Effect of Trochlear Dysplasia on Commonly Used Radiographic Parameters to Assess Patellar Instability

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Background: Trochlear dysplasia (TD) is an important anatomic risk factor for patellar instability (PI). Several imaging-based risk factors for PI have been established, but it is unclear what effect TD has on these measurements, and the Dejour method of categorizing TD has been shown to be unreliable. The lateral trochlear inclination (LTI) is a quantifiable measurement of proximal trochlear morphology. Recently, a modified technique for measuring LTI referencing the posterior condylar angle has demonstrated near-perfect reliability and may serve as a new standard for quantifying TD.

Purpose/Hypothesis: The purpose of this study was to evaluate how TD, expressed in terms of LTI, affects historically used measures of PI, including the sulcus angle (SA), tibial tuberosity to trochlear groove (TT-TG) distance, lateral patellar inclination (LPI), and Caton-Deschamps (CD) ratio. We hypothesized that lower LTI (ie, more dysplastic trochlea) will correlate with higher SA and TT-TG distances, increased patellar tilt, and more patella alta.

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

Methods: Patients aged 9 to 18 years treated for PI between January 2014 and August 2017 were queried. On magnetic resonance imaging (MRI), LTI, SA, LPI, and the TT-TG measured at the most proximal (pTT-TG) and distal (dTT-TG) aspects of the fully formed trochlear groove were measured on axial images. CD ratio was measured using sagittal MRI as well as lateral radiographs. All measurements were performed by 2 independent observers. Patients were included if there was a diagnosis of PI that was confirmed with a chart review and if there were appropriate imaging studies to analyze.

Results: A total of 65 patients met inclusion criteria for this study. Average pTT-TG distance (15.7 ± 4.5 mm) was not significantly different from dTT-TG distance (15.7 ± 4.2 mm) ($P = .94$). LTI had a weak but significant inverse correlation with pTT-TG ($r = –0.40$; $\beta = –0.15$ mm; $P < .001$) and SA ($r = –0.43$; $\beta = –0.478°$; $P < .001$). There was a moderate and significant inverse correlation of LTI with dTT-TG ($r = –0.593$; $\beta = –0.21$ mm; $P < .001$) and with LPI ($r = –0.69$; $\beta = –0.54°$; $P < .001$). There was a weak but significant correlation between LTI and the MRI-based CD ratio ($r = 0.279$; $\beta = 0.149$; $P = .005$). Radiograph-based CD ratio did not show a significant correlation with LTI ($r = –0.189$; $P = .135$).

Conclusion: Smaller (ie, more dysplastic) LTI values correlated significantly with larger TT-TG, SA, LPI, and MRI-based CD ratio measurements. The relationship between SA and LTI is intuitive, but the relationship between LTI and the other analyzed variables suggests that they are dependent variables to TD and may not be consistent independent risk factors for PI. Together, these suggest that TD alters the radiographic interpretation of TT-TG and patellar tilt. The correlation between TD and patellar height is unclear and warrants further investigation.

Keywords: trochlear dysplasia; radiology; pediatric sports medicine; patellofemoral

Patellar instability (PI) is primarily a condition of children, adolescents, and young adults, with 75% of index dislocations occurring in patients aged 25 years or younger.[1,17,35] PI is multifactorial, with several identified risk factors such as age, activity level, trochlear dysplasia (TD), patella alta, patellar tilt, and coronal and rotational plane malalignment.[4,12,21,24,31,36,41] Of these risk factors, TD has been consistently identified as having the strongest association with recurrent PI.[6,12,14,21,26,27]

Recently, some studies[9,25,40] have shown that TD alters the patellofemoral joint such that other radiographic parameters used to characterize PI, in particular the tibial tuberosity to trochlear groove (TT-TG) measurement, are changed relative to the amount of TD present. Brady et al[9] showed that the TT-TG distance was significantly correlated with the Dejour classification of TD. The higher the grade of TD, the higher the TT-TG distance. This was also noted in a study of skeletally immature patients with TD by

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Stepanovich et al.[38] This raises the question as to whether an elevated TT-TG distance, and what is traditionally thought to be associated with a lateralized tibial tubercle, is a primary anatomic abnormality or if it is dependent on the degree of dysplasia. While the Dejour classification has opened clinicians' eyes to the role of TD and prevalence in PI, it is a qualitative assessment that has been shown to have poor intra- and interobserver reliability.[5,9,28,34] Thus, these studies may not have evaluated the effect of TD on the TT-TG in an optimal fashion.

