ÖN ÇAPRAZ BAĞ YARALANMASI İÇİN BİR RİSK FAKTÖRÜ OLARAK TIBİAL TÜBERKÜL - TROKLEAR OLUK MESAFESİNİN VE PATELLAR YÜKSEKLİĞİNİN DEĞERLENDIRILMESİ

EVALUATION OF THE TIBIAL TUBERCLE - TROCHLEAR GROOVE DISTANCE AND PATELLAR HEIGHT AS A RISK FACTOR FOR ANTERIOR CRUCIATE LIGAMENT INJURY

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ÖZET

AMAÇ: Bu çalışmada Ön çapraz bağ (ÖÇB)’yi sağlam ve ÖÇB’şi kopuk olan hastalar arasındaki patellar yükseklik ve tibial tüberkül troklear oluk mesafesi (TT-TGd) arasındaki farkların değerlendirilmesi amaçlanmıştır.


BULGULAR: Gözlemci içi ve gözlemciler arası uyum her iki ölçüm için mükemmel (tüm ölçümler için p<0.001 ve k> 0.850). Patellar yükseklik ve TT-TGd, ÖÇB kopuk olan hastalarda kontrol grubuna göre anlamlı olarak daha yüksekliği (srasıyla 1.09 ± 0.37 ile 1.06 ± 0.56, p<0.001, 10.0 ± 3.3’e karşı 8.5 ± 3.0, p<0.001). ISI kadınlarda erkeklerde göre anlamlı olarak daha yüksekliği (1.13’e karşı 1.07, p<0.001), TT-TGd açısından cinsiyet ve TT-TGd ölçümleri ÖÇB’şi kopuk olan hasta grubu ve sağlam ÖÇB’şi olan kontrol grubu ile karşılıştırdı.

SONUC: ÖÇB’şi kopuk olan hastalarda patella yüksekliği ve TT-TGd anlamlı olarak artmış olmasına rağmen, bu farklılıklar normal aralığındaki önemli klinik öneme sahipti.

ANAHTAR KELİMELER: Ön çapraz bağı yaralanması, Patella yüksekliği, Risk faktör

ABSTRACT

OBJECTIVE: This study aimed to evaluate the differences in patellar height and tibial tubercle- trochlear groove distance (TT-TGd) between patients with an intact anterior cruciate ligament (ACL) and ruptured ACL.

MATERIAL AND METHODS: A total of 2019 patients (1015 with ruptured ACL and 1004 with an intact ACL) aged between 18-40 years were included. The Insall Salvati index (ISI) was used to determine the patellar height measurement. The TT-TGd was measured based on axial magnetic resonance images. Two orthopedic surgeons independently studied 50 patients’ images for two weeks to assess intra-observer and inter-observer reliability. The mean patellar height and TT-TGd measurements were compared between patients with ruptured ACL and those with an intact ACL.

RESULTS: Interobserver and intraobserver agreement were excellent for both measurements (p=0.001 and k> 0.850 for all measurements). Patellar height and TT-TGd were significantly higher in ACL ruptured patients than in the control group (1.09± 0.37 vs. 1.06± 0.56, p<0.001, 10.0± 3.3 vs. 8.5± 3.0, p<0.001, respectively). The ISI was significantly higher in women than in men (1.13 vs. 1.07, p<0.001). There was no significant difference between the sexes regarding the TT-TGd (9.5 vs. 9.3, p=0.792).

CONCLUSIONS: Although significantly increased in patellar height and TT-TGd was detected in patients with ruptured ACL, these differences are not clinically important because they are in the normal range.

KEYWORDS: Anterior Cruciate Ligament injury, Patellar height, Risk factor
INTRODUCTION

Injuries to the anterior cruciate ligament (ACL) and the related tibiofemoral instability are associated with loss of function (1). However, even if the ACL is reconstructed, the risk of osteoarthritis development is high (1, 2). Therefore, prevention and identifying risk factors are important. Although ACL rupture is multifactorial, some anatomic risk factors like the femoral intercondylar notch width, lower extremity alignment, Q-angle, tibial plateau slopes, medial plateau concavity, and lateral plateau convexity have become the focus of investigation (3 - 7).

The relationship of the increased tibial tubercle-trochlear groove distance (TT-TGd) and patellar height with patellofemoral instability has been previously documented (8 - 10). Based on the current literature, there are two conflicting studies that have evaluated the relationship between patellar height and ACL tear (11, 12).

The primary aim of this study was to evaluate the role of TT-TGd and patellar height in ACL rupture in a large group. The secondary aim was to determine the role of sex in patellar height and TT-TGd.

