

# The Influence of Preoperative Radiographic Patellofemoral Degenerative Changes and Malalignment on Patellofemoral-Specific Outcome Scores Following Fixed-Bearing Medial Unicompartmental Knee Arthroplasty

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**Background:** There is controversy as to whether the presence of degenerative changes and malalignment of the patellofemoral joint is a contraindication to medial unicompartmental knee arthroplasty. Therefore, the aim of the present study was to examine the influence of preoperative radiographic patellofemoral joint osteoarthritis and alignment on intermediate-term knee and patellofemoral joint-specific patient-reported outcomes following fixed-bearing medial unicompartmental knee arthroplasty.

**Methods:** We performed a retrospective review of the records on a consecutive series of patients who had undergone robotic arm-assisted fixed-bearing onlay medial unicompartmental knee arthroplasty and had a minimum duration of follow-up of 2 years. All records were collected from a single surgeon's arthroplasty registry. Patients with severe bone loss or grooving of the lateral patellar facet were excluded. Radiographic assessment was performed with use of the Kellgren-Lawrence and Altman classification systems as well as with patellofemoral joint alignment measurements. The latest follow-up consisted of a patient-reported questionnaire, including the Kujala (Anterior Knee Pain Scale) score, the Knee Injury and Osteoarthritis Outcome Score (KOOS), Junior (JR), and satisfaction levels.

**Results:** A total of 536 patients (639 knees) were included. After a mean duration of follow-up (and standard deviation) of  $4.3 \pm 1.6$  years (range, 2.0 to 9.2 years), good-to-excellent Kujala scores were reported independent of the presence of patellofemoral joint osteoarthritis preoperatively (Kellgren-Lawrence grade 0 compared with  $\geq 1$ ,  $p = 0.82$ ; grade  $\leq 1$  compared with  $\geq 2$ ,  $p = 0.84$ ). Similar findings were found when osteoarthritis was present in either the medial or lateral side of the patellofemoral joint as defined by an Altman score of  $\geq 2$  (medial,  $p = 0.81$ ; lateral,  $p = 0.90$ ). KOOS scores and satisfaction also were not affected by degenerative patellofemoral joint changes. Furthermore, neither the patellar tilt angle nor the congruence angle influenced patient-reported outcomes.

**Conclusions:** Preoperative radiographic mild to moderate patellofemoral joint degeneration (Kellgren-Lawrence grades 1 through 3) and/or malalignment did not compromise intermediate-term knee and patellofemoral joint-specific patient-reported outcomes in patients managed with fixed-bearing medial unicompartmental knee arthroplasty. On the basis of the results of the present study, we believe that neither mild to moderate patellofemoral degeneration nor abnormal patellar tilt or congruence should be considered a contraindication to fixed-bearing medial unicompartmental knee arthroplasty.

**Level of Evidence:** Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

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Over the last 2 decades, there has been renewed interest in unicompartmental knee arthroplasty for the treatment of isolated medial compartment osteoarthritis<sup>1</sup>. Historically, the outcomes of unicompartmental knee arthroplasty were discouraging, which resulted in specific patient-selection criteria to improve outcomes<sup>2</sup>. Adherence to these specific criteria has been associated with promising intermediate to long-term outcomes of medial unicompartmental knee arthroplasty<sup>3</sup>. Recently, multiple studies have suggested that the criteria proposed by Kozinn and Scott<sup>2</sup> are too stringent and that an expanded patient population could benefit from unicompartmental knee arthroplasty<sup>4,5</sup>. However, radiographic changes in the patellofemoral joint remain a controversial issue in terms of decision-making.

Because of the lack of supporting evidence, there is debate as to whether the presence of osteoarthritis in the patellofemoral joint should be considered a contraindication to the use of medial unicompartmental knee arthroplasty. In 2007, Beard et al. redefined this criterion and reported that mobile-bearing medial unicompartmental knee arthroplasty can be used in the presence of patellofemoral joint osteoarthritis, provided that there is no bone loss or grooving of the lateral patellar facet<sup>6,7</sup>. Since then, few authors have assessed the association between the presence of osteoarthritis in the patellofemoral joint and outcomes scores<sup>8-11</sup>, and we are aware of no studies that have used patellofemoral joint-specific patient-reported outcomes, such as the Kujala (Anterior Knee Pain Scale) score<sup>12</sup>. Furthermore, there is a lack of studies that have evaluated the importance of preoperative patellofemoral joint alignment following fixed-bearing medial unicompartmental knee arthroplasty and its effect on functional outcomes. Although patellofemoral joint alignment after total knee arthroplasty has been extensively studied, relevant studies of unicompartmental knee arthroplasty are limited<sup>13,14</sup>. Munk et al. reported that preoperative lateral subluxation of the patella was associated with poor outcomes following medial unicompartmental knee arthroplasty at 1 year of follow-up<sup>15</sup>. However, Thein et al. found no correlation between preoperative patellofemoral joint congruence or degeneration severity and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores at 2 years of follow-up<sup>16</sup>.

