Original Research

Tibial tubercle to trochlear groove and the roman arch method for tibial tubercle lateralisation are reliable and distinguish between subjects with and without major patellar instability

Sebastián Irarrázaval, Pablo Besa *, Tomás Fernández, Francisco Fernández, Rodrigo Donoso, María Jesús Tuca, María Jesús Lira, Mario Orrego

Department of Orthopedic Surgery, School of Medicine, Pontificia Universidad Católica de Chile, 8330077, Chile

ARTICLE INFO

Keywords:
Patellar dislocation
Tibial tubercle lateralization
TT-TG
TT-PCL
Tibial tubercle osteotomy

ABSTRACT

Purpose: Patellofemoral (PF) instability recurrence depends on several factors including the relative lateralisation of tibial tubercle (TT) regarding the trochlear groove (TG). TT relative lateralisation quantification has long been a topic of debate. Multiple measuring techniques have been described including TT-trochlear groove (TT-TG), TT-posterior cruciate ligament (TT-PCL) and TT-roman arch (TT-RA), with no clear consensus regarding the most reliable index or pathologic threshold. We set out to determine the normal value range of each index and their association with age, sex and PF instability status. Also, this study aims to determine a reliable pathologic distance threshold to effectively predict patellar dislocation.

Methods: Skeletally mature patients up to 45 years of age who presented a CT Scan and an MRI of the same knee between 2014 and 2018 were included and divided into subgroups based on history of PF instability. Three indexes (TT-TG, TT-PCL and TT-RA) were assessed by two independent observers blinded to instability history. ROC curves were performed for each index to obtain the cut point that better predicts instability. Univariate and multivariate models adjusted by age, sex, instability history and type of imaging technique were performed to test the influence of these variables.

Results: 208 patients were included. Mean age was 27.93 ± 8.48 years, 67.3% were female and 71 patients (34.1%) presented major instability history. Good or excellent inter and intraobserver reliability was found for all three indexes. All indexes presented significantly different distributions between subjects with and without major instability (p < 0.001), except for TT-PCL. Different cut point values differing between imaging modalities were found: 11.4 mm for MRI TT-TG, 17 mm for CT TT-TG, 15.6 mm for MRI TT-RA and 18.2 mm for CT TT-RA.

Conclusions: All indexes studied had good or excellent inter and intraobserver reliability. Measurements between imaging techniques (CT and MR) are not interchangeable. Both TT-TG and TT-RA correctly distinguish between subjects with and without major instability, while TT-PCL does not, recommending caution when evaluated on its own. Specific threshold values depending on imaging technique should be considered for surgical decision-making.

Level of evidence: Level IV, Diagnostic Test.

* Corresponding author. Diagonal Paraguay 362, Santiago, RM, Chile. Tel.: (+569) 71399611
E-mail address: pablobesa@gmail.com (P. Besa).

https://doi.org/10.1016/j.jisako.2024.01.006
Received 18 August 2023; Received in revised form 20 December 2023; Accepted 8 January 2024
Available online 14 January 2024
2059-7754/© 2024 The Authors. Published by Elsevier Inc. on behalf of International Society of Arthroscopy, Knee Surgery and Orthopedic Sports Medicine. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
What are the new findings

- Relative lateralisation indexes for the tibial tubercle are not interchangeable between different imaging modalities (computed tomography and magnetic resonance imaging)
- Tibial tubercle to trochlear groove and the roman arch method allow discrimination between stable and unstable patellas
- Tibial tubercle to posterior cruciate ligament is not a recommended index as a unique relative lateralisation measurement

INTRODUCTION

Patellar instability is a common knee injury, representing up to 3% of all knee injuries [1]. It presents as episodes of patellar dislocation or subluxation, either isolated or recurrent in time. Incidence ranges between 5 and 7 per 100,000 amongst the general population, but in teenagers (10–17 years of age) incidence rises up to 108 per 100,000 [2–6]. This fact is even more relevant, considering that the overall rate of recurrence for first-time patellar dislocation is 33.6%, increasing progressively with every risk factor, reaching up to 88.4% when 4 risk factors are present [7] and with a 50% risk in case of a second episode [8]. This makes determining the risk of recurring instability paramount to patient assessment, trying to determine the individual factors that could lead to patient recurrence.