MATERIALS AND METHODS

After receiving approval from the local ethics committee, medical records of patients who underwent ACL reconstruction between 2013 and 2018 were investigated using the International Classification of Diseases, Tenth Revision, codes. The inclusion criteria of the current study were: the patients had satisfactory axial magnetic resonance (MR) images and lateral radiographs to evaluate the TT-TGd and patellar height. The exclusion criteria were history of previous knee surgery, preexisting deformity, and multiple ligament injury (including posterior cruciate ligament and posterolateral corner injury). Finally, 1015 patients (973 male, 42 female) were included in the study (Figure 1).

As a control group, we selected 1004 age-matched randomized patients (960 male and 44 female) diagnosed with chondral lesion, degenerative meniscal injury, or plicae with intact ACL. The mean ages of the ACL ruptured and ACL intact groups were 29 ± 9.4 (range, 18 to 40) years and 31 ± 9.8 (range 18 to 40) years, respectively. The need for informed consent was waived because of the study’s retrospective design. TT-TGd measurement was performed as previously described by Schoettle et al. (13).

First, the deepest point in the cartilaginous trochlear groove was determined. Then, a line was drawn through the deepest point of the trochlear groove perpendicular to the cartilaginous posterior condylar tangent line (Figure 2).

Figure 1: The flowchart showing the process of patient inclusion and exclusion.

Figure 2: Measurement of TT-TGd on axial MR images of the knee. A) The red line is the perpendicular line from the posterior condylar tangent line (yellow line) extending to the deepest point of the TG. B) The blue line is the parallel line at the level of insertion of the patellar tendon onto the TT. The distance between these two lines is defined as TT-TGd.

Second, the middle point of the patellar tendon at the level of insertion to the tibial tubercle was determined. Then, a second line was drawn from this point parallel to the trochlear groove line. The distance between these two parallel lines was determined as the TT-TGd. Radiographs were obtained with the knee joint in the 30°
flexed position. The Insall Salvati index (ISI) is the length ratio of the patellar tendon to the greatest diagonal length of the patella (Figure 3) (14).

![Figure 3: The Insall–Salvati index (ISI) is the ratio of patellar tendon length (PTL) to the greatest diagonal length of the patella (DLP).](image)

The normal ISI is between 0.8-1.2. If the ISI>1.2, it is defined as patella alta and if the ISI<0.8, it is defined as patella baja (8, 14).

The mean patellar height and TT-TGd were compared between ACL intact and ACL ruptured groups. The patellar height and TT-TGd were compared between sexes. Measurements were performed in a blinded manner by two orthopedic surgeons with 5 years of experience who did not know the patients’ diagnoses or the study’s purposes.

Fifty randomly selected radiographs and axial MR images were measured twice for two weeks apart to assess the inter- and intra-observer reliability.

**Statistical Analyses**

In the descriptive statistics of the data, the mean, standard deviation, median, lowest, highest, frequency, and ratio values were used. The distribution of the variables was measured with the Kolmogorov Smirnov test. In the analysis of quantitative independent data, the Mann-Whitney test was used. The Chi-square test was used for the analysis of qualitative independent data. An intraclass correlation coefficient (ICC) was calculated to assess inter and intra-observer reliability. A p value less than 0.05 was considered significant. All data were analyzed by an independent professional statistician using IBM SPSS Statistics for Windows, version 22.0 (Armonk, NY: IBM Corp, USA.).

**Ethical Committee**

The ethical approval for the study was obtained from the Metin Sabancı Baltalimanı Bone Health Science University Baltalimanı Bone Diseases EducationandResearchHospital, thestudyprotocol (Approval date/number 22.05.2019/47-336)

**RESULTS**

Agreements among the two measurements for ISI (weighted kappa, 0.853; 95% confidence interval [CI] 0.682-0.932; p<0.001), TT-TGd (weighted kappa, 0.956; 95% CI 0.905-0.980; p<0.001) were excellent. Agreements between two readers for ISI (weighted kappa, 0.973; 95% CI 0.941-0.987; p<0.001), TT-TGd (weighted kappa, 0.974; 95% CI 0.944-0.988; p<0.001) were excellent. The mean ISI in the ACL ruptured and ACL intact groups was 1.09 ± 0.37 and 1.06 ± 0.56, respectively (p<0.001).

The mean TT-TGd was 10.0 ± 3.3 in the ACL ruptured group and 8.5 ± 3.0 in ACL intact group (p<0.001), (Table 1).

