


CLINICAL ARTICLE

Early Patellofemoral Function of Medial Pivot Prostheses Compared with Posterior-Stabilized Prostheses for Unilateral Total Knee Arthroplasty

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Objective: To systematically evaluate the patellofemoral joint design of medial pivot prosthesis, which incorporates a variety of “patella-friendly” design features, by comparing clinical and radiographic results with another prosthesis.

Methods: All consecutive patients who underwent unilateral total knee arthroplasty (TKA) with medial pivot prosthesis (Group MP, 126 cases) between September 2016 and April 2018 were enrolled in this retrospective study. For each patient reviewed, a control patient was matched, according to age, gender, side, body mass index (BMI), preoperative range of motion (ROM), and operating period, who had received primary unilateral TKA with a conventional posterior-stabilized prosthesis at the same period as the study group (Group PS, 126 cases). All patients underwent at least 1-year follow-up. At the preoperative and final follow-up periods, data on the Knee Society Score (KSS) score, WOMAC score, Kujala score, and ROM were collected. Merchant views were taken with the knee flexion at 30°, 60°, and 90° to measure patella shift and tilt. Preoperative posterior condylar angle (PCA) was also measured. Postoperative complications, including anterior knee pain, maltracking, patellar clunk or crepitus (PCC), were evaluated.

Results: There were no significant differences in the demographics or clinical characteristics between the two groups. No statistically significant difference was identified in the KSS total score, including knee score and function score, or in the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score between the two groups after the operation. We found statistically significant differences in the postoperative Kujala scores and the ROMs between the two groups. The mean Kujala score in group MP was better than in group PS (MP 77.16 ± 3.80 vs PS 75.97 ± 4.06, $P < 0.05$), while the ROM in group PS was significantly higher than in group MP (MP 122.24° ± 4.45° vs PS 123.78° ± 6.05°, $P < 0.05$). Simultaneously, the preoperative/postoperative Kujala score improvement in group MP was observed to be significantly larger than in group PS (MP 27.82 ± 5.31 vs PS 26.17 ± 4.89, $P < 0.05$), but the average ROM improvement in group PS was significantly greater than in group MP (MP 19.00° ± 9.90° vs PS 21.57° ± 9.62°). In the 90° Merchant view, the mean patella tilt of group MP was statistically smaller than that of group PS (MP 4.21° ± 1.62° vs PS 4.74° ± 1.95°, $P < 0.05$), and the average patella tilt change in group MP was significantly greater than in group PS (MP -3.8° ± 1.43° vs PS -3.23° ± 1.33°, $P < 0.05$). Preoperative PCA did not show significant differences between the two groups. Two cases of PCC and three cases of anterior knee pain were noted in group MP, and nine cases and six cases, respectively, were observed in group PS. The incidence of PCC was significantly lower in group MP (1.6% vs 7.1%, $P < 0.05$). There was no significant difference in follow-up time between the two groups.

Conclusion: The medial pivot prosthesis could achieve satisfactory outcomes with better patellofemoral performance attributed to its “patella-friendly” design characteristics compared to the conventional posterior-stabilized prosthesis.

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Introduction

Total knee arthroplasty (TKA) is a well-established procedure for severe osteoarthritis and other conditions of cartilage degeneration that generally results in a high level of patient satisfaction. However, as the number of TKAs performed has increased, the number of reported patellofemoral joint-related complications has also increased¹. Historically, patella-related complications have been as high as 50% of the complications following TKA². The causes of patellofemoral joint-related complications can be classified into three categories: patient, surgical technique, and prosthesis design factors. With the development of contemporary designs and improvements in surgical techniques, complication rates have decreased but remain the most challenging problem after TKA³. Component design characteristics such as conformity, shape, and depth of the femoral trochlea have been proven to be important factors in patellofemoral joint problems⁴. An incompatible patellofemoral joint design may result in multiple postoperative complications, including patellar anterior knee pain, maltracking, patellar clunk or crepitus (PCC), and avascular necrosis⁴. Several *in vitro* studies have found that patellofemoral kinematics were altered after TKA and that patellofemoral joint pressure was increased as compared with the natural knee^{5, 6}. The use of a knee prosthesis capable of reconstructing normal patellofemoral joint movement and with low patellofemoral joint pressure might be beneficial in reducing postoperative patellofemoral joint complications⁷.

