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The Outcome of Total Knee Arthroplasty With and Without Patellar Resurfacing up to 17 Years: A Report From the Australian Orthopaedic Association National Joint Replacement Registry

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ABSTRACT

Background: Patellar resurfacing in total knee arthroplasty (TKA) remains a controversial issue after more than 4 decades of TKA. Despite a growing body of evidence from registry data, resurfacing is still based largely on a surgeon's preference and training. The purpose of this study is to provide long-term outcomes for patellar resurfaced compared to when the patella is not resurfaced.
Methods: Data from the Australian Orthopaedic Association National Joint Replacement Registry (1999-2017) were used for this study. The analysis included 570,735 primary TKAs undertaken for osteoarthritis. Hazard ratios (HRs) and 17-year cumulative percent revision rates were used to compare revision rates between 4 subgroups: minimally stabilized (MS) patellar resurfacing, posterior stabilized (PS) patellar resurfacing, MS unresurfaced, and PS unresurfaced patella. Additional analyses of the patellar implant type and a comparison of inlay and onlay patellar resurfacing were also performed.
Results: For all primary TKA, procedures where the patella was not resurfaced have a higher rate of revision compared to procedures where the patella was resurfaced (HR, 1.31; confidence interval, 1.28-1.35; $P < .001$). Unresurfaced PS knees have the highest cumulative percent revision at 17 years (11.1%), followed by MS unresurfaced (8.8%), PS resurfaced (7.9%), and MS resurfaced (7.1%). Inlay patellar resurfacing has a higher rate of revision compared to onlay patellar resurfacing (HR, 1.27; confidence interval, 1.17-1.37; $P < .001$).
Conclusion: Resurfacing the patella reduces the rate of revision for both MS and PS knees. MS knees with patellar resurfacing have the lowest rate of revision. Onlay patella designs are associated with a lower revision rate compared to inlay patella designs.

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Patellar resurfacing in total knee arthroplasty (TKA) remains a controversial issue after more than 4 decades of TKA. The decision to resurface a patella is still based largely on surgeon preference, experience, and training [1]. Early-generation TKA had a high rate of patellofemoral problems. Despite advances in alignment, accuracy, and patella-friendly component design, 15.9% of knee revisions are undertaken for patellofemoral pain or erosion, and 20.2% of knee revisions are patella-only replacement, while 10.2% involve replacement of both the insert and patella [2].

The published literature supports both patellar resurfacing and unresurfaced patella without overwhelming evidence to change clinical practice [3–5]. Most clinical studies are relatively small and report no difference with reoperation rates. Proponents of patellar resurfacing claim reduced incidence of postoperative anterior knee pain, avoidance of secondary resurfacing, higher patient satisfaction, better overall function, lower revision rates, and improved cost-effectiveness [6–11].

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Opponents for resurfacing cite avoidance of patella implant-related complications such as fracture, osteonecrosis, component dissociation, wear, aseptic loosening, instability, overstuffing, and rupture of the extensor mechanism [12] and claim that there were no clinical benefits in terms of pain, function, or satisfaction to routine patellar resurfacing [13–16].

Secondary resurfacing for anterior knee pain does not appear to reliably improve patients' anterior knee pain or satisfaction with the outcome of the procedure [17–19]. Muoneke et al [18] also suggest that secondary resurfacing of a previously unresurfaced patella may increase the revision rate or hasten the time to revision of this group of patients. The research preceding the present study found a 15% re-revision rate in the first 4 years following patella-only revision and that patellar resurfacing had a lower all-cause revision rate than unresurfaced patella at 5 years [20].

Registry data have a unique role in providing information to clinicians in order to improve quality of patient care and influence decision-making. Globally, the registry rates of patellar resurfacing show wide variations between countries [19]. In Sweden, there appears to be a decreasing trend of patellar resurfacing from 15% to 2% for the period of 2004 to 2014, whereas in Australia, patellar resurfacing rates displayed an upward trend from 44% to 59% during the same 10-year period [19].

To date, there are no published studies comparing the long-term survival of inlay or onlay patellar resurfacing options.

The purpose of this study is to provide long-term outcomes for patellar resurfacing compared to unresurfaced patella according to stabilization used, with additional analyses comparing inlay and onlay patellar resurfacing and patellar implant type.

