Effect of Patellofemoral Arthroplasty on Patellar Height in Patients with Patellofemoral Osteoarthritis

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Abstract

Osteoarthritis (OA) in the knee is common, painful, and may be uni- or multicompartmental. The compartment affected by arthritis may be due to trauma, malalignment (varus or valgus), or in the case of patellofemoral OA, patella alta. Patellofemoral arthroplasty (PFA) is an effective partial knee replacement surgery for patellofemoral OA. We hypothesized that PFA can decrease patellar height. In addition, we predicted better outcomes for patients with patella alta before PFA and those whose patellar heights decreased after PFA. This is a retrospective cohort study of PFA patients from 2012 to 2020. Before and after PFA, we measured patellar heights on X-ray images and collected patient-reported outcome measures (PROMs) (International Knee Documentation Committee score, Kujala Anterior Knee Pain Score, and Veterans RAND 12-Item Health Survey for mental and physical health). Statistical analyses assessed PROMs and compared outcomes based on pre- and postoperative patella height. Of 133 knees, 73% presented with patella alta and 61% had patellar heights that decreased after PFA. Compared with patients who did not present with patella alta, patients with patella alta reported similar outcomes with respect to knee function, pain, and general physical and mental health. Compared with patients whose patellar heights decreased after PFA, patients whose knees did not decrease in height reported greater improvements in pain and function. Our findings suggest that patella alta is commonly found in patients with patellofemoral OA and that PFA can decrease patellar height. Future studies are needed to assess whether patellofemoral OA patients with greater degrees of patella alta would benefit from staged or concurrent tibial tubercle distalization.

Keywords

- patellofemoral osteoarthritis
- patellofemoral arthroplasty
- patella alta

Osteoarthritis (OA) in the knee is a common, painful, and debilitating disorder. Studies report that more than half of patients with knee pain have radiological evidence of OA.[1] In many cases, OA affects multiple compartments and can be treated with total knee replacement. OA can also affect a single compartment such as the medial or lateral tibiofemoral or patellofemoral articulation.

Patellofemoral arthroplasty (PFA) is a partial knee replacement surgery for isolated patellofemoral OA. Total knee arthroplasty (TKA) has been the "gold standard"

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treatment for this condition, but recent studies have shown better postoperative outcomes with PFA.[1] Partial knee replacement is less invasive, spares surrounding knee anatomy, and has led to faster rehabilitation, shorter hospital stays, reduced blood loss, greater range of motion and function, and fewer complications.[1,2] However, the decision between PFA and TKA for patellofemoral OA remains controversial.

Minimal research has been done assessing outcomes of PFA. Studies have shown that some patients who had PFA went on to have TKA due to progressive OA in the tibiofemoral joint.[2–4] Because of this, tibiofemoral arthritis is a contraindication for PFA.[2,5] Inflammatory arthritis and chondrocalcinosis are considered relative contraindications for PFA, since patients may benefit from PFA if their arthritis is well-controlled with disease-modifying medications. Additionally, coronal plane deformities such as genu varus and valgus lead to imbalanced loading across the knee. Severe cases may lead to tibiofemoral arthritis so this can also be a contraindication.

Studies suggest better outcomes when a pathoanatomical defect such as trochlear dysplasia or patella maltracking is the primary cause of OA.[1,5] Particularly, patella alta is a painful knee disorder in which the patella is positioned too high. This predisposes it to improper tracking along the trochlear groove and overloading of the inferior patella when the knee flexes and extends.[6] Patella alta has been associated with both OA prevalence and worsening cartilage degeneration at the patellofemoral joint.[7] Optimal PFA outcomes have been demonstrated when arthritis is a result of malalignment or trauma instead of polyarticular pathology.

Due to the risk of TKA conversion, patient selection for PFA is especially important. Better PFA outcomes have been observed when the underlying cause of arthritis is patellar malalignment. We hypothesize that the patellar height of patients with patellofemoral arthritis decreases after PFA. Subsequently, we predict better patient-reported outcomes when these patients have lower patella positions after PFA.

