Revision Surgery for Patellofemoral Problems

Should We Always Resurface?

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Abstract

Background Routine patellar resurfacing performed at the time of knee arthroplasty is controversial, with some evidence of utility in both TKA (tricompartamental) and bicompartamental knee arthroplasty. However, whether one approach results in better implant survival remains unclear. **Questions/purposes** We asked whether (1) routine patellar resurfacing in TKAs resulted in lower cumulative revision rates compared to bicompartamental knee arthroplasties, (2) patella-friendly implants resulted in lower cumulative revision rates than earlier designs, and (3) bicompartamental knee arthroplasties revised to TKAs had higher cumulative revision rates than primary TKAs. **Patients and Methods** From a community-based joint registry, we identified 8135 patients treated with 9530

cemented, all-polyethylene patella TKAs and 627 bicompartamental knee arthroplasties without patellar resurfacing. We compared age, gender, year of index procedure, diagnosis, cruciate status, revision, and revision reason.

Results TKAs had a lower cumulative revision rate for patella-only revision than bicompartamental knee arthroplasties (0.8% versus 4.8%). Adjusting for age, bicompartamental knee arthroplasties were 6.9 times more likely to undergo patellar revision than TKAs. There was no difference in the cumulative revision rate for patella-only revisions between patella-friendly and earlier designs. The cumulative revision rate for any second revision after a patella-only revision was 12.7% for bicompartamental knee arthroplasties while that for primary TKAs was 6.3%.

Conclusions Bicompartamental knee arthroplasties had higher revision rates than TKAs. Femoral component design did not influence the cumulative revision rate. Secondary patella resurfacing in a bicompartamental knee arthroplasty carried an increased revision risk compared to resurfacing at the time of index TKA. To reduce the probability of reoperation for patellofemoral problems, our data suggest the patella should be resurfaced at the time of index surgery.

Level of Evidence Level II, prognostic study. See Guidelines for Authors for a complete description of levels of evidence.

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

Each author certifies that his institution has approved the reporting of this study and that all investigations were conducted in conformity with ethical principles of research.

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Introduction

Routine resurfacing of the patella in TKA is actively debated in the literature. In the last 10 years, numerous randomized controlled trials [1, 5–7, 9, 17, 19, 20, 24, 28, 31] (Table 1) and meta-analyses [3, 8, 13, 21–23] (Table 2) have examined the question of whether surgeons should

Table 1. Summary of selected randomized controlled trials comparing BKA and TKA

Year	Study	Number of patients/knees	Followup (months)	Outcome measures	Implant	Implant manufacturer	Difference	Notes
2001	Barrack et al. [1]	97/121	70.5 mean	KSCRS, Q, R, AKP, CE, Reop	Miller-Galante II	Zimmer, Inc (Warsaw, IN)	None	Design and technique likely more important
2007	Burnett et al. [5]	32/64	121 mean	KSCRS, Q, PPQ, R, Reop	Miller-Galante II	Zimmer, Inc	None	Bilateral arthroplasties with one side BKA and the other TKA
2009	Burnett et al. [6]	97/121	120 minimum	KSCRS, Q, R, AKP, CE, Reop	Miller-Galante II	Zimmer, Inc	None	12% of BKAs and 3% of TKAs underwent revision for patellofemoral problems
2004	Burnett et al. [7]	90/100	120 minimum	KSCRS, Q, ICG, R, F, CE, Reop	Anatomic Medullary Knee	DePuy Orthopedics, Inc (Warsaw, IN)	None (trend favoring BKA)	Some trends toward BKA being better
2006	Campbell et al. [9]	100/100	120 minimum	KSCRS, WOMAC, Q, R, AKP, Reop	Miller-Galante II	Zimmer, Inc	None	No difference in preoperative AKP and outcome; decision must be made to leave the patient unresurfaced and exposure to the risk of secondary resurfacing or resurface and accept a similar incidence of AKP for which revision options are limited
2003	Mayman et al. [17]	90/100	96 minimum	KSCRS, Q, F, R, Reop	Anatomic Medullary Knee	DePuy Orthopedics, Inc	TKA favored for pain with stairs and walking; otherwise, no difference	No difference in KSCRS, pain with stairs, and walking; found TKA to be better; other subjective findings trended similarly; no difference in revision surgery
2006	Myles et al. [19]	50/50	18 minimum	KSCRS, WOMAC, EMG, pain VAS	LCS	DePuy Orthopedics, Inc	None	Focused on EMG flexion-extension measurements
2000	Newman et al. [20]	NR/125	60 minimum	BKS, CPS, R, Reop	Kinematic Modular Knee	Howmedica, (Rutherford, NJ)	TKA favored	BKS trend toward TKA; CPS showed advantage in favor of BKA; ICG was not reliable; more BKAs required revision
2003	Peng et al. [24]	35/70	38 mean	KSCRS, Q, AKP, F, CE	Multiple		None	No evidence that weight of the patient or presence of preoperative AKP should be considered as factors
2003	Waters and Bentley [28]	431/514	63.6 mean	IKSS, BOAPSS, R, AKP, CE, Reop	PFC	DePuy Orthopedics, Inc	TKA favored	25.1% BKA with postoperative AKP versus 5.3% in TKA; 10/11 of BKAs that underwent eventual resurfacing of the patella had complete relief

