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Causes and Clinical Outcomes of Patellar Post Impingement

Takenori Tomite, MD, PhD [a, *], Hidetomo Saito, MD, PhD [b], Hiroaki Kijima, MD, PhD [b], Noriyuki Ishikawa, MD, PhD [a], Yuji Hatakeyama, MD, PhD [a], Hiroshi Tazawa, MD, PhD [a], Naohisa Miyakoshi, MD, PhD [b]

[a] Department of Orthopedic Surgery, Akita Red Cross Hospital, Akita, Japan
[b] Department of Orthopedic Surgery, Akita University Graduate School of Medicine, Akita, Japan

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ABSTRACT

Background: Patellar post impingement (PPI), which occurs when the post impinges on the patella, may reportedly cause poor total knee arthroplasty (TKA) outcomes. The causes of PPI and its effect on clinical outcomes and symptoms were investigated.
Material and methods: The study subjects were 100 patients who underwent TKA (65 posterior stabilized TKA, 35 bi-cruciate stabilized [BCS] TKA). Whether PPI occurred during surgery was investigated; the patients were then classified into a PPI+ group and a PPI− group, and whether the implant or patellar shape was related to the occurrence of PPI was examined. The measurement parameters included patellar shape, joint range of motion (ROM), and clinical outcome using the new Knee Society Score.
Results: There were 38 knees in the PPI+ group and 62 knees in the PPI− group. There was no difference in patellar shape between the 2 groups, but PPI was more frequent in patients with short patellar tendon and those with low patellar height. In terms of implant type, the PPI+ group included 12 patients (18.5%) who underwent posterior stabilized TKA and 26 (74.3%) who underwent BCS TKA. There was no difference between the 2 groups in either joint ROM or new Knee Society Score. These results suggest that the position of the patella and implant shape that causes the post to be positioned anteriorly may contribute to PPI.
Conclusion: PPI occurred more frequently in knees with low patellar height and in patients who had undergone BCS TKA. PPI had no effect on joint ROM or clinical outcome.

Introduction

Total knee arthroplasty (TKA) is the established method of surgery for end-stage osteoarthritis of the knee [1]. Posterior stabilized (PS) TKA has been shown to have good long-term outcomes [2,3]. One advantage of PS TKA is that the post-cam structure artificially induces rollback in a highly reproducible manner. However, several problems with the post-cam structure have been reported, and this structure could be said to be one of the weak points of PS TKA. These post-cam issues include fracture and wear of the post itself [4,5], as well as characteristic problems such as patellar clunk syndrome [6]. Another problem is the occurrence of anterior tibial post impingement, which occurs when the knee is extended or lightly flexed [7,8], and recent studies using motion analysis, such as KneeSIM (LifeModeler, Inc, San Clemente, CA), have shown that posterior inclination of the tibia is associated with anterior tibial post impingement [9]. Implant shape and positioning are, thus, also associated with problems with the post-cam structure, and this is, thus, an area that merits in-depth investigation.

Patellar post impingement (PPI) has been identified as an issue for implants capable of deep flexion that have been developed in the past few years, and it occurs when the anterior part of the tibial post impinges on the patella when the knee is deeply flexed (Fig. 1). PPI has been reported as causing anterior knee pain, increased patellofemoral pressure, wear on the polyethylene of the patellar component and the tibial post, and decreased range of motion (ROM) [10]. The radiolucency of both the patellar component and the tibial post means that PPI is difficult to assess postoperatively, and much about this issue remains unclear [11]. This may be the

* Corresponding author. Akita Red Cross Hospital, Kamikitate Sarutaazanaeshirosawa 222-1, Akita City, Akita 018-1495, Japan. Tel.: +81 18 829 5000.
E-mail address: takenoritomite@yahoo.co.jp

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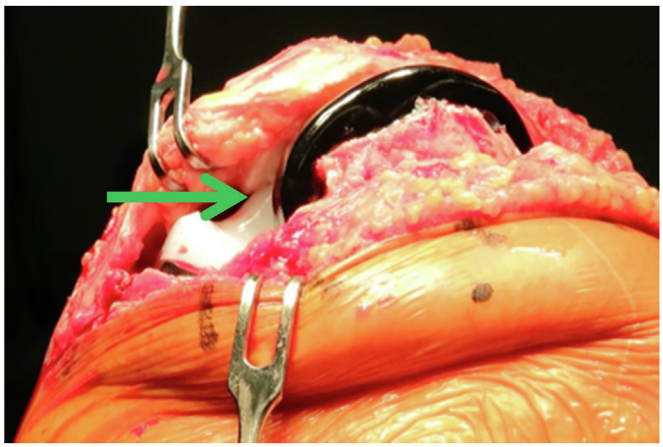

