CLINICAL ARTICLE

Comparison of Patient Satisfaction Between Medial Pivot Prostheses and Posterior-Stabilized Prostheses in Total Knee Arthroplasty

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Objective: To compare medial pivot (MP) prostheses to two types of posterior-stabilized (PS) prostheses (NexGen and NRG) in terms of patient satisfaction, causes of dissatisfaction, and risk factors for dissatisfaction after total knee arthroplasty (TKA).

Methods: A total of 453 patients who underwent primary TKA by one senior surgeon from August 2016 to August 2018 were investigated in a retrospective study, including 121, 219, and 113 patients in the MP, NexGen, and NRG groups, respectively. The mean age and follow-up time of patients were 70.82 ± 7.06 years and 20.64 ± 3.88 months. A survey was designed and responses were collected by telephone, WeChat, and outpatient follow up. Patient satisfaction, causes of dissatisfaction, post-TKA pain on a numeric rating scale (NRS), and range of motion (ROM) were compared among groups, and risk factors were investigated. Patient satisfaction included a five-level satisfaction rating (very satisfied, satisfied, neutral, dissatisfied, or very dissatisfied), with five options for causes of dissatisfaction (persistent pain, limited ROM, knee instability, asthenia, and/or other factors).

Results: Overall, 89.84% of patients were satisfied with the results of primary TKA. There were no significant differences among the three groups regarding the side of the operation, the length of hospitalization in days, or the average follow-up time. Patient satisfaction was similar among the MP (87.38%), NexGen (89.89%), and NRG groups (90.32%). Persistent pain after TKA was the major cause of dissatisfaction (32/40), but no difference in the frequency of this complaint was found among the groups ($P = 0.663$). The NRS score ($P = 0.598$) and the ROM ($P = 0.959$) of the MP group were not significantly different from those of the NexGen and NRG groups. Gender, length of hospitalization, and follow-up time were all uncorrelated with patient satisfaction, but age showed a very weak correlation with patient satisfaction ($r = 0.110$, $P = 0.033$). Moreover, the NRS score ($r = 0.459$, $P < 0.000$) and the ROM ($r = -0.175$, $P = 0.001$) were significantly correlated with patient dissatisfaction. The odds ratio of dissatisfaction was 6.37 ($P < 0.000$) in patients with moderate to severe pain (NRS ≥ 3) compared to patients with mild pain (NRS < 3).

Conclusion: Patient satisfaction and function were not found to be higher in the MP group than in the two PS groups, and persistent pain was the major cause of and an important risk factor for patient dissatisfaction.

Key words: Arthroplasty; Knee; Patient satisfaction; Prostheses and implants; Replacement

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Introduction

Total knee arthroplasty (TKA) is the main method used to treat late-stage knee osteoarthritis and rheumatoid arthritis. Due to its predictable effect of relieving pain and correcting deformity, the frequency of TKA is increasing, as confirmed by many joint registries worldwide[1]. However, as an important patient reported outcome measure, the patient satisfaction of this procedure is relatively low compared with total hip arthroplasty, ranging from 75% to 92%[2,3]. Therefore, several studies have been devoted to determining the causes of dissatisfaction of TKA and trying to improve patient satisfaction through various methods[4–7].

There are numerous factors that can influence patient satisfaction. These factors can be classified as patient-dependent factors and patient-independent factors[3]. The former includes factors such as age, gender, diagnosis, expectations, and preoperative knee function, while the latter refers to surgical technique, rehabilitation training, and design of prostheses[3,8]. Among these factors, the design of the prosthesis (e.g. single-radius or multi-radius, posterior cruciate ligament [PCL] substitution or retention, conventional or high-flexion, and geometry of the trochlear groove)[9–11] is considered to be an important factor in patient satisfaction.

