The Clinical Effect of Trochlear Dysplasia on Medial Patellofemoral Ligament Reconstruction: Supratrochlear Spur and Lateral Inclination

Jin-Gyu Kim, MD*,†, Junwoo Byun, MD*,†, Min Jung, MD*,‡, Kwangho Chung, MD*,§, Hyun-Soo Moon, MD*,‡, Se-Han Jung, MD*,‡, Chong-Hyuk Choi, MD*,‖, Sung-Hwan Kim, MD*,†

*Arthroscopy and Joint Research Institute, Yonsei University College of Medicine, Seoul,
†Department of Orthopedic Surgery, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul,
‡Department of Orthopedic Surgery, Severance Hospital, Yonsei University College of Medicine, Seoul,
§Department of Orthopedic Surgery, Yongin Severance Hospital, Yonsei University College of Medicine, Yongin,
‖Department of Orthopedic Surgery, Yonsei Bonsarang Hospital, Bucheon, Korea

Background: The Dejour classification is widely accepted for grading the severity of trochlear dysplasia. However, whether it serves as a reliable prognostic marker for patellar instability surgery or a guide for clinical decision-making has yet to be established. Medial patellofemoral ligament (MPFL) reconstruction, with or without tibial tubercle osteotomy (TTO), yields comparable outcomes across Dejour grades. Nonetheless, we hypothesized that specific trochlear parameters would be more significant predictors of surgical results.

Methods: This study included patients who underwent MPFL reconstruction, with or without TTO, for recurrent patellar dislocation at a single institution between 2010 and 2023. Patients with at least 1 year of follow-up were included. Preoperative demographics, radiographic measurements such as sulcus angle, lateral trochlear inclination (LTI), and trochlear depth, patient-reported outcome measures (PROMs), and intraoperative findings including cartilage status were analyzed. Severe trochlear dysplasia (STD) was categorized as Dejour B/D, while non-STD encompassed all other cases, and these 2 groups were compared. Postoperative PROMs were assessed at 1 year postoperatively and at the final follow-up. A noninferiority test was performed using Kujala, Lysholm, and International Knee Documentation Committee (IKDC) scores, with the inferiority margin defined by the minimal clinically important difference (MCID). Linear relationships between LTI, a widely used indicator of trochleoplasty, and PROMs were evaluated. Additionally, differences in the proportion of patients achieving MCID, substantial clinical benefit, and patient-acceptable symptom state were analyzed using odds ratios.

Results: Forty-two knees (41 patients) were finally enrolled. Radiographic measurements, except for LTI at the most proximal trochlea, showed no significant differences between the STD and non-STD groups. Clinical outcomes also demonstrated no significant differences between the 2 groups, and noninferiority was confirmed. When analyzed based on LTI, no differences in PROMs were observed at the postoperative 1 year. However, at the final follow-up (mean, 37.27 months), the most proximal trochlear LTI showed significant correlations with both Kujala and Knee Injury and Osteoarthritis Outcome Score over the follow-up period.

Conclusions: MPFL reconstruction, with or without TTO, leads to similar clinical improvements for STD classified by Dejour criteria. However, when assessed using proximal LTI, dysplasia's role as a prognostic factor should be considered.

Keywords: *Patellar dislocation, Patellar ligament, Knee joint, Lateral trochlear inclination*

53

Kim et al. Medial Patellofemoral Ligament Reconstruction and Lateral Trochlear Inclination
Clinics in Orthopedic Surgery • Vol. 18, No. 1, 2026 • www.ecios.org

Correspondence to: Sung-Hwan Kim, MD
Department of Orthopedic Surgery, Gangnam Severance Hospital, Yonsei University College of Medicine, 211 Eonju-ro, Gangnam-gu, Seoul 06273, Korea
Tel: +82-2-2019-3415, Fax: +82-2-573-5393, E-mail: orthohwan@yuhs.ac

Patellar dislocation can result from various causes, with trochlear dysplasia being a representative risk factor.[1-3] The Dejour classification is the most commonly used method for categorizing dysplasia.[2,4,5] The supratrochlear bump, in particular, is known as the greatest risk factor for lateral deviation.[6] However, there is much debate on how to define severe trochlear dysplasia (STD), and ultimately, there is limited evidence on which classification of dysplasia is reliably indicative of a poor prognosis.[2,5,7,8]

In many studies evaluating dysplasia, comparisons have primarily been made between normal groups and those with recurrent patellar dislocation.[1,8,9] However, few studies have investigated how the severity of dysplasia affects postoperative outcomes in patients with dysplasia, aside from biomechanical studies. For this reason, various methods, including sulcus angle, trochlear depth, and lateral trochlear inclination (LTI), are employed to assess severe dysplasia. Notably, among the trochleoplasty procedures, sulcus deepening trochleoplasty is most commonly performed.[10] The indications for this procedure often involve cases of Dejour B/D dysplasia with a prominent supratrochlear spur or additional considerations such as a large spur or lower LTI.[11-13] Long-term follow-up studies have also been reported, demonstrating its effectiveness as a surgical approach.[11-15] However, many surgeons have achieved favorable outcomes using only medial patellofemoral ligament (MPFL) reconstruction or with tibial tubercle medialization based on tibial tubercle-trochlear groove (TT-TG) distance.[3,16-19]

The purpose of this study was to evaluate the influence of trochlear dysplasia on postoperative outcomes and to investigate the impact of specific variables on these results. This study hypothesized that MPFL reconstruction, with or without tibial tubercle osteotomy (TTO), yields similar clinical outcomes, regardless of Dejour classification severity. Specific parameters of trochlear dysplasia may influence these outcomes.

METHODS

This study was approved by the Institutional Review Board of Gangnam Severance Hospital (IRB No. 3-2024-0348), and the requirement for informed consent was waived due to its retrospective design.

Patient Selection
This was a retrospective study conducted at a single institution, covering patients from 2010 to 2023. The inclusion criteria were patients who underwent MPFL reconstruction with or without TTO for recurrent patellar dislocation (more than twice) and had at least 1 year of follow-up. The exclusion criteria included cases involving an osteotomy other than that of the tibial tubercle, patients with neuromuscular diseases, and cases involving concomitant procedures in the tibiofemoral compartment.