The primary aim of the present large study was to determine whether preoperative radiographic patellofemoral joint degenerative changes and patellar alignment influence a patellofemoral joint-specific outcome score after fixed-bearing medial unicompartmental knee arthroplasty. The secondary aim was to evaluate the effect on general patient-reported knee outcomes. We hypothesized that preoperative radiographic patellofemoral joint osteoarthritis and alignment do not affect either knee or patellofemoral joint-specific patient-reported outcomes following fixed-bearing medial unicompartmental knee arthroplasty.

## Materials and Methods

### Study Design and Patient Selection

We performed a retrospective review of the records of patients who had undergone medial unicompartmental

knee arthroplasty at least 2 years previously; all records were obtained from the database of a single surgeon (A.D.P.). All patients were managed with cemented implants with a fixed-bearing metal-backed tibial onlay component (Restoris MCK; Stryker) with use of a robotic arm-assisted unicompartmental knee arthroplasty technique (Mako system; Stryker) from June 2007 to August 2016. The surgeon has had extensive experience with this procedure and is a consultant for the company but is not a designer and does not receive royalties. During the study period, >70% of all primary knee arthroplasties were robotic unicompartmental knee arthroplasties. The present study was approved by the institutional review board, and all patients provided consent before data collection. The surgical inclusion criteria were medial compartment osteoarthritis, the absence of definitive joint-space narrowing in the lateral compartment, a passively correctable varus deformity, and a fixed flexion deformity of <15°. Contraindications included patellofemoral joint-related symptoms (anterior knee pain with prolonged sitting with the knee flexed or pain specific to stair-climbing rather than stair descent), severe bone loss and grooving of the lateral patellofemoral joint facet, and inflammatory arthritis. To be eligible for final analysis, patients were required to have a preoperative “Merchant-view” radiograph and functional outcome data<sup>17</sup>. All patients who met these criteria were included in the study.

Seven hundred and thirty-six patients received fixed-bearing medial onlay unicompartmental knee arthroplasty. However, radiographs were missing for 32 patients (4%). Additionally, 148 patients (20%) were lost to follow-up or had incomplete follow-up, 12 patients (2%) died, and 8 patients (1%) underwent revision. Reasons for revision were unexplained pain (n = 2), aseptic loosening (n = 4), and progression of osteoarthritis in the lateral compartment (n = 2).

### Radiographic Assessment

The radiographic assessment was performed by one trained investigator (N.L.) who was blinded to the clinical outcomes. Preoperative Merchant-view radiographs (i.e., radiographs involving a superoinferior axial projection of the patella with the knee at 45° of flexion) were evaluated to determine degenerative changes and alignment of the patellofemoral joint. The overall severity of osteoarthritis in the patellofemoral joint was assessed with use of the Kellgren-Lawrence classification system (0 = none, 1 = doubtful, 2 = mild, 3 = moderate, and 4 = severe)<sup>18</sup>. In addition, the radiographic status of the patellofemoral joint was defined with use of the Altman system, which evaluates individual features of osteoarthritis, including osteophytes, joint-space narrowing, subchondral sclerosis, and bone destruction of both the lateral and medial sides of the patellofemoral joint (with each feature rated on a scale 0 to 3, with higher scores indicating increasing severity)<sup>19,20</sup>. The maximum score per side was 12; patients with an Altman score of ≥2 were considered to have degenerative changes. Patellofemoral joint alignment was assessed with use of the patellar tilt angle (Fig. 1)<sup>21</sup> as well as the patellar congruence angle (Fig. 2)<sup>17</sup>. A tilt angle of ≥14° and a congruence angle of ≥17° were considered abnormal<sup>17,21,22</sup>.

