Total Knee Arthroplasty: Posterior Stabilization vs. Posterior Cruciate Ligament Preservation. Clinical and Functional Evaluation

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ABSTRACT

Introduction: Despite the progress and numerous publications in recent years, the outcomes of posterior stabilized (PS) prosthetic designs versus those that preserve the posterior cruciate ligament (PCL) remain controversial. **Materials and Methods:** This is a consecutive retrospective series involving 164 patients surgically treated by the same surgical team. Eighty patients received cruciate-retaining (CR) prostheses, and 84 received PS designs. **Results:** The average age was 70 years. We identified 121 knees as grade 4 and 43 knees as grade 3 according to the Kellgren-Lawrence scale. The postoperative range of motion was 109.5° ± 10.5° in the CR group versus 110° ± 12° in the PS group (p = 0.50). No significant differences were found between the two groups in postoperative knee scores using the Knee Society Score (KSS): 84.7 ± 10 in the CR group versus 87 ± 10 in the PS group (p = 0.14). However, there was a significant difference in the functional score, with the CR group scoring 84 ± 12 versus 78.8 ± 17 in the PS group (p = 0.02). There were no significant differences in terms of patient satisfaction. **Conclusion:** In our study, we found no significant differences in clinical evaluation, pain, or patient satisfaction between cruciate-retaining prosthetic designs and those with posterior stabilization. However, there was a significant difference in functional evaluation using the KSS, favoring the CR group.

Keywords: Total knee arthroplasty; prosthetic design; posterior stabilization; cruciate-retaining.

Level of Evidence: III

Artroplastia total de rodilla: estabilización posterior vs. conservación del ligamento cruzado posterior. Evaluaciones clínica y funcional

RESUMEN

Introducción: Más allá del avance y de las numerosas publicaciones en los últimos años, los resultados de los diseños de prótesis estabilizada posterior vs. aquellos con conservación del ligamento cruzado posterior aún son controvertidos. **Materiales y Métodos:** Serie retrospectiva consecutiva de 164 pacientes operados por un mismo equipo. Ochenta cirugías con conservación del ligamento cruzado posterior y 84 con prótesis estabilizada posterior. **Resultados:** La edad promedio era de 70 años. Según la escala de Kellgren-Lawrence, 121 rodillas eran grado 4 y 43 rodillas, grado 3. El rango de movilidad posoperatorio fue de 109,5° ± 10,5° en el grupo de conservación del ligamento cruzado posterior y de 110° ± 12° en el grupo con prótesis estabilizada posterior (p = 0,50). Después de la cirugía, no se hallaron diferencias entre ambos grupos, en el KSS (84,7 ± 10 vs. 87 ± 10; p = 0,14), pero sí hubo una diferencia significativa en el KSS Funcional (84 ± 12 vs. 78,8 ± 17, respectivamente, p = 0,02). No se observó una diferencia significativa entre ambos grupos respecto de la satisfacción del paciente. **Conclusión:** No se hallaron diferencias significativas en cuanto a la evaluación clínica, el dolor y la satisfacción del paciente al utilizar un diseño con conservación del ligamento cruzado posterior o un diseño estabilizado posterior. Sí hubo una diferencia en el KSS Funcional a favor del grupo de conservación del ligamento cruzado posterior.

Palabras clave: Artroplastia total de rodilla; diseño protésico; estabilizado posterior; conservación ligamento cruzado posterior.