Radiologic Assessment
Knee radiographs included anteroposterior, merchant, and lateral views with the knee positioned at 30° of flexion. Trochlear dysplasia was classified using the Dejour classification and divided into 2 groups: the STD group (Dejour types B and D) and the non-severe group (non-STD) (Dejour types A, C, or normal). The classification of Dejour types was determined not only from x-ray images but also with confirmation of trochlear morphology using magnetic resonance imaging (MRI).[4] Patellar height was measured using the Caton-Deschamps index. The sulcus angle, patellar tilt, and congruence angle were measured on the knee merchant view. The TT-TG distance was measured on computed tomography (CT). Sulcus angle, LTI, and trochlear depth were measured on the MRI axial view at the level where the Roman arch appearance of the intercondylar notch was most visible, according to the method by Tanaka et al.[1] LTI was measured using the 2-image technique at the level where the epicondyle axis and the most proximal cartilage were visible, according to the method by Joseph et al.,[20] and the trans-anatomical epicondyle axis among the 3 axes (anatomical epicondyle, surgical epicondyle, and posterior femoral condyle), as described by Chen et al.,[9] was used (Fig. 1).

Patient-Reported Outcome Measures
At our institution, all surgical patients routinely completed knee-specific scoring questionnaires during outpatient visits. Clinical and functional outcomes were recorded using the Kujala, Lysholm, International Knee Documentation
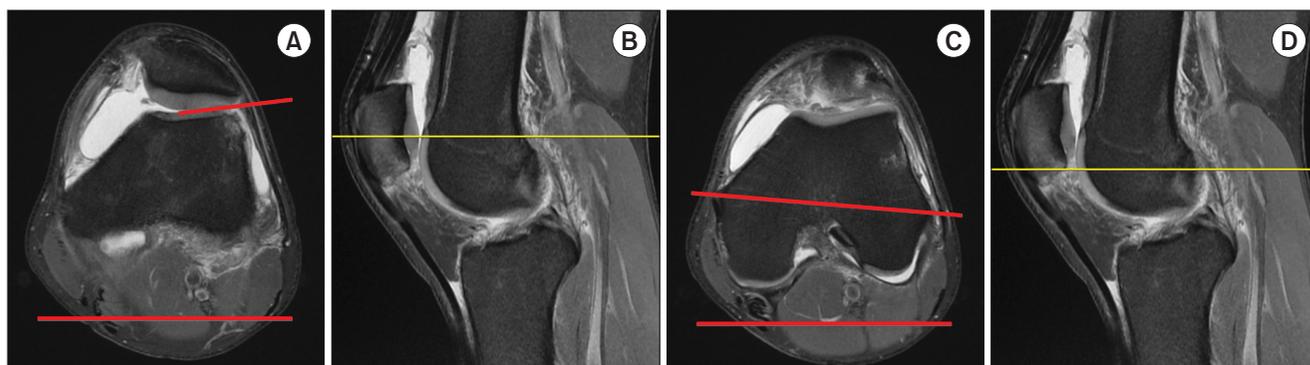
54

Kim et al. Medial Patellofemoral Ligament Reconstruction and Lateral Trochlear Inclination

Clinics in Orthopedic Surgery • Vol. 18, No. 1, 2026 • www.ecios.org

Fig. 1. Measurement of lateral trochlear inclination (LTI) using the 2-image technique according to Chen et al.[9] (A) The most proximal axial magnetic resonance imaging (MRI) image displays the cartilaginous trochlea on a sagittal slice. A red tangent line is drawn to the lateral trochlear cartilaginous surface, and a red horizontal baseline reference line is drawn. (B) The cross-sectional sagittal MRI image shows the most proximal area of the lateral trochlear facet cartilage, with the axial slice level indicated by a yellow line. (C) The anatomical trans-epicondylar axis is displayed in the axial plane with a red line, and a red horizontal baseline reference line is drawn. (D) The cross-sectional sagittal MRI image shows the reference level for the epicondylar axis indicated by a yellow line. By measuring the angle between the baseline horizontal line and the lateral trochlear surface (A) or the anatomical trans-epicondylar axis line (C), we calculated the LTI using these 2 angles.

Committee (IKDC) subjective scores, and Knee injury and Osteoarthritis Outcome Score (KOOS). Postoperative complications, including re-dislocation and infection, were also assessed.

Surgical Technique

At our institution, MPFL reconstruction is performed in cases of recurrent patellar dislocation, unless there is severe valgus alignment or femoral anteversion. If the TT-TG distance exceeds 20 mm, a TTO is performed. For MPFL reconstruction, either an autologous hamstring graft or an allogeneic tibialis tendon was used in all cases. The patellar side is fixed by attaching the tendon to the medial margin of the patella using 2 suture anchors. The 2 anchors are positioned at the superior one-third portion and the midline. On the femoral side, fixation is performed using an interference screw at the superior point of the vertical line, passing just anterior to the extension of the femur posterior cortex, and the most posterior point of Blumensaat's line on the lateral view, with the aid of a C-arm. All patients underwent reconstruction using the double bundle technique. Tension was applied by fixing the patella with less than one-quarter lateral movement at 20° knee flexion after approximately 20 cycles of knee range of motion (ROM). For TTO, an osteotomy was performed from the lateral side to the medial side using a saw and osteotome, followed by 10-mm medialization and fixation with 3 cortical screws. The grade and size of cartilage defects were also measured and recorded arthroscopically by a senior surgeon (SHK).

Statistical Analysis

A noninferiority test was performed to compare the 2 groups using Kujala, Lysholm, and IKDC scores. According to Qiao et al.,[21] the noninferiority margin was defined as the minimal clinically important difference (MCID) for improvement in scores from preoperative to final follow-up (Kujala MCID, 9.1; Lysholm MCID, 11.1; IKDC MCID, 9.9). Noninferiority was evaluated by comparing the 95% CIs of the differences in each representative variable between the groups with the corresponding noninferiority margin.

The Wilcoxon signed-rank test was used for continuous variables, and the chi-square or Fisher exact test was applied for categorical variables to compare results, including demographics, radiographic measurements, and patient-reported outcome measures (PROMs) between the groups. For preoperative and postoperative clinical scores, the paired Wilcoxon signed-rank test was performed. Linear regression was conducted to assess correlations between continuous variables.

