*Original Research*

# Preoperative Complete Patellofemoral Dislocation in Extension Predicts an Inferior Clinical Outcome After Medial Patellofemoral Ligament Reconstruction in Patients With Recurrent Patellar Dislocation

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**Background:** Habitual patellar dislocation in extension (HPD-E) is a distinctive subtype of recurrent patellar dislocation (RPD); HPD-E represents the most severe type of patellar maltracking in RPD. It has been reported that the presence of preoperative patellar maltracking is associated with a worse clinical outcome after medial patellofemoral ligament (MPFL) reconstruction (MPFL-R).

**Purpose:** To describe the radiological characteristics of HPD-E and to compare clinical outcomes after MPFL-R among patients with and without preoperative HPD-E.

**Study Design:** Cohort study; Level of evidence, 3.

**Methods:** From January 2012 to December 2015, a total of 230 consecutive patients (246 knees) with RPD were treated with MPFL-R alone or combined with tibial tubercle osteotomy. Among them, 28 patients diagnosed with HPD-E by preoperative 3-dimensional computed tomography (CT; HPD-E group) were matched in a 1:1 fashion to 28 control participants who did not show HPD-E (control group). Routine radiography and CT were performed to evaluate patellar height, trochlear dysplasia, tibial tubercle–trochlear groove distance, and torsional deformities. The mean patellar laxity index and lateral patellar translation assessed with stress radiography were measured preoperatively and postoperatively to quantify MPFL laxity. At minimum 2-year follow-up, patient-reported outcomes (Kujala, Lysholm, and Tegner scores), patellar maltracking, and redislocation rates were compared between the HPD-E and control groups.

**Results:** The radiological characteristics of the HPD-E group were as follows: 89% (25/28) of patients had severe trochlear dysplasia (Dejour type B or D), and the mean femoral anteversion angle was 35.5° ± 4.7°. At the final follow-up, the HPD-E group had a significantly lower Kujala score (76.2 vs 84.5, respectively; $P = .001$), Lysholm score (75.4 vs 86.6, respectively; $P < .001$), and Tegner score (4.1 vs 5.8, respectively; $P = .021$) compared with the control group. The postoperative patellar laxity index (43% vs 19%, respectively; $P < .001$) and redislocation rate (25% vs 0%, respectively; $P = .01$) were significantly higher in the HPD-E group than in the control group.

**Conclusion:** Preoperative 3-dimensional CT is a reliable method of identfying patients with HPD-E. Treatment of HPD-E by MPFL-R alone or combined with tibial tubercle osteotomy resulted in a higher redislocation rate, more severe MPFL residual laxity, and lower patient-reported outcome scores compared with patients without HPD-E who underwent MPFL-R.

**Keywords:** habitual patellar dislocation in extension; patellar maltracking; recurrent patellar dislocation; medial patellofemoral ligament reconstruction

Over the past decade, medial patellofemoral ligament (MPFL) reconstruction (MPFL-R) has been considered the most effective treatment for recurrent patellar dislocation (RPD), with a low redislocation rate.[1,2,10,13,19] However, because of the structural complexities of this disorder, unfavorable clinical outcomes after MPFL-R have also been reported recently.[23] It has been reported that isolated MPFL-R does not considerably improve patellar tracking or restore patellofemoral kinematics.[12,15] Moreover, some authors have found that a preoperative J-sign, especially a

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high-grade J-sign, was associated with a lower Kujala score and MPFL failure after surgery, emphasizing the adverse influence of severe patellar maltracking and patellofemoral incongruency on the reconstructed MPFL.[21,32]

As a challenging scenario in the RPD spectrum, the concept of habitual patellar dislocation in extension (HPD-E) was first introduced by Chotel et al,[3] highlighting a distinctive subtype of RPD characterized by remarkable lateral complete patellar dislocation with every episode of knee extension and a subsequent return to its normal position with continuing knee flexion.[20] HPD-E represents the most severe form of patellar maltracking and patellofemoral incongruency in patients with RPD.

To date, there is a paucity of studies reporting the treatment algorithm and clinical outcomes of patients with HPD-E. Given its distinctive characteristics, it has been suggested that HPD-E should be recognized among patients with RPD and treated differently.[20] A recent study found that patients with severe patellar maltracking had inferior functional outcomes and a high MPFL graft laxity rate.[32] In contrast, other authors have demonstrated that MPFL-R alone or combined with tibial tubercle osteotomy can effectively address patients with HPD-E, leading to excellent patient-reported outcomes.[11]

The purpose of this study was to describe the radiological characteristics of HPD-E and to compare the clinical outcomes after MPFL-R between patients with and without HPD-E.

## METHODS

From January 2012 to December 2015, a total of 230 consecutive patients (246 knees) with RPD were treated with MPFL-R and were retrospectively reviewed for this study. Patients were excluded if at least 1 of the following criteria was present on the affected side: (1) revision cases, (2) patients who underwent trochleoplasty or valgus/varus/derotational osteotomy, (3) lack of preoperative computed tomography (CT) data, and (4) minimum follow-up <2 years (Figure 1). This study was approved by the ethics board at our institution.

