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Does Recession of the Posterior Cruciate Ligament Influence Outcome in Total Knee Arthroplasty?

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ABSTRACT

Background: For a PCL-retaining (posterior cruciate ligament) total knee arthroplasty (TKA) to function suitably, proper soft tissue balancing, including PCL recession, is required. Yet, when the recession of the PCL is needed, there is still a debate as to whether a cruciate-retaining (CR) TKA should be converted to a posterior-stabilized TKA due to the concern of instability and poorer clinical outcomes. The purpose of this study is to determine whether recession of the PCL adversely affects clinical outcomes in patients who undergo CR TKA.

Methods: CR TKAs of the same design performed by the senior author (J.M.) were identified between December 2006 and July 2015. Clinical outcome measurements were collected and included the Western Ontario and McMaster Universities Osteoarthritis Index score, the Knee Society Clinical Rating System, Short Form-12 Physical Composite Score/Mental Health Composite Score, and revision rates.

Results: There were no significant differences in clinical outcome when the PCL was retained, partially recessed, or completely released during PCL-retaining TKA (Western Ontario and McMaster Universities Osteoarthritis Index: $P = .54$, Knee Society Clinical Rating System: $P = .42$, Short Form-12 Mental Health Composite Score: $P = .89$, Short Form-12 Physical Composite Score: $P = .527$).

Conclusion: This study presents evidence of similar clinical outcomes when the PCL is retained or released during PCL-retaining TKA, provided attention is paid to appropriate soft tissue balancing. CR TKA undergoing partial or complete release of the PCL should not routinely be converted to a posterior-stabilized knee design.

Level of Evidence: Level II, Prognostic study.

Total knee arthroplasty (TKA) is a reliable means of relieving pain and restoring function in arthritic knees [1–3]. Two main types of total knee replacements have been described and popularized over the years: the cruciate-retaining (CR) and the posterior-stabilized (PS) total knee replacement. A persistent issue whether to retain or resect the posterior cruciate ligament (PCL) has been debated for decades. However, numerous studies and systematic reviews comparing CR and PS TKA have shown no clinically relevant differences between the designs [4–7]. Choosing between a PS and a CR knee is still debatable; however, it is well known that for a CR TKA to function suitably, proper soft tissue balancing is required. In order to achieve proper soft tissue balancing, recession of the PCL in CR TKA is sometimes necessary. Intraoperatively, PCL tension is assessed after the bony cuts have been made. Trial components are inserted and if the knee is tight in flexion, PCL recession is indicated. Signs of tightness in flexion include excessive femoral rollback and anterior lift off of the tibial trial component (Fig. 1) [8].

Correction of knee deformity via ligamentous balancing is well described in orthopedic literature [8,9]. Yet, when a recession or an excision of the PCL is needed, there is still a debate as to whether a CR TKA should be converted to a cruciate-substituting or PS TKA due to the fear of instability and poorer clinical outcomes.

The purpose of this study is to determine whether the recession of the PCL adversely affected clinical outcomes in patients who

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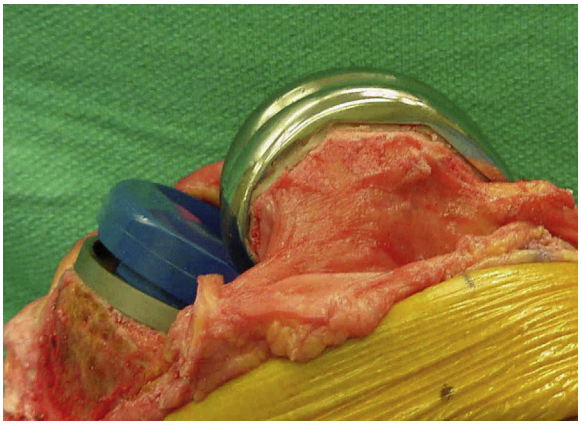

Fig. 1. Intraoperative assessment with a tight PCL creating excessive femoral rollback and anterior lift off of the trial polyethylene spacer.

undergo CR TKA and to evaluate the necessity of converting a CR knee to a PS knee when the recession of the PCL is required for adequate knee balancing. We hypothesized that recessing or fully excising the PCL in CR TKA would not adversely affect clinical outcomes and that conversion to a cruciate-substituting implant is not necessary when there is a partial or complete release of the PCL.

