Original Research Article

Outcomes of Posterior Cruciate Ligament Retaining versus Posterior Cruciate Ligament Sacrificing in Total Knee Replacement in Young Population -Meta-Analysis of 10 Years of Studies

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ABSTRACT

Introduction: Total knee arthroplasty (TKA) is a common procedure performed especially in end-stage knee osteoarthritis (OA). Since the posterior cruciate ligament (PCL) may affect knee stability, it has been debated whether the PCL needs to be preserved or sacrificed. This study aims to systematically analyze the clinical and functional outcomes following TKA with PCL retaining (PCLR) and sacrificing (PCLS).

Methods: A systematic search was performed through online databases (PubMed, Google Scholar and Cochrane Library) based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline within the searching period from 2011 to 2021. Studies involving patients undergoing total knee replacement with PCL retaining or sacrificing method for knee OA with minimum follow-up of 12 months were included. Non-comparative studies, animal studies and non-English studies were excluded. Review Manager (RevMan) Version 5.3 was used to analyze mean difference (MD) and odds ratio (OR) with a 95% confidence interval (CI).

Results: There were 194 studies on the initial search, 72 duplicates were removed and the final remaining 7 studies were used for inclusion. Seven studies with a total of 3346 patients were included. There were 2220 patients (66.35%) underwent TKA with PCL retaining method. Analyses revealed no significant difference in range of motion (ROM), knee score, maximum flexion, the Western Ontario and McMaster Universities Arthritis Index (WOMAC), and pain score between PCLR and PCLS with p-values of 0.10, 0.56, 0.42, 0.33 and 0.67, respectively. Only function score, hospital for special surgery (HSS) score and flexion contracture showed significant differences with p-values of 0.0002, 0.002 and 0.004, respectively. Further studies are needed.

Conclusion: Analysis between PCLR and PCLS showed no significant difference on the clinical or functional outcomes except in postoperative function score, flexion contracture and HSS score. PCLR had significantly higher function and HSS score with lower flexion contracture compared to PCLS.

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INTRODUCTION

Knee osteoarthritis (OA) has been the main indication for total knee arthroplasty (TKA).[1] Knee OA with radiographic classification of Kellgren-Lawrence grades III and IV are of the most common indication to perform TKA.[2] The requirement for TKA has been predicted to increase rapidly and significantly due to the increasing prevalence of knee OA globally, to be approximately 1.26 million procedures within the next ten years.[3] It is important to bear in mind that to correct knee deformity and to obtain a stable knee resulting in satisfactory functional improvement are the main goals of TKA. Two distinct methods are available to reach these purposes, including the use of cruciate retaining (CR) technique and posterior-stabilized technique, which is also known as cruciate sacrificing (CS) technique.[4] It is important to ensure stability following TKA procedure, since instability may lead to devastating consequences requiring revision surgery. Posterior stability is achieved by retaining the posterior cruciate ligament (PCLR). However, it can also be reached by PCL-sacrificing (PCLS) method.[5]

Studies have reported several advantages of each procedure. PCLR has been shown to provide inherent stability, less load between bone and cement, better proprioception and kinematics, higher degree of bone preservation and better stabilization of the implant. Meanwhile, easier ligament balancing, conforming articulation, better knee flexion, more predictable kinematics and reproducible rollback, lower range of axial rotation and condylar translation and less risk of PCL insufficiency are the superiorities of PCLS method. It is essential to thoroughly evaluate the condition of PCL intraoperatively to determine which technique to perform. PCLR is contraindicated in patients with PCL insufficiency and poor elasticity, bone defects, or the need for augments.[4] The PCL is usually released if there is anterior tibial translation of 90^0 in flexion with the presence of tight flexion gap.[5]

There have been numerous studies assessing the outcomes of PCL retaining (PCLR) and PCL sacrificing (PCLS) methods in which some have demonstrated that PCLR resulted in less consistent success, while in some meta-analyses better proprioception and kinematics were

Table 1. Population-Intervention-Comparison-Outcome, Table Describing Inclusion and Exclusion Criteria

Study Component	Inclusion	Exclusion
Population	• Patients with knee OA • At least 12 months follow-up	• Animal studies • Less than 12 months follow-up • Patients with causes other than primary OA
Intervention and Comparison	• TKA with PCLR or PCLS method	• Other methods of treatment • Studies with only one method of treatment (non-comparative studies)
Outcome	• ROM • Knee score • Function score • Flexion contracture • Maximum flexion • HSS score • WOMAC • Pain score	No outcome mentioned or different outcomes
Publication	Studies published in English in peer-reviewed journals	• Abstracts, editorials, letters • Duplicate publications of the same study that do not report on different outcomes • Meeting presentations or proceedings • Non-English studies
Study Design	All study design except case reports and review articles	Case reports and review articles

observed in PCLR method.[6] Due to scarcity of literature comparing the two methods, this study was aimed to provide an objective comparison between the two methods in the form of meta-analysis. This study focused mainly on postoperative outcome measures, including postoperative clinical and functional outcomes.

