Comparison of Imaging Characteristics in Pediatric Patients With Trochlear Versus Medial Femoral Condyle Osteochondritis Dissecans

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Background: Although osteochondritis dissecans (OCD) lesions are well-described in the femoral condyles and have been associated with varus limb alignment, there is limited data on OCD lesions in the trochlea.

Purpose: To compare the baseline imaging characteristics in pediatric patients with trochlear OCD with those with medial femoral condyle (MFC) OCD to understand whether measures of coronal plane alignment predispose to OCD development by anatomic location.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: This study retrospectively reviewed all pediatric patients (age ≤18 years) diagnosed with isolated trochlear OCD at a tertiary-care medical center from January 2016 to May 2023; all included patients had weight-bearing hip-to-ankle alignment radiographs. Hip-knee-ankle angle (HKA), mechanical lateral distal femoral angle (mLDFA), medial proximal tibial angle (MPTA), mechanical axis deviation (MAD), Caton-Deschamps Index (CDI), patellar tilt, and sulcus angle were measured on initial/preoperative anteroposterior and lateral knee radiographs. Tibial tubercle-trochlear groove (TT-TG) distance and OCD lesion size were measured on initial/preoperative magnetic resonance imaging sequences. Patients were 1 to 2 matched based on age (±2 years) and sex to a cohort with isolated MFC OCD.

Results: A total of 18 extremities in 16 patients were included in the trochlear OCD cohort and matched to 36 extremities in the MFC OCD cohort. The mean age at the first clinical visit for all patients was 14.8 ± 1.5 years and did not differ significantly between the two groups (*P* = .40). The extremities with trochlear OCD had significantly less varus HKA (1° ± 2° vs −1° ± 2°; *P* = .004) and MAD (4 ± 8 vs −3 ± 8 mm; *P* = .004) compared with the MFC cohort as well as lower mLDFA (86° ± 2° vs 88° ± 2°; *P* = .004). There were no differences in MPTA, CDI, patellar tilt, sulcus angle, TT-TG distance, or OCD lesion size between groups.

Conclusion: Pediatric patients with trochlear OCD had statistically less varus coronal plane alignment compared with age- and sex-matched patients with MFC OCD, with the latter exhibiting more significant varus based on the HKA and MAD.

Keywords: coronal plane alignment; genu valgum; medial femoral condyle; osteochondritis dissecans; trochlea

Osteochondritis dissecans (OCD) is an idiopathic, acquired defect of the subchondral bone that often presents in adolescents. Although the exact cause of OCD is unknown, most patients report a long history of intensive exercise or sport, which may predispose them to repetitive microtrauma and vascular compromise.[3] OCD lesions are most commonly reported in the posterolateral medial femoral condyle (MFC) due to watershed vascularity.[7] MFC OCD lesions have also been associated with varus limb alignment.[2,4,5,18]

There is limited data on OCD lesions in the patellofemoral joint, particularly those in the trochlear region. Several previous case reports and case series detail trochlear OCD lesions in pediatric patients with a high rate of satisfaction and return to sports after surgery.[7,8,10,12,13,15,16,19] In the largest case series of pediatric trochlear OCD lesions

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to date (n = 34 lesions), Price et al[12] speculated that increased patellofemoral joint loading may predispose to the development of trochlear OCD lesions.[12] We postulated that increased patellofemoral joint loading may be related to aberrations in alignment, which we sought to investigate.

No study to date has compared measures of lower extremity alignment in pediatric patients with trochlear OCD with those with MFC OCD. In this study, we sought to describe the imaging characteristics in pediatric and adolescent patients with trochlear OCD compared with those with MFC OCD.

METHODS

This was an institutional review board—approved retrospective case series of consecutive patients aged ≤18 years with trochlear OCD lesions at a tertiary-care hospital between January 2016 and May 2023. Two pediatric orthopaedic sports medicine surgeons (P.D.F. and D.W.G.) cared for all patients in the study. Patients were identified from a medical record query using the International Classification of Diseases–Tenth Revision–Clinical Modification codes M93.262 (osteochondritis dissecans, left knee), M93.261 (osteochondritis dissecans, right knee), and M93.269 (osteochondritis dissecans, unspecified knee). Patients with trochlear and MFC OCD lesions were confirmed via manual chart review. Patients with chondral shear or patella OCD were excluded, as were patients with patellar dislocation or instability. Given the known association of coronal plane alignment with the development of OCD, all patients at our institution presenting with OCD receive standing radiographs. Patients without complete radiographic imaging—standing hip-knee-ankle (HKA) or EOS imaging (ATEC Spine Group) radiographs and anteroposterior/Merchant/lateral knee radiographs—or magnetic resonance imaging (MRI) scans were excluded.