A medial pivot femoral prosthesis incorporates a variety of “patella-friendly” design features that facilitate the reconstruction of natural patellofemoral joint relationships. The femoral component has a single radius of curvature in the sagittal plane from fully extended to 90°, which is closer to the anatomy of the natural knee⁸. The depth of the natural trochlear groove is restored, so “overfilling” could be effectively avoided in front of the knee, which would be beneficial for extension devices to function normally^{9, 10}. The anterior lateral edge is 3–4 mm higher than the bottom of the trochlear groove, which is an essential feature for maintaining the patella track in early knee flexion¹¹. The trochlear groove extends backward so that the patella could also fully contact the femoral prosthesis in deep knee flexion¹². Besides, medial pivot prosthesis restores normal tibiofemoral kinematics, which decreases patellofemoral contact pressure and reduces the incidence of patellofemoral problems such as anterior knee pain after TKA¹³.

Based on these theoretical advantages, the “patella-friendly” design features of the medial pivot prosthesis may decrease the risk of patellofemoral joint problems and achieve satisfactory outcomes^{14, 15}. Several studies have reported clinical satisfaction and survival analysis of TKA for

the medial pivot prosthesis^{16–19}. However, the comparison of clinical and radiographic results of this prosthetic patellofemoral joint with another prosthesis was rare¹⁴. Compared with studies on the overall satisfaction and survival rate of patients with medial pivot prosthesis, we have paid less attention to patellofemoral joint-related complications, although it is one of the main factors causing revision of the prosthesis²⁰.

Another prosthesis (NexGen LPS-Flex) was designed with a deepened anterior flange on the femoral component, which aids in patellar tracking during extension and flexion⁴. The trochlear groove of the implant is elongated to prevent the patella from getting entrapped in the intercondylar space in the high-flexion state^{4, 21}. The anterior lip of the tibial polyethylene insert is beveled to avoid irritating patella during high flexion²¹. These characteristics contribute to improve patellofemoral performance. Besides, the NexGen LPS-Flex prosthesis is the most representative of the conventional posterior stabilized knee prosthesis (cruciate-substituting), which is widely used in the treatment of knee osteoarthritis due to excellent clinical and radiological results after surgery and considered as the gold standard for clinical outcome evaluation after TKA^{22, 23}. Therefore, we considered it appropriate to use the LPS flex prosthesis as the target prosthesis compared to the medial pivot prosthesis.

This study retrospectively compared the clinical and radiographic results of TKA using the medial pivot prosthesis with conventional posterior-stabilized prosthesis by a matched pair analysis. The clinical scoring system included the Knee Society’s Knee Scoring System (KSS), the Western Ontario and McMaster Universities Osteoarthritis (WOMAC) Index, patellofemoral joint-related clinical scoring system, and image evaluation, which included patella tilt and patella shift at 30°, 60°, and 90°.

The aim of the present study was to: (i) comprehensively evaluate the early clinical results of TKA using medial pivot prosthesis; (ii) assess the clinical function and imaging results of early patellofemoral joints in patients using medial pivot prosthesis; (iii) evaluate the incidence of early patellofemoral joint-related complications using medial pivot prosthesis. The hypothesis of the study was that early clinical and radiological results of the medial pivot prosthesis would be comparable or better than those of conventional posterior-stabilized prosthesis, especially in aspects related to patellofemoral function.

Materials and Methods

Patient Data

After obtaining the approval of the institutional review board of our hospital and of our patients, all consecutive patients who underwent a unilateral TKA with a medial pivot

implant (Advance® Medial-Pivot, Wright) between September 2016 and April 2018 were enrolled in this retrospective study.

Inclusion criteria: (i) diagnosed knee osteoarthritis according to the latest diagnostic criteria of the American Rheumatic Society; (ii) underwent a unilateral TKA; (iii) received Advance® Medial-Pivot implant; (iv) Knee Society Clinical Rating System (KSS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and the Kujala Scoring System were compared; (v) a retrospective study.

