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Special Article

Study of the radiographic parameters of normal ankles: literature review and technical recommendations

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Abstract

Objective: The authors carried out a bibliographic search for the radiographic parameters used to determine tibiotalar joint alignment, and suggest a set of parameters that constitute the minimum radiographic evaluation sufficient for the proper assessment of tibiotalar alignment.

Methods: The search was conducted between May 2019 and January 2020 on the online platforms PudMed and Google Scholar with the following terms, used separately or jointly: "ankle arthritis, radiographic measurement, ankle alignment, alignment, anterior ankle instability, X-ray, and ankle injury".

Results: We selected twelve studies evaluating radiographic patterns of normal ankles, and identified a total of 15 radiographic measurements.

Conclusion: The authors believe that a minimum radiographic assessment of tibiotalar alignment should include the following parameters on the anteroposterior radiograph: the distal tibial articular angle, the talar tilt and talus center migration. On the lateral radiograph, it should include: lateral distal tibial angle and lateral talar station.

Level of Evidence V; Diagnostic Study; Expert Opinion.

Keywords: Ankle; Ankle joint; X-rays; Radiography; Arthritis.

Introduction

Joint degeneration is a condition that is detrimental to the quality of life and functionality of affected patients[1]. Among the lower limb joints, knee and hip ailments are well known and widely discussed in the literature. In contrast, ankle arthrosis, which corresponds to 6 to 13% of arthrosic processes, is studied infrequently, despite being just as limiting as knee and hip ailments, if not more so[2,3].

Ankle arthrosis can be primary or secondary. Primary or idiopathic causes are rare, and generally affect subjects over 40 years of age[4]. Secondary causes are more common and include post-traumatic conditions, dysplasia, inflammatory conditions, infections and hemophilia, yet trauma is the main cause of ankle arthrosis and is related to 70% of cases[1,4].

The treatment of ankle arthrosis includes conservative measures (drug and orthotic treatment), orthobiologic resources[5] and surgical procedures (joint debridement, arthrodiastases, supramalleolar osteotomies, en bloc autologous cartilage transplantation, total arthroplasty and ankle arthrodesis)[6-12]. Surgical treatment prognosis depends, among other factors, on the degree of joint damage, patient characteristics, and tibiotalar joint realignment[6]. In order to make the joint more closely resemble the anatomy of a normal ankle, the definition of radiographic parameters of normality is extremely important.

Study performed at the Hospital Israelita Albert Einstein, São Paulo, SP, Brazil.

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Ankle joint alignment parameters are based on clinical and radiographic aspects. Clinical evaluation detects ectoscopic changes in the long axis of the lower limb as a whole, allows the assessment of hindfoot positioning (varus or valgus) relative to the leg (normal calcaneal alignment with the leg rotates around 10° of valgus)[13], and allows the determination of the degree of joint mobility and possible dynamic misalignments.

The main limitation of clinical evaluation is its inability to accurately define the specific characteristics of bone deformities and classify joint misalignments, and even to define exactly which joint or joints participate in the deformity complex.

Radiographic goniometry is extremely important in the assessment of ankle deformities due to its precision in determining the angles that express the relationship between the distal tibia and the talus, besides changes in the actual distal articular surface of the tibia[6,7,13].

There are plenty of parameters for assessing tibiotalar joint alignment described in the literature, yet they are seldom used in clinical practice. The association between the use of these radiographic parameters in surgical corrections and good patient prognosis has already been demonstrated in the literature[8-10].

After a bibliographic search to collect the parameters of radiographic goniometry relative to normal ankles, the authors suggest the standardization and use of a minimum protocol of parameters, aimed at improving surgical outcomes in patients with ankle deformities.

The parameters used for the assessment of ankle alignment are based on upright anteroposterior and lateral radiographs, in which anatomical points are used as a reference to define lines and axes from which angles or distances will be measured[6,7].

Methods

This study was approved by the Institutional Review Board and registered on the Plataforma Brazil database under CAAE (Ethics Evaluation Submission Certificate) number: 18371319.0.0000.0071.

The authors carried out a bibliographic search of the radiographic parameters used to determine tibiotalar joint alignment. The study was conducted in a single department.

The search was conducted between May 2019 and January 2020 on the online platforms PudMed and Google Scholar with the following terms, used separately or jointly: "ankle arthritis, radiographic measurement, ankle alignment, alignment, anterior ankle instability, X-ray, and ankle injury".

The parameters mentioned in the literature for radiographic assessment of ankle alignment are:

1. Anteroposterior and/or internal oblique (mortise) views:

- Tibial articular angle[7];
- Angle between the medial malleolus and the long axis of the tibia[7];
- Talar tilt, Tibiotalar angle or Convergence angle of tibia and talus[7,13,14];
- Medial distal tibial angle[8, 14,15];
- Lateral distal tibial angle[14,16];
- Talocrural angle[14];
- Talus center migration[8].