To analyze risk factors associated with achieving specific thresholds (MCID, substantial clinical benefit [SCB], and patient-acceptable symptom state [PASS]), odds ratios were calculated by comparing groups that met or did not meet these criteria. Statistical significance was set at a *p*-value < 0.05. All statistical analyses and graph generation were performed using RStudio (version 4.4.1, R Foundation for Statistical Computing).
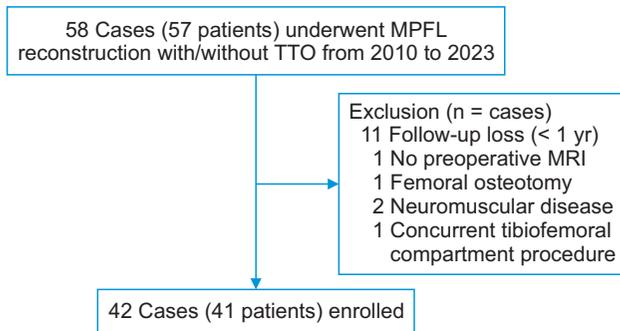
55

Kim et al. Medial Patellofemoral Ligament Reconstruction and Lateral Trochlear Inclination
Clinics in Orthopedic Surgery • Vol. 18, No. 1, 2026 • www.ecios.org

RESULTS

A total of 58 knees from 57 patients were screened, and based on the exclusion criteria, 42 knees (41 patients) were finally enrolled (Fig. 2). The demographic characteristics, including age, sex, body mass index, affected side, and follow-up period, showed no significant differences between the 2 groups (STD and non-STD). Similarly, radiographic parameters such as the sulcus angle, trochlear depth, and LTI measured using the single-image technique were comparable between the groups. However, the LTI measured using the 2-image technique was significantly lower in the STD group (11.03 ± 7.47) compared to the non-STD group (18.72 ± 9.21, $p < 0.05$) (Table 1).

Fig. 2. Flowchart of patient inclusion in the study. MPFL: medial patellofemoral ligament, TTO: tibial tubercle osteotomy, MRI: magnetic resonance imaging.

Table 1. Demographics and Radiographic Characteristics				
Variable	STD (n = 29)	Non-STD (n = 13)	ICC*	p-value
Demographics				
Age (yr)	23.55 ± 6.73	23 ± 6.71	-	0.78
Sex (male : female)	12 (41.4) : 17 (58.6)	7 (53.8) : 6 (46.2)	-	0.52
BMI (kg/m^2)	22.97 ± 3.49	22.81 ± 3.33	-	0.89
Side (right : left)	12 (41.4) : 17 (58.6)	4 (30.8) : 9 (69.2)	-	0.73
Follow-up (mo)	34.92 ± 30.9	42.52 ± 32.26	-	0.31
X-ray[†]				
Caton-Deschamps index	1.16 ± 0.16	1.20 ± 0.15	0.71	0.49
Sulcus angle	142.80 ± 8.62	139.80 ± 7.96	0.51	0.49
Congruence angle	25.32 ± 18.93	20.77 ± 22.54	0.93	0.83
Patellar tilt	27.60 ± 9.80	30.00 ± 10.85	0.89	0.87
Spur depth	4.75 ± 3.01	3.42 ± 1.88	0.28	0.13
CT[†]				
TT-TG distance	18.76 ± 3.80	19.01 ± 3.90	0.83	0.72
MRI[†]				
Sulcus angle	154.80 ± 9.98	153.30 ± 12.14	0.96	0.91
Trochlear depth	2.27 ± 1.35	2.91 ± 1.46	0.83	0.30
LTI				
Single image technique	13.73 ± 8.00	15.89 ± 7.44	0.83	0.28
Two-image technique	11.03 ± 7.47	18.72 ± 9.21	0.97	0.01

Values are presented as mean ± standard deviation or number (%).
STD: severe trochlear dysplasia, ICC: intraclass correlation coefficient, BMI: body mass index, CT: computed tomography, TT-TG: tibial tubercle-trochlear groove, MRI: magnetic resonance imaging, LTI: lateral trochlear inclination.
*ICC stands for intra-rater correlation and was only indicated for radiographic assessment. [†]The image modalities used to measure the following variables.

56

Kim et al. Medial Patellofemoral Ligament Reconstruction and Lateral Trochlear Inclination
Clinics in Orthopedic Surgery • Vol. 18, No. 1, 2026 • www.ecios.org

Table 2. Comparison of Osteotomy, Cartilage Condition, Procedure, and Graft in STD vs. Non-STD

Variable	STD (n = 29)	Non-STD (n = 13)	*p*-value
TTO			0.46
No osteotomy	15 (51.7)	5 (38.5)	
Fulkerson	2 (6.8)	0	
Elmslie-Trillat	12 (41.4)	8 (61.5)	
Cartilage defect			
ICRS grade			
G0 : 1 : 2 : 3 : 4	7 : 0 : 2 : 14 : 6	7 : 1 : 1 : 2 : 2	0.10
Low : high*	9 (31) : 20 (69)	9 (69) : 4 (31)	0.04
Size (mm^2)	128.6 ± 126.0	51.2 ± 77.3	0.03
Cartilage procedure			0.26
No procedure	24 (82.8)	12 (92.3)	
Microfracture/drilling	3 (10.3)	1 (7.7)	
ACI	1 (3.4)	0	
Graft (auto : allo)[†]	23 (79.3) : 6 (20.7)	13 (100) : 0	0.15

Values are presented as number (%) or mean ± standard deviation.
STD: severe trochlear dysplasia, TTO: tibial tubercle osteotomy, ICRS: International Cartilage Repair Society, ACI: autologous chondrocyte implantation.
*Low, ICRS G0–2; High, ICRS G3–4. [†]The auto group had autologous hamstring tendon grafts, whereas the allo group had allogeneic tibialis tendon grafts.

From the surgical perspective, no significant differences were observed between the 2 groups regarding the need for osteotomy, cartilage procedures, and ligament graft. However, in the STD group, the size of cartilage defects and the proportion of high-grade defects (International Cartilage Repair Society [ICRS] grades 3 and 4) were significantly larger and deeper compared to the non-STD group, indicating more severe cartilage damage in the STD group (Table 2).

When comparing preoperative and final postoperative PROMs within each group, the STD group demonstrated significant improvements in Kujala, Lysholm, IKDC, and KOOS subscores ($p < 0.05$). Similarly, the non-STD group showed significant improvements in Kujala, Lysholm, and IKDC scores ($p < 0.05$); however, the improvements in KOOS subscores were not statistically significant ($p > 0.05$). Separately, a comparison of PROMs between the osteotomy and non-osteotomy groups revealed no significant differences (Table 3). When comparing STD and non-STD groups directly, no significant differences were observed in the final scores (Table 4). A non-inferiority analysis was performed to assess the differences in improvements in Kujala, Lysholm, and IKDC scores between the 2 groups, using

their respective MCIDs as the threshold (Fig. 3).

