# Is tibial tuberosity-trochlear groove distance an appropriate measure for the identification of knees with patellar instability?

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## Abstract

**Purpose:**

Tibial tuberosity-trochlear groove distance (TT-TG) has been regarded as a useful tool for establishing therapeutic choices for patellar instability. Recently, it has been shown that TT-TG negatively correlated with the quadriceps angle, suggesting that if used individually, neither provide a valid measure of instability. This study aimed to compare TT-TG distance between both knees in patients with unilateral instability to assess whether this measurement is a decisive element in the management decisions for patellar instability.

**Methods:**

Sixty two patients (18 male and 44 Female), reporting to a specialist patella clinic for recurrent unilateral patellar instability, were included in the study. Patients underwent bilateral long leg computed tomography scan to determine TT-TG distance in both knees. Tibial tuberosity-trochlear groove distances in symptomatic and asymptomatic knees in the same individual were compared statistically.

**Results:**

Mean TT-TG distance in the symptomatic knee was 16.9 (±4.9) mm, compared to 15.6 (±5.6) mm in the asymptomatic knee. Tibial tuberosity-trochlear groove distance was not significantly different between stable and unstable knees (n.s.).

**Conclusions:**

The lack of difference in TT-TG distance between stable and unstable knees suggests that TT-TG distance alone may not be a decisive element in establishing therapeutic choices for patellar instability. It should, therefore, be interpreted with caution during clinical evaluations.

**Keywords:** tibial tuberosity, trochlear groove, instability, knee, patella, dislocation

**Conflict of interest**

No funding was received for the conduct of this study and the authors declare that they do not have any conflict of interest.

**Level of evidence:** **2**

## Introduction

Patellar dislocation is painful and debilitating, most often affecting young active females, most often affecting young active patients [1]. Recurrent dislocations have a well-documented association with cumulative damage to the patella femoral joint and predictably have a significant, long-term impact on the quality of life of those affected [14].

A range of factors have been associated with patellar instability including trochlear dysplasia, quadriceps dysplasia, patella alta, and tibial tuberosity-trochlear groove (TT-TG) distance [9,16]. In addition to TT-TG distance, other lower limb bony malalignments, such as increased external tibial torsion [11,28], or increased quadriceps angle (Q angle) [1,27,30], have been linked to patellar instability.

The TT-TG distance has been proposed to radiographically assess the alignment of the trochlear groove to the tibial tuberosity [9,16]. As with the Q angle [7,10], some have reported an increase in TT-TG distance in patients with patellar instability [2,3] and a threshold of 20mm has been suggested as an indication for surgical intervention [9]. However, the reliability of TT-TG distance has also been recently questioned [18], and the validity of the TT-TG distance, if used alone, has recently been questioned [11]. Despite this, a high TT-TG distance is often used by surgeons to indicate the need for medial tibial tuberosity transfer to correct malalignment within the patellofemoral joint [8].

To date, no studies have directly compared the TT-TG distance in symptomatic and asymptomatic knees in patients with unilateral recurrent patellar instability. In order to further assess the validity of TT-TG distance in indicating patellar instability and its appropriateness in indicating highly invasive surgical interventions, this study, therefore, aimed to compare TT-TG distances between knees in this patient group. Based on our clinical experience of seeing and scanning a large number of patients with patella dislocation, it was hypothesised that TT-TG distance would not be significantly different between symptomatic and asymptomatic knees in this population.

## Material and Method

Radiographic data collected prospectively as part of routine clinical practice were assessed retrospectively for patients reporting to a specialist patella clinic for recurrent unilateral patella instability. Data were available for 62 patients, of which 44 were female and 18 were male. The mean (±SD) age of the patients was 25.5 ± 8.7 years at the time of their attendance at the clinic. Only patients with recurrent unilateral patellar instability were included in this study. Patients were classed as having recurring unilateral patellar instability if they had previously had two or more dislocations to the same knee. Patients were excluded if they had previously undergone a knee realignment surgical procedure such as a tibial tuberosity transfer.

A full history and examination was undertaken in clinic, along with plain film radiographs. This was followed by bilateral long leg computed tomography (CT) scan (MX8000 CT Scanner, Philips) to determine TT-TG distance in both the symptomatic and asymptomatic knee in each patient [6]. Computed tomography scans were performed with the patient supine. Their knees were fully extended, their quadriceps were relaxed and their feet were placed in a neutral rotation. Patients lay on a wooden plinth, which had a perpendicular wooden section under the feet.