Nivel de Evidencia: III

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INTRODUCTION

Total knee arthroplasty (TKA) is one of the most common procedures in orthopedics. Despite advancements in prosthesis design and numerous publications in recent years, the debate over retaining the posterior cruciate ligament (PCL) continues. The outcomes of posterior stabilized prostheses (PS) versus cruciate-retaining designs remain controversial.[2,3]

Several studies have evaluated the kinematics and biomechanics of these designs, as well as their clinical and functional outcomes. Parsley et al. reported similar results in range of motion, functional scores, knee scores, and patient satisfaction when comparing both designs.[4] Similarly, Wünschel et al. studied strength and kinematics after TKA and found that preserving the PCL led to a more natural reproduction of knee movement, while the kinematics in posterior stabilized cases were determined by the design of the component.[5]

The PCL plays a crucial role in knee flexion. As the femoral insertion of the PCL is displaced anteriorly, it stresses the ligament and causes it to push the tibia posteriorly, a mechanism known as "rollback."[6] Resecting the PCL during surgery can create a 5 mm gap during flexion.[7] The goal of TKA is to replicate natural knee motion while maintaining stability throughout the range of motion. Various authors suggest that preserving the PCL can help achieve this stability.[7,8]

However, when selecting an implant, the surgeon must consider multiple factors, including the patient's clinical history, physical examination, intraoperative assessment of PCL degeneration, and personal preferences. As mentioned, several studies have analyzed the advantages of one design over the other,[9-12] but none have definitively established a clear difference between the two treatments.

Jacobs et al. reviewed eight randomized clinical trials and reported an 8° improvement in range of motion in favor of the PS group. However, they cautioned that these results should be interpreted carefully due to significant variability across the studies.[13]

Given the ongoing debate on this topic, we evaluated our experience with a series of patients treated with these designs.

OBJECTIVE

The objective was to perform a functional comparison between a consecutive series of patients undergoing TKA with two surgical techniques: preservation versus non-preservation of the PCL.

MATERIALS AND METHODS

We retrospectively analyzed a consecutive series of 164 patients operated on by the same surgical team from the Arthroscopy and Knee Prosthesis Sector of Hospital Italiano de Buenos Aires, a university hospital and tertiary care center.

All patients underwent TKA with an anterior approach. In 80 cases, a cruciate-retaining technique was performed using the same Optetrak® CR SLOPE prosthesis (Exactech®, Inc., Gainesville, FL, USA), while in 84 cases, a posterior stabilized design with an Optetrak® PS insert (Exactech®, Inc., Gainesville, FL, USA) was used (Figure 1). In all cases, cemented components were employed, and immediate full weight-bearing was permitted. All patients followed the same rehabilitation protocol, which focused on early mobilization under the supervision of a physiotherapist. The average hospital stay was 3 to 4 days, and patients followed a rehabilitation protocol three times a week for one month post-operation. Follow-up visits were conducted at 3 and 6 weeks, and at 3, 6, and 12 months.

Exclusion criteria included patients who required additional procedures or a more complex implant due to bone defects or bone quality, those with pre-existing conditions or neurological deficits affecting motor function (such as Parkinson's disease or post-polio syndrome), and patients with follow-up periods of less than 12 months.

Radiographs were analyzed preoperatively, and the degree of osteoarthritis was assessed using the Kellgren-Lawrence scale.

Outcome variables included the *Knee Society Score* (KSS), which evaluated both the knee and functional scores preoperatively and at one-year follow-up. Additionally, the visual analog scale, full range of motion, maximum flexion, and extension—measured with a goniometer—were recorded before and after surgery. The WOMAC (*Western Ontario and McMaster Universities Osteoarthritis Index*) questionnaire was also used, and postoperative patient satisfaction was assessed on a scale from 0 to 100, where 100 indicated maximum satisfaction.

Figure 1. **A.** Posterior stabilized prosthesis design. **B.** Posterior cruciate ligament-retaining design.

Statistical Analysis

Continuous variables are expressed as mean and standard deviation (SD) or as median and interquartile range, depending on the distribution observed. Categorical and ordinal variables are expressed as absolute and relative frequencies, along with confidence intervals. To compare the results between the two surgical techniques, as well as the pre- and postoperative outcomes, a paired samples t-test was used.

To assess the effect of the surgical technique (PCL preservation vs. non-preservation) on the outcome variables, linear regression was applied. The beta regression coefficient, reflecting the impact of using the cruciate-retaining technique compared to PS, is reported. To control for potential selection bias, a propensity score was created using logistic regression, with the surgical technique as the dependent variable. The model with the highest area under the curve (AUC) and lowest Akaike information criterion (AIC) was selected. The association between surgical technique and each outcome variable was adjusted using the propensity score.