Overall, 225 of the patients (241 knees) were analyzed retrospectively by a systematic review of office and operative records. We included patients according to preoperative congruence of the patellofemoral joint, which was assessed on preoperative 3-dimensional CT (3D-CT). In the present study, the diagnostic criteria for HPD-E were that preoperative 3D-CT showed complete proximal-lateral or lateral patellofemoral dislocation in extension (Figure 2). Of the 225 patients, 28 patients (28 knees) were verified as having preoperative HPD-E. These patients constituted the HPD-E group. From the remaining 197 patients (213 knees), 28 patients without preoperative HPD-E were chosen in a 1:1 fashion for comparison (control group). Therefore, a total of 56 patients were included in the present study.

### Radiological Assessment of HPD-E

CT was performed on an Aquilion ONE scanner (Canon Medical Systems) in all patients during a maximum quadriceps contraction. DICOM (Digital Imaging and Communications in Medicine) data from the hip-knee-ankle CT scan were reconstructed into a 3D model with Mimics Research 20.0 (Materialise) to assess congruence of the patellofemoral joint in extension. The rotational parameters of the lower extremity were measured according to the method described by Zhang et al.[32] The femoral anteversion angle was defined as the angle formed between the axis of the femoral neck and distal femur, and the external tibial torsion angle was assessed by measuring the rotational angle of the proximal tibia relative to the distal tibia.

Knee radiographs included the anteroposterior view and the lateral view with 30° of knee flexion. The Caton-Deschamps Index (CDI) was used to measure patellar height, and patella alta was defined as a CDI $\geq$1.2.[6] Trochlear dysplasia was detected on the true lateral view of the knee and classified according to the Dejour classification system.[5] All patients were examined with axial CT for measurements of the tibial tubercle–trochlear groove (TT-TG) distance according to the method described by Krych et al,[16] and an increased TT-TG distance was defined as $\geq$20 mm in this study. The femorotibial angle was measured on the whole-leg standing anteroposterior radiograph to detect the presence of valgus/varus deformities.

### Surgical Techniques

All surgical procedures were performed by the senior surgeon (H.F.), who had more than 20 years of orthopaedic training. The MPFL was reconstructed using a semitendinosus tendon autograft. The femoral tunnel was positioned under intraoperative fluoroscopy using the method described by Schöttle et al.[22] The medial edge of the patella was inserted by 2 double-loaded suture anchors placed into the proximal one-third and equator of the patella, respectively. The graft was first fixed on the patellar side, and the free ends of the graft were then pulled into the femoral tunnel and fixed with a bioabsorbable interference screw with the knee in 20° to 30° of flexion.

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Ethical approval for this study was obtained from Beijing Jishuitan Hospital.