The lateral trochlear inclination (LTI) is a measure that has been previously described for characterizing trochlear morphology.[10] Recently, a novel LTI measurement technique using 2 magnetic resonance imaging (MRI) slices has been proposed to optimally capture the angle subtended between the proximal trochlea and the posterior femoral condyles for a more accurate representation of the LTI.[22] Because the LTI provides a numeric measurement of the trochlea, it can serve not only to qualify TD but also to quantify the amount of TD present. This stands in distinction to the Dejour classification, which serves as more of a qualitative analysis of TD. To date, no one has evaluated how TD, as measured by the LTI, affects other radiographic parameters of PI.

The position of the patella is another described anatomic risk factor for PI, with patella alta and excessive tilt most commonly described.[19,21,29,32,36] No study has looked directly at the possible effects that dysplasia has on patellar position, but a recent study by Fabricant et al[15] highlighted a statistically significant improvement in radiographic measurements of alta after patellar stabilization with medial patellofemoral ligament reconstruction.

The purpose of this study was to evaluate the influence that TD, as measured by the LTI, has on other radiographic measures of PI, specifically the TT-TG distance, sulcus angle (SA), lateral patellar inclination (LPI) angle, and the Caton-Deschamps (CD) ratio in the high-risk group of pediatric and adolescent patients. We hypothesized that lower LTI measurements (ie, more dysplastic trochleas) would be correlated with increased TT-TG distances, SAs, patellar tilt, and patella alta.

METHODS

After obtaining institutional review board approval for this study, a query was conducted to identify patients who were treated for PI at our tertiary referral center between January 2014 and August 2017. Both radiographic and MRI examinations of the symptomatic knee were obtained for measurement. Exclusion criteria for this study included patients with PI because of noted coronal plane or rotational malalignment, prior knee surgery, and genetic syndromes resulting in predisposition for skeletal abnormalities; those undergoing treatment ultimately for a different diagnosis; and those who did not have both radiographs and MRI studies. To minimize the chance of arthritic changes on imaging studies, the upper age limit was set at 18 years. Prior work[38] has shown that TD can be evaluated via MRI in the skeletally immature, particularly when the measurements are taken from the surface of the articular cartilage. Further, the vast majority of PI presents in the pediatric and adolescent age group, so this population was evaluated exclusively.[21,35,36]

The LTI, LPI, and TT-TG measurements were made on axial MRI images. Proton density fat saturation (PD FS) sequences were used for measurements. T2 fat saturation (T2 FS) sequences were used if the prior was not available. The CD ratio was measured on both lateral radiographs and MRI. LTI and LPI measurements were performed using a novel 2-slice technique that most accurately references the orientation of the fully formed posterior femoral condyles, as described in the "Lateral Trochlear Inclination" and "LPI Angle" sections. Reliability of these measurements is near perfect and has been described elsewhere.[22,23] Measurement protocols were established by the principal investigator (J.L.P.) and distributed to the other authors for reference before measurement. All measurements were then made by 2 independent observers (C.C., S.M.J.).

Lateral Trochlear Inclination

The LTI measurement protocol involves initially identifying the first axial image where the proximal lateral trochlear cartilage is seen. This image should be cross-referenced with a PD FS or T2 FS sagittal image to ensure the measurement occurs at the most proximal aspect of the trochlea. The angle between a line along the lateral trochlear cartilaginous surface and the horizontal is taken and recorded. Next, a more distal axial image is chosen, in which the posterior femoral condyles are fully formed and clearly defined. An angle between a line along the posterior condyles and the horizontal is taken and recorded here as well. LTI is determined as the difference between the lateral trochlear angle and the posterior condylar angle (Figure 1).

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Ethical approval for this study was obtained from Connecticut Children's Medical Center (protocol No. 18-015).