Methods

After Institutional Research Ethics Board approval was obtained, a review of the London Health Science Centre institutional database was performed. In total, 743 primary total knee replacements were performed by the senior author (J.M.) between December 2006 and July 2015. Of these, 677 CR total knee replacements of the same design were included in the study. The study consisted of 409 females (60%) and 268 males (40%) with a mean age at the time of surgery of 68.3 ± 9.9 years. The mean body mass index was 34.1 ± 16.1 kg/m^2. The group demographics and preoperative data are listed in Tables 1 and 2.

Operative notes were reviewed individually on the electronic medical record. The patients were subdivided into 3 groups based on whether the PCL was retained, recessed, or fully excised during the TKA. All of the 677 PCL-retaining TKAs studied had complete information regarding the status of the PCL. Patients were excluded if the surgeon converted a planned CR TKA to a PS knee. No occurrences of PS conversion were noted during the chart review. The prosthesis implanted was a DePuy P.F.C. Sigma CR primary knee system. The femoral component was a nonporous cemented implant. The tibial implant was a fixed bearing cemented component with a posterior lipped tibial polyethylene insert.

The senior author (J.M.), a fellowship-trained adult reconstructive surgeon, used a standard medial parapatellar approach to the knee during total knee replacement surgery. The knees were balanced using mechanical alignment. Measured resection technique was performed. The native posterior tibial slope was reproduced, rather than using an arbitrary angle for all of the knee replacements [10]. Trial femoral and tibial components were inserted to assess coronal and sagittal balancing in flexion and in extension. Excessive femoral rollback and anterior lift off of the tibial trial component [8] would indicate that the knee was tight in flexion. A knee that was tight in flexion was balanced by partially or fully releasing the PCL from its distal femoral insertion. The postoperative care was the same whether the PCL was retained or excised. The patients were weight bearing as tolerated after surgery, and received a standard course of physiotherapy and deep venous thromboprophylaxis. The patients were assessed preoperatively and were followed up at 6 weeks, 3 months, 6 months, 12 months, and then yearly to biyearly. The mean follow-up was 2.5 ± 1.9 years with a range of 3 months to 8 years. There was no difference in mean follow-up between the 3 groups (Table 1). Patients had routine standing knee radiographs as well as clinical outcome measurements during every follow-up. The primary outcomes of the study were the postoperative Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores [11] and the Knee Society Clinical Rating System (KSCRS) scores [12], which included postoperative pain, stiffness, and function measurements. The secondary outcomes were the Short Form-12 Physical and Mental Health Composite Score (SF12 PCS/MCS) [13] and the revision rates. The postoperative outcomes were measured by the senior author (J.M.).

Statistical analysis was accomplished using SPSS 24 (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). The Kruskal-Wallis test (analysis of variance) was performed to detect differences in preoperative and postoperative outcome scores as well as patient demographics between the 3 groups. The level of significance was set at $P = .05$. The a priori sample size calculation was based on a difference in WOMAC score of 15 as the minimal clinically important difference [14]. Assuming a power of 80% and a significance level of 5%, the required sample size was 23 patients in each group [15].

Results

Of the 677 CR TKAs, the PCL was retained in 540 cases, partially recessed in 24 cases, and completely excised in 113 cases. There were no significant differences in clinical outcome when the PCL was retained, partially recessed, or completely excised (Fig. 2, Table 3).

