The Normal Value of Tibial Tubercle Trochlear Groove Distance in Patients With Normal Knee Examinations Using MRI

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Abstract- Patellar instability is a multifactorial common knee pathology that has a high recurrence rate, and the symptoms continue and ultimately predispose the patient to chondromalacia and osteoarthritis. Tibial tuberosity-trochlear groove distance (TTTG) is very important in the assessment of patellofemoral joint instability. The purpose of this study was to report the normal value of TTTG in males and females in different age groups and to assess the reliability of MRI in measuring TTTG. All patients presenting with knee pain and normal examinations of the knee joint, with a normal MRI report, referring to Shahid Sadoughi hospital of Yazd, Iran, from April 2014 to September 2014, were included in the study. MR images were studied once by two radiologists and for the second time by one radiologist. Mean value of TTTG was reported for males and females and in three age groups. Intra- and inter-observer reliability was calculated. A total of 98 patients were eligible to evaluate during 6 months (68 male and 30 female). Mean TTTG was 10.9±2.5 mm in total, which was 10.8±2.8 mm and 11.3±2.3 mm in males and females, respectively (P>0.05). Mean TTTG in males ≤30 years, 30-50 years and, ≥51-year-old were 10.8±2.6 mm, 10.8±2.7 mm, and 10.8±2.6 mm, respectively; that was 12.1±3.4 mm, 11.4±1.9 mm, and 10.5±1.7 mm in females ≤30 years, 31-50 years and, ≥51-year-old, respectively (95% CI). The coefficient of variation was <10% for both intra- and interobserver analysis. The results of the present study showed no significant difference in TTTG value between males and females in different age groups. In addition, it demonstrated that MRI is a reliable method in assessment of TTTG and identified normal value for TTTG at 10.9±2.5 mm.

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Introduction

The knee is a complex joint with high functional and biomechanical requirements and knee anatomy is considered a reflection of knee problems; accordingly, diagnosis and treatment managements are based on understanding knee anatomy (1,2). Patellar instability is a multifactorial common knee pathology that affects female adolescents more (3); in addition to the high recurrence rate, many patients may have continued symptoms that may also predispose the patients to chondromalacia and osteoarthritis (4-7). It can be diagnosed by physical examination of the knee and imaging techniques (8,9).

The horizontal distance between tibial tuberosity and the trochlear groove (TTTG) is introduced as a landmark of external patellar instability (10), also used for re-alignment procedures, such as medialization osteotomy of the tibial tubercle (11). Although computed tomography (CT) scan is recommended for TTTG measurement, its inter-rater reliability is reported less than 60% with a large measurement error, which is described to be mainly due to difficulty in determining the deepest point of trochlear groove (12,13). Thus, studies have suggested other methods and have compared the reliability of imaging techniques, in order to determine the best diagnostic tool (11). Magnetic resonance imaging (MRI), established to have reliable inter- and intra-observer reliability, can assess the soft tissue with a higher accuracy and expose the patient to

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less radiation, compared to CT scan, and is therefore suggested as an appropriate tool for diagnosis of patellofemoral ligament pathologies (9,14,15).

Nowadays, most studies that measured TTTG value using MRI used various methods and included participants with dissimilar characteristics (16). Thus, due to controversies in this regard and need to assessing TTTG on MRI of patients with the normal knee in Iranian population, the present study aimed to report the normal value of TTTG in males and females in different age groups and to assess the reliability of MRI in measuring TTTG.

Materials and Methods

Study design

This cross-sectional descriptive study recruited all patients older than 15 years who underwent knee joint MRI at Shahid Sadoughi hospital of Yazd, Iran, between March 2014 and August 2014, and had normal MRI and knee examination. Patients were included in the study when they aged over 15, had knee pain and underwent MRI results with radiologist reports. Knee examination was considered normal, when there were no positive points in physical examination, except knee tenderness. The patients were excluded if they had any abnormal findings on knee MRI or knee examination. All examinations were performed by one physician at the time of patient recruitment, which simultaneously recorded demographic characteristics of the participants and referred their MR images to the radiologists. MR images were studied once by two radiologists and for the second time by one radiologist to reduce interpretational bias.