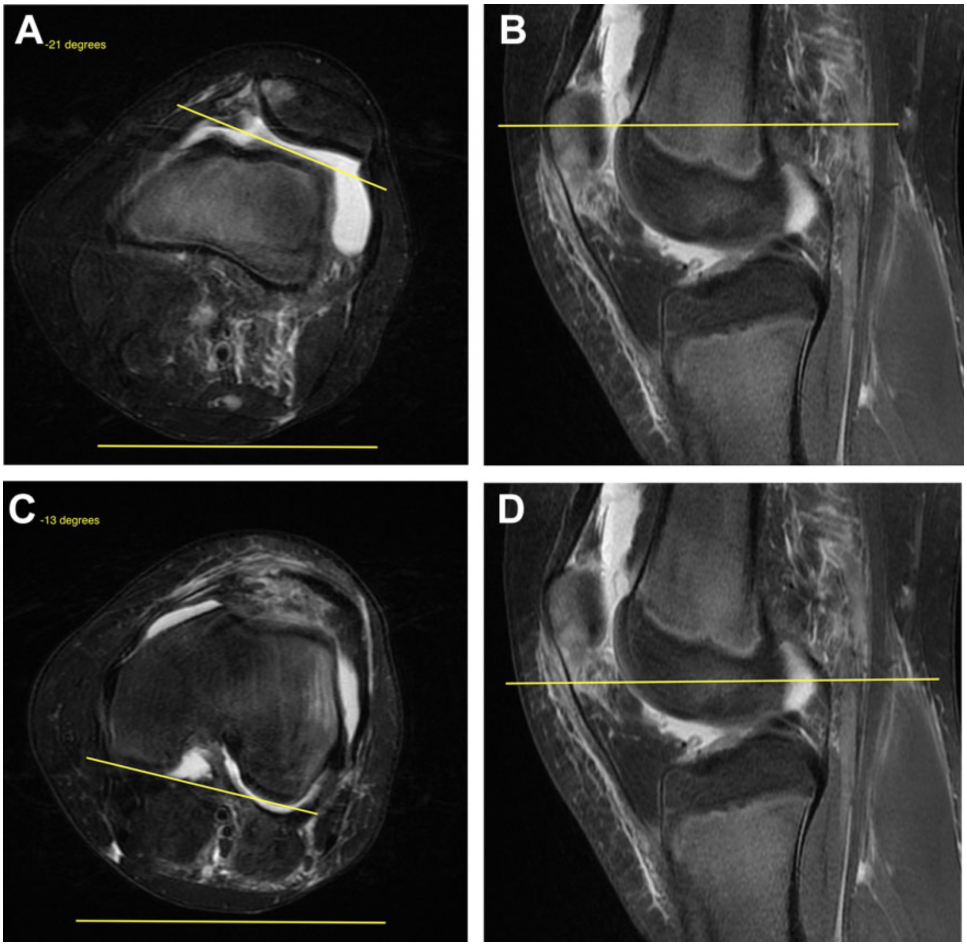

Figure 1. (A) Axial MRI image of knee showing the most proximal cut of trochlear cartilage. An angular measurement is made of the trochlear cartilage relative to the horizontal. In this case, because the angle slopes up medially (convex trochlea), it is recorded as a negative number: –21°. (B) Sagittal MRI image of knee with cross-reference lines that help the viewer identify the most proximal cut of trochlear cartilage on the axial image. The sagittal image that has the most proximal extent of visible trochlear cartilage was chosen. This tended to be just lateral to the intercondylar notch. (C) Axial image showing fully formed posterior femoral condyles. An angle is measured here between the posterior condyles and the horizontal. Angular measurements that show internal rotation are recorded as positive values. Because the condyles are externally rotated in this image, the angle here is –13°. The LTI is calculated by subtracting the angle of the posterior condyles from the angle of the proximal trochlea; in this case, it is –21° – (–13°) = –8°. (D) Sagittal MRI image of knee showing the level at which the posterior femoral condyles are fully formed. Note the distance between the proximal trochlea and the fully formed posterior condyles. LTI, lateral trochlear inclination; MRI, magnetic resonance imaging.

Sulcus Angle

The SA was measured as the angle subtended on the first axial MRI slice showing medial and lateral trochlear facets.[4] Measurements were not made on planar radiographs, as there was no way to control for the amount of knee flexion present.