Methods and Materials

This is a retrospective review of consecutive patients who had PFA at a single specialized orthopedic institution with one surgeon from 2012 to 2020. The indication for PFA was isolated patellofemoral arthritis, and all patients received the Zimmer Gender Solutions patellofemoral joint implant (Zimmer Inc., Warsaw Inc.). PFA was performed by either medial or lateral approach. Patients were excluded if they had a concomitant procedure including medial patellofemoral ligament reconstruction, tibial tubercle osteotomy, anterior cruciate ligament reconstruction, meniscus repair, or meniscectomy.

Demographic and surgical data were obtained for each patient. Patients received both pre- and postoperative imaging by lateral X-ray with 30 degree knee flexion ($n = 133$). The Insall–Salvati ratio (ISR) was measured on Sectra IDS7 to assess patella alta. The ISR is a measurement of the patellar tendon length in relation to the patella height.[8–11] In recent comparison studies of patella alta measurements, ISR was demonstrated to be the most sensitive and reliable method for identifying patella alta.[9,10] In this study, a medical student and an attending physician working together used Vaisman et al's method to calculate ISR on X-ray by dividing the distance between the patellar tendon insertion at the tibial tuberosity and the most inferior aspect of the patella by the length between the most superior and inferior aspects of the patella (►**Fig. 1**).[9] Diagnostic threshold values for ISR vary in the literature, but most studies report ISR ≥ 1.20 is indicative of patella alta.[8,9] This is the threshold we used in our study.

To assess surgical outcomes, patient-reported outcome measures (PROMs) were collected from surveys before and after PFA ($n = 73$). The PROMs were the International Knee Documentation Committee (IKDC) score, Kujala Anterior Knee Pain Score (Kujala AKPS), and Veteran's RAND 12 score for mental (VR12-MH), and physical health (VR12-PH).

The IKDC score is a widely accepted and reliable assessment of general knee symptoms, function, and activity for a wide range of knee pathologies.[12] The Kujala AKPS assesses pain around the patella, and studies have demonstrated its reliability and validity.[13] The VR12-MH and VR12-PH scores are patient-reported outcomes that incorporate mental health and social function with physical symptoms.[14]

Statistical analysis was performed using paired sample *t*-tests to compare patellar heights and PROMs before and after surgery. Two-sample *t*-tests were used to compare PROM differences between knees with and without patella alta, as well as between patella alta knees with ISR values that increased and decreased after PFA.

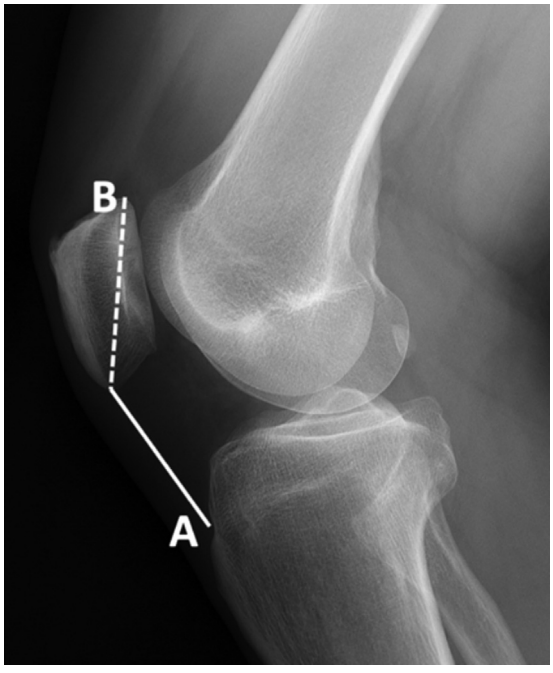

Fig. 1 Insall–Salvati ratio (ISR) on lateral X-ray via Vaisman et al. ISR is calculated A/B, where A is the distance from the inferior aspect of the patella to the insertion of the patellar tendon at the tibial tubercle and B is the length of the patella from the most superior to the most inferior aspect.[9]