Exclusion criteria: (i) previous patellectomy and high tibial osteotomy; (ii) a history of septic arthritis and rheumatoid arthritis; (iii) valgus deformity more than 15° or varus deformity more than 20°; (iv) flexion angle less than 90°, flexion contracture more than 20°; (v) outerbridge grade IV.

During this period, a total of 130 patients were included in the study group (group MP). A total of four patients were excluded because of loss of follow-up in group MP, leaving 126 patients for analysis. For each patient reviewed, we matched a control patient who had received primary unilateral TKA with the other prosthesis (NexGen LPS-Flex, Zimmer, Warsaw, IN) in the same period as the study group from our patient database; this group could be used as a reference standard for evaluating the function of other prostheses²² and it was also the most commonly used prosthesis in our department. Prostheses had been sporadically selected by the surgeon in both groups, but there had been no specific selection criteria to select the Advance Medial-Pivot prosthesis or the NexGen LPS-Flex prosthesis.

The matches were made according to age, gender, side, body mass index (BMI), preoperative range of motion (ROM), operating period, and grading of knee osteoarthritis on the Kellgren–Lawrence Scale. The average follow-up period of the study group was 1.64 ± 0.29 years (range, 1.1–2.5 years). There were no significant differences in the demographics or clinical characteristics between the two groups (Table 1).

Surgical Procedure

All TKAs in the study group and the control group (group PS) were implanted by the same senior surgeon (YZW) who had performed more than 500 cases annually. The surgical principles and postoperative rehabilitation protocol were similar between the two groups. Briefly, femoral nerve combined with sciatic nerve block was used for anesthesia. Under tourniquet control, knees were exposed through a mid-vastus approach. Osteotomy was performed by measurement. Distal femur osteotomy was performed according to valgus angle measured in X-ray of the whole lower extremity and external rotation angle measured in knee computed tomography (CT). The rotation of the tibial prosthesis was aligned with reference to the medial one-third of the tibial tubercle. The proximal tibial osteotomy was located 10 mm below the highest point of the articular cartilage on the lateral tibial plateau, perpendicular to the long axis of the tibial coronal plane, with a 3° posterior slope in the sagittal plane. All patellae were unresurfaced and de-nerved with electrocautery. No lateral retinacular release was performed. Patients initiated passive range of motion (ROM) exercise with

TABLE 1 Preoperative demographic and clinical results

Demographic	Group MP	Group PS	t or χ^2	P value
Number of cases	126	126		
Age (years)	66.92 ± 5.60	67.15 ± 6.01	-0.31	0.75
Gender (male/female)	24/102	22/104	0.11	0.74
Side (right/left)	54/72	57/69	0.15	0.70
BMI (kg/m ²)	27.74 ± 4.63	27.90 ± 4.39	-0.28	0.78
KSS	113.56 ± 16.99	114.05 ± 17.91	-0.22	0.82
Knee score	55.36 ± 12.48	54.41 ± 13.89	0.57	0.57
Function score	58.20 ± 10.19	59.63 ± 9.84	-1.14	0.26
WOMAC score	53.55 ± 11.34	52.26 ± 15.06	0.76	0.45
Kujala score	49.34 ± 5.13	49.80 ± 5.40	-0.69	0.49
ROM (°)	103.23 ± 11.80	102.21 ± 12.21	0.67	0.50
PCA (°)	5.29 ± 1.56	5.54 ± 1.39	-1.32	0.19
Patellar tilt 30° (°)	3.42 ± 2.88	3.21 ± 3.41	0.52	0.60
Patellar tilt 60° (°)	6.12 ± 2.53	5.84 ± 2.43	0.89	0.38
Patellar tilt 90° (°)	8.04 ± 2.31	7.98 ± 2.23	0.23	0.82
Patellar shift 30° (mm)	0.14 ± 2.92	0.36 ± 2.76	-0.61	0.54
Patellar shift 60° (mm)	1.61 ± 3.28	1.76 ± 3.02	-0.39	0.70
Patellar shift 90° (mm)	3.36 ± 3.48	3.63 ± 2.87	-0.66	0.51
Follow-up periods (years)	1.64 ± 0.29	1.65 ± 0.27	-0.20	0.84

BMI, Body mass index; KSS, Knee Society Score; PCA, posterior condyles angle; ROM, range of motion; WOMAC, Western Ontario McMaster Universities Osteoarthritis Index.; $P < 0.05$ was defined as statistically significant.