A p-value of <0.05 was considered statistically significant. Statistical analysis was conducted using STATA version 13.0.

RESULTS

The average age of the cohort was 70 years. According to the Kellgren-Lawrence osteoarthritis scale, 121 knees were classified as grade 4 and 43 as grade 3.

The most common anatomical axis was varus deviation, found in 67.07% of cases (43.6% in the cruciate-retaining group and 56.3% in the PS group). Valgus deviation was present in 26.8% of cases (56.8% vs. 43.1%, respectively), while 6.1% had a normal axis. No significant differences were found between the groups with respect to alignment ($p = 0.134$). All patients had a minimum follow-up period of 12 months.

The descriptive variables of the population are detailed in Table 1.

Table 1. Description of the population based on the surgical technique employed

	Cruciate-retaining design	Posterior stabilized prosthesis	p
Age, average	68.9 (SD 7.45)	70.5 (SD 9.11)	0.222
Right side (%)	53	47	0.160
Body mass index, mean	28.7 (SD 5.02)	31.7 (SD 5.67)	0.005
Follow-up, months	20.3 (SD 8.22)	27.6 (SD 11.86)	0.001

PCL = posterior cruciate ligament; SD = standard deviation.

Range of Motion

The full range of motion was 105° ± 11° in the cruciate-retaining group and 102° ± 13.5° in the PS group preoperatively, increasing to 109.5° ± 10.5° and 110° ± 12°, respectively, postoperatively (p = 0.50) (Figure 2).

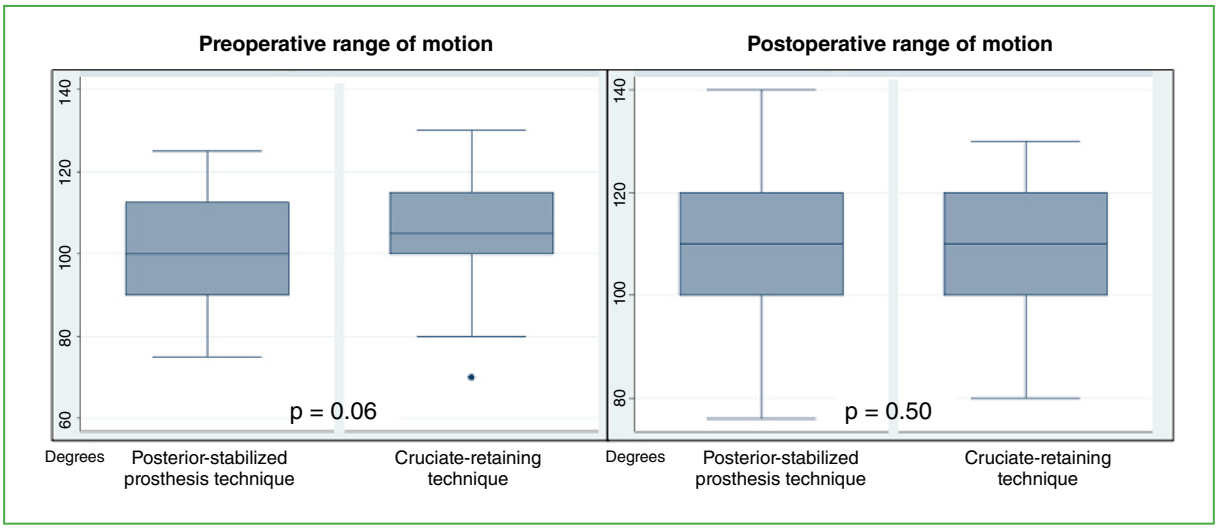

Figure 2. Comparison of preoperative and postoperative range of motion for both surgical techniques.