Radiographic Measurements

Radiographic parameters of coronal lower extremity alignment and patellofemoral instability were measured on preoperative radiographs for operative patients and on the most recent radiographs for nonoperative patients. Standing EOS imaging radiographs were used to measure 48 extremities (16 with trochlear lesions, 32 with MFC lesions), and full-length, standing hip-to-ankle radiographs were used to measure 6 extremities (2 with trochlear lesions, 4 with MFC lesions). Mechanical lateral distal femoral angle (mLDFA), medial proximal tibial angle (MPTA), and HKA were measured on full-length hip-to-ankle plain radiographs or standing, full-length EOS radiographs. Mechanical axis deviation (MAD) was calculated (in mm) as the distance from the center of the intercondylar tibial spine to the mechanical axis of the limb, measured as the line between the center of the femoral head to the center of the tibiotalar joint.[11] Patellar height was assessed via the Caton-Deschamps Index (CDI) on plain lateral radiographs.[20] Patellar tilt and sulcus angle were assessed on Merchant view radiographs. Descriptions of the radiographic measurements are available in Appendix Figures A1 to A3.

MRI Measurements

Trochlear morphology was assessed on MRI via the tibial tubercle-trochlear groove (TT-TG) distance.[1] In addition, the largest length of the OCD lesion was measured (in mm) on MRI. Descriptions of the MRI measurements are shown in Appendix Figures A4 and A5.

Statistical Analysis

An a priori power analysis indicated that at least 16 trochlear OCD extremities and 32 matched MFC OCD extremities would be required to detect a 3° difference in mLDFA assuming a SD = 4°, α = .05, and β = 0.8. To minimize selection bias, patients were matched 1 to 2 based on sex and chronologic age (±2 years) between the trochlear OCD and MFC OCD cohorts. All categorical variables were assessed using chi-square tests. Continuous variables were assessed using independent-sample t tests or Mann-Whitney U tests after data normality was assessed with Kolmogorov-Smirnov tests. Statistical analysis was performed using SPSS software Version 29 (IBM), with the 2-tailed significance threshold set as $P \leq .05$.

RESULTS

A total of 18 extremities in 16 patients with trochlear OCD were included in this series and matched to 36 extremities in 34 patients with MFC OCD. The mean age at the first clinical visit in case patients was 14.8 ± 1.5 years, and two were women. The mean age did not differ significantly between the trochlear OCD and MFC OCD groups (P = .40). Of the trochlear OCD patients, 3 of the 18 (17%)

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Ethical approval for this study was obtained from Hospital for Special Surgery (reference No. 2015-365).

TABLE 1
Characteristics of Patients with Trochlear OCD (N = 16 Patients, 18 Extremities)[a]

Characteristic	n (%) or mean ± SD
Male sex	14 (88)
Age, y	14.8 ± 1.5
Right side affected	6 (33)[b]

[a]OCD, osteochondritis dissecans.
[b]No. (%) of extremities.

extremities had valgus deformity about the knee, defined as mechanical axis deviation lateral to the lateral tibial spine, and 1 of the 18 (6%) extremities had varus deformity about the knee, defined as mechanical axis deviation medial to the medial tibial spine (Table 1).

As compared with the MFC OCD group, those with trochlear OCD had greater radiographic valgus. The mean MAD was significantly greater (less varus deviation) in the trochlear OCD group compared with the MFC OCD group (4 ± 8 vs −3 ± 8 mm; P = .004) (Figure 1). The mean HKA was significantly greater (less varus) in the trochlear group compared with the MFC OCD group (1° ± 2° vs −1° ± 2°; P = .004), driven by lower mean mLDFA in the trochlear group compared with the MFC OCD group (86° ± 2° vs 88° ± 2°; P = .004). The two groups had no differences in MPTA, CDI, patellar tilt, or sulcus angle. On preoperative or most recent MRI, no difference was found in TT-TG distance or OCD lesion size between the trochlear and MFC OCD groups (Table 2). Further analysis revealed no significant correlations between the size of the OCD lesion and MAD in patients with MFC OCD (P = .17 and P = .61) or trochlear OCD (P = .09 and P = .26).

