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Comparison of Femoral Anteversion Angle and Determination of Reliability Measured at Three Different Anatomical References of the Tibial Crest During the Trochanteric Prominence Angle Test

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Abstract

The trochanteric prominence angle test (TPAT) has been used to measure the femoral anteversion angle between the tibial crest and the vertical line. However, the exact anatomical reference of the tibial crest has not yet been identified in the literature. Thus, the purposes of this research were twofold: first, to compare the femoral anteversion angle measured at three different anatomical references of the tibial crest (the proximal tibial crest, the proximal third of tibial crest, and the proximal half of tibial crest) and, second, to determine inter-and intra-rater reliabilities of the femoral anteversion angle measured at these three different anatomical references of the tibial crest during the TPAT. We recruited 14 healthy subjects, and a total of 28 legs were examined. The TPAT was measured using a digital inclinometer. A 1-way repeated-measure analysis of variance was used to compare the femoral anteversion angle measured at three different anatomical references of the tibial crest, and intraclass correlation coefficients (ICCs) were calculated to determine reliability. The femoral anteversion angle measured at the proximal tibial crest was significantly higher than that at the proximal third of the tibial crest and the proximal half of the tibial crest. The inter-and intra-rater reliabilities of femoral anteversion angle were measured at three anatomic references of the tibial crest were all found to be high during the TPAT (ICC=.90∼.98). In conclusion, clinicians should recognize that the different degrees of the femoral anteversion angle could be measured when different anatomical references of the tibial crest were used, and that reliabilities were high when an exact anatomical reference of the tibial crest was used during the TPAT.

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Key Words: Anteversion; Tibial crest; Trochanteric prominence angle test.

Introduction

The femoral neck-shaft angle is defined as the relative rotation angle between the femoral neck and shaft in a transverse plane (Neumann, 2002). An excessive femoral anteversion angle greater than 30° has been correlated with several orthopedic conditions, such as patellofemoral pain (Powers, 2003), hip labral tears (Groh and Herrera, 2009), and osteoarthritis (Tonnis and Heinecke, 1999). In this respect, accurate assessment of the femoral anteversion angle is of utmost importance in patients with lower ex-

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tremity dysfunction (Souza and Powers, 2009). The clinical assessment of the femoral anteversion angle is commonly referred to as the "trochanteric prominence angle test (TPAT)" (Dunlap and Shands, 1953) or "Craig's test" (Gross, 1995; Davids et al, 2002). When the TPAT is performed, an inclinometer is aligned to the tibial crest and the angle between the tibial crest and the vertical line is recorded (Souza and Powers, 2009). Thus, the clear definition and identification of the tibial crest as an anatomical reference is needed to produce consistent measurements of the femoral anteversion angle.

The tibial crest is a somewhat curved rather than straight line between the tibial tuberosity and the anterior margin of the medial malleolus, meaning that the angle of femoral anteversion may be measured differently depending on which part of the tibial crest was selected while aligning the inclinometer during the TPAT. As an anatomical reference of the tibial crest, the most prominent part of the tibial crest or half portion of the tibial crest have been recommended. However, possible differences in the femoral anteversion angle measured at different anatomical references of the tibial crest have not been investigated by previous studies. In addition, reliability of the femoral anteversion angle as regards different anatomical references has not been examined to date. Because previous researchers, when measuring the femoral anteversion angle, have reported moderate to high reliabilities without identifying the tibial crest exactly (Lesher et al, 2006; Piva et al, 2006; Shultz et al, 2006), the findings of this study will contribute to more reliable measurement of the femoral anteversion angle during the TPAT.

The purposes of this research were to compare the femoral anteversion angle measured at three different anatomical references of the tibial crest (the proximal tibial crest, the proximal third of tibial crest, the proximal half of tibial crest) and to investigate the inter-and intra-rater reliabilities of the femoral anteversion angle measured at three different anatomical references of the tibial crest during the TPAT. We hypothesized that different angles of the femoral anteversion would be measured by three different reference points of the tibial crest, and inter-and intra-rater reliabilities would be moderate to high in each of three anatomical references of the tibial crest during the TPAT.

Methods

Subjects

We recruited 14 subjects, and a total of 28 legs were examined. Subjects were included if they were aged 18 to 30 years old, free of past or current inflammatory arthritis, lower extremity and back dysfunctions, and shortness of the iliotibial band. Exclusion criteria were past or present trauma to the hip and knee, painful hip and knee joint lines or patellar tendon, prior lower extremity surgery, and neurologic disease. In addition, subjects with body mass index of above 25 were excluded from the study. Demographic information is presented in Table 1. Prior to the study, the subjects read and signed a written consent form in order to participate in this study. The study protocol was approved by Yonsei University Wonju Campus Human Studies Committee.

