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Primary Knee

Selective Patella Resurfacing in Contemporary Cruciate Retaining and Substituting Total Knee Arthroplasty: A Matched Cohort Analysis



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ABSTRACT

Background: Leaving the patella unresurfaced in total knee arthroplasty (TKA) is increasing due to modern patella-friendly implants, awareness that complications are not uncommon with resurfacing, and knowledge that historical studies were scientifically confounded. This study examined the effect of selective patellar resurfacing on patient-reported outcome measures (PROMs) using modern implants and techniques in cohorts rigorously matched for demographics and osteoarthritis severity.

Methods: A total of 166 TKAs performed without patellar resurfacing were case-control matched to 166 TKAs with patella resurfacing. Case-control matching was based on demographics, American Society of Anesthesiology Physical Status, comorbidities, and osteoarthritis severity. No significant differences were observed between cohorts for demographics ($P \geq .347$), comorbidities ($P \geq .443$), or radiographic osteoarthritis severity ($P \geq .078$). Radiographic alignment and prospectively collected PROMs were evaluated preoperatively and at latest clinical follow-up.

Results: Preoperatively, patellar tilt was less for the unresurfaced patella group (3 versus 4°, $P = .003$); however, postoperative patellar tilt was not different (3 versus 3°, $P = .225$). At a mean of 2.1 years follow-up (range, 1 to 7), University of California Los Angeles Activity Level was significantly higher for the unresurfaced patella group (6.3 versus 5.5, $P = .002$), but the mean group difference did not reach a minimal clinically important difference. There were no other significant differences in PROMs or reoperation rates between cohorts ($P \geq .135$).

Conclusion: In contemporary cruciate retaining and substituting TKA designs, not resurfacing the patella in select patients may achieve comparable PROMs and re-operation rates; and potentially greater activity level compared to patella resurfacing at early follow-up.

Level of Evidence: III.

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While patellar resurfacing during total knee arthroplasty (TKA) is a debated topic [1–4], it remains the most popular technique in the United States [5]. However, complications related to costly patellar component revisions persist [4,6–8]. Given the potential

risks associated with patellar resurfacing, a shift toward leaving the patella unresurfaced during primary TKA has steadily increased from 4.1% in 2012 to 9.6% in 2020 [5] with acceptable outcomes up to 10 years [9]. Additionally, modern implants are now more “patella-friendly” and characterized by more anatomically-designed trochlear grooves and less patellar contact pressures to accommodate near-native patello-femoral tracking [2,10].

Studies demonstrate an increased risk of re-operation after TKA with unresurfaced patellae due to anterior knee pain [11–14]. However, prior studies utilized older generation femoral components without “patella-friendly” trochlear grooves. In addition, a certain percentage of anterior knee pain in historical studies

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attributed to unresurfaced patellae was likely unrecognized flexion instability, which has nearly identical presenting symptoms and was an unknown clinical entity at the time. This likely explains the often-quoted fact that up to 50% of secondary resurfacing of unresurfaced patellae in TKA failed to alleviate anterior knee pain symptoms [15–19]. Furthermore, few studies have evaluated the effect of patellar resurfacing on patient-reported outcomes (PROMs) using modern “patella-friendly” implants [20].

The aim of this study was to evaluate the effect of selective patellar resurfacing on PROMs after primary TKA with modern implants in rigorously matched cohorts. The null hypothesis was there would be no significant difference in outcomes between unresurfaced and resurfaced patella cohorts.

