (286.2)	56.5 (388)

Table 202: Descriptive statistics of patients receiving Attune/Attune.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	3854	60.6	
Age (yrs)	6363	65.7(9.2)	66(13)
Height (cm)	6363	168.5(10.5)	168(17)
Weight (kg)	6363	95.7(21.2)	94(27)
BMI(kg/m^2)	6363	33.7(6.7)	33(9.1)
Smoking - never (%)	3197	50.2	
Smoking - previous (%)	2467	38.8	
Smoking - current (%)	657	10.3	
Smoking - unknown (%)	42	0.7	

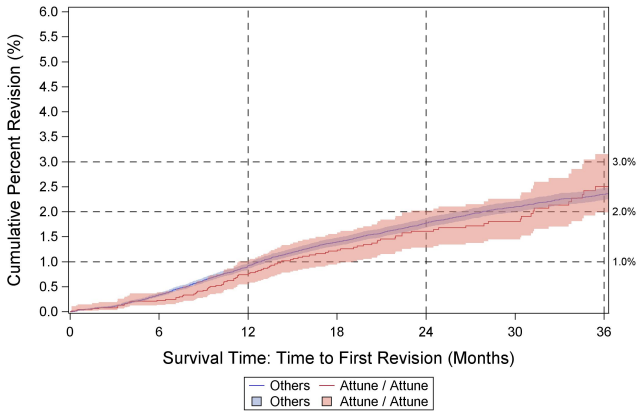

Figure 59: Cumulative percent revision curve for Attune/Attune compared to all other TKA implants.

Table 203: Cumulative percent revision for Attune/Attune compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
6356	0.74 (0.55,1.01)	1.61 (1.28,2.02)	2.50 (1.99,3.15)

Table 204: Distribution of approach used for Attune/Attune.

Approach	N	Percent
Medial parapatellar	5704	89.6
Mid-vastus	637	10.0
Sub-vastus	9	0.1
Lateral parapatellar	6	0.1
Missing/unknown/other	7	0.1

Table 205: Distribution of polyethylene used for Attune/Attune.

Polyethylene type	N	Percent
UHMWPE	1	0.0
XLPE	0	0.0
Antioxidant XLPE	6354	99.9
Missing/unknown/other	8	0.1

Table 206: Reasons for revision for Attune/Attune.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	28	30.8
2	Aseptic loosening	20	22.0
3	Joint Infection	19	20.9
4	Pain	8	8.8
5	Arthrofibrosis	6	6.6
6	Component fracture/failure	6	6.6
7	Metal reaction/Metallosis	2	2.2
8	Extensor mechanism failure	1	1.1
9	Malalignment	1	1.1

Evolution MP/Evolution MP
N=891

15 surgeons across 14 sites use this implant.

Table 207: Volume of cases by surgeon and site for Evolution MP/Evolution MP.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	59.4 (94.7)	14 (87)
Cases per site	63.6 (92.3)	32.5 (67)

Table 208: Descriptive statistics of patients receiving Evolution MP/Evolution MP.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	538	60.4	
Age (yrs)	891	65.5(9.8)	65(13)
Height (cm)	891	168.4(11.1)	167(15)
Weight (kg)	891	94.5(21.7)	92(29)
BMI(kg/m^2)	891	33.2(6.6)	32.6(8.9)
Smoking - never (%)	479	53.8	
Smoking - previous (%)	353	39.6	
Smoking - current (%)	55	6.2	
Smoking - unknown (%)	4	0.5	

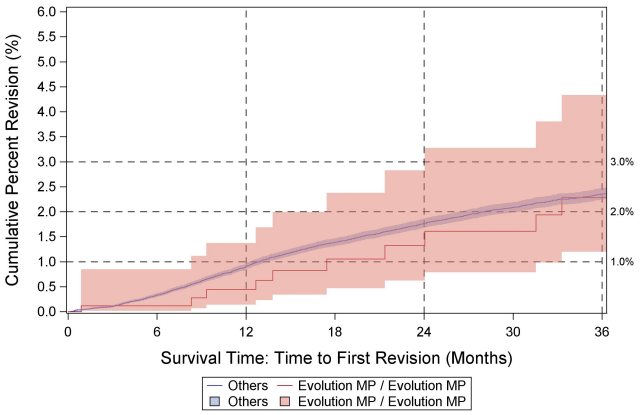

Figure 60: Cumulative percent revision curve for Evolution MP/Evolution MP compared to all other TKA implants.

Table 209: Cumulative percent revision for Evolution MP/Evolution MP compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
891	0.44 (0.14,1.38)	1.33 (0.62,2.83)	2.28 (1.20,4.33)

Table 210: Distribution of approach used for Evolution MP/Evolution MP.

Approach	N	Percent
Medial parapatellar	888	99.7
Mid-vastus	3	0.3
Sub-vastus	0	0.0
Lateral parapatellar	0	0.0
Missing/unknown/other	0	0.0

Table 211: Distribution of polyethylene used for Evolution MP/Evolution MP.

Polyethylene type	N	Percent
UHMWPE	882	99.0
XLPE	0	0.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	9	1.0

Table 212: Reasons for revision for Evolution MP/Evolution MP.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	3	30.0
2	Joint Infection	3	30.0
3	Pain	2	20.0
4	Arthrofibrosis	1	10.0
5	Aseptic loosening	1	10.0

Genesis II/Genesis II
N=6356

This page reports on both Oxinium and Cobalt Chromium versions combined. The next two pages report them separately. 166 surgeons across 52 sites use this implant.

Table 213: Volume of cases by surgeon and site for Genesis II/Genesis II.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	38.3 (69.5)	6.5 (42)
Cases per site	122.2 (155.4)	46.5 (186.5)

Table 214: Descriptive statistics of patients receiving Genesis II/Genesis II.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	3903	61.4	
Age (yrs)	6356	65.7(9.7)	66(14)
Height (cm)	6356	168.4(10.5)	167(17)
Weight (kg)	6356	96.1(22.1)	94(28)
BMI(kg/m^2)	6356	33.9(7.2)	32.9(9.7)
Smoking - never (%)	3131	49.3	
Smoking - previous (%)	2548	40.1	
Smoking - current (%)	646	10.2	
Smoking - unknown (%)	31	0.5	

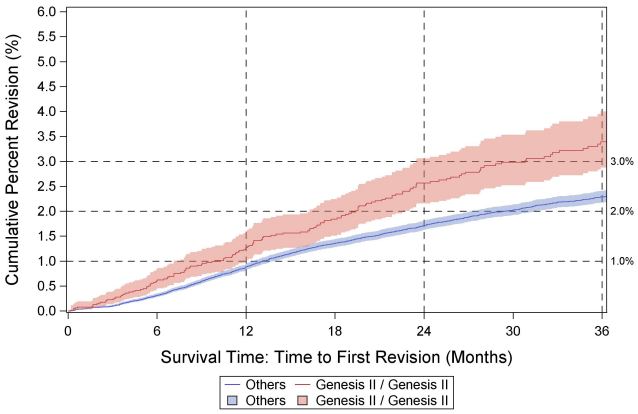

Figure 61: Cumulative percent revision curve for Genesis II/Genesis II compared to all other TKA implants.

Table 215: Cumulative percent revision for Genesis II/Genesis II compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
6338	1.27 (1.01,1.60)	2.57 (2.15,3.06)	3.39 (2.87,4.00)

Table 216: Distribution of approach used for Genesis II/Genesis II.

Approach	N	Percent
Medial parapatellar	5488	86.3
Mid-vastus	829	13.0
Sub-vastus	11	0.2
Lateral parapatellar	9	0.1
Missing/unknown/other	19	0.3

Table 217: Distribution of polyethylene used for Genesis II/Genesis II.

Polyethylene type	N	Percent
UHMWPE	1293	20.3
XLPE	4906	77.2
Antioxidant XLPE	0	0.0
Missing/unknown/other	157	2.5

Table 218: Reasons for revision for Genesis II/Genesis II.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	33	26.4
2	Aseptic loosening	25	20.0
3	Joint Infection	25	20.0
4	Pain	24	19.2
5	Arthrofibrosis	9	7.2
6	Component fracture/failure	6	4.8
7	Malalignment	1	0.8
8	Peri-prosthetic fracture (Femur)	1	0.8
9	Poly liner wear	1	0.8

Genesis II (Oxinium)/Genesis II
N=4053

This page reports on the Oxinium version. 164 surgeons across 52 sites use this implant.

Table 219: Volume of cases by surgeon and site for Genesis II (Oxinium)/Genesis II.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	24.7 (44.2)	5 (27)
Cases per site	77.9 (100.7)	29 (117.5)

Table 220: Descriptive statistics of patients receiving Genesis II (Oxinium)/Genesis II.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	2548	62.9	
Age (yrs)	4053	62.2(8.8)	62(11)
Height (cm)	4053	168.8(10.5)	167(15)
Weight (kg)	4053	98.9(22.6)	97(30)
BMI(kg/m^2)	4053	34.7(7.3)	33.9(9.9)
Smoking - never (%)	2017	49.8	
Smoking - previous (%)	1507	37.2	
Smoking - current (%)	508	12.5	
Smoking - unknown (%)	21	0.5	

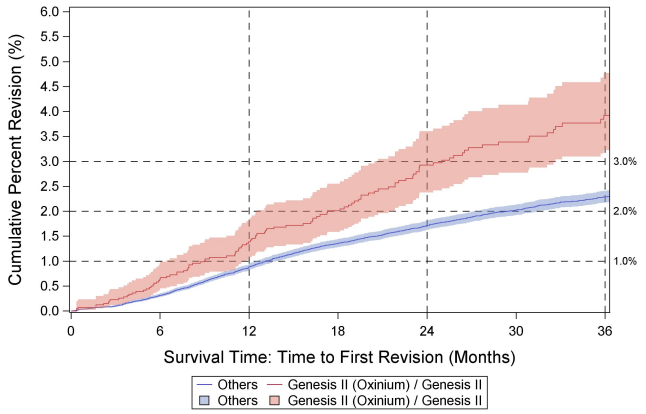

Figure 62: Cumulative percent revision curve for Genesis II (Oxinium)/Genesis II compared to all other TKA implants.

Table 221: Cumulative percent revision for Genesis II (Oxinium)/Genesis II compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
4043	1.39 (1.05,1.84)	2.93 (2.38,3.60)	3.92 (3.22,4.77)

Table 222: Distribution of approach used for Genesis II (Oxinium)/Genesis II.

Approach	N	Percent
Medial parapatellar	3379	83.4
Mid-vastus	641	15.8
Sub-vastus	10	0.2
Lateral parapatellar	6	0.1
Missing/unknown/other	17	0.4

Table 223: Distribution of polyethylene used for Genesis II (Oxinium)/Genesis II.

Polyethylene type	N	Percent
UHMWPE	300	7.4
XLPE	3640	89.8
Antioxidant XLPE	0	0.0
Missing/unknown/other	113	2.8

Table 224: Reasons for revision for Genesis II (Oxinium)/Genesis II.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	25	27.8
2	Aseptic loosening	18	20.0
3	Pain	17	18.9
4	Joint Infection	15	16.7
5	Arthrofibrosis	7	7.8
6	Component fracture/failure	5	5.6
7	Malalignment	1	1.1
8	Peri-prosthetic fracture (Femur)	1	1.1
9	Poly liner wear	1	1.1

Genesis II (CoCr)/Genesis II
N=2303

This page reports on the Cobalt Chromium (CoCr) version. 67 surgeons across 34 sites use this implant.

Table 225: Volume of cases by surgeon and site for Genesis II (CoCr)/Genesis II.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	34.4 (50.9)	12 (38)
Cases per site	67.7 (77.5)	28 (126)

Table 226: Descriptive statistics of patients receiving Genesis II (CoCr)/Genesis II.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1355	58.8	
Age (yrs)	2303	72(7.7)	72(10)
Height (cm)	2303	167.7(10.5)	167(17)
Weight (kg)	2303	91.3(20.2)	90(27)
BMI(kg/m^2)	2303	32.4(6.6)	31.6(8.7)
Smoking - never (%)	1114	48.4	
Smoking - previous (%)	1041	45.2	
Smoking - current (%)	138	6	
Smoking - unknown (%)	10	0.4	

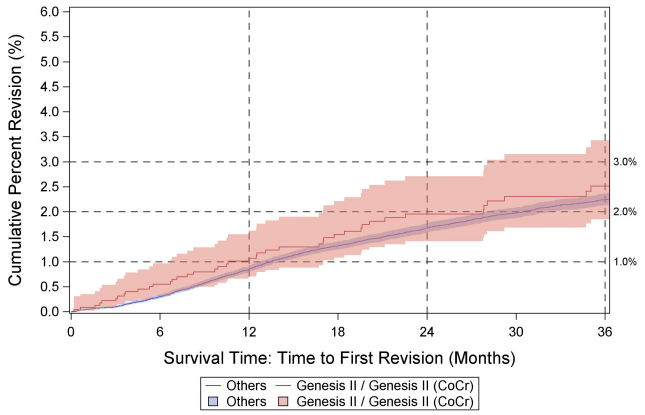

Figure 63: Cumulative percent revision curve for Genesis II (CoCr)/Genesis II compared to all other TKA implants.

Table 227: Cumulative percent revision for Genesis II (CoCr)/Genesis II compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
2295	1.07 (0.70,1.62)	1.95 (1.41,2.71)	2.52 (1.85,3.43)

Table 228: Distribution of approach used for Genesis II (CoCr)/Genesis II.

Approach	N	Percent
Medial parapatellar	2109	91.6
Mid-vastus	188	8.2
Sub-vastus	1	0.0
Lateral parapatellar	3	0.1
Missing/unknown/other	2	0.1

Table 229: Distribution of polyethylene used for Genesis II (CoCr)/Genesis II.

Polyethylene type	N	Percent
UHMWPE	993	43.1
XLPE	1266	55.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	44	1.9

Table 230: Reasons for revision for Genesis II (CoCr)/Genesis II.

Rank	Reason for revision	N	Percent
1	Joint Infection	10	28.6
2	Instability/Dislocation	8	22.9
3	Aseptic loosening	7	20.0
4	Pain	7	20.0
5	Arthrofibrosis	2	5.7
6	Component fracture/failure	1	2.9

Journey II/Journey
N=2507

This page reports on both Oxinium and Cobalt Chromium versions combined. 73 surgeons across 33 sites use this implant.

Table 231: Volume of cases by surgeon and site for Journey II/Journey.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	34.3 (56.9)	7 (41)
Cases per site	76.0 (82.8)	45 (95)

Table 232: Descriptive statistics of patients receiving Journey II/Journey.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1601	63.9	
Age (yrs)	2507	64.2(9.3)	64(12)
Height (cm)	2507	167.8(10.6)	167(15)
Weight (kg)	2507	96.1(22.1)	95(30)
BMI(kg/m^2)	2507	34.1(7.2)	33.2(9.8)
Smoking - never (%)	1275	50.9	
Smoking - previous (%)	927	37	
Smoking - current (%)	300	12	
Smoking - unknown (%)	5	0.2	

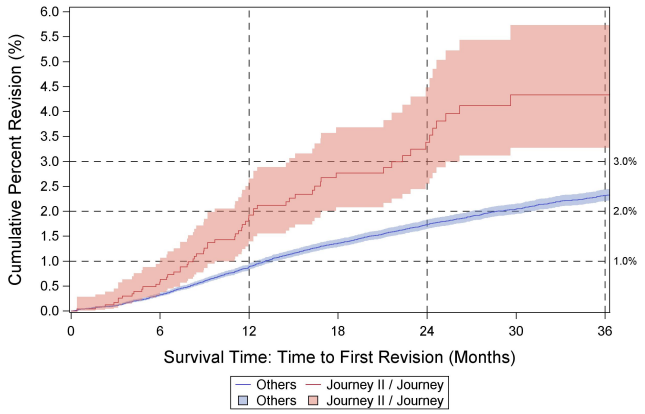

Figure 64: Cumulative percent revision curve for Journey II/Journey compared to all other TKA implants.