Although all of the prostheses are designed to mimic the kinematics of the normal knee, the kinematics are somewhat different from the normal knee in practice. In the normal knee, the femoral condyle has a rollback mechanism to increase the angle of flexion during kneeling or squatting[12]. To mimic this mechanism, there are currently two major design concepts for prostheses: cruciate-retaining (CR) and posterior-stabilized (PS) designs[13]. The PS prosthesis substitutes the function of the PCL with either the so-called cam-and-post mechanism or a scoop-shaped tibial polyethylene insert. The motion and rollback of the femoral component are mended during flexion. In contrast, the CR type relies on the PCL to provide stability and to guide femoral rollback. However, it has been reported that 40% of CR prostheses and 60% of PS prostheses may present the phenomenon known as "paradoxical anterior movement" during normal walking, meaning anterior femoral translation during flexion[14]. This paradoxical anterior movement causes the femoral component to impact the patella and can produce pain around the knee, which may affect patient satisfaction after TKA. Therefore, prosthesis design overcoming the issue of paradoxical anterior movement may be helpful for improving patient satisfaction.

The medial pivot (MP) design was invented to avoid this movement using its special asymmetric polyethylene insert, which has a highly congruent medial compartment and a less conforming lateral compartment. This design allows rolling of the medial femoral condyle, but there is no limitation to the lateral condyle[15]. Fluoroscopic analysis has confirmed the MP functionality of the prosthesis[16]. Furthermore, it has been reported that the MP system can mimic the kinematics of the natural knee in rotation, squatting, kicking, and walking up and down the stairs[17]. Theoretically, this design avoids paradoxical anterior movement and may bring about superior patient satisfaction. However, different reports have achieved conflicting results. For example, Prittchett *et al.* found that 77% and 79% of patients were more satisfied with MP prostheses than PS and CR prostheses, while Bae *et al.* found that the improvements of both prostheses were similar when comparing MP prostheses with PS prostheses[18–20]. Therefore, it remains controversial whether this design can achieve superior patient satisfaction in practice. In addition, the causes and risk factors for dissatisfaction still need to be further investigated. The understanding of this question could help surgeons to better identify the patients who are likely dissatisfied and provided the corresponding treatment promptly. Therefore, the aims of the present study were: (i) to investigate patient satisfaction after TKA using MP prostheses compared with two PS prostheses to provide further clinical evidence on the MP type; (ii) to explore the causes of dissatisfaction; and (iii) to identify possible risk factors for dissatisfaction.

Materials and Methods

Ethics Statement

The protocol was approved by the ethics committee of the university. Informed consent was obtained from all patients.

Inclusion and Exclusion Criteria

The inclusion criteria were: (i) patients who received primary TKA from one senior surgeon (Z.Y.) in our department from August 2016 to August 2018; (ii) the prostheses used were the Advance (Microport, Arlington, TN, USA), the NexGen (Zimmer, Warsaw, IN, USA) or the Scorpio NRG (Stryker, Mahwah, NJ, USA) systems (the Advance prosthesis is an MP design, while the NexGen and NRG prostheses are PS designs); (iii) the major evaluation indicators included level of satisfaction, causes of dissatisfaction, level of pain, and range of motion (ROM); and (iv) this study is a retrospective study.

The exclusion criteria were: (i) revised cases; (ii) patients who had a history of spinal or spinal cord disease affecting the pain judgment of the knee; (iii) patients who had serious medical diseases that affected the recovery of joint function; and (iv) patients with previous TKA in the other knee.

Surgical Procedures

All the operations were performed with patients in a supine position under spinal or general anesthesia as follows. A tourniquet was kept in place constantly to obtain a bloodless field. Initially, a longitudinal midline skin incision was made at the knee joint. Then, the meniscus and synovium were completely resected, and part of the fat pad under the tibia was removed. After the ligaments and the posterior joint capsules were released to achieve a primary balance, osteotomy procedures were performed according to the manual. The prosthesis was fixed in place after the flexion and

extension gaps were balanced. Autologous blood transfusion was used, and rehabilitation was performed according to a standard protocol.