Knee MRI was considered normal, when the MRI reports had no positive points, except mild to moderate effusion. TTTG was determined as the midpoint of the patellar tendon junction. The mouse indicator was placed on this point and sections were moved to reach the first section, where the trochlear groove was completely evident in the cartilage area. A reference line was then drawn posterior to condyles and the second line perpendicular to the deepest part of the trochlear groove. The final distance between two parallel lines was determined as TTTG (Figure 1).

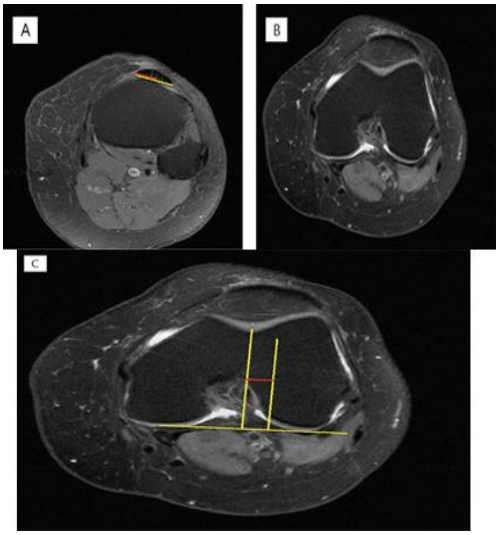

Figure 1. The calculation method of TTTG: the midpoint of the patella tendon junction (A) was specified. Mouse indicator was kept on this point and sections were moved to reach the first section, where the trochlear groove was completely evident in the cartilage area (B, the blue arrow). A reference line was then drawn posterior to condyles and the second line perpendicular to the deepest part of the trochlear groove (C). The final distance between two parallel lines was determined as TTTG (Red line)

Images were obtained by Siemens Magnetom Avanto device (MAGNETOM® Avanto), with 1.5 Tesla power by Pd Axial fat sat protocol in full extension of the knee without rotation.

Ethical considerations

The protocol of the study was approved by Shahid Sadoughi University of Medical Science after explaining the study protocol to patients, written informed consent was obtained from those who were willing to participate in the study, and they were ensured that their information would be kept confidential and anonymous

in all phases of the study.

Statistical analysis

Mean TTTG distance was calculated for women and men with 95% confidence interval (CI). Independent samples t-test was used to detect the difference between the two groups. Mean TTTG for men and women with 95% CI was considered in three age groups: ≤30 years, 31-50 years and ≥51 years and ANOVA test was performed to compare age groups. Mean inter- and intra-observer reliability was obtained by calculating the difference obtained from each source and the coefficient of variation <10% indicated appropriate reliability. Data were calculated by K-PACS© and analyzed by the statistical software SPSS 19.0. The *P* less than 0.05 were considered statistically significant.

Results

Among 361 consecutive patients were referred with knee pain during 12 months, 98 participants (68 male and 30 female) with mean age of 34±4.5 years met the study criteria. The TT-TG distances at all levels throughout the trochlear range were successfully quantified for all subjects in MRI examinations. Mean TTTG distance in the total population was 10.9±2.5 mm, which was 10.8±2.6 mm in male patients and 11.3±2.3 mm for females (*P*=0.43). Mean TTTG in age groups >30, 31-50 and <50 years in a total population presenting with knee pain were 11±2.8, 11±2.4, and 11.7±1.8, respectively (*P*=0.94) (Table 1).

Table 1. Mean TTTG by age and gender of patients

Variables		Number	Mean TTTG	*P*
Total		98	10.9±2.5	
Age	**<30**	48	11±2.8	
	30-50	37	11±2.4	0.94
	>50	13	11.7±1.8	
Gender	**Male**	68	10.8±2.6	0.43
	Female	30	11.3±2.3	

Mean TTTG in age groups of female and male was not statistically significant (*P*=0.35, and 0.86, respectively), as shown in Table 2. The difference between assessments of the two observers and one observer was 0.95 that confirmed the accuracy of the results reported by one observer; also the difference between assessments of the two observers was 0.96 that confirmed the accuracy of the results reported by two observers.