Instrumentation

An industrial digital inclinometer[1)] was used for the measurement of the femoral anteversion angle

Table 1. General characteristics of subjects (N=14)

Characteristics	Mean±SD[b]
Age (years)	19.4±1.5
Height (㎝)	168.5±7.6
Weight (㎏)	59.0±8.2
BMI[a] (㎏/㎡)	20.7±1.9
Range of tibial torsion (°)	23.2±5.2

[a]body mass index, [b]mean±standard deviation.

1) GemRed DBB, Gain Express Holdings, Ltd., Hong Kong, China.

during the TPAT in this study.

Procedures

1) Trochanteric prominence angle test

The subject was asked to assume a prone position, and the investigator stood by the participant's side being examined. The investigator palpated the subject's greater trochanter with the knee on the side being tested flexed passively at 90°. Then, the subject's hip was rotated internally and externally to find the position where the greater trochanter became most prominent. In this position, a wooden frame was used to maintain the hip and knee angle. The inclinometer was aligned to the subjects' tibial crest in three different anatomical references based on the orientation of the tibia tuberosity (Wynne-Davies, 1964). Three different anatomical references of tibial crest were operationally defined to improve internal validity in this study. The proximal tibial crest was defined as the tibia tuberosity. The proximal third of tibial crest was defined as a one third point from the tibia tuberosity to the medial malleolus. It is sinuous and prominent in the proximal one-thirds of the tibial crest. The proximal half of tibial crest was defined as a halfway point between the tibial tuberosity and the medial malleolus (Figure 1). We measured the femoral anteversion angle at three different anatomical references in a randomized order. The femoral anteversion angle was measured between each anatomical reference of the tibial crest and vertical line (Gulan, 2000; Souza and Powers, 2009) (Figure 2). We used the total mean value of the femoral anteversion angle from the two investigators (total mean from 4 values) to compare the femoral anteversion angle measured at the three different reference points of the tibial crest (Figure 2).

Figure 1. Digital inclinometer alignment on the tibial crest during the trochanteric prominence angle test.

Figure 2. Three anatomical references of the tibial crest.

2) Reliability study

Two investigators independently measured the femoral anteversion angle of each subject to establish inter-rater reliability. The investigators (1 and 2) are both licensed physical therapists. Investigator 1 had nine years of clinical experience and the other tester had a year of clinical experience in neuro-musculoskeletal physical therapy. To evaluate the intra-rater reliabilities for the TPAT, each investigator performed the femoral anteversion angle measurement twice per session. A thirty minute resting period was provided between the two sessions. To evaluate the inter-rater reliabilities, the investigators were blinded to each other's examination findings to prevent any influence of the other's result. We used the mean value from two trials for all reliability tests.

3) Statistical analysis

All statistical analyses were performed using PASW Statistics version 18.0 software. Kolmogorov-Smirnov Z-tests were performed to assess the normality of distribution. A 1-way repeated-measures analysis of variance was used to compare the femoral anteversion angle in three different anatomical references of the tibial crest. If a significant difference was found, a Bonferroni adjustment was performed (with alpha=.05/3=.017). Intraclass correlation coefficients (ICCs) were calculated, and ICC was defined ICCs were interpreted using the following criteria:.00～.10, virtually none;.11～.40, slight;.41～.60, fair;.61～.80, moderate;.81～1.0, high (Souza and Powers, 2009). Standard error of measurement (SEM) was also calculated for the femoral anteversion angles during the TPAT. SEM was determined using the equation $SD\sqrt{1-ICC}$. Statistical significance was set at .05.

Results

There was a significant difference in the femoral anteversion angles measured at the three anatomical references of the tibial crest during the TPAP ($F_{2,26}$=47.723, $p<.05$). The femoral anteversion angle measured in the proximal tibial crest was significantly greater compared with the anteversion angle measured in the proximal third of the tibial crest ($p<.001$) and the proximal half of the tibial crest ($p<.001$). The femoral anteversion angle measured at the proximal third of the tibial crest was significantly greater compared with that measured at the proximal half of the tibial crest ($p=.002$) (Table 2) (Figure 3). High inter-rater reliabilities were demonstrated for all femoral anteversion angles measured at the different anatomical references of the tibial crest (Table 2).

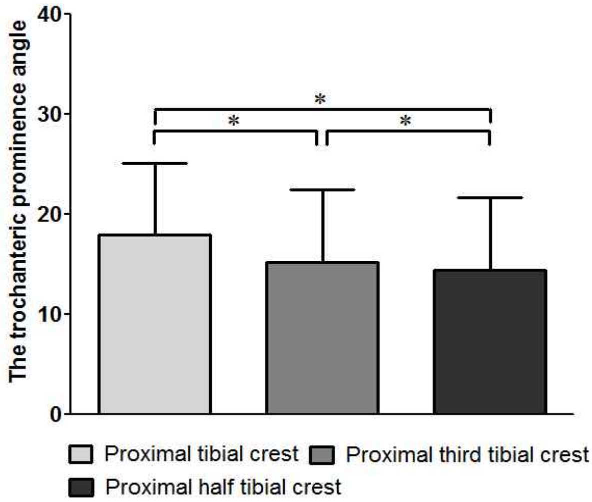

Figure 3. Multiple comparisons among three anatomical references of the tibial crest during the trochanteric prominence angle test.