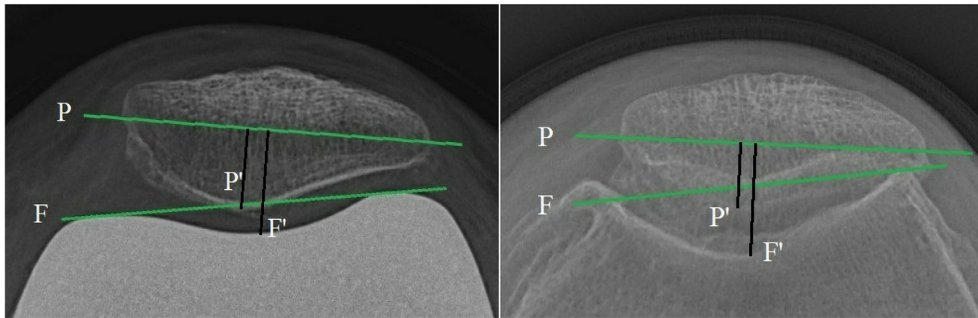


Fig. 1 Patella tilt was defined as angle between the transverse axis of the patella (P) and the anterior intercondylar line (F). Patella shift was defined as the distances between the lowest point of the trochlea (F') relative to the anterior intercondylar line and the deepest point of the patella (P') relative to the transverse axis of the patella.

continuous passive motion (CPM) machine and partial weight-bearing walking training on postoperative day 2.

Data Collection

At pre-operation and at the last follow-up, the clinical results were assessed, including the KSS score, the WOMAC score, Kujala score, and range of motion (ROM). Merchant views were also taken with the knee flexion at 30°, 60°, and 90° to measure patella shift and tilt (Fig. 1)²⁴. To reduce measurement bias, radiographic results were measured three times with a time interval of 2 weeks, then averaged to obtain the final measurements, by the same independent orthopaedic surgeon preoperatively and at the final follow-up. Reliability was confirmed by intraclass correlation coefficient values exceeding 0.75 for all measurements. Imaging were read on a PACS (General Electric, Chicago, IL, USA) monitor and measured with a mouse pointer and automatic computer calculations.

Clinical Assessment

The Knee Society Clinical Rating System (KSS)

The Knee Society Clinical Rating System (KSS) is a condition-specific validated questionnaire widely used to evaluate the functional capabilities of the knee joint before and after total knee arthroplasty. The scoring system consists of two parts. One part is the knee score. The assessment includes pain (maximum 50 points), stability (maximum 25 points), total range of flexion (maximum 25 points), and other items (varus, valgus, extension delay, and flexion contracture). The other part is the function score. The assessment includes walking distance (maximum 50 points), ability to climb stairs (maximum 50 points), and the use of walking aids. The highest score for each part is 100 points, and a higher score means better knee function. The evaluation result score is rated as four levels: 80–100 points, 70–79 points, 60–69 points, <60 points.

Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)

The WOMAC is a validated questionnaire to evaluate lower extremity osteoarthritis and joint replacement. The WOMAC questionnaire produces three subscale scores (pain, stiffness,

and physical function) and a total score. Patients are asked to answer each question about the severity of pain, stiffness, or behavioral difficulties experienced in the previous 48 hours. There are five response options ranging from “none” to “extreme” to choose. A response of “none” was scored as 0, “mild” as 1, “moderate” as 2, “severe” as 3, and “extreme” as 4. The scores of the questions in each subscale were summed together to get scores for pain, stiffness, and physical function. A lower subscale score indicates less pain, less stiffness, or better physical function. A total score of <70 is considered a severe score, 21–48 is moderate, <21 is mild.

Kujala Scoring System

The Kujala scoring system is widely used to assess subjective symptoms and functional limitations in patellofemoral disorders²⁵. It is a 100-point scoring system, consisting of 13 items with a score ranging from 5 to 10 points each item. For each question, patients chose the choice which corresponds to their latest knee symptoms to get a corresponding score. The scores for each question are added together to get the total score. The Kujala scoring system is scored on a worst-to-best scale so that a total score of 0 indicates the most severe limitation, and 100 indicates normal conditions.

