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RESEARCH ARTICLE

Comparison of the Clinical Results of Patients who Underwent PCL-retaining and PCL-substituting Total Knee Arthroplasty

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ABSTRACT

Objective: This study aimed to retrospectively evaluate patients undergoing total knee arthroplasty (TKA) and compare clinical results of patients with posterior cruciate ligament (PCL)-retaining and PCL-substituting TKA.

Method: The clinical results of 60 patients who underwent TKA (30 PCL retaining and 30 PCL substituting) at Düzce University Faculty of Medicine Hospital between September 2014 and September 2016 were evaluated and compared. The clinical results were evaluated using knee scores and knee functional scores according to the American Knee Society Criteria.

Results: The mean postoperative flexion angles were 110.33° ± 5.71° (100°–120°) in the PCL-substituting group and 102.50° ± 5.69° (90°–110°) in the PCL-retaining group, the postoperative knee scores were 90.20 ± 5.16 and 84.07 ± 5.87, respectively, and postoperative knee functional scores were 80.60 ± 7.86 and 78.17 ± 7.25, respectively. Knee scores were significantly different between the groups ($P < 0.001$). There was no significant difference between the groups in terms of knee functional scores.

Conclusion: Compared with the literature, knee scores of the PCL-substituting group yielded significant results, whereas the knee functional scores were similar to those of the PCL-retaining group. The results reported here indicate that clinical outcomes and survival are not different for either surgical option, and it is possible to achieve good results in both groups when appropriate soft tissue balance is achieved.

Keywords: knee osteoarthritis, posterior cruciate ligament-retaining total knee arthroplasty, posterior cruciate ligament-substituting total knee arthroplasty, total knee arthroplasty

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INTRODUCTION

Knee osteoarthritis causes pain and limitation of movement in the middle-aged and elderly population and decreases quality of life. Because of the complex anatomical structure and biomechanical properties of the knee, the development of knee prostheses occurred later and was more difficult compared with hip prostheses. Total knee arthroplasty (TKA) gives satisfactory results when non-surgical treatment methods are inadequate. TKA applications are predicted to increase in number with prolonged life expectancy and improvement of surgical techniques [1]. With accurate patient selection and appropriate surgical technique, TKA provides pain relief and high patient satisfaction [2]. The presentation of clinical outcomes in TKA has traditionally been based on objective criteria such as implant survival, joint range of motion, joint balance, and radiological results [3]. There is an ongoing controversy as to whether the posterior cruciate ligament (PCL) should be preserved during TKA. The goal is to maintain natural knee movement and stability in patients undergoing PCL-retaining TKA [4,5]. Further, it is believed that PCL has different types of mechanoreceptors for proprioception, thereby preserving PCL may provide a better postoperative response in the knee [6]. If PCL is preserved, good knee balancing is necessary; a tight knee or a loose knee may be encountered in the absence of good balancing [7]. On the other hand, PCL

Figure 1. A. Preoperative anterior–posterior knee X-ray of the PCL-substituting group, B. Preoperative lateral knee X-ray of the PCL-substituting group

substitution may facilitate the correction of severe knee deformities and contractures [8]. In addition, PCL substitution results in an increase in flexion range [9].

Both designs were used in the present study. Posterior stabilized design is used in patients with non-functional PCL. However, in patients with a functional PCL, the choice of design depends largely on the surgeon's preferences and training. There is a limited number of studies in the literature comparing the outcomes of the two designs. These studies are characterized by a small numbers of patients, different outcome measures, low randomization, and comparison of designs from different manufacturers [10].

In the present study, we aimed to present the mid- and long-term clinical results of PCL-retaining and PCL-substituting TKA cases in our clinic.

METHODS

The study design was approved by the Duzce University Clinical Research Ethics Committee (Duzce, Turkey) (No. 2019/237), and the study was performed in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from the parents/guardians of the patients included in the study. It was decided to recruit a total of sixty patients to obtain clinically and statistically significant difference in accordance with the study with a 5% significance level, 80% power and an effect size of 0.32. The clinical results of 60 patients who underwent TKA (30 PCL retaining and 30 PCL substituting) at the Orthopedics and Traumatology Clinic of Düzce University Faculty of Medicine Hospital between September 2014 and September 2016, with adequate follow up and control, were evaluated and compared. The patients included those with primary osteoarthritis undergoing PCL-retaining or PCL-substituting unilateral arthroplasty without patellar joint surface replacement. All procedures were performed with standard Scorpi NRG Knee System instrumentation (Stryker). Patients undergoing revision and bilateral arthroplasty and those with fixed varus greater than 20°, skeletal development problems, rheumatic disease, and secondary osteoarthritis were excluded from the study. Demographic data of the patients in both groups were kept similar for a homogeneous distribution. All patients underwent preoperative and postoperative stepping anterior–posterior, lateral, patella tangential, or merchant X-ray, and lower extremity orthoreontgenogram for viewing the alignment. Femoral–tibial alignment, narrowing of the joint space, osteophyte, bone loss, cyst, and knee mechanical axis were evaluated for each patient on these X-rays, and appropriate prosthesis was selected (**Figures 1** and **2**).