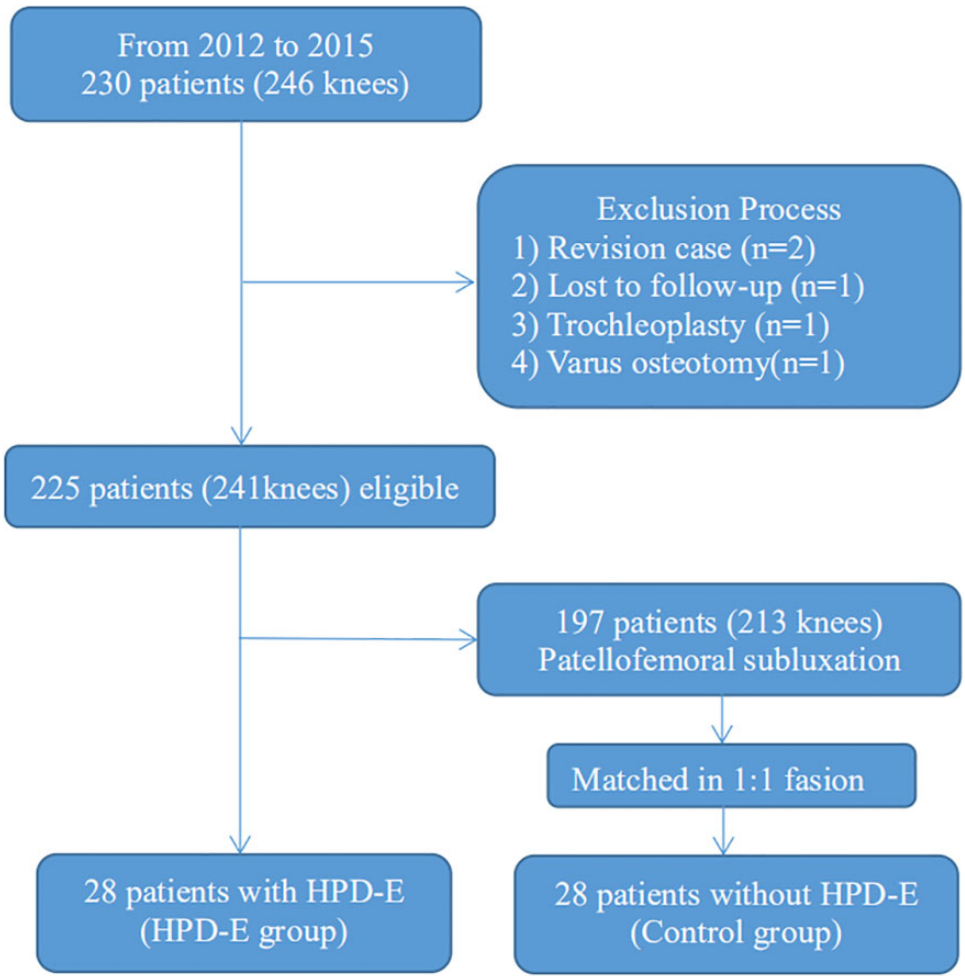


**Figure 1.** Flowchart of patient selection. HPD-E, habitual patellar dislocation in extension.

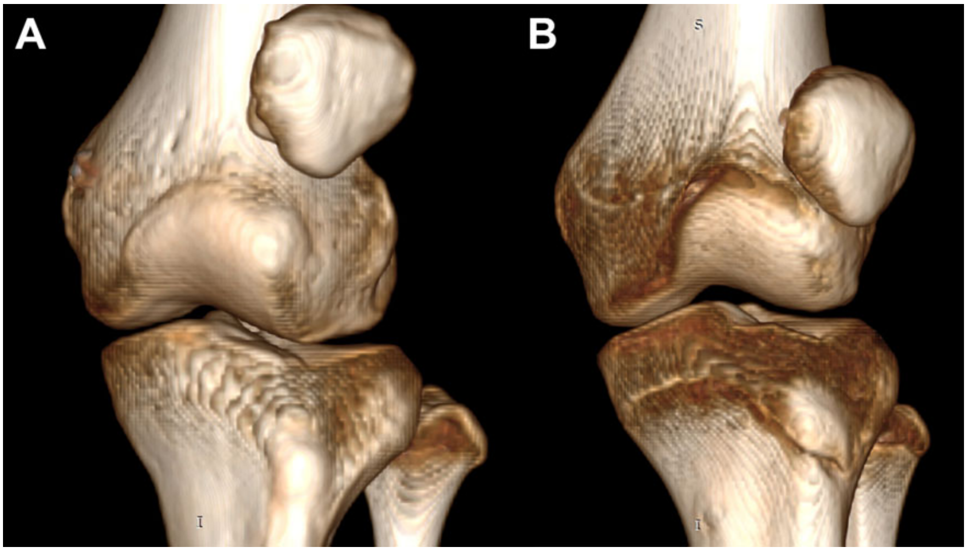


**Figure 2.** Representative 3-dimensional computed tomography (3D-CT) of knees with habitual patellar dislocation in extension. There is no contact between the patella and femoral trochlea in extension on 3D-CT. (A) Proximal-lateral dislocation. (B) Lateral dislocation.

The Elmslie-Trillat procedure (medialization) was performed in patients with a TT-TG distance ≥20 mm to normalize the TT-TG distance to 10 to 12 mm. In addition, tibial tubercle distalization was performed in patients with patella alta to decrease the patellar height. A 4- to 5-cm length of tuberosity was identified, mobilized using an oscillating saw, and shifted medially and/or distally. After the tuberosity was temporarily stabilized with a 2-mm K-wire at its distal end, intraoperative fluoroscopy was performed to verify the desired patellar position. To this end, 4.0-mm cortical screws (Depuy Synthes) were used to fix the tuberosity in its new position.

### Postoperative Rehabilitation

Patients wore a protective knee brace without limitations in range of motion during the first 4 weeks after surgery. A crutch providing protective weightbearing was also used during this period, and patients were allowed partial weightbearing (<10 kg) for the first 4 weeks, followed by full weightbearing. Isometric quadriceps muscle training started immediately after surgery. Flexion was increased slowly each week as tolerated.

### Patient-Reported Outcomes, MPFL Residual Laxity, and Patellar Maltracking

Kujala, Lysholm, and Tegner scores were assessed preoperatively and at the final follow-up, at a minimum 2 years postoperatively. At the 2-year follow-up, axial stress fluoroscopy was used to assess MPFL laxity with the knee flexed at 30°. First, a stress-free radiograph of the patellofemoral joint was obtained. Then, the examiner (H.Z.) supported the lateral side of the knee with his hand to prevent rotation of the limb, while maximum manual pressure was applied to the medial side of the patella, displacing it laterally.[30] The patellar laxity index was measured according to the method described in Figure 3. Lateral patellar translation was further graded according to the 4-quadrant method on stress radiography[28] (grade 1: ≤1 quadrant; grade 2: >1 quadrant; grade 3: >2 quadrants; grade 4: >3 quadrants). For all patients, patellar tracking was evaluated and recorded with a video camera by the senior author (H.Z.) and it was defined as a positive J-sign when there was a lateral patellar shift in terminal extension.[24,31] We were able to identify 3 distinctive patterns of the J-sign in patients with HPD-E (Table 1 and Video Supplements 1-3).