DISCUSSION

In this study, patients presenting with trochlear OCD had statistically significantly less varus alignment relative to patients with MFC OCD. The mean MAD was within the normal range (3-7 mm)[6] in the trochlear group, whereas the MAD of the MFC OCD group had a mean varus deviation. Despite a statistically significant difference in mLDFA between the two groups, mean values for both groups were within normal reported ranges for this

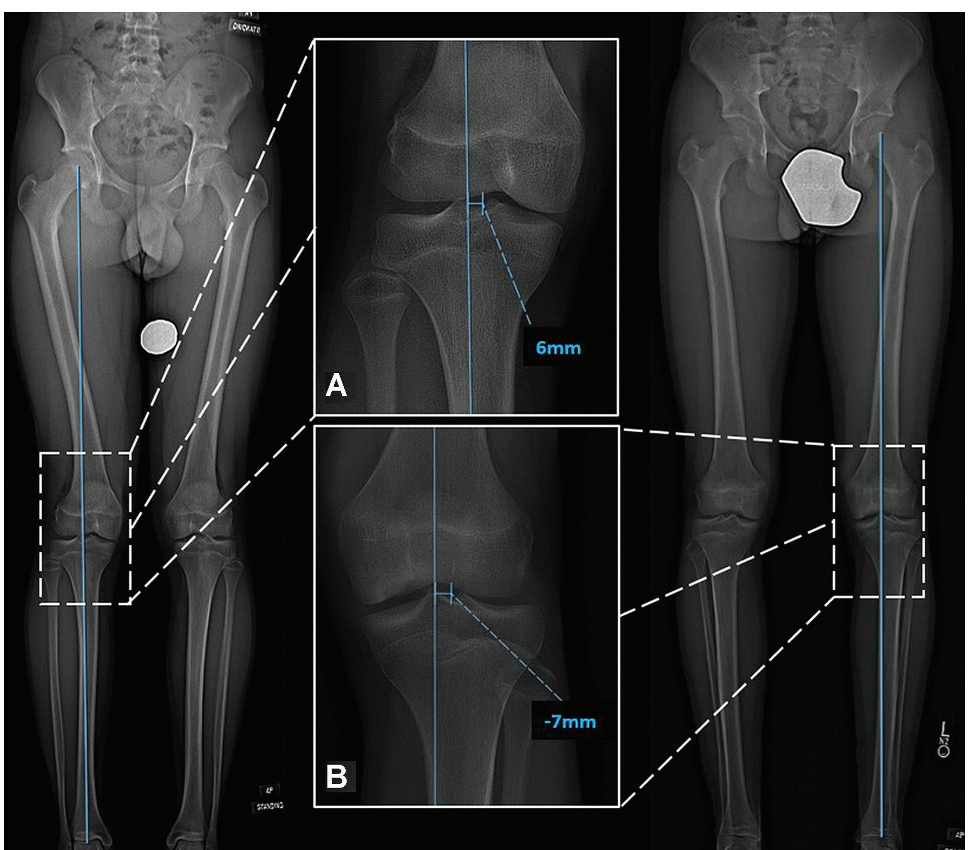

Figure 1. Neutral coronal plane alignment of a patient with trochlear OCD compared with the varus deviation of a patient with MFC OCD. Weightbearing hip-to-ankle alignment radiograph with details of MAD demonstrating (A) neutral and (B) varus alignment. MAD, mechanical axis deviation; MFC, medial femoral condyle; OCD, osteochondritis dissecans.