Table 233: Cumulative percent revision for Journey II/Journey compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
2502	1.93 (1.39,2.66)	3.38 (2.55,4.48)	4.33 (3.27,5.73)

Table 234: Distribution of approach used for Journey II/Journey.

Approach	N	Percent
Medial parapatellar	2204	87.9
Mid-vastus	294	11.7
Sub-vastus	2	0.1
Lateral parapatellar	2	0.1
Missing/unknown/other	5	0.2

Table 235: Distribution of polyethylene used for Journey II/Journey.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	2415	96.3
Antioxidant XLPE	0	0.0
Missing/unknown/other	92	3.7

Table 236: Reasons for revision for Journey II/Journey.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	19	32.8
2	Aseptic loosening	12	20.7
3	Arthrofibrosis	9	15.5
4	Joint Infection	7	12.1
5	Pain	5	8.6
6	Peri-prosthetic fracture (Femur)	2	3.4
7	Component fracture/failure	1	1.7
8	Extensor mechanism failure	1	1.7
9	Malalignment	1	1.7
10	Metal reaction/Metallosis	1	1.7

Journey II (Oxinium)/Journey
N=2410

This page reports on the Oxinium version. 73 surgeons across 33 sites use this implant.

Table 237: Volume of cases by surgeon and site for Journey II (Oxinium)/Journey.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	33.0 (54.6)	7 (41)
Cases per site	73.0 (80.6)	45 (90)

Table 238: Descriptive statistics of patients receiving Journey II (Oxinium)/Journey.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1534	63.7	
Age (yrs)	2410	63.8(9.3)	64(12)
Height (cm)	2410	167.9(10.6)	167(15)
Weight (kg)	2410	96.3(22.2)	95(30)
BMI(kg/m^2)	2410	34.1(7.2)	33.3(9.8)
Smoking - never (%)	1221	50.7	
Smoking - previous (%)	888	36.9	
Smoking - current (%)	296	12.3	
Smoking - unknown (%)	5	0.2	

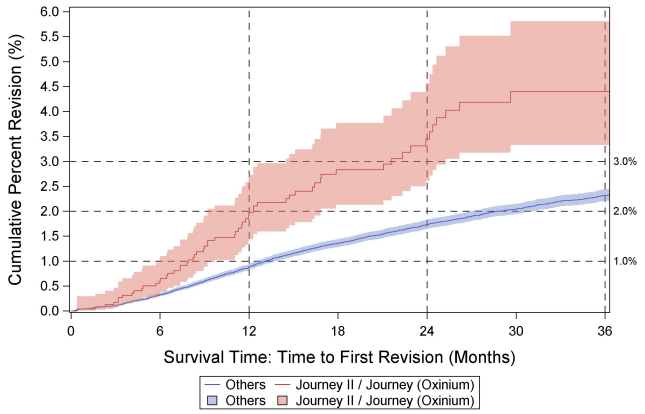

Figure 65: Cumulative percent revision curve for Journey II (Oxinium)/Journey compared to all other TKA implants.

Table 239: Cumulative percent revision for Journey II (Oxinium)/Journey compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
2406	1.98 (1.44,2.73)	3.45 (2.60,4.57)	4.40 (3.33,5.81)

Table 240: Distribution of approach used for Journey II (Oxinium)/Journey.

Approach	N	Percent
Medial parapatellar	2111	87.6
Mid-vastus	290	12.0
Sub-vastus	2	0.1
Lateral parapatellar	2	0.1
Missing/unknown/other	5	0.2

Table 241: Distribution of polyethylene used for Journey II (Oxinium)/Journey.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	2326	96.5
Antioxidant XLPE	0	0.0
Missing/unknown/other	84	3.5

Table 242: Reasons for revision for Journey II (Oxinium)/Journey.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	19	32.8
2	Aseptic loosening	12	20.7
3	Arthrofibrosis	9	15.5
4	Joint Infection	7	12.1
5	Pain	5	8.6
6	Peri-prosthetic fracture (Femur)	2	3.4
7	Component fracture/failure	1	1.7
8	Extensor mechanism failure	1	1.7
9	Malalignment	1	1.7
10	Metal reaction/Metallosis	1	1.7

Journey II(CoCr)/Journey

N=96, which does not meet 500 threshold for analysis.

LCS Complete/M.B.T
N=936

Fewer then 10 surgeons use this this implant at fewer than ten 10 sites

Table 243: Volume of cases by surgeon and site for LCS Complete/M.B.T.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	133.7 (233.0)	14 (259)
Cases per site	117 (220.8)	10.5 (141.5)

Table 244: Descriptive statistics of patients receiving LCS Complete/M.B.T.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	597	63.8	
Age (yrs)	936	66.9(9.6)	67(14)
Height (cm)	936	167.4(9.9)	167(15)
Weight (kg)	936	94.5(20.3)	92(27)
BMI(kg/m^2)	936	33.7(6.6)	33.1(8.7)
Smoking - never (%)	509	54.4	
Smoking - previous (%)	283	30.2	
Smoking - current (%)	93	9.9	
Smoking - unknown (%)	51	5.5	

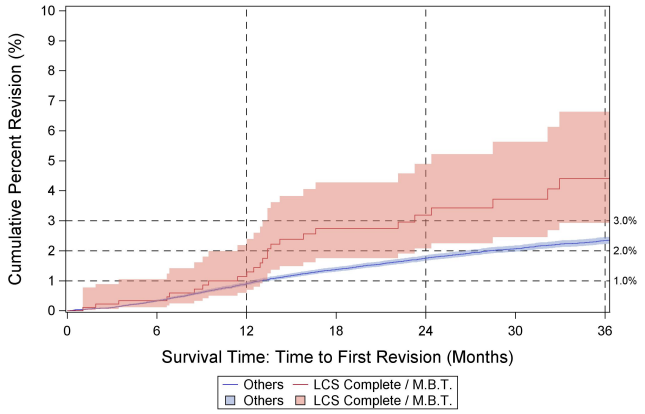

Figure 66: Cumulative percent revision curve for LCS Complete/M.B.T compared to all other TKA implants.

Table 245: Cumulative percent revision for LCS Complete/M.B.T compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
934	1.14 (0.59,2.19)	3.19 (2.07,4.89)	4.41 (2.92,6.63)

Table 246: Distribution of approach used for LCS Complete/M.B.T.

Approach	N	Percent
Medial parapatellar	931	99.5
Mid-vastus	1	0.1
Sub-vastus	0	0.0
Lateral parapatellar	1	0.1
Missing/unknown/other	3	0.3

Table 247: Distribution of polyethylene used for LCS Complete/M.B.T.

Polyethylene type	N	Percent
UHMWPE	935	99.9
XLPE	0	0.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	1	0.1

Table 248: Reasons for revision for LCS Complete/M.B.T.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	9	42.9
2	Pain	7	33.3
3	Aseptic loosening	5	23.8

Legion/Genesis II
N=1138

75 surgeons across 35 sites use this implant.

Table 249: Volume of cases by surgeon and site for Legion/Genesis II.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	15.2 (23.8)	5 (18)
Cases per site	32.5 (62.3)	9 (36)

Table 250: Descriptive statistics of patients receiving Legion/Genesis II.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1105	97.1	
Age (yrs)	1138	65.7(9.1)	66(11)
Height (cm)	1138	162.1(7.3)	162(10)
Weight (kg)	1138	88.9(19.2)	87(26)
BMI(kg/m^2)	1138	33.8(6.9)	33.3(9.4)
Smoking - never (%)	642	56.4	
Smoking - previous (%)	397	34.9	
Smoking - current (%)	92	8.1	
Smoking - unknown (%)	7	0.6	

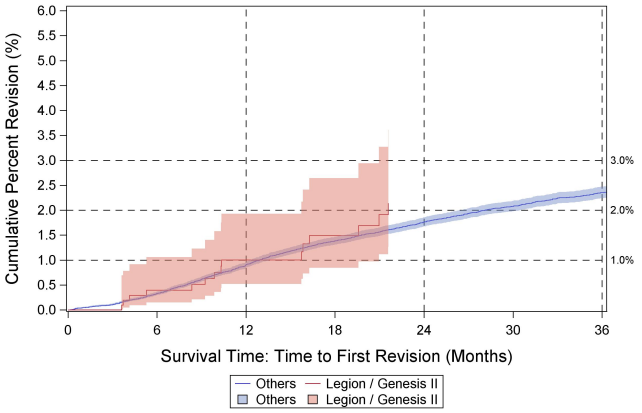

Figure 67: Cumulative percent revision curve for Legion/Genesis II compared to all other TKA implants.

Table 251: Cumulative percent revision for Legion/Genesis II compared to all other TKA implants (numerical values).

N	1 year	2 years*	3 years*
1138	1.00 (0.52,1.93)	2.14 (1.27,3.61)	2.14 (1.27,3.61)

* No revision occurred after the termination of the red curve in figure above; therefore, numerical revision risk at this time point is the same as it was at the time of the last revision.

Table 252: Distribution of approach used for Legion/Genesis II.

Approach	N	Percent
Medial parapatellar	891	78.3
Mid-vastus	239	21.0
Sub-vastus	1	0.1
Lateral parapatellar	3	0.3
Missing/unknown/other	4	0.4

Table 253: Distribution of polyethylene used for Legion/Genesis II.

Polyethylene type	N	Percent
UHMWPE	72	6.3
XLPE	1011	88.8
Antioxidant XLPE	0	0.0
Missing/unknown/other	55	4.8

Table 254: Reasons for revision for Legion/Genesis II.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	7	46.7
2	Aseptic loosening	3	20.0
3	Joint Infection	3	20.0
4	Arthrofibrosis	1	6.7
5	Malalignment	1	6.7

NexGen GS/NexGen Pegged
N=576

16 surgeons across 10 sites use this implant.

Table 255: Volume of cases by surgeon and site for NexGen GS/NexGen Pegged.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	36 (88.4)	6.5 (24.5)
Cases per site	57.6 (108.7)	14.5 (39)

Table 256: Descriptive statistics of patients receiving NexGen GS/NexGen Pegged.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	480	83.3	
Age (yrs)	576	67.8(9.4)	68(14)
Height (cm)	576	165(8.8)	165(10)
Weight (kg)	576	85.2(18)	83(25)
BMI(kg/m^2)	576	31.3(6.2)	30.7(8.9)
Smoking - never (%)	342	59.4	
Smoking - previous (%)	203	35.2	
Smoking - current (%)	30	5.2	
Smoking - unknown (%)	1	0.2	

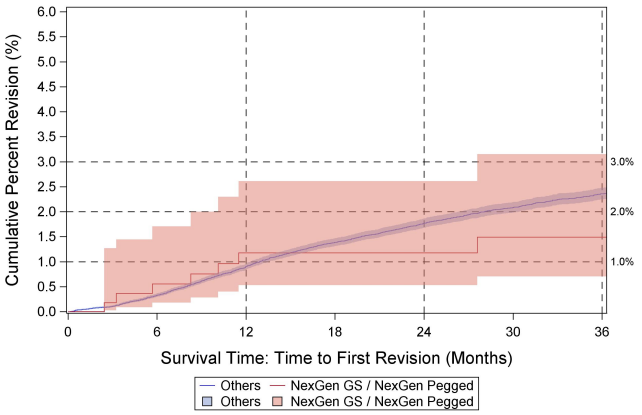

Figure 68: Cumulative percent revision curve for NexGen GS/NexGen Pegged compared to all other TKA implants.

Table 257: Cumulative percent revision for NexGen GS/NexGen Pegged compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
575	1.18 (0.53,2.61)	1.18 (0.53,2.61)	1.49 (0.70,3.15)

Table 258: Distribution of approach used for NexGen GS/NexGen Pegged.

Approach	N	Percent
Medial parapatellar	553	96.0
Mid-vastus	19	3.3
Sub-vastus	2	0.3
Lateral parapatellar	2	0.3
Missing/unknown/other	0	0.0

Table 259: Distribution of polyethylene used for NexGen GS/NexGen Pegged.

Polyethylene type	N	Percent
UHMWPE	40	6.9
XLPE	530	92.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	6	1.0

Table 260: Reasons for revision for NexGen GS/NexGen Pegged.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	2	66.7
2	Pain	1	33.3

NexGen LPS GS/NexGen Precoat
N=514

38 surgeons across 18 sites use this implant.

Table 261: Volume of cases by surgeon and site for NexGen LPS GS/NexGen Precoat.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	13.5 (18.8)	6 (14)
Cases per site	28.6 (76.4)	6.5 (14)

Table 262: Descriptive statistics of patients receiving NexGen LPS GS/NexGen Precoat.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	505	98.3	
Age (yrs)	514	65.6(9.6)	65(13)
Height (cm)	513	161.9(7.5)	162(10)
Weight (kg)	514	90.2(21.3)	88(29)
BMI(kg/m^2)	513	34.4(7.5)	33.8(11)
Smoking - never (%)	304	59.1	
Smoking - previous (%)	176	34.2	
Smoking - current (%)	33	6.4	
Smoking - unknown (%)	1	0.2	

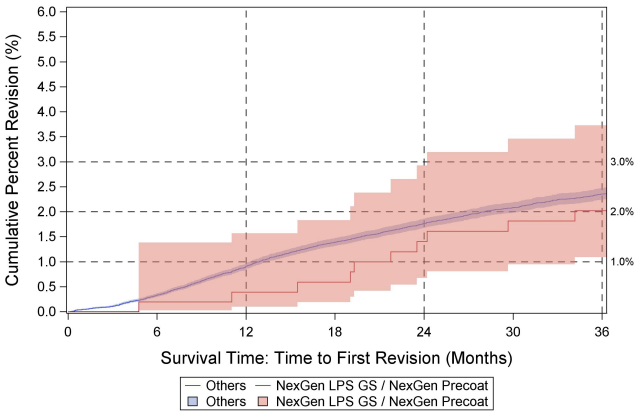

Figure 69: Cumulative percent revision curve for NexGen LPS GS/NexGen Precoat compared to all other TKA implants.

Table 263: Cumulative percent revision for NexGen LPS GS/NexGen Precoat compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
513	0.39 (0.10,1.57)	1.41 (0.67,2.93)	2.02 (1.09,3.73)

Table 264: Distribution of approach used for NexGen LPS GS/NexGen Precoat.

Approach	N	Percent
Medial parapatellar	498	96.9
Mid-vastus	5	1.0
Sub-vastus	0	0.0
Lateral parapatellar	4	0.8
Missing/unknown/other	7	1.4

Table 265: Distribution of polyethylene used for NexGen LPS GS/NexGen Precoat.

Polyethylene type	N	Percent
UHMWPE	436	84.8
XLPE	70	13.6
Antioxidant XLPE	0	0.0
Missing/unknown/other	8	1.6

Table 266: Reasons for revision for NexGen LPS GS/NexGen Precoat.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	3	60.0
2	Aseptic loosening	1	20.0
3	Pain	1	20.0

NexGen LPS Option/NexGen Precoat
N=642

58 surgeons across 27 sites use this implant.

