

## Original Article

# Evaluation of Normal Tibial Tubercle to Trochlear Groove Distance in Adult Turkish Population

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### ABSTRACT

**Purpose:** Many studies have confirmed the significance of tibial tuberosity-trochlear groove (TTTG) distance measurement for the preoperative assessment of tibial tubercle osteotomy and refixation of the patients that need surgery. TTTG distance is being used as threshold value for surgery decision. The purpose is to determine the TTTG values for the adult Turkish population and compare this with the values of other studies and establish a possible index. **Materials and Methods:** This study was conducted on 200 patients (97 female, 103 male) aged between 18 and 65 years, retrospectively, who had magnetic resonance imaging at Istanbul Medipol Mega University Hospital Radiology Department. Individuals with no knee surgical history and deformation included to research group, any deformities related with knee were excluded. The scans were analyzed in Picture Archiving Communication System program and compared with other populations. Significance was evaluated with independent Student's *t*-test. **Results:** The mean TTTG distance was found  $10.07 \pm 1.60$  mm in males,  $9.96 \pm 1.41$  mm in females, and  $10.02 \pm 1.51$  mm for total cases. There was no statistically significant difference between sex ( $P > 0.05$ ). However, overall TTTG distance of right and left knees found significantly different ( $P < 0.05$ ). **Conclusion:** Obtained results are similar with the results of Caucasian population but different than Asian. It is believed that these results will be significant in evaluation of patellofemoral disorders and helpful in treatment.

**KEYWORDS:** Knee joint, magnetic resonance imaging, patellar dislocation, sexual dimorphism, tibial tuberosity-trochlear groove, Turkish population

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## INTRODUCTION

Tibial tuberosity-trochlear groove (TTTG) distance was first described by Goutallier and Bernageau on axial radiography with 30° knee flexed.<sup>[1,2]</sup> Later, Dejour *et al.* used superimposing computed tomography (CT) images with fully extended knee as a method and reported improved accuracy and reliability.<sup>[1,3,4]</sup> So that, historically, fully extended knee on CT used as golden method for TTTG measurement.<sup>[5,6]</sup> However, recently, MR imaging also considered as an equivalent method.<sup>[7]</sup> Many studies conducted to show magnetic resonance imaging (MRI) can substitute CT method; for

instance, Schoettle *et al.*<sup>[6]</sup> reported high correlation between CT and MRI studies.<sup>[8]</sup> For this reason, MRI measurements are preferred for examination of knee joint pathology without radiation exposure.<sup>[9]</sup> It is also stated in the literature that it is not possible to measure TTTG distance clinically.<sup>[10]</sup>

The bone structure of the knee joint is anatomically formed by femur, tibia, and patella. The fibula also

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participates in the clinical evaluation. Two joints, tibiofemoral and patellofemoral, are involved in the active movements of the knee. Knee is stabilized by bone and connective tissue stabilizers. It is stated that an important part of knee pain encountered in clinic is related to the patellofemoral joint.<sup>[11]</sup> It is important to know the biomechanics of the patellofemoral joint during treatment planning. Increased patellofemoral joint reaction force causes excessive stress on articular cartilage. This can cause additional problems, such as stress, chondromalacia, and osteoarthritis. The morphological abnormalities of the dorsal joint surface of the trochlear formation or patellar and the magnitude of the forces acting laterally may cause lateral subluxation or dislocation of the patella. Static stabilizers forming the patellofemoral joint are medial patellofemoral ligament, patellar tendon, retinaculum, joint capsule, and trochlear groove. Trochlear groove is the primary bone stabilizer with its depth and width. Patellofemoral instabilities may result in various predisposing factors, such as excessive femoral anteversion, patellar dysplasia, genu valgum, trochlear dysplasia, and joint hyperlaxity.<sup>[11]</sup> The TTTG distance is one of the most important parameters for determining the degree of external torsion and the lateralization of tibial tuberosity. The obtained measurement is important in assessing patellar instability.<sup>[2]</sup> It is also stated in the literature that it is not possible to measure TTTG distance clinically.<sup>[6]</sup>