The kappa value (in the detection of HPD-E on 3D-CT) and intraclass correlation coefficient (for the patellar laxity index) were calculated to determine interobserver and intraobserver variability. Twenty randomly selected knees (10 from the HPD-E group and 10 from the control group) were assessed by 1 senior surgeon (H.Z.) and 1 orthopaedic resident (Z.J.Z.), and the assessment was repeated 6 weeks later by the senior surgeon. The interobserver and intraobserver kappa values were 0.89 and 0.91, respectively, for the detection of HPD-E on 3D-CT, and the interobserver and intraobserver intraclass correlation coefficients of the patellar laxity index were 0.93 and 0.96, respectively.

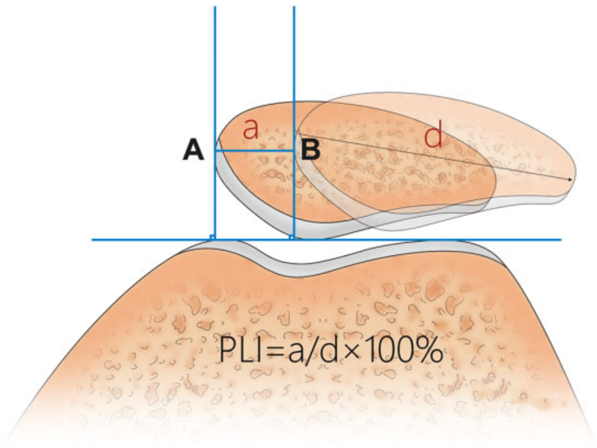


**Figure 3.** Measurement of the patellar laxity index (PLI). On lateral stress fluoroscopy, a line was drawn tangent to the femoral trochlea, and 2 perpendicular lines (*A*, medial condylar tangent point and *B*, medial border of the patella) were drawn through the medial condyle tangent point and the medial border of the patella, respectively. The lateral shift distance is represented by (*a*), and the mediolateral width of the patella is represented by (*d*); the ratio of *a*/*d* × 100% is the PLI.

TABLE 1
Specific Patterns of J-Sign in Patients With Habitual Patellar Dislocation in Extension

| Pattern | Clinical Characteristics of J-Sign |
|---|---|
| I | Patellar clunk: obvious patellar clunk in terminal knee extension (Video Supplement 1) |
| II | Patellar locking: locked in early flexion with subsequent relocation in deep flexion or by manual force (Video Supplement 2) |
| III | Extension apprehension: patient refuses to extend knee out of fear for dislocation (Video Supplement 3) |

### Statistical Analysis

Analyses were performed with the SPSS 20.0 software package (IBM). The Pearson chi-square test or Fisher exact test was used to compare categorical variables, and the Student *t* test or Mann-Whitney *U* test (if data did not meet the assumptions of normality and homoscedasticity) was used to compare continuous variables.

## RESULTS

Regarding the radiological characteristics of the HPD-E group, 89% of patients (25/28) had severe trochlear dysplasia, and the mean femoral anteversion angle was

TABLE 2
Descriptive Characteristics of Patients Before Surgery[a]

| | HPD-E Group | Control Group | *P* Value |
|---|---|---|---|
| Sex, n | | | ≥.999 |
| Female | 24 | 24 | |
| Male | 4 | 4 | |
| Age, y | 20.9 ± 5.6 | 19.5 ± 3.8 | .912 |
| Follow-up time, y | 6.0 ± 0.8 | 5.8 ± 1.0 | .896 |
| Femoral anteversion angle, deg | 35.5 ± 4.7 | 29.6 ± 8.3 | **.024** |
| >30°, n (%) | 15 (54) | 10 (36) | |
| >40°, n (%) | 9 (32) | 2 (7) | |
| >50°, n (%) | 4 (14) | 0 (0) | |
| External tibial torsion angle, deg | 30.1 ± 9.3 | 30.9 ± 6.5 | .894 |
| CDI, n (%) | | | .179 |
| <1.2 | 13 (46) | 18 (64) | |
| ≥1.2 | 15 (54) | 10 (36) | |
| TT-TG distance, n (%) | | | .237 |
| <20 mm | 6 (21) | 10 (36) | |
| ≥20 mm | 22 (79) | 18 (64) | |
| Valgus angle, deg | 1.6 ± 0.7 | 1.8 ± 0.8 | .834 |
| Trochlear dysplasia, n (%) | | | **.002** |
| Type A | 3 (11) | 11 (39) | |
| Type B | 15 (53) | 14 (50) | |
| Type C | 0 (0) | 1 (4) | |
| Type D | 10 (36) | 2 (7) | |
| J-sign, n (%) | 28 (100) | 17 (61) | **<.001** |
| Clunk | 19 (68) | 4 (14) | |
| Locking | 7 (25) | 0 (0) | |
| Extension apprehension | 2 (7) | 0 (0) | |

[a]Boldfaced values indicate statistical significance ($P < .05$). Data are shown as mean ± SD unless otherwise indicated. CDI, Caton-Deschamps Index; HPD-E, habitual patellar dislocation in extension; TT-TG, tibial tubercle–trochlear groove.