Table 1. continued

Year	Study	Number of patients/knees	Followup (months)	Outcome measures	Implant	Implant manufacturer	Difference	Notes
2002	Wood et al. [31]	201/221	48 mean	IKSS, Q, R, AKP, F, Reop	Miller-Galante II	Zimmer, Inc	TKA favored	12% of BKAs and 10% of TKAs underwent revision/reoperation; higher incidence AKP in BKA; weight but not body mass index was correlated to AKP in BKA group

BKA = bicompartamental knee arthroplasty; NR = not reported; KSCRS = Knee Society clinical rating score; Q = questionnaire; R = radiographs; AKP = anterior knee pain; CE = clinical examination; Reop = reoperations; PPQ = Patellofemoral Patient Questionnaire; ICG = intraoperative cartilage grade; F = functional testing; VAS = visual analog scale; BKS = Bristol Knee Score; CPS = Clinical Patella Score; IKSS = International Knee Society Score; BOAPSS = British Orthopaedic Association Patient-Satisfaction Score.

always resurface the patella at the index TKA or not resurface the patella as a bicompartamental knee arthroplasty (BKA). Most of the recent randomized controlled trials [1, 5–7, 9, 19, 24] reported no difference in BKA versus TKA outcome measures, including Knee Society clinical rating score and reoperation rate, while others point to TKA superiority [17, 20, 28, 31]. Nevertheless, with pooled data, nearly all of the recent meta-analyses favor resurfacing [3, 13, 21–23], the minority opinion being there is no difference [8]. While data from a registry study were included [26] in a recent meta-analysis [3], dedicated registry studies were decidedly rarer, with one study [15] focusing on problems common to both TKAs and BKAs and another suggesting lower revision rates in patients having TKA [10].

A 2009 poll of American Association of Hip and Knee Surgeons found 76% of members resurface “virtually all” of their TKA cases, 16% resurface more than 90% of the time, and only 5% resurface fewer than 10% of their TKA cases [2]. While North American surgeons traditionally resurface the patella, the same is not true elsewhere; the registries of Norway and Sweden indicate resurfacing occurs less than 11% and 14% of the time, respectively [25]; the Australian registry notes a rate of 43% [10]; and Denmark’s registry records a 76% rate of resurfacing in primary knee arthroplasty [25]. Thus, there does not appear to be agreement on whether to routinely resurface the patella and whether resurfacing or not results in better implant survival.

We asked whether (1) routine patellar resurfacing resulted in a lower cumulative revision rate (CRR) in TKAs compared to BKAs, (2) implant designs designated as patellar-friendly (PF) resulted in lower TKA and BKA CRRs than earlier models, and (3) BKAs revised to TKAs had a higher overall CRR compared to primary TKAs.