Methods

With Institutional Review Board approval, a retrospective review was performed on 208 patients who underwent primary TKA with an unresurfaced patellae and 1,230 patients who underwent primary TKA with a resurfaced patella. All cases were consecutively performed by a single surgeon from October 1, 2012, to December 30, 2019 with consistent clinical protocols with one of two modern “patella-friendly” implant systems: Implant A (Triathlon, Stryker Orthopaedics, Mahwah, New Jersey) or Implant B (EMPOWR 3D, Enovis, Wilmington, Delaware). A median parapatellar approach was used for all cases and computer navigation was used on most cases for the distal femoral cut. Traditional extramedullary guides were used for the proximal tibial cut. In general, neutral mechanical coronal alignment and femoral flexion of 5 to 6 degrees was targeted for the femoral component position. Neutral mechanical tibial alignment was targeted in native valgus knees and moderate constitutional varus up to 2-degrees mechanical varus was targeted in native varus knees utilizing a traditional extramedullary alignment guide. The patients' native tibial slope was targeted based on the topography of the tibial surface both visualized from the front of the knee, as well as visualizing from the medial aspect of the knee with a stylus inserted through the cutting guide. Femoral rotation was determined with manual instrumentation set at 3-degrees external to the posterior femoral condylar line in varus knees and 5-degrees in valgus knees with postero-lateral femoral condyle hypoplasia. Whiteside's line was checked to confirm proper femoral rotation intraoperatively.

Exclusion criteria for both cohorts included early reoperations; hybrid cementation technique; medical complications; orthopaedically complex cases; patella fracture, osteonecrosis, or patellae too thin for resurfacing. The decision for leaving the patella unresurfaced was determined by the operating surgeon. General indications for leaving the patella unresurfaced were consistent with “selective patella resurfacing” and included central congruent tracking, radiographic joint space preservation, $\leq$ grade 3 patellar chondral damage, and lack of systemic inflammatory arthropathy.

The surgical technique with respect to the patella was consistent and standardized across both groups. For patellae that were resurfaced, a free-hand technique was utilized to cut the patella surface with a wide “fan blade” while the surgical assistant opposite the surgeon held the patella with two towel clips placed inferiorly and superiorly. The surgeon ensured all four remaining bone quadrants were symmetrical in thickness before sizing the patella and drilling the three holes for the patella pegs. All patella components were three-peg all polyethylene components, positioned as medially on the patella cut surface as feasible, sized appropriately to avoid overhang, and were cemented with low-viscosity cement. Any residual uncovered and exposed bone on the lateral facet was removed with a rongeur.

The surgical technique of leaving the patella unresurfaced was standardized as well. After inspection of the patella to ensure symmetric congruity when tracking and there was no eburnated lateral bone, electrocautery was used to elevate the lateral retinaculum off the anterior lateral patella facet approximately 3 to 4 millimeters while avoiding any perforation of the retinaculum. This allowed a moderate lateral facetectomy with a rongeur to optimize patella tracking long-term as previously described. Electrocautery of the circumferential patella border was not performed. Once the trial implants were in place, the unresurfaced patella was observed through the range of motion to ensure optimal congruent tracking. Lateral releases were not performed in either group.

Demographic, surgical, and comorbidity data were manually collected from the electronic medical record. Radiographic tibio-femoral angle and patellar tilt [21] were measured by one experienced rater on standardized radiographs. Tibio-femoral alignment values were grouped into varus, neutral, and valgus based on accepted criteria [22]. In addition, the medial and lateral facets of the patella were radiographically assessed on preoperative radiographs to evaluate the extent of osteoarthritis (OA) in the patello-femoral joint (PFJ) using the Kellgren-Lawrence (KL) grading system [23] and the Osteoarthritis Research Society International (OARSI) atlas [24] as previously described [25].

Case-control matching was performed with SPSS (IBM Corp. 2019. IBM SPSS Statistics for Windows, Armonk, New York). After exclusions, an attempt to match 200 cases with unresurfaced patellae to 200 cases with resurfaced patellae from the potential match pool of 1,153 cases was performed. Matching variables were age (± 7 years), body mass index (BMI) (± 7 kg/m²), American Society of Anesthesiology Physical Status (ASA-PS) (± 1), sex (exact match), degree of PFJ OA according to KL grade in the medial (± 1) and lateral (± 1) facet and the OARSI osteophyte score medially (± 1) and laterally (± 1), and the number of comorbidities (exact match based on presence of none, 1, or ≥ 2). A total of 166 cases with unresurfaced patellae were successfully matched to 166 cases with resurfaced patellae. Thirty-four cases could not be matched due to combinations of younger age (range, 35 to 63 years), higher BMI (range, 25 to 55 kg/m²), and severe KL and OARSI Osteophyte grades.