TABLE 3
Patient-Reported Outcomes and Objective Measurements[a]

| | HPD-E Group | Control Group | *P* Value |
|---|---|---|---|
| Kujala score | | | |
| Preoperative | 51.3 ± 10.3 | 50.3 ± 10.2 | .851 |
| Postoperative | 76.2 ± 6.4 | 84.5 ± 5.0 | **.001** |
| Lysholm score | | | |
| Preoperative | 58.3 ± 8.7 | 57.6 ± 9.7 | .812 |
| Postoperative | 75.4 ± 8.6 | 86.6 ± 5.1 | **<.001** |
| Tegner score | | | |
| Preoperative | 3.2 ± 0.6 | 3.4 ± 0.7 | .736 |
| Postoperative | 4.1 ± 0.5 | 5.8 ± 0.9 | **.021** |
| Patellar laxity index, % | | | |
| Preoperative | 94 | 89 | .784 |
| Postoperative | 43 | 19 | **<.001** |
| Postoperative MPFL laxity, n (%) | | | **.001** |
| Grade 1 | 5 (18) | 24 (86) | |
| Grade 2 | 15 (53) | 4 (14) | |
| Grade 3 | 3 (11) | 0 (0) | |
| Grade 4 | 5 (18) | 0 (0) | |
| Redislocation, n (%) | 7 (25) | 0 (0) | **.01** |
| Inward patella, n (%) | | | |
| Preoperative | 0 (0) | 0 (0) | ≥.999 |
| Postoperative | 5 (18) | 3 (11) | .705 |

[a]Boldfaced values indicate statistical significance ($P < .05$). Data are shown as mean ± SD unless otherwise indicated. HPD-E, habitual patellar dislocation in extension; MPFL, medial patellofemoral ligament.

35.5° ± 4.7°, which was significantly greater than that of the control group ($P = .024$) (Table 2). Moreover, the HPD-E group had a significantly higher prevalence of a preoperative J-sign than the control group (100% vs 61%, respectively; $P < .001$) (Table 2).

At the final follow-up (mean ± SD, 5.9 ± 0.9 years), the HPD-E group had a significantly lower Kujala score (76.2 vs 84.5, respectively; $P = .001$), Lysholm score (75.4 vs 86.6, respectively; $P < .001$), and Tegner score (4.1 vs 5.8, respectively; $P = .021$) than the control group. The postoperative patellar laxity index was significantly higher in the HPD-E group than in the control group (43% vs 19%, respectively; $P < .001$) (Table 3). Moreover, 8 patients (29%) demonstrated MPFL laxity (lateral translation >2 quadrants) in the HPD-E group; in contrast, no patient showed MPFL laxity in the control group ($P = .004$). There were 5 patients in the HPD-E group and 3 patients in the control group who demonstrated a visible inward patella postoperatively (Figure 4).

The redislocation rate in the HPD-E group was significantly higher than in the control group (25% vs 0%, respectively; $P = .01$). Of these, 6 patients underwent revision surgery with revision MPFL-R and combined derotational distal femoral osteotomy. At the subsequent follow-up, no redislocation was noted.

## DISCUSSION

The most important findings of this study are that 3D-CT was a reliable method to identify patients with HPD-E and that the presence of preoperative HPD-E predicted an inferior clinical outcome after MPFL-R alone or combined with tibial tubercle osteotomy in patients with RPD.

Currently, there is a paucity of studies investigating the pathogenesis, surgical treatment, and clinical outcomes of HPD-E. Parikh and Lykissas[20] classified such cases as type IIIB patellar instability and attributed the severity of the condition to underlying patella alta and a short trochlea. The authors further pointed out that isolated MPFL-R could not restore normal patellar stability. Chotel et al[3] suggested that the following procedures should be considered besides MPFL-R in children and adolescents: sectioning of the lateral retinaculum guided by the severity of the contracture, patellar distalization if needed, and trochleoplasty. Zhang et al[32] reported that in patients with a high-grade J-sign treated by MPFL-R and combined tibial tubercle medialization, nearly 20% showed MPFL graft laxity. In contrast, Franciozi et al[11] concluded that MPFL-R alone or combined with tibial tubercle osteotomy could effectively address patients with HPD-E, with excellent patient-reported outcomes and patellar stability. In