The WOMAC score was 80.4 ± 18.7 with PCL retention, 77.3 ± 19.0 with PCL recession, and 78.9 ± 18.9 with PCL excision ($P = .54$). Refer to Table 4 for a more detailed breakdown of individual WOMAC outcome scores such as pain, stiffness, and function, which all did not have significant differences. The Knee Society score was 176.5 ± 24.9 with PCL retention, 179.0 ± 24.8 with PCL recession, and 179.8 ± 27.6 with PCL excision ($P = .42$). There were no significant differences in mental health scores between the 3 groups. The postoperative SF12 MCS was 52.4 ± 10.3 with PCL retention, 52.8 ± 9.4 with PCL recession, and 52.7 ± 8.2 with PCL excision ($P = .89$). There were no significant differences in physical

Table 1
Patient Mean Demographic (SD) Comparison Between Cruciate-Retaining Total Knee Replacement Groups With Retention, Recession, and Excision of the PCL.

Patient Demographic	PCL Retained	PCL Recessed	PCL Excised	*P* Value
Age (y)	68.1 (10.2)	69.2 (8.2)	68.7 (9.1)	.751
Gender (% male)	36.7	41.7	53.1	.005[a]
BMI (kg/m^2)	34.41 (17.6)	32.17 (6.5)	33.04 (6.8)	.618
Follow-up (y)	2.71 (2.0)	2.6 (1.9)	2.11 (1.6)	.073

SD, standard deviation; PCL, posterior cruciate ligament; BMI, body mass index.
[a] Significant.

Table 2
Preoperative Clinical Score Mean (SD) Comparison Between Cruciate-Retaining Total Knee Replacement Groups With Retention, Recession, and Excision of the PCL.

Outcome Measures	PCL Retained	PCL Recessed	PCL Excised	*P* Value
SF12-MCS	52.68 (11.0)	54.2 (11.5)	55.61	.175
SF12-PCS	31.24 (8.4)	28.71 (8.6)	31.27	.385
KSCRS	95.23 (24.6)	88.71 (23.2)	98.34	.39
WOMAC	45.14 (17.2)	43.49 (14.4)	49.78	.257

SD, standard deviation; PCL, posterior cruciate ligament; SF12, Short Form-12; MCS, Mental Health Composite Score; PCS, Physical Composite Score; KSCRS, Knee Society Clinical Rating System; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

health between the 3 groups. The SF12 PCS was 41.4 ± 10.7 with PCL retention, 39.6 ± 12.1 with PCL recession, and 42.7 ± 10.6 with PCL excision ($P = .53$). Of the 5 implant failures requiring revisions, 4 were in the cruciate-retention group, none were in the cruciate-recession group, and 1 was in the cruciate-excision group (Table 5). In the PCL-excision groups, 1 TKA failed due to instability. Implant failures in the PCL-retention group included 1 secondary to pain and stiffness 1.6 years following surgery, 1 periprosthetic femur fracture 1.5 years following surgery, 1 case of aseptic loosening 6.6 years following surgery, and 1 revision due to polyethylene fracture 1.3 years postoperatively. There were no significant differences in revision rates between PCL-retaining total knee replacements that were balanced via PCL retention, recession, or excision.

Twenty-six of the 677 (3.8%) TKAs had patellar resurfacing. There were 22 patellae resurfaced in the PCL-retention group. One patella was resurfaced in the PCL-recession group. Three patellae were resurfaced in the PCL-excision group. There were no significant differences in the number of patellar resurfacings between the study groups ($P = .692$). There were no significant differences in preoperative outcome scores or mean follow-up (Tables 1 and 2).

Discussion

This study presents evidence of equivalent clinical outcomes when the PCL is retained, partially recessed, or completely excised during CR TKA. There were no significant differences in the study's primary outcomes (WOMAC and KSCRS) or secondary outcomes (SF12 PCS/MCS and revision rates). Patient-reported physical health, mental health, knee function, pain, and stiffness did not differ between the 3 groups. Confounding factors such as patellar resurfacing and preoperative clinical outcome score differences were evaluated. There were no significant differences in patellar resurfacing or preoperative clinical outcomes between the 3 groups. Although there were no differences in revision rate, the PCL-excision group did have 1 TKA fail due to instability. When the chart was reviewed in further detail, explorative knee surgery was required and it was unclear whether the clinical instability was due to the implant and the soft tissue balancing or a weak extensor mechanism and previous deconditioning secondary to multiple past knee surgeries. The failure occurred at 6 months.

