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Research Article

Comparison of Routine PCL Resection Versus Selective PCL Balancing Using a Medial Congruent Polyethylene in Total Knee Arthroplasty: A Matched-Cohort Analysis

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Abstract

Background: Total knee arthroplasty (TKA) techniques and implant designs vary significantly regarding management of the posterior cruciate ligament (PCL). The clinical implications of routinely resecting or selectively balancing the PCL in modern congruent or pivot designs remain debated. This study compares clinical outcomes between routine PCL resection and selective PCL balancing using a medial congruent (MC) polyethylene.

Methods: A retrospective matched-cohort study was conducted with 304 patients undergoing primary unilateral TKA between September 2020 and April 2024. Patients were matched based on demographics (age, gender, BMI, Charlson Comorbidity Index (CCI), The Risk Assessment and Prediction Tool (RAPT) score) and based on preoperative Knee Injury and Osteoarthritis Outcome Score for Joint Replacement (KOOS JR) scores. Postoperative outcomes were analyzed including patient-reported outcome measures, physical therapy parameters, readmission rate, overall complication rate and 90 day return to operating room.

Results: The PCL resection group had significantly longer operative times (86.5 vs. 73.9 minutes, $p<0.001$) but lower all-cause 90-day readmission rates (1.3% vs 5.9% $p = 0.032$). No significant differences were observed in KOOS JR, PROMIS scores, Forgotten Joint Score, postoperative pain levels, physical therapy parameters, or discharge disposition.

Conclusion: Routine PCL resection in TKA utilizing a medial congruent polyethylene design did not influence patient-reported outcomes compared to selective balancing and should be left up to surgeon preference.

Keywords: Total Knee Arthroplasty; Posterior Cruciate Ligament; Medial Congruent Polyethylene; Patient-Reported Outcomes; Matched-cohort Analysis

Introduction

Total knee arthroplasty (TKA) remains one of the most effective surgical treatments for advanced knee osteoarthritis, significantly improving patient quality of life [1,2]. However, controversy persists regarding optimal management of the posterior cruciate ligament (PCL), with practices varying from routine resection to selective preservation [3,4]. This discussion has evolved in the setting of more modern implant designs which can influence knee kinematics [5].

Medial congruent (MC) polyethylene inserts have emerged as a design aiming to mimic more natural knee kinematics, promoting stability through increased medial conformity while allowing greater lateral femoral rollback [6,7]. This theoretically enhances knee function, stability, and patient satisfaction by replicating native joint motion more closely than traditional designs [8]. Several implant design variations of this are available on the market including a true medial pivot design, medial congruent designs, and a dual pivot design [9].

PCL resection is one strategy to create an increased flexion gap through this surgical technique [10]. In TKA, PCL resection increases the flexion gap and may contribute to mediolateral laxity in flexion due to the loss of the PCL's stabilizing effect [10]. PCL resection is often influenced by physician training and preference, the extent of structural damage of the PCL due to osteoarthritis, and implant design [3,5]. An alternative approach, selective PCL balancing, involves the targeted release of PCL fibers if needed to optimize both the flexion gap and femoral rollback while preserving some of the stabilizing effect of the PCL [11]. When comparing outcomes of PCL retaining, PCL resecting, and selectively balanced approaches, one study found no significant differences in clinical outcomes [12]. Previous studies have explored differences between PCL resection and retention without consensus. This is thought to be due to the heterogeneity of surgeon techniques, alignment strategy, implant differences and poorly matched patient populations [10,13]. One study evaluated PCL resection versus PCL retention when using the Stryker CS implant and found no differences between groups [14].

We sought to directly compare outcomes of routine PCL resection versus selective PCL balancing in a meticulously matched cohort using a single contemporary TKA design with a medial congruent polyethylene insert. We hypothesized that routine PCL resection would not affect patient reported outcome measures (PROMs).