Patients and Methods

The HealthEast Joint Registry (HEJR) is a total joint registry that tracks hip and knee arthroplasties performed by 95 surgeons at five community hospitals in the St Paul, MN, metropolitan area. We collected information on 14,927 knee arthroplasties in the HEJR between September 1, 1991, and December 31, 2009. Details of the data collection methods and application of statistical analyses were previously reported [11]. From the database, we identified 8231 patients who had 10,298 primary cemented BKAs and TKAs. We excluded 20 patients (22 knees) who had either highly constrained designs or hinged TKA designs primarily implanted and 103 patients (119 knees) with inflammatory arthritis. This left 8135 patients with 10,157 knees: 9530 TKAs and 627 BKAs. Of the patients

Table 2. Summary of meta-analyses comparing BKA and TKA

Year	Study	Papers reviewed	Number of knees	Minimum followup (months)	Conclusion	Notes
2004	Bourne and Burnett [3]	Swedish Knee Registry (27,372) 4 bilateral studies 2 selective resurfacing studies 6 RCTs (471 patients)	NR	NR	TKA reasonable in most	BKAs might be considered in patients < 60 years with mild or no patellar arthritis, a well-tracking extensor mechanism, and particularly if a patella-friendly femoral component is used
2009	Calvisi et al. [8]	5 meta-analyses 1 systematic review 6 RCTs	NR	NR	Neither is superior	TKAs can reduce rate of AKP but must accept complications
2008	Helmy et al. [13]	7 RCTs	1024	24	TKA is superior at index procedure	Recommendation would remain the same as long as the incidence of persistent AKP with resurfacing remains less than 29% (currently 12%) or the incidence of AKP after nonresurfacing falls below 12% (currently 26%); delayed resurfacing has inferior results
2005	Nizard et al. [21]	12 RCTs/QRCTs	1490	12	Favors TKA	Recommendation made noting many confounding factors exist; no differences in IKS function score, HSS score, or patient satisfaction
2005	Pakos et al. [22]	10 RCTs	1223	12	Favors TKA	TKAs reduced the absolute risk of postoperative AKP by 13.8%; there was no difference in knee scores
2005	Parvizi et al. [23]	14 RCTs/QRCTs	1519	NR	Favors TKA	Secondary resurfacings for AKP was needed in 8.7% of BKAs

BKA = bicompartamental knee arthroplasty; RCT = randomized controlled trial; QRCT = quasirandomized controlled trial; NR = not reported; AKP = anterior knee pain; IKS = International Knee Society; HSS = Hospital for Special Surgery.

included, 63% were female and the average age was 67 years (range, 16–96 years). The minimum followup was 0 years (mean, 6.8 years; range, 0–18.8 years). The HealthEast Institutional Review Board approved this study.

We determined CRR using three end points: (1) patella-only revisions before June 30, 2010, as our primary end point, with patella-only revision defined as the removal, exchange, or addition of the patella component only; (2) all revisions; and (3) all second revisions, which we defined as the removal, exchange, or addition of any component before June 30, 2010, that occurred in a patient with an earlier revision surgery on the same knee. For these analyses, we used the Kaplan-Meier method, calculated CRRs, and compared them using the log-rank test. We compared patients with BKA and TKA using the following variables: age, gender, year of index procedure, primary diagnosis, cruciate status (posterior cruciate-retaining [CR] or substituting [CS]), and design of the patellofemoral articulation of the TKA. We based this last variable on

established design characteristics and peer-reviewed studies of the designs in question, where available. Numerous studies demonstrated diminished contact stresses on both native and resurfaced patellas when designs allowed for adequate femoral component external rotation and incorporated a deep patellar groove and a supportive lateral flange, which supports the patella in deep flexion and directs the patella to the midline [3, 4, 12, 16, 27, 29, 30]. Such designs have been more widely used since 2002 and were designated as “patellar-friendly” to contrast them to earlier designs, since that term is typically utilized to describe this design characteristic (Table 3) [3, 29].