It is indicated that 15 mm or higher deviation of TT shows lateralization/transposition.<sup>[12]</sup> Lateralization of the patellar tendon/TT is also at the origin of the quadriceps femoris muscle, which increases the tendency of the tendon on the patella and predisposes to patellofemoral diseases.<sup>[13]</sup>

It has been suggested in previous studies that the normal values of the population are important as well as the values of the patient groups because of the variability of the data present in the sources.<sup>[8,14,15]</sup>

Orthopedic surgeons explain that TTTG measurement is especially important for the patients who are planned to undergo tibial tuberosity osteotomy and refixation. For this reason, we believe that the index study will be useful for informing surgeons.

## MATERIALS AND METHODS

### Study group

The ethical approval of this study was obtained prior to the commencement of work from the Medipol University Clinical Ethics Committee (decision 368, dated 21/07/2016). Two hundred Turkish patients were

included to study from 2016 through 2017 (103 males, 97 females; mean age  $35.37 \pm 9.82$ ) at Istanbul Medipol Mega University Hospital Radiology Department. Because of the studies indicating that MR imaging can be used with accurate results and less radiation exposure, we preferred using MR imaging. MR images registered in Picture Archiving Communication Systems (PACS) used for measurement. Patients with no patellofemoral instability, degenerative changes in bone structure, ligamentous laxity, congenital malformations, and knee surgery were included in the study group. Those with ligament damage were excluded.

### Imaging

MRI was performed with the patient in supine and has the knee  $5^\circ$  of external rotation with relaxed position on a 3-T unit with following parameters TR 3029, TE 30, and slice thickness 4 mm. In order to analyze scan images, PACS were used.

### Measurement

The technique defined by Schoettle *et al.* used for measurement.<sup>[6]</sup> Although the patient in supine position with fully extended knee, two sections from the proximal of trochlea and tibial tubercle are sufficient for the measurement. After superimposing those two sections, a perpendicular line through the deepest point of trochlea should be drawn to the transverse line passing from the posterior end of femur condyles. Then, a parallel line should be drawn to trochlea line starting from the tibial tubercle where patellar tendon attaches [Figure 1]. TTTG measurement is defined by distance between those two parallel lines.<sup>[16]</sup> Each MRI was measured in a double blinded, randomized manner.

### Statistics

Independent Student's *t*-test was used for the comparison of TTTG distance value with gender and side of the knee. Mean values of TTTG for all samples were calculated with 95% confidence intervals and *P* - values  $< 0.05$  were regarded as statistically significant. Statistical analyses were performed using SPSS (Version 17.0 for Windows; SPSS Inc, Chicago, Illinois, USA).

## RESULTS

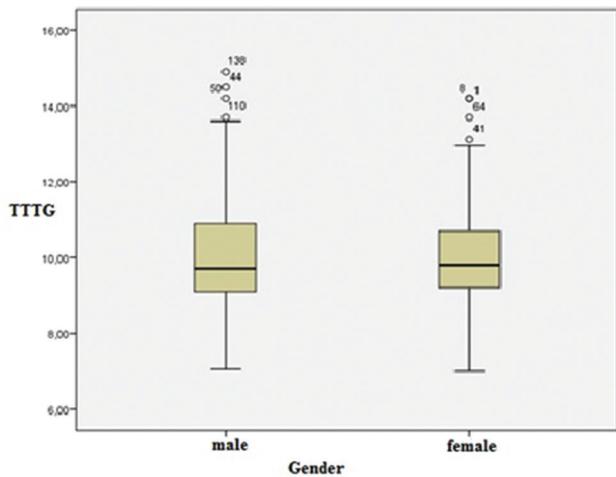
Total mean TTTG was  $10.02 \pm 1.51$  mm (min. 7.00 mm