Table 267: Volume of cases by surgeon and site for NexGen LPS Option/NexGen Precoat.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	11.1 (14.3)	5 (11)
Cases per site	23.8 (34.8)	14 (29)

Table 268: Descriptive statistics of patients receiving NexGen LPS Option/NexGen Precoat.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	266	41.4	
Age (yrs)	642	66.6(10.1)	67(14)
Height (cm)	642	170.6(10.5)	172(16)
Weight (kg)	642	95.8(20)	94(28)
BMI(kg/m^2)	642	33(6.7)	32.1(9)
Smoking - never (%)	285	44.4	
Smoking - previous (%)	283	44.1	
Smoking - current (%)	73	11.4	
Smoking - unknown (%)	1	0.2	

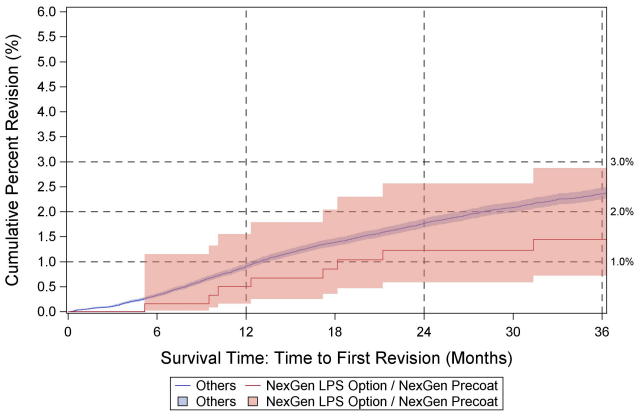

Figure 70: Cumulative percent revision curve for NexGen LPS Option/NexGen Precoat compared to all other TKA implants.

Table 269: Cumulative percent revision for NexGen LPS Option/NexGen Precoat compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
640	0.50 (0.16,1.55)	1.23 (0.59,2.57)	1.44 (0.72,2.88)

Table 270: Distribution of approach used for NexGen LPS Option/NexGen Precoat.

Approach	N	Percent
Medial parapatellar	617	96.1
Mid-vastus	17	2.6
Sub-vastus	2	0.3
Lateral parapatellar	2	0.3
Missing/unknown/other	4	0.6

Table 271: Distribution of polyethylene used for NexGen LPS Option/NexGen Precoat.

Polyethylene type	N	Percent
UHMWPE	517	80.5
XLPE	116	18.1
Antioxidant XLPE	0	0.0
Missing/unknown/other	9	1.4

Table 272: Reasons for revision for NexGen LPS Option/NexGen Precoat.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	2	40.0
2	Component fracture/failure	1	20.0
3	Joint Infection	1	20.0
4	Pain	1	20.0

NexGen LPS Option/NexGen TM
N=1047

Fewer then 10 surgeons use this this implant at fewer than ten 10 sites

Table 273: Volume of cases by surgeon and site for NexGen LPS Option/NexGen TM.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	130.9 (232.4)	20 (178)
Cases per site	174.5 (295.5)	2.5 (318)

Table 274: Descriptive statistics of patients receiving NexGen LPS Option/NexGen TM.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	541	51.7	
Age (yrs)	1047	66.6(8.4)	67(11)
Height (cm)	1047	169.7(10.3)	170(15)
Weight (kg)	1047	93.2(19.8)	92(26)
BMI(kg/m^2)	1047	32.3(6.2)	31.6(7.7)
Smoking - never (%)	573	54.7	
Smoking - previous (%)	428	40.9	
Smoking - current (%)	44	4.2	
Smoking - unknown (%)	2	0.2	

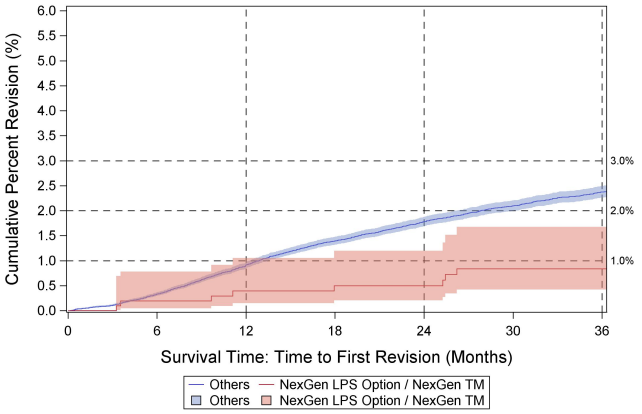

Figure 71: Cumulative percent revision curve for NexGen LPS Option/NexGen TM compared to all other TKA implants.

Table 275: Cumulative percent revision for NexGen LPS Option/NexGen TM compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
1046	0.40 (0.15,1.05)	0.50 (0.21,1.20)	0.84 (0.42,1.68)

Table 276: Distribution of approach used for NexGen LPS Option/NexGen TM.

Approach	N	Percent
Medial parapatellar	404	38.6
Mid-vastus	633	60.5
Sub-vastus	4	0.4
Lateral parapatellar	1	0.1
Missing/unknown/other	5	0.5

Table 277: Distribution of polyethylene used for NexGen LPS Option/NexGen TM.

Polyethylene type	N	Percent
UHMWPE	1046	99.9
XLPE	0	0.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	1	0.1

Table 278: Reasons for revision for NexGen LPS Option/NexGen TM.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	4	66.7
2	Arthrofibrosis	1	16.7
3	Aseptic loosening	1	16.7

NexGen Option/NexGen Option
N=996

11 surgeons use this implant at fewer than 10 sites.

Table 279: Volume of cases by surgeon and site for NexGen Option/NexGen Option.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	90.6 (89.6)	49 (141)
Cases per site	332 (396.1)	153 (729)

Table 280: Descriptive statistics of patients receiving NexGen Option/NexGen Option.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	516	51.8	
Age (yrs)	996	69.5(8.5)	70(11)
Height (cm)	996	169.3(10.3)	170(16)
Weight (kg)	996	92.6(19.7)	92(25)
BMI(kg/m^2)	996	32.3(6.1)	31.6(8.4)
Smoking - never (%)	460	46.2	
Smoking - previous (%)	457	45.9	
Smoking - current (%)	79	7.9	
Smoking - unknown (%)	0	0.0	

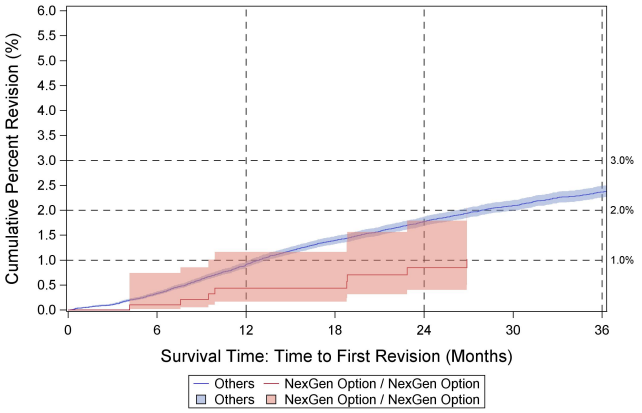

Figure 72: Cumulative percent revision curve for NexGen Option/NexGen Option compared to all other TKA implants.

Table 281: Cumulative percent revision for NexGen Option/NexGen Option compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years*
993	0.44 (0.16,1.16)	0.85 (0.40,1.79)	1.02 (0.51,2.05)

* No revision occurred after the termination of the red curve in figure above; therefore, numerical revision risk at this time point is the same as it was at the time of the last revision.

Table 282: Distribution of approach used for NexGen Option/NexGen Option.

Approach	N	Percent
Medial parapatellar	980	98.4
Mid-vastus	12	1.2
Sub-vastus	0	0.0
Lateral parapatellar	4	0.4
Missing/unknown/other	0	0.0

Table 283: Distribution of polyethylene used for NexGen Option/NexGen Option.

Polyethylene type	N	Percent
UHMWPE	154	15.5
XLPE	841	84.4
Antioxidant XLPE	0	0.0
Missing/unknown/other	1	0.1

Table 284: Reasons for revision for NexGen Option/NexGen Option.

Rank	Reason for revision	N	Percent
1	Joint Infection	2	28.6
2	Pain	2	28.6
3	Arthrofibrosis	1	14.3
4	Aseptic loosening	1	14.3
5	Instability/Dislocation	1	14.3

NexGen Option/NexGen Pegged
N=605

Fewer then 10 surgeons use this this implant at fewer than ten 10 sites

Table 285: Volume of cases by surgeon and site for NexGen Option/NexGen Pegged.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	75.6 (123.5)	43 (33.5)
Cases per site	121 (182.8)	25 (109)

Table 286: Descriptive statistics of patients receiving NexGen Option/NexGen Pegged.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	305	50.4	
Age (yrs)	605	66.9(8.9)	67(12)
Height (cm)	605	169.8(10.5)	170(16)
Weight (kg)	605	95.5(19.9)	94(29)
BMI(kg/m^2)	605	33.1(5.9)	32.4(9)
Smoking - never (%)	268	44.3	
Smoking - previous (%)	268	44.3	
Smoking - current (%)	67	11.1	
Smoking - unknown (%)	2	0.3	

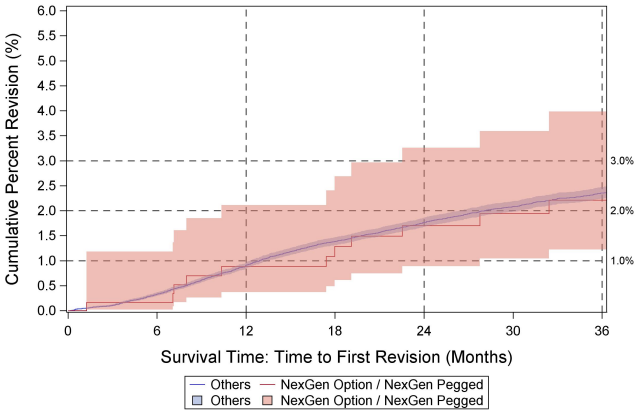

Figure 73: Cumulative percent revision curve for NexGen Option/NexGen Pegged compared to all other TKA implants.

Table 287: Cumulative percent revision for NexGen Option/NexGen Pegged compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
602	0.88 (0.37,2.11)	1.70 (0.89,3.26)	2.21 (1.22,3.98)

Table 288: Distribution of approach used for NexGen Option/NexGen Pegged.

Approach	N	Percent
Medial parapatellar	593	98.0
Mid-vastus	2	0.3
Sub-vastus	0	0.0
Lateral parapatellar	10	1.7
Missing/unknown/other	0	0.0

Table 289: Distribution of polyethylene used for NexGen Option/NexGen Pegged.

Polyethylene type	N	Percent
UHMWPE	1	0.2
XLPE	603	99.7
Antioxidant XLPE	0	0.0
Missing/unknown/other	1	0.2

Table 290: Reasons for revision for NexGen Option/NexGen Pegged.

Rank	Reason for revision	N	Percent
1	Aseptic loosening	3	33.3
2	Instability/Dislocation	2	22.2
3	Pain	2	22.2
4	Joint Infection	1	11.1
5	Peri-prosthetic fracture (Tibia)	1	11.1

NK II/NK II
N=960

10 surgeons use this implant at fewer than 10 sites.

Table 291: Volume of cases by surgeon and site for NK II/NK II.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	96 (169.7)	6.5 (100)
Cases per site	160 (163.4)	115.5 (310)

Table 292: Descriptive statistics of patients receiving NK II/NK II.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	621	64.7	
Age (yrs)	960	66.9(9.3)	67(13)
Height (cm)	960	167.8(10.2)	167(15)
Weight (kg)	960	93.3(21.6)	90(28)
BMI(kg/m^2)	960	33.1(6.8)	32.1(8.8)
Smoking - never (%)	523	54.5	
Smoking - previous (%)	362	37.7	
Smoking - current (%)	71	7.4	
Smoking - unknown (%)	4	0.4	

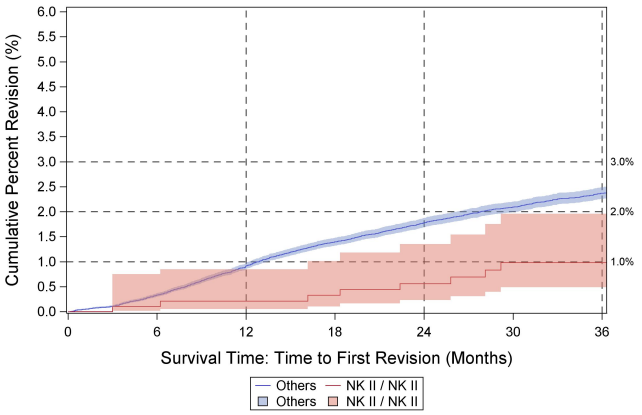

Figure 74: Cumulative percent revision curve for NK II/NK II compared to all other TKA implants.

Table 293: Cumulative percent revision for NK II/NK II compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
960	0.21 (0.05,0.85)	0.56 (0.23,1.35)	0.98 (0.49,1.96)

Table 294: Distribution of approach used for NK II/NK II.

Approach	N	Percent
Medial parapatellar	892	92.9
Mid-vastus	40	4.2
Sub-vastus	12	1.3
Lateral parapatellar	5	0.5
Missing/unknown/other	11	1.1

Table 295: Distribution of polyethylene used for NK II/NK II.

Polyethylene type	N	Percent
UHMWPE	497	51.8
XLPE	455	47.4
Antioxidant XLPE	0	0.0
Missing/unknown/other	8	0.8

Table 296: Reasons for revision for NK II/NK II.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	3	37.5
2	Joint Infection	2	25.0
3	Pain	2	25.0
4	Aseptic loosening	1	12.5

NK II GS/NK II
N=2071

11 surgeons use this implant at fewer than 10 sites.

Table 297: Volume of cases by surgeon and site for NK II GS/NK II.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	188.3 (242.0)	74 (340)
Cases per site	258.9 (219.5)	188.5 (374.5)

Table 298: Descriptive statistics of patients receiving NK II GS/NK II.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1252	60.5	
Age (yrs)	2071	67.5(9.1)	68(13)
Height (cm)	2070	168.6(10.7)	167(17)
Weight (kg)	2069	93(21.8)	90(29)
BMI(kg/m^2)	2069	32.6(6.4)	31.9(9)
Smoking - never (%)	1080	52.2	
Smoking - previous (%)	831	40.1	
Smoking - current (%)	159	7.7	
Smoking - unknown (%)	1	0.1	

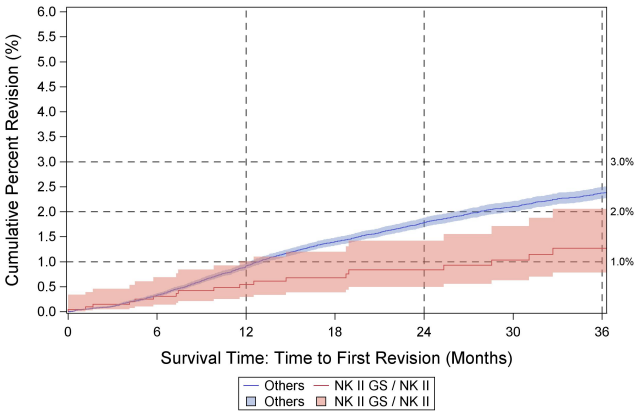

Figure 75: Cumulative percent revision curve for NK II GS/NK II compared to all other TKA implants.

Table 299: Cumulative percent revision for NK II GS/NK II compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
2067	0.55 (0.29,1.02)	0.84 (0.49,1.42)	1.27 (0.78,2.06)

Table 300: Distribution of approach used for NK II GS/NK II.