Patients and Methods

The Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) commenced data collection on September 1, 1999, achieving complete national implementation by mid-2002. Since then, it has collected data on almost 100% of THAs and TKAs performed in Australia. These data are validated against patient-level data provided externally by all Australian state and territory health departments. A sequential, multilevel matching process is used to identify any missing data which are subsequently retrieved by contacting the relevant hospital. Each month, in conjunction with internal validation and data quality checks, all primary procedures are linked to any subsequent revision involving the same patient, joint, and side. Data are also matched biannually with the Australian Government's National Death Index to obtain information on the date of death. Linking revision and death to the primary procedure enables revision rates to be determined.

In this study, all primary TKA procedures performed for osteoarthritis (OA) between September 1, 1999, and December 31, 2017, were analyzed according to patellar usage and stabilization type. Fully stabilized and hinged prostheses were excluded as the indications for use are largely for revision or severe deformity. The cumulative percentage revision (CPR) of procedures using minimally stabilized (MS) patellar resurfacing, posterior stabilized (PS) patellar resurfacing, MS unresurfaced patella, and PS unresurfaced patella was compared. Further analyses comparing inlay and onlay resurfacing and patellar implant type were also performed. Reasons for revision were determined, and differences between resurfaced and unresurfaced patellae were identified.

Statistics

Kaplan-Meier estimates of survivorship were used to report the time to revision of a TKA, with censoring at the time of death or closure of the dataset at the end of December 2017. The unadjusted CPR, with 95% confidence intervals (CI), was calculated using unadjusted pointwise Greenwood estimates. Age-adjusted and gender-adjusted hazard ratios (HRs) calculated from Cox proportional hazard models were used to compare the rate of revision between the groups. The assumption of proportional hazards was checked analytically for each model. If the interaction between the predictor and the log of time was statistically significant in the standard Cox model, then a time-varying model was estimated. Time points were selected based on the greatest change in hazard, weighted by a function of events. Time points were iteratively chosen until the assumption of proportionality was met and HRs were calculated for each selected time period. For the present study, if no time period was specified, the HR was calculated over the entire follow-up period. All tests were 2-tailed at 5% levels of significance. Statistical analysis was performed using SAS software version 9.4 (SAS Institute Inc, Cary, NC).

Results

There were 570,735 primary TKA procedures performed for OA included in the analysis. Of these, 301,769 (52.9%) involved patellar resurfacing and 268,966 (47.1%) were unresurfaced procedures. There were 415,537 (72.8%) MS procedures of which 191,327 (46.0%) were MS patellar resurfaced and 224,210 (54.0%) were MS unresurfaced. There were 155,198 (27.2%) PS procedures of which 110,442 (71.2%) were PS patellar resurfaced and 44,756 (28.8%) were PS unresurfaced.

There were more female patients than males across the 4 groups (59.3% MS resurfaced, 53.7% MS unresurfaced, 57.9% PS resurfaced, and 54.0% PS unresurfaced). The mean age was similar across the 4 groups and across gender groups. There were more female patients with a resurfaced patella (Table 1).

The resurfaced group had a lower overall cumulative revision rate than the unresurfaced group (HR, 1.31; CI, 1.28-1.35; $P < .001$). At 17 years, the CPR of the resurfaced group was 7.4% compared to 9.2% for the unresurfaced group. These differences were more pronounced in the PS group (Fig. 1, Table 2). The lowest CPR at 17 years was 7.1% for the MS resurfaced group, followed by PS resurfaced group (7.9%), MS unresurfaced group (8.8%), and PS unresurfaced group (11.1%; Table 2). There was a significantly higher rate of revision for MS unresurfaced compared to MS resurfaced (HR, 1.28; CI, 1.23-1.32; $P < .001$). This was also the case for PS knees with PS unresurfaced patella having a significantly higher rate of revision than PS resurfaced (HR, 1.64; CI, 1.56-1.72; $P < .001$; Fig. 1).

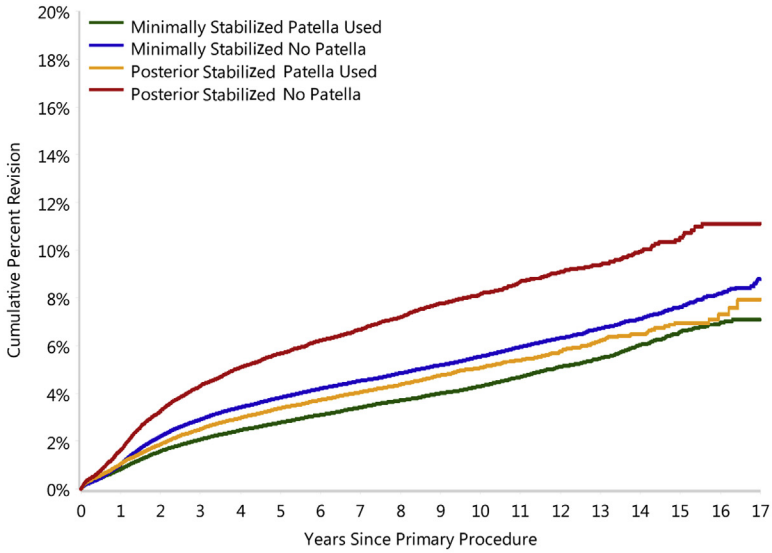
When MS and PS patellar resurfacing were compared, MS patellar resurfacing had a significantly lower rate of revision compared to PS patellar resurfacing for the first 5 years, with no difference after this time (Fig. 1).