Preoperative flexion was 108° ± 10° in the cruciate-retaining group and 107° ± 12° in the PS group (p = 0.48). After surgery, flexion improved to 109.8° ± 9.9° in the cruciate-retaining group and 110.9° ± 11.7° in the PS group (p = 0.508).

Extension in the cruciate-retaining group was 2.8° ± 4.4° preoperatively and improved to 0.56° ± 1.5° at follow-up. In the PS group, extension was 4.9° ± 5.4° preoperatively and 0.53° ± 1.7° postoperatively. No significant differences were observed between the groups (p = 0.91) (Table 2).

Table 2. Preoperative and postoperative range of motion, flexion, and extension of both groups.

	Cruciate-retaining design	Posterior stabilized prosthesis	p
Preoperative range of motion	105.62° (SD 11.67°)	102° (SD 13.57°)	0.069
Postoperative range of motion	109.5° (SD 10.51°)	110.67° (SD 12.21°)	0.509
Preoperative flexion	108.25° (SD 10.37°)	107.01° (SD 12.10°)	0.483
Postoperative flexion	109.81° (SD 9.98°)	110.94° (SD 11.71°)	0.508
Preoperative extension	2.81° (SD 4.42°)	4.96° (SD 5.43°)	0.006
Postoperative extension	0.56° (SD 1.58°)	0.53° (SD 1.76°)	0.919

PCL = posterior cruciate ligament; SD = standard deviation.

Outcome Variables According to Surgical Technique

Pain

Pain was assessed using the visual analog scale (VAS). The cruciate-retaining group had a preoperative score of 8.68 (SD ± 0.94), while the PS group scored 8.09 (SD ± 1.36) (p = 0.001). After surgery, the pain score decreased to 1.82 (SD ± 1.43) in the cruciate-retaining group and 1.91 (SD ± 1.31) in the PS group (p = 0.67). Pain was also evaluated using the KSS (Figure 3).

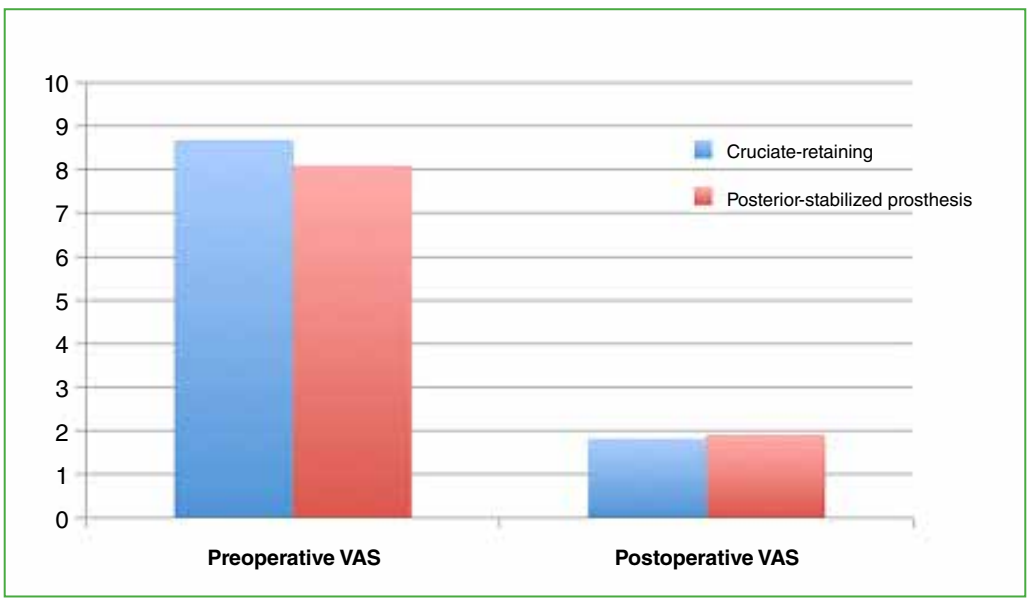

Figure 3. Preoperative and postoperative pain scores.