Supratrochlear Bump and LTI
STD (Dejour B/D), characterized by the presence of a supratrochlear bump, demonstrated significant differences in LTI measured using the 2-image technique compared to other continuous variables. Based on this observation, LTI was analyzed as an independent variable to evaluate its relationship with improvements in PROMs at 1 year postoperatively and at the final follow-up. Additionally, the association between LTI and final PROM outcomes was analyzed separately (Table 5).

There was no significant correlation between LTI and postoperative scores at the 1-year follow-up. However, at the final follow-up, significant associations were observed between LTI and Kujala scores as well as KOOS subscores related to sports and symptoms ($p < 0.05$) (Table 5, Fig. 4).

Odds Ratio for Achieving MCID, SCB, and PASS
According to Dippmann et al.,[13] it has been suggested that an LTI < 11° is an indication for trochleoplasty. In this cohort, 41% (17 of 42 cases) fell into this category. The study

57

Kim et al. Medial Patellofemoral Ligament Reconstruction and Lateral Trochlear Inclination
Clinics in Orthopedic Surgery • Vol. 18, No. 1, 2026 • www.ecios.org

Table 3. Intergroup PROM Comparison: With vs. Without Osteotomy

Variable	Preoperative			Final follow-up		
	Osteotomy	No-osteotomy	p-value	Osteotomy	No-osteotomy	p-value
Kujala	61.09 ± 24.31	60.85 ± 21.82	0.99	80.14 ± 16.11	80.25 ± 22.19	0.55
Lysholm	67.45 ± 25.69	63.45 ± 24.14	0.62	83.50 ± 13.15	80.95 ± 20.15	0.88
IKDC	52.69 ± 18.23	53.74 ± 17.19	0.55	68.65 ± 18.64	74.20 ± 15.04	0.42
KOOS	69.94 ± 17.95	70.78 ± 18.98	0.84	81.99 ± 13.94	86.00 ± 14.14	0.25
Sports	45.45 ± 29.03	48.38 ± 32.45	0.77	64.09 ± 26.84	74.75 ± 21.37	0.17
QOL	39.21 ± 25.83	47.82 ± 23.32	0.17	55.69 ± 24.63	66.89 ± 19.98	0.11
ADL	79.68 ± 19.91	81.92 ± 18.50	0.78	91.98 ± 11.93	93.67 ± 11.45	0.58
Pain	75.00 ± 18.11	73.57 ± 16.97	0.91	85.86 ± 13.74	87.22 ± 16.72	0.61
Symptom	70.77 ± 21.73	69.39 ± 23.20	0.91	80.68 ± 14.78	84.83 ± 17.58	0.22

Values are presented as mean ± standard deviation.
PROM: patient-reported outcome measure, IKDC: International Knee Documentation Committee, KOOS: Knee injury and Osteoarthritis Outcome Score, QOL: quality of life, ADL: activities of daily living.

Table 4. Intergroup PROM Comparison: STD vs. Non-STD

Variable	Preoperative			Final follow-up		
	STD	Non-STD	p-value	STD	Non-STD	p-value
Kujala	59.03 ± 21.95	65.31 ± 25.20	0.26	80.24 ± 16.44	80.08 ± 24.56	0.71
Lysholm	64.69 ± 23.36	67.46 ± 28.50	0.60	82.72 ± 13.44	81.31 ± 22.97	0.59
IKDC	52.19 ± 16.95	55.43 ± 19.29	0.58	71.23 ± 16.91	71.45 ± 18.05	0.92
KOOS	69.76 ± 17.20	71.62 ± 21.01	0.76	84.35 ± 11.92	82.89 ± 18.37	0.67
Sports	45.17 ± 29.41	50.58 ± 33.29	0.60	67.59 ± 24.84	72.69 ± 24.97	0.40
QOL	41.38 ± 23.94	47.61 ± 26.96	0.43	59.28 ± 21.88	64.91 ± 25.73	0.37
ADL	80.28 ± 18.69	81.79 ± 20.57	0.69	93.51 ± 10.07	91.18 ± 14.79	0.69
Pain	73.66 ± 16.58	75.78 ± 19.65	0.88	87.93 ± 12.29	83.33 ± 20.16	0.68
Symptom	69.83 ± 19.79	70.75 ± 27.68	0.68	83.87 ± 12.14	79.94 ± 23.04	0.97

Values are presented as mean ± standard deviation.
PROM: patient-reported outcome measure, STD: severe trochlear dysplasia, IKDC: International Knee Documentation Committee, KOOS: Knee injury and Osteoarthritis Outcome Score, QOL: quality of life, ADL: activities of daily living.

then categorized patients according to whether they met the satisfaction criteria—namely MCID, SCB, or PASS—for each PROM, and calculated the corresponding odds ratios. Odds ratios were used to evaluate the association of LTI < 11° as a risk factor with achieving improvement (MCID, SCB) or reaching satisfactory final scores (PASS) for each PROM (Fig. 5, Table 6). Although statistical significance was observed only for the KOOS subscore re-

lated to activities of daily living (ADL) in achieving SCB, a general trend of odds ratios of less than 1 was noted across all outcomes. This suggests a potential association between LTI < 11° and a lower likelihood of achieving these satisfaction thresholds.

Among the 42 cases, redislocation occurred in only 1 case (2.4%), which was attributed to traumatic redislocation. This case was notable for a shallow trochlea,
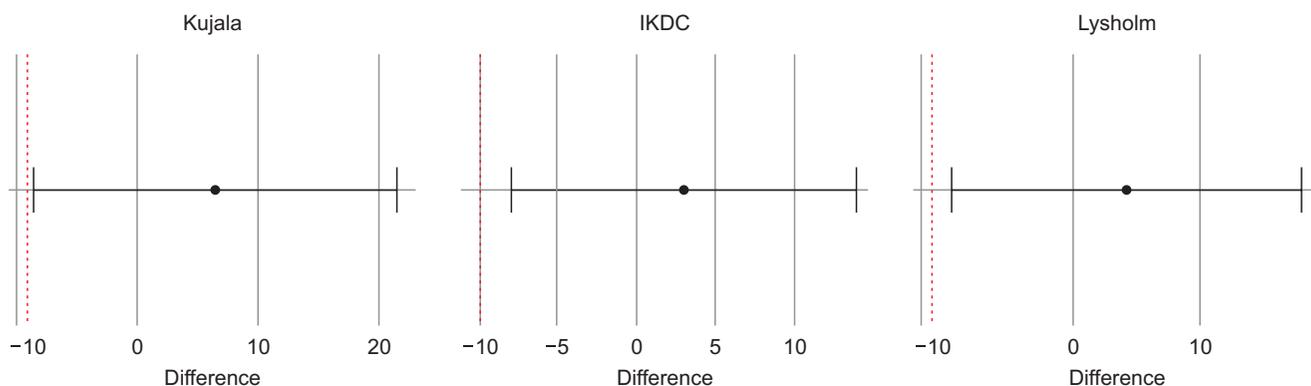
58