2. Lateral View:

- Lateral distal tibial angle, anteroposterior distal tibial angle or Anterior distal tibial angle[7,8,14,16];
- Lateral talar station[11];
- Talar center of rotation relative to the anatomical axis of the tibia (TibCOR)[17];
- Angle between the long axis of the tibia and talus[11,14];
- Angle between posterior tibial line and the talus[11];
- Angle between the long axis of the tibia and the lateral process of the talus[11].

3. Saltzman View:

- Distance between the tibia and the calcaneus[13];
- Tibiocalcaneal angle[13];
- Line of convergence between the tibia and the talus[13];

Based on the ease of the measurements, the authors suggest a set of parameters that constitute the minimum radiographic evaluation sufficient for the proper assessment of tibiotalar alignment.

The recommendation was based on a study of parameters of normality of tibiotalar alignment, assessing 156 radiographic images of normal ankles, the subject of another study that will be published soon.

Results

We selected 12 studies assessing radiographic patterns of normal ankles, and identified a total of 15 possible radiographic measurements[6-17].

Discussion

Anteroposterior and lateral radiographs should be taken in compliance with the appropriate criteria for patient positioning, alignment of X-ray equipment, and film positioning, in order to conduct tests with ideal quality, without which the measurement becomes inefficient[15].

The authors indicate the following parameters as the ideal radiographic evaluation for determining tibiotalar alignment:

- In the anteroposterior view, the distal tibial articular angle, the talar tilt, and the talus center migration.

The long axis of the distal tibia in the anteroposterior view can be determined from the center of a circle that touches the medial and lateral cortices 10 cm proximal to the ankle joint, and the center of a second circle tangent to the 3 cortices of the distal tibial metaphysis, as shown by Ahn[8]. The line connecting both centers is the long axis of the tibia in the

anteroposterior view. We chose to evaluate the long axis of the distal tibia using this technique due to the better reproducibility and greater ease of execution.

The medial distal tibial articular angle in the coronal plane is determined by the measurement between the long axis of the tibia and the straight-line tangent to the distal tibial articular surface (Figure 1)[9]. The angle considered is medial to the long axis of the tibia[8,9].

This angle allows the assessment of the presence of medial or lateral tilt of the distal tibia and, when suggesting mechanical overload, can negatively influence the prognosis of surgical procedures[8,9].

The talar tilt angle is determined by the measurement between the straight line that touches the distal articular surface of the tibia, and another that touches the dorsal articular surface of the talus in the coronal plane (Figure 2)[9].

This parameter allows an adequate assessment of the presence of medial and lateral ankle instability in the arthrosic process[7], a situation that must be properly corrected.

Talus center migration is defined as the shortest distance between the center of the talus and the long axis of the tibia (Figure 3)[8,10]. Medial displacements are considered positive and lateral displacements negative[8].

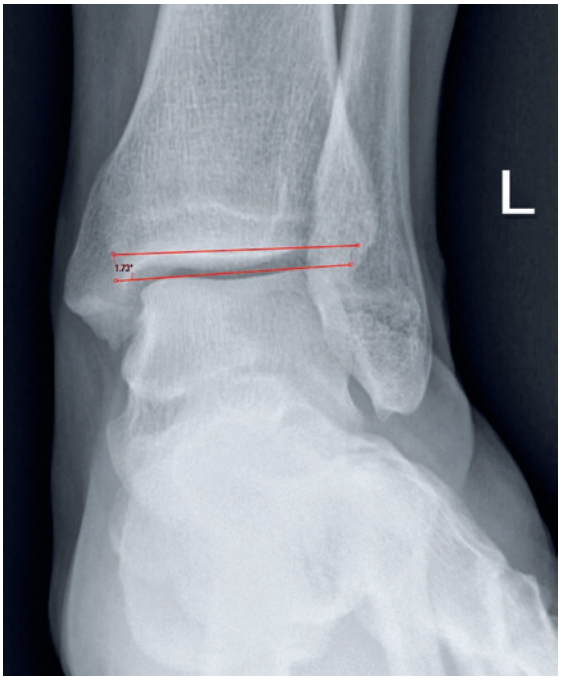

Figure 2. Talar tilt.