Table 1 Demographic information for all knees, knees with patella alta, and knees without patella alta with comparison by *t*-test

	All ($n = 133$)	Patella alta ($n = 97$)	No patella alta ($n = 36$)	*p*-Value
Mean age (y)	54 (SD = 8)	54 (SD = 8)	54 (SD = 9)	0.83
Gender (male)	34 (25.6%)	24 (24.7%)	10 (27.8%)	0.72
Knee (right)	71 (53.4%)	49 (50.5%)	22 (61.1%)	0.28
Mean BMI (kg/m^2)	27.3 (SD = 5.6)	27.0 (SD = 5.6)	28.2 (SD = 5.8)	0.28

Abbreviations: BMI, body mass index; SD, standard deviation.

Results

After reviewing available charts and X-ray images, there were 110 eligible patients with a total of 133 knees that had PFA. Of all 133 knees, there were 71 (53%) right knees and 34 (26%) knees from male patients. The mean age at surgery was 54 ± 8 years (range, 36–76 years), and the mean body mass index (BMI) was 27.3 ± 5.6 kg/m^2. Patients with and without patella alta were comparable with respect to age and BMI (►**Table 1**). The PFA approach was recorded for 132 knees, of which 87 (66%) were medial and 45 (34%) were lateral. The patella height changes were comparable between the medial (-0.037 ± 0.118) and lateral (-0.043 ± 0.140) approaches ($p = 0.81$). PROMs were collected from 73 patients before surgery and up to 6 years after PFA.

The mean ISR was 1.29 ± 0.17 (range, 0.84–1.80). Given the patella alta cut-off value of ISR $\geq$ 1.20 reported in the literature, the prevalence of patella alta before PFA was 73% (97 out of 133) on lateral X-ray (►**Fig. 2**).

The patella height in 63% of all knees ($n = 133$) and 61% of knees with patella alta ($n = 97$) decreased after PFA (►**Fig. 3**). For all knees, the mean ISR difference between post- and preoperative patellar height was −0.04, or a decrease of 3% ($p < 0.001$). The data support a statistically significant decrease in patellar height after PFA.

Of 133 knees with available radiographic imaging, there were 73 (55%) complete sets of pre- and postoperative PROMs (►**Table 2**). On average, patients reported improved knee function, patella pain, and general physical health, but not mental health after PFA (►**Fig. 4**, Kujala AKPS: 23.1, $p < 0.001$; IKDC: 26.1, $p < 0.001$; VR12-PH: 10.5, $p < 0.001$; VR12-MH: −0.92, $p = 0.54$).

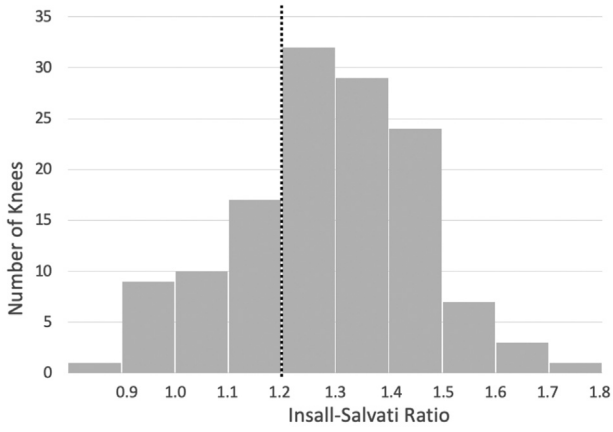

Fig. 2 Distribution of Insall–Salvati ratio (ISR) in knees with patellofemoral osteoarthritis. Dashed line indicates diagnostic threshold value for patella alta (ISR $\geq$ 1.20).