TABLE 2
Comparison of Imaging Parameters of Lower Extremity Alignment and Patellofemoral Stability in Patients With Trochlear OCD and MFC OCD[a]

Variable	Trochlear OCD (n = 18)	MFC OCD (n = 36)	*P*
HKA	1 ± 2	–1 ± 2	**.004**
mLDFA	86 ± 2	88 ± 2	**.004**
MPTA	88 ± 2	87 ± 2	.26
MAD	4 ± 8	–3 ± 8	**.004**
CDI	1 ± 0.2	1 ± 0.2	.67
Patellar tilt	5 ± 5	5 ± 5	.32
Sulcus angle	140 ± 8	140 ± 8	.89
TT-TG distance	10 ± 5	11 ± 5	.33
OCD lesion size			
Sagittal	20 ± 6	22 ± 6	.30
Coronal	14 ± 5	16 ± 4	.11

[a]Data are presented as means ± standard deviation. Boldface *P* values indicate a statistically significant difference between groups ($P \leq .05$). CDI, Caton-Deschamps Index; HKA, hip-knee-ankle angle; MAD, mechanical axis deviation; MFC, medial femoral condyle; mLDFA, mechanical lateral distal femoral angle; MPTA, medial proximal tibial angle; OCD, osteochondritis dissecans; TT-TG, tibial tubercle–trochlear groove.

measurement.[11] Overall, patients with trochlear OCD demonstrated a neutral coronal plane alignment on average based on MAD, suggesting no clinically meaningful coronal malalignment predisposition to the underlying pathogenesis of trochlear OCD.

OCD lesions of the trochlea are less common as compared with OCD lesions of the medial femoral condyle.[3] While no clear causes have been determined, repeated microtrauma to the bone and increased loading on the patellofemoral joint have been proposed as plausible causes.[12] Previous literature has examined the association between trochlear OCD lesion formation and athletic activity in adolescent patients. Price et al[12] identified a correlation between trochlear OCD lesion formation and basketball or soccer participation, suggesting that repetitive loading of the patellofemoral joint may play a role in the development of trochlear OCD lesions. These authors derived their hypothesis based on work by McElroy et al,[9] who identified specific joint loading patterns associated with athletic positions that can predispose to OCD lesion formation in the knee. Further, Wall et al[22] identified 95% of adolescent patients with trochlear OCD as athletes, suggesting a strong association between OCD lesion formation and sports. However, it is possible that patients who do not participate in sports could have asymptomatic trochlear OCD lesions that are not identified due to less loading of the patellofemoral compartment.

Previous research has identified the association between mechanical axis deviation and OCD lesions, with varus alignment increasing the risk of MFC OCD formation due to increased loading stress in the medial compartment of the knee.[18,21] In a study by Brown et al,[2] valgus mechanical axis deviation was found in two-thirds of patients with symptomatic lateral femoral condyle OCD, and varus MAD was found in one-third of patients with MFC OCD. Gonzalez-Herranz et al[4] found a similar association between varus deformity and lower limb axis deviation in patients with MFC OCD. However, they also found valgus deformity in patients with lateral femoral condyle lesions. All patients were reported to have either lateral (24.5%) or medial (75.5%) condyle lesions, with no trochlear lesions reported.[4] Jacobi et al[5] reported that valgus deformity was closely associated with lateral condyle OCD, while varus deformity was associated with medial condyle OCD. In none of these studies was lesion size associated with a specific coronal deviation, with our study similarly failing to identify a correlation between MAD and OCD lesion size on MRI.

Our work observed that patients with trochlear OCD had statistically less varus alignment compared with those with MFC OCD, driven largely by more distal femoral varus in the MFC cohort. Additional patellofemoral radiographic measurements have been previously studied in assessing knee alignment in patients with lower extremity OCD lesions. Kramer et al[7] suggested that an elevated TT-TG distance was a risk factor for patellar and trochlear OCD development. However, in reporting their findings, the authors did not differentiate the TT-TG distance measurements between the patellar and trochlear OCD groups. They also observed no difference in patellar height between OCD groups.[7] Our study similarly observed trochlear OCD and MFC OCD to have both mean TT-TG distance and CDI values within normal ranges.[14,17] This suggests that alterations in coronal alignment and patellofemoral mechanics may not predispose to trochlear OCD development.

Limitations

Our study had several limitations. First, not all patients were skeletally mature at the time of imaging or surgical intervention, and therefore, further growth may alter future alignment that was not captured on initial preoperative radiographs. However, further research should investigate how lower extremity alignments may change over time in patients with OCD. Second, long-term functional outcomes and follow-up were beyond the scope of this study, which sought primarily to evaluate predisposing factors to trochlear OCD development. Third, patients were matched only on age and sex, as OCD lesion size and stability are heterogeneous between trochlear and MFC lesions. It was felt that attempting to match these other characteristics would potentially introduce bias. Additionally, MAD was assessed utilizing a distance measurement (in mm) as is most common, although this is not standardized to height, which may affect this parameter. Trochlear OCD lesion location (central, lateral, and medial) was not available for all patients and was therefore not included. However, the study population was adequately powered to our primary outcome and observed differences in alignment between OCD groups.