Approach	N	Percent
Medial parapatellar	1885	91.0
Mid-vastus	65	3.1
Sub-vastus	108	5.2
Lateral parapatellar	5	0.2
Missing/unknown/other	8	0.4

Table 301: Distribution of polyethylene used for NK II GS/NK II.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	2048	98.9
Antioxidant XLPE	0	0.0
Missing/unknown/other	23	1.1

Table 302: Reasons for revision for NK II GS/NK II.

Rank	Reason for revision	N	Percent
1	Pain	6	28.6
2	Aseptic loosening	4	19.0
3	Joint Infection	3	14.3
4	Component fracture/failure	2	9.5
5	Instability/Dislocation	2	9.5
6	Malalignment	2	9.5
7	Peri-prosthetic fracture (Femur)	1	4.8
8	Poly liner wear	1	4.8

Persona/Persona
N=25251

159 surgeons across 49 sites use this implant.

Table 303: Volume of cases by surgeon and site for Persona/Persona.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	158.8 (264.0)	62 (188)
Cases per site	515.3 (688.9)	306 (628)

Table 304: Descriptive statistics of patients receiving Persona/Persona.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	15983	63.3	
Age (yrs)	25251	66.1(9.2)	66(12)
Height (cm)	25247	168(10.5)	167(15)
Weight (kg)	25247	94(21.3)	92(28)
BMI(kg/m^2)	25247	33.3(6.7)	32.4(9.1)
Smoking - never (%)	13025	51.6	
Smoking - previous (%)	9967	39.5	
Smoking - current (%)	2132	8.4	
Smoking - unknown (%)	127	0.5	

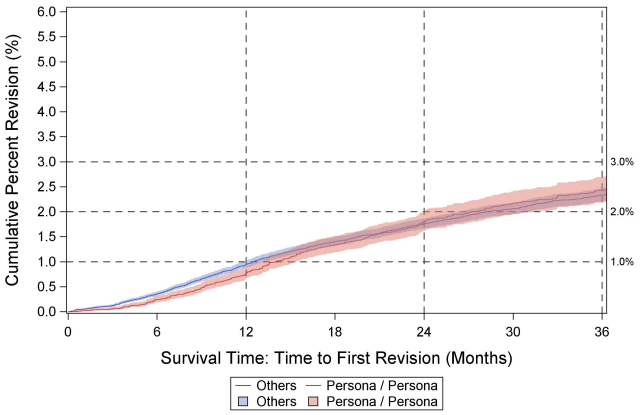

Figure 76: Cumulative percent revision curve for Persona/Persona compared to all other TKA implants.

Table 305: Cumulative percent revision for Persona/Persona compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
25220	0.77 (0.66,0.90)	1.80 (1.61,2.01)	2.42 (2.18,2.69)

Table 306: Distribution of approach used for Persona/Persona.

Approach	N	Percent
Medial parapatellar	22207	87.9
Mid-vastus	2221	8.8
Sub-vastus	744	2.9
Lateral parapatellar	25	0.1
Missing/unknown/other	54	0.2

Table 307: Distribution of polyethylene used for Persona/Persona.

Polyethylene type	N	Percent
UHMWPE	13362	52.9
XLPE	1	0.0
Antioxidant XLPE	11736	46.5
Missing/unknown/other	152	0.6

Table 308: Reasons for revision for Persona/Persona.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	133	35.3
2	Joint Infection	77	20.4
3	Pain	63	16.7
4	Aseptic loosening	56	14.9
5	Arthrofibrosis	19	5.0
6	Component fracture/failure	8	2.1
7	Malalignment	6	1.6
8	Peri-prosthetic fracture (Femur)	5	1.3
9	Poly liner wear	5	1.3
10	Extensor mechanism failure	3	0.8
11	Metal reaction/Metallosis	1	0.3
12	Peri-prosthetic fracture (Tibia)	1	0.3

Scorpio/Series 7000
N=574

Fewer then 10 surgeons use this this implant at fewer than ten 10 sites

Table 309: Volume of cases by surgeon and site for Scorpio/Series 7000.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	82 (160.5)	13 (80)
Cases per site	143.5 (167.3)	67 (192)

Table 310: Descriptive statistics of patients receiving Scorpio/Series 7000.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	279	48.6	
Age (yrs)	574	66(9.5)	65(14)
Height (cm)	574	170.3(10.4)	170(16)
Weight (kg)	574	97.9(21.5)	96(28)
BMI(kg/m^2)	574	33.8(7.1)	32.6(9.6)
Smoking - never (%)	298	51.9	
Smoking - previous (%)	227	39.6	
Smoking - current (%)	47	8.2	
Smoking - unknown (%)	2	0.4	

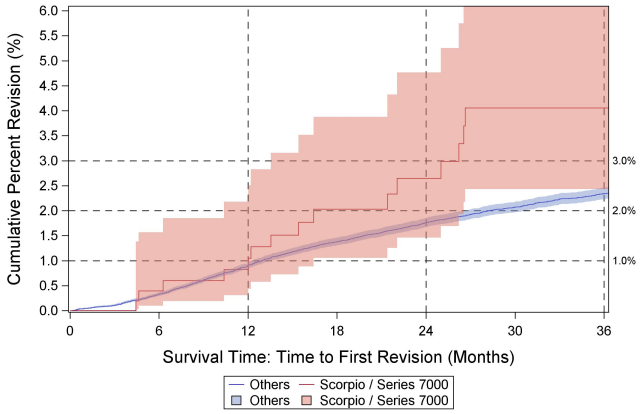

Figure 77: Cumulative percent revision curve for Scorpio/Series 7000 compared to all other TKA implants.

Table 311: Cumulative percent revision for Scorpio/Series 7000 compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
572	0.82 (0.31,2.18)	2.65 (1.46,4.77)	4.06 (2.43,6.72)

Table 312: Distribution of approach used for Scorpio/Series 7000.

Approach	N	Percent
Medial parapatellar	10	1.7
Mid-vastus	564	98.3
Sub-vastus	0	0.0
Lateral parapatellar	0	0.0
Missing/unknown/other	0	0.0

Table 313: Distribution of polyethylene used for Scorpio/Series 7000.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	571	99.5
Antioxidant XLPE	0	0.0
Missing/unknown/other	3	0.5

Table 314: Reasons for revision for Scorpio/Series 7000.

Rank	Reason for revision	N	Percent
1	Aseptic loosening	4	25.0
2	Instability/Dislocation	4	25.0
3	Pain	4	25.0
4	Joint Infection	2	12.5
5	Component fracture/failure	1	6.3
6	Peri-prosthetic fracture (Tibia)	1	6.3

Sigma/M.B.T
N=688

39 surgeons across 27 sites use this implant.

Table 315: Volume of cases by surgeon and site for Sigma/M.B.T.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	17.6 (26.7)	4 (21)
Cases per site	25.5 (26.9)	22 (36)

Table 316: Descriptive statistics of patients receiving Sigma/M.B.T.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	441	64.1	
Age (yrs)	688	64.2(10.1)	63(13)
Height (cm)	688	168.2(10.9)	167(17)
Weight (kg)	688	98.1(22.6)	97(31)
BMI(kg/m^2)	688	34.7(7.3)	34.1(9.6)
Smoking - never (%)	336	48.8	
Smoking - previous (%)	240	34.9	
Smoking - current (%)	76	11.1	
Smoking - unknown (%)	36	5.2	

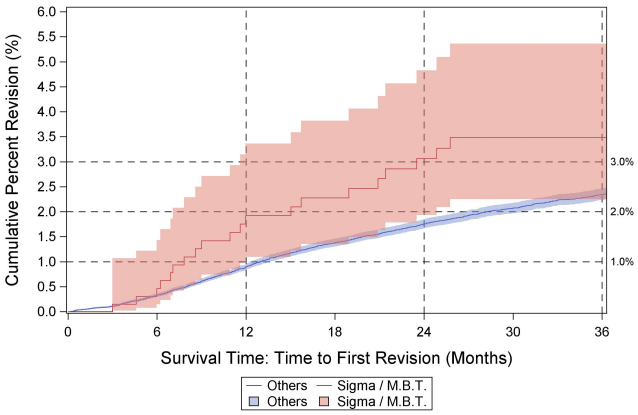

Figure 78: Cumulative percent revision curve for Sigma/M.B.T compared to all other TKA implants.

Table 317: Cumulative percent revision for Sigma/M.B.T compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
688	1.92 (1.10,3.36)	3.06 (1.94,4.83)	3.48 (2.25,5.36)

Table 318: Distribution of approach used for Sigma/M.B.T.

Approach	N	Percent
Medial parapatellar	609	88.5
Mid-vastus	69	10.0
Sub-vastus	1	0.1
Lateral parapatellar	1	0.1
Missing/unknown/other	8	1.2

Table 319: Distribution of polyethylene used for Sigma/M.B.T.

Polyethylene type	N	Percent
UHMWPE	469	68.2
XLPE	11	1.6
Antioxidant XLPE	207	30.1
Missing/unknown/other	1	0.1

Table 320: Reasons for revision for Sigma/M.B.T.

Rank	Reason for revision	N	Percent
1	Joint Infection	6	30.0
2	Pain	5	25.0
3	Aseptic loosening	3	15.0
4	Instability/Dislocation	2	10.0
5	Malalignment	2	10.0
6	Arthrofibrosis	1	5.0
7	Metal reaction/Metallosis	1	5.0

Sigma/Sigma
N=1366

35 surgeons across 21 sites use this implant.

Table 321: Volume of cases by surgeon and site for Sigma/Sigma.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	39.0 (72.6)	4 (37)
Cases per site	65.1 (142.8)	7 (36)

Table 322: Descriptive statistics of patients receiving Sigma/Sigma.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	873	63.9	
Age (yrs)	1366	67.6(10.1)	68(14)
Height (cm)	1366	167.5(10.5)	167(15)
Weight (kg)	1366	89.7(20.6)	87(27)
BMI(kg/m^2)	1366	31.9(6.2)	31.2(8.8)
Smoking - never (%)	721	52.8	
Smoking - previous (%)	542	39.7	
Smoking - current (%)	99	7.3	
Smoking - unknown (%)	4	0.3	

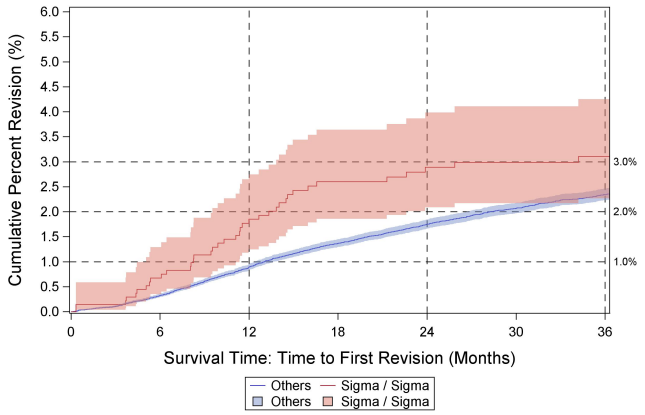

Figure 79: Cumulative percent revision curve for Sigma/Sigma compared to all other TKA implants.

Table 323: Cumulative percent revision for Sigma/Sigma compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
1364	1.85 (1.24,2.75)	2.89 (2.09,3.99)	3.11 (2.27,4.25)

Table 324: Distribution of approach used for Sigma/Sigma.

Approach	N	Percent
Medial parapatellar	1322	96.8
Mid-vastus	29	2.1
Sub-vastus	0	0.0
Lateral parapatellar	1	0.1
Missing/unknown/other	14	1.0

Table 325: Distribution of polyethylene used for Sigma/Sigma.

Polyethylene type	N	Percent
UHMWPE	502	36.7
XLPE	855	62.6
Antioxidant XLPE	0	0.0
Missing/unknown/other	9	0.7

Table 326: Reasons for revision for Sigma/Sigma.

Rank	Reason for revision	N	Percent
1	Joint Infection	9	28.1
2	Instability/Dislocation	7	21.9
3	Pain	5	15.6
4	Arthrofibrosis	4	12.5
5	Aseptic loosening	4	12.5
6	Component fracture/failure	1	3.1
7	Extensor mechanism failure	1	3.1
8	Malalignment	1	3.1

Sigma PFC/Sigma
N=2734

48 surgeons across 24 sites use this implant.

Table 327: Volume of cases by surgeon and site for Sigma PFC/Sigma.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	57.0 (102.1)	16 (60.5)
Cases per site	113.9 (185.9)	30 (84.5)

Table 328: Descriptive statistics of patients receiving Sigma PFC/Sigma.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1682	61.5	
Age (yrs)	2734	67(9.2)	67(13)
Height (cm)	2733	167.8(10.5)	167(15)
Weight (kg)	2732	93(20.9)	91(28)
BMI(kg/m^2)	2732	33(6.6)	32.1(8.6)
Smoking - never (%)	1341	49.1	
Smoking - previous (%)	1123	41.1	
Smoking - current (%)	258	9.4	
Smoking - unknown (%)	12	0.4	

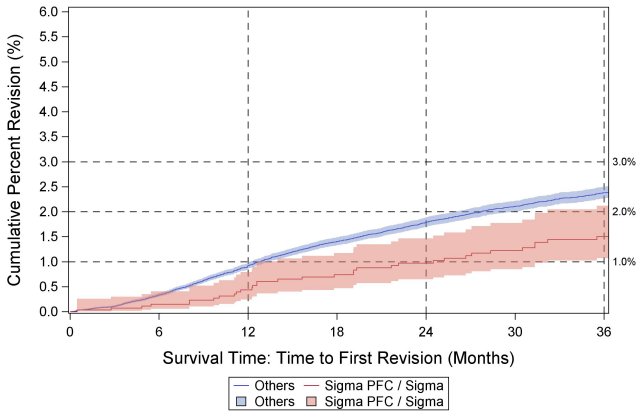

Figure 80: Cumulative percent revision curve for Sigma PFC/Sigma compared to all other TKA implants.

Table 329: Cumulative percent revision for Sigma PFC/Sigma compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
2730	0.44 (0.24,0.79)	0.97 (0.65,1.46)	1.51 (1.07,2.12)

Table 330: Distribution of approach used for Sigma PFC/Sigma.

Approach	N	Percent
Medial parapatellar	2600	95.1
Mid-vastus	125	4.6
Sub-vastus	1	0.0
Lateral parapatellar	2	0.1
Missing/unknown/other	6	0.2

Table 331: Distribution of polyethylene used for Sigma PFC/Sigma.

Polyethylene type	N	Percent
UHMWPE	220	8.0
XLPE	2506	91.7
Antioxidant XLPE	0	0.0
Missing/unknown/other	8	0.3

Table 332: Reasons for revision for Sigma PFC/Sigma.

Rank	Reason for revision	N	Percent
1	Joint Infection	10	31.3
2	Aseptic loosening	7	21.9
3	Instability/Dislocation	7	21.9
4	Pain	4	12.5
5	Arthrofibrosis	2	6.3
6	Component fracture/failure	1	3.1
7	Malalignment	1	3.1

Triathlon/Triathlon
N=14829

118 surgeons across 43 sites use this implant.