The most common causes for revision in all 4 groups were loosening and infection, as well as patellofemoral pain, pain and patella erosion in the unresurfaced groups (Table 3). The majority of

Table 1
Age and Gender by Patella Use and Constraint.

Constraint	Patella	Gender	Number (%)	Mean Age (SD)	Age Range
Minimally stabilized	Yes	Male	77,963 (40.7)	68.6 (8.9)	15-101
		Female	113,364 (59.3)	68.9 (9.2)	13-99
Minimally stabilized	No	Male	103,706 (46.3)	68.1 (9.0)	22-98
		Female	120,504 (53.7)	68.9 (9.3)	21-103
Posterior stabilized	Yes	Male	46,548 (42.1)	68.2 (9.0)	22-98
		Female	63,894 (57.9)	68.7 (9.2)	18-98
Posterior stabilized	No	Male	20,583 (46.0)	68.0 (9.2)	28-97
		Female	24,173 (54.0)	69.1 (9.4)	22-98

SD, standard deviation.



Number at Risk		0 Y	1 Y	2 Y	3 Y	4 Y	5 Y	6 Y	7 Y	8 Y
Minimally Stabilized	Patella Used	1,91,327	1,66,537	1,44,687	1,24,809	1,07,015	90,887	76,438	63,407	52,538
	No Patella	2,24,210	2,05,599	1,86,536	1,67,597	1,49,010	1,30,770	1,12,800	95,989	80,547
Posterior Stabilized	Patella Used	1,10,442	98,074	85,374	73,348	62,010	51,881	42,583	34,066	26,409
	No Patella	44,756	42,009	39,158	36,128	32,848	29,541	26,185	22,541	18,287

Number at Risk		9 Y	10 Y	11 Y	12 Y	13 Y	14 Y	15 Y	16 Y	17 Y
Minimally Stabilized	Patella Used	43,072	34,792	27,573	21,249	15,542	10,425	6008	2484	456
	No Patella	66,487	53,460	42,289	32,111	22,626	15,166	8902	3906	1050
Posterior Stabilized	Patella Used	20,162	14,694	10,182	6754	4288	2438	1244	432	94
	No Patella	14,293	10,450	7421	4927	3073	1778	904	372	86

HR - adjusted for age and gender
Minimally Stabilized No Patella vs Minimally Stabilized Patella Used
Entire Period: HR=1.28 (1.23, 1.32),*P*<.001
Minimally Stabilized Patella Used vs Posterior Stabilized Patella Used
0 - 2Y: HR=0.84 (0.79, 0.88),*P*<.001
2Y - 2.5Y: HR=0.72 (0.64, 0.81),*P*<.001
2.5Y - 3Y: HR=0.84 (0.73, 0.96),*P*=.010
3Y - 3.5Y: HR=0.81 (0.70, 0.94),*P*=.004
3.5Y - 5Y: HR=0.86 (0.78, 0.96),*P*=.005
5Y+: HR=1.01 (0.94, 1.08),*P*=.827
Minimally Stabilized No Patella vs Posterior Stabilized No Patella
Entire Period: HR=0.67 (0.64, 0.70),*P*<.001
Posterior Stabilized No Patella vs Posterior Stabilized Patella Used
Entire Period: HR=1.64 (1.56, 1.72),*P*<.001

Fig. 1. Cumulative percent revision of primary total knee arthroplasty by stability and patella usage (primary diagnosis OA). OA, osteoarthritis; HR, hazard ratio.

MS unresurfaced and PS unresurfaced were revised to a patella only (29.2% and 34.1%, respectively). MS resurfaced and PS resurfaced were revised to an insert only or a TKA (tibial/femoral).

The type of patellar resurfacing, inlay or onlay, was analyzed and compared to unresurfaced patella for prosthesis combinations where both patella options were available. The CPR at 16 years for onlay patellar resurfacing was 5.1%, inlay patellar resurfacing 6.6%, and unresurfaced 8.2%. Inlay patellar resurfacing had a significantly higher rate of revision compared to onlay patellar resurfacing over the entire period (HR, 1.27; CI, 1.17-1.37; $P < .001$) (Fig. 2, Table 4).

