Review Article

Methods for Measurement of Tibial Torsion

Abdulla Ahmed Eyadah, Maria Kondeva Ivanova
Physical Medicine and Rehabilitation Hospital, Kuwait

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ABSTRACT

No conventional technique for routine assessment of tibial torsion, the twisting of tibia around the longitudinal axis, has yet gained acceptance. Clinical measurements give approximate values only. Methods employing tropometers and other mechanical devices have mainly been used for measurement in skeletal specimens and in patients, though on a limited scale. Certain roentgenographic methods are considered complicated, whereas others require trigonometric calculations on the roentgenograms. With the development of the whole body computed tomography (CT) where distinct cross-sectional images can be obtained, reference points are easy to be determined, which make it possible to accurately measure this torsional deformity. Considering the demands for availability, simplicity, and precision, fluoroscopic techniques have been developed.

KEYWORDS: computer tomography (CT), fluoroscopy, measurement, Tibial torsion

INTRODUCTION

Varus, valgus and other axial deformities are well known in osteoarthritis of the knee joint, but the coexistence of torsional deformity is a recent addition to our knowledge. In clinical practice, adduction of the foot in a patient standing with the patella facing directly forward results from torsional deformity and is generally called internal tibial torsion.

Torsional abnormalities are considered by some authors to be a possible cause or result of gonarthrosis[1-5]. In the opinion of some authors, torsional deformities must be corrected at the same time as axial deformities[2]. The importance of understanding and evaluating rotational alignment of the lower extremity in connection with surgical planning of the arthritic knee has been emphasized[2,6-9]. Consequently, it is important to the understanding of the pathogenesis of osteoarthritis of the knee, as well as for compound treatment of it, whether torsional deformity is present and to measure it. Torsional deformities of the tibia have been reported to be associated also with club foot[10], patello-femoral instability[11,12], and Osgood–Schlatter's disease[1].

Tibial torsion can be defined as a physiologic twist of the distal versus the proximal articular axis of the tibial bone in the transverse plane. The definition of tibial torsion put forward by Le Damany[13] was based on studies in cadavers. Since then, various clinical, arthropometric and radiological methods have been used to determine tibial torsion. Depending on which points of reference are chosen at the proximal and distal end of tibia, the recorded values for tibial torsion in the different studies will vary and are not directly comparable (Table 1).

Mechanical Methods

On necropsy specimens, tibial torsion may be measured using anthropometry. The angle between a pin passed through the condylar axis of the head of the tibia and another one through the distal surface of the tibia is measured. This is the most accurate technique but the disadvantage is that this method cannot be used clinically. In 1909, Le Damany[13] reported that the mean lateral tibial torsion measured by anthropometry using Broca's instrument was 23.7 degrees. Other studies[14-18] have reported clinical values employing instruments similar to the anthropometer. They used the patella or tibial tuberosity and the malleoli as reference points. Difficulty in centering the instrument on the mobile patella or the tibial tubercle decreases the accuracy of these methods. Therefore, methods employing tropometers or other mechanical devices have been used mostly for measurements in specimens and in patients, though on a limited scale.

CLINICAL METHODS

A simple clinical method is to have the patient sit with the legs hanging over the edge of the

Address correspondence to:
Dr. Maria Kondeva Ivanova, P.O. Box 31282, 90803 Sulaibikhat, Kuwait. Tel.: 965-488-9441 - Email: monika@ncc.moc.kw

examination table. The angle formed by the second metatarsal ray and the tibial tuberosity gives the tibial rotation. A similar method is to measure the angle formed by the transmalleolar axis and the edge of the table.

In children, another method is to turn the plantigrade foot into maximal medial and lateral rotations. The tibial torsion is approximately equal to the mean of the two angles. A generally accepted view is that a slight or moderate torsion can not be estimated clinically. Results from the studies indicated that the clinician should expect an error of 1˚ to 4˚ as being routine for goniometry in normals. A change of greater magnitude is necessary to denote a difference other than by measurement error alone[17,19-22]. The clinical methods for measurement of tibial torsion are based on the assumption that the proximal tibial tilt invariably is 0˚, an assumption that is not really valid[23].

Roentgenographic methods

The conventional radiologic methods have not gained general acceptance. Several approximate pseudoaxal radiologic methods are on record[24,25]. Rosen and Sandick[25] described a rather elaborate radiological technique for measuring tibial torsion. They introduced the concept of measuring tibiofibular as opposed to isolated tibial torsion; the implication being that the alignment of the ankle joint is determined by the relationship of the thalus to the complete ankle mortise. There is a general agreement that all clinical and radiological methods for measuring tibial torsion allow only an approximation, which ranges up to 15˚ from the true value. For this reason, a technique using computerized transverse tomography (CT) for measuring torsion of long bones has been developed with the goal of achieving the same accuracy as the direct measurements in necropsy specimens. This method is based on computerized transverse tomograms of the proximal and juxta–articular areas. The angle defined by the two transverse axes gives the tibial torsion (Fig. 1,2)

Several methods of measurements have been described using different anatomical landmarks to define the transverse axis and, consequently, a great variation on the values has been obtained[2,26-29]. The current "golden standard" technique[27] is solely dependent on tibial landmarks and, therefore, measures true tibial rather than tibiofibular torsion. Jacob et al.,[26] as well as Yagi and Sasaki[2] determined the proximal reference line by the transverse line of the tibia, whereas Jend et al.,[27] used the dorsal aspect of tibia. Distally, Jacob et al.,[26] used the transverse axis of tibia as a reference line, whereas Jend, et al.,[27] and Yagi and Sasaki[2]