Recurrence of patellofemoral (PF) instability is considered to be multifactorial, with varied anatomical alterations described in the literature as predisposing factors [9,10]. Anatomical factors involved in patellar instability include patella alta, trochlear dysplasia, competence of the medial patellofemoral ligament (MPFL), the relative lateralisation of tibial tubercle (TT) regarding the trochlear groove (TG) and rotational deformities [10]. Of interest for this study is the TT, which arises from the anterior tibia cortex and serves as the insertion point for the extensor force vector [9].

Various methods have been described in an attempt to objectively quantify relative TT lateralisation. Dejour et al. [11], described in 1994 a method using superimposed CT Scan (Computed Tomography Scan) axial slices to measure the distance between the TT and the deepest point of the TG. This TT-TG distance has been widely used in literature and clinical practice as a measurement to determine which patients could benefit from TT realignment osteotomies. Based on this observational study, the normal threshold value was set at 20 mm for adult subjects [11]. However, this threshold was estimated on a relatively small sample, and newer evidence has revealed that TT-TG varies based on age and sex, among other factors [12,13]; meaning that a reliable cut-off value, to determine the need for surgical correction, remains unknown.

Some authors have used TT-TG interchangeably between CT and Magnetic Resonance Imaging (MRI) using the same 20 mm threshold, however, recent studies have shown that the correlation of TT-TG between imaging modalities would not be as reliable as previous evidence had suggested [14]. TT-TG has proven to be affected by the degree of knee flexion, rotation of the lower extremity associated and trochlear dysplasia among other factors [15,16]. Given these controversies, other radiologic measurements have been proposed as alternatives to the TT-TG. Settlinger et al. [17] described in 2012 the TT-posterior cruciate ligament (TT-PCL) as an MRI measurement that could quantify the position of the TT independent from the degree of knee flexion, trochlear geometry and knee alignment. Furthermore, the key feature of the TT-PCL is that the whole measurement is done on the tibia, extra-tibial factors. Additionally, Xu et al. [18] presented a new CT measurement known as the TT-roman arch method (TT-RA), suggesting that the roman arch (intercondylar sulcus) is a more consistent femoral landmark. However, the growing body of evidence has not reached a consensus regarding the most reliable measurement method. Different studies comparing TT-TG and TT-PCL reach opposing conclusions of whether the new TT-PCL can reliably differentiate patients with and without patellar instability [19].

Given current controversies regarding the varying measurement techniques and controversial cut-off values predicting PF instability, the purpose of this study is to determine the normal values of each index among adult (skeletally mature) patients; the association of each index with demographic variables including age and sex; the inter and intra-observer reliability; and the correlation of each index to recurrent instability. We hypothesise that commonly used cut-off values do not accurately resemble pathologic distances, are not equivalent and reliably interchangeable between different imaging techniques, and that all indexes are associated with demographic variables.

MATERIALS AND METHODS

Institutional review board approval for this study was obtained (IRB N°190703007).

Study population

A retrospective search was performed, using the imaging database of our institution. All skeletally mature patients, up to 45 years of age (range in which most primary instability episodes occur) were scanned. Among this group, patients who had a CT Scan and an MRI of the same knee for any diagnostic hypothesis between 2014 and 2018 were included. On the contrary, patients with injuries to collateral or cruciate ligaments, and/or the presence of fractures (past or present), were excluded from further analysis. Included patient records were assessed for knee pathology history. All patients were then divided into two groups based on previous history of major PF instability, defined as one or more patellar dislocations.

Index measurements

Both CT scan and MRI images were imported from DICOM into a software developed in MATLAB (MATLAB -2019- version 9.6 -R2019a-Natick, Massachusetts, The MathWorks Inc.). This software was used to standardise index measurements from all images, using a computerised semi-automatic algorithm, which automatically calculates indexes based on selected axial slices both on CT and MRI. For MRI analysis, bony landmarks were used, not considering cartilage width, to standardise landmarks between both imaging techniques.