The feet were strapped to this foot section of the board to ensure they maintained the correct position during the scanning procedure. Axial CT sections were taken through the proximal femur, knee joint, proximal tibia and ankle. These had channels of 16 9 0.625, slices of 1.4/0.7 mm, in high resolution, with 140 kV, 300 mAs and a rotation time of 0.75 s. To measure the tibial tuberosity–trochlear groove distance axial sections depicting the deepest part of the trochlear groove and the centre of the tibial tuberosity were superimposed. Using a General Electric workstation, a line was drawn on the posterior margins of the femoral chondyles, a second line at right angles from the posterior margins of the femoral chondyles such that it passed through the centre of the trochlear groove, and a third line was drawn from the centre of the tibial tuberosity such that it dissects the second line at right angles. The length of this third line was the TT-TG distance (Figure 1). The distance was recorded to the nearest tenth of a millimetre. All measurements were performed by a single experienced musculoskeletal consultant radiologist. Test-retest reliability was determined by measuring

TT-TG distance in 20 knees twice. The order of measurements was randomised and the radiologist was blinded to the images being used to remove bias. Test-retest reliability was determined using the intraclass correlation coefficient, which was 0.98.

**Statistical Analysis**

Based on previously published data comparing TT-TG distance between asymptomatic knees and those with mild instability [19], an *a priori* power calculation was performed ($\alpha < 0.05$, power = 95%) which suggested a minimum sample size of at least 42 patients. All data were checked for normal distribution using Q-Q and box plots. Tibial tuberosity-trochlear groove distances were then compared statistically between symptomatic and asymptomatic knees using paired samples t tests. 95% confidence intervals were determined and the threshold for statistical significance was set at $p<0.05$. All statistical tests were performed using SPSS version 19. The number of patients who showed a TT-TG distance that was greater in the symptomatic side, the same in both knees, and greater in the asymptomatic side were also determined and reported as a percentage of the total sample. The study was approved as an audit by the Gateshead Health NHS Foundation Trust research committee.

## Results

All data were normally distributed. Thirty nine (63%) right knees were symptomatic and 23 (37%) left knees were symptomatic. Thirty five (56%)

patients reported first dislocating their knee as a direct result of a traumatic injury. Thirteen (21%) patients had trochlear dysplasia, 17 (27%) patients had medial patellofemoral ligament dysfunction, 7 (11%) patients had patella alta, 4 (6%) patients had a synovial plica, and 8 (13%) patients had signs of osteoarthritis. Mean TT-TG distance in the symptomatic knees was 16.9 (±4.9) mm, compared to 15.6 (±5.6) mm in the asymptomatic knee, with a mean difference of 1.3mm (95% confidence interval = -0.5 - 3.2 mm). Tibial tuberosity-trochlear groove distance was not significantly different between symptomatic and asymptomatic knees ($t(122)=1.404$, p=n.s.).

Four (6%) patients had the same TT-TG distance in symptomatic and asymptomatic knees. Thirty two (52%) patients had a TT-TG distance that was greater in the symptomatic knee than in the asymptomatic knee, and 24 (39%) had TT-TG greater in the asymptomatic knee.

## Discussion

The most important finding of this study was that TT-TG distance was not significantly different between symptomatic and asymptomatic knees. As the sample size used far exceeded the minimum required sample size based on the *a priori* power calculation, this lack of difference is unlikely to be due to an underpowered statistical test.

An accepted normal range for TT-TG distance is 10 – 15 mm [7], although Monk et al [20] suggested that a TT-TG distance of greater than 14.5 mm is potentially unstable. In the patients investigated here with recurrent unilateral patellar instability, the mean TT-TG distance in the symptomatic side was approximately 17 mm compared to approximately 16 mm in the asymptomatic side. Although these were not significantly different, they are both above the threshold for instability suggested by Monk et al [20]. A TT-TG distance of 20 mm or greater is considered sufficiently excessive to proceed to surgery [19]. Approximately 30% of symptomatic knees showed TT-TG distances of 20 mm or more. Previously, Dejour et al [9] reported 56% of their patients having TT-TG distance greater than, or equal to, 20 mm in the symptomatic knee. The difference in the proportion of symptomatic knees found with TT-TG distances above the 20 mm threshold between the current data and that presented by Dejour et al [9] could be the result of a number of factors. In the current study, only patients with recurrent patellar instability were included. Dejour et al [9] included both patients with recurrent instability and those with a first episode patellar dislocation. Interestingly, approximately 20% of the asymptomatic knees also showed TT-TG distances exceeding this threshold which is in line with the findings of Dejour et al [9].

The lack of significant difference in TT-TG distance between symptomatic and asymptomatic knees of the same patients supports the notion that the cause of patellar instability is multifactorial. Factors such as the TT-TG distance, patellar shape, patellar tilt, patella alta, trochlear dysplasia, Q angle, and other bony malalignments within the knee are all likely to play some part in the

stability of the patellofemoral joint [1,9,11,27,28,30]. Previously, we observed that despite previous reports of increases in TT-TG [2,9,19,20] and Q-angle [15,27] being linked to increased patellar instability, the two variables can be negatively related [6]. The findings of Cooney et al [6], and those presented here demonstrate that in isolation, the usefulness of TT-TG distance to indicate patellar instability is controversial. Despite this, a high TT-TG is often used as an indication for medial tibial tuberosity transfer.