LPI Angle

LPI measurement was similar to what was described by Fucentese et al,[18] with modifications similar to what were made to LTI. First, the axial image showing the patella at its maximum width was used to measure the LPI. An angle was measured between the major axis of the patella and the horizontal. This value was subtracted from an angle measurement of the fully formed posterior femoral condyles relative to the horizontal to determine the LPI (Figure 2). This measurement has excellent to near-perfect inter- and intrarater reliability.[23]

TT-TG, Proximal and Distal

The TT-TG distance was measured at the most proximal and distal extents of the trochlea (pTT-TG and dTT-TG, respectively) as described by Brady et al.[9] The pTT-TG was measured on the axial MRI slice in which medial and lateral trochlear facets were clearly visible. As discussed above in the "Sulcus Angle" section, this image was also used to measure the SA. The dTT-TG was measured on the most

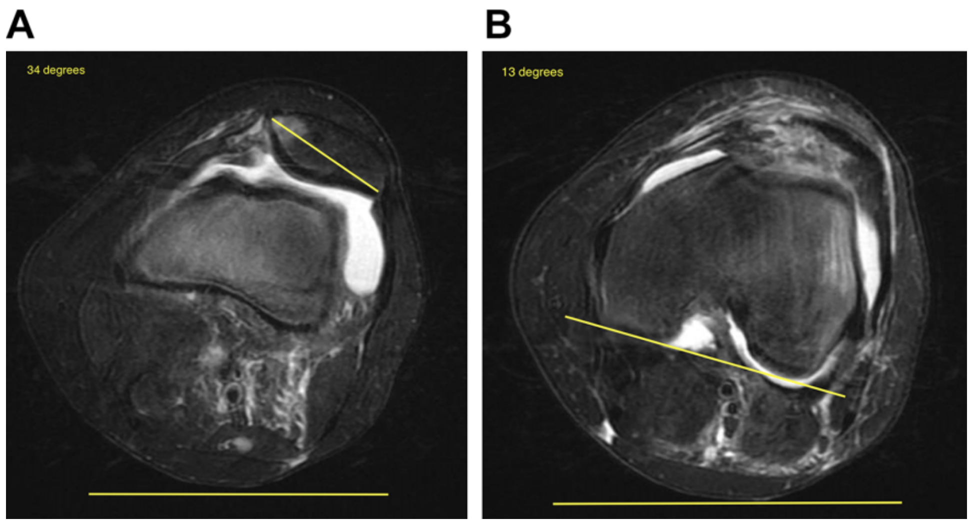

Figure 2. (A) Axial MRI image of knee showing the widest portion of the patella. An angular measurement is made between the most medial and lateral aspects of the patella and the horizontal. In this case, the angle is 34°. (B) Axial MRI image showing the fully formed posterior condyles, similar to Figure 1C. The angle between the posterior condyles and the horizontal is measured. In this situation, external rotation of the condyles is recorded as a positive value because it has the same vector as the laterally tilted patella; thus, it is +13°. LPI is calculated by subtracting the angle of the posterior condyles from the angle of the patella. In this case, the LPI is 34° – 13° = 21°. Inter- and intrarater reliability indicate near-perfect intraclass correlation coefficients of 0.89 and 0.98, respectively.[23] LPI, lateral patellar inclination; MRI, magnetic resonance imaging.

distal axial image in which a trochlear groove could be clearly visualized before visualizing the intercondylar notch.

CD Ratio

The CD ratio was measured on lateral radiographs and sagittal MRI. Radiograph evaluation was consistent with the protocol described by Caton.[11] MRI evaluation was per the protocol by Yue et al,[42] in which the sagittal MRI image showing the longest length of patellar articular cartilage was chosen. This distance was measured as was the distance from the inferior aspect of the patellar articular cartilage to the most proximal and anterior aspect of the tibial plateau. Regarding planar radiograph interpretation, preoperative films were used to ensure that patellar height was not altered as a result of surgery.[15]

Statistical Analysis

Means and standard deviations were calculated for all variables studied. Linear regression analyses were used to evaluate correlation between LTI and SA, pTT-TG, dTT-TG, LPI, and CD ratio. *P* values of $<.05$ were considered statistically significant.

RESULTS

A total of 65 patients met the inclusion criteria for this study. The average patient age was 14.2 years (range, 9.2-18.1 years); 54% of patients were male and 46% were female. The average SA was 158° ± 9°. The pTT-TG and dTT-TG distances in this cohort were 15.7 ± 4.5 mm and 15.7 ± 4.2 mm, respectively, and were not significantly different ($P = .94$). The average LTI was 4.2° ± 11.9° and the average LPI was 19.6° ± 9.4°. Average CD ratio measurement was 1.3 ± 0.3 on radiograph and 1.25 ± 0.19 on MRI; this difference was statistically significant ($P < .001$).