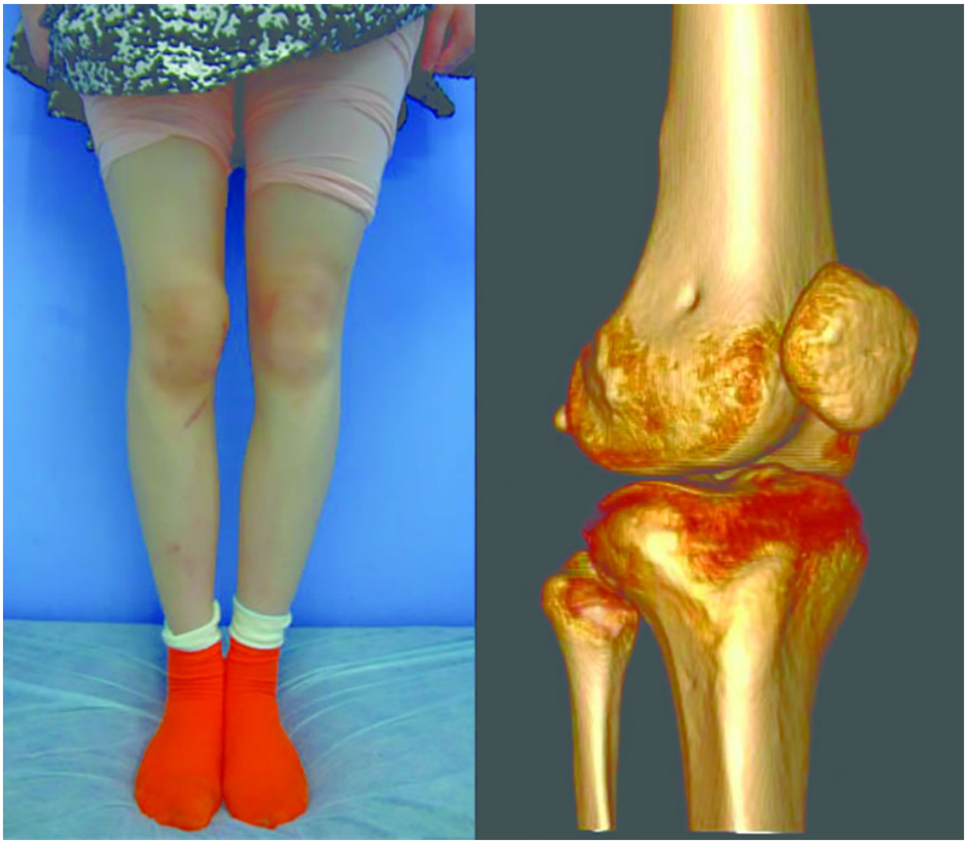

**Figure 4.** Representative image of a patient with an inward patella. The 18-year-old woman underwent medial patellofemoral ligament reconstruction and tibial tubercle medialization. The preoperative "normal" patella turned into an inward patella (right leg). Postoperative 3-dimensional computed tomography also showed the internally rotated femoral trochlea and inward patella.

the present study, the HPD-E group showed lower patient-reported outcomes (Kujala, 76.2; Lysholm, 75.4; Tegner, 4.1) and a higher failure rate (25% redislocation rate; 29% MPFL graft laxity rate) than the control group, which indicated that MPFL-R was insufficient to stabilize the patella postoperatively in patients with HPD-E. We speculate that severe preoperative patellar maltracking (HPD-E) can produce a persistently increased lateralizing force vector that acts on the patella after MPFL-R, and this may increase stress on the reconstructed MPFL graft, leading to stretching and finally to MPFL failure. We believe that further studies to elucidate the underlying mechanisms of HPD-E and surgical treatment to correct this challenging scenario are still needed.

We used 3D-CT as an objective method to identify cases with HPD-E. In the present study, the interobserver and intraobserver agreement for HPD-E detection was 0.89 and 0.91, respectively, which demonstrated that 3D-CT can help orthopaedic surgeons accurately recognize patients with HPD-E. Additionally, the J-sign was a frequently used physical examination tool in the clinic to evaluate patellar maltracking, and two of the unique patterns of the J-sign (patterns II and III) could be regarded as a preliminary clue for diagnosing HPD-E. Therefore, for patients with RPD, the J-sign assessment could be performed initially in the clinic, and whenever suspicious, 3D-CT could be further applied to determine the presence of HPD-E.

In the present study, excessive femoral anteversion and severe trochlear dysplasia were found to be remarkable radiological features for HPD-E. Increased femoral anteversion has been recognized as a predisposing factor of RPD,[9,17,25] and etiotropic derotational femoral osteotomy has shown satisfactory clinical outcomes.[7,14,18,26,29] Zhang et al[32] suggested that osteotomy for correcting torsional deformities, in addition to MPFL-R, might be needed to manage RPD with severe patellar maltracking. Of note, the 6 failed cases in the present study were successfully treated with revision MPFL-R and derotational femoral osteotomy, which further indicates the critical role of torsional deformities in the development of HPD-E. It should be kept in mind that other procedures, such as trochleoplasty, tibial tubercle distalization, and sectioning of the lateral retinaculum, may play a role as well. Further studies are needed to investigate these additional procedures.