Patients with ($n = 51$) and without ($n = 22$) preoperative patella alta experienced similar levels of improvement with respect to knee function, patella pain, general physical health, and mental health (Kujala AKPS, patella alta [PA]: 24.5 vs. no patella alta [NPA]: 19.7, $p = 0.37$; IKDC, PA: 27.9 vs. NPA: 22.0, $p = 0.29$; VR12-PH, PA: 10.8 vs. NPA: 10.1, $p = 0.81$; VR12-MH, PA: −2.57 vs. NPA: 2.91, $p = 0.09$). The minor difference between knees with and without patella alta were not statistically significant (►**Fig. 5**).

Finally, we looked at changes in patellar height of patients with preoperative patella alta ($n = 51$). Compared with patients who had lower ISR values after PFA ($n = 26/51$, 51%), patients who had increased ISR values ($n = 25/51$, 49%) reported greater improvements in knee function and pain (Kujala AKPS, inc: 30.6 vs. dec: 19.5, $p = 0.04$; IKDC, inc: 35.0 vs. dec: 21.0, $p = 0.02$; VR12-PH, inc: 12.4 vs. dec: 9.13, $p = 0.30$; VR12-MH, inc: −2.60 vs. dec: −2.54, $p = 0.99$). The differences in general physical and mental health were not statistically significant (►**Fig. 6**).

Discussion

Most patients who required PFA for patellofemoral arthritis presented with patella alta (ISR $\geq$ 1.20). After PFA, more than 60% of knees with and without patella alta had lower patellar heights. On average, there was a significant decrease between pre- and postoperative ISR values ($p < 0.001$). The data support our hypothesis that patellar height decreases after PFA.

In this study, the surgeon used both medial and lateral approaches to PFA. There were more PFAs performed by the medial parapatellar approach (87 out of 132, 66%) than lateral (45 out of 132, 35%) but the change in ISR was comparable between the approaches. This is consistent with current literature that compares medial and lateral approaches. While lateral arthrotomy is useful to normalize congruence angle and patellar tilt, the change in patellar height after medial and lateral parapatellar approaches is comparable.[15,16] The patella is flipped and retracted in both approaches so that the patellar and femoral surfaces can be replaced. It is most likely that the arthroplasty itself rather than the approaches impacts patellar height, so medial and lateral surgical exposures would not be significantly different.

According to the PROMs, patients with patella alta before PFA reported slightly greater improvements than

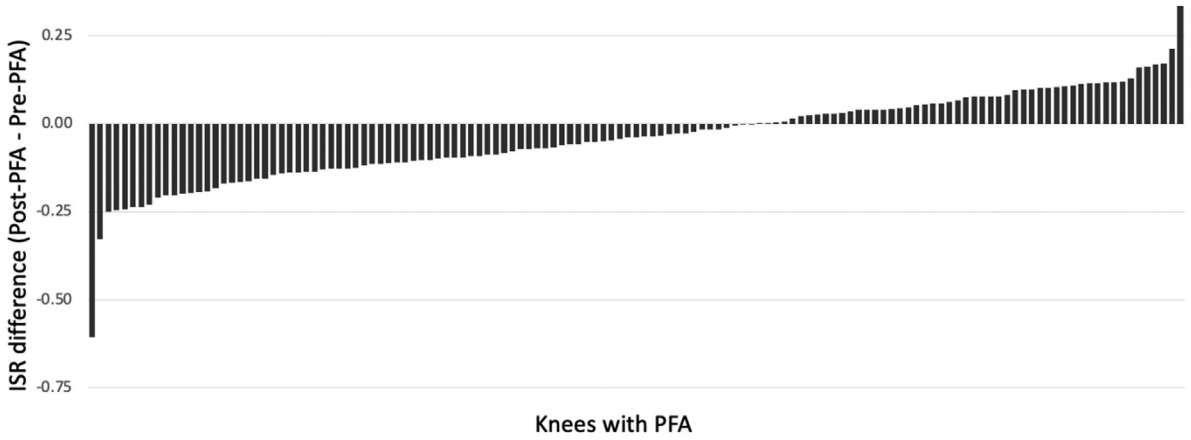

Fig. 3 Change in Insall–Salvati ratio (ISR) from before to after PFA for all knees.