Two independent reviewers, blinded to instability status, measured all patients using this novel software. Three indexes were measured on MRI: TT-TG, TT-PCL and TT-RA, whilst on CT Scan, TT-TG and TT-RA were measured given the impossibility of the soft tissue landmark required for TT-PCL. Differences among reviewers were averaged for analysis. Agreement among reviewers was estimated using the intraclass correlation coefficient (ICC) for average measurements and absolute agreement. Each index measurement shared a common landmark: the tibial tuberosity (TT). The location of this landmark was selected on the axial
slice which included the most anterior point of the TT. The selected landmark was the central point of the patellar tendon insertion on this slice, and not the most anterior point, as suggested by Dejour [11]. Furthermore, both TT-TG and TT-RA required the calculation of the dorsal femoral condylar line (dFCL). This line was not the same for each measurement as both depend on precise anatomic references which may be found on different axial cuts. This landmark was defined as the most posterior point of each femoral condyle generating a tangent line between them (osseous landmark on MRI).

**TT-TG**

The TT-TG (on CT and MRI) was measured using the technique described by Camp et al. [20] and Charles P. Ho et al. [16]. This consists of the measurement of the medio-lateral distance between the central distance of the patellar tendon insertion (TT landmark) and the deepest bony point of the TG. This distance is measured based on a line parallel to the dFCL. The axial slice selected for the TG landmark was the slice that contained the deepest bony point, and in the case of MRI, this slice had to include articular cartilage [21] (Fig. 1).

**TT-PCL**

As this measurement relies on soft tissue landmarks, this was only assessed on MRI. This index as described by Seitlinger et al. [17] is defined as the medio-lateral distance between the TT and the medial border of the PCL. This distance is measured on a line parallel to the dorsal tibial condylar line (dTCL) which is tangent to the posterior aspect of the proximal tibia on an area distal to the articular line but proximal to the fibula head. The PCL landmark was selected on the most distal axial cut in which the PCL was still clearly visible (considering that the cut was between the articular surface and the fibular head, as described) (Fig. 2).

**TT-RA**

This index was measured following the original description by Xu et al. [18] TT-RA was defined as the distance between the TT and the highest point of the roman arch (intercondylar sulcus). This index was originally described only on CT Scan imaging using the same reference for TT described previously and the most proximal axial cut in which the intact roman arch and posterior femoral condyles were visible. As with the other distances, TT-RA was calculated on a line parallel to the dFCL (Fig. 3). We performed this measurement also on MRI using the same bony landmarks as the original description to assess the correlation between imaging techniques.

**Statistical analysis**

All indexes measured both on CT (TT-TG and TT-RA) and on MRI (TT-TG, TT-PCL and TT-RA) were assessed descriptively to obtain variable distribution and summary data. Other variables included were age, sex and PF instability status. All indexes were assessed for normality using the Shapiro–Wilk test.

Association between the three distances and demographic variables (age, sex and PF instability status) was assessed (chi-square test and independent T-test). Multivariate analysis was performed using linear

---

**Fig. 1.** Representation of the TT-TG measurement. A) Axial drawing, B) MRI and C) CT axial cuts of the distal femur overlayed with an axial drawing and cuts of the tibia and fibula at the tibial tubercle level and measured distance as letter d. TT: tibial tuberosity (blue arrow), TG: trochlear groove (green arrow), dFCL: dorsal femoral condylar line.

**Fig. 2.** Representation of the TT-PCL measurement A) Axial drawing and B) MRI axial cuts of proximal tibia and the posterior cruciate ligament overlayed with an axial drawing and cut of the tibia and fibula at the tibial tubercle level and measured distance as letter d. TT: tibial tuberosity (blue arrow); PCL: posterior cruciate ligament (green arrow); dTCL: dorsal tibial condylar line.
Inter and intraobserver reliability.

### Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Major instability history</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes (n = 71)</td>
<td>No (n = 157)</td>
</tr>
<tr>
<td></td>
<td>Female sex [% (n)]</td>
<td>70.4 (50)</td>
</tr>
<tr>
<td></td>
<td>Age [mean ± SD]</td>
<td>25.0 ± 8.0</td>
</tr>
</tbody>
</table>

* Chi-square test.

RESULTS

A total of 208 knees were included in this study. Average patient age was 27.9 ± 8.5 years with a predominance of female patients (67.3%). Regarding instability status, 71 (34.1%) patients presented major instability, being significantly younger as compared to patients without major instability (25 vs 29 years of age, respectively; p = 0.009). No differences were observed regarding sex between groups (Table 1).

### Measurement indexes

Mean index values were: 17.1 ± 5 mm (TT-TG CT); 11 ± 4.6 mm (TT-TG MRI); 20.9 ± 4.4 mm (TT-PCL); 18.8 ± 5.1 mm (TT-RA CT); and 13.1 ± 4.7 mm (TT-RA MRI).