Functional Evaluation

Preoperative knee KSS was 44 ± 16 in the cruciate-retaining group and 45 ± 16 in the PS group (p = 0.82). The preoperative functional KSS was 53 ± 17 in the cruciate-retaining group compared to 46 ± 18 in the PS group (p = 0.02).

Postoperatively, no significant differences were found between the groups regarding knee KSS (84.7 ± 10 vs. 87 ± 10, respectively, p = 0.14). However, there was a significant difference in the functional KSS, with the cruciate-retaining group scoring 84 ± 12 compared to 78.8 ± 17 in the PS group (p = 0.02) (Figure 4).

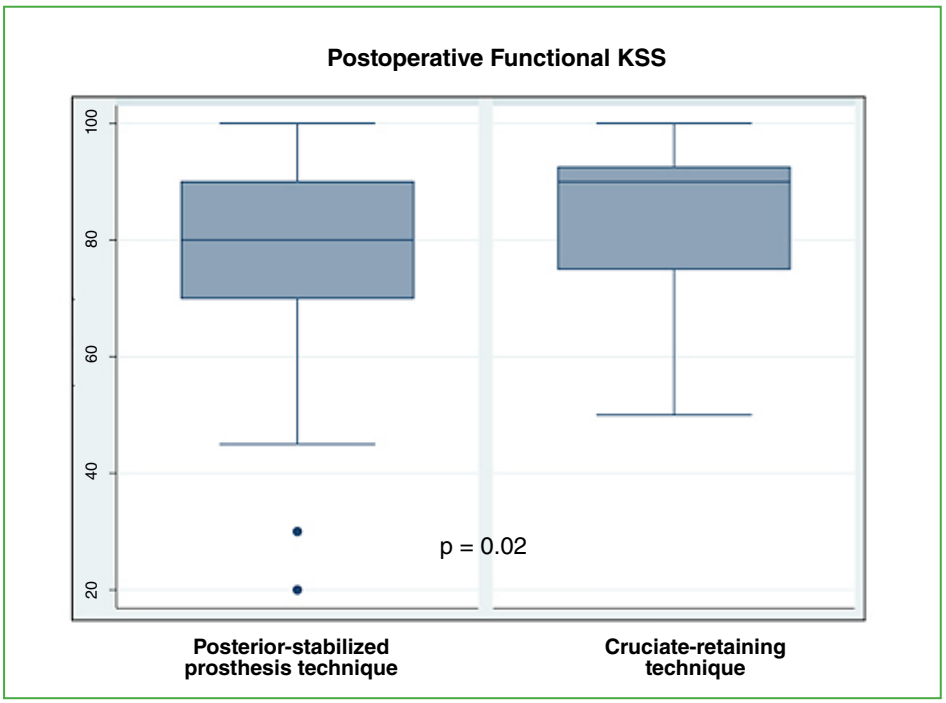

Figure 4. Functional KSS score for both surgical techniques.

The WOMAC questionnaire showed a preoperative score of 45 ± 12 in the cruciate-retaining group and 52 ± 18 in the PS group (p = 0.12). Postoperatively, there were no significant differences between the groups (14 ± 7 vs. 19 ± 14, respectively) (p = 0.10).

As seen in Table 3, all variables showed significant improvement after surgery.

Table 3. Details of outcome variables.

	Cruciate-retaining design			Posterior stabilized prosthesis		
	Preoperative	**Postoperative**	**p**	**Preoperative**	**Postoperative**	**p**
Range of motion	105.6°	109.5°	0.002	102°	110.6°	0.001
KSS (Knee)	44.8	87	0.001	44.4	84.7	0.001
KSS (Functional)	53.1	84.3	0.001	46.6	78.8	0.001
Visual analog scale	8.6	1.8	0.001	8	1.9	0.001

PCL = posterior cruciate ligament; KSS = Knee Society Score.

No clinically significant differences were observed in the effect of the cruciate-retaining technique compared to PS on any outcome variable before and after adjusting for the propensity score (Table 4).

Table 4. Effect of posterior cruciate ligament-retaining technique on postoperative functional assessment using propensity score-adjusted linear regression.