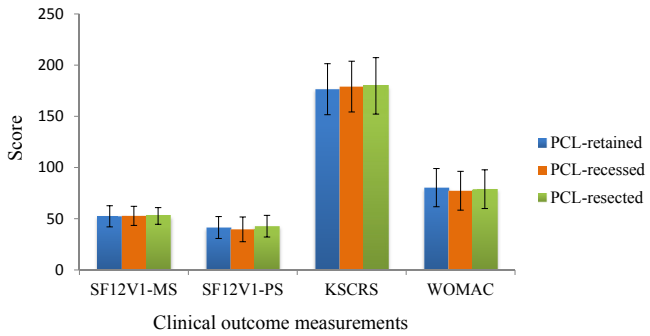

Fig. 2. Comparison of mean postoperative clinical outcome scores in cruciate-retaining total knee arthroplasty with the PCL retained, recessed, and resected. SF12V1-MS, Short Form-12 Version 1 Mental Health Composite Score; SF12V1-PS, Short Form-12 Version 1 Physical Composite Score.

The similarities in postoperative clinical outcomes between the PCL retention, resection, and excision groups may be due to accurate balancing of the knee and restoration of native knee biomechanics. In the knee, the PCL is the main restraint against posterior translation of the tibia. It also maintains a proper contact point between the medial femoral condyle and the medial tibial plateau [16]. Functionally, the PCL contributes to normal anatomical femoral rollback. Beyond 90° of knee flexion, the PCL tightens and therefore encourages femoral rollback increasing the quadriceps moment arm and improving the ability to engage in activities such as stair climbing [8]. The PCL must be neither too tight nor too loose in both native knee and PCL-retaining TKA. A loose PCL may result in anteroposterior instability and pain. A tight PCL may cause excessive femoral rollback, restrictions in flexion [17], increased contact stresses leading to polyethylene wear, and even posteromedial subluxation [18]. The senior author (J.M.) achieved adequate knee balancing during TKA surgery by making sure the PCL was properly tensioned. The measured resection technique was used during this study; nevertheless, other studies using gap balancing in CR knees have shown clinical similarity when the PCL is retained or recessed [19]. Proper knee balancing during CR total knee replacement surgery offers excellent stability regardless of the status of the PCL.

PCL-retaining total knee replacements requiring PCL recession or excision have been shown to have similar outcomes and should not routinely be converted to a PCL-substituting knee provided the knee can be adequately balanced. Studies have supported not needing a revision of the CR implant to a PS implant when the PCL is partially recessed [19–22] or fully excised [19,21,23]. Other studies have had conflicting results when the PCL is fully resected advocating for a conversion to a cruciate-substituting TKA design since PCL deficient CR knees were reported to have lower ranges of motion [24], higher postoperative pain [22], and poorer stair stepping outcomes when the PCL was fully resected [20]. However, the studies reporting poorer outcomes in PCL-resected CR knees had confounding results and methodically differed from the present study. They all recessed or excised the PCL off the tibia where we resected it off the femur in order to have a more precise and gradual release of the PCL. A flat tibial implant was used in the study by Ritter et al and Straw et al in comparison to the posterior lipped tibial insert utilized in the present study [20,22]. Hirsch et al [24] did not mention what tibial insert they used during their study. Ritter et al [25] also mentioned that CR TKAs with the PCL excised had better range of motion in flexion and therefore concluded that revision to a PS TKA was not indicated. Furthermore, although PCL-recessed CR TKAs had statistically poorer stair climbing, it was unlikely that this was clinically significant. Straw et al preoperatively randomized the release of the PCL. Randomizing the release of the PCL might have contributed to erroneous results. The release

Table 3
Postoperative Clinical Score Mean (SD) Comparison Between Cruciate-Retaining Total Knee Replacement Groups With Retention, Recession, and Excision of the PCL.