CONCLUSION

The results of this study demonstrated that patients with trochlear OCD have less varus radiographic coronal alignment than patients with MFC OCD. No differences were observed in patellofemoral radiographic parameters between trochlear and MFC OCD patients, suggesting no obvious alignment predisposition to trochlear OCD development. Despite statistical differences in varus alignment between the trochlear and MFC OCD patients, the clinical relevance of these findings is unknown, and it is unclear whether differences in coronal plane alignment predispose to OCD lesion formation.

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REFERENCES

1. Brady JM, Sullivan JP, Nguyen J, et al. The tibial tubercle–to–trochlear groove distance is reliable in the setting of trochlear dysplasia, and superior to the tibial tubercle–to–posterior cruciate ligament distance when evaluating coronal malalignment in patellofemoral instability. *Arthroscopy*. 2017;33(11):2026-2034.
2. Brown ML, McCauley JC, Gracitelli GC, Bugbee WD. Osteochondritis dissecans lesion location is highly concordant with mechanical axis deviation. *Am J Sports Med*. 2020;48(4):871-875.
3. Flynn JM, Kocher MS, Ganley TJ. Osteochondritis dissecans of the knee. *J Pediatr Orthop*. 2004:434-443.
4. Gonzalez-Herranz P, Rodriguez ML, de la Fuente C. Femoral osteochondritis of the knee: prognostic value of the mechanical axis. *J Child Orthop*. 2017;11(1):1-5.
5. Jacobi M, Wahl P, Bouaicha S, Jakob RP, Gautier E. Association between mechanical axis of the leg and osteochondritis dissecans of the knee: radiographic study on 103 knees. *Am J Sports Med*. 2010;38(7):1425-1428.
6. Kamath J, Danda RS, Jayasheelan N, Singh R. An innovative method of assessing the mechanical axis deviation in the lower limb in standing position. *J Clin Diagn Res*. 2016;10(6):RC11-3.
7. Kramer DE, Yen YM, Simoni MK, et al. Surgical management of osteochondritis dissecans lesions of the patella and trochlea in the pediatric and adolescent population. *Am J Sports Med*. 2015;43(3):654-662.
8. Kumahashi N, Matsumoto A, Kuwata S, Kadowaki M, Uchio Y. Sporadically occurred bilateral osteochondritis dissecans on the trochlea of the femur: Case report. *J Pediatr Orthop. Part B*. 2017;26(5):482-486.
9. McElroy MJ, Riley PM, Tepolt FA, Nasreddine AY, Kocher MS. Catcher's knee: posterior femoral condyle juvenile osteochondritis dissecans in children and adolescents. *J Pediatr Orthop*. 2018;38(8):410-417.
10. Ogawa H, Matsumoto K, Akiyama H. Repair of osteochondritis dissecans of the lateral femoral condyle by a trochlea osteochondral autograft: a case report. *JBJS Case Connect*. 2022;12(1). doi: 10.2106/JBJS.CC.21.00570
11. Paley D, Pfeil J. Prinzipien der Kniegelenknahen Deformitätenkorrektur [Principles of deformity correction around the knee]. *Orthopade*. 2000;29(1):18-38.
12. Price MJ, Tuca M, Nguyen J, et al. Juvenile osteochondritis dissecans of the trochlea: a cohort study of 34 trochlear lesions associated with sporting activities that load the patellofemoral joint. *J Pediatr Orthop*. 2020;40(3):103-109.
13. Richie LB, Sytsma MJ. Matching osteochondritis dissecans lesions in identical twin brothers. *Orthopedics*. 2013;36(9):e1213-1216.
14. Roberts D, Delgado J. Caton-Deschamps index (knee). Radiopaedia.org. 2023. Accessed May 1, 2024. https://radiopaedia.org/articles/caton-deschamps-index-knee?lang=us
15. Ronga M, Zappalà G, Cherubino M, Genovese EA, Bulgheroni P. Osteochondritis dissecans of the entire femoral trochlea. *Am J Sports Med*. 2006;34(9):1508-1511.
16. Smith JB. Osteochondritis dissecans of the trochlea of the femur. *Arthroscopy*. 1990;6(1):11-17.
17. Song EK, Seon JK, Kim MC, Seol YJ, Lee SH. Radiologic measurement of tibial tuberosity-trochlear groove (TT-TG) distance by lower extremity rotational profile computed tomography in Koreans. *Clin Orthop Surg*. 2016;8(1):45-48.
18. Swindell HW, Kerzner B, Obioha OA, et al. Osteochondral allograft transplantation of the lateral femoral condyle and distal femoral osteotomy in the setting of failed osteochondritis dissecans fixation. *Arthrosc Tech*. 2022;11(7):e1301-e1310.
19. Takahashi Y, Nawata K, Hashiguchi H, Kawaguchi K, Yamasaki D, Tanaka H. Bilateral osteochondritis dissecans of the lateral trochlea of the femur: a case report. *Arch Orthop Trauma Surg*. 2008;128(5):88-92.
20. Thévenin-Lemoine C, Ferrand M, Courvoisier A, Damsin JP, Le Pointe HD, Vialle R. Is the Caton-Deschamps index a valuable ratio to investigate patellar height in children? *J Bone Joint Surg Am*. 2011;93(8):e35.
21. Turati M, Anghilieri FM, Bigoni M, et al. Osteochondritis dissecans of the knee: epidemiology, etiology, and natural history. *J Child Orthop*. 2023;17(1):40-46.
22. Wall EJ, Heyworth BE, Shea KG, et al. Trochlear groove osteochondritis dissecans of the knee patellofemoral joint. *J Pediatr Orthop*. 2014;34(6):625-6230.

