

Demystifying Tibial-Tuberosity Trochlear Groove Distance, the J-Sign and Trochlear Dysplasia: An Imaging Encomium

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Abstract

Aims and objective: The purpose of our study was to examine the association of the clinical J-sign with trochlear dysplasia and TTTG distance in patients with symptomatic patellofemoral instability.

Material and methods: After obtaining approval from the institutional review board (class: 8.1-16/47-2, Nr.: 02/21AG, April 11, 2017), in our retrospective cross-sectional review study, 2 raters mutually assessed the type of trochlear dysplasia and separately measured the TTTG distance at 4-week intervals using 2 methods (standard and by Nizi#) on static and dynamic CT-images of 55 knees (46 patients) with clinical record of J-sign and anterior knee pain.

Statistical analysis: All reported P values were 2-tailed with a level of <0.05 indicating statistical significance. The associations between variables were analyzed with appropriate correlation coefficients (Pearson, rp, point-biserial, rpb, and phi, r#). The Wilcoxon signed-rank test for paired samples was used to evaluate the differences between static and dynamic tibial tuberosity-trochlear groove.

Conclusion: The clinical manifestation of the J-sign, considered a dynamic marker of patellofemoral instability, has been frequently associated with numerous conditions, such as trochlear dysplasia, higher values of the Q-angle, and lateralized tibial tuberosity, yet its fundamental cause remains unknown, and the diagnostic value uncertain.

Keywords: J sign; Trochlea; Dysplasia; (TTTG) Tibial tuberosity trochlear groove

Introduction

A severe lateral subluxation of the patella at active terminal extension of the knee is called the J-sign [1,2] or J-tracking [3]. It is a straight forward clinical sign, sometimes shortly referred to as "dislocation in extension" [4]. A positive J-sign might suggest patellar maltracking [5], and potentially a need for trochleoplasty [6]. Yet, the underlying anatomical features and its actual diagnostic value are somewhat cryptic [7]. On the contrary, both trochlear dysplasia and the tibial tuberosity-trochlear groove (TTTG) distance, as a measure of lateralization of the extensor mechanism of the knee, are well-known phenomena with regard to recurrent patellofemoral instability [6].

In skeletally mature patients, the anterior knee pain and the value of the TTTG distance #20 mm could imply surgical treatment [8], namely medialization of the tibial tuberosity [6]. The purpose of our study was to examine the association of the clinical J-sign with trochlear dysplasia and TTTG distance in patients with symptomatic patellofemoral instability. After obtaining approval from the institutional review board in 2017, in our retrospective cross-sectional review study (Figure 1), 2 raters mutually assessed the type of trochlear dysplasia (Figure 2) and separately measured the TTTG distance at 4-week intervals using 2 methods (standard [9] and by Nizi# [10])

(Figure 3 and 4) on static and dynamic CT-images of 55 knees (46 patients) with clinical record of J-sign and anterior knee pain [11].

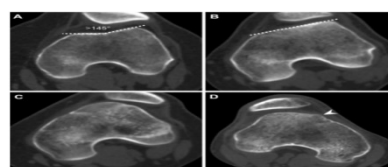
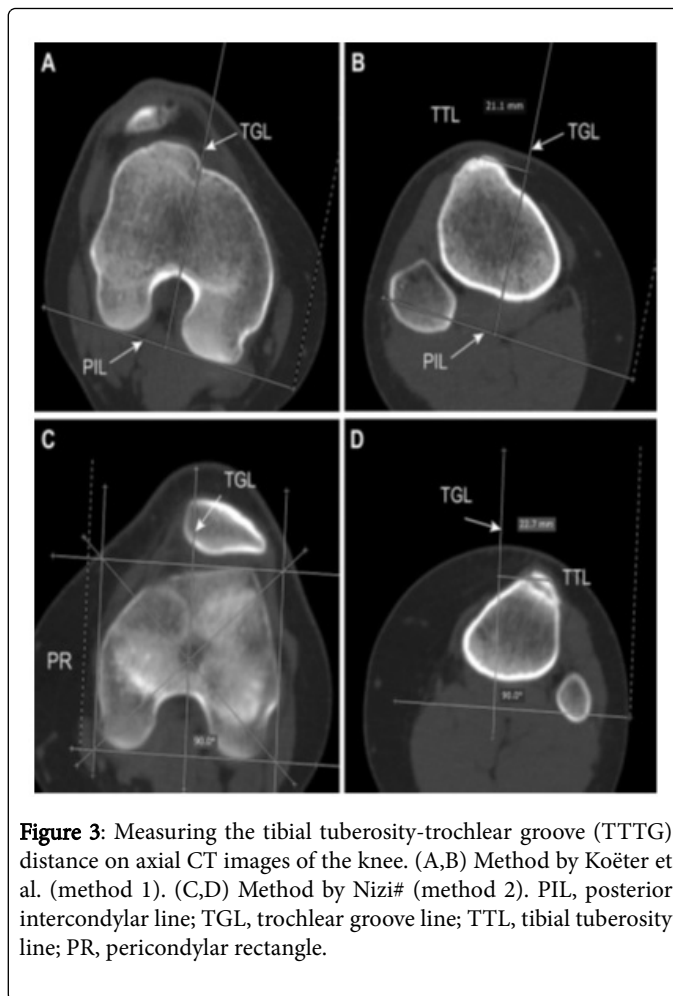
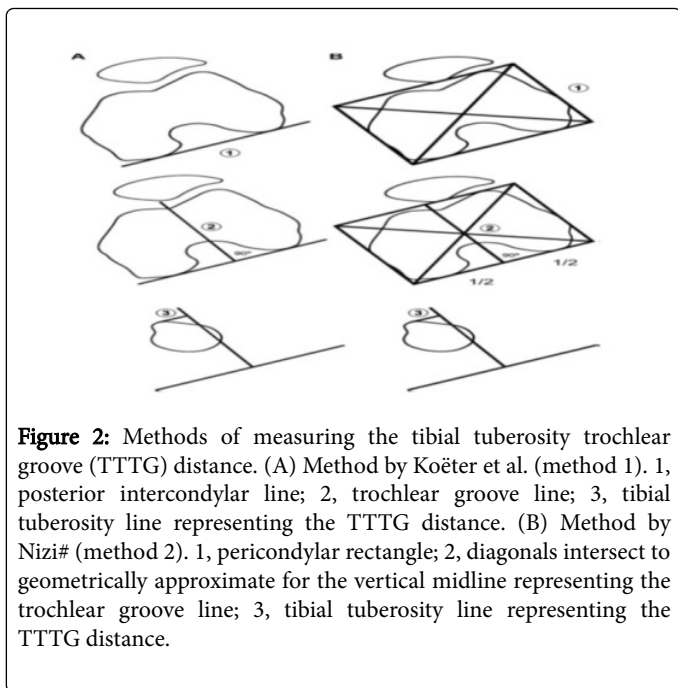