**Table 1: Mean values for female and male subjects for right, left, and all measurements**

	Gender					
	Mean					
	Male			Female		
	Right	Left	All	Right	Left	All
TTTG	9.89	10.30	10.07	9.72	10.19	9.96

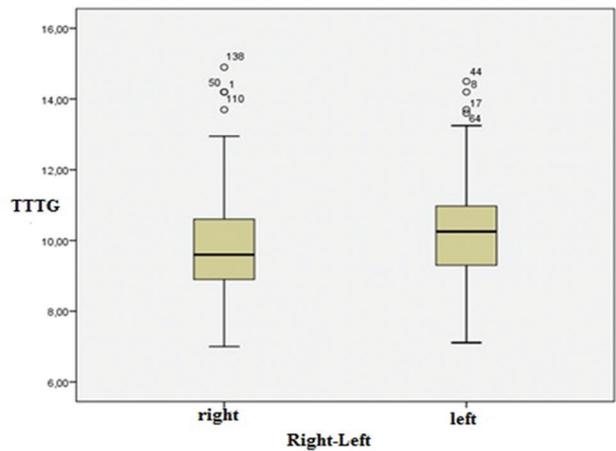
TTTG=Tibial tuberosity-trochlear groove

**Table 2: Chart of tibial tuberosity-trochlear groove measurement distribution according to gender**



TTTG=Tibial tuberosity-trochlear groove

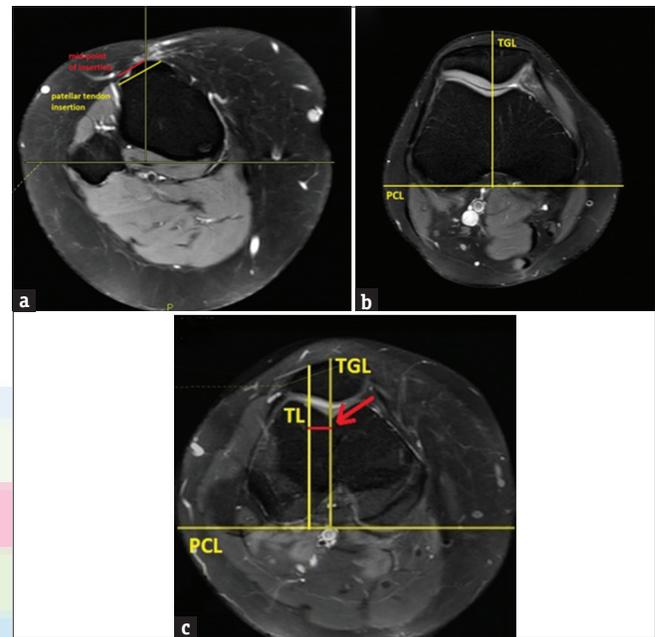
**Table 3: Chart of tibial tuberosity-trochlear groove measurement distribution according to right and left knee**



TTTG=Tibial tuberosity-trochlear groove

and max. 14.90 mm). There was no statistically significant difference between males and females. The mean TTTG for males was  $10.07 \pm 1.60$  mm and  $9.96 \pm 1.41$  mm for females ( $P > 0.05$ ) [Tables 1 and 2].

However, when TTTG compared with left and right knee, mean TTTG for right was  $9,81 \pm 1,49$  mm ( $n = 105$ ) and  $10.24 \pm 1.50$  mm for left knee. The difference was found statistically significant ( $P < 0.05$ ) [Table 3].