Prosthesis specific effects were analyzed by comparing the type of patellar resurfacing, inlay or onlay, to unresurfaced patella for prosthesis combinations where both inlay and onlay options were used in more than 500 procedures (Tables 5-6—years 1, 3, 5, 10, 15, 16, and 17 only shown but all available).

Table 2
Yearly Cumulative Percent Revision of Primary Total Knee Arthroplasty by Stability and Patella Usage (Primary Diagnosis OA).

Stability	Patella Usage	1 y	2 y	3 y	4 y	5 y
Minimally stabilized	Patella used	0.8 (0.8, 0.9)	1.6 (1.5, 1.6)	2.1 (2.0, 2.1)	2.5 (2.4, 2.5)	2.8 (2.7, 2.9)
	No patella	1.0 (1.0, 1.1)	2.2 (2.1, 2.3)	2.9 (2.8, 3.0)	3.4 (3.3, 3.5)	3.8 (3.7, 3.9)
Posterior stabilized	Patella used	1.0 (1.0, 1.1)	1.9 (1.8, 2.0)	2.5 (2.4, 2.6)	3.0 (2.9, 3.1)	3.4 (3.3, 3.5)
	No patella	1.6 (1.5, 1.8)	3.3 (3.1, 3.4)	4.3 (4.1, 4.5)	5.1 (4.9, 5.3)	5.7 (5.5, 5.9)

Stability	Patella Usage	6 y	7 y	8 y	9 y	10 y	11 y
Minimally stabilized	Patella used	3.1 (3.0, 3.2)	3.4 (3.3, 3.5)	3.7 (3.6, 3.8)	4.0 (3.9, 4.1)	4.3 (4.2, 4.4)	4.7 (4.5, 4.8)
	No patella	4.2 (4.1, 4.3)	4.5 (4.4, 4.6)	4.9 (4.8, 5.0)	5.2 (5.1, 5.3)	5.5 (5.4, 5.7)	6.0 (5.8, 6.1)
Posterior stabilized	Patella used	3.7 (3.6, 3.9)	4.0 (3.9, 4.2)	4.4 (4.2, 4.5)	4.8 (4.6, 4.9)	5.1 (4.9, 5.3)	5.4 (5.2, 5.6)
	No patella	6.2 (6.0, 6.5)	6.7 (6.4, 6.9)	7.2 (6.9, 7.5)	7.8 (7.5, 8.1)	8.1 (7.8, 8.5)	8.7 (8.3, 9.0)

Stability	Patella Usage	12 y	13 y	14 y	15 y	16 y	17 y
Minimally stabilized	Patella used	5.1 (5.0, 5.3)	5.5 (5.3, 5.7)	6.0 (5.8, 6.3)	6.6 (6.3, 6.9)	7.0 (6.6, 7.3)	7.1 (6.7, 7.5)
	No patella	6.3 (6.2, 6.5)	6.7 (6.6, 6.9)	7.1 (7.0, 7.3)	7.6 (7.4, 7.8)	8.2 (7.9, 8.5)	8.8 (8.3, 9.2)
Posterior stabilized	Patella used	5.8 (5.5, 6.0)	6.2 (5.9, 6.5)	6.5 (6.2, 6.8)	6.9 (6.5, 7.4)	7.3 (6.7, 8.0)	7.9 (6.9, 9.1)
	No patella	9.1 (8.7, 9.5)	9.4 (9.0, 9.8)	9.9 (9.4, 10.4)	10.5 (9.9, 11.2)	11.1 (10.3, 12.0)	11.1 (10.3, 12.0)

OA, osteoarthritis.

Other covariates analyzed including age at primary procedure and gender had no influence on revision rate between the groups (data not shown).

Discussion

Patellar resurfacing in TKA at 17 years is associated with a lower rate of revision than if the patella remains unresurfaced. When stability was assessed, MS knees with patellar resurfacing have the lowest rate of revision. Onlay patella designs are associated with a lower revision rate compared to inlay patella designs.

