
ORIGINAL ARTICLE

Normal Tibial Tubercle to Trochlear Groove Distance in an Adult Chinese Population

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ABSTRACT

Objective: To define the normal tibial tubercle to trochlear groove (TT-TG) distance in an adult Chinese population and to confirm that magnetic resonance imaging (MRI) measurements of TT-TG distance are reliable and reproducible.

Methods: We conducted a retrospective review of MRI scans of 100 skeletally mature knees in an adult Chinese cohort from January 2015 to January 2016. Patients with MRI or clinical evidence of previous lateral patellar dislocation were excluded. TT-TG distance in MRI scans of normal knees was measured. Intraobserver and interobserver agreement was evaluated.

Results: In our study, the mean normal value of the TT-TG distance in an adult Chinese cohort was found to be 10.36 ± 2.52 mm (men 10.92 ± 2.59 mm and women 9.67 ± 2.28 mm). Intraobserver and interobserver agreement regarding TT-TG distance measurement with MRI was excellent.

Conclusion: This study can form the basis for future studies on the relationship between TT-TG distance and patellar instability in the adult Chinese population.

Key Words: Asian continental ancestry group; Magnetic resonance imaging; Patellar dislocation; Tibia

中文摘要

華人成年人脛骨結節到滑車溝距離的正常值

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目的：確定華人成年人的正常脛骨結節—滑車溝（TT-TG）距離，並確認磁共振成像（MRI）測量TT-TG距離的可靠性和可重複性。

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Data Availability: All data generated or analysed during the present study are available from the corresponding author on reasonable request.

Ethics Approval: This study was approved by the Hong Kong East Cluster Research Ethics Committee (Ref HKECREC-2017-064).

方法：我們對2015年1月至2016年1月的華人成人隊列中100例骨骼成熟膝關節的 MRI 掃描進行回顧研究。排除具有MRI或臨床證據提示曾經有髌骨外側脫位的患者。測量正常膝關節MRI掃描中的TT-TG距離。評估同一觀察者及不同觀察者間測量的一致性。

結果：研究結果顯示華人成人TT-TG距離的平均正常值為 10.36 ± 2.52 毫米（男性 10.92 ± 2.59 毫米，女性 9.67 ± 2.28 毫米）。同一觀察者及不同觀察者以MRI測量TT-TG距離均有優異的一致性。

結論：本研究可為未來華人成年人群中 TT-TG距離與髌骨不穩關係的研究奠定基礎。

INTRODUCTION

The amount of lateralisation of the tibial tubercle relative to the trochlear groove has been termed the tibial tubercle to trochlear groove (TT-TG) distance and has become a useful tool in guiding surgical management of patients with recurrent patellar instability. There are multiple studies describing the measurement of TT-TG distance using various modalities such as X-ray, computed tomography (CT), and magnetic resonance imaging (MRI).¹⁻⁹ However, to the best of our knowledge, the TT-TG distance is not well documented in the adult Chinese population. A previous study compared the TT-TG distance in Chinese patients with or without recurrent patellar dislocation using MRI,¹⁰ but there was no clear definition of a normal control knee.

The aim of the present study was to report normal values of the TT-TG distance in normal skeletally mature adult Chinese knees and to assess the reliability of MRI in measuring TT-TG distance.

METHODS

Study Population

We retrospectively reviewed 125 MRI scans of skeletally mature knees, which were retrieved using the dedicated Radiology Information System, from January 2015 to January 2016. Cases recruited in this study had undergone MRI due to knee pain or suspected internal knee derangement.