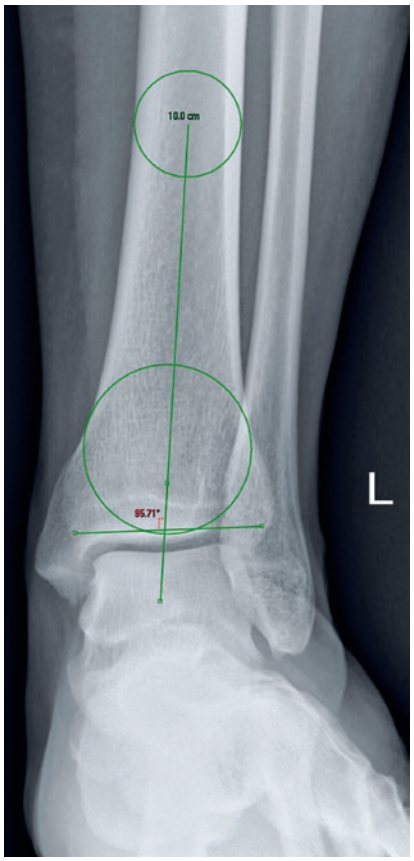

Figure 1. Distal tibial articular angle.

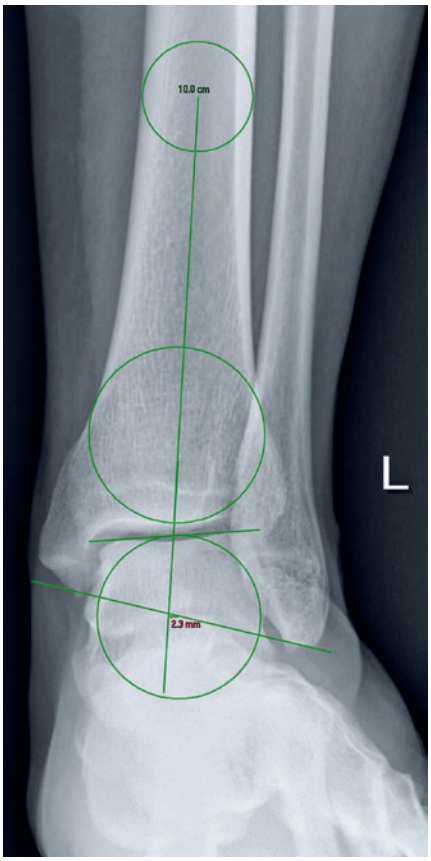

Figure 3. Talus center migration.

This measurement allows us to assess the presence of medial or lateral displacement of the talus within the malleolar pincer, usually associated with deviations secondary to fractures, or the presence of major ankle instabilities.

The center of the talus in the anteroposterior view corresponds to the center of a circle that touches the midpoint of the talar dome (which in the anteroposterior view is seen as a plateau), and at the same time coincides with one of the points that make up the straight line that touches both tibial and fibular malleoli from below[8,10].

- In lateral radiographs, the lateral distal tibial articular angle and the lateral talar station[11].

The long axis of the tibia in the lateral view can be determined by joining the center of a circle adjusted to the anterior and posterior tibial cortices, located 10cm above the ankle joint, and the center of a second circle, also adjusted to the anterior and posterior tibial cortices, 5cm above the ankle joint[11].

The lateral distal tibial articular angle is formed between the long axis of the tibia and the articular surface of the distal tibia[7], which is determined by a line tangent to the articular surface in the lateral view (Figure 4).

This angle allows us to assess the presence of anterior or posterior deviations of the distal tibia joint related to vicious fracture consolidations, post-fracture sinking of articular surfaces, or the presence of a more severe degenerative disease.

The lateral talar station is defined as the distance measured perpendicularly between the line of the long axis of the tibia and the center of rotation of the talus. The center of rotation is defined as the center of a circle adjusted to the talar dome (Figure 5)[11]. Anterior displacements to the long axis of the tibia are considered positive values, while posterior displacements are deemed negative[11].

This distance is useful in the assessment of anterior or posterior talar displacements within the malleolar pincer.

Conclusion

The authors believe that a minimum radiographic evaluation of tibiotalar alignment should include the following parameters:

- In anteroposterior radiography: distal tibial articular angle, talar tilt and talus center migration;
- In lateral radiography: lateral distal tibial articular angle and lateral talar station.

Figure 4. Lateral distal tibial articular angle.

Figure 5. Lateral talar station.

Authors' contributions: Each author contributed individually and significantly to the development of this article: PCB *(https://orcid.org/0000-0002-4209-0564) wrote the article, interpreted the results of the study; CASN *(https://orcid.org/0000-0002-9286-1750) conceived and planned the activities that led to the study, participated in the review process, approved the final version; ALGS *(https://orcid.org/0000-0002-6672-1869) conceived and planned the activities that led to the study, participated in the review process, approved the final version; JFMA *(https://orcid.org/0000-0002-7664-2064) conceived and planned the activities that led to the study, participated in the review process, approved the final version; MPP *(https://orcid.org/0000-0003-0325-8050) wrote the article, interpreted the results of the study. *ORCID (Open Researcher and Contributor ID).

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