However, patient's age, lifestyle, and bone quality were the most important parameters for making the decision of retaining or substituting PCL. We paid attention to ensure that the patients in both groups were similar in terms of all these parameters. The patients included in the study were divided into two groups according to the prosthesis designs applied (PCL-retaining group and PCL-substituting group). Each patient was called for follow up at 2 weeks, 4 weeks, 2 months, 6 months, and 1 year postoperatively. Postoperative follow-up X-rays were obtained from both groups (**Figures 3** and **4**).

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Figure 2. A. Preoperative anterior–posterior knee X-ray of the PCL-retaining group, B. Preoperative lateral knee X-ray of the PCL-retaining group

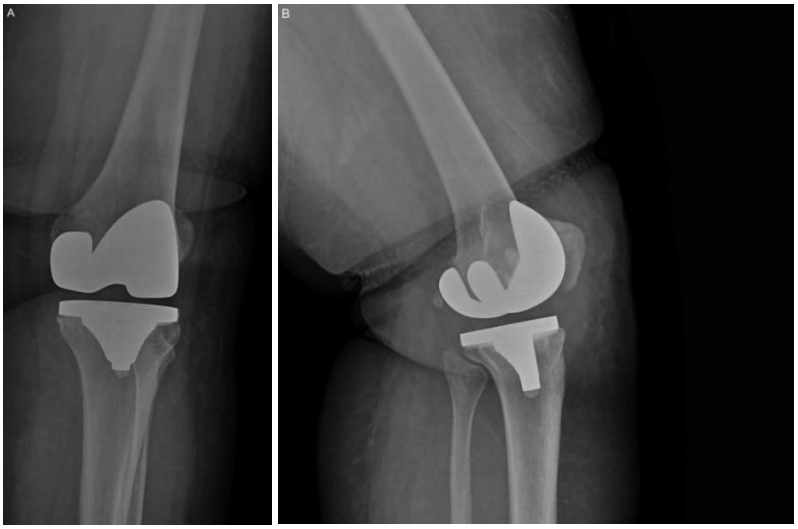

Figure 3. A. Postoperative anterior–posterior knee X-ray of the PCL-substituting group, B. Postoperative lateral knee X-ray of the PCL-substituting group

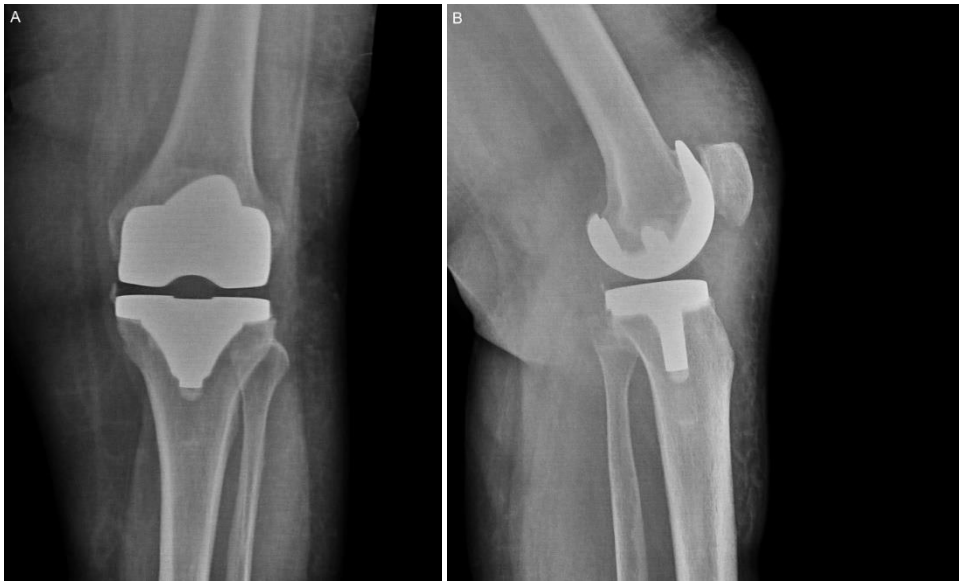

Figure 4. A. Postoperative anterior–posterior knee X-ray of the PCL-retaining group, B. Postoperative lateral knee X-ray of the PCL-retaining group

