308. Dynamic photoplantography examination for tibial torsion measurement

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Abstract. In our work we used glass pedograph with digital camera under pedograph, computer and ultrasonograph. For tibial torsion measurement a patient was standing on the glass pedograph. A luminodiods was settled directly under tips of malleoli. Ankle joint axis passes through tips of malleoli and it was distal reference line. Rectangular ultrasound scanner probe was placed in parallel with posterior margin of the proximal articular surface of the tibia, it was proximal reference line. To avoid optic distortion we placed crus axis in line with optical system axis. Photoplantogramm was captured and estimated. We estimated angle between two reference lines (direct method of tibial torsion measurement). We measured tibial torsion with our method and MRI (5 patients, 10 legs). Tibial torsion measurement by MRI was performed by Schneider method (1997). Mean value of tibial torsion was 29^0 (our method) and 40^0 (Schneider method). Pearson correlation coefficient was 0.9. Dynamic photoplantography is cheap, informative, easy method in early pathology revelation. It can be used as screening method among large collectives. Functional photoplantograms help us to estimate foot arch function. Treatment control is very easy to perform with dynamic photoplantography.

Keywords: footprint, pedograph, tibial torsion, dynamic photoplantography

Introduction

At present time there is a steady increase of orthopedic pathology and pathology of lower extremities in particular. Determination of tibial torsion is important element for lower extremities deformities estimation. Tibial torsion measured as transverse plane angle between knee and ankle joint axises. The three-dimensional arrangement of lover leg joints axes influences biomechanics of walking [1,2]. Pathologic tibial torsion leads to excessive external or internal rotation of foot axis during walking, reduce walking speed, increase power expenditures, causes the second deformations of foot skeleton. Excessive torsion of crus bones can be primary or secondary deformities (caused by changes of foot skeleton). Estimation of tibial torsion is important for treatment tactic planning.

Photoplantography relates to the objective methods of foot pathology diagnostics [4,5,7]. Dynamic photoplantography examination introduced in our clinic makes it possible to quickly and effectively evaluate foot development and dynamics of arch flattening, to create data bank, to control the treatment process.

Materials and methods

Our research was performed at schools and at the child orthopedic department. The glass pedograph equipped with a digital camera under it and a computer was used. Three photoplantograms of each foot were captured and analyzed. Footprints were captured in sitting position (foot pressure is minimum), standing position, standing separately on the right and on the left foot (foot pressure is maximum similarly to the midstance of gate cycle). Ankle joint is in neutral position; knee joint is directly over the midfoot (Fig. 1). Foot indices were studied in dynamic under increasing foot pressure (in sitting and standing position). The next foot indices were studied: foot length and width, length/width ratio, transverse arch function (foot width in sitting/standing position ratio), longitudinal arch flattens under weightbearing (longitudinal arch index in dynamic), foot length/body height ratio, and arch index. This method made it possible to estimate subtalar complex torsion and tibial torsion.