Data Collection

A survey was designed and responses were collected by telephone, WeChat software (Tencent Tech, Shenzhen, China) and outpatient follow up. This survey collected two categories of information: basic and satisfaction information. Basic information included demographic characteristics, diagnosis, days of hospitalization, and prosthesis information. Satisfaction information included the following types of information.

Five-Level Satisfaction Rating

The satisfaction rating defined the level of satisfaction of patients. It included a five-level satisfaction rating (very satisfied, satisfied, neutral, dissatisfied, or very dissatisfied). Generally, "very satisfied" and "satisfied" patients were defined as the satisfied group, while "neutral," "dissatisfied," and "very dissatisfied" patients were defined as the dissatisfied group.

Causes of Dissatisfaction

Causes of dissatisfaction described the causes why patients were dissatisfied with the operation when they were classified into the dissatisfied group. Five options for causes of dissatisfaction (persistent pain, limited ROM, knee instability, asthenia, and/or other factors) were listed in the survey.

Numeric Rating Scale Pain Score

The numeric rating scale (NRS) is a method commonly used to evaluate the level of pain. Patients rated their pain on a scale that had 11 points, from 0 to 10. Zero means "no pain," while 10 means "the worst possible pain."[21]. The mild pain group was classified as NRS < 3, while moderate–severe pain was classified as NRS ≥ 3.

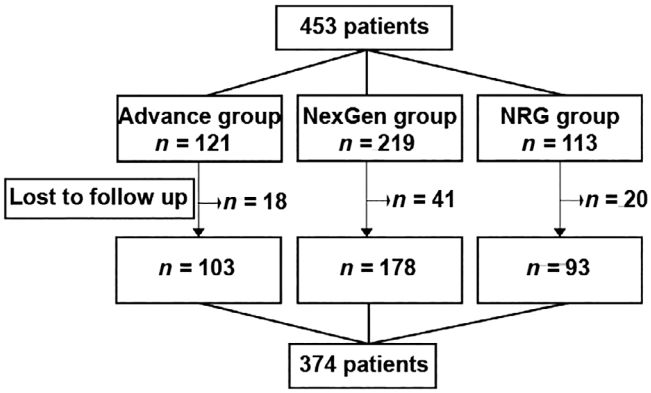

Fig. 1 Flow chart for the selection of patients in different groups.

Knee Range of Motion

Knee ROM recorded the angle of motion from extension to flexion after TKA. The pictures of maximum extension and flexion of patients were collected by email or WeChat or outpatient follow up and were analyzed using an app named Bangni (Bangni Online Tech, Beijing, China).

Statistical Analysis

Data analysis and statistics were processed using SPSS 20.0 (IBM, Armonk, NY, USA). Patient characteristics were reported as the mean and standard deviation. Pain scores and knee ROM were described as the mean and 95% confidence interval. The χ^2-test was used for satisfaction analysis. A non-parametric rank sum test was used to compare pain and ROM between groups. Correlation was analyzed using Spearman's rho. $P < 0.05$ was defined as a significant difference.

Results

Patient Demography

Initially, 453 patients were enrolled in this study. However, 79 patients were lost to follow up during the investigation. Therefore, a total of 374 patients were included and analyzed in the retrospective study (Fig. 1). The demography and patient characteristics of each group are illustrated in Table 1. Most of the women used NexGen prostheses (173/255), and most of the men used Advance (70/119) or NRG (44/119) devices. The average age in the MP group was similar to that in the NexGen group and approximately 3.8 years younger than that in the NRG group. There was no significant difference among the three groups regarding the side of the operation, the length of hospitalization in days, or the average follow-up time. Most patients had been diagnosed with knee osteoarthritis. Typical images of one MP and two PS prostheses are shown in Fig. 2.