All measurements were performed independently by two blinded observers, correlation coefficients for each measurement are presented in Table 2, highlighting that all measurements show excellent inter and intraobserver reliability, except TT-RA between both observers.

Univariate analysis revealed significant differences between male and female patients for TT-TG (p = 0.011) and TT-RA (p = 0.007) on CT imaging, and for TT-PCL (p < 0.001) on MRI. Furthermore, comparing the index differences according to instability status, significant differences were found for TT-TG and TT-RA, both on CT and MRI, always showing a higher distance in patients who presented a major instability history. TT-PCL didn't discriminate between healthy and unstable subjects (Table 3).

Linear regression revealed significantly higher coefficients for patients with major instability using TT-TG both on CT (R² = 0.0913; p < 0.001) and MRI (R² = 0.1183; p < 0.001). After adjusting by sex and age, TT-TG measured on CT showed that females had a negative coefficient (i.e. lower overall indexes) compared to males (p = 0.009). Regarding TT-RA, higher coefficients were observed also for patients with major instability, both on CT (R² = 0.978; p < 0.001) and MRI (R² = 0.1108; p < 0.001). Multivariate analysis also showed significantly negative coefficients in female patients using this index on CT imaging (p = 0.006). No differences were found for TT-PCL, as this index did not show discrimination capacity.

As for pathologic thresholds found in this sample, ROC curve analysis found different values for each of the five indexes. Different cut point values differing between imaging modalities were found: 11.4 mm for MRI TT-TG, 17 mm for CT TT-TG, 15.6 mm for MRI TT-RA and 18.2 mm for CT TT-RA. The highest combined sensitivity and specificity (Youden's point) corresponded to CT TT-RA with a threshold of 18.2 mm as the pathologic discrimination distance for this index.

Regarding measurement differences among imaging modalities, MRI TT-TG averaged 6.1 mm less compared to CT TT-TG (p = 0.001) and MRI TT-RA averaged 5.7 mm less than CT TT-RA (p = 0.001). Furthermore, agreement assessment revealed poor agreement between MRI and CT scan for TT-TG (Rho = 0.302; p < 0.001), observing similar results for TT-RA (Rho = 0.345; p < 0.001).

### DISCUSSION

This is one of the largest series in current literature which addresses the controversies of TT relative lateralisation measurements. The key
findings of this study include: the characterisation of index behaviours in a large sample; their association with sex but not age; and new pathologic threshold determination. This study presents a novel software designed to streamline TT relative lateralisation measurements based on observer selection of anatomic landmarks. As a novel software, it had not been previously validated, presenting this study with the opportunity to assess software reliability. Nonetheless this software was designed following the same procedure that would be done manually on routine imaging measurements to keep index reproducibility. Following this premise, this study was designed with two independent observers blinded to the patient's previous history of instability. Further analysis of the correlation between both observers revealed excellent correlation both inter and intraobserver for each measurement. The only exception was CT TT-RA which revealed a good interobserver correlation, maintaining excellent intraobserver correlation. Based on the same purpose of validating relative lateralisation measurement indexes, other studies have revealed similar results. Anley et al. [15] revealed excellent inter and intraobserver reliability both for TT-TG (>0.89) and TT-PCL (>0.92). Further, Brady et al. [22] revealed high intrarater reliability for TT-TG (ICC 0.94), whilst TT-PCL revealed to be moderately reliable (ICC 0.63). Regarding TT-RA, the group which proposes this novel measurement found excellent correlation for TT-RA (ICC 0.95) and for TT-RA (0.85), maintaining excellent correlation among different Dejour dysplasia categories in which TT-TG ICC was lower than for TT-RA [18].

Regarding influence of other demographic variables on TT relative lateralisation regarding the TG such as age and sex, this study found an association of some indexes with sex, but multivariate models adjusted by age and PF instability history revealed this association to be spurious. However, multiple variable regression also revealed that CT TT-TG adjusted by age and sex manifested a negative signification that accurately distinguishes between healthy and major instability patients, supporting that the proposed thresholds possess the precision to correctly discriminate between these groups.