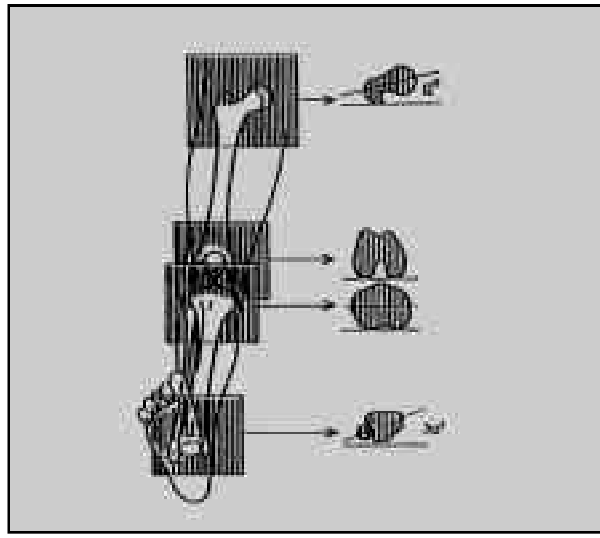

Fig. 1: Torsion in long bones is measured by the angle between the transverse axes determined in CT cuts of the proximal and distal juxta-articular areas.

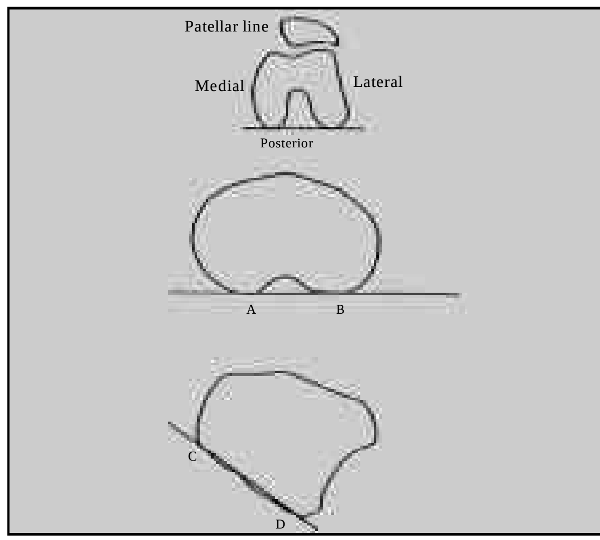

Fig. 2: Proximal and distal axes for measurement of tibial.

used the transmalleolar axis. These authors reported average values of external tibial torsion that varied from 24˚ to 40˚. Such inconsistent results agree with the observation of Laasonen et al., and Reikeras[28], who state that it is difficult to obtain precise reference lines on CT scans on the tibia, either proximally and distally, because of its rounded form. Therefore some authors recommended the dorsal tangent to the femoral condyles as the proximal reference line for measurement of torsional alignment of the leg[28,29].

Errors in CT assessment can be generated from ankle joint instability when methods involving fibula are used to determine the distal reference line[27,31]. The ligamentous fixation of the fibula to the tibia provides some movements of the lower fibula in the transverse plane and around its longitudinal axis[30]. In the case of tibial fractures, the adjacent fibula is often displaced. By

Table 1
Studies of Tibial Torsion

Authors	Year	Method	Results (°)
Le Damany[13]	1909	Mechanical	α(R)= 25; α (L) = 22
Elftman[14]	1945	Mechanical	α(R)= 22; α (L) = 18
Hutter and Scott[15]	1949	Mechanical	α= 27.4; SD = 7.4
Dupuis[16]	1951	Mechanical	-7 < α< 47
Staheli & Engel[17]	1972	Mechanical	α(R)= 11; α (L) = 10
Jacob et al[26]	1980	CT	α=30
Elgeti et al[29]	1980	CT	α=28.8; SD = 6.7
Turner & Smillie[1]	1981	Mechanical	15 < α < 25
Jend et al[27]	1981	Mechanical	25 < α < 55
Larsson et al[31]	1983	Roentgeno-graphic	α (R) = 23.5; α (L) = 23.1
Clementz[33]	1989	Roentgeno-graphic	α (R) = 30.7; SD = 7.8 α (L) = 28.6; SD = 7.6

α - mean value of tibial torsion angle
L – left tibia; R – right tibia
SD – standard deviation

exclusively using the medial malleolus for determination of the distal line of reference, this source of error is excluded.

A serious disadvantage of CT scanning is the disturbance of the image caused by implants and external fixation devices, especially at the level of the ankle joint. Also, to be evaluated with CT, the patient has to be moved to the scanner. The method is not suitable when dealing with acute fractures and cannot be used in the operating room.

Fluoroscopic techniques

A CT scanner is an expensive piece of special equipment that is not universally available where fractures are treated. Considering the demands for availability, simplicity and applicability, fluoroscopic techniques have been developed, using the mobile C-arm fluoroscope equipped with a protractor[32,33].

After fracture reduction and stabilization by a mechanical method of fixation or by a conservative method with a plaster cast, the rotational situation of the tibia can be determined before the patient leaves the operating room.

A stable knee joint is a prerequisite for the fluoroscopic methods. Combined injuries, e.g., tibial fractures with injuries to the knee ligaments of the same leg, are not common. When they do occur, CT scan described by Jend et al.,[27] is probably the most reliable method for determining tibial torsion or rotational deformity, provided the patient does not have advanced osteoarthritis of the knee or ankle joint and that there are no displaced fractures through the articular surfaces of tibia.

Conclusion

Clinical methods used for measurement of tibial torsion are based on clinical identification of bone structures and determination of points of reference leads to approximations and unsatisfactory reproducibility. CT scan has become the preferable technique enabling accurate determination of transverse axes for measurement of tibial torsion.

Techniques using C-arm fluoroscope meet the requirements of routine measurement of tibial torsion and control of rotational deformity when dealing with acute fractures in the operating room.

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