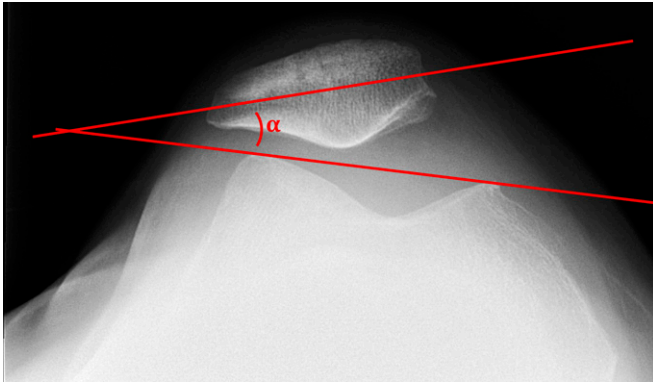


Fig. 1  
Merchant-view radiograph showing the patellar tilt angle. A line from the lateral to the medial edge of the patellar facets is drawn, and a line from the highest point of the lateral condyle to the highest point of the medial condyle is drawn. These lines are continued until they intersect, establishing the tilting angle ( $\alpha$ ). Lateral tilting is designated as a positive angle, and medial tilting is designated as a negative angle.

### Clinical Outcomes

The latest follow-up consisted of the completion of a patient-reported questionnaire including the Kujala<sup>12</sup> (Anterior Knee Pain Scale) score and the Knee Injury and Osteoarthritis Outcome Score (KOOS), Junior (JR)<sup>23</sup>. Each score ranges from 0 to 100, with higher scores indicating better outcomes. Furthermore, patients were asked about their satisfaction with the outcomes of surgery on a 5-point Likert scale (with scores ranging from 1 to 5, corresponding with “very satisfied,” “satisfied,” “neutral,” “dissatisfied,” and “very dissatisfied,” respectively). Additionally, they were asked about whether they would undergo the procedure again if given the choice. All patients were contacted by email or postal mail at a minimum of 2 years of follow-up. Patients who did not respond were contacted by telephone. A sensitivity analysis was performed to account for discrepancies (in terms of baseline characteristics and preoperative radiographic measures) between patients who completed the questionnaire and those who did not respond.

### Statistical Analyses

Descriptive analyses were reported with use of means, standard deviations (SDs), and ranges for continuous variables and with use of frequencies and percentages for discrete variables. The radiographic measurements (Kellgren-Lawrence classification, Altman score, patellar congruence angle, and patellar tilt angle) were dichotomized for subgroup analyses. In addition, the Likert scale scores were dichotomized into satisfied versus neutral and dissatisfied. Independent t tests and chi-square tests were used for continuous and categorical outcome variables, respectively. In addition, a linear regression model was fitted to assess the association between preoperative radiographic patellofemoral joint measures and patient-reported outcome scores, with adjustment for sex, age, and body mass index (BMI). All statistical analyses were performed with use of SPSS software (version 25; IBM). A p value of <0.05 was considered to be significant.

### Results

A total of 536 patients (639 knees) with preoperative radiographs and patient-reported outcomes were available for inclusion. The mean duration of follow-up was  $4.3 \pm 1.6$  years (range, 2.0 to 9.2 years). The mean age at the time of surgery was  $63.4 \pm 9.1$  years (range, 41.1 to 86.8 years). The mean BMI was  $28.4 \pm 5.1$  kg/m<sup>2</sup> (range, 16.3 to 47.3 kg/m<sup>2</sup>); 18 patients were morbidly obese, and BMI information was unavailable for 4 patients. The study group included 239 women (44.6%) and 297 men (54.4%). In total, 433 unilateral and 103 bilateral unicompartmental knee arthroplasties were included. No statistical differences were observed, in terms of either baseline characteristics or preoperative radiographic measures, between patients with missing patient-reported outcomes and those who completed the questionnaires.

### Presence of Osteoarthritis

Preoperatively, a total of 356 knees (55.7%) had patellofemoral joint degenerative changes (Kellgren-Lawrence grade  $\geq 1$ ); specifically, 159 knees (24.9%) had doubtful changes (grade 1), 169 knees (26.4%) had mild changes (grade 2), 28 knees (4.4%) had moderate changes (grade 3), and none had severe changes (grade 4). When the medial and lateral sides of the patellofemoral joint were evaluated separately with use of the Altman score (with involvement defined as a score of  $\geq 2$ ), the medial side was more often affected than the lateral side (204 knees [31.9%] compared with 156 knees [24.4%], respectively). An Altman score of  $\geq 2$  in both the medial and lateral sides of the patellofemoral joint was seen in 108 knees (16.9%) (Table I).

