

Radiologic Measurement of Tibial Tuberosity-Trochlear Groove (TT-TG) Distance by Lower Extremity Rotational Profile Computed Tomography in Koreans

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Background: Tibial tuberosity-trochlear groove (TT-TG) distance is important in the assessment and treatment of patellofemoral disorders. However, normal and pathological TT-TG values have not been established in Koreans. The purpose of this study was to evaluate the TT-TG distance in the Korean population using lower leg rotational profile computed tomography (CT) scans.

Methods: One hundred rotational profile CT scans were retrospectively collected from patients without knee joint problems aged between 25 to 82 years. TT-TG distances were measured, and statistical analysis was performed. Each CT scan was measured twice in a blinded, randomized manner by three reviewers. Patients with pre-existing knee joint problems were excluded from the study; hence 15 of the 100 patients were excluded because of deformity or unreadable CT scans. Thus, 85 of the 100 patients were included in the study.

Results: Interobserver and intraobserver reliability of TT-TG distance measurements was good. The median TT-TG distance for this Korean population was 11.24 mm (mean, 10.24 ± 0.8 mm). TT-TG distance measured nearly 2 mm less on rotational profile CT scans.

Conclusions: Some of the TT-TG distances on rotational profile CT scans were significantly correlated, indicating that they could be accepted. Furthermore, the values on CT scans showed good reliability. In this study, the TT-TG distance in normal Korean people was approximately 10.24 mm without significant differences in TT-TG values between genders.

Keywords: *Tibial tubercle-trochlear groove, Rotational profile computed tomography*

Tibial tuberosity-trochlear groove (TT-TG) distance is a measure of lateralization of the tibial tuberosity in relation to femoral trochlea. Many studies have confirmed that lateralization of the tuberosity is linked to patellar instability, thus TT-TG is an important parameter for evalua-

tion of patellofemoral disorders.¹⁻⁴⁾ However, the degree of lateralization that may contribute to actual dislocation varies among studies.²⁻⁴⁾ Alemparte et al.⁵⁾ studied healthy volunteers and found that normal values for TT-TG were 13.6 ± 8.8 mm, indicative of large variation. Dejour et al.²⁾ reported that the TT-TG in the control group was 12.7 ± 3.4 mm and > 20 mm in pathological cases. Thus, there is reportedly a high degree of variability in the normal TT-TG values and furthermore, some methods of measurement are complicated with significant intra- and interobserver measurement errors.^{6,7)}

Anterior knee pain is a common finding in young adults with no definite etiology or diagnostic test.⁸⁾ Patel-

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lofemoral instability is often considered an important contributing factor and X-ray and computed tomography (CT) scans are used to understand the aberrations in the normal anatomy contributing to instability.⁸⁾ However, a variety of methods for performing these scans and a wide normal range of various studied parameters are reported, which makes the diagnosis of patello femoral syndrome a challenge.

The TT-TG distance represents the radiographic measurement of the quadriceps vector, which represents a lateral force displacement on the patella during knee motion. It is > 20 mm in patients with recurrent patellar dislocations, as compared with 13 mm in control subjects.²⁾ Thus, a lateralized tibial tubercle may be a relevant anatomic indicator for a distal realignment procedure. However, TT-TG distance parameter values at different developmental stages are not defined in the current literature. Additionally, the reference of TT-TG is based upon the value obtained in European or American populations. Since the pathological significance of the TT-TG distance depends on the force vector of the extensor mechanism resulting from individual knee size, different somatometric values are expected to be related to the TT-TG distance in Koreans. Therefore, the purpose of this study was to evaluate the TT-TG distance in Korean patients with normal knee joint function using rotational profile CT scans.

METHODS

Patients

We recruited 100 completely asymptomatic patients of both genders (50 each) to obtain unilateral standard lower extremity rotational CT scans for evaluation of hip joint pain and anteversion angle of the affected acetabulum. Patients with no clinical signs or symptoms in the knee joint for 1 year prior were included in the study. Exclusion criteria were poor quality CT scan data that was unreadable for evaluating anatomic landmarks and newly detected deformities at the level of the knee joint or below the knee joint. Based on the 2 exclusion criteria, six patients and nine patients were excluded, respectively.

TT-TG Measurement

TT-TG was measured using a Light Speed Plus (General Electric Medical Systems, Milwaukee, WI, USA) with a scan time of 0.5 second and 2.5 mm slice thickness. The X-ray tube voltage was 120 kV with a scan exposure of 250 mA. Each subject was examined in a supine position during CT examination. The TT-TG distance was assessed according to Schoettle et al.⁹⁾ The first transverse cranio-

caudal image that depicted a complete cartilaginous trochlea was used to determine the deepest point within the trochlear groove. A line was drawn through the deepest point of the trochlear groove, perpendicular to the posterior condylar tangent. A second line was drawn in parallel to the trochlear line through the most anterior portion of the tibial tubercle. The distance between the 2 lines represented the TT-TG distance (Fig. 1).