Methods

This retrospective matched-cohort analysis included 304 consecutive patients diagnosed with osteoarthritis who were undergoing a primary unilateral TKA from September 1, 2020 to April 30, 2024. Institutional review Board approval was granted (HHC-2024-0223). All surgeries utilized a Zimmer Biomet Persona knee system with a medial congruent polyethylene insert (Zimmer Biomet, Warsaw, IN). All surgeries were performed manually by two arthroplasty fellowship trained orthopedic surgeons. The medial parapatellar approach was utilized with routine tourniquet use. A preoperative adductor canal and posterior capsular block were utilized, along with immediate post operative enhanced recovery protocols with physical therapy beginning on postoperative day 0.

Both surgeons employed a mechanical alignment philosophy with measured resection technique utilizing manual instrumentation. Selective soft tissue releases are performed to achieve appropriately balanced flexion and extension gaps. Both surgeons make effort to utilize the medial congruent insert, regardless of preoperative deformity.

One surgeon routinely resects the PCL upon exposure and cuts the tibia with 3° of posterior slope based on preference and fellowship training. The other surgeon selectively balances the PCL on all cases and cuts the tibia aiming to match native posterior slope. Selective PCL balancing involves routine maintenance of the PCL unless there is lift off of the trial tibial tray in flexion. In these instances, the PCL is released subperiosteally off the intercondylar notch from anterior to posterior until there is the appropriate laxity of the flexion gap.

Patients were matched 1:1 based on preoperative Knee Injury and Osteoarthritis Outcome Score (KOOS, JR ± 3 points), gender (exact match), age (± 3 years), Body Mass Index (± 3 points), Charlson Comorbidity Index (CCI, ± 2 points), and the Risk Assessment and Prediction Tool (RAPT, ± 2 points) score.. Revision surgeries, or procedures utilizing robotics were excluded to avoid introducing confounding variables. Matching was performed using the Calipmatch plug-in within STATA (Version 17, StataCorp, College Station, TX). Initially, there were 1,196 patients available for matching. Of those patients, 826 used a Zimmer Persona Implant with an MC polyethylene insert. 179 patients had a routine PCL resection. After matching, there were 152 patients in each group who were subsequently analyzed.

Data collected included patient demographics, surgical parameters, inpatient outcomes (pain scores, opioid consumption, physical therapy parameters), discharge disposition, complications, and 90-day postoperative events. PROMs (KOOS JR, PROMIS 10 physical and mental health subscores, Forgotten Joint Score) were collected preoperatively and at 12 weeks, 6 months, and 1-year postoperatively. Minimum clinically important difference (MCID) for the KOOS, JR was set at 15 points per Lyman., *et al*. [15].

Statistical analysis included paired t-tests, *chi*-square, and Fisher's exact tests, depending on the underlying distribution of the variable. *Chi*-squared or Fisher Exact tests were used to compare single outcome measures, such as complications, readmissions, and surgical site infections. For continuous variables, such as PROMs, length of stay, or pain, t-tests were utilized. Statistical significance was set as a p-value <0.05. STATA (Version 17, STATACorp, College Station, TX) and Microsoft Excel 2016 (Microsoft, Redmond, WA), were used to analyze the data.

Results

Both cohorts (n = 152 each) were well matched without significant demographic differences or differences in comorbidities, except for minor variations in racial distribution (Table 1). No significant differences emerged in length of hospital stay, anesthesia type, or inpatient pain scores between groups (Table 2). However, operative time was significantly longer in the PCL resection group (86.5 ± 14.5 vs. 73.9 ± 11.9 minutes, p < 0.001). There were more uncemented implants in the PCL resection group, but over 85% of all implants were cemented in both groups (p = 0.017).