We compared TKAs and BKAs using Wilcoxon rank-sum test for continuous variables (age, followup time, cost of index implant, and length of stay) and the Pearson’s chi square test for categorical variables (gender, year of index procedure, cruciate status, PF design, reason for patella-only revision, and reason for revision). We performed a subgroup analysis separating CR implants from CS

Table 3. Designation of total knee designs

Designation	Product line	Manufacturer*	Number of BKAs	Number of TKAs
Patella-friendly designs	Insall-Burstein II	Zimmer	1	94
	Legacy Posterior Stabilized	Zimmer	0	55
	NexGen	Zimmer	1	86
	NexGen CR-Flex Gender Solutions Female	Zimmer	0	64
	Natural-Knee II	Zimmer	0	6
	LCS	DePuy	0	2
	PFC Sigma	DePuy	63	3809
	Sigma RP	DePuy	4	350
	Genesis	Smith and Nephew	0	23
	Genesis II	Smith and Nephew	0	750
	Vanguard	Biomet	1	1
	Duracon	Stryker	71	379
	Omnifit	Stryker	0	6
	Scorpio	Stryker	190	566
	Series 7000	Stryker	117	91
	Triathlon	Stryker	12	1495
	Kinematic	Stryker	1	5
	Advance	Wright	1	233
	Advance Stature	Wright	1	12
	Axium	Orthomet	3	5
	Optetrak	Exactech	2	325
	Foundation	Encore	1	10
	Continuum	Implex	0	1
Earlier designs	Porous Coated Anatomic	Stryker	2	9
	Anatomic Modular Knee	DePuy	0	1
	PFC	DePuy	151	780
	Advantim	Wright	3	314

* Manufacturers include: Zimmer, Inc (Warsaw, IN); DePuy Orthopaedics, Inc (Warsaw, IN); Smith and Nephew, Inc (Memphis, TN); Biomet, Inc (Warsaw, IN); Stryker Orthopaedics (Mahwah, NJ); Wright Medical Technology, Inc (Arlington, TN); Orthomet, Inc, (Minneapolis, MN); Exactech, Inc (Gainesville, FL); Encore Medical Corp (Austin, TX); Implex Corp (Allendale, NJ); BKA = bicompartamental knee arthroplasty.

implants to determine whether the risk of revision, based on patella resurfacing, was different for these groups. We calculated relative risk of revision using Cox proportional-hazards regression and considered all variables mentioned previously (except reason for revision) for potential confounding. We defined a confounder as a variable of interest that changed the main effect estimate by greater than 10% and included variables that met this definition in the final Cox regression model.

Results

The registry data showed a difference in the CRR for patella-only revisions: 4.8% versus 0.8% for BKAs and TKAs, respectively (Fig. 1). Similarly, there was a difference in all revisions between BKAs and TKAs at 18 years,

8.2% versus 6.3%, respectively (Fig. 2). Resurfacing was performed in younger patients (66.6 years versus 69.6 years), had a later year of index procedure, and was more often performed with a PF design (Table 4). There was no difference in gender between the BKA and TKA groups. The most common reason for patella-only and all revisions in the TKA group was aseptic loosening (16 of 37 [43%] and 68 of 244 [28%], respectively), while the most common reason for patella-only and all revisions in the BKA group was progressive arthritis (20 of 23 [87%] and 20 of 38 [53%], respectively) (Table 5). BKAs were 6.9 times as likely to have a patella-only revision compared to TKAs after adjusting for age (hazard ratio [HR] = 6.9; 95% confidence interval [CI] = 4.1–11.8; $p < 0.0001$). BKAs were also 1.7 times as likely to be revised for any reason as compared to TKAs after adjusting for age (HR = 1.67; 95% CI = 1.2–2.4; $p = 0.004$).

Fig. 1 Kaplan-Meier survival analysis shows a higher ($p < 0.001$) patellar CRR for BKAs (4.8%) than for TKAs (0.8%) for patella-only revisions.

Fig. 2 Kaplan-Meier survival analysis shows a higher ($p = 0.01$) patellar CRR for BKAs (8.2%) than for TKAs (6.3%) for all revisions.

The subgroup analysis of CR versus CS designs revealed no difference in the number of revisions for BKAs or TKAs. There was no difference in patellar-only revisions in CR versus CS TKAs (0.8% versus 0.5%; $p = 0.63$); similarly, there was no difference in patellar-only revisions in CR versus CS BKAs (1% versus 4%; $p = 0.17$). There was also no difference in the CRR after controlling for age and gender between CR and CS designs for either the TKAs or BKAs.