Table 2 Mean preoperative PROMs for all knees ($n = 73$), knees with patella alta ($n = 50$), and knees without patella alta ($n = 23$) with comparison by *t*-test

	All patients ($n = 73$)	Patella alta ($n = 50$)	No patella alta ($n = 23$)	*p*-Value
Pre-OP Kujala	47.8 ± 12.9	50.4 ± 12.8	42.3 ± 11.4	0.011
Pre-OP IKDC	36.0 ± 12.2	37.7 ± 11.8	32.3 ± 12.5	0.075
Pre-OP VR-12 MH	52.7 ± 10.0	54.1 ± 8.1	49.7 ± 13.0	0.081
Pre-OP VR-12 PH	36.9 ± 10.3	38.6 ± 10.9	33.1 ± 8.0	0.036
Post-OP Kujala	70.9 ± 19.3	75.0 ± 18.4	61.9 ± 18.6	0.0061
Post-OP IKDC	62.1 ± 20.6	66.1 ± 20.3	53.4 ± 18.6	0.013
Post-OP VR-12 MH	51.8 ± 11.0	51.5 ± 11.9	52.6 ± 9.2	0.70
Post-OP VR-12 PH	47.4 ± 10.2	49.5 ± 9.7	42.9 ± 10.0	0.0096
Follow-up time (y)[a]	1.90 ± 1.32	2.02 ± 1.5	1.67 ± 0.82	0.23

Abbreviations: IKDC, International Knee Documentation Committee; Post-OP, postoperative; Pre-OP, preoperative VR-12, Veterans RAND 12-Item Health Survey;
[a]Years between surgery and postoperative PROMs were recorded for 63 knees, including 42 knees with patella alta and 21 without patella alta.

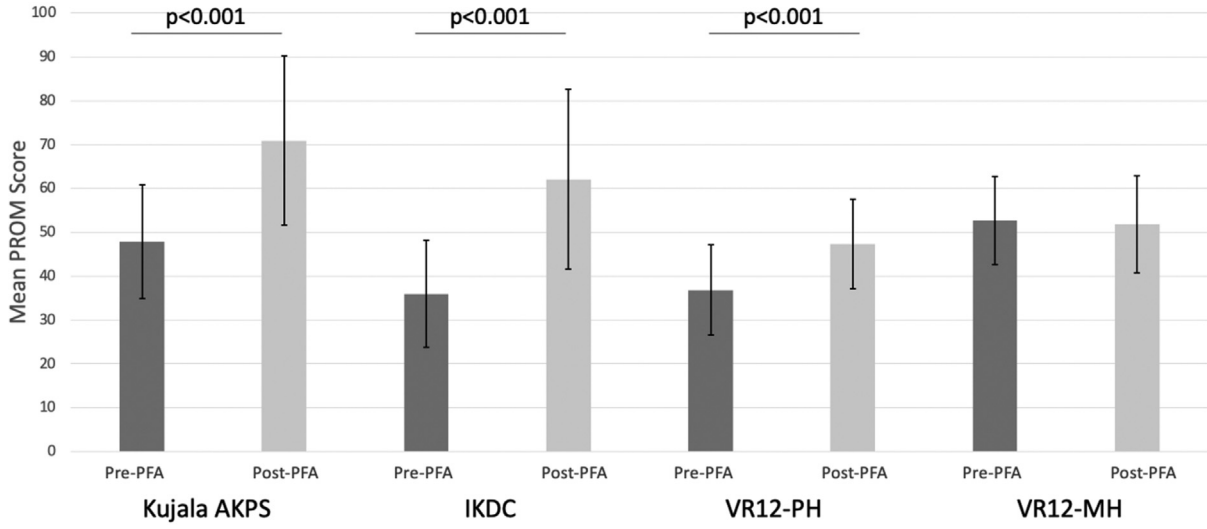

Fig. 4 Mean PROMs pre- and post-PFA ($n = 73$). Standard deviations represented by error bars for significant differences. PFA, patellofemoral arthroplasty; PROM, patient-reported outcome measures.