Table 1. Baseline demographic and clinical characteristics of the patients

	PCL-substituting TKA (n = 30)	PCL-retaining TKA (n = 30)	P
Age	64.63±6.75	62.73±8.77	0.351
Weight	81.77±11.93	87.07±10.95	0.078
Height	161.10±5.78	163.37±6.08	0.144
BMI	31.56±4.88	32.82±5.64	0.360
Gender			
Male	2 (6.7)	4 (13.3)	0.671
Female	28 (93.3)	26 (86.7)	
Side			
Left	10 (33.3)	11 (36.7)	0.787
Right	20 (66.7)	19 (63.3)	
Length of hospital stay	3 (3-4)	4 (3-5)	<0.001

Continuous variables are presented as mean ± standard deviation or median [minimum–maximum], and categorical variables are presented as n (%)

STATISTICAL ANALYSIS

The distribution of continuous variables was examined using Shapiro–Wilk test. Independent samples t test was used to compare normally distributed variables, and Mann–Whitney U test was used to compare non-normally distributed variables. The relationships between categorical variables were examined using Pearson chi-square and Fisher's exact test. Repeated measures analysis of variance was used to compare preoperative and postoperative data between the groups. Continuous variables were presented as mean ± standard deviation or median [minimum–maximum] depending on the distribution type, and categorical variables were presented as frequency and percentage. Statistical analyses were performed using SPSS v.22 package software, and $P < 0.05$ was considered statistically significant.

RESULTS

This retrospective study included 60 patients who underwent TKA for degenerative arthritis of the knee. The baseline demographic and clinical characteristics of the patients are shown in **Table 1**. The mean age of the patients in the PCL-substituting group was 64.63 ± 6.75 years (range, 51–79 years). Further, 28 (93.3%) patients were female, and 2 (6.7%) were male. The mean age of the patients in the PCL-retaining group was 62.73 ± 8.77 years (range, 47–80 years). Furthermore, 26 (86.7%) patients were female, and 4 (13.3%) were male. There was no significant difference between the groups in terms of age, gender, height, weight, body mass index, and length of hospital stay.

Knee flexion, knee scores, and knee functional scores of the groups are shown in **Table 2**. Knee flexion increased postoperatively in both groups, but the preoperative–postoperative difference was higher in the PCL-substituting group than in the PCL-retaining group ($P < 0.001$). Knee scores were significantly higher in the PCL-substituting group ($P < 0.001$). In other words, knee scores increased in both groups, but the preoperative–postoperative difference was higher in the PCL-substituting group than in the PCL-retaining group. Group × time interaction was not significant in terms of knee functional scores ($P = 0.202$). Knee functional scores were elevated in both groups, and preoperative–postoperative difference was similar in both groups. The length of hospital stay was significant in the PCL-substituting group ($P < 0.001$).

Table 2. Preoperative and postoperative knee flexion, knee score, and knee functional scores between the groups

	PCL-substituting TKA (n = 30)	PCL-retaining TKA (n = 30)	P
Knee flexion			
Preoperative	70.67±8.58	73.33±8.44	**<0.001**
Postoperative	110.33±5.71	102.50±5.69	
Knee score			
Preoperative	42.83±9.62	46.33±9.28	**<0.001**
Postoperative	90.20±5.16	84.07±5.87	
Knee functional score			
Preoperative	30.83±11.53	31.33±11.21	0.202
Postoperative	80.60±7.86	78.17±7.25	

Table 3. Knee extension in the groups

	PCL-substituting TKA (n = 30)	PCL-retaining TKA (n = 30)	P
Preoperative Knee extension			
−5,−1	8 (26.7)	5 (16.7)	0.347
0	22 (73.3)	25 (83.3)	

Knee extension distribution of the groups is shown in **Table 3**. Preoperative knee extension was between −5 and −1 in 8 (26.7%) patients in the PCL-substituting group and in 5 (16.7%) patients in the PCL-retaining group, and there was no significant difference ($P = 0.347$). Postoperative knee extension was 0 in all patients in both groups.