APPENDIX

Trochlear OCD Measurements on Radiographs

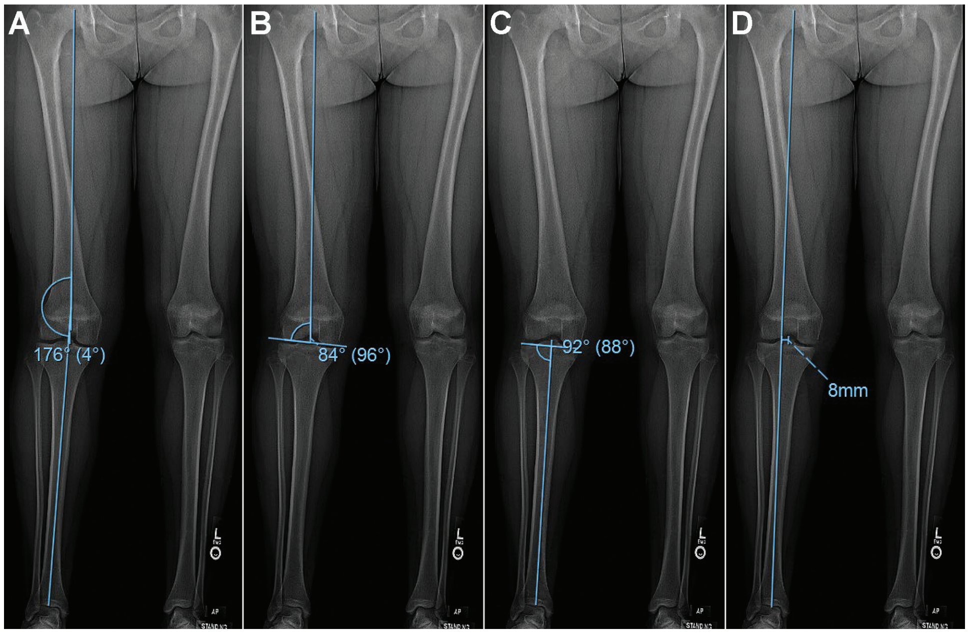

Figure A1. (A) The HKA—measured as the angle formed between a line drawn from the center of the femoral head to the center of the femoral intercondylar notch and a line from the center of the tibial spines to the center of the talus. (B) The mLDFA—measured as the angle formed between a line drawn from the center of the femoral head to the femoral intercondylar notch and a line across the most distal aspect of the femoral condyles. (C) The MPTA—measured as the angle formed between a line drawn across the proximal tibial plateau and a line from the center of the tibial spines to the center of the talus. (D) The MAD—calculated as the distance from the center of the intercondylar tibial spines to the mechanical axis of the limb, measured as the line between the center of the femoral head to the center of the tibiotalar joint (image adapted from Paley D, Pfeil J. Prinzipien der Kniegelenknahen Deformitätenkorrektur [Principles of deformity correction around the knee]. Orthopade. 2000;29(1):18-38). HKA, hip-knee-ankle angle; MAD, mechanical axis deviation; mLDFA, mechanical lateral distal femoral angle; MPTA, medial proximal tibial angle.