	Raw coefficient (95%CI)	PS-adjusted coefficient*
Postoperative range of motion	-1.18 (from -4.70 to 2.34)	-3.6 (from -7.48 to 0.23)
Postoperative subjective KSS	5.46** (0.73-10.19)	2.42 (from -2.82 to 7.65)
Postoperative objective KSS	-2.36 (from -5.51 to 0.79)	-4.41** (from -7.9 to 0.92)
Postoperative extension contracture	0.026 (from -0.49 to 0.54)	0.31 (from -0.25 to 0.89)
Postoperative flexion	-1.12 (from -4.49 to 2.23)	-3.05 (from -6.79 to 0.67)

*PS = propensity score constructed with body mass index, preoperative extension contracture, preoperative pain, and preoperative subjective KSS. **Results with p<0.05. 95%CI = 95% confidence interval.

Patient Satisfaction

Patient satisfaction was evaluated at the last follow-up. The average satisfaction score was 83.1 (SD ± 4.82) in the cruciate-retaining group and 81.9 (SD ± 5.94) in the PS group. No significant difference was observed between the two groups (p = 0.096).

DISCUSSION

Over the past decades, numerous studies, including systematic reviews and meta-analyses, have explored the differences in clinical outcomes between posterior cruciate ligament-retaining and posterior stabilized (PS) designs.[14,15] However, no consensus has been reached regarding whether one design is superior to the other. Traditionally, it has been argued that the PS design allows for a greater range of motion than the cruciate-retaining design.[16] This is because the PS design can avoid the paradoxical anterior translation during flexion, often observed in cruciate-retaining TKA, which may limit the flexion angle.[17] However, in our study, while the PS group achieved greater postoperative flexion, there was no major difference between the two prosthesis designs in terms of overall range of motion. This is consistent with recent findings by Yamamoto et al.[18] who reported no significant difference in postoperative range of motion between cruciate-retaining and PS designs, with both types showing a significant increase in postoperative flexion angle. Similarly, a meta-analysis by Berick et al.,[16] which included 1,265 knees from 12 randomized controlled trials, found that knee flexion and range of motion were significantly improved in knees with PS designs.

The literature is also inconsistent regarding postoperative pain and patient satisfaction. In a prospective, randomized study of 58 knees, Yagishita et al.[19] found no significant differences in the *Knee Society Score* (KSS) or visual analog scale (VAS) scores, but they did observe a higher degree of satisfaction in the PS group. These results are consistent with those from our series regarding the postoperative pain variable, while both groups had satisfaction levels above 80%. Singleton et al.[20] also found no differences in pain scores at 1 year, 5 years, and 10 years postoperatively.

In our series, no significant differences were found in functional outcomes as measured by the WOMAC questionnaire or the knee KSS. However, the Functional KSS favored the cruciate-retaining group. Singleton et al.[20] found no difference in overall functional improvement between cruciate-retaining and PS groups. They suggested that the slight improvements in knee range of motion provided by the PS design may translate into better functional outcomes and patient satisfaction in the short term. However, over time, patients may become more accustomed to their knee motion, and these differences tend to diminish.

Lützner et al.[21] also found similar intraoperative stability between the two designs, with no statistically significant differences. Despite the variations in femoral rollback, both PS and cruciate-retaining TKA designs have demonstrated improvements in both intraoperative and postoperative stability.

Our study has certain limitations: it is a retrospective series, has a relatively short follow-up, and lacks an assessment of kinematics or proprioception.

CONCLUSIONS

No significant differences were found in clinical outcomes, pain levels, or patient satisfaction between cruciate-retaining and PS prosthesis designs. However, there was a difference in the Functional KSS in favor of the cruciate-retaining group.

We consider the cruciate-retaining prosthetic design to be a viable option for TKA, as the clinical and functional outcomes are comparable to those of the PS design, with the added advantage of preserving more bone stock.

Conflict of interest: The authors declare no conflicts of interest.

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