Figure 1: Dejour's classification of trochlear dysplasia. Type A (A), B (B), C (C) and D (D); cliff

All reported P values were 2-tailed with a level of <0.05 indicating statistical significance. The associations between variables were analyzed with appropriate correlation coefficients (Pearson, rp, point-biserial, rpb, and phi, r#) [12-14].

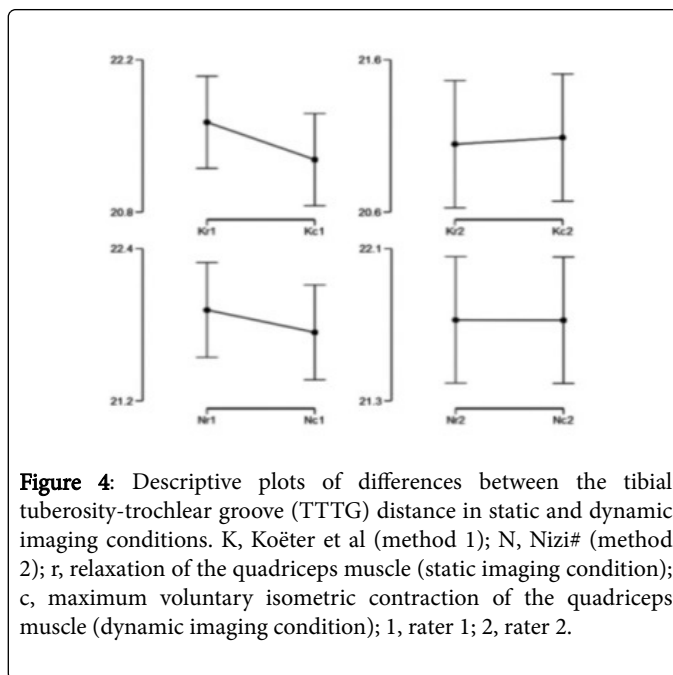
The Wilcoxon signed-rank test for paired samples was used to evaluate the differences between static and dynamic TTTG values. The intermethod and interrater agreements were assessed using intraclass correlation coefficient (ICC), with visualization on Bland-Altman plots [15].



Results

No significant association was detected when the clinical record of J-sign was compared to various variables, such as age ($P=0.127$), sex ($P=0.329$), laterality ($P=0.383$), presence of trochlear dysplasia ($P=0.999$) and severe trochlear dysplasia ($P=0.651$), or TTTG values obtained by both methods, whether non-dichotomized ($P=0.457$ to 0.655), or dichotomized ($P=0.347$ to 1.000), as well as clinical record of prior lateral patellar (sub)luxation ($r\#=-0.07$, $P=1.000$). Out of 55 knees, 50 (90.0%) were dysplastic, with 27 (49.1%) exhibiting trochlear dysplasia type A, 15 (27.3%) type B, 5 (9.1%) type C, 3 (5.5%) type D and 5 (9.1%) were non-dysplastic. Therefore, 18 (32.7%) knees had high-grade trochlear dysplasia. On average, the mean value of the TTTG distance was 21.3 ± 5.70 mm for method 1, and 21.5 ± 4.53 mm for method 2.