Imaging Assessment

Patella Tilt

Patella tilt was formed by the angle between the transverse axis of the patella and the anterior intercondylar line. Pre- and postoperative patellar tilt angles were measured in Merchant's view, taken with the knee joint flexed at 30°, 60°, and 90°. A positive value of patella tilt indicated that the transverse axis of the patella was tilted outward relative to the anterior intercondylar line²⁴. We defined the patellar tilt more than $\pm 10^\circ$ as patellar maltracking.

Patella Shift

Patella shift was defined as the distance between the intercondylar sulcus and the median ridge of the patella. Pre- and postoperative patellar shift angles were also measured in Merchant's view, taken with the knee joint flexed at 30°, 60°, and 90°. When the median ridge of the patella was on the lateral side relative to the intercondylar sulcus, we defined

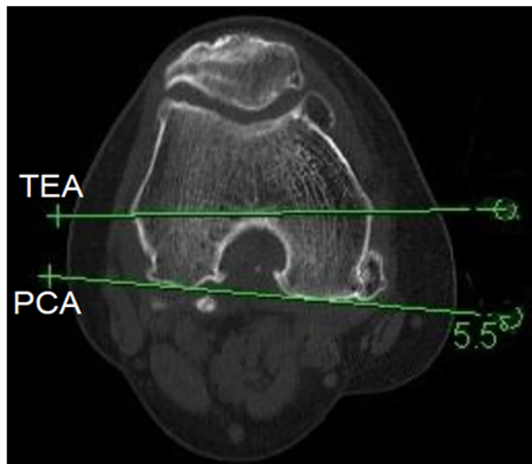


Fig. 2 Posterior condyles angle (PCA). PCA was defined as the angle between the transepicondylar axes (TEA) and posterior condyles axes (PCA).

the shift as a positive value; otherwise, it was considered a negative value²⁴. We defined the patellar shift more than ± 5 mm as patellar maltracking.

Posterior Condylar Angle (PCA)

Posterior condylar angle was defined as the angle between the transepicondylar axes and posterior condyles axes. Since the femoral prosthesis was implanted according to preoperative external rotation angle, the posterior condylar angle (PCA) of each knee in the two groups was evaluated at pre-operation (Fig. 2). The measurement of the patella tilt was based on the anterior intercondylar line, the femoral prosthesis rotation was the main factor influencing the position of the anterior intercondylar line. In addition, rotational

deviation of the femoral prosthesis was one of the factors affecting the function of and complications associated with the patellofemoral joint²⁶. If there is no significant difference in preoperative PCA between the two groups, it is proved that the measurement baseline of the patella tilt is approximately the same.

Statistical Analysis

The clinical scores, ROM, and radiographic measurements at the last follow-up were compared (Student's *t*-test). The preoperative/postoperative improvement of the above indicators between the two groups was also compared. The difference in the incidence of postoperative complications between the two groups was compared (χ^2 test). SPSS (IBM Corporation, USA) version 20.0 was used for the statistical analysis. $P < 0.05$ was defined as statistically significant.

Results

Follow-up Period

There was no significant difference in follow-up time between the two groups (MP 1.64 ± 0.29 years vs PS 1.65 ± 0.27 years, $P > 0.05$).

Clinical Results

Postoperative clinical results and changes in the results are summarized in Table 2.

KSS

No statistically significant difference was identified in the KSS total score (MP 175.43 ± 8.89 vs PS 174.25 ± 6.75 , $P > 0.05$), including knee score (MP 86.89 ± 4.45 vs PS 86.31 ± 4.04 , $P > 0.05$) and function score (MP 88.54 ± 6.21 vs PS 87.93 ± 5.53 , $P > 0.05$) between the two groups after the operation. No statistically significant difference was identified in