Linear regression analysis showed significant inverse correlations between LTI and pTT-TG, dTT-TG, LPI, and SA ($P < .001$ for all). There was also a significant linear correlation between LTI and MRI-based CD ratio ($P = .005$), although no association was found between LTI and

TABLE 1
Linear Regression Analysis Between Trochlear Dysplasia as Measured by the LTI and Several Common Radiographic Measurements of Patellar Instability[a]

	r	β	*P*
pTT-TG	–0.40	–0.15	<.001
dTT-TG	–0.593	–0.21	<.001
LPI	–0.69	–0.54	<.001
SA	–0.43	–0.478	<.001
CD ratio (radiograph)	–0.189		.135
CD ratio (MRI)	0.279	0.149	.005

[a]The value of *r* represents the strength of the correlation between LTI and the dependent variable of interest. Beta (β) represents the dependent variable change per 1 unit change in the independent variable; in this case, the independent variable is LTI. CD, Caton-Deschamps ratio; dTT-TG, distal tibial tubercle to trochlear groove distance; LPI, lateral patellar inclination; LTI, lateral trochlear inclination; MRI, magnetic resonance imaging; pTT-TG, proximal tibial tubercle to trochlear groove distance; SA, sulcus angle.

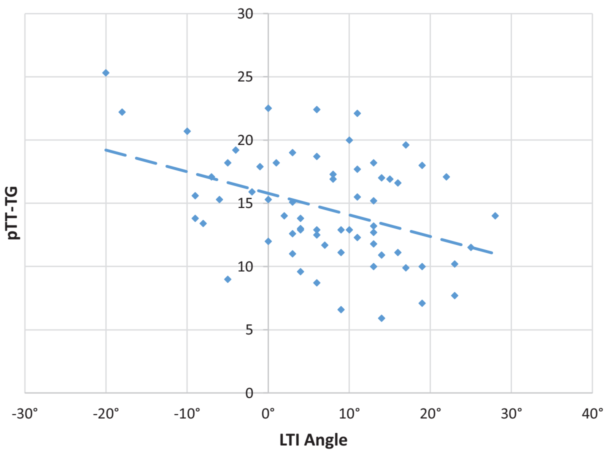

Figure 3. Scatter plot with best-fit line showing the relationship between LTI and pTT-TG. Negative LTI values (more severe dysplasia) are to the left of the *x*-axis. Thus, as depicted in this figure, as LTI increases (less dysplasia), the pTT-TG decreases and vice versa. LTI, lateral trochlear inclination; pTT-TG, proximal tibial tuberosity to trochlear groove.

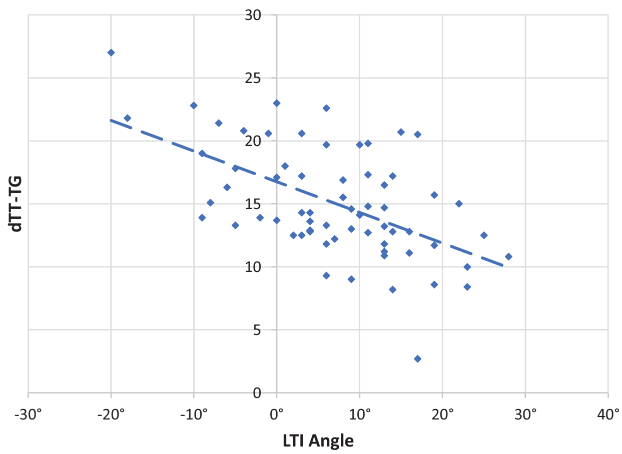

Figure 4. Scatter plot with best-fit line showing the relationship between LTI and dTT-TG. Negative LTI values (more severe dysplasia) are to the left of the *x*-axis. Thus, as depicted in this figure, as LTI increases (less dysplasia), the dTT-TG decreases and vice versa. dTT-TG, distal tibial tuberosity to trochlear groove; LTI, lateral trochlear inclination.

the radiograph-based CD ratio. Results are listed in Table 1 as well as in Figures 3-7. These results show that for every 1° decrease in LTI (more dysplasia), there was a 0.15-mm increase in the pTT-TG, a 0.21-mm increase in the dTT-TG, a 0.54° increase in the LPI, and a 0.478° increase in the SA. For every 1° increase in LTI, there was a 0.149-unit increase in the MRI-based CD ratio. While these correlations were statistically significant, the linear relationships that exist between LTI and the SA and MRI-based CD ratio were rather neutral (Figures 6-7).