Measures such as TT-TG distance and Q-angle do not provide direct measures of the congruence between the two articulating surfaces of the patellofemoral joint (i.e. the patella and the trochlear). The TT-TG distance provides a measure of the alignment between the femoral trochlear and the tibial tuberosity. It does not consider the alignment between the articulating surfaces of the patellofemoral joint. On the other hand, the Q-angle gives an indication of the position of the patella with respect to the tibia and pelvis, yet fails to consider the trochlear. In patients with a ruptured medial patellofemoral ligament, for example, the patella would be more laterally positioned with a higher propensity to dislocate. However the TT-TG distance would not reflect this, as tibiofemoral alignments would not be changed [17,23]. With a subluxed or dislocated patella, a normal Q angle might also be observed.

As unstable knees lead to subluxation of the patellar with respect to the trochlear, then it could be useful to measure the position of the patella with respect to the trochlear, avoiding the use of surrogate measures such as TT-

TG distance. Perhaps the radiographical measurement of the lateral distance between the patellar ridge and the deepest part of the trochlear, or the PR-TG distance, is a better reflection of the patella position in relation to the trochlea.

The usefulness of the TT-TG distance has also been brought into question as it will not identify the location of any patellofemoral malformation [24]. Seitlinger et al [24] investigated the use of the distance between the tibial tuberosity and the posterior cruciate ligament, or TT-PCL, in comparison to the TT-TG distance, in the evaluation of tibial tuberosity lateralisation. Their findings supported the notion that a pathological TT-TG distance (>20mm) might not indicate lateralisation of the tibial tuberosity, and that a high TT-TG might not be an appropriate indication for surgical realignment of the tibial tuberosity.

Whilst the aim of this study was to determine whether TT-TG distance was different between symptomatic and asymptomatic knees in patients with recurrent unilateral patellar instability to determine whether TT-TG distance should be used for indicating surgical intervention, it should be noted that some patients with unilateral instability can develop instability in the asymptomatic knee at a later date. Nikku et al [21] observed that 15% of patients developed contralateral instability at two years after an initial dislocation, and this figure rose to 27% by seven years.

A limitation of this study was that only TT-TG distance was considered. Patellar instability is likely to be multifactorial, with other factors such as

trochlear dysplasia, external tibial torsion, femoral neck anteversion, patella height and medial patellofemoral ligament integrity also potentially influencing stability of the patellofemoral joint [1,9,11,27,28,30]. Future studies should consider the interactions between these factors in patients with patellar instability in order to determine the best combinations of measures to use in informing corrective surgical interventions. A limitation of the TT-TG distance, and potentially other anatomical measures taken from CT images, is that the true anatomical alignments cannot be fully appreciated, as the cartilaginous architecture is not demonstrated. Magnetic resonance studies have clearly documented the difference in bony versus cartilaginous relationship of the patella-trochlear anatomy [4,5,10,12,13,22], and this was explored in detail by Van Huyssteen et al [29], who demonstrated a significant anatomical mismatch between the bony architecture and cartilaginous morphology in patients with trochlear dysplasia. Despite this limitation of CT imaging based measures of TT-TG, however, any errors would likely be similar between symptomatic and asymptomatic knees in this study as both knees were evaluated in each patient.

The finding of a lack of difference in TT-TG distance between the symptomatic and asymptomatic knees of patients with recurrent unilateral patellar instability suggests that surgeons should not base their decision to perform highly invasive surgical interventions such as medial tibial tuberosity transfer to restore correct alignment within the patellofemoral joint purely on the basis of a high TT-TG distance. Whilst good results have certainly been reported for osteotomy and medialisation procedures [8,25,26], incomplete

assessment means the decompensatory malefactor may remain unacknowledged and thus untreated, leaving the avenue open for chronic instability. It would thus be prudent to carefully consider the role of the choice of imaging investigations as well as the indications for medialisation procedures where MPFL reconstruction, capsular plication or trochleoplasty may be more appropriate.

## Conclusions

Despite the TT-TG distance being routinely used by many knee surgeons to assess patellar instability, the data presented here show that it can be the same in symptomatic and asymptomatic knees of patients with recurrent unilateral patellar instability. This brings into question the usefulness of the measure in the evaluation of these patients, especially for indicating surgical interventions such as medial tibial tuberosity transfer.

295 **References**

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## Figure captions

Figure 1. Axial computed tomography scan showing measurement of the tibial tuberosity-trochlear groove distance in the left knee.

**Figure 1**