Figure A2. The CDI—measured as the ratio between the shortest distance from the posterior edge of the patella to the proximal, anterior aspect of the tibia and the length of the patellar articular cartilage (Adapted from Thévenin-Lemoine C, Ferrand M, Courvoisier A, Damsin J-P, Pointe HD le, Vialle R. Is the Caton-Deschamps Index a Valuable Ratio to Investigate Patellar Height in Children? J Bone Joint Surg Am. 2011;93(8):e35). CDI, Caton-Deschamps Index.

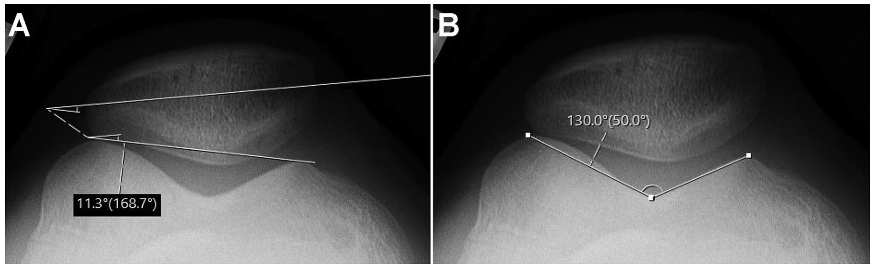

Figure A3. (A) Patellar tilt—measured as the angle between a line along the femoral condyles and a line through the center of the patella on Merchant/sunrise view. This value was recorded as positive if the patella was laterally tilted and negative if the patella was medially tilted. (B) The sulcus angle—measured as the 3-point angle between the most prominent aspect of the lateral femoral condyle, the deepest portion of the trochlear groove, and the most prominent aspect of the medial femoral condyle on Merchant/sunrise view.

Trochlear OCD Measurements on MRI

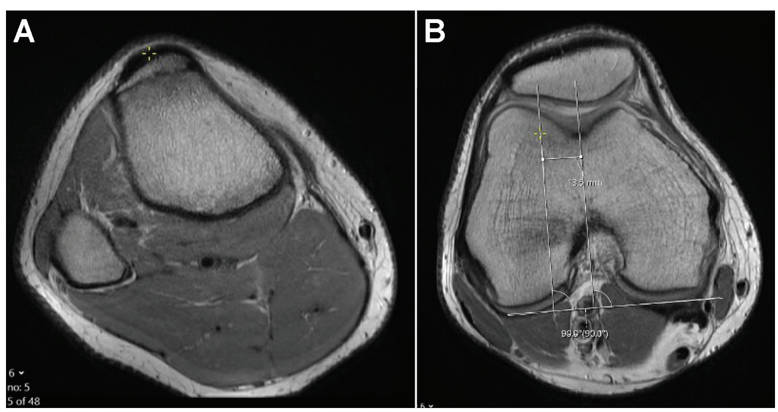

Figure A4. Tibial tuberosity-trochlear groove distance. (A) On axial view MRI, locate the most proximal slice with complete articular cartilage covering the trochlea. Draw a line parallel to the posterior femoral condyles. Draw a line perpendicular to this line. Move the perpendicular line so that it sits at the deepest part of the trochlear groove. Locate the tibial apophysis. Select the most distal axial slice at which the patellar tendon inserts on the tibial tubercle—usually the slice where the tibial apophysis looks the largest. Place the crosshair in the center of the patellar tendon from medial to lateral. (B) On the trochlear view, draw a line through the crosshair that is parallel to the line through the trochlear groove and perpendicular to the line through the posterior condyles. Measure the distance between the 2 parallel lines. MRI, magnetic resonance imaging.

Figure A5. Lesion size, measured as the distance of the OCD lesion on (A) sagittal and (B) coronal MRI. MRI, magnetic resonance imaging; OCD, osteochondritis dissecans.