**Figure 1:** (a) The yellow line below indicates the attachment of patellar tendon. Upper red line shows mid-point of insertion. (b) Trochlear groove was identified. A perpendicular line from the trochlear groove to axis of posterior condyles was drawn (trochlear line). (c) Section images at the level of a and b superimposed. Distance between two parallel lines as red showing tibial tuberosity-trochlear groove distance. TGL = trochlear groove line, PCL = posterior condylar line, and TL: tibial linea

**Table 4: Previous studies indicating the tibial tuberosity-trochlear groove distance**

Author	Year	Modality	Sample size	Mean TTTG distance	TTTG distance for males	TTTG distance for females
Our study	2017	MRI	200	$10.02 \pm 1.51$	$10.07 \pm 1.60$	$9.96 \pm 1.41$
Kulkarni, Shetty, Alva, Talekar and Shetty <sup>[20]</sup>	2012	MRI	100	$13.5 \pm 6.2$ mm	$13.19 \pm 6.28$	$14.07 \pm 6.06$
Pandit, Frampton, Stoddart and Lynske <sup>[8]</sup>	2011	MRI	100	$10 \pm 1$ mm	9.91 mm (95% CI 8.9-10.8 mm)	10.04 mm (95% CI 8.9-11.1)
Alemparte <i>et al.</i> <sup>[19]</sup>	22007	Radiographic images CT	60	$13.6 \pm 8.8$ mm	$14.8 \pm 5.19$	$12.5 \pm 3.16$
Wittstein, Bartlett, Easterbrook, and Byrd <sup>[18]</sup>	2006	MRI	20	$9.4 \pm 0.6$ mm	-	-
Dejour, Walch, Nove-Josserand, Ch. Guier <sup>[3]</sup>	1994	Radiographic images CT	190 Radiograph 27 axial scan	$12.7 \pm 3.4$ mm	-	-

TTTG=tibial tuberosity-trochlear groove, MRI=magnetic resonance imaging, CT=computed tomography, CI=confidence interval

## DISCUSSION

TTTG distance is normal, <15 mm, border between 15 and 20 mm, >20 mm is considered pathological. Measurements made with MRI have been shown to be slightly less than those performed with CT.<sup>[17]</sup>

The normal values of the TTTG range made in different study groups were widely variable in many studies. Table 4 contains data on normal values in the literature. Chronologically, in 1994, 190 radiographic and 27 axial images were used to compare symptomatic and asymptomatic samples. The mean value was found  $12.7 \pm 3.4$  mm without discrimination between males and females.<sup>[3]</sup> In another study, the average value over 20 MRI images was calculated as 19.6 mm in 2006.<sup>[18]</sup>

Another study on 60 healthy subjects aimed to compare the statistical reliability of radiographic and CT imaging methods. Total mean value was reported as  $13.6 \pm 8.8$  mm,  $14.8 \pm 5.19$  in males and  $12.5 \pm 3.16$  in females.<sup>[19]</sup>

Pandit *et al.* aimed to measure the normal values of the TTTG range over MRI images. The results were  $10 \pm 1$  mm in total in 100 subjects, 9.91 mm in males and 10.04 mm in females.<sup>[8]</sup>

Finally, in 2012, Kulkarni *et al.* performed a similar study on 100 subjects with MRI images.<sup>[20]</sup> They reported  $13.5 \pm 6.2$  mm for overall mean values;  $13.19 \pm 6.28$  mm in males and  $13.07 \pm 6.06$  mm in females.

These studies have provided an evaluation without considering the origins of the sample groups. It is obvious that the results are very different from each other as they are within themselves in terms of female, male, and total values. We think that this difference is likely to result from the origin characteristics of the sample groups. Also, a previous study indicates that TTTG distance may differ with age and height.<sup>[15]</sup> So that anthropological differences of the bone structures may result with different values.

In our study, we evaluated cases reported to have clinically normal patellofemoral joint structure. Our results show that there is no statistical difference between males and females. The obtained data were found to be different from Asian,<sup>[15]</sup> giving results consistent with TTTG distance results obtained from Caucasian individuals in the literature. We believe that these results will help diagnosis and treatment in the relevant population.

## CONCLUSION

Clinically, TTTG value more than 20 mm considered as pathological and suitable for surgical operation. Our standard normal results for this value regardless of the gender and side of the knee was found  $10.07 \pm 1.60$  mm for male and  $9.96 \pm 1.41$  for female.

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## Conflicts of interest

There are no conflicts of interest.

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