We found no difference in the CRR for patella-only revisions between PF and earlier designs for either the TKAs (0.7% versus 1.1%, respectively; $p = 0.23$) or BKAs (3.8% versus 6.1%, respectively; $p = 0.35$). There was also no difference in CRR for all revisions between PF

Table 4. Univariate analysis

Parameter	TKAs (n = 8693)	BKAs (n = 655)	p Value*
Cost of implant (US dollars) [†]	\$3947.24 (\$993.78)	\$3806.37 (\$1030.30)	<0.001
Length of stay (days) [†]	3.9 (1.5)	4.8 (1.8)	<0.001
Gender			
Male	3125 (36%)	243 (37%)	0.55
Female	5568 (64%)	412 (63%)	
Age categories			
< 55 years	1112 (13%)	51 (8%)	<0.001
55–70 years	4292 (49%)	281 (43%)	
≥ 70 years	3289 (38%)	323 (49%)	
Year of index procedure			
1991–1997	1554 (18%)	305 (47%)	<0.001
1998–2003	2293 (26%)	256 (39%)	
2004–2009	4846 (56%)	94 (14%)	
Primary diagnosis			
Osteoarthritis	8509 (98%)	615 (94%)	<0.001
Rheumatoid arthritis	93 (1%)	17 (3%)	
Other	91 (1%)	23 (3%)	
Cruciate status			
Retaining	6471 (75%)	555 (85%)	<0.001
Substituting	2168 (25%)	96 (15%)	
Patella friendly			
Yes	7544 (87%)	488 (75%)	<0.001
No	1125 (13%)	166 (25%)	

* p Values were calculated using the Wilcoxon rank-sum test for continuous variables and the Pearson chi square test for categorical variables; [†]values are expressed as mean, with SD in parentheses; the remaining values are expressed as number of TKAs or BKAs, with percentage in parentheses; BKA = bicompartamental knee arthroplasty.

Table 5. Reasons for patellar revisions

Reason	BKAs (n = 23)	TKAs (n = 37)
Wear/osteolysis	2 (9%)	0 (0%)
Aseptic loosening	0 (0%)	16 (43%)
Periprosthetic fracture	0 (0%)	3 (8%)
Dislocation	1 (4%)	3 (8%)
Mechanical failure/breakage	0 (0%)	3 (8%)
Progressive arthritis	20 (87%)	2 (5%)
Instability	0 (0%)	5 (14%)
Pain	0 (0%)	4 (11%)
Other	0 (0%)	1 (3%)

Values are expressed as number of TKAs or BKAs, with percentage in parentheses; BKA = bicompartamental knee arthroplasty.

and earlier designs for the TKAs (4.5% versus 7.6%, respectively; $p = 0.19$) or BKAs (7.0% versus 10.8%, respectively; $p = 0.20$). In addition, there was no

difference in the risk of patella-only revisions or all revisions for PF and earlier designs after controlling for resurfacing.

The CRR for any type of second revision after a patella-only revision was 12.7% for BKAs and 21.1% for TKAs ($p = 0.30$). However, when the CRR for BKAs that ultimately underwent resurfacing (12.7%; 95% CI = 0%–29.8%) was also compared to the CRR for primary TKAs in our registry (6.3%; 95% CI = 4.7%–7.9%), the log-rank p value comparing these two groups was 0.31, based on the relatively small numbers in the BKA group.

Discussion

Surgeons worldwide variably perform routine resurfacing of the patella at the time of index TKA. Survival of the implant construct and minimizing further surgery are important concerns for both patient and surgeon. In an effort to contribute to the discussion on resurfacing versus not resurfacing the patella, we utilized our registry data and asked whether (1) routine patellar resurfacing resulted in a lower CRR in TKAs compared to BKAs, (2) PF implant designs resulted in a lower CRR in TKAs and BKAs than earlier models, and (3) BKAs revised to TKAs had a higher CRR compared to primary TKAs.