At a mean of 2.1 years follow-up (range, 1 to 7), there were no significant differences between unresurfaced and resurfaced patella groups related to demographics ($P \geq .347$), comorbidities ($P \geq .443$), or radiographic PFJ OA severity (See Table 1, $P \geq .078$). The patellar resurfaced group had a higher prevalence of cement use, implant A use, tourniquet use, and drain use (See Table 1, $P < .001$) due to the evolution of the surgeon's practice, however, these variables did not significantly influence PROMs with statistical significance at latest follow-up ($P \geq .077$). Furthermore, the proportion of patients considered to be in ‘neutral’ coronal tibio-femoral alignment postoperatively was found to be slightly higher for the unresurfaced patella cohort (See Table 1, $P = .007$). However, the mean difference in tibio-femoral angle between cohorts was 0.9 degrees and therefore unlikely to be clinically meaningful. Mean preoperative patella tilt was significantly more neutral for the unresurfaced patella group (See Table 1, $P = .003$). The resurfaced patella group had significantly more change in patella tilt (0 versus -1 degrees, $P < .001$). However, patella tilt and tibio-femoral alignment did not significantly influence PROMs at latest follow-up (effect sizes ≤ 0.107).

Outcomes

Patient-reported outcome measures (PROMs) were prospectively collected during routine clinic visits or via telephone interview. PROMs included University of California Los Angeles (UCLA)

Activity Level [26,27]; components of the modern Knee Society Score (KSS) [28] related to pain with level walking, pain while climbing stairs, and the question “does your knee feel normal?”; Knee Injury and Osteoarthritis Outcome Score for Joint Replacement (KOOS JR) [29]; and a global satisfaction question.

Latest follow-up was truncated at minimum 1 year (≥ 11.0 months postoperatively), as patients frequently have 12-month postoperative visits that are not exactly 12 months after surgery due to personal schedules, life events, etc. In addition, contemporary TKA outcome studies demonstrate no difference in PROM values between 12 and 24 months follow-up [30–33].

Procedure time (in minutes) was collected from intraoperative documentation within the electronic medical record. Procedure time was operationally defined as initial incision to the start of incision closing. In addition, any re-operations were documented from the electronic medical record.

Data Analyses

All statistical comparisons were performed in Minitab 19 (State College, Pennsylvania). Outliers were identified with Dixon's r22 ratio tests. Student's two sample *t*-tests (*t*) were used to compare two group means. Chi-square tests (X^2) were used to compare group proportions with Fisher's exact test *P*-values used for 2×2 contingency tables. All confidence intervals were calculated at the 95th percentile. A significance level of 0.05 was used for all statistical comparisons.

Statistical power ($1-\beta$) was $\geq 77.8\%$ using minimal clinically important differences (MCIDs) for PROMs as the effect size [34–36], standard deviations dependent on each outcome, sample sizes, and a significance level of 0.05. Furthermore, while statistical power

and subsequently *P*-values are traditionally used to reduce the probability of Type II and Type I errors in research, there is an emerging body of literature in other disciplines suggesting an evaluation of the observed confidence intervals is a more useful tool for validity of non-significant study findings [37–41]. Confidence intervals, MCIDs, and *P*-values were used to determine if significant differences existed between study groups.

Results

UCLA Activity Level was significantly higher (exceeding the MCID) at latest follow-up for the unresurfaced patella cohort compared to the resurfaced patella cohort ($P < .001$), however, preoperative UCLA activity levels were also significantly higher for the unresurfaced patella cohort (4.9 versus 4.4, $P = .014$). Despite these differences, the mean improvement in UCLA Activity level was not different between the two cohorts (See Table 2, $P = .628$).