TABLE 2 Postoperative clinical outcomes and the changes

Indexes		Group MP	Group PS	<i>t</i> or χ^2	<i>P</i> value
Postoperative	KSS	175.43 ± 8.89	174.25 ± 6.75	-1.18	0.24
	Knee score	86.89 ± 4.45	86.31 ± 4.04	1.07	0.29
	Function score	88.54 ± 6.21	87.93 ± 5.53	0.82	0.42
	WOMAC score	14.65 ± 7.32	13.65 ± 10.04	0.91	0.36
	Kujala score	77.16 ± 3.80	75.97 ± 4.06	2.40	0.017
	ROM (°)	122.24 ± 4.45	123.78 ± 6.05	-2.30	0.022
Changes	KSS	61.87 ± 15.79	60.20 ± 17.80	0.79	0.43
	Knee score	31.90 ± 11.20	31.85 ± 14.07	-0.23	0.82
	Function score	30.34 ± 11.95	28.30 ± 10.18	1.46	0.15
	WOMAC score	38.89 ± 12.96	38.61 ± 17.63	0.14	0.89
	Kujala score	27.82 ± 5.31	26.17 ± 4.89	2.57	0.011
	ROM (°)	19.00 ± 9.90	21.57 ± 9.62	-2.08	0.038
Complication (cases)	Anterior knee pain	3	6	1.04	0.31
	PCC	2	9	4.66	0.03
	Subluxation	0	0	-	-

KSS, Knee Society Score; PCC, patellar clunk or crepitus; ROM, range of motion; WOMAC, Western Ontario McMaster Universities Osteoarthritis Index.; $P < 0.05$ was defined as statistically significant.

TABLE 3 Postoperative radiographic results and tilt changes (mean \pm SD)

Radiographic results		Group MP	Group PS	t value	P-value
Postoperative	Patellar tilt 30° (°)	1.22 \pm 1.90	1.10 \pm 2.07	0.47	0.64
	Patellar tilt 60° (°)	2.66 \pm 1.68	2.70 \pm 1.89	-0.20	0.84
	Patellar tilt 90° (°)	4.21 \pm 1.62	4.74 \pm 1.95	-2.38	0.018
	Patellar shift 30° (mm)	-0.83 \pm 1.38	-0.48 \pm 1.69	-1.82	0.70
	Patellar shift 60° (mm)	0.63 \pm 1.63	1.02 \pm 1.85	-1.79	0.08
	Patellar shift 90° (mm)	2.12 \pm 1.81	2.31 \pm 1.94	0.82	0.41
Changes	Patellar tilt 30° (°)	-2.19 \pm 1.73	-2.10 \pm 1.92	-0.39	0.70
	Patellar tilt 60° (°)	-3.45 \pm 1.60	-3.13 \pm 1.59	-1.61	0.11
	Patellar tilt 90° (°)	-3.84 \pm 1.43	-3.23 \pm 1.33	-3.47	0.001

$P < 0.05$ was defined as statistically significant.

the preoperative/postoperative improvements of the above clinical scores (MP 61.87 \pm 15.79 vs PS 60.20 \pm 17.80 in KSS total score, 31.90 \pm 11.20 vs 31.85 \pm 14.07 in knee score, 30.34 \pm 11.95 vs 28.30 \pm 10.18 in function score, $P > 0.05$).

WOMAC

There was no significant difference in the postoperative WOMAC score between the two groups (MP 14.65 \pm 7.32 vs PS 13.65 \pm 10.04, $P > 0.05$). There was no significant difference in the improved amount of WOMAC score between the two groups (MP 38.89 \pm 12.96 vs PS 38.61 \pm 17.63, $P > 0.05$).

Kujala Scoring System

There were statistically significant differences in the postoperative Kujala scores between the two groups. The mean Kujala score in group MP was better than in group PS (MP 77.16 \pm 3.80 vs PS 75.97 \pm 4.06, $P < 0.05$). The preoperative/postoperative Kujala score improvement in group MP was observed to be significantly greater than in group PS (MP 27.82 \pm 5.31 vs PS 26.17 \pm 4.89, $P < 0.05$).

Range of Motion (ROM)

There were statistically significant differences in the postoperative ROMs between the two groups. The ROM in group MP was significantly less than in group PS (MP 122.24° \pm 4.45° vs PS 123.78° \pm 6.05°, $P < 0.05$). The average preoperative/postoperative ROM improvement in group MP was significantly smaller than in group PS (MP 19.00° \pm 9.90° vs PS 21.57° \pm 9.62°, $P < 0.05$).