Our study was subject to limitations. First, we used revision, or more specifically, CRR, as the relatively crude end point for the common outcome measure for implant registries. We could not capture complaints of anterior knee pain or poor knee scores that did not result in revision. Second, there was a risk of loss of revisions performed outside the registry database capture. The HEJR may have captured only 94% of the revisions performed on primary arthroplasties [11], similar to the Scandinavian registries. However, we would expect revisions performed outside the capture area to occur in both groups equally. Third, local practices could have skewed the HEJR, a community-based joint registry, based on training or partner practices, which would not necessarily be seen in a national joint registry with a larger and more diverse group of surgeons. Fourth, an implant registry could not account for varying indications for revision surgery among surgeons or acceptance by patients. We acknowledge surgeons may be more inclined to offer a patient undergoing a BKA a patella-only revision to a TKA for anterior knee pain or even unexplained pain, artificially increasing the BKA revision rate [10], but we had no way to control for these variables. Finally, formulating firm conclusions on the benefit of revision surgery as gauged by the number of rerevisions (a total of three surgeries including the index operation) was problematic given the small numbers involved—two from the initial BKA group and six from the initial TKA group.

Numerous randomized controlled trials and meta-analyses addressed our first question, whether routine patellar resurfacing results in a lower CRR in TKAs compared to BKAs. Interestingly, most of the recent randomized controlled trials (Table 2) found no difference or favored TKA, while nearly all of the meta-analyses (Table 3) favored TKA, possibly indicating the randomized trials were underpowered to detect a difference. Given the number of patients included in our community-based joint registry (8135), we presumed we would find a result similar to the meta-analyses. Our registry data showed routine patellar resurfacing resulted in a lower TKA CRR compared to BKA, consistent with the meta-analyses and other registry studies. Clements et al. [10] had the largest registry study on this topic to date, analyzing 134,799 knee arthroplasties from the Australian Orthopaedic Association National Joint Replacement Registry and comparing the CRR between TKA and BKA. At 5 years, the BKA group had a 1.33 times higher risk of revision than the TKA group, with revisions for patellofemoral pain being more common in the BKA group. Lindstrand et al. [15] utilized data from the Swedish Knee Arthroplasty Registry, which included 16,067 arthroplasties (5139 TKAs and 10,928 BKAs). Early revision for patella problems occurred in 36 patients (0.7%) in the TKA group and 99 patients (0.9%) in the BKA group with a range of followup from 1 to 6 years.

One confounding variable we addressed in our study was CR versus CS design status. We found no difference in the CRR between the CR and CS groups. Waters and Bentley [28] reported the only study in the last decade that simultaneously randomized patients into CR and CS groups, as well as TKA and BKA groups. They also found no difference based on cruciate design status.

Our second question was whether PF implant designs result in a lower CRR in TKAs and BKAs than earlier models. For a femoral component to be considered PF, it must have had a deep trochlear groove to support the patella in deep flexion, direct the patella to the midline with flexion, and allowed for adequate femoral component external rotation; some authors suggest such designs minimize the risk of anterior knee pain and patellar failure [3, 30]. Although the majority of the designs presently utilized in the HEJR met these criteria, not every design had peer-reviewed literature documenting the design of the patellofemoral articulation. We utilized the criteria outlined in the above studies to categorize designs if there was not a specific discussion of this aspect of the TKA design published elsewhere. In their registry studies, Clements et al. [10] and Lindstrand et al. [15] did not stratify their data based on patellofemoral design characteristics and the majority of randomized controlled trials tested single implants and were unable to comment on different patellofemoral designs [1, 5–7, 9, 17, 19, 20, 28, 31].

Similarly, the meta-analyses from the past decade failed to stratify their data based on the patellofemoral articulation of the implants [3, 8, 13, 21–23]. Specifically, the meta-analysis by Bourne and Burnett [3] noted, “not resurfacing the patella might be considered in selected younger patients (< 60 years) with mild or no patellar arthritis, a well-tracking extensor mechanism, and particularly if a patella-friendly femoral component is used,” but data on different patellofemoral designs did not appear in their publication. Our result may be due to the predominance of PF designs in the registry that may be equally beneficial for both native and resurfaced patellas, thereby eliminating any appreciable effect.