No significant differences were found between the two matched cohorts in preoperative, latest, or the mean change (delta) in KOOS JR total scores (See Table 2, $P \geq .135$). Similarly, no significant differences were observed in preoperative, latest, or the mean change in KSS pain with level walking or KSS pain while climbing stairs scores (See Table 2, $P \geq .149$). Furthermore, no significant differences were found between the matched cohorts in the proportion of patients who reported their knee to “never,” “sometimes,” or “always” feel normal preoperatively or at latest follow-up ($P \geq .066$). However, while comparing proportions of knees that “always” feel normal to those that “sometimes” or “never” feel normal, the patella resurfaced group showed a statistically higher proportion of patients that reported their knee to “always” feels normal, but this difference did not reach the MCID (See Table 2, $P = .040$).

Table 1
Patellar Resurfacing Cohort Comparisons.

Variable	Unresurfaced Patella (%)	Resurfaced Patella (%)	Test Statistic	<i>P</i> -value
N	166	166	–	–
Mean Age, in years (range) ^a	63 (35 to 80)	64 (37 to 80)	0.94	0.347
Mean BMI, kg/m ² (range) ^a	35 (20 to 56)	35 (22 to 52)	0.26	0.794
Sex, Women ^a	54	54	0.00	1.000
ASA-PS, I or II ^a	42	39	0.20	0.737
Rheumatoid Arthritis	1	2	0.68	0.685
Psoriatic Arthritis	1	2	0.20	1.000
Systemic Lupus Erythematosus	1	0	2.00	0.498
Fibromyalgia	2	1	0.68	0.685
Lumbar Spine Pathology	10	12	0.13	0.860
Depression	16	15	0.09	0.880
Preoperative Narcotic Use (prn or scheduled)	13	17	0.85	0.443
Presence of comorbidities, None ^a	64	64	0.00	1.000
Prior arthroscopic procedure on index knee	35	26	2.9	0.107
Fixation, cemented	45	80	41.69	<0.001
Postoperative Drain Use	16	66	86.00	<0.001
Tourniquet Use	12	55	72.12	<0.001
KL Medial PFJ score, 0 or 1 ^a	40	34	1.31	0.519
KL Lateral PFJ score, 0 or 1 ^a	36	27	5.11	0.078
OARSI Medial PFJ Osteophyte Grade, 0 or 1 ^a	71	76	1.24	0.322
OARSI Lateral PFJ Osteophyte Grade, 0 or 1 ^a	80	78	0.17	0.787
OARSI Medial PFJ JSN Grade, 0 or 1	92	93	0.17	0.839
OARSI Lateral PFJ JSN Grade, 0 or 1	90	83	3.11	0.108
Preoperative Tibio-femoral Alignment, Neutral	24	18	2.45	0.294
Postoperative Tibio-femoral Alignment, Neutral	87	74	9.94	0.007
Mean Delta Tibio-femoral Alignment, degrees	–4	–4	1.23	0.218
Mean Preoperative Patellar Tilt, degrees	3	4	3.04	0.003
Mean Postoperative Patellar Tilt, degrees	3	3	1.22	0.225
Mean Delta Patellar Tilt, degrees	0	–1	3.71	<0.001

Italicized *P*-values indicate statistically significant group differences however these variables had minimal effect on outcomes.

Test Statistic, means were compared using a two-sample *t*-test (*t*) while proportions were compared with a chi-square test (X^2).

Delta, mean change calculated as postoperative minus preoperative values.

N, sample size; BMI, body mass index; ASA-PS, American society of anesthesiology physical status; Prn, as needed; KL, kelly-lawrence; PFJ, patello-femoral joint; OARSI, osteoarthritis research society international; JSN, joint space narrowing;

^a indicates a variable used for case-control matching

Table 2
Patient Reported Outcome Measures (PROMs) Comparison by Matched Patellar Resurfacing Groups.