The strengths of this Registry study include the large sample size and consequent ability to detect small differences, the population and data being a representative cohort of current practice, the duration, and completeness of follow-up. The limitations of this study are that the only outcome measure is CPR. The Registry is unable to capture failures in the resurfaced group that are unable to have another implant inserted due to lack of bone stock; however, this is likely to be small. Likewise, the Registry does not record repeat surgeries that do not involve components, such as arthrolysis, releases, etc. The AOANJRR does not currently capture patient satisfaction, functional knee scores, or radiographs. Also, the difference between inlay and onlay patellar may be prosthesis specific, which is not addressed in this study. It is also acknowledged that a generalized analysis such as this does not allow for prosthesis-specific variation and that the multiple types of MS and PS knees may have differing revision rates. However, further confirmatory analysis showed that for the most commonly used prostheses, patellar resurfacing was consistently significantly superior to not resurfacing, for both MS and PS knees on both a combined and individual prosthesis level, and MS knees were consistently superior to PS knees, where the patella was resurfaced or not.

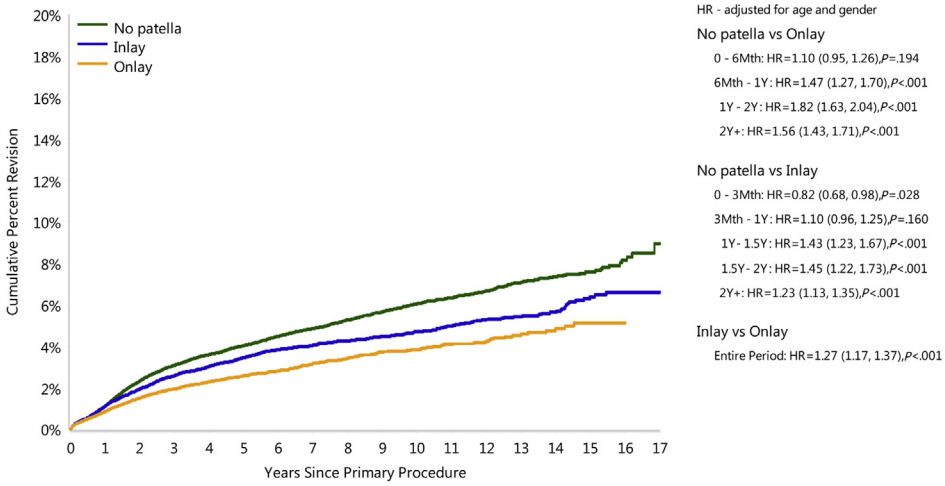
Surgeon preference for prosthesis selection and use of resurfacing are multifactorial, diverse and complex, and not related solely to published revision rates [21]. This selection bias cannot be accounted for in this study.

Although previous clinical randomized, controlled trials have been unable to identify a lower revision rate for resurfaced patellar, this may be due to inadequate numbers to identify small, but real, differences. Previous Registry literature has reported lower overall revision rates in patients having undergone patellar resurfacing at their primary TKA. Our study confirms this finding, with the resurfaced group having a lower revision rate over 15 years than the unresurfaced group with no late patella implant failures. The unresurfaced group was more likely to have both patellofemoral

Table 3
Reason for Revision of Primary Total Knee Arthroplasty by Patella Usage (Primary Diagnosis OA).

Revision Diagnosis	MS Patella Used		MS No Patella		PS Patella Used		PS No Patella	
	Number	% Primaries Revised	Number	% Primaries Revised	Number	% Primaries Revised	Number	% Primaries Revised
Loosening	1663	0.9	2100	0.9	1132	1.0	628	1.4
Infection	1558	0.8	1659	0.7	1166	1.1	555	1.2
Instability	545	0.3	619	0.3	338	0.3	176	0.4
Fracture	199	0.1	228	0.1	136	0.1	63	0.1
Lysis	160	0.1	181	0.1	50	0.0	34	0.1
Malalignment	159	0.1	177	0.1	89	0.1	41	0.1
Other	777	0.4	1037	0.5	452	0.4	226	0.5
Total not patellar related	5061	2.64	6001	2.68	3363	3.05	1723	3.85
Patellofemoral pain	13	0.0	1665	0.7	6	0.0	587	1.3
Pain	332	0.2	951	0.4	202	0.2	322	0.7
Patella erosion	—	—	894	0.4	1	0.0	296	0.7
Implant breakage patella	95	0.0	2	0.0	22	0.0	—	—
Patellar maltracking	30	0.0	67	0.0	29	0.0	21	0.0
Wear patella	11	0.0	—	—	13	0.0	—	—
Patellar dislocation	1	0.0	—	—	—	—	—	—
Total patellar related	482	0.25	3579	1.60	273	0.25	1226	2.74
Total revision	5543	2.90	9580	4.27	3636	3.29	2949	6.59
Total primary	191,327		224,210		110,442		44,756	

OA, osteoarthritis; MS, minimally stabilized; PS, posterior stabilized.