Inclusion criterion was an intact patellofemoral joint on arthroscopy. Exclusion criteria were ≥ 3 of the following: MRI or clinical evidence of previous lateral patellar dislocation, characterised by joint effusion, contusion of the lateral femoral condyle/medial patellar facet, osteochondral fragments; or injury to the medial ligamentous stabilisers, the medial retinaculum, and the medial patellofemoral ligament.⁸ We also excluded MRI scans showing any ligamentous injury or any internal derangement of the knee, other than meniscal injury. For clinical criteria, cases of documented patellar dislocation

requiring reduction by a physician, or a convincing history of giving way along with clinical findings of joint effusion and tenderness along the medial patella facet, along the medial retinaculum, and/or the medial femoral condyle were excluded.⁸ We also excluded MRI scans of those individuals who, on clinical examination, showed signs and symptoms of patellofemoral instability, ligamentous laxity, malalignment, or osteoarthritis, as this may give abnormal measurement of the TT-TG distance.^{7,11}

Eight cases showed clinical or MRI evidence of lateral patellar dislocation. Ten cases were excluded due to presence of anterior cruciate ligament injury, significant osteoarthritic changes, total knee replacement, or fracture of the patella or of the medial or lateral tibial plateau. Seven patients were excluded due to non-Chinese ethnicity (Figure 1).

These criteria were used to identify 100 cases, which formed the study group. The institutional research ethics committee approved this investigation. Written consent was waived as it was retrospective.

Magnetic Resonance Imaging Technique

The MRI examinations were performed on a 1.5-T imager (MAGNETOM Avanto 1.5T; Siemens, Erlangen, Germany). The patients underwent imaging in the supine position with the knee in full extension. A proton-density weighted turbo spin-echo with fat suppression imaging sequence (TR/TE, 3500/20 ms; flip angle, 150°; field of view, 256 × 256 mm; section thickness, 4.0 mm) was routinely acquired and used for this study.

Tibial Tubercle to Trochlear Groove Distance Measurement

Axial images were used to measure the TT-TG distance in all individuals. The TT-TG distance was measured in accordance with the technique described by Schoettle et al⁵ (Figure 2). All readings were done using OsiriX software, which runs on Macintosh system (Apple Inc. Cupertino [CA], United States).