With respect to our third question, we could not show BKAs revised to TKAs had a higher overall CRR compared to primary TKAs undergoing subsequent revision with the numbers available. Of the 23 BKAs undergoing a first revision to resurface the patella, only two were rerevised for any reason (CRR, 15.2%). The CRR of BKAs undergoing a first revision to resurface the patella (12.7%; 95% CI, 0%–29.8%) could be contrasted to the CRR of TKAs undergoing a first revision for any reason (6.3%; 95% CI, 4.7%–7.9%). Larger numbers of BKAs might better demonstrate our contention that, if a patella was to be resurfaced, it was best to do it during the primary operation. The registry study performed by Clements et al. [10] supported this argument. At 4 years, they found there was a 4.1 times greater risk of revision within 4 years for secondary resurfacing compared to primary resurfacing, leading them to conclude “patella resurfacing is more effective in terms of early revision when performed at the primary arthroplasty rather than at the first revision” [10]. Others agreed secondary resurfacing was not a panacea. Muoneke et al. [18] noted, of the 20 of 623 BKAs that underwent secondary resurfacing in their report, only 44% reported an improvement in their knee pain, and six of the 20 had complications. According to Khatod et al. [14], only 52% of patients with BKAs undergoing secondary patellar resurfacing in their series were satisfied.

Our data suggest BKAs undergo revision for patella-related issues more frequently than TKAs, irrespective of TKA design or cruciate status, and resurfacing the patella at the primary operation results in fewer revision operations overall. To reduce the probability of reoperation for patellofemoral problems, we suggest surgeons resurface the patella at the time of index surgery. Tracking revision surgery in a registry database can be an effective mechanism for change in surgeon practice. In our registry, the percentage of all patellas resurfaced rose from 84% in 1991 to 98% in 2009.

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References

1. Barrack RL, Bertot AJ, Wolfe MW, Waldman DA, Milicic M, Myers L. Patellar resurfacing in total knee arthroplasty: a prospective, randomized, double-blind study with five to seven years of follow-up. *J Bone Joint Surg Am.* 2001;83:1376–1381.
2. Berry DJ, Bozic KJ. Current practice patterns in primary hip and knee arthroplasty among members of the American Association of Hip and Knee Surgeons. *J Arthroplasty.* 2010;25(6 Suppl): 2–4.
3. Bourne RB, Burnett RS. The consequences of not resurfacing the patella. *Clin Orthop Relat Res.* 2004;428:166–169.
4. Bourne RB, Rorabeck CH, Vaz M, Kramer J, Hardie R, Robertson D. Resurfacing versus not resurfacing the patella during total knee replacement. *Clin Orthop Relat Res.* 1995;321: 156–161.
5. Burnett RS, Boone JL, McCarthy KP, Rosenzweig S, Barrack RL. A prospective randomized clinical trial of patellar resurfacing and nonresurfacing in bilateral TKA. *Clin Orthop Relat Res.* 2007;464:65–72.
6. Burnett RS, Boone JL, Rosenzweig SD, Steger-May K, Barrack RL. Patellar resurfacing compared with nonresurfacing in total knee arthroplasty: a concise follow-up of a randomized trial. *J Bone Joint Surg Am.* 2009;91:2562–2567.
7. Burnett RS, Haydon CM, Rorabeck CH, Bourne RB. Patella resurfacing versus nonresurfacing in total knee arthroplasty: results of a randomized controlled clinical trial at a minimum of 10 years’ followup. *Clin Orthop Relat Res.* 2004;428:12–25.
8. Calvisi V, Camillieri G, Lupporelli S. Resurfacing versus non-resurfacing the patella in total knee arthroplasty: a critical appraisal of the available evidence. *Arch Orthop Trauma Surg.* 2009;129:1261–1270.
9. Campbell DG, Duncan WW, Ashworth M, Mintz A, Stirling J, Wakefield L, Stevenson TM. Patellar resurfacing in total knee replacement: a ten-year randomised prospective trial. *J Bone Joint Surg Br.* 2006;88:734–739.
10. Clements WJ, Miller L, Whitehouse SL, Graves SE, Ryan P, Crawford RW. Early outcomes of patella resurfacing in total knee arthroplasty. *Acta Orthop.* 2010;81:108–113.
11. Gioe TJ, Killeen KK, Mehle S, Grimm K. Implementation and application of a community total joint registry: a twelve-year history. *J Bone Joint Surg Am.* 2006;88:1399–1404.
12. Healy WL, Wasilewski SA, Takei R, Oberlander M. Patellofemoral complications following total knee arthroplasty: correlation with implant design and patient risk factors. *J Arthroplasty.* 1995;10:197–201.
13. Helmy N, Anglin C, Greidanus NV, Masri BA. To resurface or not to resurface the patella in total knee arthroplasty. *Clin Orthop Relat Res.* 2008;466:2775–2783.
14. Khatod M, Codsì M, Bierbaum B. Results of resurfacing a native patella in patients with a painful total knee arthroplasty. *J Knee Surg.* 2004;17:151–155.
15. Lindstrand A, Robertsson O, Lewold S, Toksvig-Larsen S. The patella in total knee arthroplasty: resurfacing or nonresurfacing of patella. *Knee Surg Sports Traumatol Arthrosc.* 2001;9(Suppl 1): S21–S23.
16. Matsuda S, Ishinishi T, Whiteside LA. Contact stresses with an unresurfaced patella in total knee arthroplasty: the effect of femoral component design. *Orthopedics.* 2000;23:213–218.
17. Mayman D, Bourne RB, Rorabeck CH, Vaz M, Kramer J. Resurfacing versus not resurfacing the patella in total knee arthroplasty: 8- to 10-year results. *J Arthroplasty.* 2003;18:541–545.
18. Muoneke HE, Khan AM, Giannikas KA, Hagglund E, Dunningham TH. Secondary resurfacing of the patella for