Number at Risk	0 Y	1 Y	2 Y	3 Y	4 Y	5 Y	6 Y	7 Y	8 Y
No patella	74,433	67,559	60,627	53,870	47,494	41,161	34,688	28,452	22,563
Inlay	28,261	26,131	23,801	21,523	19,100	16,570	13,979	11,491	9276
Onlay	64,136	54,043	44,497	35,953	28,036	21,544	15,979	11,433	8302

Number at Risk	9 Y	10 Y	11 Y	12 Y	13 Y	14 Y	15 Y	17 Y
No patella	17,354	12,979	9564	6596	4216	2532	1443	151
Inlay	7533	6031	4756	3594	2556	1666	1002	86
Onlay	6097	4376	3023	2061	1370	893	480	21

Fig. 2. Cumulative percent revision of primary total knee arthroplasty by patella type (primary diagnosis OA).

pain and pain as a cause of revision compared to the resurfaced group.

The unresurfaced group was also more likely to have a patella-only revision. This may be related to surgeon bias for resurfacing a patella if that option is still available in a patient with pain. This is despite literature suggesting that the survivorship and satisfaction of isolated patella revision is less reliable [17,18,22]. Clinically it can be difficult to determine the cause of anterior knee pain in a patient without patellar resurfacing as many other pathologies can present in a similar way (subclinical infection, patella maltracking, mid-flexion instability, and component malrotation). We have previously shown the cumulative percent re-revision rate for patella-only revisions to be 15% over 4 years [20].

The patellofemoral contact forces when using a PS knee have been shown to be higher than that of a MS knee during flexion [23]. Our study also finds a higher rate of revision for PS unresurfaced compared to the resurfacing group. However, there were 44,756 PS unresurfaced knees which represents 28.8% of all PS knees in the Registry. The lowest revision rate at 17 years was for MS knees with patellar resurfacing. From our analysis of all TKAs performed for OA only, 33.5% of patients received this optimal implant combination.

No prior studies have had adequate power to perform a meaningful analysis comparing inlay and onlay patellar resurfacing. Biomechanically it has been shown that inlay patellar resurfacing options are 25% more resistant to shear forces than onlay patella [24]. This does not translate to an increase in survival of the implant. This study shows a higher revision rate associated with inlay patellar resurfacing than onlay patellar resurfacing. This could be due to a variety of reasons. Inlay or inset patella designs leave a rim of native bone around the prosthesis. If this bone contacts the femoral prosthesis, it may be a cause of patellofemoral pain in this cohort.

Table 4
Yearly Cumulative Percent Revision (CPR) of Primary Total Knee Arthroplasty by Patella Type (Primary Diagnosis OA).

CPR	1 y	2 y	3 y	4 y	5 y
No patella	1.1 (1.0, 1.2)	2.3 (2.2, 2.4)	3.1 (2.9, 3.2)	3.6 (3.5, 3.7)	4.0 (3.9, 4.2)
Inlay	1.1 (1.0, 1.2)	1.9 (1.8, 2.1)	2.6 (2.4, 2.8)	3.0 (2.8, 3.2)	3.5 (3.2, 3.7)
Onlay	0.8 (0.8, 0.9)	1.5 (1.4, 1.6)	1.9 (1.8, 2.1)	2.3 (2.1, 2.4)	2.6 (2.4, 2.7)

CPR	6 y	7 y	8 y	9 y	10 y	11 y
No patella	4.5 (4.3, 4.7)	4.9 (4.7, 5.0)	5.3 (5.1, 5.5)	5.7 (5.5, 5.9)	6.0 (5.8, 6.3)	6.3 (6.1, 6.6)
Inlay	3.8 (3.6, 4.1)	4.0 (3.8, 4.3)	4.3 (4.0, 4.5)	4.5 (4.2, 4.8)	4.7 (4.4, 5.0)	5.0 (4.6, 5.3)
Onlay	2.8 (2.6, 3.0)	3.2 (3.0, 3.4)	3.4 (3.2, 3.6)	3.7 (3.5, 4.0)	3.8 (3.6, 4.1)	4.1 (3.8, 4.4)

CPR	12 y	13 y	14 y	15 y	16 y	17 y
No patella	6.7 (6.4, 6.9)	7.1 (6.8, 7.4)	7.3 (7.0, 7.7)	7.6 (7.2, 8.0)	8.2 (7.5, 8.8)	9.0 (7.8, 10.2)
Inlay	5.3 (4.9, 5.7)	5.4 (5.0, 5.8)	5.6 (5.2, 6.1)	6.4 (5.8, 7.0)	6.6 (5.9, 7.3)	6.6 (5.9, 7.3)
Onlay	4.2 (3.9, 4.6)	4.6 (4.2, 5.0)	4.9 (4.3, 5.4)	5.1 (4.5, 5.8)	5.1 (4.5, 5.8)	

OA, osteoarthritis.