Outcome Measures	PCL Retained	PCL Recessed	PCL Excised	*P* Value
SF12-MCS	52.4 (10.3)	52.8 (9.4)	52.7 (8.2)	.894
SF12-PCS	41.4 (10.7)	39.6 (12.1)	42.7 (10.6)	.527
KSCRS	176.5 (24.9)	179.0 (24.8)	179.8 (27.6)	.415
WOMAC	80.4 (18.7)	77.3 (19.0)	78.8 (18.9)	.541

SD, standard deviation; PCL, posterior cruciate ligament; SF12, Short Form-12; MCS, Mental Health Composite Score; PCS, Physical Composite Score; KSCRS, Knee Society Clinical Rating System; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

of the PCL cannot be preoperatively randomized since it is a means to properly balance the knee during surgery. Randomization would suggest that some knees were not properly balanced since one cannot know if the release was truly warranted.

Furthermore, some surgeons argue that in order to preserve the PCL intraoperatively, a trade-off must be made which can affect CR TKA clinical outcomes. They claim that a decrease in posterior slope and a limit to tibial component rotation is needed to accommodate an adequate PCL bone block to protect the PCL, which translated into poor flexion range of motion and may cause kinematic dysfunction [26]. We have demonstrated that recession or excision of the PCL intraoperatively does not make any difference in clinical outcomes; therefore, surgeons are not required to make any trade-offs in order to protect the PCL.

One study by Sherif et al [26] studied 368 consecutive primary TKAs using a Vanguard total knee system with a flat or posterior dished polyethylene tibial bearing design. They documented the status of the PCL intraoperatively after the initial arthrotomy, after all bone cuts and after final balancing with all components in place. They found that 94% of PCLs were intact initially after the arthrotomy, 51% of PCLs were intact after all bone cuts, and only 33% remained intact after knee balancing and the insertion of all components. The PCL was attenuated either by mechanical damage or surgeon release. They claimed that surgeons should be ready to substitute deficient PCL when using a CR TKA. In the study, they converted the PS TKA to a PCL-stabilizing knee (CS) using an anterior stabilized bearing or “ultra congruent” design that could mate with the CR femur [26]. They observed that the anterior stabilized bearing provided acceptable function and stability. In the present study, we used the Sigma CR knee with a posterior lipped tibial insert. We believe that the conversion of a PCL-retaining (CR) to a PS or PCL-substituting (CS) knee during TKA surgery is not needed when the knee is well balanced. The data acquired during this study support this statement. Most research comparing CR and PS knees compared flat/posterior lipped CR knees to PS knees showing no significant differences. The authors also comment on the fact that as time progresses, the attenuated PCL can be further damaged by arthrofibrosis needing manipulation, trauma (ie, falls), and PCL stretch out due to its functional use. Even with only a few reported cases in the literature of delayed rupture of the PCL causing flexion instability [17], they still strongly felt that PCLs which were partially or completely deficient should be treated with an anterior stabilized knee. We had a mean follow-up of 2.5 years and believe that further PCL attenuation would have manifested itself during this time and still no significant clinical differences were found.

Asian-Pacific patients have native tibial slopes of 10°-13°, which entails a steep tibial cut that may remove the entire PCL attachment regardless of whether the PCL needed to be retained or excised for proper knee balancing. We did not collect data on the ethnicity of the patients in our study and therefore we cannot generalize our results to this population. Furthermore, our results are based on total knees with proper soft tissue balancing; therefore, resection of the PCL that was not warranted for proper balancing could affect the extrapolation of our results to this population.

PS knees and CR knees have similar clinical outcomes [2–4,7,15,24,26–30]. Some argue that the PCL-retaining TKA offers enhanced inherent stability, greater range of motion, improved proprioception, and increased rollback [28]. Biomechanics studies have also shown that CR knees exhibited kinematics which resembled more that of the natural knee in comparison to the PS knee [3]. Others claim that PCL-substituting TKA offers better knee flexion and stair climbing ability and a greater ease of exposure and balancing of soft tissues [2]. Even with the present study showing similar clinical outcomes when the PCL is released in CR knees, surgeon can argue that advantages of a CR TKA are lost when the PCL is released; therefore, mandating a revision to a PS knee. Moreover, there are many advantages to the CR knee that are not inherent to PCL retention. CR TKA is generally felt to be less noisy with fewer flexion clicks and rattles that can be alarming for patients [26]. There is less bone removed from the intercondylar notch in CR knees, which can be advantageous especially in smaller femurs [31].