Few studies have described the phenomenon of the inward patella as a sequela of RPD, and little is known about its clinical significance in the literature.[4,8,27] Zhang et al[33] speculated that the procedure of MPFL-R without addressing concomitant increased femoral anteversion might iatrogenically create a squinting patella. The authors further pointed out that a postoperative inward patella might be a contributing factor to inferior clinical outcomes. In the present study, 5 patients who had a normal patellar appearance before surgery demonstrated a visibly inward patella postoperatively. In such cases, even patellar stability and patellofemoral congruence were restored, but axial malalignment of the lower extremity still existed. Therefore, surgery could not be recognized as the optimal treatment.

The clinical relevance of the present study was that (1) the clinical recognition of HPD-E as a subtype of RPD is necessary, (2) other surgical approaches in addition to MPFL-R should be considered to guarantee a better clinical outcome, and (3) further studies are needed to uncover its underlying skeletal risk factors.

There were several limitations to this study. First, the retrospective nature and relatively small sample size might influence statistical analyses. Second, the diagnostic criteria of HPD-E were based on 3D-CT, which could limit its routine use.

## CONCLUSION

Preoperative 3D-CT is a reliable method to identify patients with HPD-E. The treatment of HPD-E by MPFL-R alone or combined with tibial tubercle osteotomy resulted in a higher redislocation rate, more severe MPFL residual laxity, and lower patient-reported outcome scores.

A Video Supplement for this article is available at http://journals.sagepub.com/doi/suppl/10.1177/2325967120938981.