Moreover, as previously mentioned, these cut-off points differ from previously published literature. This study is the first to present lateralisation cut-off points in a large general population-based sample, including both healthy and PF unstable patients, allowing for parametric statistical analysis given the normal distribution observed. Previous published evidence is mainly based on patients with diagnosed PF instability and concomitant anatomical alterations [11,24], or smaller samples [17,18]. Moreover, ROC curve analysis allows the determination of TT relative lateralisation distance cut-off points that possess the highest combined sensitivity and specificity that accurately distinguish between healthy patients and from those with pathologic lateralisation. Further analysis of the obtained ROC curves reveals that routinely used cut-off points possess suboptimal diagnostic accuracy. Among these, 20 mm TT-TG [11] shows 56% sensitivity and 99% specificity on MRI and 47% sensitivity with 81% specificity on CT. TT-PCL presented 31% and 91%, sensitivity and specificity, respectively for the original 24 mm proposed cut-off point [17]; whilst TT-RA, using 26 mm CT cut-off proposed [18] revealed 10% and 96.4%, sensitivity and specificity, respectively, with no previous MRI cut-off points reported before this study. Having accurate cut-off values to recognise patients with a significantly laterised tibial tuberosity that would benefit from surgical correction is clinically relevant in the treatment algorithm of PF instability.

Regarding instability prediction capacity, this study found that both TT-TG and TT-RA significantly differed between patients with and without instability history, independently from the imaging technique used for calculations. On the other hand, TT-PCL was not found to significantly distinguish between healthy and unstable patients. This finding has been previously reported in literature. Different studies have found that TT-PCL presents a broad range in patients with instability history, suggesting that both TT-TG and TT-PCL could be combined in decision-making [25,26]. Other studies have evaluated images in patients with instability compared to controls without instability who took an MRI for ACL tear suspicion, further revealing that while TT-TG was predictive of a diagnosis of PF instability, TT-PCL was not able to differentiate between unstable and healthy patients. A subsequent review by the same group further supported these findings [19,22], in agreement with the results obtained in this study as well.

Technical difficulties regarding TT relative lateralisation measurements may be encountered during the evaluation of patients with PF instability. An important anatomic abnormality which can alter results and further difficult measurement is trochlear dysplasia, posing a challenge for both surgical resolution and TT relative lateralisation distance measurement. TT-TG, the first measurement index proposed, is based on the TG anatomic landmark. This reference may not be clearly and reliably located in dysplasia patients as the groove may not be present. Following this premise is that Xu and colleagues [18] present TT-RA as an alternative index. TT-RA is then based on the intercondylar sulcus (roman arch), which the authors consider to be a more reliable anatomic landmark independent of the presence of trochlear dysplasia. The authors present a cut-off value to predict patellar dislocation determined through ROC-curve analysis: 23.74 mm, but this value showed 53.57% sensitivity and 63.3% specificity, based on a small sample, proposing 26 mm as the most appropriate value. Further supporting the usefulness of this index, this study found that CT TT-RA cut-off (18.2 mm) presented the highest sensitivity and specificity of the evaluated methods (80.28% and 61.31% respectively).

Other technical difficulties encountered while measuring TT relative lateralisation is the internal-external rotation of the studied extremity during image acquisition. Rotation can be assessed by calculating the angle between the femoral dorsal condylar line and the tibial dorsal

Table 3

<table>
<thead>
<tr>
<th></th>
<th>Major Instability, mean (SD)</th>
<th>No Major Instability, mean (SD)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT TT-TG</td>
<td>19 (4.0)</td>
<td>16 (5.2)</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>MRI TT-TG</td>
<td>13.2 (4.3)</td>
<td>9.9 (4.4)</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>MRI TT-PCL</td>
<td>21.6 (5.0)</td>
<td>20.6 (4.0)</td>
<td>0.13</td>
</tr>
<tr>
<td>CC TT-RA</td>
<td>21 (3.9)</td>
<td>17.6 (5.2)</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>MRI TT-RA</td>
<td>15.3 (4.9)</td>
<td>12.0 (4.2)</td>
<td>&lt;0.01*</td>
</tr>
</tbody>
</table>

Of all the variables studied, only height and age demonstrated a significant correlation with TT-TG observing that each extra centimeter distance of 18.2 and 15.6 on CT and MRI, respectively as more suitable cut-off values. Moreover, these findings gain even more importance as this series revealed that distribution of the distance significantly differs between healthy and major instability patients, supporting that the proposed thresholds possess the precision to correctly discriminate between these groups.