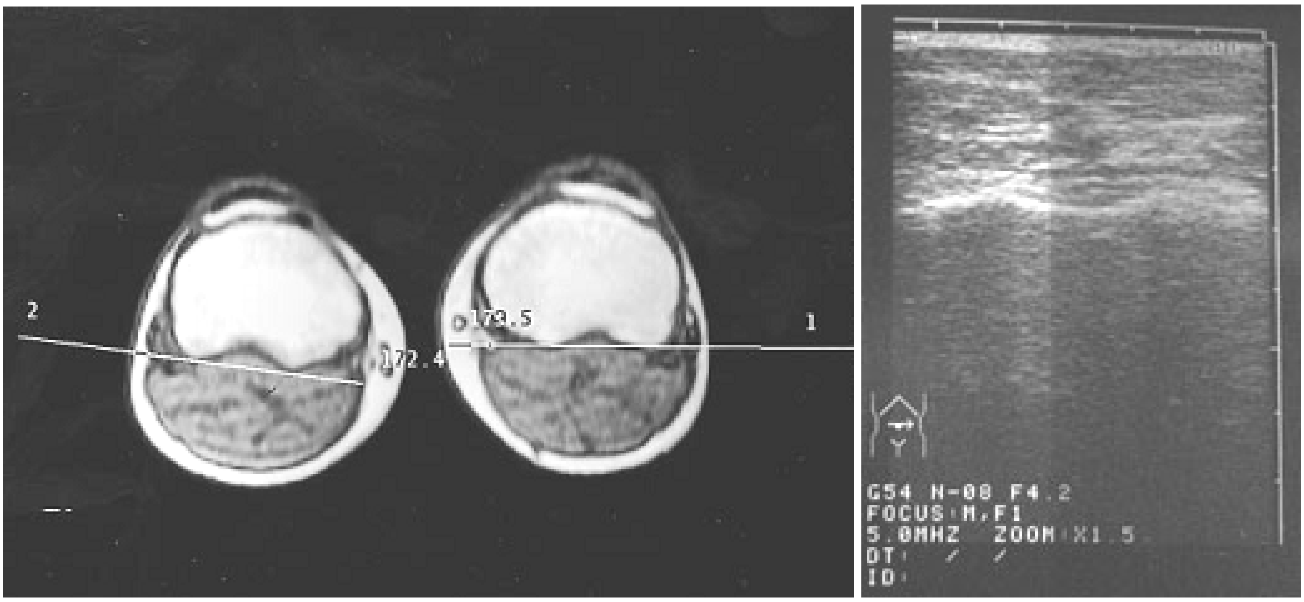
a b c d

Fig. 1. Dynamic photoplantography examination:
a - sitting position; b - standing position; c- standing separately on the right foot; d - standing separately on the left foot

For tibial torsion measurement we placed patient crus (standing position) over glass plantograph in line with the optical axis of camera object-glass. To perform torsion measurement we have to determine position of proximal (knee joint axis) and distal reference lines (ankle joint axis) and to measure angle between lines. Ankle joint axis passes between tips of malleoli and this fact is well known. To determine distal reference line we settled luminodiodes under tips of malleoli (which indicates the position of ankle joint axis in the horizontal plane). Eyadah [3] proved that Computer Tomography (CT) and Magnetic Resonance Imaging (MRI) methods for torsion measurement are most objective and accurate. Eyadah determines proximal reference line as tangent to the rear surface of proximal tibia epiphysis (fig. 2a.). To determine same line we placed ultrasound scanner probe (in rectangular shape) in popliteal fossa at the level of the tibia condyles. We placed probe in parallel with tangent to the rear surface of proximal tibia epiphysis (fig. 2b.).

The photoplantogramma carried out then probe placed as described above. On the photoplantogramma the position of probe and luminodiodes are evident.

We drew ***line a*** (fig. 3) along probe side. ***Line b*** is perpendicular to the ***line a***, and is parallel to the working surface of probe, which is parallel to rear surface of proximal tibia epiphysis. Through the position of luminodiodes a line AB was drawn (which corresponds to the axis of ankle joint). The angle between line b and line AB was measured. The obtained value of the angle is the value of tibial torsion. Photoplantogramma was analysed with aid of the computer.



a b

Fig. 2. Proximal reference line determination by CT (a) and photoplantography (2b) methods

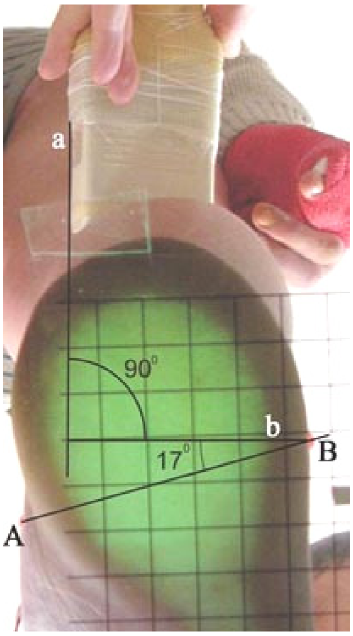


Fig. 3. Tibial torsion measurement: line **a** – along probe side; line **b** – perpendicular to line **a**; line AB – ankle joint axis (point A and B - luminodiodes)

Results

Torsion of the bones of crus was evaluated according to proposed method. For establishing the correlation between the proposed method and MRI we inspected 5 adolescents (10 legs) by two methods (tab. 1).