## REFERENCES


1. Blanke F, Watermann K, Haenle M, Feitenhansl A, Camathias C, Vogt S. Isolated medial patellofemoral ligament reconstruction can be an effective procedure in patellofemoral instability with risk factors [published online May 23, 2019]. *J Knee Surg*. doi:10.1055/s-0039-1688917
2. Bouras T, Edmond U, Brown A, Gallacher P, Barnett A. Isolated medial patellofemoral ligament reconstruction significantly improved quality of life in patients with recurrent patella dislocation. *Knee Surg Sports Traumatol Arthrosc*. 2019;27(11):3513-3517.
3. Chotel F, Berard J, Raux S. Patellar instability in children and adolescents. *Orthop Traumatol Surg Res*. 2014;100(1 suppl):S125-S137.
4. Cooke TD, Price N, Fisher B, Hedden D. The inwardly pointing knee: an unrecognized problem of external rotational malalignment. *Clin Orthop Relat Res*. 1990;260:56-60.
5. Dejour D, Le Coultre B. Osteotomies in patello-femoral instabilities. *Sports Med Arthrosc*. 2007;15(1):39-46.
6. Dejour H, Walch G, Nove-Josserand L, Guier C. Factors of patellar instability: an anatomic radiographic study. *Knee Surg Sports Traumatol Arthrosc*. 1994;2(1):19-26.
7. Dickschas J, Harrer J, Reuter B, Schwitulla J, Strecker W. Torsional osteotomies of the femur. *J Orthop Res*. 2015;33(3):318-324.
8. Dickschas J, Tassika A, Lutter C, Harrer J, Strecker W. Torsional osteotomies of the tibia in patellofemoral dysbalance. *Arch Orthop Trauma Surg*. 2017;137(2):179-185.
9. Diederichs G, Kohlitz T, Kornaropoulos E, Heller MO, Vollnberg B, Scheffler S. Magnetic resonance imaging analysis of rotational alignment in patients with patellar dislocations. *Am J Sports Med*. 2013;41(1):51-57.
10. Erickson BJ, Nguyen J, Gasik K, Gruber S, Brady J, Shubin Stein BE. Isolated medial patellofemoral ligament reconstruction for patellar instability regardless of tibial tubercle-trochlear groove distance and patellar height: outcomes at 1 and 2 years. *Am J Sports Med*. 2019;47(6):1331-1337.
11. Franciozi CE, Ambra LF, Albertoni L, et al. Anteromedial tibial tubercle osteotomy improves results of medial patellofemoral ligament reconstruction for recurrent patellar instability in patients with tibial tuberosity-trochlear groove distance of 17 to 20 mm. *Arthroscopy*. 2019;35(2):566-574.
12. Gobbi RG, Demange MK, de Ávila LFR, et al. Patellar tracking after isolated medial patellofemoral ligament reconstruction: dynamic evaluation using computed tomography. *Knee Surg Sports Traumatol Arthrosc*. 2017;25(10):3197-3205.
13. Hiemstra LA, Kerslake SA, Lafave MR. Influence of risky pathoanatomy and demographic factors on clinical outcomes after isolated medial patellofemoral ligament reconstruction: a regression analysis. *Am J Sports Med*. 2019;47(12):2904-2909.
14. Imhoff FB, Cotic M, Liska F, et al. Derotational osteotomy at the distal femur is effective to treat patients with patellar instability. *Knee Surg Sports Traumatol Arthrosc*. 2019;27(2):652-658.
15. Kita K, Horibe S, Toritsuka Y, et al. Effects of medial patellofemoral ligament reconstruction on patellar tracking. *Knee Surg Sports Traumatol Arthrosc*. 2012;20(5):829-837.
16. Krych A, Camp CL, Stuart MJ. CT and MRI measurements of tibial tubercle-trochlear groove distances are not equivalent in patients with patellar instability. *Am J Sports Med*. 2013;41(8):1835-1840.
17. Lee TQ, Anzel SH, Bennett KA, Pang D, Kim WC. The influence of fixed rotational deformities of the femur on the patellofemoral contact pressures in human cadaver knees. *Clin Orthop Relat Res*. 1994;302:69-74.
18. Nelitz M, Dreyhaupt J, Lippacher S. Combined trochleoplasty and medial patellofemoral ligament reconstruction for recurrent patellar dislocations in severe trochlear dysplasia: a minimum 2-year follow-up study. *Am J Sports Med*. 2013;41(5):1005-1012.
19. Neri T, Parker DA, Putnis S, et al. Clinical and radiological predictors of functional outcome after isolated medial patellofemoral ligament reconstruction at midterm follow-up. *Am J Sports Med*. 2019;47(6):1338-1345.
20. Parikh SN, Lykissas MG. Classification of lateral patellar instability in children and adolescents. *Orthop Clin North Am*. 2016;47(1):145-152.
21. Sappey-Marinier E, Sonnery-Cottet B, O'Loughlin P, et al. Clinical outcomes and predictive factors for failure with isolated MPFL reconstruction for recurrent patellar instability: a series of 211 reconstructions with a minimum follow-up of 3 years. *Am J Sports Med*. 2019;47(6):1323-1330.
22. Schöttle PB, Schmeling A, Rosenstiel N, Weiler A. Radiographic landmarks for femoral tunnel placement in medial patellofemoral ligament reconstruction. *Am J Sports Med*. 2007;35(5):801-804.
23. Shah JN, Howard JS, Flanigan DC, Brophy RH, Carey JL, Lattermann C. A systematic review of complications and failures associated with medial patellofemoral ligament reconstruction for recurrent patellar dislocation. *Am J Sports Med*. 2012;40(8):1916-1923.
24. Sheehan FT, Derasari A, Fine KM, Brindle TJ, Alter KE. Q-angle and J-sign: indicative of maltracking subgroups in patellofemoral pain. *Clin Orthop Relat Res*. 2010;468(1):266-275.
25. Souza RB, Draper CE, Fredericson M, Powers CM. Femur rotation and patellofemoral joint kinematics: a weight-bearing magnetic resonance imaging analysis. *J Orthop Sports Phys Ther*. 2010;40(5):277-285.
26. Stambough JB, Davis L, Szymanski DA, Smith JC, Schoenecker PL, Gordon JE. Knee pain and activity outcomes after femoral derotation osteotomy for excessive femoral anteversion. *J Pediatr Orthop*. 2018;38(10):503-509.

27. Strecker W, Dickschas J. Torsional osteotomy: operative treatment of patellofemoral maltracking. *Oper Orthop Traumatol*. 2015;27(6): 505-524.
28. Tanaka MJ, Elias JJ, Williams AA, Demehri S, Cosgarea AJ. Characterization of patellar maltracking using dynamic kinematic CT imaging in patients with patellar instability. *Knee Surg Sports Traumatol Arthrosc*. 2016;24(11):3634-3641.
29. Teitge RA. Osteotomy in the treatment of patellofemoral instability. *Tech Knee Surg*. 2006;5(1):2-18.
30. Teitge RA, Faerber WW, Des Madryl P, Matelic TM. Stress radiographs of the patellofemoral joint. *J Bone Joint Surg Am*. 1996; 78(2):193-203.
31. Xue Z, Song GY, Liu X, et al. Excessive lateral patellar translation on axial computed tomography indicates positive patellar J sign. *Knee Surg Sports Traumatol Arthrosc*. 2018;26(12):3620-3625.
32. Zhang Z, Zhang H, Song G, Zheng T, Feng H. A pre-operative grade 3 J-sign adversely affects short-term clinical outcome and is more likely to yield MPFL residual graft laxity in recurrent patellar dislocation. *Knee Surg Sports Traumatol Arthrosc*. 2020;28(7):2147-2156.
33. Zhang Z, Zhang H, Song G, Zheng T, Ni Q, Feng H. Increased femoral anteversion is associated with inferior clinical outcomes after MPFL reconstruction and combined tibial tubercle osteotomy for the treatment of recurrent patellar instability. *Knee Surg Sports Traumatol Arthrosc*. 2020;28(7):2261-2269.