Table 333: Volume of cases by surgeon and site for Triathlon/Triathlon.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	125.7 (213.9)	25 (173)
Cases per site	344.9 (536.0)	74 (450)

Table 334: Descriptive statistics of patients receiving Triathlon/Triathlon.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	8901	60	
Age (yrs)	14829	65.4(9.7)	65(13)
Height (cm)	14829	168.5(10.5)	167(17)
Weight (kg)	14829	95.7(21.9)	94(29)
BMI(kg/m^2)	14829	33.7(6.9)	32.8(9.2)
Smoking - never (%)	7550	50.9	
Smoking - previous (%)	5630	38	
Smoking - current (%)	1549	10.5	
Smoking - unknown (%)	100	0.7	

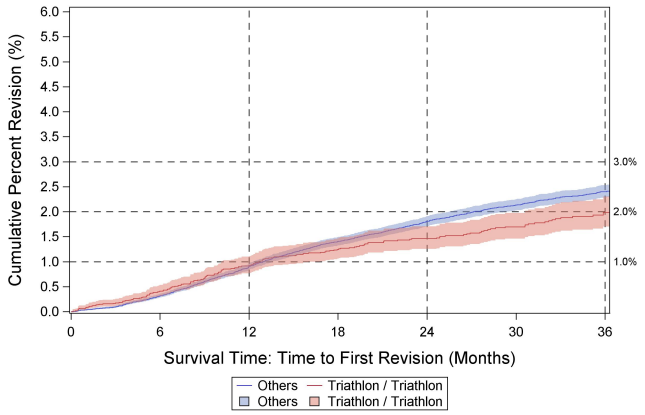

Figure 81: Cumulative percent revision curve for Triathlon/Triathlon compared to all other TKA implants.

Table 335: Cumulative percent revision for Triathlon/Triathlon compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
14802	0.93 (0.77,1.11)	1.46 (1.25,1.71)	1.98 (1.70,2.31)

Table 336: Distribution of approach used for Triathlon/Triathlon.

Approach	N	Percent
Medial parapatellar	12032	81.1
Mid-vastus	1883	12.7
Sub-vastus	854	5.8
Lateral parapatellar	19	0.1
Missing/unknown/other	41	0.3

Table 337: Distribution of polyethylene used for Triathlon/Triathlon.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	14501	97.8
Antioxidant XLPE	0	0.0
Missing/unknown/other	328	2.2

Table 338: Reasons for revision for Triathlon/Triathlon.

Rank	Reason for revision	N	Percent
1	Joint Infection	46	26.6
2	Instability/Dislocation	34	19.7
3	Aseptic loosening	27	15.6
4	Pain	20	11.6
5	Arthrofibrosis	10	5.8
6	Component fracture/failure	8	4.6
7	Peri-prosthetic fracture (Femur)	7	4.0
8	Malalignment	6	3.5
9	Peri-prosthetic fracture (Tibia)	6	3.5
10	Extensor mechanism failure	2	1.2
11	Patellofemoral joint	2	1.2
12	Metal reaction/Metallosis	1	0.6
13	Poly liner wear	1	0.6
14	Unknown	3	1.7

Triathlon/Triathlon TS
N=13667

136 surgeons across 42 sites use this implant.

Table 339: Volume of cases by surgeon and site for Triathlon/Triathlon TS.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	100.5 (227.8)	16 (98)
Cases per site	325.4 (777.6)	51.5 (173)

Table 340: Descriptive statistics of patients receiving Triathlon/Triathlon TS.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	8869	64.9	
Age (yrs)	13667	66.8(9.6)	67(13)
Height (cm)	13666	167.5(10.6)	167(15)
Weight (kg)	13666	93.2(22.1)	91(30)
BMI(kg/m^2)	13666	33.2(7.1)	32.3(9.5)
Smoking - never (%)	7463	54.6	
Smoking - previous (%)	5157	37.7	
Smoking - current (%)	1018	7.5	
Smoking - unknown (%)	29	0.2	

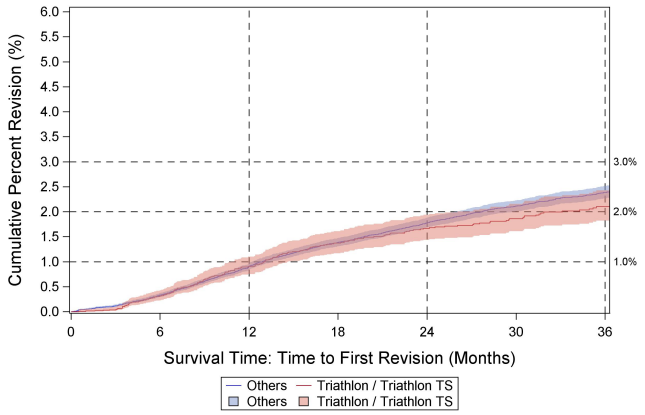

Figure 82: Cumulative percent revision curve for Triathlon/Triathlon TS compared to all other TKA implants.

Table 341: Cumulative percent revision for Triathlon/Triathlon TS compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
13659	0.91 (0.75,1.10)	1.67 (1.44,1.94)	2.10 (1.82,2.43)

Table 342: Distribution of approach used for Triathlon/Triathlon TS.

Approach	N	Percent
Medial parapatellar	9773	71.5
Mid-vastus	3760	27.5
Sub-vastus	76	0.6
Lateral parapatellar	13	0.1
Missing/unknown/other	45	0.3

Table 343: Distribution of polyethylene used for Triathlon/Triathlon TS.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	13603	99.5
Antioxidant XLPE	0	0.0
Missing/unknown/other	64	0.5

Table 344: Reasons for revision for Triathlon/Triathlon TS.

Rank	Reason for revision	N	Percent
1	Joint Infection	63	32.6
2	Instability/Dislocation	57	29.5
3	Pain	23	11.9
4	Arthrofibrosis	17	8.8
5	Aseptic loosening	14	7.3
6	Component fracture/failure	9	4.7
7	Peri-prosthetic fracture (Femur)	4	2.1
8	Extensor mechanism failure	2	1.0
9	Metal reaction/Metallosis	1	0.5
10	Osteolysis	1	0.5
11	Patellofemoral joint	1	0.5
12	Peri-prosthetic fracture (Tibia)	1	0.5

Vanguard/Maxim
N=15195

100 surgeons across 44 sites use this implant.

Table 345: Volume of cases by surgeon and site for Vanguard/Maxim.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	152.0 (254.9)	44 (177.5)
Cases per site	345.3 (474.6)	134 (470)

Table 346: Descriptive statistics of patients receiving Vanguard/Maxim.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	9487	62.4	
Age (yrs)	15195	66.3(9.6)	66(13)
Height (cm)	15195	168(10.5)	167(15)
Weight (kg)	15195	94.8(22.2)	93(29)
BMI(kg/m^2)	15195	33.5(7.2)	32.6(9.5)
Smoking - never (%)	7740	50.9	
Smoking - previous (%)	5835	38.4	
Smoking - current (%)	1422	9.4	
Smoking - unknown (%)	198	1.3	

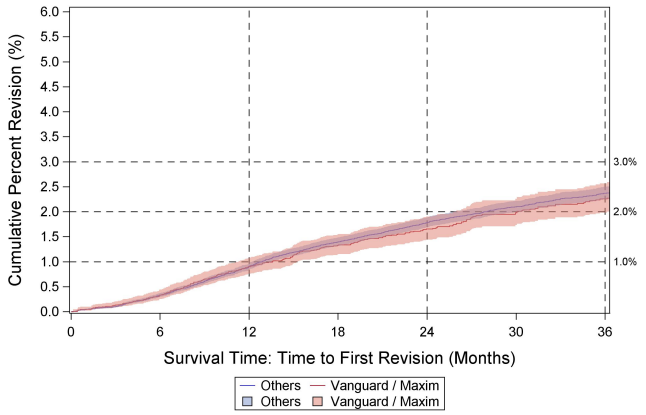

Figure 83: Cumulative percent revision curve for Vanguard/Maxim compared to all other TKA implants.

Table 347: Cumulative percent revision for Vanguard/Maxim compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
15184	0.90 (0.75,1.08)	1.66 (1.44,1.90)	2.26 (1.98,2.57)

Table 348: Distribution of approach used for Vanguard/Maxim.

Approach	N	Percent
Medial parapatellar	13879	91.3
Mid-vastus	1087	7.2
Sub-vastus	146	1.0
Lateral parapatellar	40	0.3
Missing/unknown/other	43	0.3

Table 349: Distribution of polyethylene used for Vanguard/Maxim.

Polyethylene type	N	Percent
UHMWPE	8493	55.9
XLPE	0	0.0
Antioxidant XLPE	6600	43.4
Missing/unknown/other	102	0.7

Table 350: Reasons for revision for Vanguard/Maxim.

Rank	Reason for revision	N	Percent
1	Instability/Dislocation	54	27.4
2	Joint Infection	47	23.9
3	Pain	30	15.2
4	Aseptic loosening	21	10.7
5	Arthrofibrosis	18	9.1
6	Component fracture/failure	8	4.1
7	Metal reaction/Metallosis	7	3.6
8	Peri-prosthetic fracture (Femur)	5	2.5
9	Malalignment	4	2.0
10	Extensor mechanism failure	1	0.5
11	Unknown	2	1.0

Vanguard/Maxim Mono-Lock
N=757

56 surgeons across 30 sites use this implant.

Table 351: Volume of cases by surgeon and site for Vanguard/Maxim Mono-Lock.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	13.5 (27.3)	3 (5.5)
Cases per site	25.2 (46.9)	6.5 (11)

Table 352: Descriptive statistics of patients receiving Vanguard/Maxim Mono-Lock.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	651	86	
Age (yrs)	757	64.7(9.3)	65(11)
Height (cm)	757	164.6(9)	163(10)
Weight (kg)	757	93.9(23.4)	90(31)
BMI(kg/m^2)	757	34.6(7.6)	33.8(10.1)
Smoking - never (%)	364	48.1	
Smoking - previous (%)	293	38.7	
Smoking - current (%)	98	13	
Smoking - unknown (%)	2	0.3	

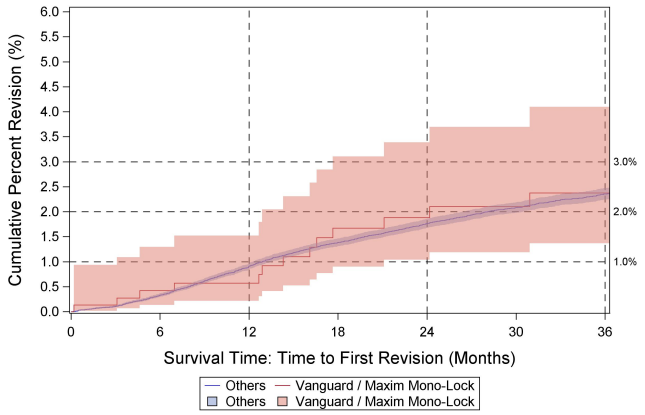

Figure 84: Cumulative percent revision curve for Vanguard/Maxim Mono-Lock compared to all other TKA implants.

Table 353: Cumulative percent revision for Vanguard/Maxim Mono-Lock compared to all other TKA implants (numerical values).

N	1 year	2 years	3 years
756	0.57 (0.22,1.52)	1.88 (1.04,3.39)	2.38 (1.37,4.10)

Table 354: Distribution of approach used for Vanguard/Maxim Mono-Lock.

Approach	N	Percent
Medial parapatellar	662	87.5
Mid-vastus	89	11.8
Sub-vastus	4	0.5
Lateral parapatellar	2	0.3
Missing/unknown/other	0	0.0

Table 355: Distribution of polyethylene used for Vanguard/Maxim Mono-Lock.

Polyethylene type	N	Percent
UHMWPE	410	54.2
XLPE	0	0.0
Antioxidant XLPE	336	44.4
Missing/unknown/other	11	1.5

Table 356: Reasons for revision for Vanguard/Maxim Mono-Lock.

Rank	Reason for revision	N	Percent
1	Pain	5	50.0
2	Instability/Dislocation	3	30.0
3	Aseptic loosening	2	20.0

3.5 UKA descriptive statistics

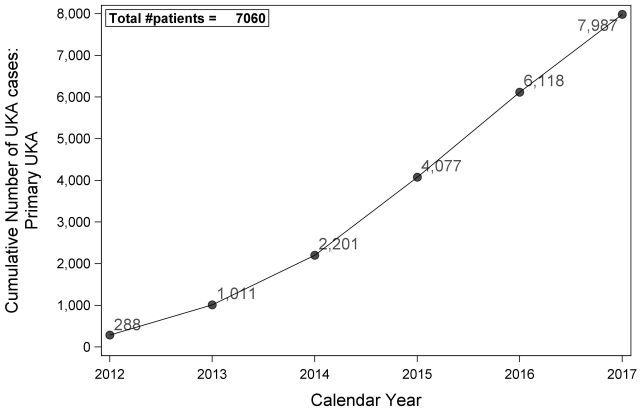

Figure 85: Primary UKA cases over time.

Table 357: Descriptive statistics of patients in UKA cases.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	4057	50.8	
Age (yrs)	7987	64(10.2)	64(14)
Height (cm)	7985	169.6(10.4)	170(15)
Weight (kg)	7985	90.3(19.6)	89(25)
BMI(kg/m^2)	7984	31.3(5.8)	30.6(7.5)
Smoking - never (%)	3830	48	
Smoking - previous (%)	3301	41.3	
Smoking - current (%)	782	9.8	
Smoking - unknown (%)	74	0.9	

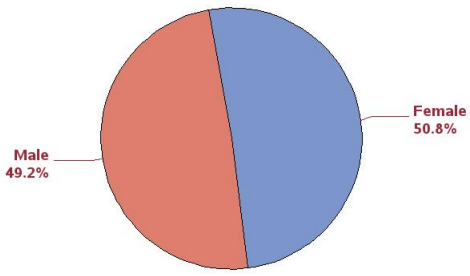

Figure 86: Percent of primary UKA cases by sex.

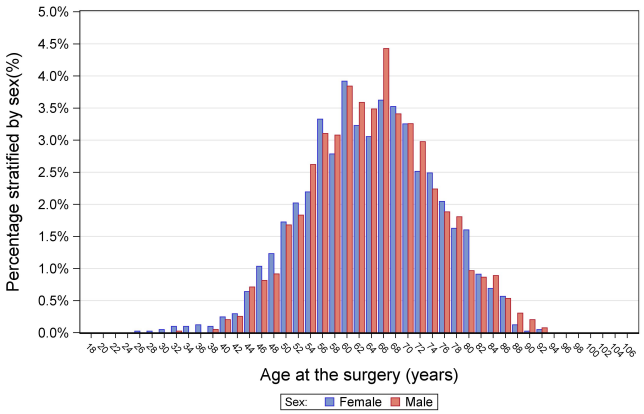

Figure 87: Age distribution of primary UKA cases by sex.

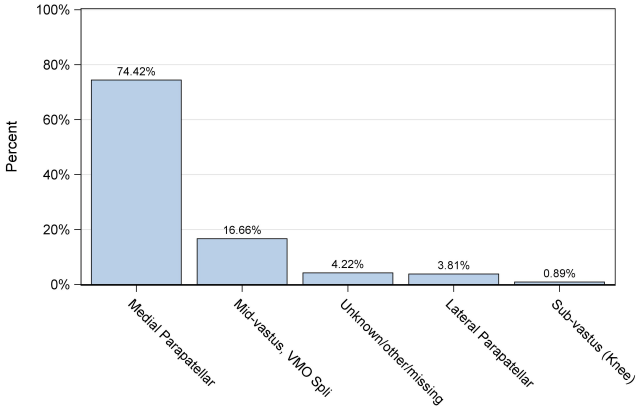

Figure 88: Percent of primary UKA cases by approach.