Figure 1. The arrow shows where PPI is occurring.

reason that, although some studies have addressed PPI, there have been few reports of its association with actual clinical outcomes and clinical symptoms. We hypothesized that differences in implant type would affect the incidence of PPI and that PPI would reduce ROM and result in poorer clinical outcomes. The first objective of this study was, therefore, to ascertain whether PPI had actually occurred during surgery in patients who underwent either PS TKA or bi-cruciate stabilized (BCS) TKA and to investigate whether patellar shape, height, or the type of implant was associated with any difference in its incidence. A further objective was to classify these patients into 2 groups depending on the occurrence of PPI and investigate whether there were any differences between these groups in ROM, clinical outcomes, or clinical symptoms.

Material and methods

The study subjects were 100 patients who had undergone unilateral TKA. The implant used for PS TKA was a Persona (Zimmer Biomet, Warsaw, IN), and that used for BCS TKA was a Journey II (Smith & Nephew, Memphis, TN). PS TKA was conducted for 65 knees, with BCS TKA for 35. The patients included 20 men and 80 women, with a mean age of 76 ± 6 years. All underwent TKA for osteoarthritis of the knee for the first time. Patients who had previously undergone knee joint surgery such as osteotomy, meniscectomy/suturing, or anterior cruciate ligament reconstruction and those with rheumatoid arthritis were excluded. All operations were performed by the same surgeon. In all cases, the bone was exposed by the medial parapatellar approach, the modified gap technique was used, the implant was anchored with cement, and patellar resurfacing was performed. We gained informed consent of all patients.

Whether PPI occurred intraoperatively after the insertions of the femoral component, tibial component, and patellar component and all insertions were completed was investigated, and if PPI did occur, the angle was also measured. The patients were classified accordingly into a PPI+ group, in which PPI occurred, and a PPI− group, in which no PPI occurred. The parameters evaluated were (a) patellar length, (b) patellar width, (c) patellar thickness, (d) patellar tendon length, (e) patellar height (Insall-Salvati ratio), (f) patella articular-nonarticular angle, (g) patella inferior pole angle, and (h) patella