Patient Satisfaction and Causes of Dissatisfaction in Different Groups

To investigate patient satisfaction in each group, we collected a survey from patients. The overall rate of patient satisfaction was 89.84%. The numbers of satisfied and dissatisfied patients in each group are presented in Fig. 3. Although the MP group had lower patient satisfaction (87.38%) than the NexGen group (89.89%) and the NRG group (90.32%), there was no significant difference among groups ($P = 0.754$). In addition, gender, length of hospitalization, and follow-up time were all uncorrelated with patient satisfaction, but age showed a very weak correlation with patient satisfaction ($r = 0.110$, $P = 0.033$). In brief, the MP group did not exhibit superior patient satisfaction compared with the two PS groups.

To explore the causes of dissatisfaction, we administered a survey asking patients why, if at all, they were dissatisfied; the response options were persistent pain, limited ROM, instability of the knee, asthenia of the knee, and other causes. The dissatisfied patients in each group are

TABLE 1 Demography and other characteristics of patients in the three groups

	MP group	PS group		Total
		NexGen	NRG	
Male/female	70/33	5/173	44/49	119/255
Age (years)	70.38 ± 6.37	69.32 ± 7.42	74.18 ± 5.89	70.82 ± 7.06
Left/right	91/87	53/50	46/47	190/184
Days of hospitalization	10.98 ± 4.06	11.37 ± 4.13	11.82 ± 4.26	11.37 ± 4.14
Months of follow up	19.22 ± 3.17	21.52 ± 3.74	20.53 ± 4.38	20.64 ± 3.88
Diagnosis				
OA	102	174	92	368
RA	1	3	1	5
Others	0	1	0	1
Total	103	178	93	374

MP, medial pivot; NexGen, NexGen prosthesis from Zimmer; NRG, Scorpio NRG prosthesis from Stryker; OA, osteoarthritis; PS, posterior-stabilized; RA, rheumatoid arthritis.

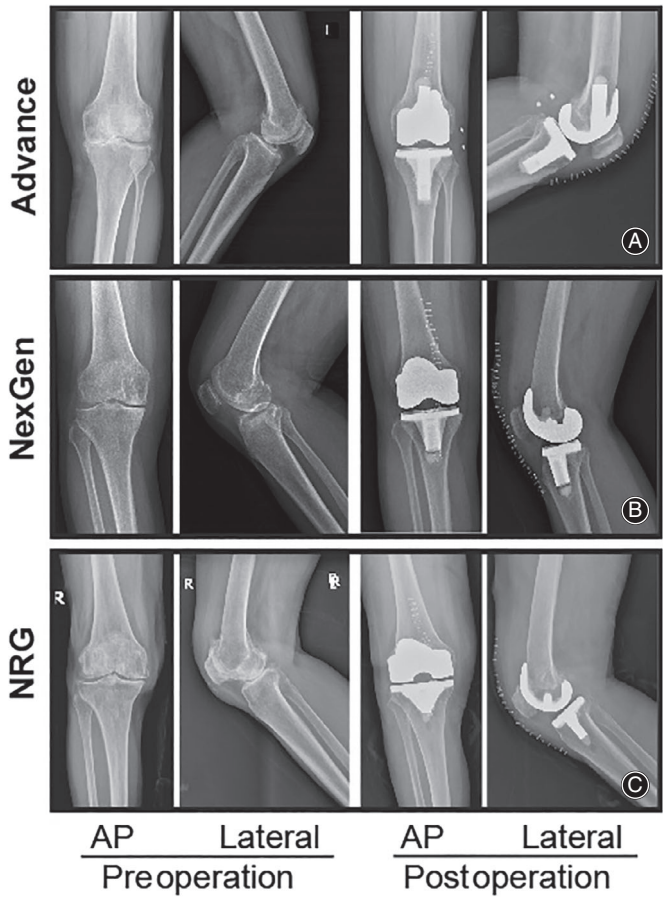

Fig. 2 X-ray images before and after total knee arthroplasty (TKA) using a medial pivot (MP) prosthesis and two PS prostheses. (A) MP prosthesis (Advance, Microport, Arlington, TN, USA); (B) posterior-stabilized (PS) prosthesis (NexGen, Zimmer, Warsaw, IN, USA); (C) PS prosthesis (Scorpio NRG, Stryker, Mahwah, NJ, USA). AP, anteroposterior.