Kim et al. Medial Patellofemoral Ligament Reconstruction and Lateral Trochlear Inclination
Clinics in Orthopedic Surgery • Vol. 18, No. 1, 2026 • www.ecios.org

Fig. 3. Noninferiority test with 95% CI of each patient-reported outcome measure. The lower CI is higher than the inferior margin in Kujala, International Knee Documentation Committee (IKDC), and Lysholm scores. The mean differences of clinical outcomes were 6.44 (95% CI, −8.63 to 21.50) for the Kujala score, 3.02 (95% CI, −7.93 to 13.96) for the IKDC score, and 4.19 (95% CI, −9.60 to 17.97) for the Lysholm score.

Table 5. Linear Correlation between PROM and LTI

Variable	Preoperative		Postop 1 yr		Final follow-up	
	R^2	p-value	R^2	p-value	R^2	p-value
Kujala	0.004	0.70	0.074	0.10	0.160	0.01*
Lysholm	0.048	0.16	0.013	0.49	0.040	0.19
IKDC	0.007	0.59	0.020	0.36	0.070	0.10
KOOS	0.003	0.73	0.037	0.24	0.134	0.02*
Sports	0.044	0.18	0.095	0.06	0.195	0.003*
QOL	0.242	0.33	0.008	0.58	0.080	0.07
ADL	0	0.97	0.044	0.20	0.081	0.07
Pain	0	0.92	0.008	0.59	0.091	0.05
Symptom	0.027	0.29	0.007	0.61	0.111	0.03*

PROM: patient-reported outcome measure, LTI: lateral trochlear inclination, IKDC: International Knee Documentation Committee, KOOS: Knee injury and Osteoarthritis Outcome Score, QOL: quality of life, ADL: activities of daily living.
*Statistically significant ($p < 0.05$).
R^2 refers to the square of the Pearson correlation coefficient in linear correlations.

characterized by an LTI of 11°, a sulcus angle of 156°, and a trochlear depth of 1.8 mm, classified as Dejour type A. Aside from this, no other complications, such as infections, were observed.

DISCUSSION

The findings in this study indicate that the LTI at the most proximal trochlea has an impact even after MPFL reconstruction with or without TTO. This aligns with recent trends in trochlear morphology research using 3-dimensional modeling, which emphasize the importance of a lateralized entry point.[8] Trochlear dysplasia is a significant

risk factor for recurrent patellar dislocation and has been evaluated using various methods. Among these, the Dejour classification remains the most widely used system. Types B and D, characterized by a supratrochlear spur, are often classified as severe dysplasia.[11] The spur reflects an anteriorly positioned trochlear groove relative to the lateral trochlear facet, which is associated with biomechanical changes in the patellofemoral joint.[6,22] However, its limitations as a categorical variable in predicting clinical outcomes and guiding surgical interventions are increasingly acknowledged.[23,24] To address these limitations, alternative assessment methods—such as sulcus angle, trochlear depth, and LTI—have been explored.[1,2,5,9,24] Notably, the

59

Kim et al. Medial Patellofemoral Ligament Reconstruction and Lateral Trochlear Inclination

Clinics in Orthopedic Surgery • Vol. 18, No. 1, 2026 • www.ecios.org
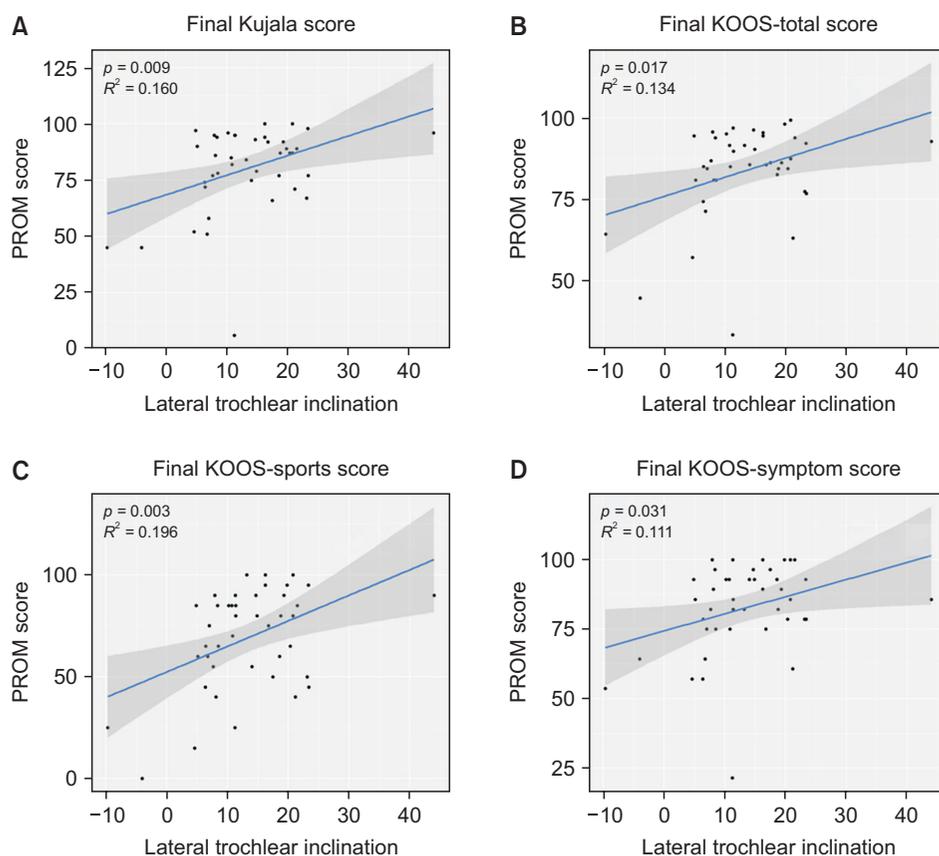
Fig. 4. Linear relationships between lateral trochlear inclination (LTI) at the most proximal trochlea and patient-reported outcome measures. Graphs depict the significant associations identified in Table 5. The relationship between LTI and final follow-up scores. (A) Kujala score. (B) Knee injury and Osteoarthritis Outcome Score (KOOS)-total score. (C) KOOS-sports score. (D) KOOS-symptom score. PROM: patient-reported outcome measure.