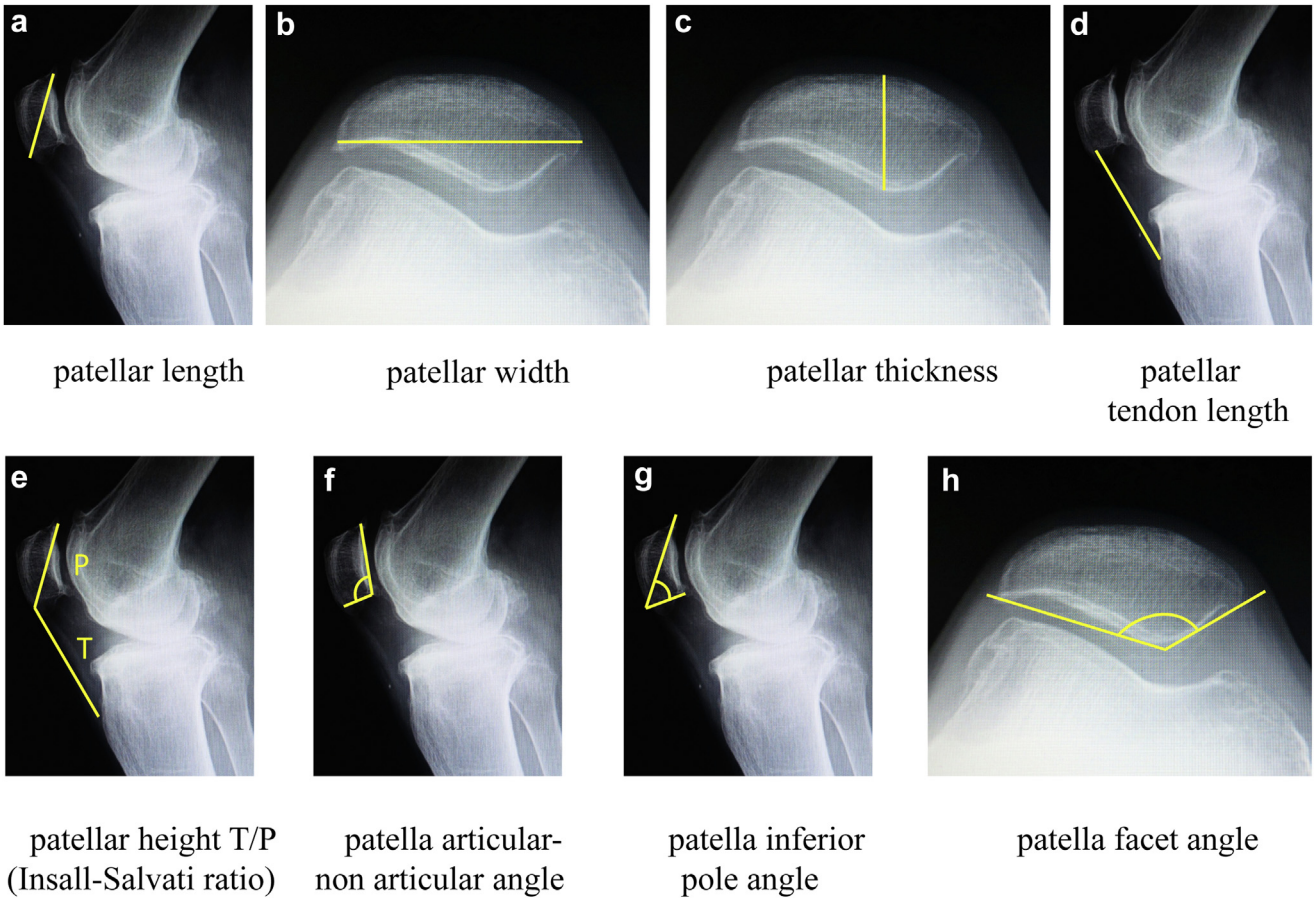

Figure 2. Parameters evaluated on radiographs.

Table 1
Patients' characteristics.

Characteristics	PPI+ group	PPI− group	*P* value
Number of patients	38	62	
Age (y)	75.9 (71.0-82.0)	76.2 (70.0-81.0)	n.s
Sex (male/female)	7/31	13/49	n.s
Body mass index (kg/m^2)	26.1 (20.5-36.5)	26.8 (21.1-36.9)	n.s
Number of legs (right/left)	20/18	31/31	n.s

There were no significant differences between the 2 groups in age, sex, body mass index, or laterality of the affected side.

facet angle, which were all measured on radiographs (Fig. 2). Whether the use of different implants affected the incidence of PPI was also investigated. Joint ROM and new Knee Society Score (new KSS), a patient-based assessment tool, were evaluated preoperatively and at 1 year postoperatively, and patients were also asked if they had anterior knee pain and crepitation.

The study was approved by the local ethics committee of the Akita Red Cross Hospital. Informed consent was obtained from all patients.

Statistical analysis

All data were analyzed using the Statistical Package for the Social Sciences (SPSS) ver. 23.0 (IBM Corp., Armonk, NY). An unpaired *t*-test was used to evaluate patients' characteristics, X-ray measurements, joint ROM, and new KSS assessments, with $P < .05$ considered significant.

Results

In the 100 patients, PPI actually occurred intraoperatively in 38 knees (38%, PPI+ group) and did not occur in 62 (62%, PPI− group). There were no significant differences between the 2 groups in age, sex, body mass index, or laterality of the affected side (Table 1). PPI occurred at a mean angle of 127.3°. At the 1-year postoperative follow-up visit, no patients had required implant replacement because of PPI. In terms of implant type, the PPI+ group included 12 of 65 knees (18.5%) treated by PS TKA and 26 of 35 (74.3%) treated by BCS TKA, with PPI more than 4 times as common when BCS TKA was performed than when PS TKA was performed.

Patellar length, patellar width, patellar thickness, patellar tendon length, patellar height (Insall-Salvati ratio), patella articular-nonarticular angle, patella inferior pole angle, and patella facet angle were measured on preoperative radiographs. Postoperatively, because the patellar component is radiolucent, patellar thickness, patellar articular-nonarticular angle, patellar inferior pole angle, and patellar facet angle were not measured. Intraoperatively, however, the patellar thickness was measured using calipers. Patellar osteotomy was conducted to remove a section of bone of the same thickness as that of the type of patellar component used, and it was confirmed that the patellar thickness after patellar component placement was the same as its preoperative value. Because the preoperative and postoperative patellar thicknesses were the same, there was no great difference in the patellar facet angle compared with its preoperative value. There were significant differences between the PPI+ and PPI− groups in patellar tendon length and patellar height (Table 2). These results showed that, although the shape of the patella itself had no effect on the occurrence of PPI compared with its preoperative shape, it was more likely to occur in patients with a short patellar tendon and low patellar height.

