CONVERGENT VALIDITY OF GONIOMETRIC AND MOTION CAPTURE TECHNIQUES USED TO MEASURE TIBIAL TORSION

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INTRODUCTION

Rotational and torsional abnormalities in the pediatric lower extremity can result in static and dynamic toeing-in or toeing-out, and are two of the most common reasons for parents to seek orthopaedic advice.[1] One common lower extremity torsional abnormality is atypical tibial torsion. Computed tomography (CT) is the gold standard for measurement of tibial torsion,[2] but its practicality is limited due to expense. Several goniometric measurement techniques have been described, but debate remains over which is most valid.[3] One goniometric method as described by King and Staheli was found to be within the accepted variability of CT, and therefore an accurate assessment tool.[4] The purpose of this prospective study was to determine the convergent validity of two other common goniometric methods used to measure tibial torsion, as well as a novel method using motion capture, by comparing them to the validated method described by King and Staheli.

METHOD

Twenty normal subjects (12 female, 8 male) between the ages of 10 and 25 years underwent four different measures of tibial torsion on the right lower extremity, including the CT validated method as described by King and Staheli (MKS), the thigh-foot angle (TFA) [4], a supine trans-malleolar axis measure (TMA) [5], and a novel method using motion capture (MC). One examiner, who was masked from the measurements via modification to a standard goniometer, assessed tibial torsion using the first three methods, while a second examiner recorded the results. After three measurements were obtained for each technique, a third examiner placed 6-mm markers on each subject's right medial and lateral tibial plateau, as well as medial and lateral malleoli.[6] Tibial torsion was then calculated as the rotation between two planes, one containing the tibial plateau markers and mid-point of malleolus markers and the other containing the malleoli and midpoint of the tibial plateau markers, about an axis between the proximal and distal midpoints. Three static motion capture trials were performed on each subject using a 10-camera Vicon 612 system (Oxford Metrics Group, Oxford, England). Biomechanical modeling was performed using Visual3D (C-Motion, Inc., Rockville, MD). Tibial torsion data were compared using a repeated measures analysis of variance with Tukey HSD *post hoc* tests performed in Statistica (Statsoft, Inc., Tulsa OK, USA).

RESULTS AND DISCUSSION

Statistically significant differences ($p < 0.05$) were demonstrated between our goniometric gold standard MKS and the goniometric methods of TFA and TMA (Table 1, Table 2). No significant differences were found between MKS and the novel MC technique, or between TFA and TMA. The results demonstrate discrepancies in the validity of TFA and TMA when compared to MKS, which was found to be a valid measure when compared to CT in previous literature. These findings may be considered when performing goniometric measurement of tibial torsion in the clinical setting. Because motion capture demonstrated convergent validity when compared to MKS, it is concluded that it is also a valid method for measuring tibial torsion. It is recommended that care be taken to ensure accurate placement of the centroid of the markers over the bony landmarks when using the motion capture technique. The absence of comparison to CT, which is the gold standard for measurement of tibial torsion, was a minor limitation of this study. Because the distal reference line for measuring tibial torsion via CT involves the fibular notch of the tibia, but not the medial malleolus,[2] use of the trans-malleolar axis in all four of the techniques described in this study is another area of weakness for determination of true tibial torsion.

Table 1: Descriptive Statistics

Assessment Technique	Range (°)	Mean (°)	Standard Dev. (°)
MKS	20.0	23.3	4.7
TMA	14.0	17.8	3.6
TFA	17.0	17.6	3.8
MC	26.0	19.3	6.7

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Table 2. Results of Post Hoc Tests (asterisks indicate significant differences at $p < 0.05$)

MKS-TMA	MKS-TFA	MKS-MC	TMA-TFA	TMA-MC	TFA-MC
0.000188*	0.000176*	0.871097	0.991780	0.000640*	0.000460*