Table 5
Prosthesis Combination of Primary Total Knee Arthroplasty by Patella Type.

Prosthesis Combination	No Patella		Inlay		Onlay		Unclassified Patella	
	N	Col%	N	Col%	N	Col%	N	Col%
Triathlon CR/Triathlon	34,016	45.7	2206	7.8	33,910	52.9	6	42.9
Genesis II CR/Genesis II	12,886	17.3	6816	24.1	2458	3.8	—	—
Genesis II PS/Genesis II	6314	8.5	6194	21.9	4849	7.6	1	7.1
Genesis II Oxinium PS/Genesis II	5348	7.2	6159	21.8	5292	8.3	2	14.3
Scorpio CR/Series 7000	5943	8.0	1472	5.2	4143	6.5	1	7.1
Legion Oxinium PS/Genesis II	1275	1.7	1898	6.7	7918	12.3	1	7.1
Genesis II Oxinium CR/Genesis II	4020	5.4	2297	8.1	1853	2.9	—	—
Profix/Profix	4126	5.5	588	2.1	646	1.0	3	21.4
Legion PS/Genesis II	505	0.7	631	2.2	3067	4.8	—	—
Total	74,433	100.0	28,261	100.0	64,136	100.0	14	100.0

CR, cruciate retaining; PS, posterior stabilized.

Knee arthroplasty designs have evolved over time and various implants are now marketed as having patella-friendly trochlear designs. In order to try to draw meaningful conclusions from the Registry, a subgroup analysis of implants with at least 500 implanted knees with both inlay and onlay patella options was performed. In the majority of cases, resurfacing of the patella showed improved results and no evident advantage in an unresurfaced patella.

The use and outcomes of patellar resurfacing vary throughout arthroplasty registries globally. In 2001, the Swedish Knee Arthroplasty Registry showed a 1.3-fold relative risk of revision in the unresurfaced group. However, in 2016, the use of resurfacing has diminished significantly with only 2.4% of patellar resurfacing procedures recorded in the Swedish registry. The Swedish registry now shows a relative revision risk of 1.4 in the resurfaced group. The Swedish Registry annual report suggests that the lower usage of resurfacing may be due to patella revisions associated with patient dissatisfaction, an additional surfacing for loosening, and progression of femoral component designed to be more patella-friendly. This is in contrast to the AOANJRR results, which may be further explored in future research into the impact of regional variations in implant selection on revision rates.

The results of this study suggest that in the long term the mechanical forces of patellar resurfacing have no detrimental effect on implant survival. Furthermore, patellar resurfacing shows improved survivorship when compared to unresurfaced patella. The combination of an MS implant with patellar resurfacing has the lowest rate of revision, but only represents one-third of procedures. Onlay patellar resurfacing has a lower rate of revision compared to inlay patellar resurfacing.

Table 6
Yearly Cumulative Percent Revision of Primary Total Knee Arthroplasty by Prosthesis Combination and Patella Type (Primary Diagnosis OA). Summarized Years Shown but Full Data Available.