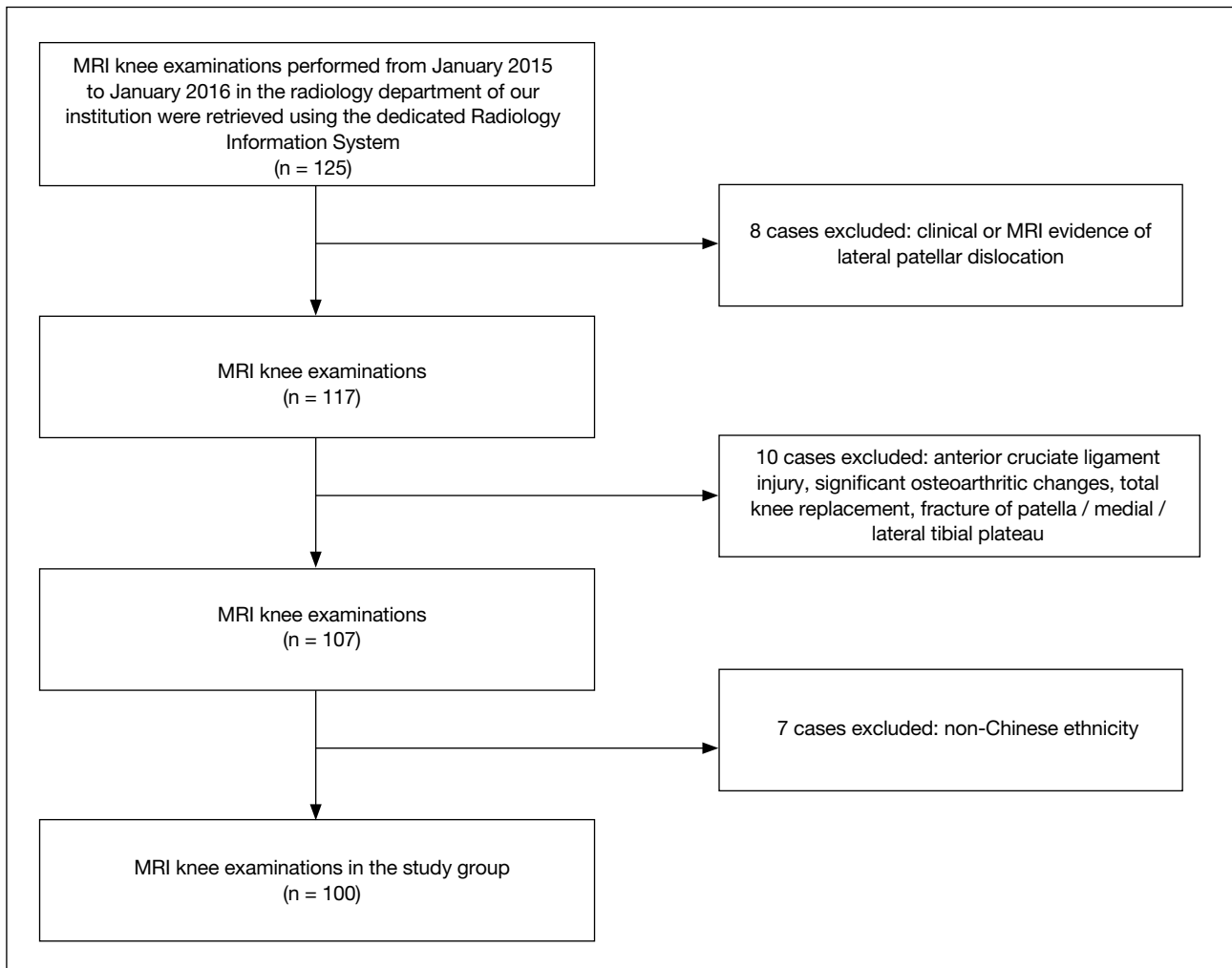


Figure 1. Flowchart of case recruitment.
Abbreviation: MRI = magnetic resonance imaging.

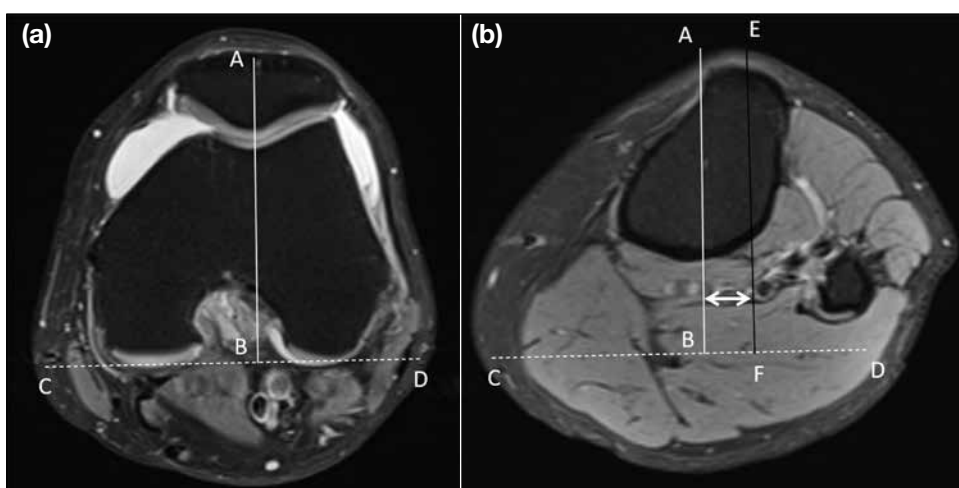


Figure 2. The first axial craniocaudal image (a) that depicted a complete cartilaginous trochlea was used to determine the deepest point within the trochlear groove. A vertical line was drawn through the deepest point of the trochlear groove, perpendicular to the posterior condyle tangent (white line). (b) A second line was drawn parallel to the trochlear line on the image including the most anterior portion of the tibial tubercle (black line). The distance between the two lines represents the tibial tubercle to trochlear groove distance (double arrow).