The study was performed in 2 stages. Stage 1 of the study involved the analysis of interobserver and intraobserver reliability of the CT scan. Three observers were involved in the study, including one consultant and two trainee surgeons. Radiographs of the 85 patients were evaluated by all three observers independently, on 3 separate occasions at least 2 weeks apart. Stage 2 of the study assessed the validity of the measurement by comparing each data set. The results obtained by the senior consultant were used for validation purpose and compared with those obtained by other observers.

Statistical Analysis

Data were compared using chi-square test and *t*-test. In all tests, an alpha level of 0.05 was considered statistically significant. All statistical analyses were conducted using the SPSS ver. 18.0 (SPSS Inc., Chicago, IL, USA).

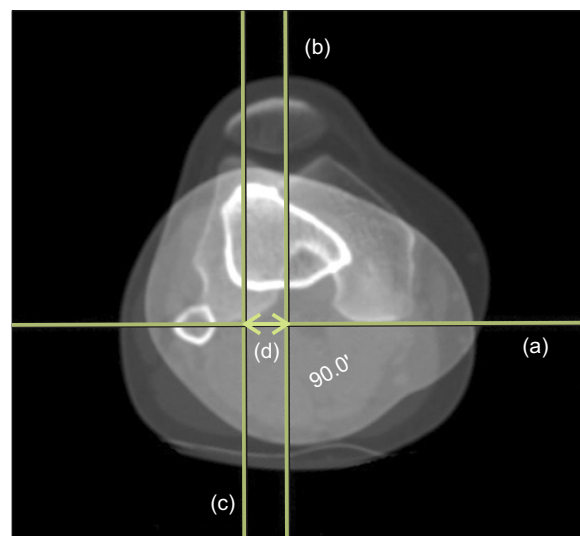


Fig. 1. A line tangent to the posterior epicondyle (a) and a perpendicular line through the deepest point of trochlea (b) are drawn. Another line parallel to the trochlea line through the most anterior portion of the tibial tuberosity (c) is drawn. Tibial tuberosity-trochlear groove distance (d) is measured between line (b) and (c).

RESULTS

General Characteristics

The study included 44 male and 41 female patients with an average age of 54.89 years (range, 25 to 82 years). Table 1 showed the mean weight, height, and body mass index of the patients. The mean Q angle was 13.1° with a maximum angle of 22°.

Inter- and intraobserver agreement for TT-TG readings was excellent, with statistical significance ($p < 0.001$ for both). The mean kappa value for interobserver reliability was 0.61 (range, 0.59 to 0.63) and the mean kappa value for intraobserver reliability was 0.74 (range, 0.39 to 0.86; intraclass correlation coefficient, 0.912).

CT Scans

Overall median TT-TG distance was 11.24 mm, and ranged from 2.1 to 17.35 mm. The median value for male patients was 10.19 mm and the median value for female patients was 10.36 mm, with no statistical significance ($p = 0.20$). The mean TT-TG distance in the entire cohort was 10.24 ± 0.8 mm. The mean TT-TG distance was 10.36 ± 0.5 mm for female subjects and 10.19 ± 0.5 mm for male patients. Increased TT-TG distance of > 20 mm is reportedly associated with pathologic patellar instability.²⁾

DISCUSSION

In the study by Dejour et al.,²⁾ the mean TT-TG distance for the control group was 12.7 ± 3.4 mm and the mean TT-TG distance for the patellar instability group was 19.8 ± 1.6 mm in addition, 20 mm was determined as the cutoff value for patellar instability. In our study, we established the cutoff value of TT-TG distance according to their result. Few studies have reported the TT-TG distance, including under pathologic conditions, in Koreans. Hence, the cutoff

value used in the current study was based on studies in Western populations despite some bias. Normal range of the TT-TG distance value varies among studies from 9.4 ± 0.6 mm to 13.6 ± 8.8 mm;⁴⁻⁸⁾ and most of these studies were performed in Europeans or North Americans. The conclusion of these studies is that patients with patellar instability have higher TT-TG distances.^{1,2,10)}

Reports of the normal ranges of the Q angle are varied with slight differences between male and female.¹¹⁾ Our findings were in agreement with this observation. However, in our study, despite the differences in Q angle between female and male patients, the TT-TG of female and male patients were not significantly correlated. Biedert and Warnke¹²⁾ reported similar results in their study of 56 knees with patello-femoral pain.