At intermediate-term follow-up, good to excellent Kujala scores were reported independent of the presence of patellofemoral joint osteoarthritis preoperatively (Kellgren-Lawrence

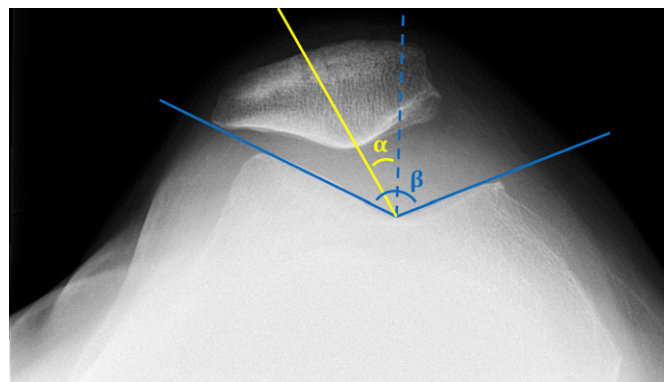


Fig. 2  
Merchant-view radiograph showing the patellar congruence angle. The sulcus angle ( $\beta$ ) was determined by identifying the highest points of the medial and lateral condyles and the lowest point of the intercondylar sulcus. A zero reference (dotted line) is established by bisecting the sulcus angle. A final line is drawn from the lowest point of the intercondylar sulcus to the vertical ridge of the patella to establish the congruence angle ( $\alpha$ ). Angles medial to the zero line are designated as negative, and those lateral to the zero line are designated as positive.

**TABLE I Outcomes After Medial Unicompartmental Knee Arthroplasty According to Patellofemoral Osteoarthritis Severity\*†**

	N	Kujala†	KOOS, JR†	Satisfaction§	Repeat Surgery§
<b>Kellgren-Lawrence grade</b>					
No osteoarthritis	283	83.1 ± 15.3	84.0 ± 15.9	258 (91.2%)	262 (92.6%)
Kellgren-Lawrence grade ≥1	356	83.4 ± 15.4	84.8 ± 15.7	322 (90.4%)	329 (92.4%)
P value		0.82	0.53	0.79	1.00
<b>Kellgren-Lawrence grade ≤1</b>					
Kellgren-Lawrence grade ≤1	442	83.15 ± 15.0	84.1 ± 15.6	402 (91.0%)	410 (92.8%)
Kellgren-Lawrence grade ≥2	197	83.41 ± 16.3	85.3 ± 16.2	178 (90.4%)	181 (91.9%)
P value		0.84	0.40	0.88	0.75
<b>Altman score</b>					
<b>Medial side of PFJ</b>					
≤1	435	83.3 ± 15.0	84.2 ± 15.4	396 (91.0%)	406 (93.3%)
≥2	204	83.0 ± 16.3	85.2 ± 16.5	184 (90.2%)	185 (90.7%)
P value		0.81	0.45	0.77	0.26
<b>Lateral side of PFJ</b>					
≤1	483	83.3 ± 15.2	83.8 ± 16.0	439 (90.9%)	446 (92.3%)
≥2	156	83.1 ± 16.1	86.3 ± 15.0	141 (90.4%)	145 (92.9%)
P value		0.90	0.10	0.87	0.86
<b>Both sides of PFJ</b>					
≤1 on at least 1 side	531	83.3 ± 15.1	84.0 ± 15.9	481 (90.6%)	492 (92.7%)
≥2 on both sides	108	83.0 ± 16.7	86.8 ± 15.2	99 (91.7%)	99 (91.7%)
P value		0.88	0.10	0.86	0.69

\*PFJ = patellofemoral joint. †A p value of <0.05 represents a significant difference between subgroups. ‡The scale ranges from 0 to 100, with higher scores indicating better outcomes. The values are given as the mean and standard deviation. §The values are given as the number (and percentage) of patients who were either very satisfied or satisfied with the results of the surgery or who would choose to undergo the procedure again if given the choice.

grade 0 compared with ≥1,  $p = 0.82$ ; Kellgren-Lawrence grade ≤1 compared with ≥2,  $p = 0.84$ ). Similar findings were noted when osteoarthritis was present on at least the medial side, on at least the lateral side, or on both sides of the patellofemoral joint as defined by an Altman score of ≥2, with the mean Kujala scores being equivalent in all subgroups (medial side,  $p = 0.81$ ; lateral side,  $p = 0.90$ ; both sides,  $p = 0.88$ ) (Table I).