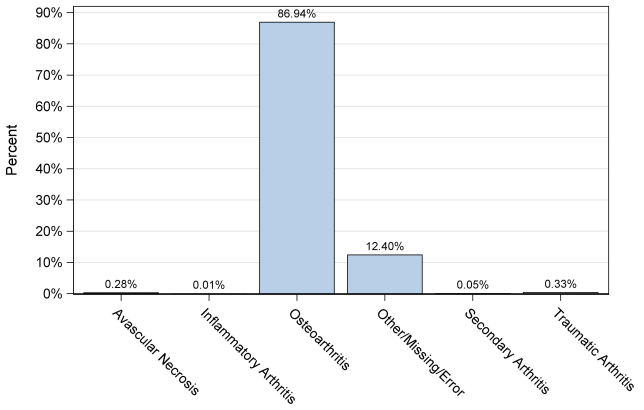

Figure 89: Percent of primary UKA cases by diagnosis.

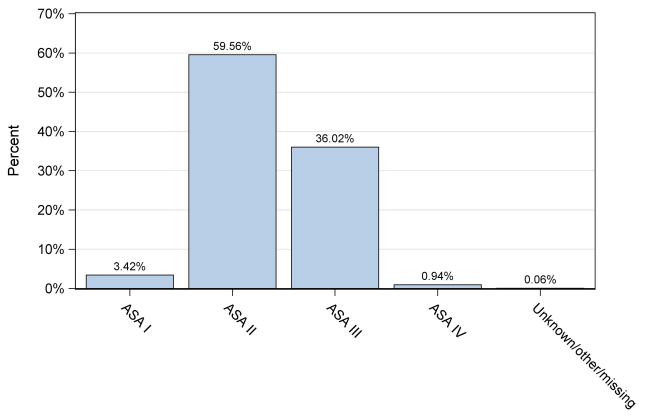

Figure 90: Percent of primary UKA cases by ASA class.

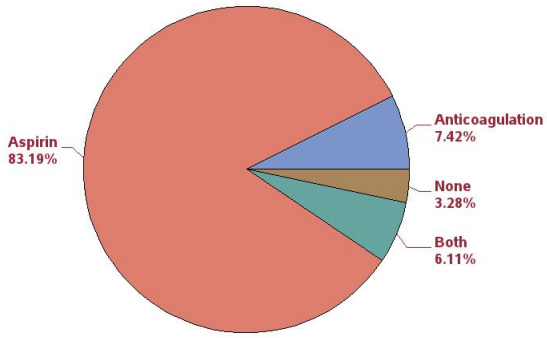

Figure 91: Percent of primary UKA patients (first case) by thombosis pharmacoprophylaxis between 10/1/2017 and 12/31/2017 (this time window is shorter than rest of figures because of significant change over time).

3.6 Most commonly used UKA implants

The following three tables provide utilization data of implants used in primary UKA.

Table 358: Ten most commonly used femoral components in primary UKA.

Rank	Femoral component	N	Percent
1	Restoris MCK	2507	31.4
2	ZUK*	2341	29.3
3	Oxford	2109	26.4
4	Triathlon PKR	267	3.3
5	Journey	194	2.4
6	iBalance	168	2.1
7	Sigma HP	142	1.8
8	Persona	106	1.3
9	Stride	89	1.1
10	Mirror	36	0.5
11	Others	28	0.3

* ZUK (Zimmer Unicondylar Knee) was formerly known as the Zimmer High Flex Knee.

Table 359: Ten most commonly used tibial components in primary UKA

Rank	Tibial component	N	Percent
1	Restoris MCK	2498	31.3
2	ZUK*	2402	30.1
3	Oxford	2040	25.5
4	Triathlon PKR	266	3.3
5	iBalance	167	2.1
6	Sigma HP	141	1.8
7	Persona	107	1.3
8	Journey	103	1.3
9	Stride	89	1.1
10	Vanguard M	59	0.7
11	Others	115	1.4

* ZUK (Zimmer Unicondylar Knee) was formerly known as the Zimmer High Flex Knee.

Table 360: Ten most commonly used femoral/tibial component combinations in primary UKA.

Rank	Femural/tibial component combination	N	Percent
1	Restoris MCK / Restoris MCK	2498	31.3
2	ZUK/ZUK*	2313	29.0
3	Oxford / Oxford	2040	25.5
4	Triathlon PKR / Triathlon PKR	266	3.3
5	iBalance / iBalance	167	2.1
6	Sigma HP / Sigma HP	141	1.8
7	Persona / Persona	106	1.3
8	Journey / Journey	103	1.3
9	Journey / Zimmer High Flex	89	1.1
10	Stride / Stride	89	1.1
11	Others	175	2.2

* ZUK (Zimmer Unicondylar Knee) was formerly known as the Zimmer High Flex Knee.

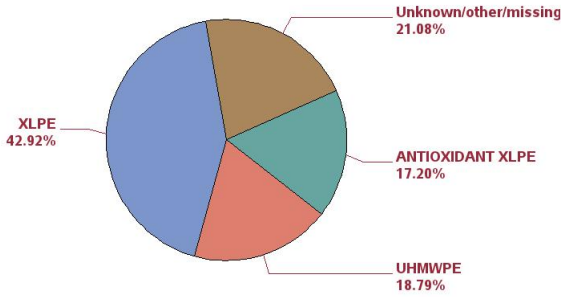

Figure 92: Percentage of polyethylene inserts by type of polyethylene in primary UKA.

3.7 UKA revision risk summary

Reason for revision is of central importance to quality improvement because it helps focus attention on specific causes that may be addressed. Therefore, the data are presented in two formats below: tabular and Pareto chart. The tabular format is consistent with how other arthroplasty registries report cause of revision. The Pareto chart figure presents the same data in a format commonly used in quality improvement. The Pareto chart sorts the reasons for revision by frequency (bar chart on bottom, from left to right) and presents a cumulative percent using a line graph above. The causes corresponding to each bar are numbered and a key at the bottom links the numbers to text descriptions. In addition to an overall summary of reason for revision, tables showing reason for revision for the first, second, and third year post-operatively are provided because the reasons change over this time horizon. It is important to note that the time window for the cases reported in reasons for revision tables and figures differ from the time window used for other figures because reason for revision was added to the database on 1/1/2015. While these data capture revisions for primaries performed back to 2/15/2012, only revisions occurring on or after 1/1/2015 are included in the reasons for revision figure and tables. Also note that for knees instability/dislocation should be interpreted as instability.

Table 361: Reasons for first revision following primary UKA.

Rank	Reason for revision	N	Percent
1	Conversion of UKA	66	29.3
2	Aseptic loosening	47	20.9
3	Pain	45	20.0
4	Instability/Dislocation	17	7.6
5	Joint Infection	14	6.2
6	Component fracture/failure	12	5.3
7	Peri-prosthetic fracture (Tibia)	8	3.6
8	Extensor mechanism failure	4	1.8
9	Osteolysis	3	1.3
10	Metal reaction/Metallosis	2	0.9
11	Malalignment	2	0.9
12	Patellofemoral joint	2	0.9
13	Poly liner wear	1	0.4
14	Peri-prosthetic fracture (Femur)	1	0.4
15	Arthrofibrosis	1	0.4

Table 362: Reasons for first revision following primary UKA in first year post-operatively.

Rank	Reason for revision	N	Percent
1	Conversion of UKA	16	18.0
2	Pain	15	16.9
3	Aseptic loosening	14	15.7
4	Joint Infection	11	12.4
5	Instability/Dislocation	8	9.0
6	Peri-prosthetic fracture (Tibia)	8	9.0
7	Component fracture/failure	4	4.5
8	Extensor mechanism failure	4	4.5
9	Osteolysis	2	2.2
10	Metal reaction/Metallosis	2	2.2
11	Patellofemoral joint	2	2.2
12	Peri-prosthetic fracture (Femur)	1	1.1
13	Malalignment	1	1.1
14	Arthrofibrosis	1	1.1

Table 363: Reasons for first revision following primary UKA in second year post-operatively.

Rank	Reason for revision	N	Percent
1	Conversion of UKA	27	34.2
2	Aseptic loosening	18	22.8
3	Pain	16	20.3
4	Instability/Dislocation	7	8.9
5	Component fracture/failure	7	8.9
6	Joint Infection	2	2.5
7	Osteolysis	1	1.3
8	Poly liner wear	1	1.3

Table 364: Reasons for first revision following primary UKA in third year post-operatively.

Rank	Reason for revision	N	Percent
1	Conversion of UKA	13	32.5
2	Pain	12	30.0
3	Aseptic loosening	10	25.0
4	Instability/Dislocation	2	5.0
5	Joint Infection	1	2.5
6	Component fracture/failure	1	2.5
7	Malalignment	1	2.5

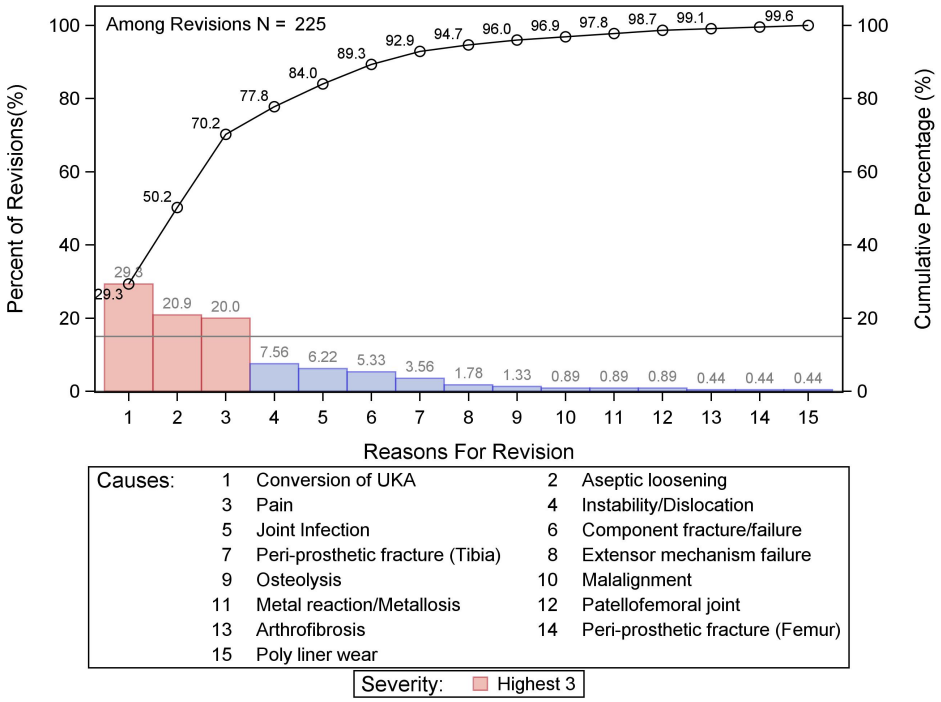

Figure 93: Most common reasons for first revision following primary UKA (Pareto chart).

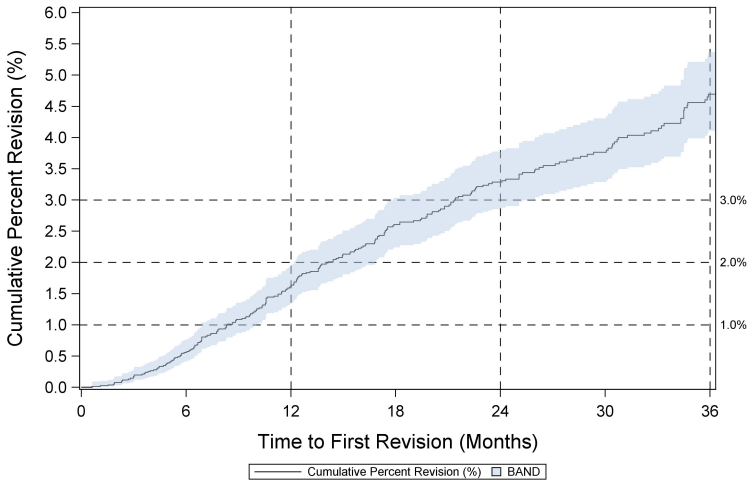

Figure 94: Cumulative percent revision for primary UKA.

Table 365: Cumulative percent revision for primary UKA (numerical values).

N	1 year	2 years	3 years
7984	1.62 (1.35,1.95)	3.28 (2.86,3.78)	4.70 (4.11,5.37)

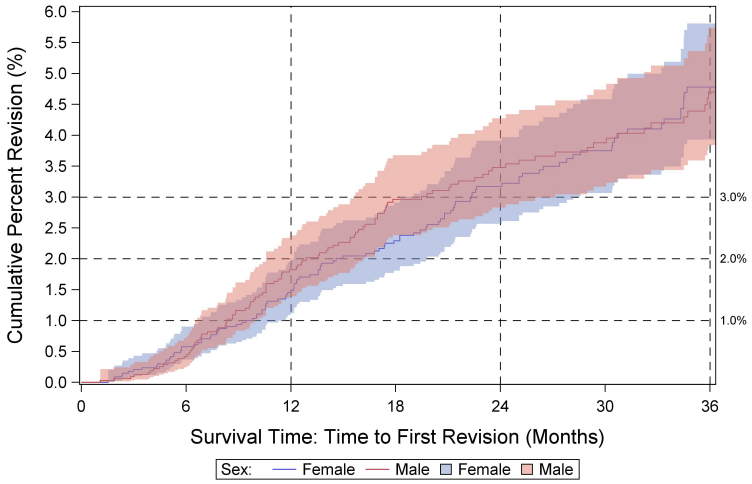

Figure 95: Cumulative percent revision for primary UKA by sex for osteoarthritis diagnosis.

Table 366: Cumulative percent revision for primary UKA by sex for osteoarthritis diagnosis (numerical values).

Sex	N	1 year	2 years	3 years
Female	3553	1.49 (1.12,1.99)	3.17 (2.57,3.91)	4.78 (3.93,5.81)
Male	3388	1.82 (1.39,2.38)	3.48 (2.83,4.27)	4.70 (3.84,5.74)
Unknown/Missing	0			

3.8 Revision risk for UKA implant combinations

In interpreting CPR curves, the reader should remember that all implant combinations have a minimum follow up of at least three years. Therefore, if the red line and shaded confidence interval end prior to three years, this does not mean the longest follow up was less than three years. Instead, it means that no additional revisions occurred after the end of the red line and confidence interval band.

Similar to previous sections on implant-specific revision, the reader should go to the online supplement describing each table and figure to understand inclusion and exclusion criteria when there are questions about the total number of cases reported.

While the reader is encouraged to read the details of each femur/tibia implant combination, the following table summarizes the three-year CPR values.

Table 367: Cumulative percent revision risk for femoral/tibial combinations having at least 500 primary cases, sorted alphabetically.

Femur/Tibia combination	N*	1 year	2 years	3 years
Oxford / Oxford	2039	1.92 (1.38,2.67)	4.08 (3.20,5.19)	5.40 (4.28,6.80)
Restoris MCK / Restoris MCK	2498	1.40 (0.97,2.03)	2.93 (2.20,3.91)	4.49 (3.27,6.15)
ZUK/ZUK**	2312	1.28 (0.88,1.86)	2.33 (1.74,3.10)	3.19 (2.44,4.16)

Notes:

* Number of patients that contribute to survival analysis used to compute cumulative percent revision.

** This implant (Zimmer Unicondylar Knee) was formerly known as the Zimmer High Flex Knee.

Oxford/Oxford
N=2040

71 surgeons across 40 sites use this implant.