Variable	Unresurfaced Patella	Resurfaced Patella	Mean Difference (95% CI)	Test Statistic	P-value
Preoperative UCLA Activity Level	4.9	4.4	0.53 0.11-0.96	2.5	0.014^a
Latest UCLA Activity Level	6.3	5.5	0.71 0.26-1.15	3.1	0.002^a
Delta UCLA Activity Level	1.4	1.2	0.12 -0.38-0.63	0.5	0.628
Preoperative KOOS JR Total	48.5	48.4	0.13 -3.1-3.3	0.1	0.936
Latest KOOS JR Total	79.4	82.4	-3.0 -7.0-1.0	1.5	0.135
Delta KOOS JR Total	31.3	33.2	-2.0 -7.7-3.8	0.7	0.501
Preoperative KSS pain with level walking	6.0	5.6	0.38 -0.1-0.9	1.5	0.149
Latest KSS pain with level walking	1.4	1.0	0.34 -0.17-0.85	1.3	0.186
Delta KSS pain with level walking	-4.6	-4.5	-0.1 -0.85-0.65	0.3	0.802
Preoperative KSS pain with stair climbing	7.8	7.5	0.31 -0.16-0.78	1.3	0.199
Latest KSS pain with stair climbing	2.1	2.0	0.06 -0.59-0.72	0.2	0.849
Delta KSS pain with stair climbing	-5.7	-5.4	-0.34 -1.2-0.52	0.8	0.432
Preoperative KSS knee “always” feels normal	1%	2%	1.3% -1.2-3.8%	1.0	0.623
Latest KSS knee “always” feels normal	36%	49%	12.5% 1.0-24.0%	4.5	0.040^b
Latest Global Satisfaction “satisfied or very satisfied”	78%	84%	-5.8% -14.9%-3.4%	1.5	0.223

Table values represent statistical means unless noted as a percentage.

Bold P-values indicate statistical significance.

UCLA, University of California Los Angeles; KOOS JR, Knee Injury and Osteoarthritis Outcome Score for Joint Replacement; KSS, Knee Society Score; Delta, mean change calculated as latest minus preoperative values; 95% CI, confidence interval at the 95th percentile.

Test Statistic, means were compared using a two-sample t-test (t) while proportions were compared with a chi-square test (χ^2).

^a A statistically significant difference was observed, and only the confidence interval exceeded the established minimal clinically importance difference (MCID) signifying possible clinical significance.

^b A statistically significant difference was observed, but the mean difference and confidence interval did not reach the established MCID.

Also, no significant difference was found in the proportion of “satisfied or very satisfied” patients at latest follow-up (See Table 2, $P = .223$).

There was no significant difference in all-cause reoperation rates between the unresurfaced ($n = 5$) and resurfaced patella ($n = 3$) cohorts (3.0% versus 1.8%, $\chi^2 = 0.51$, $P = .723$). No reoperations related to patellar complications or secondary resurfacing were performed in either cohort. The three septic reoperations were treated with superficial irrigation and debridement at a mean of 1.2 months after initial TKA. The five aseptic reoperations were revised at a mean of 24.6 months after initial TKA due to arthrofibrosis (1), aseptic loosening of the femoral component (2), polyethylene wear (1), and nickel allergy and metal hypersensitivity (1).

In addition, procedure time was found to be significantly shorter in the unresurfaced patella cohort (66 versus 73 minutes, $t = 6.90$, $P < .001$).

Discussion

There was no overwhelming evidence to reject the null hypothesis of this study. The unresurfaced patella group showed a significantly shorter procedure time compared to the resurfaced patella group which highlights the possible increase in surgical efficiency of not implanting a patellar component, a mean of 7 minutes shorter per case. In addition, only preoperative and latest follow-up UCLA Activity level scores were found to be significantly higher with the mean difference confidence intervals exceeding the MCID for the unresurfaced patella cohort. However, there was no

significant difference in the UCLA Activity level improvement scores between groups (1.6 versus 1.3, $P = .215$). Additionally, there were no other statistically and clinically significant differences between study groups comparing PROMs or reoperation rates (See Table 2).