Mean KOOS scores were consistently higher for patients with degenerative patellofemoral joint changes than those without; however, the differences were not significant (Table I). Furthermore, there were no differences with regard to rates of satisfaction and willingness to repeat surgery between patients with or without degenerative patellofemoral joint changes assessed with the Kellgren-Lawrence grade and Altman score (Table I).

**TABLE II Outcomes After Medial Unicompartmental Knee Arthroplasty Categorized by Normal and Abnormal Alignment Angle\***

	N	Kujala†	KOOS JR†	Satisfaction‡	Repeat Surgery‡
<b>Patellar congruence angle</b>					
Normal (≤16°)	517	83.2 ± 15.4	84.4 ± 15.9	467 (90.3%)	478 (92.5%)
Abnormal (≥17°)	122	83.6 ± 15.5	84.8 ± 15.4	113 (92.6%)	113 (92.6%)
P value		0.80	0.83	0.49	1.00
<b>Patellar tilt angle</b>					
Normal (≤13°)	511	83.5 ± 15.1	84.6 ± 15.8	463 (90.6%)	470 (92.0%)
Abnormal (≥14°)	128	82.1 ± 16.5	83.9 ± 15.8	117 (91.4%)	121 (94.5%)
P value		0.36	0.67	0.87	0.45

\*A p value of <0.05 represents a significant difference between subgroups. †The scale ranges from 0 to 100, with higher scores indicating better outcomes. The values are given as the mean and standard deviation. ‡The values are given and the number (and percentage) of patients who were either very satisfied or satisfied with the results of the surgery or who would choose to undergo the procedure again if given the choice.

TABLE III Multivariable Analysis Using a Linear Regression Model with Kujala and KOOS Patient Outcome Scores as Dependent Variables \*

	Coefficient (95% CI)†	Standard Error	P Value‡
<b>Kujala§</b>			
Sex (male vs. female)	4.5 (2.1, 6.8)	1.2	<0.01
Age	-0.1 (-0.2, 0.0)	0.1	0.13
BMI	-0.5 (-0.8, -0.3)	0.1	<0.01
Patellar congruence angle	0.1 (-0.0, 0.2)	0.1	0.18
Patellar tilt angle	-0.0 (-0.3, 0.2)	0.1	0.80
Kellgren-Lawrence grade (0-1 vs. 2-3)	0.8 (-3.1, 4.9)	2.1	0.67
Altman score			
Medial side of PFJ	-0.6 (-2.4, 1.2)	0.9	0.51
Lateral side of PFJ	0.0 (-1.3, 1.4)	0.7	0.99
<b>KOOS, JR§</b>			
Sex (male vs female)	1.9 (-0.6, 4.3)	1.4	0.14
Age	0.1 (-0.1, 0.2)	0.1	0.29
BMI	-0.5 (-0.7, -0.2)	0.1	<0.01
Patellar congruence angle	0.1 (-0.0, 0.2)	0.1	0.17
Patellar tilt angle	-0.1 (-0.4, 0.2)	0.1	0.49
Kellgren-Lawrence grade (0-1 vs. 2-3)	0.7 (-3.5, 4.8)	2.1	0.75
Altman score			
Medial side of PFJ	-0.6 (-2.5, 1.3)	0.9	0.53
Lateral side of PFJ	0.8 (-0.6, 2.2)	0.7	0.26

\*PFJ = patellofemoral joint. †The coefficient indicates the change in the Kujala or KOOS score of 1 group relative to the reference group (categorical variables) or the change resulting from a 1-unit increase of the input variable (continuous variables). ‡A p value of <0.05 represents a significant regression coefficient. §Each scale ranges from 0 to 100 with high scores indicating good outcomes.

### Patellar Alignment

Preoperatively, 122 (19.1%) of the 639 knees had an abnormal patellar congruence angle and 128 (20.0%) had an abnormal patellar tilt angle. No differences in Kujala scores were found between patients with normal and abnormal patellar congruence or tilt angles ( $p = 0.80$  and  $p = 0.36$ ) (Table II). Similarly, equivalent KOOS scores and rates of satisfaction and willingness to undergo repeat surgery were observed between patients with normal and abnormal patellar congruence or tilt angles (Table II).