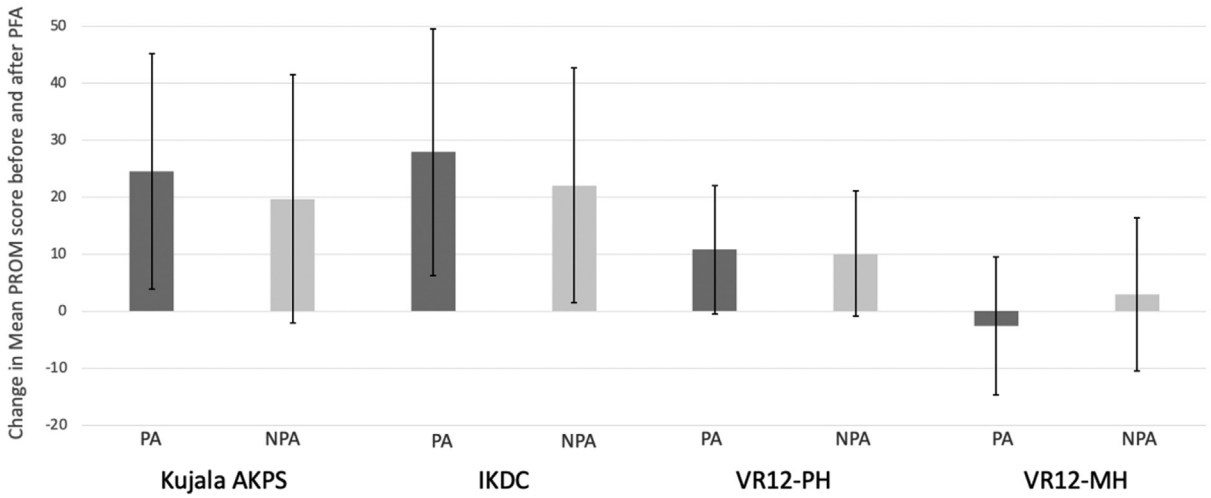

Fig. 5 Change in mean PROMs from pre-PFA to post-PFA for knees with (PA, $n = 51$) versus without (NPA, $n = 22$) patella alta. No significant differences. PA, patella alta; NPA, no patella alta; PFA, patellofemoral arthroplasty.