We determined the TT-TG distance of asymptomatic knees in a Korean population based on the recommendations by Wright and Feinstein¹³⁾ and achieved low variability in the study data. All patients were evaluated under similar conditions with similar test protocols. All tests were performed with a relaxed quadriceps muscle in the supine position. Tests were performed by the same radiologist using the same equipment and technique. Also, all three trained operators performed the measurements in all cases by consensus.

Reports on normal TT-TG values in the Korean population are rare, hence our study serves as the basis for future work. The mean TT-TG distance for the normal population was 10.24 ± 0.8 mm, with similar average values between female or male patients. Furthermore, rotational profile CT scan is a reliable and reproducible method for evaluating TT-TG. The TT-TG value provides a guideline for the use of a distal realignment procedure.

The limitation of our study was that our study population was mainly aged over 20 years with very few young patients. CT scan data of the younger age group could not be obtained due to the special feature of the clinic that provides health care to primarily adults. This could have biased the results and CT scans from a younger population may provide a different range of values. Determination of the pathologic TT-TG value in Korean patients is an ongoing process. Future prospective studies in a more homogeneous group are required to further establish the normal range of TT-TG values.

In conclusion, the TT-TG distance in normal Korean people is approximately 10.24 mm with no statistically significant difference in the median TT-TG distance between genders.

Table 1. Demographics Data

Parameter	Mean (range)
Age (yr)	54.89 (25–82)
Sex (male:female)	44:41
Height (m)	1.64 (1.49–1.79)
Weight (kg)	62.5 (41–81.2)
Body mass index (kg/m ²)	24.7 (18.5–29.2)
Q angle (°) (male:female)	13.1 (15.2:12.1)

Values are presented as mean (range) unless otherwise indicated.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Wilcox JJ, Snow BJ, Aoki SK, Hung M, Burks RT. Does landmark selection affect the reliability of tibial tubercle-trochlear groove measurements using MRI? *Clin Orthop Relat Res.* 2012;470(8):2253-60.
2. Dejour H, Walch G, Nove-Josserand L, Guier C. Factors of patellar instability: an anatomic radiographic study. *Knee Surg Sports Traumatol Arthrosc.* 1994;2(1):19-26.
3. Nagamine R, Miura H, Inoue Y, et al. Malposition of the tibial tubercle during flexion in knees with patellofemoral arthritis. *Skeletal Radiol.* 1997;26(10):597-601.
4. Wittstein JR, Bartlett EC, Easterbrook J, Byrd JC. Magnetic resonance imaging evaluation of patellofemoral malalignment. *Arthroscopy.* 2006;22(6):643-9.
5. Alemparte J, Ekdahl M, Burnier L, et al. Patellofemoral evaluation with radiographs and computed tomography scans in 60 knees of asymptomatic subjects. *Arthroscopy.* 2007; 23(2):170-7.
6. Lustig S, Servien E, Ait Si Selmi T, Neyret P. Factors affecting reliability of TT-TG measurements before and after medialization: a CT-scan study. *Rev Chir Orthop Reparatrice Appar Mot.* 2006;92(5):429-36.
7. Saudan M, Fritschy D. AT-TG (anterior tuberosity-trochlear groove): interobserver variability in CT measurements in subjects with patellar instability. *Rev Chir Orthop Reparatrice Appar Mot.* 2000;86(3):250-5.
8. Fulkerson JP. Patellofemoral pain disorders: evaluation and management. *J Am Acad Orthop Surg.* 1994;2(2):124-32.
9. Schoettle PB, Zanetti M, Seifert B, Pfirrmann CW, Fucen-tese SF, Romero J. The tibial tuberosity-trochlear groove distance; a comparative study between CT and MRI scanning. *Knee.* 2006;13(1):26-31.
10. Balcarek P, Walde TA, Frosch S, et al. Patellar dislocations in children, adolescents and adults: a comparative MRI study of medial patellofemoral ligament injury patterns and trochlear groove anatomy. *Eur J Radiol.* 2011;79(3):415-20.
11. Grelsamer RP. Patellar malalignment. *J Bone Joint Surg Am.* 2000;82(11):1639-50.
12. Biedert RM, Warnke K. Correlation between the Q angle and the patella position: a clinical and axial computed tomography evaluation. *Arch Orthop Trauma Surg.* 2001; 121(6):346-9.
13. Wright JG, Feinstein AR. Improving the reliability of orthopaedic measurements. *J Bone Joint Surg Br.* 1992;74(2):287-91.