Prosthesis Combination	Patella Type	1 y	3 y	5 y	10 y	15 y	16 y	17 y
Genesis II CR/Genesis II	No patella	0.9 (0.8, 1.1)	3.0 (2.7, 3.3)	3.9 (3.5, 4.2)	5.3 (4.8, 5.8)	6.4 (5.7, 7.2)	7.2 (6.1, 8.4)	7.2 (6.1, 8.4)
	Inlay	1.0 (0.8, 1.3)	2.2 (1.9, 2.6)	3.0 (2.5, 3.4)	4.1 (3.6, 4.7)	5.4 (4.6, 6.4)	5.8 (4.7, 7.1)	
	Onlay	0.7 (0.5, 1.2)	2.0 (1.5, 2.7)	2.5 (1.9, 3.3)	3.3 (2.5, 4.4)	4.5 (3.0, 6.8)	4.5 (3.0, 6.8)	
Genesis II Oxinium CR/ Genesis II	No patella	1.2 (0.9, 1.5)	3.6 (3.0, 4.2)	4.4 (3.8, 5.2)	8.0 (7.0, 9.1)	12.1 (10.0, 14.6)		
	Inlay	1.2 (0.8, 1.7)	3.1 (2.5, 4.0)	4.2 (3.4, 5.2)	5.4 (4.4, 6.5)	9.0 (6.4, 12.4)	9.0 (6.4, 12.4)	
	Onlay	1.1 (0.7, 1.7)	2.8 (2.1, 3.8)	3.6 (2.7, 4.7)	6.3 (4.8, 8.3)	8.2 (5.9, 11.2)		
Genesis II Oxinium PS/ Genesis II	No patella	1.9 (1.6, 2.3)	4.9 (4.3, 5.6)	6.5 (5.8, 7.3)	10.0 (9.0, 11.1)			
	Inlay	1.4 (1.1, 1.7)	3.2 (2.8, 3.7)	4.6 (4.0, 5.2)	6.6 (5.7, 7.5)			
	Onlay	1.4 (1.1, 1.8)	3.5 (3.0, 4.1)	4.9 (4.2, 5.6)	6.7 (5.9, 7.7)			
Genesis II PS/Genesis II	No patella	1.4 (1.1, 1.7)	3.7 (3.3, 4.2)	5.0 (4.4, 5.6)	7.0 (6.2, 7.7)	8.2 (7.1, 9.5)		
	Inlay	1.0 (0.8, 1.3)	2.2 (1.8, 2.6)	2.9 (2.5, 3.4)	4.0 (3.4, 4.6)	4.9 (3.8, 6.2)	4.9 (3.8, 6.2)	
	Onlay	1.3 (1.0, 1.6)	2.6 (2.2, 3.1)	3.3 (2.8, 3.9)	5.0 (4.1, 6.1)	6.5 (5.0, 8.5)		
Legion Oxinium PS/Genesis II	No patella	2.6 (1.9, 3.7)	8.1 (6.7, 9.9)	11.6 (9.7, 13.8)				
	Inlay	1.6 (1.1, 2.3)	4.5 (3.5, 5.6)	5.4 (4.3, 6.7)				
	Onlay	0.7 (0.5, 0.9)	1.9 (1.6, 2.3)	2.7 (2.2, 3.2)				
Legion PS/Genesis II	No patella	0.4 (0.1, 1.6)	1.3 (0.6, 2.9)	1.6 (0.8, 3.4)				
	Inlay	1.4 (0.8, 2.8)	3.0 (1.9, 4.8)	4.3 (2.8, 6.6)				
	Onlay	1.0 (0.7, 1.5)	2.0 (1.6, 2.7)	2.2 (1.7, 2.9)				
Profix/Profix	No patella	1.2 (0.9, 1.6)	3.1 (2.6, 3.7)	4.0 (3.4, 4.6)	5.6 (4.9, 6.4)	5.8 (5.1, 6.7)	6.4 (5.2, 8.0)	8.3 (5.2, 13.3)
	Inlay	1.0 (0.5, 2.3)	2.2 (1.3, 3.8)	2.8 (1.7, 4.5)	4.0 (2.6, 5.9)	6.7 (4.2, 10.5)		
	Onlay	0.3 (0.1, 1.2)	1.9 (1.1, 3.3)	3.2 (2.1, 4.9)	4.4 (3.0, 6.4)	4.4 (3.0, 6.4)		
Scorpio CR/Series 7000	No patella	1.1 (0.8, 1.4)	3.2 (2.7, 3.6)	4.3 (3.8, 4.8)	6.7 (6.0, 7.4)	8.6 (7.6, 9.6)	8.8 (7.8, 10.0)	8.8 (7.8, 10.0)
	Inlay	0.7 (0.4, 1.3)	1.6 (1.1, 2.4)	2.4 (1.7, 3.3)	3.6 (2.8, 4.8)	4.9 (3.8, 6.4)	5.2 (4.0, 6.9)	
	Onlay	0.7 (0.5, 1.1)	1.6 (1.3, 2.1)	2.3 (1.9, 2.9)	3.5 (2.9, 4.3)	5.0 (3.9, 6.5)	5.0 (3.9, 6.5)	
Triathlon CR/Triathlon	No patella	0.9 (0.8, 1.1)	2.4 (2.2, 2.6)	3.0 (2.8, 3.3)	4.6 (4.2, 5.0)			
	Inlay	0.7 (0.4, 1.2)	1.5 (1.0, 2.2)	1.9 (1.3, 2.7)				
	Onlay	0.7 (0.6, 0.8)	1.5 (1.4, 1.7)	2.0 (1.8, 2.2)	2.8 (2.5, 3.2)			

MS is referred to in this table as CR.
OA, osteoarthritis; CR, cruciate retaining; PS, posterior stabilized.

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