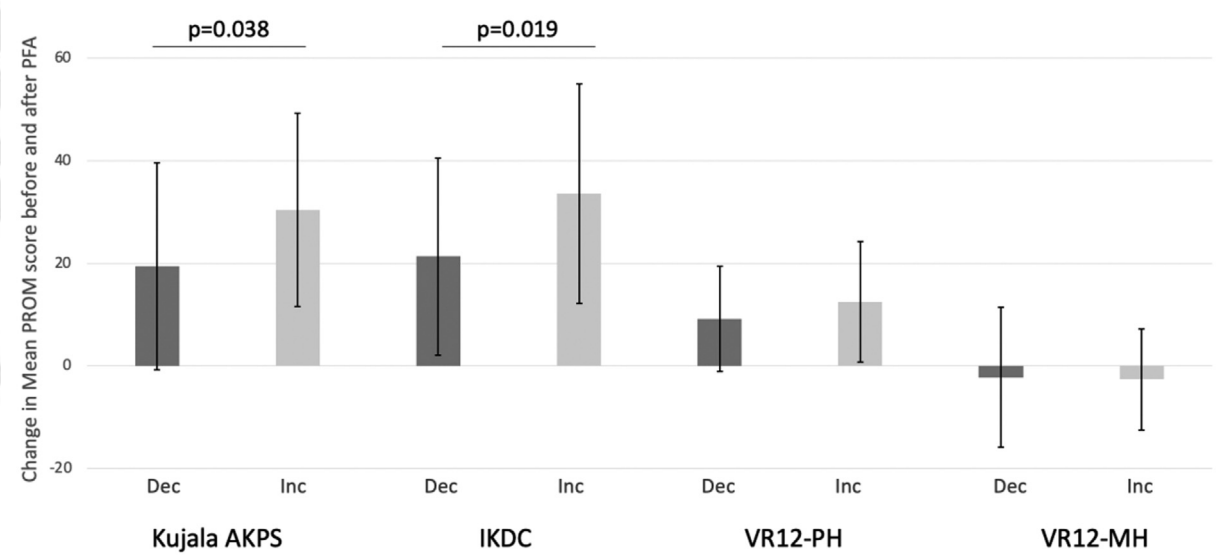

Fig. 6 Change in mean PROMs from pre-PFA to post-PFA for patella alta knees with decreased ($n = 26$) versus increased ($n = 25$) ISR after PFA. Standard deviations represented by error bars for significant differences. ISR, Insall–Salvati ratio; PFA, patellofemoral arthroplasty; PROM, patient-reported outcome measures.

patients without patella alta, but this difference was not statistically significant. Of patients who had patella alta before surgery, those with increased patellar heights reported more positive outcomes than patients with lower patella positions. These findings challenge our prediction that PFA leads to better outcomes due to concomitant patella alta correction.

If patella alta predisposes knees to patellofemoral arthritis, we would assume that lowering patellar height during PFA would correct patella alta, realign the patella, and trochlear groove and normalize contact forces, which would lead to better outcomes. However, the data show that patients reported more positive improvements when patella height increased than when it decreased. The reason for this is unclear. Future studies should increase the sample size. Also, some studies on TKA and patellar height warn against the risks of patella baja, or a low patella position, such as worse flexion ability and greater fracture risk.[17,18] Patients in this study may have had radiographic patella alta but clinically normal knees. Lowering the patellar height may have caused relative patella baja and less positive postoperative outcomes.

However, it should be noted that PROMs in this study showed positive outcomes after PFA regardless of whether patients presented with patella alta or had changes in patellar height. The overall decrease in patellar height and positive

PROMs after PFA support our hypotheses that PFA is both an effective treatment for patellofemoral arthritis and potential corrective measure for patella alta.

This finding is important because many patients who require PFA due to patellofemoral arthritis have underlying patella alta. Patellofemoral malalignment due to a high patella can disrupt patella tracking and cause cartilage degeneration. Correcting patella alta could not only lead to better knee physiology but may also reduce polyethylene wear over time. In comparison to TKA, more of the native knee anatomy is preserved by correcting only the affected patellofemoral compartment. According to the PROMs in this study, PFA leads to favorable outcomes for all patients.

A limitation of this study is that PROMs were collected up to 6 years after surgery, and patient outcomes are variable during this time frame. To control for variable outcomes with time, future studies should collect PROMs at exactly 1 or 2 years postoperation. Another limitation is that there is some variability in the lateral X-ray images on which some knees were flexed slightly more or less than 30 degrees. If the imaging technique was more consistent, the results of this study may have been stronger. This study only addressed the relationship between PFA and patella alta. To study other forms of patella maltracking, future studies can look at the effects of trochlear dysplasia, genu varus/valgus, and patellar tilt on patellofemoral OA and PFA. Further studies can also assess whether patellofemoral OA patients with greater degrees of patella alta would benefit more from staged or concurrent tibial tubercle distalization.

This study shows that there is a high incidence of patella alta among patients with patellofemoral arthritis. In a single surgery, PFA can replace the damaged patellofemoral joint and partially correct patella tracking on the trochlear groove. The decision between PFA and TKA is controversial. Our findings will assist surgeons in patient selection for PFA to optimize postoperative outcomes.

Conflict of Interest
None declared.

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