Table 2
Results of X-ray measurements.

Measurement	PPI+ group	PPI− group	*P* value
Preoperative			
Patellar length (cm)	45.3	44.4	n.s
Patellar width (cm)	51.2	53.8	n.s
Patellar thickness (cm)	20.2	20.8	n.s
Patellar tendon length (cm)	40.3	44.6	<.05
Patellar height (Insall-Salvati)	0.88	1.04	<.05
Patellar articular-non articular angle (°)	117.4	113.2	n.s
Patellar inferior pole angle (°)	49.6	53.2	n.s
Patellar facet angle (°)	139.9	140.6	n.s
Postoperative			
Patellar length (cm)	44.4	43.9	n.s
Patellar width (cm)	50.7	53.2	n.s
Patellar tendon length (cm)	39.2	44.6	<.05
Patellar height (Insall-Salvati)	0.87	1.03	<.05

PPI was significantly more likely to occur in patients with a short patellar tendon and low patellar height.

Table 3
Preoperative and postoperative joint ROM.

Range of motion	PPI+ group	PPI− group	*P* value
Preoperative extension (°)	−9.3	−8.4	n.s
Preoperative flexion (°)	118.3	116.5	n.s
Postoperative extension (°)	−4.3	−4.1	n.s
Postoperative flexion (°)	124.9	126.8	n.s

The joint ROM was significantly improved postoperatively compared with preoperatively in both the PPI+ and PPI− groups. There was no significant difference between the 2 groups in either preoperative or postoperative joint ROM.

In terms of joint ROM, there was no difference between the PPI+ and PPI− groups in either extension or flexion. Although there was a greater improvement in flexion in the PPI− group, there was no significant difference between the 2 groups in either extension or flexion (Table 3).

Preoperatively, there were no significant differences between the PPI+ and PPI− groups in the new KSS results for symptoms, satisfaction, expectation, or functional activity. Although the preoperative scores for symptoms, satisfaction, and functional activity were often somewhat higher in the PPI− group, the difference between the 2 groups was not significant for any of these parameters (Table 4).

When the 38 patients with PPI were asked if they had anterior knee pain and crepitation, 3 of 38 (7.9%) complained of anterior knee pain and 1 of 38 (2.6%) of crepitation. Two of the 3 patients who complained of anterior knee pain had undergone BCS TKA, and 1 had undergone PS TKA; the patient who complained of crepitation had undergone BCS TKA.

Discussion

The most important information obtained from this study is that PPI occurs more frequently in patients with a shorter patellar tendon and a lower patellar height, a result obtained from actual

Table 4
Preoperative and postoperative new KSS results.

KSS domain	PPI+ group	PPI− group	*P* value
Preoperative			
Symptoms	7.8	7.5	n.s
Satisfaction	13.0	13.3	n.s
Expectation	12.3	12.4	n.s
Functional activity	36.3	36.5	n.s
Postoperative			
Symptoms	20.2	21.2	n.s
Satisfaction	24.3	25.4	n.s
Expectation	10.3	10.2	n.s
Functional activity	60.4	61.6	n.s

There was no significant difference between the PPI+ and PPI− groups in either their preoperative or postoperative new KSS scores.