values reported by Tanaka et al.,[1] who were the first to present these figures and discuss the intraclass correlation coefficients (ICCs) (sulcus angle, 0.93; trochlear depth, 0.89; LTI, 0.88), are similar to the ICC values found in our study (Table 1).[1] In particular, their finding that the ICC for LTI at the most proximal trochlea was higher than that at the more distal trochlea aligns with our results (single-image LTI, 0.83; 2-image LTI, 0.97) (Table 1).[9,20]

Surgeons performing trochleoplasty have suggested using the depth of the supratrochlear spur or LTI as additional criteria for determining the need for surgical intervention.[11] Good outcomes have been reported in groups undergoing trochleoplasty.[12,25-27] However, some studies have pointed out that there is a lack of evidence regarding patient selection for this procedure.[3,10,13] A recent systematic review concluded that there was no significant difference in outcomes between performing trochleoplasty in combination with MPFL reconstruction and performing MPFL reconstruction alone. It also noted that the indications for trochleoplasty varied across studies.[7]

This study utilized the Dejour classification to categorize patients into severe (types B/D) and non-severe dysplasia groups. While clinical outcomes based on this classification showed no significant differences, a significant distinction in LTI was observed between these groups (Table 2). Furthermore, LTI demonstrated a strong association with the improvement in PROMs, highlighting its prognostic value in surgical decision-making (Table 5).

The improvement from preoperative to final scores corresponded to MCID and SCB, while the absolute final scores aligned with PASS. To further explore this, the 3 patient satisfaction outcomes proposed by Qiao et al.[21] were analyzed across each PROM. Using the commonly cited threshold of 11° for LTI, which is traditionally considered an indication for trochleoplasty, this study calculated odds ratios for achieving these outcomes.[13] Although our study faced limitations due to a small sample size, resulting in wide CIs, notable trends were observed. Specifically, PASS achievement demonstrated a trend toward significance in Kujala scores and certain KOOS subscores ($p < 0.1$). Additionally, a significant difference was observed in SCB achievement for the KOOS-ADL subscore. These findings suggest that LTI, particularly when analyzed with a threshold of 11°, may serve as a valuable parameter for assessing patient satisfaction and guiding surgical decisions.

Regarding cartilage status, the relationship between increased sulcus angle in trochlear dysplasia and osteochondral damage has already been established.[28] In our
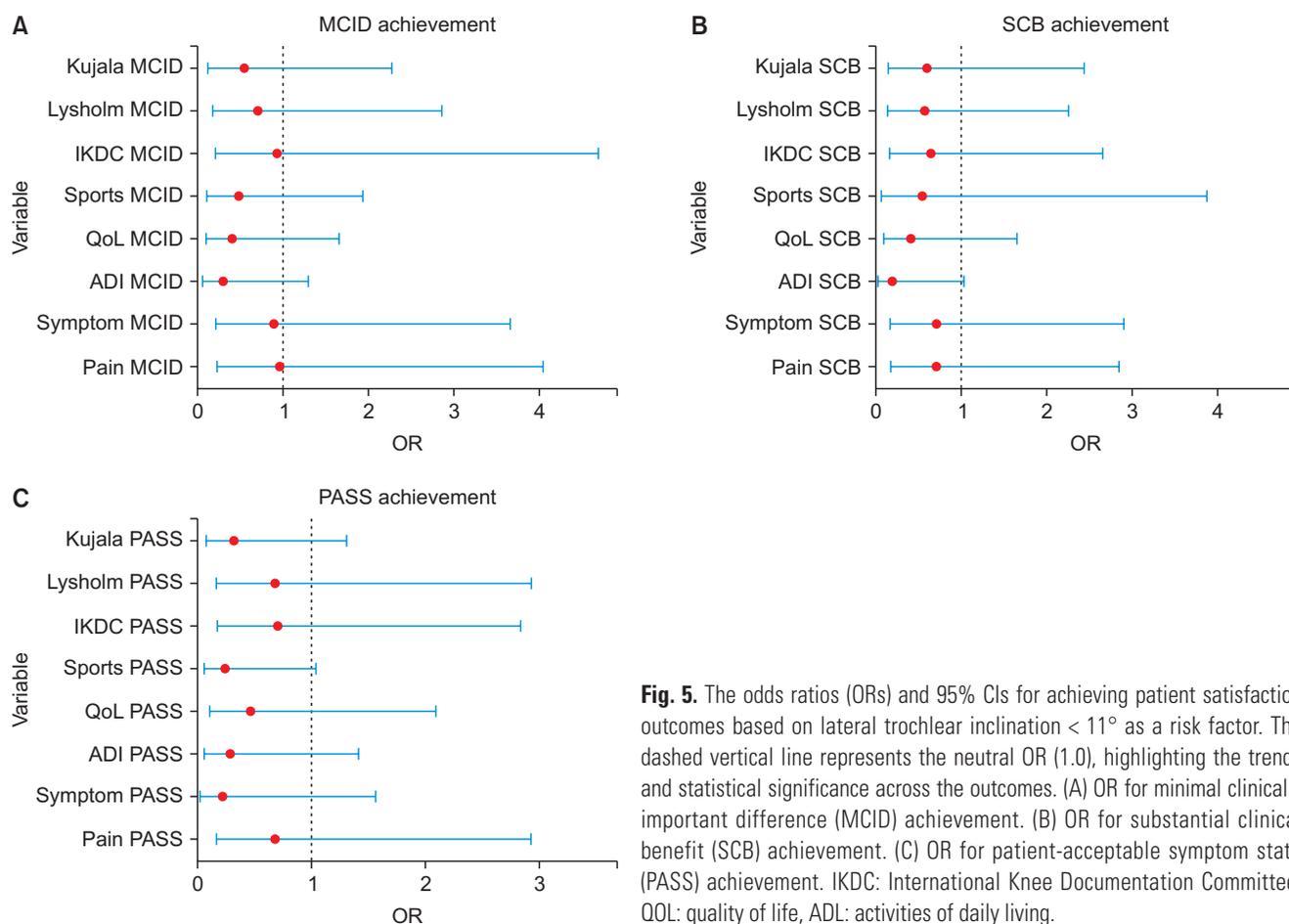
60