Table 2. Mean TTTG in male and female patients according to age categories

Gender	Age groups			*P*
	≤30	**31-50**	**≥51**	
Male	10.8±2.6	10.9±2.7	11.6±2.5	0.86
Female	12.1±3.4	11.4±1.9	10.5±1.7	0.35

Discussion

The objectives of the present study was to determine the normal value and reliability of TTTG on MRI images; thus, we have investigated patients with normal knee examination and MRI findings, but other studies have evaluated patients with patellar instability (10,14) that have concluded MRI as a reliable presurgical assessment method, which is easy to perform, but they have questioned its reliability in more severe patellar instabilities (11), which indicates the necessity of conducting further studies to determine different aspects of this issue.

This study did not show a significant difference in mean TTTG between males and females in different age groups (*P*>0.05). In addition, it demonstrated that inter- and intra-observer reliability of was less than 10% that indicated MRI as a reliable method in assessment of TTTG and normal value for TTTG was identified at 10.9±2.5 mm.

Similarly, several other studies have evaluated the normal value of TTTG in different participants with different approaches. For example, Pandit *et al.*, have evaluated 100 patients with a suspected meniscus injury who had normal arthroscopy and have reported mean TTTG at 9.91 mm in male and 10.04 mm in female

patients with no statistically significant difference and have reported a desirable inter- and intra-observer reliability (16). The results and technique of the present study are very similar to the study by Pandit *et al.*, which confirms the reliability of MRI in the assessment of TTTG in patients with normal knee examination. Wilcox et al. (17) and Thakkar *et al.*, (15) have also reported inter- and intra-observer reliability of TTTG, measured by MRI, less than 10%, which was consistent with the results of the current study. In another study, Wittstein *et al.*, have investigated knee MRI findings and have reported higher TTTG in patients with anterior knee pain than the control group and have concluded patellofemoral pain being caused by subtle malalignment (18). Schoettle et al. have also compared the reliability of CT scan with MRI images and have reported mean TTTG 13.5±4.6 mm on MR images, which was higher than the value reported by Pandit *et al.*, and the present study. But the sample size of the study by Schoettle *et al.*, was limited. Besides, the difference in mean TTTG value could be due to the difference in the inclusion/exclusion criteria of patients, as they have assessed patients with a history of patellar instability; in addition, the different MRI techniques might have resulted in different results.

Further studies are required to compare the methods and meta-analysis reports are required to identify the best imaging technique and measurement method. Hingelbaum *et al.*, compared 200 knee MRI scans with a method, similar to Shoettle *et al.*, concluded that TTTG values were not statistically different between genders (19), which was in line with the results of the current study. They have reported mean TTTG distance 7.5± 3.5 mm in the control group and 13.5±4.1 mm in the patient's group. The differences in demographic characteristics of the included patients, measurement method, and different sample size may account for the different values reported. Yet, meta-analysis studies should evaluate the accuracy of studies and their results, in order to be able to determine a standard TTTG value for each specific population. Izadpanah *et al.*,

have compared TTTG values in different angles of knee flexion that results in different TTTG values (20,21). Meanwhile, the value they reported at 0^{o} flexion (11.6 4.4 mm) was very close to the total value of the present study (10.9±2.5 mm). As long as both studies are conducted in Iranian population and have resulted in similar values, it can be concluded that the difference in studies may be attributable to the ethnicity of the recruited patients.

The strengths of the present study included indicating a normal value for TTTG by considering patients' MRI results with the normal knee in an Iranian study, where it has scarcely been studied. Nevertheless, the present study was limited in some aspects, including the fact that the patients were selected from one center and were not followed. Therefore, it is suggested that larger studies evaluate the long-term results of the patients assessed by TTTG on MRI.

In conclusion, as the results of the present study showed, MRI is a reliable method in assessment of TTTG and there is no significant difference in TTTG value between males and females in different age groups. Thus, TTTG measurement on MR images is a proper diagnostic tool that can help physician efficiently diagnose patellar pathologies.

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