The measurement of TT-TG distance was done by two independent radiologists with special interest in musculoskeletal radiology. Each TT-TG distance was measured twice by each radiologist (raters A and B) on two different occasions and in randomised order. The radiologists were blinded to patient age, sex, diagnosis, their previous measurement, and the measurements of the other reader.

Statistical Analysis

All analyses were undertaken using commercial software SPSS (Windows version 22.0; IBM Corp, Armonk [NY], United States). We were interested in estimating the mean TT-TG distance in this adult group at a 95% confidence interval (95% CI) with a maximum error of 1 mm. The standard deviation based on a study was 3.1 mm.⁷ An estimated sample size of at least 37 would be needed. Descriptive statistics for TT-TG distance of men and women were calculated (Table); an independent t test was used to detect any significant differences between the two values. An intraclass correlation coefficient was used to evaluate intraobserver and interobserver reliability of the MRI measurements. A p value of <0.05 was considered statistically significant.

RESULTS

Total 100 cases were included. The median age of the cohort was 41 years (range, 19-82 years). Preliminary analysis confirmed that the TT-TG measurements had a normal distribution. Mean TT-TG distance for this adult Chinese cohort was 10.36 ± 2.52 mm, 95% CI = 9.86-10.86 mm). The mean TT-TG distance was 10.92 ± 2.59 mm for men and 9.67 ± 2.28 mm for women (p = 0.013).

Intraclass correlation coefficients for intraobserver and interobserver reliability were excellent. Intraobserver

reliability for raters A and B at two different time points was 0.993 (95% CI = 0.990-0.995) and 0.983 (95% CI = 0.975-0.989), respectively, p < 0.001. Respective interobserver reliability was 0.961 (95% CI = 0.943-0.974) and 0.967 (95% CI = 0.952-0.978), p < 0.001.

DISCUSSION

Both CT and MRI can accurately measure TT-TG distance; however, MRI study has several advantages over CT scan study as it is free of radiation hazards and can also evaluate cartilage damage as a result of recurrent patellar dislocations.^{5,7}

Different studies reported wide range of normal TT-TG values. For instance, Wittstein et al³ found it as 9.4 ± 0.6 mm, Pandit et al⁴ found it as 9.91 mm in men and 10.04 mm in women, Kulkarni et al⁷ found it as 13.19 ± 3.14 mm in men and 14.07 ± 3.03 mm in women in an Indian population. Tse et al¹⁰ found it as 12.7 ± 3.4 mm. In our study, the mean normal value of the TT-TG distance in an adult Chinese population was found to be 10.36 ± 2.52 mm (10.92 ± 2.59 mm for men and 9.67 ± 2.28 mm for women).

In Caucasian populations, the cut-off value of TT-TG distance for tibial tuberosity transfer is 20 mm.¹ It is not certain if an absolute value is applicable to all patients, with different sex and ethnicity. The threshold for tibial tuberosity transfer may be lower in Chinese patients.¹⁰ Further study is required to better define the cut-off value, and its relationship with patellar instability and body size metrics in the Chinese population.

Our study also confirmed that MRI measurements of TT-TG distances in the adult Chinese population were reliable and reproducible. There was excellent intraobserver and interobserver reliability in our study.

CONCLUSION

Our study defined normal MRI measurements of the TT-TG distance in an adult Chinese population. We believe that this study could form the basis for further research to study the association between TT-TG distance and patellar instability in the adult Chinese population.

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Table. Summary of patient demographics and TT-TG distance.*

Age, y, median (range)	41 (19-82)
Sex	
Men	55 (55%)
Women	45 (45%)
Laterality of knee examination	
Right	48 (48%)
Left	52 (52%)
TT-TG (overall) [n = 100], mm	10.36 ± 2.52 (9.86-10.86)
TT-TG (men) [n = 55], mm	10.92 ± 2.59 (10.22-11.62)
TT-TG (women) [n = 45], mm	9.67 ± 2.28 (9.0-10.3)

Abbreviation: TT-TG = tibial tubercle–trochlear groove distance.

* Data are presented as No. (%) or mean \pm standard deviation (95% confidence interval) except where indicated.

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