Kim et al. Medial Patellofemoral Ligament Reconstruction and Lateral Trochlear Inclination
Clinics in Orthopedic Surgery • Vol. 18, No. 1, 2026 • www.ecios.org

Fig. 5. The odds ratios (ORs) and 95% CIs for achieving patient satisfaction outcomes based on lateral trochlear inclination < 11° as a risk factor. The dashed vertical line represents the neutral OR (1.0), highlighting the trends and statistical significance across the outcomes. (A) OR for minimal clinically important difference (MCID) achievement. (B) OR for substantial clinical benefit (SCB) achievement. (C) OR for patient-acceptable symptom state (PASS) achievement. IKDC: International Knee Documentation Committee, QOL: quality of life, ADL: activities of daily living.

Table 6. OR for Achieving Patient Satisfaction

Variable	MCID		SCB		PASS	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
PROM						
Kujala	0.54 (0.13–2.27)	0.35	0.6 (0.14–2.44)	0.53	0.32 (0.07–1.31)	0.12
Lysholm	0.70 (0.17–2.85)	0.75	0.56 (0.13–2.26)	0.53	0.68 (0.16–2.94)	0.74
IKDC	0.94 (0.20–4.68)	> 0.90	0.64 (0.15–2.66)	0.53	0.7 (0.17–2.85)	0.75
KOOS						
Sports	0.48 (0.11–1.93)	0.35	0.54 (0.05–3.89)	0.68	0.24 (0.05–1.04)	0.06
QOL	0.40 (0.09–1.65)	0.21	0.40 (0.09–1.65)	0.21	0.46 (0.1–2.09)	0.31
ADL	0.29 (0.05–1.31)	0.11	0.18 (0.02–1.03)	0.04	0.28 (0.05–1.41)	0.09
Symptom	0.89 (0.21–3.66)	> 0.90	0.7 (0.16–2.91)	0.75	0.22 (0.02–1.57)	0.10
Pain	0.95 (0.23–4.04)	> 0.90	0.70 (0.17–2.85)	0.75	0.68 (0.16–2.94)	0.74

OR: odds ratio, MCID: minimally clinically important difference, SCB: substantial clinical benefit, PASS: patient acceptable symptomatic state, PROM: patient-reported outcome measure, IKDC: International Knee Documentation Committee, KOOS: Knee injury and Osteoarthritis Outcome Score, QOL: quality of life, ADL: activities of daily living.

61

Kim et al. Medial Patellofemoral Ligament Reconstruction and Lateral Trochlear Inclination
Clinics in Orthopedic Surgery • Vol. 18, No. 1, 2026 • www.ecios.org

study, as shown in Table 1, the STD group, characterized by a supratrochlear bump and low proximal LTI ($p = 0.01$), had significantly larger cartilage sizes and a tendency for high-grade lesion ICRS grades ($p < 0.05$) than the non-STD group. However, cartilage lesions were not directly associated with differences in clinical outcomes, consistent with other known studies.[29]

This study has limitations due to its retrospective cohort design, small sample size, and single-center scope, which risk a biased evaluation. Additionally, the follow-up period was short and varied widely. In addition, due to the retrospective observation of a limited number of cases over a long period, there were limitations in presenting the exact number of patellar dislocations or the precise time from trauma to surgery. Second, it is based on a small cohort, with only 1 case (2.4%) of re-dislocation occurring out of 42 cases postoperatively. This is lower than the generally known rate of 7% reported in a 2022 study by Cohen et al.[30] Therefore, this study could not determine if LTI affects re-dislocation in recurrent patellar dislocation. Furthermore, according to Tanaka et al.,[1] the cutoff value for LTI differs between males and females. Due to the small sample size in this study, this study could not analyze both sexes separately. Lastly, although numerous radiographic parameters can be applied to evaluate patel-

lofemoral pathology, this study focused on sulcus angle, LTI, and trochlear depth due to practical constraints. This narrowed focus may limit the generalizability of the findings.

In conclusion, MPFL reconstruction, with or without TTO, demonstrates noninferior improvements in clinical outcomes for STD, as classified by the Dejour criteria. However, when dysplasia is assessed using LTI, its potential role as a prognostic factor warrants consideration.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ORCID

Jin-Gyu Kim   https://orcid.org/0009-0005-7648-8334
Junwoo Byun   https://orcid.org/0000-0002-8372-5247
Min Jung   https://orcid.org/0000-0002-7527-4802
Kwangho Chung   https://orcid.org/0000-0003-3097-3332
Hyun-Soo Moon   https://orcid.org/0000-0001-8678-2960
Se-Han Jung   https://orcid.org/0000-0001-8422-093X
Chong-Hyuk Choi https://orcid.org/0000-0002-9080-4904
Sung-Hwan Kim   https://orcid.org/0000-0001-5743-6241

REFERENCES

1. Tanaka MJ, Sodhi A, Wadhavkar I, et al. Redefining trochlear dysplasia: normal thresholds vary by measurement technique, landmarks, and sex. Am J Sports Med. 2023;51(5):1202-10.

2. Saccomanno MF, Maggini E, Vaisitti N, et al. Sulcus angle, trochlear depth, and Dejour's classification can be reliably applied to evaluate trochlear dysplasia: a systematic review of radiological measurements. Arthroscopy. 2023;39(2):549-68.

3. Drapeau-Zgoralski V, Swift B, Caines A, Kerrigan A, Carsen S, Pickell M. Lateral patellar instability. J Bone Joint Surg Am. 2023;105(5):397-409.

4. Martinez-Cano JP, Tuca M, Gallego A, Rodas-Cortes Y, Post WR, Hinckel B. The Dejour classification for trochlear dysplasia shows slight interobserver and substantial intraobserver reliability. Knee Surg Sports Traumatol Arthrosc. 2024;32(6):1363-9.

5. Pineda T, Dejour D. Inconsistent repeatability of the Dejour classification of trochlear dysplasia due to the variability of imaging modalities: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2023;31(12):5707-20.

6. Van Haver A, De Roo K, De Beule M, et al. The effect of trochlear dysplasia on patellofemoral biomechanics: a cadaveric study with simulated trochlear deformities. Am J Sports Med. 2015;43(6):1354-61.