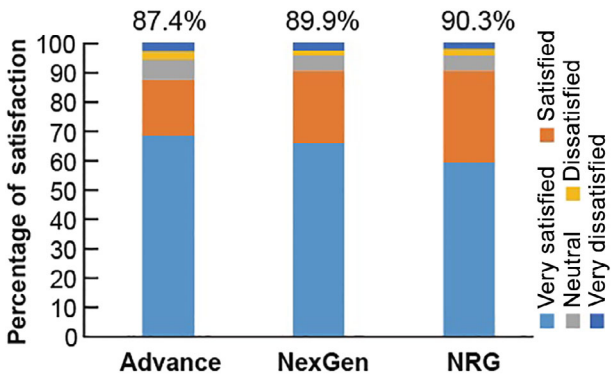

Fig. 3 Percentage of satisfaction after total knee arthroplasty (TKA) using three prostheses. The number of patients is shown in each bar. The percentage of satisfaction is shown above each bar.

summarized in Table 2 along with the reasons for their dissatisfaction. In total, 80.0% (32/40) of dissatisfied patients felt pain related to the knee, and 55.0% (22/40) of dissatisfied patients reported pain alone as the cause. Moreover, pain was the major cause of patient dissatisfaction in every group. Four dissatisfied patients complained of a limited ROM, instability of the knee or asthenia alone. Ten patients were dissatisfied with the results for multiple reasons. However, the MP group did not significantly differ from the two PS groups in the distribution of causes for dissatisfaction ($P = 0.663$). Regarding complications, one patient in the MP group developed a superficial infection, and one patient in the NRG group developed a deep infection. The former patient was cured after using antibiotics, while the latter patient was diagnosed with periprosthetic joint infection 8 months later and received revised TKA. One of the dissatisfied patients in the MP group suffered a stroke after the operation. No other complications were found in any of the three groups. In short, pain was the major cause of patient dissatisfaction but did not differ in frequency among groups.

TABLE 2 Causes of patient dissatisfaction in the three groups

		MP group	PS group		
		Advance	NexGen	NRG	Total
1	Pain	8	8	6	22
2	Limited ROM	1	0	0	1
3	Unstable	1	0	1	2
4	Asthenia	0	1	0	1
5	Pain + Limited ROM	1	2	0	3
6	Pain + Unstable	0	1	1	2
7	Pain + Asthenia	1	3	0	4
8	Pain + Limited ROM + Asthenia	0	1	0	1
9	Other Reasons	1[†]	2[‡]	1[§]	4
	Total	13	18	9	40

[†] This patient was dissatisfied because of a stroke after the operation.; [‡] One patient was dissatisfied because the outcome of TKA did not meet her expectations, and the other patient was dissatisfied because the knee made a noise when moving.; [§] This patient developed periprosthetic joint infection preceded by persistent knee pain.; MP, medial pivot; NexGen, NexGen prosthesis from Zimmer; NRG, Scorpio NRG prosthesis from Stryker; OA, osteoarthritis; PS, posterior-stabilized; RA, rheumatoid arthritis; ROM, range of motion.

TABLE 3 Number of painful knees, pain score, and ROM in each of the three groups

	Number of painful knees	NRS (mean, 95% CI)	ROM (degrees)	*n*
Advance	35	0.67 (0.45–0.89)	98.6 (96.0–101.2)	103
NexGen	49	0.54 (0.40–0.69)	98.3 (96.4–100.1)	178
NRG	28	0.60 (0.40–0.81)	97.9 (94.6–101.2)	93
Total	112	0.59 (0.49–0.70)	98.3 (96.9–99.7)	374

CI, confidence interval; NexGen, NexGen prosthesis from Zimmer; NRG, Scorpio NRG prosthesis from Stryker; NRS, numeric rating scale; ROM, range of motion.