METHODS

This is a meta-analysis of relevant studies comparing between PCL retaining and PCL sacrificing in total knee replacement. A thorough and systematic search was conducted within the searching period from 2011 to 2021 to obtain and identify relevant studies through several online databases, including PubMed, Google Scholar and Cochrane Library, based on the Preferred Report-

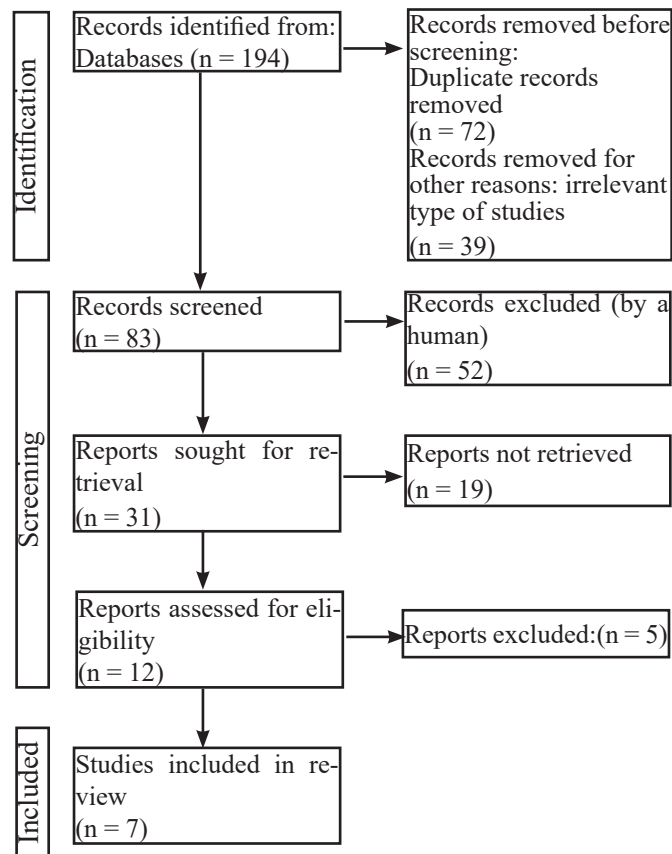Identification of studies via databases and registers

Figure 1. Flow chart for article selection process

ing Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline (Figure 1). The keywords utilized were "Total knee replacement" AND "PCL Retaining" AND "PCL Sacrificing" AND "Outcome".

The obtained articles following the search were then manually scanned and reviewed by the authors according to PICO method to determine the inclusion and exclusion criteria (Table 1). Studies involving patients undergoing total knee replacement with PCL retaining or sacrificing method for knee OA with minimum follow-up of 12 months were included. Non-comparative studies, animal studies and non-English studies were excluded.

Data extraction was performed for basic characteristics and outcomes. Review Manager (RevMan) [Computer program, Version 5.3. Copenhagen: The Nordic Cochrane Centre, the Cochrane Collaboration, 2014] was used to analyze mean difference (MD) and odds ratio (OR) with a 95% confidence interval (CI). Fixed effect model was used when the heterogeneity was <50%, whereas random effect model was used when the heterogeneity was >50%.

Abbreviations: PICO, Population-Intervention-Comparison-Outcome. OA, osteoarthritis. TKA, total knee arthroplasty. PCLR, posterior cruciate ligament retaining. PCLS, posterior cruciate ligament sacrificing. ROM, range of motion. HSS, hospital for special surgery. WOMAC, the Western Ontario and McMaster Universities Arthritis Index (WOMAC).

RESULTS

After an initial search of 194 studies, 72 duplicates were removed, and eventually there were remaining 7 studies used for inclusion. Seven studies with a total of 3346 patients were included. Out of the seven studies, only one study was a randomized controlled trial (RCT) (Level I evidence), whereas three were prospective cohort studies (Level II evidence) and the rest three other studies were retrospective cohort studies (Level III evidence) (Table 2.). Approximately 2220 patients (66.35%) underwent TKA with PCL retaining method. There was a female predominance (61.98%) in subjects involved.