Discussion

We compared three different anatomical references

Table 2. Comparisons of inter- and intra-rater reliabilities among three reference points on the tibial crest for the trochanteric prominence angle test

Anatomical reference	Mean±SD[a]	Inter-rater reliability (95% CI[b], SEM[c])	Intra-rater reliability 1 (95% CI, SEM)	Intra-rater reliability 2 (95% CI, SEM)
Proximal tibial crest (°)	17.91±7.21	.91 (.81～.95, 2.16)	.99 (.97～.99, .72)	.95 (.92～.98, 1.61)
Proximal third of tibial crest (°)	15.18±7.24	.91 (.80～.96, 2.17)	.98 (.95～.99, 1.02)	.98 (.95～.99, 1.02)
Proximal half of tibial crest (°)	14.42±7.2	.90 (.78～.95, 2.28)	.98 (.96～.99, 1.02)	.97 (.94～.99, 1.25)

[a]mean±standard deviation, [b]confidence interval, [c]standard error of the measurement, Values are presented as mean difference (95% CI).

of the tibial crest to determine whether different degrees of femoral anteversion angle can be produced, and examined the inter-and intra-rater reliabilities of the femoral anteversion angles during TPAT. The findings of our study supported our hypotheses that there were significant differences in the femoral anteversion angle among the three different anatomical references of the tibial crest. Furthermore, high inter-and intra-rater reliabilities were demonstrated at each different anatomical reference of the tibial crest during the TPAT.

The femoral anteversion angle measured at the proximal tibial crest was the greatest, followed by the proximal third of the tibial crest and the proximal half of the tibial crest in that order. These results indicate that different anatomical references of the tibial crest can produce different degrees of the femoral anteversion angle in the same subject. In addition, we found that the femoral anteversion angle measured during the TPAT decreased significantly as an anatomical reference was selected from a proximal reference to distal reference (i.e. from the proximal tibial crest to the half tibial crest). This is the first study to specifically define each anatomical reference of the tibial crest and then report different degrees of femoral anteversion angle with respect to the different anatomical reference points of the tibial crest.

We demonstrated high inter- and intrarater reliability at each anatomical reference of the tibia because of a clear definition of each anatomical reference for the tibial crest. Previous studies have reported a wide range of reliability of the femoral anteversion angle during the TPAT without definite identification of the tibial crest. The results of our study are comparable to those of a previous study by Souza and Powers (2009) who reported high intra-rater reliability of the TPAT (ICC values from .77 to .97; SEM values from 2.0° to 3.11°). However, Souza and Powers (2009) reported only fair inter-rater reliability (ICC=.48, SEM=6.5°). A few studies that have reported fair agreement for the TPAT. Lesher et al (2006), Piva et al (2006), and Shultz et al (2006) reported fair agreement with ICC values of .45, .47, and .58 and SEMs of 4. 5, 7, and 4.2°, respectively, for the TPAT. Possible explanations for the high variability in reported reliability are high body mass index causing difficulty in palpating the greater trochanter (Souza and Powers, 2009), ligament laxity (Ruwe et al, 1992), and tibial torsion (Lesher et al, 2006). Among the possible factors contributing to variable reliability; we controlled for body mass index and difficulty in palpating the greater trochanter by excluding subjects who were overweight or obese. The medial collateral ligament laxity and tibial torsion was controlled by the valgus test and the tibial torsion test (Lee et al, 2009) in this study precluding the subjects with lax ligaments and excessive tibial torsion. Thus, the findings of this study suggest that the precise definition, palpation, and placement of the inclinometer in the proximal, proximal third, and proximal half of the tibial crest are necessary to elicit high reliability by producing a consistent femoral anteversion angle.

Our study has several limitations. First, generalizability is limited because healthy and young subjects without musculoskeletal injuries were recruited. The results of a replicated study using the same methodology but recruiting different subjects would be different from the results of the present study. Therefore, further studies should investigate subjects of various ages and several orthopedic conditions, such as patellofemoral pain, hip labral tears, and osteoarthritis. Second, a wooden frame was used in this study to provide support for the test leg during the TPAT; We cannot exclude the possibility that the wooden frame could have contributed to the higher reliability observed in this study.

Conclusion

We focused on comparing the femoral anteversion angles and examining inter- and intra-rater reliability measured at three different references of the tibial crest during the TPAT. The femoral anteversion angle measured at the proximal tibial crest was significantly higher than those at the proximal third of the tibial crest and the proximal half of the tibial crest. The inter-and intra-rater reliabilities of femoral anteversion angle at all three anatomic references of the tibial crest were high during the TPAT. Thus, the findings of our study have contributed to our knowledge of the importance of selecting anatomical references and reselecting the anatomical reference when repeated measurements are required during the TPAT to ensure a reliable anteversion angle.

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