The MP Group Had Similar Postoperative Pain and ROM to the PS Groups

To further compare the clinical results between the MP group and PS groups, NRS pain scores and ROM were analyzed (Table 3). In total, 29.9% (112/374) of patients still had varying degrees of knee pain. However, no significant difference was found among groups in terms of pain scores ($P = 0.598$). In addition, compared with the two PS groups, the MP group did not exhibit superior ROM ($P = 0.959$). Therefore, MP prostheses had similar pain and ROM results to PS prostheses.

Persistent Pain was a Critical Risk Factor for Patient Dissatisfaction

To further investigate risk factors of patient dissatisfaction, we compared pain scores between satisfied and dissatisfied patients (Supplement Table 1). NRS scores were significantly higher in dissatisfied patients than in satisfied patients ($P < 0.000$) and were significantly correlated with satisfaction ($r = 0.459$, $P < 0.000$). Furthermore, compared with the mild pain group (NRS < 3), the odds ratio (OR) of dissatisfaction reached 6.37 ($P < 0.000$) in the moderate–severe pain group (NRS≥3). However, ROM was significantly better in the satisfied group than in the dissatisfied patients ($P = 0.002$) and was significantly negatively correlated with patient dissatisfaction ($r = -0.175$, $P = 0.001$). In summary, pain scores were a critical risk factor correlated with patient satisfaction.

Discussion

Patient satisfaction after TKA is one of the most important issues facing doctors and patients[3]. Different prosthesis designs lead to varied knee kinematics and result in discrepant satisfaction rates[3,8,10]. Despite efforts to mimic the motion of the natural knee, paradoxical anterior movement is still a common phenomenon after TKA and leads to various discomforts, such as pain caused by patellofemoral impact during flexion, which reduces patient satisfaction and joint function scores[14]. CR and PS prostheses may exhibit this phenomenon during normal walking, deep squatting, and other activities[17]. The MP prothesis, designed with the goal of overcoming this disadvantage, was first introduced by Wright Medical Technology in 1998. The prosthesis uses a ball-in-socket design with a raised anteroposterior lip (Fig. 4A,B) and does not roll back, in contrast to the post-and-cam mechanism of PS arthroplasties; therefore, this design theoretically prevents paradoxical anterior

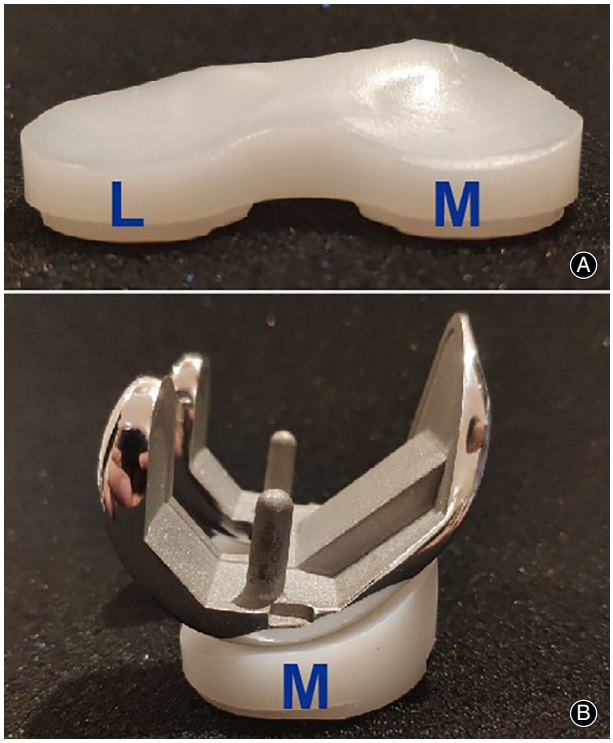

Fig. 4 The Advance prosthesis. (A) The polyethylene insert used in the Advance prosthesis system. L, lateral side; M, medial side. (B). The femoral component and the polyethylene insert in the Advance prosthesis from a medial view. M, medial side.