Table 368: Volume of cases by surgeon and site for Oxford/Oxford.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	28.7 (64.0)	12 (25)
Cases per site	51 (101.4)	16 (52.5)

Table 369: Descriptive statistics of patients receiving Oxford/Oxford.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1000	49	
Age (yrs)	2040	64.3(10.2)	64(14)
Height (cm)	2040	170(10.3)	170(16)
Weight (kg)	2040	91.4(19.8)	90(26)
BMI(kg/m^2)	2040	31.6(5.8)	30.8(7.5)
Smoking - never (%)	975	47.8	
Smoking - previous (%)	844	41.4	
Smoking - current (%)	206	10.1	
Smoking - unknown (%)	15	0.7	

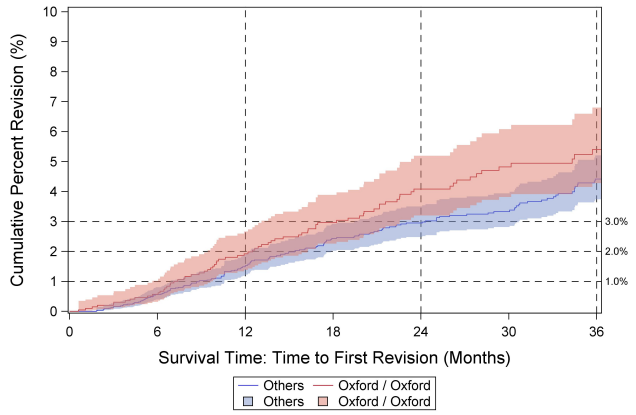

Figure 96: Cumulative percent revision curve for Oxford/Oxford compared to all other UKA implants.

Table 370: Cumulative percent revision for Oxford/Oxford compared to all other UKA implants (numerical values).

N	1 year	2 years	3 years
2039	1.92 (1.38,2.67)	4.08 (3.20,5.19)	5.40 (4.28,6.80)

Table 371: Distribution of approach used for Oxford/Oxford.

Approach	N	Percent
Medial parapatellar	1832	89.8
Mid-vastus	123	6.0
Sub-vastus	18	0.9
Lateral parapatellar	4	0.2
Missing/unknown/other	63	3.1

Table 372: Distribution of polyethylene used for Oxford/Oxford.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	2017	98.9
Antioxidant XLPE	0	0.0
Missing/unknown/other	23	1.1

Table 373: Reasons for revision for Oxford/Oxford.

Rank	Reason for revision	N	Percent
1	Aseptic loosening	20	27.8
2	Conversion of UKA	19	26.4
3	Pain	11	15.3
4	Instability/Dislocation	10	13.9
5	Extensor mechanism failure	3	4.2
6	Joint Infection	3	4.2
7	Patellofemoral joint	2	2.8
8	Peri-prosthetic fracture (Tibia)	2	2.8
9	Component fracture/failure	1	1.4
10	Osteolysis	1	1.4

Restoris MCK/Restoris MCK
N=2498

51 surgeons across 12 sites use this implant.

Table 374: Volume of cases by surgeon and site for Restoris MCK/Restoris MCK.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	49.0 (85.9)	18 (40)
Cases per site	208.2 (303.5)	81.5 (267.5)

Table 375: Descriptive statistics of patients receiving Restoris MCK/Restoris MCK.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1280	51.2	
Age (yrs)	2498	64.3(9.5)	65(13)
Height (cm)	2498	169.9(10.7)	170(15)
Weight (kg)	2498	91.2(19.4)	90(27)
BMI(kg/m^2)	2498	31.6(5.8)	30.8(7.6)
Smoking - never (%)	1257	50.3	
Smoking - previous (%)	1049	42	
Smoking - current (%)	188	7.5	
Smoking - unknown (%)	4	0.2	

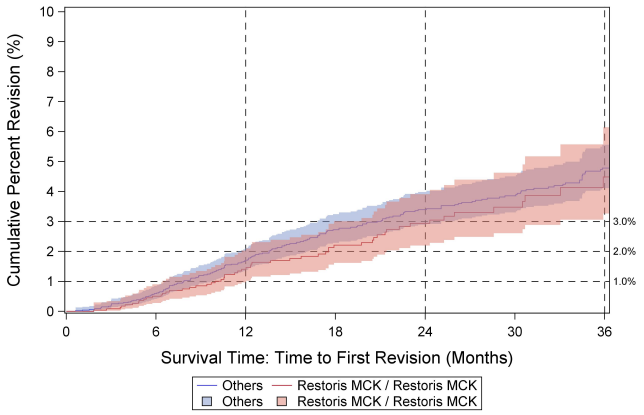

Figure 97: Cumulative percent revision curve for Restoris MCK/Restoris MCK compared to all other UKA implants.

Table 376: Cumulative percent revision for Restoris MCK/Restoris MCK compared to all other UKA implants (numerical values).

N	1 year	2 years	3 years
2498	1.40 (0.97,2.03)	2.93 (2.20,3.91)	4.49 (3.27,6.15)

Table 377: Distribution of approach used for Restoris MCK/Restoris MCK.

Approach	N	Percent
Medial parapatellar	1850	74.1
Mid-vastus	312	12.5
Sub-vastus	1	0.0
Lateral parapatellar	160	6.4
Missing/unknown/other	175	7.0

Table 378: Distribution of polyethylene used for Restoris MCK/Restoris MCK.

Polyethylene type	N	Percent
UHMWPE	1062	42.5
XLPE	0	0.0
Antioxidant XLPE	0	0.0
Missing/unknown/other	1436	57.5

Table 379: Reasons for revision for Restoris MCK/Restoris MCK.

Rank	Reason for revision	N	Percent
1	Aseptic loosening	12	21.1
2	Pain	12	21.1
3	Conversion of UKA	11	19.3
4	Joint Infection	6	10.5
5	Instability/Dislocation	5	8.8
6	Peri-prosthetic fracture (Tibia)	5	8.8
7	Component fracture/failure	4	7.0
8	Arthrofibrosis	1	1.8
9	Osteolysis	1	1.8

ZUK/ZUK

N=2313

This implant (Zimmer Unicondylar Knee) was formerly known as the Zimmer High Flex Knee. 112 surgeons across 38 sites use this implant.

Table 380: Volume of cases by surgeon and site for ZUK/ZUK.

Quantity	Mean (SD)	Median (IQR)
Cases per surgeon	20.7 (40.4)	7 (16)
Cases per site	60.9 (77.1)	22 (87)

Table 381: Descriptive statistics of patients receiving ZUK/ZUK.

Quantity	N	Mean (SD)	Median (IQR)
Female (%)	1156	50	
Age (yrs)	2313	64.3(10.7)	64(16)
Height (cm)	2311	169.5(10.5)	170(15)
Weight (kg)	2312	88.6(19.2)	88(26)
BMI(kg/m^2)	2311	30.8(5.7)	30.1(7.6)
Smoking - never (%)	1105	47.8	
Smoking - previous (%)	939	40.6	
Smoking - current (%)	246	10.6	
Smoking - unknown (%)	23	1	

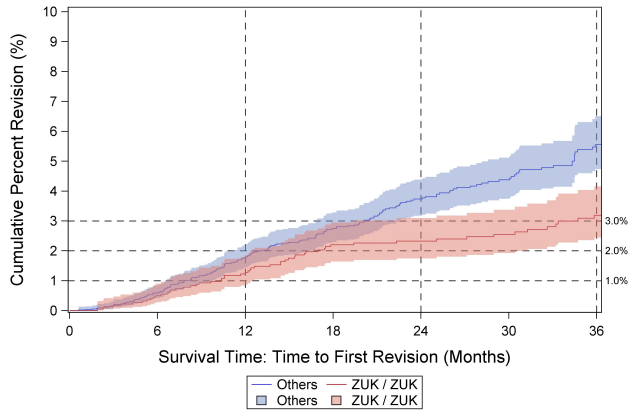

Figure 98: Cumulative percent revision curve for ZUK/ZUK compared to all other UKA implants.

Table 382: Cumulative percent revision for ZUK/ZUK compared to all other UKA implants (numerical values).

N	1 year	2 years	3 years
2312	1.28 (0.88,1.86)	2.33 (1.74,3.10)	3.19 (2.44,4.16)

Table 383: Distribution of approach used for ZUK/ZUK.

Approach	N	Percent
Medial parapatellar	1502	64.9
Mid-vastus	644	27.8
Sub-vastus	47	2.0
Lateral parapatellar	90	3.9
Missing/unknown/other	30	1.3

Table 384: Distribution of polyethylene used for ZUK/ZUK.

Polyethylene type	N	Percent
UHMWPE	0	0.0
XLPE	1107	47.9
Antioxidant XLPE	1163	50.3
Missing/unknown/other	43	1.9

Table 385: Reasons for revision for ZUK/ZUK.

Rank	Reason for revision	N	Percent
1	Conversion of UKA	24	46.2
2	Pain	8	15.4
3	Aseptic loosening	6	11.5
4	Component fracture/failure	4	7.7
5	Joint Infection	4	7.7
6	Extensor mechanism failure	1	1.9
7	Instability/Dislocation	1	1.9
8	Osteolysis	1	1.9
9	Peri-prosthetic fracture (Femur)	1	1.9
10	Peri-prosthetic fracture (Tibia)	1	1.9
11	Poly liner wear	1	1.9

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Appendices

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Appendix A

Statistical methods

This appendix is intended to provide a clear and precise description of the analytical methods used to generate figures, tables, and text in this report. It is written primarily for registry methodologists. It can be used as a reference for readers most interested in clinical aspects of arthroplasty.

A.1 Multi-level closed-loop data quality QC/QA

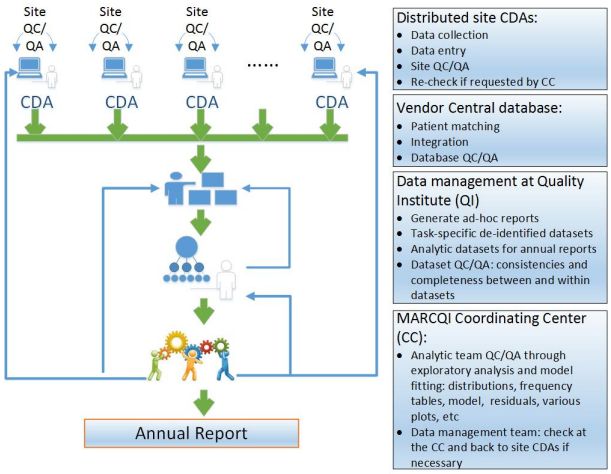

Figure 99: Flowchart of MARCQI 4-level QC/QA process.

Data quality is critical in MARCQI. In order to meet quality dimensions, including accuracy/validity, reliability/consistency, completeness, precision, timeliness, confidentiality, and integrity (Sheppard and Terveen, 2011), MARCQI data has been checked and validated on four levels: (1) hospital, (2) vendor database, (3) data management, and (4) analytical. The first three levels were addressed in chapter two. At the analytical level, the measures were further checked through distributions, frequency tables, model fittings, residuals, and other visualization tools. The questionable measures were directed to the coordinating center data management team and then returned to site clinical data abstractors (CDAs) if necessary. The CDAs validated data and made necessary corrections in the database if a measure was found to be in error. Figure 99 is the flowchart of four-level QC/QA process.

The following goals are the focus of data quality in MARCQI:

1. *Accuracy/validity*. MARCQI data accuracy is validated based on the definitions and medical domain knowledge to ensure that data is entered correctly and appropriately into the domain. At the data entry stage, validation messages are created and a warning message window will pop-up if a value is out of normal range as pre-defined by the domain experts. This helps filter out potential data collection errors and allows confirmation of out-of-range but accurate values.

2. *Reliability/consistency*. The coordinating center staff ensures that the definition of measures is consistent over time and across sites. They assure data collection processes are consistent over time, across distributed hospital sites, and between collection systems through MARCQI CDA training, Collaborative meetings, and consultation with the sites.

3. *Completeness*. Data are fully inclusive, *e.g.*, complete list of eligible implant names, device materials, patient demographics, etc. Missing data, invalid data, and/or incomplete data are checked.

4. *Precision*. MARCQI data are detailed and includes demographics, lab, OR log, implant, etc.

5. *Timeliness*. MARCQI data are up-to-date and available quickly and frequently. Data reports are updated monthly, and the analytical datasets are updated quarterly.

6. *Integrity*. MARCQI maintains the accuracy, validity, and consistency of data over whole data lifecycle, within and between data tables so that data is recoverable, searchable, traceable, and stable.

7. *Confidentiality*. MARCQI data are maintained according to national/international standards for data. All MARCQI data are protected and used appropriately.

This entire process guarantees the MARCQI data quality ranging from protocol, data collection, data entry, patient matching, data merging, data transfer, data storage, and data analysis to decision making.

A.2 Time window, inclusion and exclusion criteria for the hip and knee chapters

This report covers MARCQI activities from 02/15/2012 to 12/31/2017, and included both primary and revision(s) cases. The inclusion and exclusion criteria for each table and figure in the hip and knee chapters are provided in an online supplement *MARCQI Six-Year Report Specifications* available at the MARCQI annual reports web page.

A.3 Data structure for analytics

Two formats of data sets are used for this report, called "long" format and "wide" format.

1. The "long" format has a record (or row) for each case, *i.e.*, an individual record for each primary and revision case. Some patients may have multiple records indicating they have had multiple hip or knee replacement procedures over time. There may be a few patients with primary cases before 02/15/2012, and revision after 02/15/2012 (but before the end of the study 12/31/2017). This dataset is used to calculate statistics for total number of performed cases, overall and per calendar year.

2. In contrast, the "wide" format has one record (or row) for each primary case because a patient can only have one primary surgery per joint; subsequent procedures on the same joint would indicate revisions. There are no stand-alone records dedicated to revision(s). Rather, in the wide format the existence of a first revision is indicated as a dummy variable (1 means having a revision, 0 means not having a revision).

Time to first revision in days was calculated for implant survival analysis. No revisions beyond first revision are coded in the wide data format. Some patients may have multiple records (or rows) if this patient had more than one primary surgery on different joints and/or lateralities. In this report, each primary surgery was treated as a new case. The date of primary cases must fall within the study window. This dataset is used to calculate descriptive statistics for primary cases, overall and breakdown by sex, diagnosis, and type of implant. It is also used for implant survival analysis.

A.4 Definition of revision event for statistical modeling

Total hip arthroplasty and total knee arthroplasty are surgical procedures in which a prosthesis is implanted to replace an arthritic or damaged joint to relieve pain and to improve patient function and quality of life. Joint replacements may require a revision surgery for various reasons. *For the purposes of MARCQI revision analyses, a revision is defined to be a procedure that involves either (a) removing and replacing some, or all, of the joint replacement components or (b) adding a component*. This applies to all MARCQI qualifying cases. There are two situations likely to cause confusion that need to be clarified: (1) adding a cup after a hemi-arthroplasty is a conversion, which is a primary case according to MARCQI criteria; and (2) adding a unicompartmental knee to another compartment of a knee having pre-existing unicompartmental components is considered another primary case rather than a revision.This report focuses on the time-to-first revision.

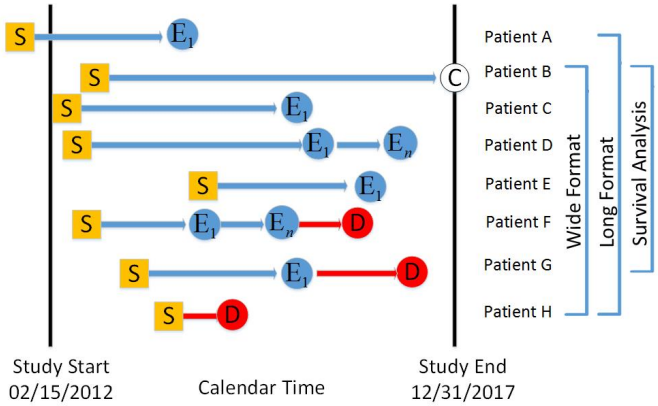

Figure 100: Illustration of event flow and eight types of patients in MARCQI database.