Demographics	PCL Resection n = 152		PCL Balancing n = 152		p Value
Female Gender	67.1%	102	67.1%	102	***
Age (years)	68.3 ± 8.8		69.7 ± 9.0		p = 0.173
Race					**p = 0.037**
Black or African American	10.5%	16	5.3%	8	
Multiracial / Other	12.5%	19	6.6%	10	
White or Caucasian	77.0%	117	88.1%	134	
Ethnicity					p = 0.305
Hispanic or Latino	8.6%	12	3.9%	6	
Not Hispanic or Latino	89.6%	137	94.7%	144	
Unknown/ Patient Refused	1.8%	3	1.3%	2	
BMI (kg/m^2)	34.0 ± 6.4		34.7 ± 6.8		p = 0.322
Comorbidities					
RAPT Score	9.0 ± 1.7		8.9 ± 2.0		p = 0.490
CCI Score	3.2 ± 1.6		3.6 ± 1.9		p = 0.195

Table 1: Demographics for the matched cohort, showing similar populations overall.

Bolded values indicate statistical significance. Data presented as means ± standard deviation.

Operative Factors	PCL Resection n = 152		PCL Balancing n = 152		p Value
Overall Length of Stay	1.1 ± 0.44		1.1 ± 0.39		p = 0.785
Anesthesia Type					p = 0.652
Spinal	98.0%	149	98.6%	150	
General	2.0%	3	1.4%	2	
Operative Time (minutes)	86.5 ± 14.5		73.9 ± 11.9		**p < 0.001**
PACU Time	81.0 ± 26.8		83.2 ± 25.7		p = 0.471
Laterality					p = 0.808
Right	65.8%	100	67.1%	102	
Left	34.2%	52	32.9%	50	
Uncemented Implant	15.1%	23	6.5%	10	**p = 0.017**
Stem Extension Used	5.9%	9	3.9%	6	p = 0.427
Total Cost	$29,685 ± $3,978		$29,843 ± $4,663		p = 0.751

Table 2: Operative factors for the matched cohort, showing longer operative time in the PCL resection group.

Bolded values indicate statistical significance. Data presented as means ± standard deviation.

There was a significantly higher rate of all-cause readmissions within 90 days in the PCL preservation cohort (5.9% vs. 1.3%, p = 0.032), though only three cases in both groups were directly related to the surgery. Other complications, including ED visits, re-operations, and infections, did not significantly differ (Table 3). There were four manipulations under anesthesia performed in the PCL resection group and none performed in the PCL preservation group. PROM evaluations at all intervals showed no clinically significant differences between groups. The percentage of patients achieving the minimally clinically important difference in KOOS JR scores was similar between cohorts (74.0% PCL resection vs. 82.0% preservation, p = 0.253) (Table 3).

Outcomes	PCL Resection n = 152		No PCL Resection n = 152		p Value
In Patient Pain Scores					
At Rest	3.1	± 1.6	3.0	± 1.3	p = 0.347
With Activity	4.4	± 1.7	4.3	± 1.5	p = 0.764
Morphine Milligram Equivalents	72.3 ± 85.8		66.5 ± 46.4		p = 0.471
Inpatient Physical Therapy Parameters					
Maximum Ambulation Distance (feet)	166.1	± 77.1	157.8	± 72.1	p = 0.333
Timed Up and Go (TUG) Score	25.6	± 8.6	24.8	± 7.3	p = 0.411
30 second Sit to Stand	7.9	± 2.6	8.2	± 2.8	p = 0.432
Discharge Disposition					p = 0.735
Home/Home Health Aide	96.7%	147	97.4%	148	
Skilled Nursing Facility	3.3%	5	2.6%	4	
All Cause Return to ED within 90 days	6.6%	10	7.2%	11	p = 0.821
All Cause Readmission within 90 days	1.3%	2	5.9%	9	**p = 0.032**