Table 1.

Patient	Side	Photoplantography	MRI	Difference
1.	Right	34^0	47^0	13^0
	Left	36^0	45^0	9^0
2.	Right	27^0	37^0	10^0
	Left	23^0	34^0	11^0
3.	Right	24^0	37^0	13^0
	Left	30^0	43^0	13^0
4.	Right	29^0	41^0	12^0
	Left	23^0	35^0	12^0
5.	Right	31^0	41^0	10^0
	Left	29^0	40^0	11^0

Mean difference between two methods was to 11^0 less than the result of torsion measuring by MRI method. Since proximal line for torsion measurement by two methods are determined similarly, then the difference in the results of a study is due to differences in the methods of distal line drawing. As can be seen from figure 4, distal line passes in front of the base of internal malleolus with the measurement by the MRI method, which increases measurement result.

Distal reference line determination with a fotoplantography examination is determined more accurate and easy. The Pearson correlation coefficient between the results of measurement by two methods is equal to their 0.95, which mean strong interrelation.

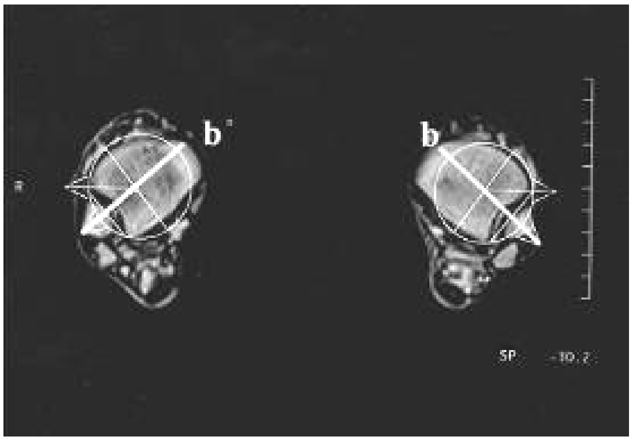


Fig. 4. Distal reference line determination for MRI measurement method (line b)

Discussion

Usually torsion measurement of tibial bones was carried out by clinical methods and by objective methods (special devices, roentgenologically, CT, MRI). According to the Eyadah data significant differences exists in the torsion estimation, which depend on the method of measurement (tab. 2) [3].

Table 2.

Author	Year	Method	Result
Le Damany	1909	Mechanical	α(R)= 25; α(L) = 22
Elftman	1945	Mechanical	α(R)= 22; α(L) = 18
Hutter and Scott	1949	Mechanical	α= 27.4; SD = 7.4
Dupuis	1951	Mechanical	-7 < α< 47
Staheli & Engel	1972	Mechanical	α(R)= 11; α(L) = 10
Jacob et al.	1980	CT	α=30
Elgeti et al.	1980	CT	α=28.8; SD = 6.7
Turner & Smillie	1981	Mechanical	15 < α< 25
Jend et al.	1981	Mechanical	25 < α< 55
Larsson et al.	1983	Rtg	α(R) = 23.5; α(L) = 23.1
Clementz	1989	Rtg	α(R) = 30.7; SD = 7.8 α(L) = 28.6; SD = 7.6

Torsion measurement with clinical methods is based on the assumption that with the 90^0 of knee flexion, the axis of knee joint is located in the frontal plane. CT and MRI methods proved the inaccuracy of this assumption [3,6]. Clinical methods of torsion measurement are considered indirect, and CT and MRI methods are direct methods of measurement.

CT and MRI methods demand to keep fixed position during 20 minutes, which is difficult for the children, the especially for youngest one. CT method bring significant X-ray radiation dose for the patient. The high cost of this methods and the overloading of equipment considerably limits the application of CT and MRI methods for torsion measurement. Objective and dynamic observation of tibial torsion improvement is difficult, especially in preschool child without introduced method.

Conclusion

Proposed method makes it possible to directly measure tibial torsion. It possesses high informativeness. It makes it possible to objectify dynamic observation of revealed deformity. Introduced method does not require application of the expensive medical equipment and the time of the investigation is shortened.

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