An analysis on ROM was made from five studies with a total sample of 687 patients. Calculation showed a mean ROM of 118.21^0 for PCLS group and 120.31^0 for PCLR group. Figure 2 shows, however, no significant difference in terms of postoperative ROM between the two groups (Heterogeneity, $I^2 = 67\%$; WMD -2.56; 95%CI,-5.57 – 0.45; p=0.10).

As for analysis of knee score, four studies were included, comprised of a total sample of 2864 patients. In PCLS group, the mean knee score was 91.03 while in PCLR mean knee score was 91.98. Analysis showed no signif-

Table 2. Studies included in the analysis

| No	Authors	Study design (Level of evidence)	No of Knees	Mean age (range) (years)		Publication Year	Journal
1	Ishii et al.	Cohort prospective (Level II)	108	71	74	2011	Knee Surg Sports Traumatol Arthrosc
2	Bae et al.	Cohort retrospective (Level III)	137	67.5 ± 4.6	65.8 ± 9.0	2011	The Journal of Arthroplasty
3	Roh et al.	Randomized controlled trial (Level I)	90	69.8 ± 4.7	71.0 ± 4.9	2012	Knee Surg Sports Traumatol Arthrosc
4	Ritter et al.	Cohort prospective (Level II)	105	66.8	67.2	2012	BONE & JOINT RESEARCH
5	Ünkar et al.	Cohort prospective (Level II)	112	69.7 ± 5.9	68.2 ± 6.8	2017	Acta Orthopaedica et Traumatologica Turcica
6	Kim et al.	Cohort retrospective (Level III)	253	69.6 ± 7.1	68.3 ± 7.2	2021	Scientific Reports
7	Saleh et al.	Cohort retrospective (Level III)		64.8 ± 13.185	67.63± 8.416	2021	Hip Knee Journal
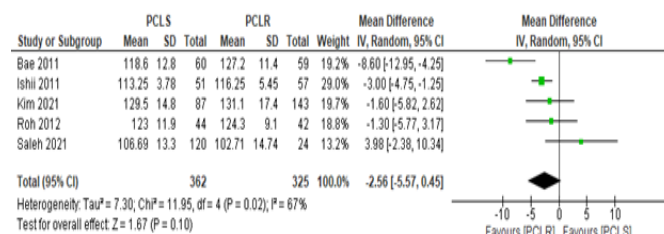
Figure 2. Forest plot for range of motion (ROM)

Figure 3. Forest plot for knee score

p=0.0002) (Figure 4).

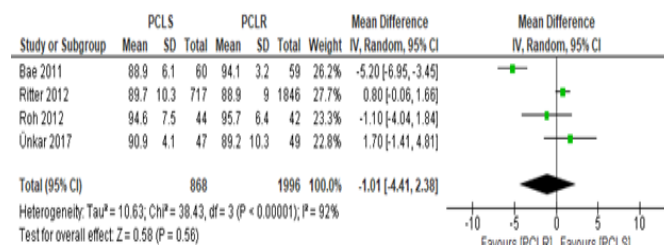**Figure 4.** Forest plot for function score
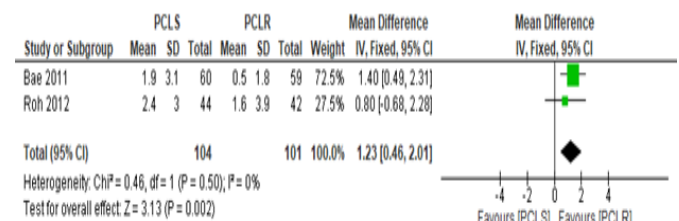
Figure 5. Forest plot for flexion contracture

icant difference in knee score between the two groups (Figure 3) (I^2 = 92%; WMD -1.01; 95%CI, -4.41 – 2.38; p=0.56).

Five studies were included in the analysis of function score, involving a total number of 3094 patients. Mean function score in PCLS group was 82.74 whereas in PCLR group was 84.54. Analysis showed significantly higher function score in PCLR group compared to PCLS group (I^2 = 0%; WMD -2.58; 95%CI, -3.94 – -1.22;

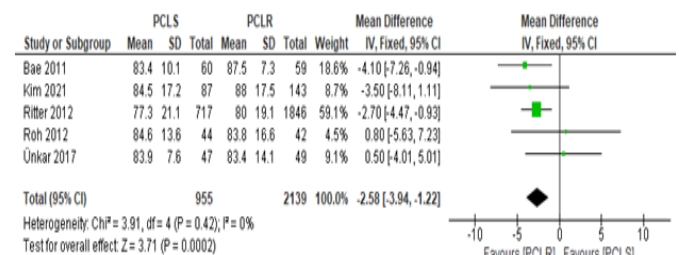Only two studies evaluated flexion contracture as outcome following TKA with PCLR or PCLS method. Calculation was performed from a total of 205 samples, revealing a mean flexion contracture of 2.15 in PCLS group and 1.05 in PCLR group. Analysis showed a significantly higher flexion contracture in PCLR group compared to PCLS group (I^2 = 0%; WMD 1.23; 95%CI, 0.46 – 2.01; p=0.002) (Figure 5).