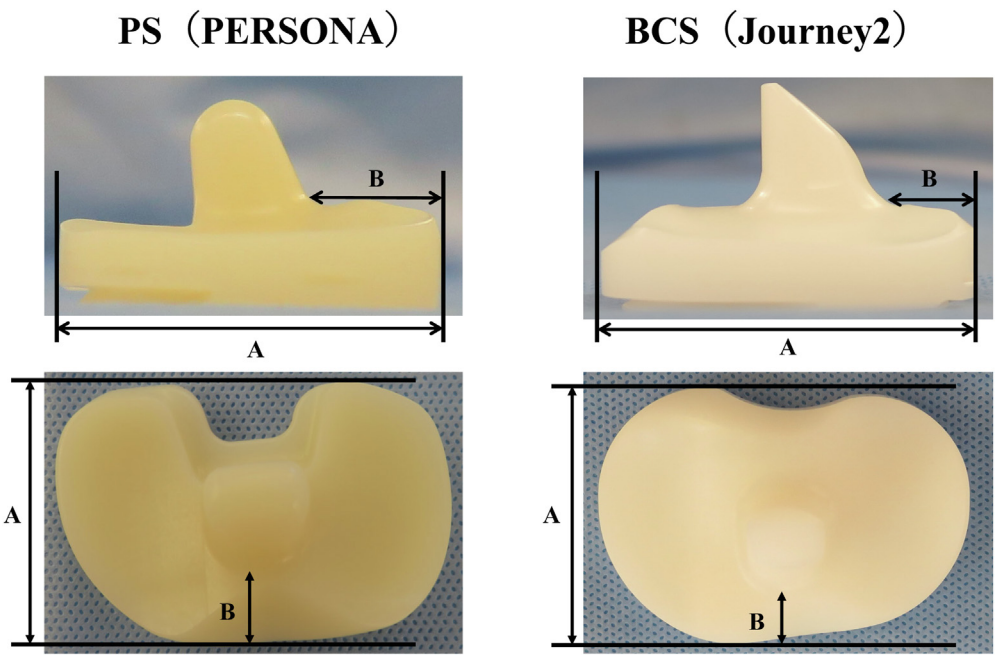

Figure 3. Differences in the anterior-posterior position of the post in PS TKA and BCS TKA. A, Implant anterior-posterior length. B, Distance from the anterior surface of the implant to the base of the post. The actual values are shown in Table 5.

intraoperative findings in living knees, and that it is more common in BCS TKA. The radiolucency of both the patellar component and the tibial post means that PPI is difficult to assess postoperatively [11], and few studies have addressed the problem. Minoda et al. defined the distance between the lower edge of the patellar component and the cut surface of the tibia as the tibial-patellar clearance (TPC), which represents the length of the patellar tendon, and they reported that shorter TPCs resulted in smaller PPI angles, and longer TPCs resulted in larger PPI angles [12]. They also stated that the design of the tibial post affects the occurrence of PPI [11,12], but those studies were conducted using Sawbones model bones. Verborgt and Victor reported that a raised joint line, patella infera, too-anterior placement of the tibial component, and smaller femoral component size are associated with the occurrence of PPI [10]. Taking the results of these previous reports in conjunction with those of the present study, the important causes of PPI may be (1) the positions of the patella, such as patella infera, a small TPC, or a raised joint line and (2) an implant shape that places the post in a more anterior position. In light of the study by Verborgt and Victor [10] on the causes of PPI, it may be that, if the joint line is raised, the relatively lower position of the patellar makes the occurrence of PPI more likely. In the present study, the patients' original joint line was difficult to define and was, therefore, not evaluated. However, no additional osteotomy of the distal femur was carried out during surgery in patients who underwent either BCS TKA or PS TKA, with only the amount of bone designated by the osteotomy guide being cut away in either case. Thus, the osteotomies performed in patients who underwent BCS TKA or PS TKA were of similar size. The position of the tibial component was evaluated on radiographs, and no patient who underwent either BCS TKA or PS TKA showed an obvious anterior overhang. Placing the post in a more anterior position that results in too-anterior placement of the tibial component may also make the occurrence of PPI more likely. BCS is designed specifically to provide postoperative anterior-posterior knee stability, and its AP position places the femur more anteriorly relative to the tibia than conventional PS, in which their positional relationship is close to that of the normal knee [13]. In terms of the shapes of the Persona and Journey II implants used for PS TKA and BCS TKA, respectively, the post is positioned more anteriorly in BCS TKA than in PS TKA, as can be seen in Figure 3 and Table 5. PPI may, thus, occur more frequently in BCS TKA because more anterior post placement makes it more likely to occur when the knee is flexed. A few cases of low-riding patella after TKA have been reported [14,15], but other studies have found no change in patellar height in the short-term postoperative period [16,17]. The present results are short term, covering 1 year postoperatively, but there was no difference in patellar height between before and after surgery.

The occurrence of PPI has been reported to cause decreased ROM, anterior knee pain, increased patellofemoral pressure, and polyethylene wear of the patellar component and tibial post [10]. In the present study, ROM and anterior knee pain were investigated, but there was no significant difference in ROM between the PPI+ and PPI− groups. Only 3 of 38 (7.9%) patients who developed PPI complained of anterior knee pain, and only 1 of 38 (2.6%) complained of crepitation. These percentages are not much higher than those reported by Waters and Bentley, who found that 25.1% of

Table 5
Implant anterior-posterior length and distance from the anterior surface of the implant to the base of the post.