### Multiple Regression

Multivariable analysis showed 2 independent predictors of high postoperative Kujala scores: male sex ( $\beta = 4.5$  [95% confidence interval (CI), 2.1 to 6.8];  $p < 0.01$ ) and lower BMI ( $\beta = -0.5$  [95% CI, -0.8 to -0.3];  $p < 0.01$ ). Lower BMI was also an independent predictor of higher postoperative KOOS scores ( $\beta = -0.5$  [95% CI, -0.7 to -0.2],  $p < 0.01$ ). Other factors included in the regression models that were not significant included the Kellgren-Lawrence grade, Altman score, patellar congruence angle, and patellar tilt angle (Table III).

### Discussion

The main findings of the present study were that neither the presence of preoperative mild to moderate osteoarthritis

nor abnormal patellar tilt or congruence compromised outcomes at intermediate-term follow-up. Kozinn and Scott, in 1989, suggested that degenerative changes in the patellofemoral joint need to be considered as a contraindication to medial unicompartmental knee arthroplasty<sup>2</sup>. Despite a lack of supporting evidence, this recommendation was reinforced by subsequent authors<sup>24,25</sup>. However, consistent with our results, recent literature showed no association between the presence of mild to moderate patellofemoral joint osteoarthritis and poor patient-reported outcome scores. Murray et al. showed good to excellent Oxford Knee Scores and American Knee Society Scores at short and long-term follow-up (average, 2 and 10 years, respectively) independent of the presence of patellofemoral joint osteoarthritis as recorded radiographically and intraoperatively<sup>6,7,9</sup>. Other studies have supported those findings with use of various outcome scores at different follow-up intervals<sup>4,10,26-28</sup>.

The etiologies of osteoarthritis are considered to be different for the lateral and medial sides of the patellofemoral joint. Medial patellofemoral joint osteoarthritis is associated with medial tibiofemoral osteoarthritis and varus alignment of the knee, whereas lateral patellofemoral joint osteoarthritis is associated with valgus alignment of the knee<sup>9,29</sup>. Because of the different etiologies of lateral and medial patellofemoral joint osteoarthritis, several studies have evaluated the medial and lateral sides of the patellofemoral joints

separately<sup>6-9,11</sup>. Song et al. reported no differences in terms of anterior knee pain, the Hospital for Special Surgery knee score, or range of motion between patients with lateral and medial osteoarthritis of the patellofemoral joint<sup>11</sup>. Other authors have reported that patients with degenerative changes in the lateral facet had significantly lower scores on some patient-reported outcomes than those without, although the scores for both groups could be ranked as clinically good<sup>6-9</sup>. The contrasting results between the aforementioned studies may be a consequence of the small number of patients included in the group with degenerative changes in the lateral patellofemoral joint facet relative to those without. In the current study, a large number of patients were included in the group with patellofemoral joint degenerative changes. We found no evidence that mild to moderate degenerative changes in either the medial or lateral patellofemoral joint facet compromised knee and patellofemoral joint-specific outcomes.

It is still unclear why the presence of osteoarthritis in the patellofemoral joint did not seem to impact patient-reported outcomes. A possible explanation may be centralization of the patellar congruence angle due to correction of the varus malalignment following medial unicompartmental knee arthroplasty as reported by Thein et al.<sup>16</sup>. Such centralization might result in reduction of contact stress in the patellofemoral joint, which could favor outcomes<sup>16,30</sup>. The influence of preoperative varus alignment combined with patellar congruence and its relationship to outcomes is beyond the scope of our study; nevertheless, this is important information and should be the focus of future studies. However, no correlation was found between preoperative patellofemoral joint alignment and any patient-reported outcome measures. Equivalent scores were reported by patients who had normal and abnormal patellar congruence preoperatively, supporting the observations made at short-term follow-up by Thein et al.<sup>16</sup>. In the present study, slightly lower Kujala scores were observed in knees with an abnormal patellar tilt angle than those with a normal tilt angle; however, no significant difference was found. We are not aware of any studies that have assessed the influence of multiplanar patellar alignment on outcomes after medial unicompartmental knee arthroplasty. Future studies are necessary to support our findings.