Reoperation within 90 days	2.6%	4	2.0%	3	p = 0.702
Surgical Site Infection within 90 days	0.7%	1	0.7%	1	p = 1.000
KOOS JR Scores					
Preoperative	47.3	± 12.6	47.8	± 12.4	***
12 weeks	68.1	± 11.8	70.7	± 10.9	p = 0.092
6 months	72.9	± 10.8	75.3	± 12.0	p = 0.183
1 year	75.5	± 11.4	77.5	± 13.2	p = 0.361
Met Minimally Clinically Important Difference	74.0%	48	82.0%	51	p = 0.253
PROMIS 10 Physical Health Subscore					
Preoperative	39.6 ± 6.2		40.3 ± 6.0		p = 0.315
12 weeks	46.7 ± 6.1		47.6 ± 6.4		p = 0.245
6 months	48.7 ± 6.9		49.2 ± 6.2		p = 0.646
1 year	48.3 ± 6.6		50.1 ± 7.8		p = 0.166
PROMIS 10 Mental Health Subscore					
Preoperative	48.6 ± 7.8		49.6 ± 7.7		p = 0.242
12 weeks	50.7 ± 7.0		52.2 ± 8.4		p = 0.121
6 months	52.1 ± 7.4		53.7 ± 7.0		p = 0.148
1 year	51.3 ± 7.1		54.2 ± 8.3		**p = 0.033**
Forgotten Joint Score	53.0 ± 24.9		54.2 ± 22.2		p = 0.803

Table 3: Overall Outcomes, both inpatient and patient reported, for the matched cohort.

Bolded values indicate statistical significance. Data presented as means ± standard deviation. *** indicates the variable was used for matching.

Discussion

Our findings demonstrate minimal clinical benefit associated with routine PCL resection when using a modern TKA implant featuring a medial congruent polyethylene. Despite slightly increased operative time in the PCL resection group and a higher readmission rate in the non-resected group, patient-reported outcomes were equivalent at all postoperative intervals.

TKA often results in significant improvements in quality of life, pain relief, and function, with patient satisfaction rates reported between 82%-89%, yet a notable proportion of patients remain dissatisfied [16,17]. Approximately 20% of patients report dissatisfaction following TKA, although a recent study suggests this rate may be closer to 10% depending on how dissatisfaction is measured and defined [16,18]. Contributing factors to post TKA dissatisfaction include unmet patient pre-operative expectations, residual pain, perioperative complications, and functional outcomes [17,19,20]. Predictive factors of dissatisfaction following TKA include high body mass index (BMI), presence of additional joint pain, patient age, and psychiatric status [19,20].

When comparing PCL-sparing and PCL-resecting TKAs, there are no meaningful differences in clinical or functional outcomes between the two approaches [21,22], which is supported by our findings. Preserving the PCL and resection of the PCL using medial congruent polyethylene in TKA did not lead to significant differences in patient reported or clinical outcomes. No differences were seen in PROMIS 10 Physical Health sub scores or KOOS Jr scores, indicating similar patient reported outcomes and functionality of the knee post TKA.

The absence of significant functional differences suggests that either PCL resection or balancing are sufficient for achieving excellent clinical outcomes without incurring additional risk utilizing a medial congruent implant [21,22]. Longer operative duration in the resection cohort likely reflects different surgeon operative efficiency. It could also reflect the technical demands of achieving appropriate gap balancing following ligament removal [23]. Readmission differences were statistically significant but the reasons for readmission did not appear to be connected to PCL resection anatomically or mechanically. The majority were isolated cases in the PCL preservation group, including cardiac pacemaker adjustment, COVID pneumonia, and abdominal pain due to constipation.

Limitations of the study include the single center nature of the study and the inclusion of only two arthroplasty surgeons. Additionally, this was a retrospective review of a very homogenous group of patients, which may limit its generalizability. This study does include rigorous cohort matching, uniform implant use, and consistent surgical techniques between surgeons. Additionally, no author is funded by a surgical implant company, limiting bias. Larger multicenter randomized studies could further confirm these findings.

Conclusion

Routine PCL resection in TKA utilizing medial congruent polyethylene did not influence patient-reported outcomes compared to selective preservation and should be left up to surgeon preference. Future prospective randomized trials may help elucidate the influence of the PCL on patient outcomes.

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