Persona (size: femur/tibia)	A (mm)	B (mm)	Journey II (size: tibia)	A (mm)	B (mm)
Size: 3-5/C-D	42	14	Size: 1-2	42	10
Size :6-9/C-D	42	13			
Size: 3-5/E-F	46	17	Size: 3-4	48	12
Size: 6-9/E-F	46	16	Size: 5-6	53	14

Anterior-posterior length (A) and distance from the anterior surface of the implant to the base of the post (B) in frequently used sizes of the Persona and Journey II implants used for PS TKA and BCS TKA, respectively. In the Persona, the distance to the base of the post varies depending on the size of the femur, and the "Size" entries show the femoral and tibial implant sizes. The Persona tibia C-D size is approximately equivalent to the Journey II tibia 1-2 size, and the anterior-posterior lengths of the E-F and 3-4 sizes are about the same, but the distance to the post (B) is shorter in the Journey II, meaning that the post is positioned more anteriorly in the Journey II than in the Persona.

post-TKA patients complained of anterior knee pain if patellar resurfacing was not conducted and 5.3% if it was [18]. Anterior knee pain is usually discussed in the context of whether to resurface the patella, and some studies have found that omitting patellar resurfacing may cause anterior knee pain [19,20]. Other studies, however, have found that there is no difference in the occurrence of anterior knee pain regardless of whether the patella is resurfaced [21,22]. Guman et al. conducted a systematic review and meta-analysis of risk factors for anterior knee pain, and they reported that patients who did not undergo patellar resurfacing and those who underwent infrapatellar fat pad excision tended to experience anterior knee pain [23]. In the present study, as many factors that might cause anterior knee pain as possible were eliminated by performing patellar resurfacing in all cases and excising the infrapatellar fat pad to the extent to which it did not interfere with the field of view. In terms of patellofemoral pressure, Sawaguchi et al. compared patellofemoral contact stress in mobile-bearing to that in fixed-bearing TKA, and they found that contact stress is lower in mobile-bearing TKA than in fixed-bearing TKA [24], but to the best of our knowledge, no study has measured the patellofemoral pressure using other types of devices such as BCS TKA and PS TKA. In addition, no study has yet reported that the occurrence of PPI increases wear of the patellar component or the tibial post.

As a method of dealing with PPI when it occurs, Jegyun et al. reported that resecting the lower portion of the patella increases the space between the patella and the tibial post, preventing PPI from occurring [25]. However, if the lower portion of the patella is resected, it may not be possible to carry out appropriate patellar resurfacing. In terms of surgical procedure, what is important is not to raise the joint line unnecessarily, as reported by Verborgt and Victor [10]. In patients with a low patellar tendon and when carrying out BCS TKA, it may be possible to adapt the procedure by means such as resecting a slightly greater amount of the patella if it is of sufficient thickness.

The most important limitation of this study was that it was only possible to investigate 2 types of implants. Minoda et al. investigated PPI in a variety of different implants [11], and they found that TPC of 20 mm for PS TKA with a Persona implant and 22 mm for BCS TKA with a Journey II implant is required to achieve flexion $\geq$130° to prevent PPI from occurring. They showed that PPI is more likely to occur in BCS TKA, unless the position of the patella is higher. However, that study used Sawbones models, and it would be quite difficult to insert a range of different implants into living knees for investigation. A second limitation is the short follow-up period of 1 year. No study has yet examined the long-term postoperative outcomes of PPI. In such a short study period of 1 year, PPI did not cause any serious symptoms that caused implant failure or required revision, but implant failure and patient symptoms are among the issues that must be monitored long term in the future. Third, the small sample size should be mentioned. As noted previously, the mean angle at which PPI occurred was 127.3°, but in 21 (55%) of the 38 patients who developed PPI, the ROM did not reach the angle at which PPI occurred, and it improved to greater than the angle at which PPI occurred in 17 (45%) of these patients. In view of the small number of patients in whom ROM improved to above the angle at which PPI actually occurred, and taken in conjunction with the second limitation described previously, studies with a larger sample size and longer follow-up time might show a drop in the KSS score, diminished ROM, or larger numbers of patients complaining of anterior knee pain or crepitations.

Conclusion

PPI occurred more frequently in knees with a shorter patellar tendon, which is approximately equivalent to a low patellar height, and in patients who had undergone BCS TKA, suggesting that the occurrence of PPI may be determined by the position of the patella and implant shape. PPI had no effect on joint ROM or clinical outcome at 1 year postoperatively, and the postoperative complaint rate was also low.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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