Our review of the current literature indicated that the reason for revision to total knee arthroplasty after mobile-bearing medial unicompartmental arthroplasty is often unrelated to the patellofemoral joint. Berend et al., in a study of 638 knees, reported that none of the implants were revised because of symptomatic degenerative changes in the patellofemoral joint following mobile-bearing unicompartmental knee arthroplasty<sup>31</sup>. In addition, the Oxford group found no difference in the revision rate at the time of the 15-year follow-up between patients with or without damage to the medial or lateral facet of the patellofemoral joint<sup>9</sup>. A few authors have suggested that symptomatic patellofemoral joint degenerative changes are more commonly reported following fixed-bearing

medial unicompartmental knee arthroplasty as most designs have a polyradial femoral component (similar to the normal anatomy of the femoral condyle), which may lead to patellar impingement<sup>4,9,32</sup>. However, Lim et al. found that none of 263 fixed-bearing implants were revised because of progression of patellofemoral joint osteoarthritis or anterior knee pain at 10 years of follow-up<sup>27</sup>. In addition, those authors found that preexisting patellofemoral joint osteoarthritis did not affect survivorship. Similar results were observed by Winnock de Grave et al. in a study of 460 knees with an average duration of follow-up of 5.5 years<sup>33</sup>. Other recent studies have shown that preoperative patellofemoral joint degenerative changes did not correlate with poor patient-reported outcomes following fixed-bearing medial unicompartmental knee arthroplasty<sup>10,11,27</sup>.

Both previous studies and the current study support the use of fixed-bearing medial unicompartmental knee arthroplasty in knees with mild to moderate osteoarthritis of the patellofemoral joint, independent of location<sup>10,11,27,33</sup>. Furthermore, on the basis of the results of our study, a preoperative abnormal patellar tilt or congruence angle on skyline radiographs should not be considered an absolute contraindication to medial unicompartmental knee arthroplasty. These findings could have important implications because expanding the surgical inclusion criteria may increase the number of patients eligible for medial unicompartmental knee arthroplasty by 20% to 40%<sup>9,27</sup>. Future studies are needed to assess the influence of patellar alignment and the presence of osteoarthritis in the patellofemoral joint on patient-reported outcomes.

Patellofemoral joint-related symptoms, such as anterior knee pain with prolonged sitting with the knee flexed or pain specific to stair-climbing rather than stair descent, are used as contraindications to medial unicompartmental knee arthroplasty in the practice of the senior author (A.D.P.). Although it is unclear what our results would have been if we had included patients with patellofemoral joint-related symptoms in the present study, the presence of such symptoms may be better than radiographic criteria for determining which patients are eligible for medial unicompartmental knee arthroplasty. Preoperative Kujala scores or other patellofemoral joint-specific outcome scores may be an appropriate measure to support surgeons in their decision-making process for unicompartmental knee arthroplasty<sup>12</sup>. However, further research is required to provide evidence for this possibility.

One of the limitations of the present study was the retrospective nature of data collection. In addition, postoperative patellofemoral joint alignment was not assessed. Therefore, centralization of the patellofemoral joint congruence angle after medial unicompartmental knee arthroplasty could not be determined, as shown in the study by Thein et al. at short-term follow-up<sup>16</sup>. Another limitation was the use of Merchant-view radiographs. Despite the wide use of this technique to assess the presence of patellofemoral joint osteoarthritis and alignment, 2-dimensional radiographs may be imprecise<sup>34</sup>. In addition,

quadriceps contraction and relaxation can influence radiographic patellofemoral joint alignment<sup>35</sup>. Finally, our findings cannot be extrapolated to patients with severe patellofemoral joint osteoarthritis (Kellgren-Lawrence grade 4), as such patients were not included in the present study.

In conclusion, our study showed that patients with preoperative radiographic mild to moderate patellofemoral joint osteoarthritis and abnormal patellar tilt or congruence angles had good to excellent intermediate-term patient-reported outcome scores after fixed-bearing medial unicompartmental knee arthroplasty. This finding possibly may be due to improvement of patellofemoral joint congruence after unicompartmental knee arthroplasty, resulting in altered contact pressures across the joint. On the basis of the results of this study, we believe that neither mild to moderate patellofemoral joint degeneration nor abnormal radiographic patellar tilt or congruence should be considered a contraindication to fixed-bearing medial unicompartmental knee arthroplasty. Future

studies are necessary to assess the influence of multiplanar patellar alignment on outcomes. ■

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