Radiographic Results

The imaging measurement data are summarized in Table 3.

Patella Tilt

No significant between-group difference was observed in the Merchant view at 30° or 60° of patella tilt; however, at the 90° position, the mean patella tilt of group MP was

statistically smaller than that of group PS (MP 4.21° \pm 1.62° vs PS 4.74° \pm 1.95°, $P < 0.05$), and the average patella tilt change in group MP was significantly greater than in group PS (MP -3.84° \pm 1.43° vs PS -3.23° \pm 1.33°, $P < 0.05$).

Patella Shift

There were no statistically significant differences in the patella shift between the two groups at 30°, 60°, and 90° (MP -0.83 \pm 1.38 mm vs PS -0.48 \pm 1.69 mm at 30°, 0.63 \pm 1.63 mm vs 1.02 \pm 1.85 mm at 60°, 2.21 \pm 1.81 mm vs 2.31 \pm 1.94 mm at 90°, $P > 0.05$).

Posterior Condylar Angle (PCA)

Preoperative PCA did not show significant differences between the two groups (MP 5.29° \pm 1.56° vs PS 5.54° \pm 1.39°, $P > 0.05$).

Complications

At the last follow-up, three cases of anterior knee pain and two cases of PCC in group MP and six cases and nine cases, respectively, in group PS were observed. Compared with group PS, the incidence of PCC was significantly lower in group MP (1.6% vs 7.1%, $P < 0.05$). There were no incidences of patellar maltracking.

Discussion

This study illustrates that the medial pivot prosthesis could achieve satisfactory early clinical outcomes with better patellofemoral performance compared to the conventional posterior-stabilized prosthesis. In the early development of total knee prostheses, the tibiofemoral joint design was considered most important, with little attention paid to the design of the patellofemoral joint. Patella-related complications had been as high as 50% of complications following TKA². With the continuous improvement in and development of prosthetic design and surgical techniques, there are significantly fewer patellofemoral joint complications than before; however, patellofemoral joint problems are still a common complication²⁷ after TKA. Compared with the

natural knee joint, the kinematics of the patellofemoral joint are changing and the pressure of the patellofemoral joint are increased after TKA^{5, 6, 28}. It has been reported that using a knee prosthesis that could reconstruct the natural patellofemoral joint movement and achieve low patellofemoral pressure would be beneficial in improving patellofemoral function⁷. Despite claims of a theoretical advantage in the “patella-friendly” design characteristics of the medial pivot prosthesis, rare previous prospective clinical study focused on comparing the patellofemoral joint of this prosthesis with other total knee prostheses.

Analysis of Results

In this study, the Kujala score, which is widely used to assess functional limitations and subjective symptoms in patellofemoral disorders and TKAs, was 77.16 ± 3.80 in group MP, which was significantly better than the 75.97 ± 4.06 in group PS. We also evaluated differences in the postoperative improvement of the Kujala scores from the preoperative baseline, with group A predominating. In the 90° Merchant view, the patella tilt in group A was smaller than in group PS. It has been reported that the incidence of patellar clunk increases by 1.27 for each degree raise in patellar tilt²⁹. We believed that group A was also superior to group B in terms of imaging performance. The advantage was attributed to the use of a prosthesis with “patella-friendly” properties and the characteristics of the reconstructed natural patellofemoral joint.

PCC is presumably attributed to fibrous nodule impingement after TKA³⁰, especially the overgrowth of fibrous tissue where the extensor mechanism is attached to the upper pole of the patella^{31, 32}. Several surgeons recommended surgical intervention, such as arthroscopic excision of the nodule^{33–35} as a treatment option for disabled patients with persistent, painful PCC after nonoperative management. In this study, two cases of patellar clunk syndrome were noted in group A, and the incidence was significantly lower compared to the nine cases in group B and previous studies (Table 4)^{33, 36–39}. We had two cases in group B with painful PCC, which did not reach the point where surgery was needed and were treated with

nonoperative management including anti-inflammatory medication and physical therapy for pain relief. It has been reported that some femoral prosthesis designs for total knee prosthesis systems are associated with a high incidence of PCC, the most notable of which was the posterior stabilized knee prosthesis^{31, 40, 41}. The fibrous tissue impinges on the intercondylar box of the femoral component when the knee flexes more than 90°⁴². Fukunaga *et al.*³³ indicated that when the length ratio of the intercondylar box/anteroposterior femoral components of the femoral prosthesis are less than 0.7, the incidence of PCC is significantly reduced. The posterior extension of the MP femoral prosthetic trochlear groove reduces the ratio of the intercondylar box, making the patella trajectory more natural¹².