Article: Journal of ISAKOS 9 (2024) 272-278
condylar line. When the knee joint moved from extension to flexion, the tibia would internally rotate relative to the femur, which may decrease the TT-TG and TT-RA distance [27], with a greater effect on the TT-TG measured on MRI than on CT [28]. Given the impact that this rotation angle may have on true TT relative lateralisation is that TT-PCL is being more widely used, as both anatomic references are located on the same bone (tibia). This makes measurements independent from joint rotation and flexion angles, as well as trochlear internal rotation secondary to increased femoral anteversion [17,26]. Anley et al. [15] assessed the influence of joint rotation on TT-TG measurement obtaining an average of 8.33° and 5.59° on CT and MRI, respectively. Analysing these rotation angles this group found a moderate correlation between TT-TG and joint rotation being stronger on CT imaging, suggesting that joint rotation effectively affects relative lateralisation measurement. Furthermore, their group analysed subgroups with normal and altered TT-TG considering a normal TT-PCL in both groups and found significant differences regarding joint rotation angles revealing that abnormal TT-TG may be falsely abnormal by influence of extremity position. In this regard, this study did not address joint rotation angles which could influence measurement results, but both groups were defined according to medical history rather than measured distance. Based on these criteria, this study found that among patients who reported instability, ROC curve thresholds correctly classified patients as unstable over 65% for each index.

The use of both MRI and CT imaging modalities has long been an unsolved controversy, with studies arguing against the common idea that a unique cut-off value may be considered for any technique [20,21]. Following this trend, our findings provide evidence that cut-offs are not reliably interchangeable, being a more appropriate approach to consider a different distance limit for each imaging technique to classify findings as pathological or not. Following this hypothesis, Camp et al. [20] examined TT-TG variations between MRI and CT imaging, showing that MRI more often underestimates the distance by an average of 3.8 mm, significantly differing from CT measurements (p < 0.001). These findings correlate with our study as MRI TT-TG averaged 6.1 mm less as compared to CT (p < 0.001) and MRI TT-RA averaged 5.7 mm less than CT TT-RA (p < 0.001). Additionally, considering that MRI gives additional information compared with CT, and that CT images have radiation concerns that should push to avoid, when possible, we believe that it is no longer necessary to use both and that MRI should be preferred.

This study then, is one of the largest series reported in current literature regarding TT relative lateralisation measurement comparing different measurement indexes and imaging techniques. However, this study is not exempt from limitations. Most importantly the retrospective nature of this study may limit the conclusions found in which the history and patient data was obtained from previous registries in which an information bias may be present. This study also included patients which had both CT and MRI images available within our institution’s imaging system, limiting our capacity to include all patients evaluated for PF instability during the study period due to absence of images for the purpose of this study, introducing a potential selection bias. Also, regarding imaging limitations, as a retrospective study no standard extremity position was instructed aside from our institution’s regular protocol. Subjects used as normal controls had images taken for intra articular pathology suspicion, not constituting “normal” patients per se, but this decision was made given potential costs and the retrospective way we collected data. Additionally, as mentioned previously, we are aware that patient size could impact measurements. We did not explore new ways to measure lateralisation based on ratios as were considered these beyond the scope of the current article. Further studies should focus on ratio-based measurements. Another main limitation of this study was not including joint rotation angles measurement as an adjustment variable, which could influence the results. Nonetheless, this study is the first we have knowledge of that compares 3 different relative lateralisation measurements, comparing between imaging techniques and among each other, allowing us to describe distance distribution, normal values and pathologic thresholds in a large and population-wise manner. This study then establishes bases for future research and introduces more accurate pathological TT relative lateralisation cut-offs to further optimise clinical decision-making in patients with recurrent PF instability.

CONCLUSION

The three indexes we studied (TT-TG, TT-RA and TT-PCL) proved to be reliable measurements regarding intra and interobserver reliability. Measurements in CT and MRI showed different values in all three indexes, thus requiring adjustments and individual cut-off points. Finally, TT-TG and TT-RA significantly correlated with patellar instability, with the latter (measured in CT) having the greatest combination of sensibility and specificity.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: one of the co-authors is a Member at Large in the ISAKOS Board of Directors (MJT).

References