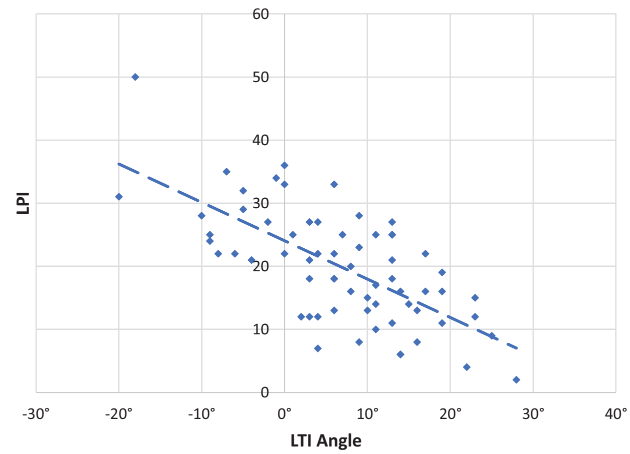

Figure 5. Scatter plot with best-fit line showing the relationship between LTI and LPI. Negative LTI values (more severe dysplasia) are to the left of the *x*-axis. Thus, as depicted in this figure, as LTI increases (less dysplasia), the LPI decreases and vice versa. LPI, lateral patellar inclination; LTI, lateral trochlear inclination.

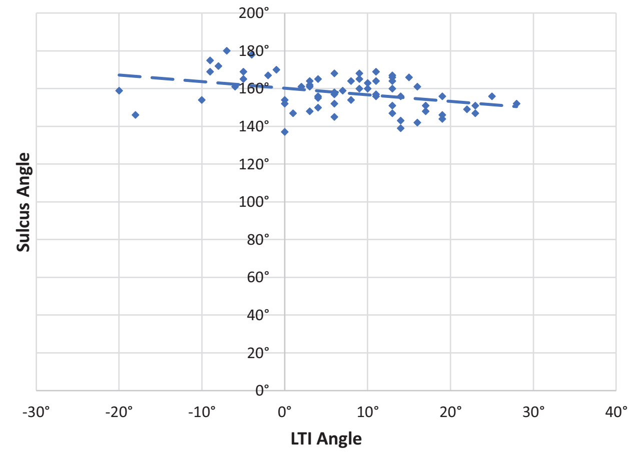

Figure 6. Scatter plot with best-fit line showing the relationship between LTI and SA. Negative LTI values (more severe dysplasia) are to the left of the *x*-axis. Thus, as depicted in this figure, as LTI increases (less dysplasia), the SA decreases (less dysplasia) and vice versa. However, the slope of the best-fit line is rather flat in comparison with the relationship of LTI with pTT-TG, dTT-TG, and LPI. dTT-TG, distal tibial tuberosity to trochlear groove; LPI, lateral patellar inclination; LTI, lateral trochlear inclination; pTT-TG, proximal tibial tuberosity to trochlear groove; SA, sulcus angle.

DISCUSSION

This study sought to evaluate the relationship between TD and other radiographic markers of PI by using a quantitative and reliable measurement of dysplasia, the LTI. In contrast to the Dejour classification, the LTI provides a numeric assessment of proximal trochlear morphology. Given that other radiographic measurements to analyze

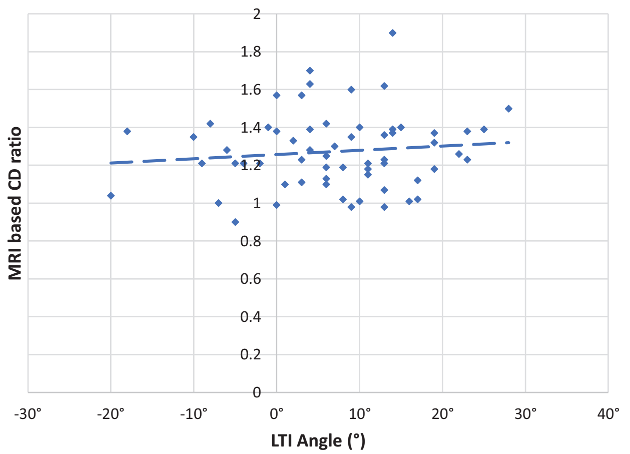

Figure 7. Scatter plot with best-fit line showing the relationship between LTI and MRI-based CD ratio. Negative LTI values (more severe dysplasia) are to the left of the *x*-axis. Thus, as depicted in this figure, as LTI increases (less dysplasia), the CD ratio increases (more patella alta) and vice versa. However, the slope of the best-fit line is rather flat in comparison with the relationship of LTI with pTT-TG, dTT-TG, and LPI. CD, Caton-Deschamps; dTT-TG, distal tibial tuberosity to trochlear groove; LPI, lateral patellar inclination; LTI, lateral trochlear inclination; MRI, magnetic resonance imaging; pTT-TG, proximal tibial tuberosity to trochlear groove.