Maximum flexion was evaluated in four studies. A to-

tal of 2853 patients were included. The mean maximum flexion in PCLS group was 120.1⁰ and 118.04⁰ in PCLR group. As depicted in Figure 6, analysis showed no statistically significant difference in terms of maximum flexion between PCLR and PCLS group (I^2 = 97%; WMD 2.15; 95%CI, -3.06 – 7.36; p=0.42).
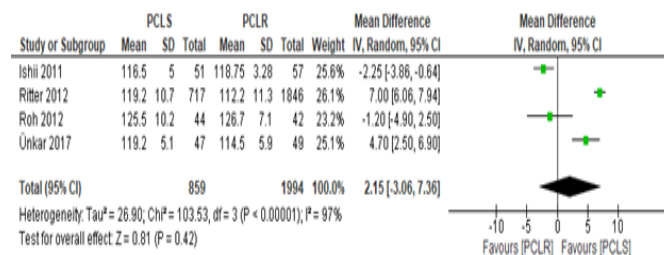

Figure 6. Forest plot for maximum flexion

We estimated HSS score from three studies, comprised of 424 patients. The mean HSS score in PCLS group was 90.07 and 90.9 in PCLR group. Analysis revealed a significantly higher HSS score in PCLR group compared to PCLS group (I^2 = 9%; WMD -1.52; 95%CI, -2.55 – -0.49; p=0.004) (Figure 7).
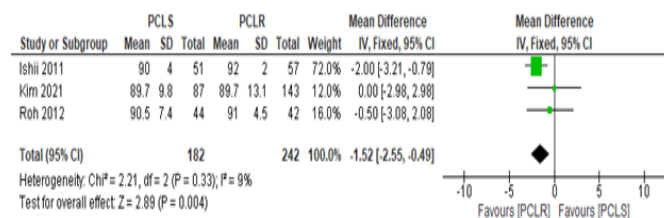

Figure 7. Forest plot for HSS score

WOMAC score was assessed in two studies involving 316 patients. A mean WOMAC score of 14.51 and 13.3 were observed in PCLS and PCLR group, respectively. Figure 8 shows no significantly different mean between the two groups (I^2 = 0%; WMD 1.24; 95%CI, -1.28 – 3.76; p=0.33).
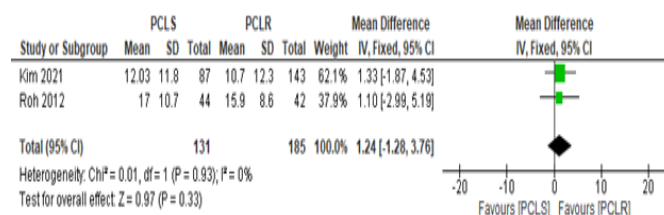

Figure 8. Forest plot for WOMAC score

Calculation and analysis of two studies with a total of 2793 patients assessing pain score revealed a mean pain score of 45.2 and 45.4 in PCLS and PCLR group, respectively. Analysis showed no significant difference in pain score between the two groups (I^2 = 0%; WMD 0.14; 95%CI, -0.52 – 0.80; p=0.67).
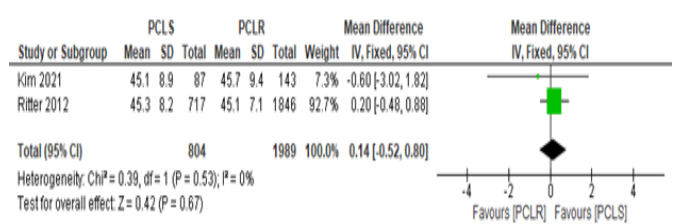

Figure 9. Forest plot for pain score

DISCUSSION

Total knee arthroplasty (TKA) has become the most common treatment for knee osteoarthritis (OA), especially the at the end-stage ones. The increasing prevalence of knee OA, especially due to aging population, has resulted in a significant increase in the rate of TKA.[1,3] TKA is performed by resecting the defected articular knee surface and placing a prosthetic implant. The posterior cruciate ligament (PCL) may be removed or retained, depending on the type of implant used.[7] The role of PCL is, however, still debatable since some argued that it increases proprioception, stability, mechanical properties of the quadriceps and femoral rollback. This results in reduced excessive wear of the polyethylene along with loosening due to decreased stress on the joint surfaces. The ligament can also be completely removed, this has been believed to simplify the correction of fixed deformities.[8]