This study has a number of limitations. First, the study was based on a single implant with a posterior lipped tibial polyethylene insert as well as a single surgeon (J.M.). One can question the external validity of the results when the data are extrapolated to other surgeons with slightly different operative technique as well as other knee designs with different companies and different tibial inserts such as the flat tibial bearing component. However, all previous studies have had this limitation except for the systematic reviews. It is an inherent limitation in arthroplasty research due to the quasi impossibility of accounting for all knee designs in an academic center. Second, there was a significant difference in gender between the 3 groups with the PCL-excision group having a higher percentage of males. This reflects the gender-specific susceptibility of having a contracted PCL requiring an excision of the PCL. Having a higher percentage of males in one group may also

Table 4
Postoperative Difference in Mean WOMAC Outcome Scores (SD) in Cruciate-Retaining Total Knee Replacement With Retention, Recession, and Excision of the PCL.

WOMAC Outcome Measures	PCL Retained	PCL Recessed	PCL Excised	*P* Value
Pain	83.2 (19.5)	82.4 (19.3)	81.6 (20.4)	.754
Stiffness	73.6 (23.4)	69.0 (18.0)	71.0 (23.1)	.348
Function	80.3 (19.2)	76.3 (22.4)	80.2 (19.2)	.73
Total score	80.4 (18.7)	77.3 (19.0)	78.8 (18.9)	.541

SD, standard deviation; PCL, posterior cruciate ligament; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

Table 5
Number and Cause of Implant Failure for Primary TKA With Retention, Recession, and Excision of the PCL.

Cause of Implant Failure	PCL Retained (n = 540)	PCL Recessed (n = 24)	PCL Excised (n = 113)
Instability	0 (0)	0 (0)	1 (0.88%)
Pain/stiffness	1 (0.19%)	0 (0)	0 (0)
Periprosthetic fracture	1 (0.19%)	0 (0)	0 (0)
Aseptic loosening	1 (0.19%)	0 (0)	0 (0)
Polyethylene fracture	1 (0.19%)	0 (0)	0 (0)
Total	4 (0.74%)	0 (0)	1 (0.88%)

TKA, total knee arthroplasty; PCL, posterior cruciate ligament.

affect the validity of comparing postoperative outcomes between the groups. Third, the study was retrospective. Nevertheless, designing the study as a retrospective cohort enabled us to have multiple patient-reported outcomes and a large patient population (n = 677) in a timely fashion. As discussed, randomization of the treatment groups is not suitable for this study. Fourth, the observer assessing the postoperative clinical outcomes was not formally blinded; however, the operative report was not accessed before the postoperative clinical measurements. Fifth, the angular deviations of the knees were not measured during the study. We are unable to state whether the angular deviations in the knees were homogenous between groups or whether patients requiring PCL release had greater angular deviations of the knee in the preoperative period. Finally, the groups were not evenly distributed in numbers; yet, they had similar mean ages and preoperative clinical outcomes. There were far less patients who underwent a partial PCL release in comparison to a complete PCL release. The sample size was calculated using 80% power and a minimal clinically important difference of 15 for the total WOMAC score in TKA quoted by Escobar et al [14]. If a power of 90% and a lower effect size is used, the study could be considered underpowered. In this case, future studies with a greater number of participants are required to confirm the results presented in this study. Moreover, pooled data in a meta-analysis that includes this study would offer a higher powered study.

Conclusion

This study presents evidence of similar clinical outcome when the PCL is retained, partially recessed, or fully excised during PCL-retaining TKA. This suggests that PCL-retaining total knee replacements undergoing partial recession or complete excision of the PCL should not routinely be converted to a PCL-substituting knee.

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