Albeit in the early term, the results of this study contradict most studies comparing reoperation rates by patellar resurfacing cohorts which consistently show an increased risk of reoperation when the patella is left unresurfaced [11–14,42]. Longo and colleagues [42] report unresurfaced patellae during TKA were associated with a significantly higher risk of patella-related reoperations compared to resurfaced patella (odds ratio [OR] 5.6, 95% confidence interval [CI] 3.4–9.1). In addition, the authors found postoperative Knee Society pain (OR 1.52, 95% CI 0.68–2.35), and Hospital for Special Surgery scores (OR 4.35, 95% CI 3.21–5.49) were significantly higher for the resurfaced patella group [42], which is contradicted by results of this study. Interestingly, most of the studies included in the meta-analysis for reoperation rates were published before the introduction of modern “patella-friendly” femoral components. This is a potential source of bias for extrapolating results with previous femoral component designs to modern designs which have more accommodating trochlear grooves. Furthermore, several OR confidence intervals cross the null hypothesis (1.0) which suggests there is potentially no difference between groups. Maradit-Kremers et al [43] found in a comprehensive analysis of 21,371 cases that patellar non-resurfacing was associated with higher complications and re-operations, but when statistically controlling for femoral component type, the risk was no longer significant for

the non-resurfaced patella group. This finding was corroborated in another recent study of 27,192 primary TKAs which found surgical year (before 2000 compared to after 2000) to be a risk factor for loosening, instability, fracture, and wear with the largest effect size for each model (hazard ratio range 1.4–33.3, $P \leq .02$) [44]. As implants have continued to be refined over time, increased attention was given to the geometry of the trochlear groove. Specifically, modern implants have more anatomically designed trochlear grooves, which are designed to articulate with or without a patellar implant while limiting contact pressures and improving patellar tracking [2,10]. As many studies on the effect of patellar resurfacing were performed with previous implant designs, it is difficult to extrapolate these previous findings to results using modern implants.

An additional consideration is that flexion instability is a potential confounding diagnosis in previous studies with a nearly identical clinical presentation of anterior knee pain in flexion-based activities. More recently, flexion instability is a topic of much interest and is found to be a significant cause of reoperation after TKA [45]. However, it remains challenging to diagnose clinically and may be incorrectly diagnosed as pain due to an unresurfaced patella in earlier studies leading to artificially high rates of reoperation for secondary patellar resurfacing [46], which did not alleviate the patient's anterior knee pain.

Another consideration is that many studies were based on strictly patellar resurfacing or not, rather than selective resurfacing based on criteria that would facilitate a better outcome for patients. In fact, it is shown that selective patellar resurfacing demonstrates comparable results to routine patellar resurfacing. For example, Kim et al [47] showed acceptable results at 10-year follow-up of selective patellar non-resurfacing after TKA with only one case requiring secondary resurfacing. The results from Kim et al's study indicate patellar resurfacing may not provide an optimized benefit in certain patient cohorts.

This study should be considered in the context of its limitations. While PROMs were prospectively collected, its retrospective nature may introduce inherent bias. Also, the decision to leave the patella unresurfaced during TKA was intraoperatively determined by the treating surgeon, which could create the potential for selection bias. While study groups were able to be tightly matched on several variables, it is possible that group differences related to the surgeon's clinical practice or other confounders may explain the differences observed in UCLA activity score or similarities in other outcomes scores between cohorts. This study was also limited to the radiographic evaluation of patello-femoral osteoarthritis only, as radiographic tibio-femoral arthritic changes predict postoperative outcomes [48,49]. In addition, shorter operative time when not resurfacing the patella presents as a potential financial bias given that surgeons can reduce the time and effort per case with no patellar resurfacing and receive equivalent financial returns. Additionally, only one rater evaluated radiographs for measurements and OA severity scores. However, the rater had extensive training from the senior surgeon and research team before formal data collection. Furthermore, the results of this study are pertinent to cruciate retaining type implant designs and may not be applicable in the posterior stabilized TKA setting. Also, postoperative anterior knee pain and patello-femoral function were not collected as outcomes in this study as neither are routinely collected at our institution; however, our database does collect data on pain with flexion-based activities which is a surrogate for anterior knee pain. Future studies should investigate the pain and function of the patello-femoral joint with more rigorous objective measures.

In summary, not resurfacing the patella in select patients may achieve comparable PROMs and reoperation rates; and potentially greater postoperative activity level compared to patella resurfacing

using contemporary TKA techniques with cruciate retaining and substituting implant designs.

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