Mihalko *et al.*⁴³ reported that knee mobility is associated with “overfilling” of the patellofemoral joints; each 4 mm thick increase in the front of the femoral prosthesis will result in a reduction in knee flexion by 4°. Advance MP femoral prosthetic groove is deepened to the natural anatomical level, which could minimize the “overfilling” of the patellofemoral joint and improve knee joint mobility. Hosain *et al.*⁴⁴ conducted a randomized controlled trial with a greater improvement in MP prosthesis mobility 1 and 2 years after surgery compared with PS prostheses. In the present study, group PS performed superior to group MP in terms of postoperative activity improvement, while the improvement in the Kujala score in group MP was better than in group PS; however, similar KSS and WOMAC scores were recorded in the two groups. There are two hypotheses for this similarity between the groups: one, knee mobility may be taken into account in the KSS and WOMAC scores, compensating for the deficiency in the Kujala score in group PS; two, the KSS and WOMAC clinical scoring systems may have been subjected to a ceiling effect⁴⁵, resulting in the scoring systems not being sensitive enough to determine between-group differences.

Optimize the Selection of Prosthesis

Patellofemoral complications after TKA can reduce patient satisfaction and even lead to revision surgery. Increasing evidence has shown that proper surgical techniques^{46–48} and

TABLE 4 The incidence of PCC reported in previous studies

Studies	Year	Number of knees	Prostheses	Incidence (%)
Fukunaga <i>et al.</i> ²³	2009	113	Press-Fit Condylar® Sigma®	13.3
Frye <i>et al.</i> ²⁴	2012	108	Press-Fit Condylar® Sigma®	12.0
Choi <i>et al.</i> ²⁵	2013	113	Press-Fit Condylar® Sigma®	9.7
Gholson <i>et al.</i> ²⁶	2017	1488	Press-Fit Condylar® Sigma®	3.1
Bae <i>et al.</i> ²⁷	2017	100	Press-Fit Condylar® Sigma®	18.0
		100	Vanguard®	4.0
Current study	2019	126	NexGen LPS-Flex	7.1
		126	Advance® Medial - Pivot	1.6

PCC, patellar clunk or crepitus.

optimizing prosthesis design^{49, 50} could reduce the incidence of patellofemoral complications. In addition to optimized surgical skills, it is equally important to choose a prosthesis that is beneficial to the patellofemoral joint, especially for patients with a preoperative risk of patellofemoral complications, such as dysplastic trochlea, subluxation of the patella, or malrotation of the distal femur²⁹. The prosthesis with “patella-friendly” design features used in this study would be an optimal option, which could achieve excellent patellofemoral performance while resulting in a clinical evaluation similar to that with conventional PS prosthesis.

Limitations

This study has limitations in the loss of follow-up and the rather short time of follow-up. Long-term follow-up is needed to obtain patellofemoral clinical scores, especially for the incidence of patellofemoral complications. Another limitation was the evaluation of patella tracking by X-ray; the

evaluation of patellofemoral tracking includes static and dynamic factors, and CT or magnetic resonance imaging (MRI) might be a more sensitive and accurate method for assessing the position of the patella⁵¹. However, compared to the previous clinical study, we evaluated the patella tilt and shift more comprehensively from three different angles¹⁴. Furthermore, we excluded PCA factors that may have had an impact on patella tilt.

Conclusions

In summary, unilateral TKA with a medial pivot prosthesis can yield satisfactory outcomes with superior patellofemoral performance attributed to the prosthesis’ “patella-friendly” design characteristics compared with a conventional posterior-stabilized prosthesis. The theoretical advantages of medial pivot prosthesis, combining multiple characteristics to optimize patellofemoral function, were clinically proven.

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