DISCUSSION

Currently, implant selection may depend on the surgeon's preference and training and the presence of any existing PCL pathology. TKA that substitutes or retains PCL provides excellent results in the long-term follow up of clinical measurements such as joint range of motion and function [12-14]. No clear difference between the two designs has been observed so far [10,15,16]. However, there are studies suggesting that PCL-retaining knee surgeries have a higher survival rate [17]. In one study, it has been argued that PCL-retaining surgery cannot guarantee proprioception [18]. In the present study comparing PCL-substituting and PCL-retaining TKA, we found a significant difference in knee flexion and knee scores between the groups, whereas no significant difference was found in terms of knee functional scores. Despite the high success rates of

TKA, there is still ongoing controversy between substituting and retaining PCL. Advocates of PCL-retaining designs believe that preserving the original anatomy as much as possible is important and that PCL can continue to stabilize the knee during flexion. PCL-substituting designs use the tibial column and the femoral cam to replace PCL, allowing femoral return and attempting to prevent anterior movement of the femur. These two types of prostheses have been compared in many studies with mixed results. The present study was performed to directly compare the clinical results of both designs made by the same manufacturer over a 5-year follow-up period to ensure that any significant advantage between the designs could be objectively determined.

In the present study, all patients were well 1–4 years after the procedure, showing that both designs had excellent clinical outcomes over a 5-year follow-up period with minor differences between 2-year-old prostheses.

Many other studies have directly compared the two prosthetic designs and reported contradicting results. Maruyama et al. [19] examined 20 patients who underwent bilateral TKA with a PCL-substituting or PCL-retaining implant and found that the clinical scores of the two implants were similar over a 30-month follow-up period, but flexion was higher in the PCL-retaining group (131° vs. 122°; $P < 0.05$). In another study involving kinematic analysis of 20 patients who underwent bilateral TKA with PCL-substituting implant in one knee and PCL-retaining implant in the other knee, it was found that PCL-retaining implants provided a better joint range of motion (131° ± 12° vs. 121° ± 16°) [20]. In the present study, we found a higher flexion angle using PCL-substituting implants (110.33° ± 5.71°; $P < 0.001$). Bolanos et al. examined 14 patients who underwent bilateral TKA with PCL-substituting implant in one knee and PCL-retaining implant in the other knee. Knee scores, knee parameters, and the results of electromyographic waveforms during movement and stair climbing were similar between the two types of implants over a mean follow-up period of 98 months (72–136 months) [21]. In the present study, knee score was significantly better in the PCL-substituting group (90.20 ± 5.16; $P < 0.001$), but knee functional scores were similar between the groups. Hofmann et al. examined PCL-substituting and PCL-retaining TKA applications over a mean follow-up period of 60 months and found no significant difference between the two groups in terms of Modified Special Surgery Hospital score or joint range of motion [22]. In contrast, we found significant difference in joint range of motion and knee scores using the PCL-substituting implant. In a retrospective study of 114 patients who underwent PCL-substituting TKA with a mean follow-up period of 8.3 years, significantly improved joint range of motion and knee scores were reported [23]. In another study, no significant difference was found in knee kinematics and gait analysis between the two groups [24]. In a prospective randomized study, 20 patients who underwent bilateral TKA for osteoarthritis were examined, and all procedures were clinically and radiographically evaluated. No significant difference was found in postoperative knee scores between PCL-retaining and PCL-substituting groups. However, improvement in postoperative joint range of motion was significantly superior in the PCL-substituting group [25]. In the present study, we found a significant difference in knee scores and joint range of motion of the PCL-substituting group. Thippanna et al. compared PCL-substituting and PCL-retaining surgeries and found no significant difference in terms of forgotten joint score [26]. In 20 patients who underwent bilateral TKA with PCL-substituting implant in one knee and PCL-retaining implant in the other knee, flexion range was measured preoperatively and postoperatively over a follow-up period of at least 2 years, and flexion range was found to be higher in patients who underwent PCL-substituting TKA [27]. Moreover, in the present study, we found significantly higher flexion range in the PCL-substituting group.

We found no difference in the frequency of complications between the two groups. Although there is an ongoing controversy as to which treatment method is superior, we obtained better results in terms of knee scores and joint range of motion using PCL-substituting prosthesis design compared with the PCL-retaining prosthesis design. Because potential long-term problems such as polyethylene wear or detailed kinematic or functional analyses such as quadriceps force during stair climbing were not investigated in the present study, we cannot recommend the use of PCL-substituting prosthesis design solely based on the results of this study. Therefore, implant selection may depend on the surgeon's preference and training and the presence of any existing PCL pathology.

CONCLUSION

Good and excellent results were obtained in both groups. Postoperative joint range of motion and knee scores were better using the PCL-substituting prosthesis design. When performed with the right indication, good results may be obtained using both prosthesis designs.

Declaration of interest: The authors report no conflicts of interest.

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