7. Aljadaan BM, Alhakbani MS, Almonaie SH, Cahusac PMB. Outcomes of surgical interventions for patellofemoral instability in the presence of trochlear dysplasia: a systematic review and meta-analysis. Am J Sports Med. 2025;53(5):1216-30.

8. Yu KE, Cooperman DR, Schneble CA, et al. Reconceptualization of trochlear dysplasia in patients with recurrent patellar dislocation using 3-dimensional models. Orthop J Sports Med. 2022;10(11):23259671221138257.

9. Chen J, Li X, Feng Y, et al. Lateral trochlear inclination measured by the transepicondylar axis holds potential for evaluating trochlear dysplasia in patients with lateral patellar dislocation. Knee Surg Sports Traumatol Arthrosc. 2023;31(12):5611-20.

10. Tarchala M, Kerslake S, Hiemstra LA. Sulcus-deepening trochleoplasty for high-grade trochlear dysplasia: demystifying the procedure-a review of the current literature. Curr

62

Kim et al. Medial Patellofemoral Ligament Reconstruction and Lateral Trochlear Inclination
Clinics in Orthopedic Surgery • Vol. 18, No. 1, 2026 • www.ecios.org

Rev Musculoskelet Med. 2023;16(11):538-49.

11. Dejour DH, Deroche É. Trochleoplasty: indications in patellar dislocation with high-grade dysplasia. Surgical technique. Orthop Traumatol Surg Res. 2022;108(1S):103160.

12. Ferrua P, Compagnoni R, Calanna F, Randelli PS, Dejour D. Good patient satisfaction with low complications rate after trochleoplasty in patellofemoral instability. Knee Surg Sports Traumatol Arthrosc. 2022;30(10):3444-50.

13. Dippmann C, Lavard P, Kourakis AH, et al. Good 5-year results and a low redislocation rate using an à la carte treatment algorithm for patellofemoral instability in patients with severe trochlea dysplasia. Knee Surg Sports Traumatol Arthrosc. 2025;33(2):401-12.

14. Balcarek P, Rehn S, Howells NR, et al. Results of medial patellofemoral ligament reconstruction compared with trochleoplasty plus individual extensor apparatus balancing in patellar instability caused by severe trochlear dysplasia: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2017;25(12):3869-77.

15. Testa EA, Camathias C, Amsler F, Henle P, Friederich NF, Hirschmann MT. Surgical treatment of patellofemoral instability using trochleoplasty or MPFL reconstruction: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2017;25(8):2309-20.

16. Berton A, Salvatore G, Nazarian A, et al. Combined MPFL reconstruction and tibial tuberosity transfer avoid focal patella overload in the setting of elevated TT-TG distances. Knee Surg Sports Traumatol Arthrosc. 2023;31(5):1771-80.

17. Migliorini F, Oliva F, Maffulli GD, et al. Isolated medial patellofemoral ligament reconstruction for recurrent patellofemoral instability: analysis of outcomes and risk factors. J Orthop Surg Res. 2021;16(1):239.

18. Shi WL, Hu FY, Xu MT, et al. Arthroscopic anatomical double-bundle medial patellofemoral complex reconstruction improves clinical outcomes in treating recurrent patellar dislocation despite trochlear dysplasia, elevated tibial tubercle-trochlear groove distance, and patellar alta. Arthroscopy. 2023;39(1):102-11.

19. Lee JI, Jaffar MS, Choi HG, Kim TW, Lee YS. Effect of isolated medial patellofemoral ligament reconstruction in patellofemoral instability regardless of predisposing factors. J Knee Surg. 2022;35(3):299-307.

20. Joseph SM, Cheng C, Solomito MJ, Pace JL. Lateral trochlear inclination angle: measurement via a 2-image technique to reliably characterize and quantify trochlear dysplasia. Orthop J Sports Med. 2020;8(10):2325967120958415.

21. Qiao Y, Wu C, Wu X, et al. The value of minimal clinically important difference, substantial clinical benefit, and patient-acceptable symptomatic state for commonly used patient-reported outcomes in recurrent patellar instability patients after medial patellofemoral ligament reconstruction and tibial tubercle transfer. Arthroscopy. 2024;40(1):115-23.

22. Paiva M, Blønd L, Hölmich P, et al. Quality assessment of radiological measurements of trochlear dysplasia; a literature review. Knee Surg Sports Traumatol Arthrosc. 2018;26(3):746-55.

23. Lippacher S, Dejour D, Elsharkawi M, et al. Observer agreement on the Dejour trochlear dysplasia classification: a comparison of true lateral radiographs and axial magnetic resonance images. Am J Sports Med. 2012;40(4):837-43.

24. Nelitz M, Lippacher S, Reichel H, Dornacher D. Evaluation of trochlear dysplasia using MRI: correlation between the classification system of Dejour and objective parameters of trochlear dysplasia. Knee Surg Sports Traumatol Arthrosc. 2014;22(1):120-7.

25. Davies MR, Allahabadi S, Diab TE, et al. Sulcus-deepening trochleoplasty as an isolated or combined treatment strategy for patellar instability and trochlear dysplasia: a systematic review. Arthrosc Sports Med Rehabil. 2020;2(5):e661-9.

26. Hiemstra LA, Peterson D, Youssef M, Soliman J, Banfield L, Ayeni OR. Trochleoplasty provides good clinical outcomes and an acceptable complication profile in both short and long-term follow-up. Knee Surg Sports Traumatol Arthrosc. 2019;27(9):2967-83.

27. Longo UG, Vincenzo C, Mannering N, et al. Trochleoplasty techniques provide good clinical results in patients with trochlear dysplasia. Knee Surg Sports Traumatol Arthrosc. 2018;26(9):2640-58.

28. Fones L, Jimenez AE, Cheng C, et al. Trochlear dysplasia as shown by increased sulcus angle is associated with osteochondral damage in patients with patellar instability. Arthroscopy. 2021;37(12):3469-76.

29. Zhang ZJ, Di ML, Song GY, et al. Clinical and second-look arthroscopic results for derotational distal femoral osteotomy with medial patellofemoral ligament reconstruction for recurrent patellar dislocation with increased femoral anteversion: a series of 102 cases with a minimum clinical follow-up of 2 years. Am J Sports Med. 2023;51(3):663-71.

30. Cohen D, Le N, Zakharia A, Blackman B, de Sa D. MPFL reconstruction results in lower redislocation rates and higher functional outcomes than rehabilitation: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2022;30(11):3784-95.