**Table 1:** Mean (± standard deviation) of tibial tubercle-trochlear groove distance (TT-TGd) and patellar height values in the ACL intact and deficient groups

<table>
<thead>
<tr>
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<th>ACL intact group</th>
<th>ACL deficient group</th>
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<tbody>
<tr>
<td></td>
<td>Mean ± s.d./n (%)</td>
<td>Median (IQR)</td>
</tr>
<tr>
<td>TT-TGd</td>
<td>8.5 ± 3.0</td>
<td>8.32</td>
</tr>
<tr>
<td>Patellar height</td>
<td>1.06 ± 0.56</td>
<td>1.02</td>
</tr>
<tr>
<td>p-value</td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
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Patella alta or patella baja was not observed in the ACL ruptured group. However, the patellar height was significantly higher in the ACL ruptured group (p<0.001). The TT-TGd was also significantly increased in the ACL ruptured group (p<0.001).

There was no significant difference between male and female patients regarding the TT-TGd (p=0.792). Patellar height in women was significantly higher than in men (p<0.001) (Table 2).

No significant correlation was observed between age and TT-TGd or patellar height (p=0.113 and p=0.083, respectively).
Table 2: Mean (±standard deviation) of tibial tubercle-trochlear groove distance (TT-TGd) and patellar height values in the female and male groups

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Male</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Mean±s.d./n-%</td>
<td>Median</td>
</tr>
<tr>
<td>TT-TGd</td>
<td>9.5±3.5</td>
<td>9.2±3.2</td>
</tr>
<tr>
<td>Insall Salvati Index</td>
<td>1.13±0.18</td>
<td>1.15±0.40</td>
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* Mann Whitney u test

**DISCUSSION**

The most important finding of this study is that the patellar height and TT-TGd was higher in the ACL injury group. Second, patellar tendon height was found to be higher in women. Despite the increasing number of papers on anatomical risk factors for ACL rupture over the past ten years, there is still no conclusive evidence of a direct cause-and-effect relationship. Female athletes have a higher incidence of ACL rupture than their male counterparts. The risk factors for non-contact ACL injuries can be classified as intrinsic and extrinsic (15, 16). Shambaugh et al. reported that women had a significantly smaller notch width index (17). Muneta et al. stated that there was a significant difference between male and female ACL widths (18). In several studies, the ACL size was smaller in women (1, 18). Women have been reported to have larger Q-angles than men (5). However, there are still a number of risk factors and mechanisms regarding non-contact ACL injuries that are not yet well understood (19). Therefore, we hypothesized that TT-TGd and patellar height may have a role in ACL injury. According to our hypothesis, these two parameters may vary between the sexes; this may explain the differences in the ACL injury rates between sexes. We acknowledge that the TT-TGd is an established measurement to assist diagnosis and treatment of patellofemoral instability (10,20,21). Based on the current literature, a TT–TGd of 15–20 mm is classified as abnormal; a TT–TGd >20 mm is defined as pathological (20, 22 - 24).

According to our results, TT–TGd values are in the normal range in both patient and control groups. However, in the ACL injury group, the TT–TGd values were closer to the upper limit. Even though the results were statistically significant, we believe there was no clinical significance.

Another important finding of the present study was that the patellar height was also higher in the patient group. Patella alta (defined as an ISI >1.2) has been shown to be a strong predictor of the recurrent instability in patients with patella dislocation following conservative treatment (14, 25). However, there are only two published studies that evaluated the ISI measurements in individuals with an ACL injury. Lin et al. stated that there is an association between ACL tears and patella baja (11). They observed a decreased patellar height in 115 patients with ACL tears with an average ISR of 0.99 versus 1.05 in 102 patients without ACL tears. Degnan concluded that the ISI was increased in children with acute ACL tears compared to the control group (average ISR 1.16 and 0.99, respectively) (12). They stated that even if the mechanism is unclear, relative patella alta may be a risk factor for ACL injury. Based on the current literature, there is a conflict on whether increased or decreased patellar height is a risk factor for ACL tear. It is important to note that Lin et al. recommend that patellar height should be taken into consideration for the graft choice (14). We noted that the ISI was significantly increased in the ACL deficient group, close to the upper limit. However, it has no clinical relevance because the results were in the normal range in both patient and control groups and were close to each other. On the other hand, there are numerous anatomical differences between the sexes. One of the possible risk factors might be the patellar height that explains ACL injury rates between genders. Perhaps several risk factors resulting in a cumulative effect. There are some limitations of this study. First, we investigated the patients radiologically however we did not evaluate their functional situation. Second, the other anatomical risk factors for ACL injury were not excluded. The presence of other associated risk factors may make our results less reliable. Prospective studies which evaluate these measurements with clinical situation should be designed. Although significantly increased patellar height and TT–TGd were detected in ACL ruptured patients, these differences are not clinically important because of they are in normal range.
REFERENCES