movement[22–24]. Furthermore, the MP system has been reported to mimic the kinematics of the natural knee in several studies[16,17]. With these characteristics, MP prostheses achieved good clinical outcomes. Macheras *et al.* found that the function of the knee greatly improved after TKA using MP in 325 patients, as assessed by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Short Form (SF)-12, and Oxford Knee scores[25]. Karachalios *et al.* found that the 15-year cumulative survival rate of MP reached 97.7% and that the average ROM was 117° (85°–130°)[22]. Prittchett *et al.* compared the MP prosthesis with PS and CR prostheses and found that 77% and 79% of patients, respectively, were more satisfied with MP prostheses because they felt that those prostheses were more natural and powerful during walking and going up or down stairs, more stable, and less noisy[18,19]. Therefore, MP prostheses could achieve good clinical results by greatly reducing pain and improving the function of the knee. Owing to the good performance of this type of design, different MP systems were invented by different companies, including the SAIPH (TM) prosthesis (MatOrtho Corporation, UK), the FINE prosthesis (Nakashima, Japan) and the Persona prosthesis with internal shaft gaskets (DEPUY, USA).

Due to the advantages of the MP prosthesis, its design was expected to achieve superior patient satisfaction. However, in this study, the MP group did not show an improvement in patient satisfaction, ROM, or pain score compared to the other two PS designs. This result was consistent with some previous studies. After comparing MP prostheses with PS prostheses, Bae *et al.* found that the improvements of both prostheses were similar, while MP prostheses did not show the expected advantage in relieving patellar symptoms[20]. Choi *et al.* found that self-reported scores were similar between MP prostheses and PFC mobile-bearing prostheses, but patients preferred PFC prostheses when they were involved in more demanding activities[26]. Kim *et al.* reported that the survival rates of the MP and PFC CR groups were almost identical, but the PFC CR group had better knee function than the MP groups and had fewer complications (5% *vs.* 26%)[24]. Another study analyzed the patellar track after TKA using MP prosthesis and found that the MP prosthesis could not mimic the natural track of the patella[27,28]. Therefore, from the above-described research and our results, it is still controversial whether MP prostheses achieve better patient satisfaction and knee function than other prosthesis designs.

Persistent pain after TKA is still the major problem affecting the improvement of satisfaction in our study. This outcome is consistent with other research[7,29]. However, no significant difference was found between the MP group and the PS groups. This is mainly due to the complicated causes of pain. Although causes of pain after TKA have been reported in numerous studies, the exact mechanisms still need to be further investigated. Generally, the mechanisms include host factors, surgical techniques, infection and prosthesis features. Among these mechanisms, prosthesis design leads to different degrees and types of pain in several ways. For example, some prosthesis designs were demonstrated to have high pressure at the patellofemoral joint, leading to patellar pain[30,31]. In addition, different materials and bearing types may lead to various degrees of polyethylene wear and aseptic loosening[32]. In this study, we found that pain existed in 29.9% of patients after TKA; these data were consistent with other research[3]. Furthermore, we found a significant correlation between pain or ROM and patient satisfaction. Similar to our results, several other studies have reported that pain and ROM play critical roles in patient satisfaction[7,29]. Moreover, we found that pain was an important risk factor related to patient satisfaction. Therefore, exploring the mechanisms of pain and reduction of pain would inform efforts to increase patient satisfaction.

This study has several limitations. First, the demography of patients may affect their satisfaction ratings. On the one hand, NexGen prosthesis was used in most of the females, while most of the males used Advance or NRG prostheses. The significant intergroup difference in gender ratio may affect the results. On the other hand, age could also be an important factor affecting the outcome. Second, the follow-up period was relatively short. In the future, randomized, multi-centre studies with large sample sizes are needed to clarify this issue.

Conclusion

In summary, this study showed that MP prostheses achieved satisfactory short-term clinical outcomes, but not superior to PS protheses. Persistent pain served as an important risk factor for dissatisfaction after TKA.

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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