pathoanatomy in a patient with PI are also numeric, a more representative correlation between these parameters and dysplasia can be established by using the LTI. In our study, it was found that the smaller or more negative LTI values (more dysplasia) were significantly associated with larger TT-TG, SA, and LPI values.

TD has consistently been associated with PI, and several studies[4,12,20,21,26,27,31] have identified it as either the primary or one of the strongest associated risk factors for instability or recurrent instability. Dejour et al[14] observed that in a population of patients undergoing surgical stabilization for PI, 85% had 2 radiographic signs of TD and 96% had 1 sign of TD, versus only 6% of the control group with any radiographic signs of TD. While the association between TD and PI is well established, an agreed-upon and reliable measure of TD has not been established, and although the Dejour classification is widely accepted, its shortcomings include its low inter- and intraobserver reliability and its qualitative nature.[9,28] The SA has also been used, and while it can provide a precise numeric value, it is of limited usefulness, as it is measured at a position on the trochlea that is distal to the most severe location of dysplasia.

The LTI has been a proposed quantitative measurement of TD via MRI since it was first described by Carrillon et al.[10] Since then, others[25,30] have highlighted its usefulness and reliability. Our group recently described a novel method to measure the LTI using a 2-MRI-slice technique that allows reliable assessment of the most proximal aspect of the cartilaginous trochlea and the fully formed posterior condyles.[22] The intra- and interobserver reliability for this novel measurement technique was near perfect. A reliable measure that can be numerically quantified is well suited for clinical diagnosis, treatment algorithms, and research purposes.

Recently, Brady et al[9] and Stepanovich et al[38] noted an association between TD and elevated TT-TG values in patients with PI. Despite using the Dejour classification to describe TD, they found that the TT-TG values increased along with the dysplasia. Elevated TT-TG values have long been associated with PI, and it has been assumed that this is because of a laterally positioned tibial tubercle.[9,25,33,37,40] However, an association between TD and increased TT-TG values begs the question: Is an elevated TT-TG value really representative of a lateralized tibial tubercle or is it more representative of a medialized trochlear groove? In our study, by using the LTI as our measure of TD, we found that for every 1° decrease in the LTI (more dysplasia), there was a corresponding 0.15- and 0.21-mm increase in the pTT-TG and dTT-TG, respectively. This is the principal finding of this study, and while it does not establish a direct linkage between a medialized trochlear groove against a statically fixed tibial tubercle, it does show that higher degrees of TD increase the distance between the trochlear groove and the tibial tubercle.

Prior work by Fucentese et al[18] evaluated computed tomography (CT) trochlear measurements before and after groove-deepening trochleoplasty. In their cohort of 17 knees, they found, among several other findings, that the pTT-TG lateralized an average of 6.1 mm and the dTT-TG lateralized an average of 2.5 mm after a groove-deepening trochleoplasty. Our data are complementary to theirs in that correction of the trochlea shortened the distance between the 2 anatomic sites. Thus, the TT-TG may more accurately represent an indirect measure of dysplasia, as opposed to a direct measure of rotational alignment, at least in the setting of PI because of TD. Further work using a fixed anatomic landmark between a control and study group is needed to further investigate this question. While our findings were highly significant ($P < .001$ for pTT-TG and dTT-TG), the correlation was weak to moderate ($r = -0.40$ for pTT-TG and $r = -0.593$ for dTT-TG). As normal TT-TG measurements are considered to be within a range, typically 10-13 mm,[14,37] a weak-to-moderate correlation in this context makes sense, given normal variation from person to person. Interestingly, in our cohort, no significant difference was found comparing TT-TG distances measured from the proximal (pTT-TG) and distal (dTT-TG) trochlea. These data are consistent with what was reported by Brady et al[9] in both their dysplastic and their control cohorts. Thus, regardless of what effect TD may have on the position of the trochlear groove, it proceeds distally in a fairly straight line.