A.5 MARCQI cohort: Qualifying patients and events for descriptive statistics and implant survival analysis

MARCQI was designed to improve quality of care for elective primary total hip and knee arthroplasty and associated revisions, excluding treatment for trauma cases. CDAs review each case for admission type and use the following criteria to determine if the case qualifies for inclusion in MARCQI:

1. *Elective*. All primary and revision hip and knee joint replacement cases qualify that meet three requirements: (1) a surgical procedure has been planned, (2) screening and optimization have been completed, and (3) the patient presented at a pre-planned surgical date for treatment of a non-emergent condition.

2. *Urgent/emergent*. The only urgent/emergent cases that qualify are revisions. This means that (1) a surgical procedure that has not been planned (screening and optimization have not been completed), and (2) the patient presents for care in a stable medical condition without an pre-planned surgical date. The patient may be admitted from an outpatient clinic or surgeon office.

3. *Trauma*. Primary trauma cases do not qualify. The CDA reviews the case to determine if an urgent/emergent qualifying revision of a knee or hip was performed.

There are many different combination of events that can occur for each patient within and outside the 2/15/2012 - 12/31/2017 time window. For example, a patient could have a primary and revision, have a primary and then die, or have a primary and have no revision before 12/31/2017 but remain alive. It is important to understand each when interpreting data in this report, especially time-to-revision and the resulting cumulative percent revision curves and numbers. Figure 100 illustrates the possible events (*e.g.*, revision) for the report window using eight types of patients. Symbols in the figure represent start of a primary surgery (S), single event (E_1) and/or multiple events (E_n), death (D), and censoring (C). The figure helps define important concepts used in MARCQI analyses:

1. *Study time window*. All primary and revision surgeries performed between 02/15/2012 to 12/31/2017 are included. The revision event might be registered after 12/31/2017 in the database, but those post-study end event(s) do NOT qualify for implant survival analysis and were censored at the end of the study. In addition, primary surgeries performed prior to 02/15/2012 are not included in the revision analysis.

2. *Qualified patients*. All eight types of patients qualify for volume reporting, including patient A and patient H. Patient B through patient G qualified for implant survival analysis (thus patients A and H are disqualified). Patient C and patient E are of same type, even though starting time varies. Deaths are addressed in (7) below. Patient type A included in long format dataset is only qualified to calculate total volumes over time. Patient types B through H are included in the wide format dataset as primary surgery cases.

3. *Censoring*. The patients who did not have the event as of the study-end are considered right-censored. These patients provide some information, but not complete information, *e.g.*, Patient B. Patient A is excluded in implant survival analysis because the surgery occurred prior to the onset of the MARCQI registry; thus no left-censoring is considered in this report.

4. *Time-to-event*. Number of days elapsed from primary surgery to the event of interest (*e.g.* first revision following surgery).

5. *Qualified revision events for implant survival analysis*. First event E_1 after primary surgery (thus events E_2, E_3, ..., E_n disqualified). However, E_2, E_3, ..., E_n are counted in the total volume calculations.

6. *Lost-to-follow-up (LTFU)*. This report does not consider LTFU (*e.g.*, due to geographical relocation of patient) as an event of interest. Instead, if MARCQI has no follow-up or death information until study-end, that patient is treated as a right-censoring at the study-end.

7. *Handling of deaths*. In the MARCQI six-year report window, the death rate after primary THA surgeries is about 0.2%, including patient types F, G, and H. The death rate without any event(s) after primary surgery is approximately 0.19%, like patient type H. Following primary TKA cases, death rate is 0.15% without any revision event(s). Patients A and H are treated as qualified patients (in the denominator) in calculating descriptive statistics, implant combinations, surgeon and site volumes, but are excluded in implant survival

analysis. Patients that die after a revision event (like patient F and G) are included in the implant survival analysis since those patients contributed information of time-to-first revision. This strategy ensures a minimal information loss. Kandala *et al.* (2015) showed that low death rate does not substantially affect the implant survival analysis. Thus in the report, the patient type A and H are excluded in the implant survival analysis without conducting competing risk analysis and left censoring.

Finally, for purposes of this report, “unit” is a general term and context specific and may refer to the surgeon, hospital, or implant that a patient is embedded.

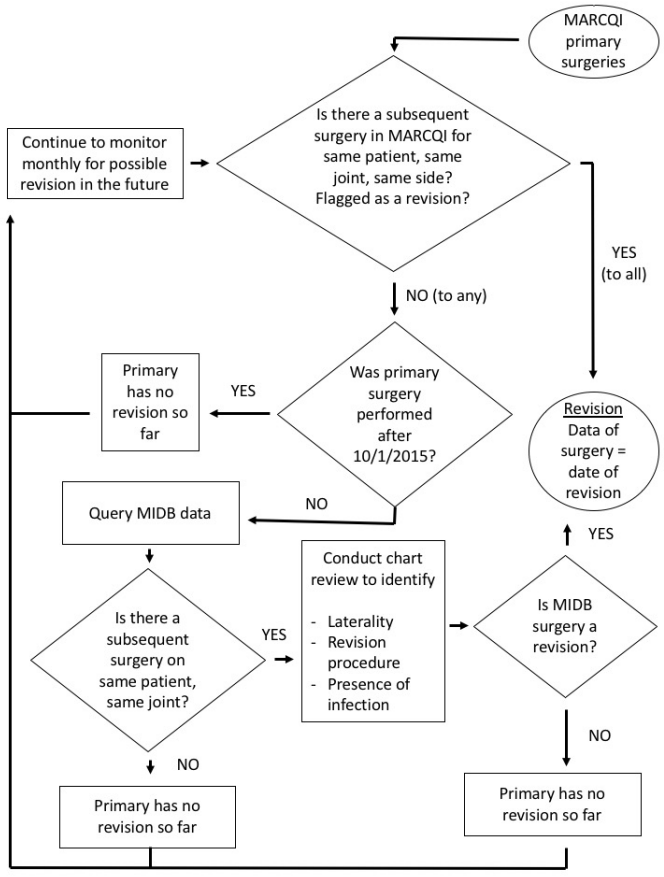

Figure 101: Flowchart of method used to identify revisions.

MARCQI uses a multi-faceted methodology for identifying revisions for two reasons: (1) revision data comes from both abstracted and administrative data sources, and (2) hospitals switched from ICD-9 to ICD-10 coding in 2015. Figure 101 illustrates the process used to identify revisions for this report. For surgeries occurring on or after October 1, 2015, a registry-based MARCQI revision is a case identified by ICD-10 code and confirmed by a CDA. For surgeries occurring prior to October 1, 2015, a revision surgery was identified by the ICD-9 procedure recorded for the case and confirmed by a CDA. Codes for primary procedures were: 81.51 (hip), 00.85 (hip), and 81.54 (knee). Hip revision codes were: 81.53, 00.70, 00.71, 00.72, and 00.73. Knee revision codes were: 81.55, 00.80, 00.81, 00.82, 00.83, and 00.84.

A.6 Descriptive statistics and visualization

For this report continuous measures were checked for normality and skewness. Categorical variables were checked for cell sizes and questionable categories values. If any potential issues were found and confirmed by the MARCQI data management team, then the data quality checking/correction was directed to a different level accordingly.

Univariate variate analyses are performed to compute descriptive statistics for this report, including frequency tables for smoking, both mean and standard deviation (SD), median and interquartile range (IQR) for age, weight, height, body mass index (BMI), and surgeon volumes (overall and device-specific). Frequency tables and various visualization tools, including pie charts, bar charts, Pareto charts (Montgomery, 2009; Tague, 2004), and line plots are employed to present data for sex, approach, diagnosis, distribution of primary vs. revision cases, venous thrombosis prophylaxis, polyethylene type, procedure type, bearing surface couple, head size, reason for revision, and American Society of Anesthesiologists (ASA) class.

A.7 Kaplan-Meier: Unadjusted survival probabilities and cumulative percent revision rates (CPR)

MARCQI presents revision risk for implants using a curve called the “cumulative percent revision,” which is abbreviated CPR and inspired by the Australian Orthopaedic Association National Joint Replacement Registry. Obviously, lower revision risk is preferred to higher risk.

The CPR is constructed starting with the time a primary joint replacement is performed, with the endpoint of interest being revision surgery on that joint. MARCQI computes the time to first revision since the primary procedure for those patients having revision surgery, which is the X-axis in the CPR curve. The Y-axis is the percent of patients who have had a revision among patients with the joint replacement by the corresponding X-axis time.

Computationally, the CPR curve is derived from unadjusted survival probabilities, $\hat{S}(t)$, which is calculated using the Kaplan-Meier product-limit estimator (Kaplan and Meier, 1958; Rich *et al.*, 2010), and corresponding standard errors are calculated with Greenwood's formula (Kalbfleisch and Prentice, 2002). Then the overall, stratified, and implant-specific CPRs are expressed as percentages and calculated by $\hat{CPR} = (1 - \hat{S}(t)) \times 100$. The log-rank test is used to compare survival curves between groups at the $\alpha = 0.05$. There is a significant difference in the survival time between groups if the *p*-value is less than 0.05.

A.8 Database and software platform

The raw data sources are securely transported to MARCQI by the data vendor (Ortech) in MS SQL format. All the data management, exploratory data analysis, descriptive statistics, graphs, statistical modeling are performed using SAS 9.4 (SAS® Institute Inc., Cary, North Carolina)[1], SAS / Interactive Matrix Language (IML)[2], and SAS Macro Language [3]

[1] SAS® 9.4 Product Documentation
[2] SAS/IML® 14.2: User's Guide, Copyright © 2016, SAS Institute Inc., Cary, NC, USA.
[3] SAS® 9.4 Macro Language: Reference, Fifth Edition.

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Appendix B

Awards and publications

B.1 Awards

2016 Current Concepts in Joint Replacement/Orthopaedic Research and Education Foundation - Clinical Practice Award Paper, *No difference in dislocation seen in anterior vs posterior approach total hip arthroplasty* by J.D. Maratt, J.J. Gagnier, P.D. Butler, B.R. Hallstrom, A.G. Urquhart, and K.C. Roberts.

B.2 Journal publications

Franklin, P.D., Lewallen, D., Bozic, K., Hallstrom, B., Jiranek, W., and Ayers, D.C. (2014) Implementation of patient-reported outcome measures in U.S. Total joint replacement registries: rationale, status, and plans. *Journal of Bone and Joint Surgery - American Volume*, 96 Suppl 1:104-109.

Hughes, R.E. Hallstrom, B.R., Cowen, M.E., Igrisan, R.M., Singal, B.M., and Share, D.A. (2015) Michigan Arthroplasty Collaborative Quality Initiative (MARCQI) as a model for regional registries in the United States. *Orthopaedic Research and Reviews*, 7:47-56.

Ellimoottil, C., Ryan, A.M., Hou, H., Dupree, J., Hallstrom, B., and Miller, D.C. (2016) Medicare's new bundled payment for joint replacement may penalize hospitals that treat medically complex patients. *Health Affairs*, 35(9):1651-1657.

Hallstrom, B.R., Singal, B., Cowen, M.E., Roberts, K.C., and Hughes, R.E. (2016) The Michigan experience with safety and effectiveness of tranexamic acid use in hip and knee arthroplasty. *Journal of Bone and Joint Surgery - American Volume*, 98:1646-1655.

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Markel, D.C., Allen, M.W., and Zappa, N.M. (2016) Can an arthroplasty registry help decrease transfusions in primary total joint replacement? A quality initiative. *Clinical Orthopaedics and Related Research*, 474:126-131.

Hughes, R.E., Batra, A., and Hallstrom, B.R. (2017) Arthroplasty registries around the world: valuable sources of hip implant revision risk data. *Current Reviews in Musculoskeletal Medicine*, 10:240-252.

Courtney, P.M., Huddleston, J.I., Iorio, R., and Markel, D.C. (2017) Socioeconomic risk adjustment models for reimbursement are necessary in primary total joint arthroplasty. *Journal of Arthroplasty*, 32:1-5.

Courtney, P.M. and Markel, D.C. (2017) Arthroplasty registries: Improving clinical and economic outcomes. *Journal of Knee Surgery*, 30(1):7-11.

Omari. A., Hughes, R.E., Hallstrom, B.R., Singal, B.M., Igrisan, R.M., and McCardel, B.R. (2017) Using device data to improve identification of intraoperative femur fractures in total hip arthroplasty. *Michigan Journal of Medicine*, 2(1).

Charles, R.J., Singal, B.M., Urquhart, A.G., Masini, M.A., and Hallstrom, B.R. (2017) Data sharing between providers and quality initiatives eliminate unnecessary nursing home admissions. *Journal of Arthroplasty*, 32(5):1418-1425.

Markel, D.C., Allen, M., Hughes, R., Singal, B., and Hallstrom, B. (2017) Quality initiative programs can decrease total joint arthroplasty transfusion rates - A multicenter study utilizing the MARCQI total joint registry database. *Journal of Arthroplasty*, 32(11):3292-3297.

B.3 Conference abstracts

Hughes, R.E., Igrisan, R., and Hallstrom, B. (2014) Designing pay-for-performance incentives for an arthroplasty quality improvement collaborative. *3rd International Congress of Arthroplasty Registeries*, May 31-June 2, Cambridge, MA, 2014.

Hughes, R. (2015) Development and operation of a regional arthroplasty quality improvement collaborative. *Healthcare Systems Process Improvement Conference 2015*, February 18-20, Orlando, FL, 2015.

Maratt, J.D., Gagnier, J., Butler, P., Hallstrom, B.R., Urquhart, A.G., and Roberts, K. (2015) Direct anterior approach does not reduce dislocation risk. *American Association of Hip and Knee Surgeons*, November 5-8, Dallas, TX, USA, 2015.

Hallstrom, B.R., Hughes, R., Igrisan, R., Cowen, M., and Singal, B. (2015) Dramatic reduction in blood transfusion through a quality improvement project in the Michigan arthroplasty registry. *4th International Congress of Arthroplasty Registries*, Gothenburg, Sweden, May 23-25, 2015.

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Hughes, R.E., Chan, M.Y.H., and Hallstrom, B.R. (2016) A Bayesian network model for hip implant outlier detection in post-market surveillance. *2016 BMES/FDA Frontiers in Medical Devices Conference*, College Park, MD, USA, May 23-25, 2016.

Zheng, H., Hughes, R.E., Kabara, J., Cowen, M.E., and Hallsrom, B.R. (2017) A multi-stage modeling framework to analyze discrete events with applications to venous thromboembolism (VTE) prophylaxis following total knee arthroplasty (TKA) within MARCQI. *6th International Congress of Arthroplasty Registries*, San Francisco, CA, USA, May 20-22, 2017.

Hughes, R.E., Batra, A., Pack, B.J., and Hallstrom, B.R. (2017) Translating registry data into clinical practice: Summary of arthroplasty registry reports of revision risk for hips. *6th International Congress of Arthroplasty Registries*, San Francisco, CA, USA, May 20-22, 2017.

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Hood, B., Singal, B., Zheng, H., Hughes, R., Cowen, M., and Hallstrom, B. (2017) Aspirin for venous thromboembolism prophylaxis after primary total knee arthroplasty: An analysis of 41,537 cases in the Michigan arthroplasty registry. *6th International Congress of Arthroplasty Registries*, San Francisco, CA, USA, May 20-22, 2017.

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