The TTTG values, non-dichotomized as well as dichotomized, were not associated with age ($P=0.107$ to 0.873), laterality ($P=0.165$ to 1.000), or trochlear dysplasia ($P=0.140$ to 0.643), yet showed a low positive correlation with sex ($rpb=0.43$ to 0.50 , $P<0.0001$ to 0.001 , and $r\#=-0.37$ to 0.46 , $P=0.0007$ to 0.009 , respectively), except in one case (method 2, rater 1: $r\#=-0.26$, $P=0.098$) [16]. The non-dichotomized TTTG values in static and dynamic imaging conditions were not significantly different with regard to both methods ($P=0.348$ to 0.987) (Figure 5). The intermethod correlation was very high for each rater ($n=53$, $rp=0.90$, $P<0.0001$, $rp\ 2=0.81=81.0\%$, and $n=54$, $rp=0.92$, $P<0.0001$, $rp\ 2=0.85=85.0\%$, respectively). Both intermethod and interrater agreements were almost perfect (0.937 ; 95% CI, $0.891-0.964$, 0.944 ; 95% CI, $0.902-0.968$, and 0.982 ; 95% CI, $0.968-0.989$ and 0.994 ; 95% CI, $0.989-0.997$, respectively), with little to very little bias (-0.35 , -0.63 and 0.39 , 0.08 , respectively). Method 1 systematically underestimated the TTTG values while method 2 showed 1.6 times lesser mean variance, with 5 times lesser interrater bias and 2 times narrower limits of agreement [17].



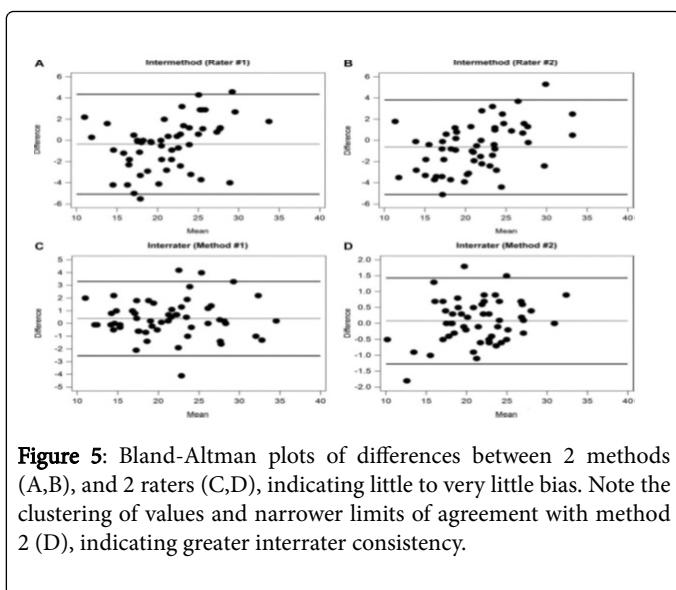


Figure 5: Bland-Altman plots of differences between 2 methods (A,B), and 2 raters (C,D), indicating little to very little bias. Note the clustering of values and narrower limits of agreement with method 2 (D), indicating greater interrater consistency.

Conclusion

The clinical manifestation of the J-sign, considered a dynamic marker of patellofemoral instability, has been frequently associated with numerous conditions, such as trochlear dysplasia, higher values of the Q-angle, and lateralized tibial tuberosity, yet its fundamental cause remains unknown, and the diagnostic value uncertain. To the best of our efforts, we have not been able to detect a comparable study to analogize. If the TTTG distance were indeed a radiological analogue of the Q-angle, which in itself is dubious, we could draw a parallel with the study by Sheehan et al. [18] who found no correlation of the Q-angle and the clinical J-sign. McDermott et al. [19] deemed the J-sign useful as preoperative estimation of the distance needed for tibial tuberosity transfer, quantifying the clinical J-sign with the help of preoperative axial MRI-images in full knee extension and 30 degrees of flexion. Edwards et al. [20] falsely hypothesized that the quadriceps active measure of the lateral patellar edge was the best predictor of how far the tibial tuberosity needs to be transferred to in order to eliminate the J-sign.

Nevertheless, both studies are conceptually and methodologically too distant to allow any juxtapositions. We can, therefore, merely speculate that our results indirectly support the theory of the clinical J-sign as an indicator of ligamentous disorder rather than a patellofemoral malalignment, as the deficiency of the vastus medialis muscle seems an unlikely cause. Even so, the association of the clinical J-sign with other relevant indices of patellofemoral maltracking, such as patella alta or patellar tilt, remains to be thoroughly scrutinized. Since the biases available from the literature (up to 4.5 mm) exceeded the biases obtained in our study (0.08 to 0.63 mm), both methods appeared interchangeable. In addition, the interrater agreement was almost perfect, which is similar to other studies, at least partially comparable in this segment. As to limitations, the sex bias was evident, yet expected. Also, we have not evaluated intrarater agreement because the purpose of this study was not to fully validate the two methods but rather to investigate the potential association of J-sign with the TTTG distance. Moreover, the intrarater validation of the TTTG distance has already been investigated.

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