The SA is a described numeric description for TD that can be measured on axial radiographs or MRI. An SA >145°-150° has been considered diagnostic of dysplasia.[8,13,39] However, its utility is questionable, as it requires a fully formed trochlear groove, to include a medial facet, to perform the measurement. Given that TD is most severe at the most proximal aspect of the trochlea when a medial facet is not present,[7] the SA may not capture the real magnitude of dysplasia. That being said, the significant inverse relationship between LTI and SA is intuitive. What is interesting is that the correlation between the 2 was weak ($r = -0.43$) and that the linearity of the relationship was rather neutral. Interpretation of these data suggests that while both are valid numeric measurements of TD, a shallow groove more distally cannot highly predict the presence or absence of convexity or a large spur proximally. Thus, while SA has been shown to have significant value in assessing the risk of future PI,[3] it is not a reliable reflection of more proximal trochlear morphology (where dysplasia is most severe) and thus may have less value in surgical decision making, particularly when it comes to determining the need for a groove-deepening trochleoplasty.

The relationship between increased patellar tilt and TD should come as no surprise. For every 1° decrease in LTI, there was a 0.54° increase in patellar tilt. This suggests that as the trochlea becomes more shallow to convex, the lateral facet of the patella, particularly when the knee is extended as in for MRI studies, tends to tilt laterally to maximize contact area with the proximal lateral trochlea, as there is no appropriate geometry to accept the median ridge or medial facet of the patella.

The relationship between patellar height and TD is of interest. A recent study by Ferlic et al[16] found a significant relationship between TD and patellar height, as measured by the amount of patellar and trochlear overlap on axial CT imaging. While our study looked at the relationship of the patella to the proximal tibia (CD ratio), we also found a correlation between patella alta and TD ($P = .005$) via MRI analysis. This finding is odd because the direct relationship suggests that as the LTI increases (less dysplasia), the CD ratio increases. While this correlation was statistically significant, the linearity of the correlation was rather neutral, and thus this finding should be interpreted with caution. We used a tibial-based measurement (CD ratio), and further investigation with a trochlear-based measurement, the patellar trochlear index (PTI)[2] for example, is warranted to further explore this relationship. However, one must consider that any 2-dimensional sagittal plane assessment of patellar height in the setting of PI is inherently going to be flawed, given that the patella is often out of plane of the central trochlea and intercondylar notch of the femur. In addition to exploring 2-image measurement techniques, perhaps a coronal or axial plane assessment technique or a 3-dimensional modeling technique could yield a more reliable assessment of patellar height. Last, given that radiographic evaluation of the CD ratio had no correlation with LTI and was significantly different ($P < .001$) from MRI evaluation, we recommend using radiographic evaluation of patellar height as a supplement to advanced imaging studies such as CT or MRI.

This study has several limitations. First, no control group was assessed in this study, as we sought only to evaluate correlations between LTI and various other measurements of abnormal trochlear morphology in patients with PI. Follow-up studies using an age- and sex-matched control group would help establish a new quantifiable threshold value for pathological LTI. This new value would help more appropriately risk stratify patients with PI. Second, this study limited the comparison of LTI to only 3 commonly used methods in the evaluation of PI. Other measurements that contribute to PI, including but not limited to patellar-trochlear index, patellar shape, and lateral condyle index, could also be investigated in the future regarding their correlation with TD. Last, torsional and coronal plane malalignment was not optimally excluded from our study. Our ability to exclude these patients was based on chart and imaging review. It is possible that some patients had unrecognized genu valgum or femoral anteversion that could have contributed to their PI. However, given the relative rarity of these pathoanatomic findings in the setting of PI, these factors are thought to have a minimal to negligible bias on our results.

CONCLUSION

TD has a significant effect on several radiographic measurements used to evaluate patients with PI. The TT-TG measurement, taken proximally or distally, and patellar tilt are significantly altered in the presence of TD. While we cannot determine the exact reason based on our study design, the TT-TG distance was increased in the setting of dysplasia and patellar tilt (LPI) was increased, likely because of an adaptation of patellar position to accommodate a dysplastic trochlea. These findings show that TD drives evaluation of the patellofemoral joint in the setting of PI and increases our understanding of how dysplasia plays a central role in most cases of PI. This can greatly improve our ability to provide risk-assessment analysis for patients with PI as well as improve our surgical algorithms. Last, the relationship between patellar height and TD continues to be unclear, and further study looking at other metrics of patellar height (eg, PTI) is warranted to further evaluate if there is any correlation between these 2 entities.

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