Postoperative functional outcome in TKA includes postoperative range of motion (ROM). Knee ROM is important for a patient to be able to perform daily activities. In this study, we analyzed postoperative ROM from five studies and found no significant difference between PCLR and PCLS. Bae et al., observed a statistically significant difference in postoperative ROM between PCLR and PCLS. However, the increased amount of ROM was not significant between the two groups.[9] On the contrary, Ishii et al., also concluded that postoperative ROM had no significant difference at any time point during the follow-up period.[10] Similarly, in a study by Kim et al., postoperative ROM at final follow-up at 1 year following the surgery did not show any significant difference between PCLR and PCLS.[11] There was also no significant difference in the postoperative ROM between PCLR and PCLS according to Roh et al.[12]

Knee score was found to be not significant among the PCLR and PCLS group and this was in accordance with the results from previous studies.[6,12,13] Bae et al., however, observed a significantly higher postoperative knee score in PCLR group compared to PCLS group (94.1 ±

3.2 vs 88.9 ± 6.1, p<0.001). But this difference turned out to be insignificant when the improvement of knee score between the two groups were compared (33.3 ± 5.8 in PCLR and 30.5 ± 11.8 in PCLS, p=0.108).[9] Knee score is an essential postoperative assessment for evaluating patient's ability to perform basic daily tasks, including walking, stair climbing, and it also assesses the necessity for walking aids, pain, ROM and stability.[14]

On the contrary to the knee score, the mean function score according to our meta-analysis on five studies showed a significant difference. The function score being higher in PCLR group compared to PCLS group (p=0.0002). Function score was used to evaluate the pain and the function of the knee and similar to the knee score, this also included the measurement of ROM. Interestingly, however, when each study was individually assessed, it was observed that postoperative function score was statistically not significant between PCLR and PCLS in each included study.[6,9,11–13] This might result from a greater summed sample size included in the analysis.

Flexion contracture was significantly higher in PCLS compared to PCLR according to the data obtained from two studies (p=0.002). In accordance with this, Bae *et al*., reported higher flexion contracture in PCLS (1.9 ± 3.1 degrees vs 0.5 ± 1.8 degrees; p=0.001).[9] On the other hand, Roh reported that the difference in flexion contracture between the two groups was not significant.[12] Nevertheless, maximum flexion was not significantly different between PCLR and PCLS postoperatively. Out of four studies included in the analysis for maximum flexion, only one study reported a significantly higher maximum flexion in PCLS group.[6,10,12,13]

Our analysis on HSS score showed a significant difference in postoperative HSS score, with it being higher in PCLR group. In contrast to our result, previous study concluded that postoperative HSS score was not different between the two groups. However, it was estimated that in longer term PCLR may result in worse clinical outcome due to ongoing degenerative changes of the PCL, contributing to worsening of clinical outcomes.[10–12] WOMAC score also showed no significant difference in our study, similar to previously reported results.[11,12]

Pain, as one of the most commonly reported symptoms of OA, may significantly affect patient's quality of life since it limits their ability to perform daily activities and they may depend on pain-relieving medication on a daily basis to lessen the pain. Following the surgery, the patient may not be completely free of pain, but surgery aids in overall improvement, including much less pain. However, according to our meta-analysis, postoperative pain score did not significantly differ between PCLR and PCLS. This finding was similarly observed in previous studies.[6,11]

Like any medical procedure, TKA with either PCLR or PCLS technique is also at risk of complications, intra- or post-operatively. Frequently reported complications include infection, periprosthetic femoral fracture, periprosthetic patellar fracture, instability, and aseptic loosening. Previous studies reported that postoperative complications between the two groups were not significantly different.[9,11–13]

Our study included a sufficiently large number of subjects to conduct adequate analysis on the outcome following TKA with PCLR and PCLS technique. Nevertheless, we only included one RCT study, having the highest level of evidence, while the rest included were of those with lower level of evidence. Further investigations using multiple studies with better study designs are necessary for evaluating outcomes following TKA with PCLR and PCLS technique. The limitation of this research is that only a small number of variables studied, thus the data coverage is not yet broad and deep.

CONCLUSION

In general, analysis between PCLR and PCLS showed no significant difference on the clinical or functional outcomes except in postoperative function score, flexion contracture and HSS score. PCLR had significantly higher function and HSS scores with lower flexion contracture compared to PCLS. Further research involving studies with better study designs is necessary to aid surgeons in determining whether to retain or sacrifice the PCL in TKA.

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