- persistent anterior knee pain after primary knee arthroplasty. *J Bone Joint Surg Br.* 2003;85:675–678.
19. Myles CM, Rowe PJ, Nutton RW, Burnett R. The effect of patella resurfacing in total knee arthroplasty on functional range of movement measured by flexible electrogoniometry. *Clin Biomech (Bristol, Avon).* 2006;21:733–739.
  20. Newman JH, Ackroyd CE, Shah NA, Karachalios T. Should the patella be resurfaced during total knee replacement? *Knee.* 2000;7:17–23.
  21. Nizard RS, Biau D, Porcher R, Ravaud P, Bizot P, Hannouche D, Sedel L. A meta-analysis of patellar replacement in total knee arthroplasty. *Clin Orthop Relat Res.* 2005;432:196–203.
  22. Pakos EE, Ntzani EE, Trikalinos TA. Patellar resurfacing in total knee arthroplasty: a meta-analysis. *J Bone Joint Surg Am.* 2005;87:1438–1445.
  23. Parvizi J, Rapuri VR, Saleh KJ, Kuskowski MA, Sharkey PF, Mont MA. Failure to resurface the patella during total knee arthroplasty may result in more knee pain and secondary surgery. *Clin Orthop Relat Res.* 2005;438:191–196.
  24. Peng CW, Tay BK, Lee BP. Prospective trial of resurfaced patella versus non-resurfaced patella in simultaneous bilateral total knee replacement. *Singapore Med J.* 2003;44:347–351.
  25. Robertsson O, Bizjajeva S, Fenstad AM, Furnes O, Lidgren L, Mehnert F, Odgaard A, Pedersen AB, Havelin LI. Knee arthroplasty in Denmark, Norway and Sweden. *Acta Orthop.* 2010;81:82–89.
  26. Robertsson O, Dunbar M, Pehrsson T, Knutson K, Lidgren L. Patient satisfaction after knee arthroplasty: a report on 27,372 knees operated on between 1981 and 1995 in Sweden. *Acta Orthop Scand.* 2000;71:262–267.
  27. Tanzer M, McLean CA, Laxer E, Casey J, Ahmed AM. Effect of femoral component designs on the contact and tracking characteristics of the unresurfaced patella in total knee arthroplasty. *Can J Surg.* 2001;44:127–133.
  28. Waters TS, Bentley G. Patellar resurfacing in total knee arthroplasty: a prospective, randomized study. *J Bone Joint Surg Am.* 2003;85:212–217.
  29. Whiteside LA. Patella resurfacing no longer considered routine in TKA: counterpoint. *Orthopedics.* 2006;29:833–835.
  30. Whiteside LA, Nakamura T. Effect of femoral component design on unresurfaced patellas in knee arthroplasty. *Clin Orthop Relat Res.* 2003;410:189–198.
  31. Wood DJ, Smith AJ, Collopy D, White B, Brankov B, Bulsara MK. Patellar resurfacing in total knee arthroplasty: a prospective, randomized trial. *J Bone Joint Surg Am.* 2002;84:187–193.