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Normal Foot and Ankle Radiographic Angles, Measurements, and Reference Points

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ABSTRACT

The limb deformity-based principles originate from a standard set of lower extremity radiographic angles and reference points. Objective radiographic measures are the building blocks for surgical planning. Critical preoperative planning and intraoperative and postoperative evaluation of radiographs are essential for proper deformity planning and correction of all foot and ankle cases. A total of 33 angles and reference points were measured on 24 healthy feet. The radiographic measurements were performed on standard weightbearing anteroposterior, lateral, and axial views of the right foot. A total of 4 measurements were made from the axial view, 12 from the lateral view, and 17 from the anteroposterior view. All angles were measured by both senior authors twice, independent of each other. The radiographic angles and measurements presented in the present study demonstrate a comprehensive and useful set of standard angles, measures, and reference points that can be used in clinical and perioperative evaluation of the foot and ankle. The standard radiographic measures presented in the present study provide the foundation for understanding the osseous foot and ankle position in a normal population.

Limb deformity principles are the basic building blocks for surgical planning. These principles provide accurate reference points for producing predictable surgical results (1,2). The geometrically based principles originate from a standard set of radiographic angles and reference points (3). Proper foot and ankle deformity correction requires extensive surgical experience and consideration of the many factors that affect realignment. Foot and ankle deformities are evaluated in an objective manner with static radiographic measures. Critical preoperative planning and intraoperative evaluation of radiographs are essential for successful foot and ankle deformity correction.

Several investigators have defined normal foot and ankle radiographic angles, with various limitations (4–7). Fuson and Smith (4) reported a radiographic analysis of the angular relationships of the foot; however, they only analyzed lateral radiographs. They reviewed a total of 84 radiographs obtained from their radiology department. Radiographs were not reviewed and included in their analysis if an obvious osseous deformity were present. Also, their study did not comment on the indication for the radiograph or on any type of examination of the patients (4).

Steel et al (5) reported various radiographic angles and measurements in adult female feet to demonstrate the wide variation in bony relationships. Axial measurements were not investigated in their study. Their study was limited because all the participants were female and aged 40 to 60 years. Also, the participants were initially included only on the basis of being symptom free but not necessarily anatomically normal. Steel et al (5) justified using patients in this age group by suggesting that the anatomic relationships had withstood the stress of time while remaining symptom free.

Bryant et al (6) used normal radiographic measurements to compare normal, hallux valgus, and hallux limitus feet. Although the goal of their study was not to produce standard normal values, the data from 30 normal subjects were analyzed and reported. They only analyzed the data from anteroposterior (AP) and lateral radiographs and performed 13 measurements (6). The investigators quantified the intraobserver reliability and reported good or very good

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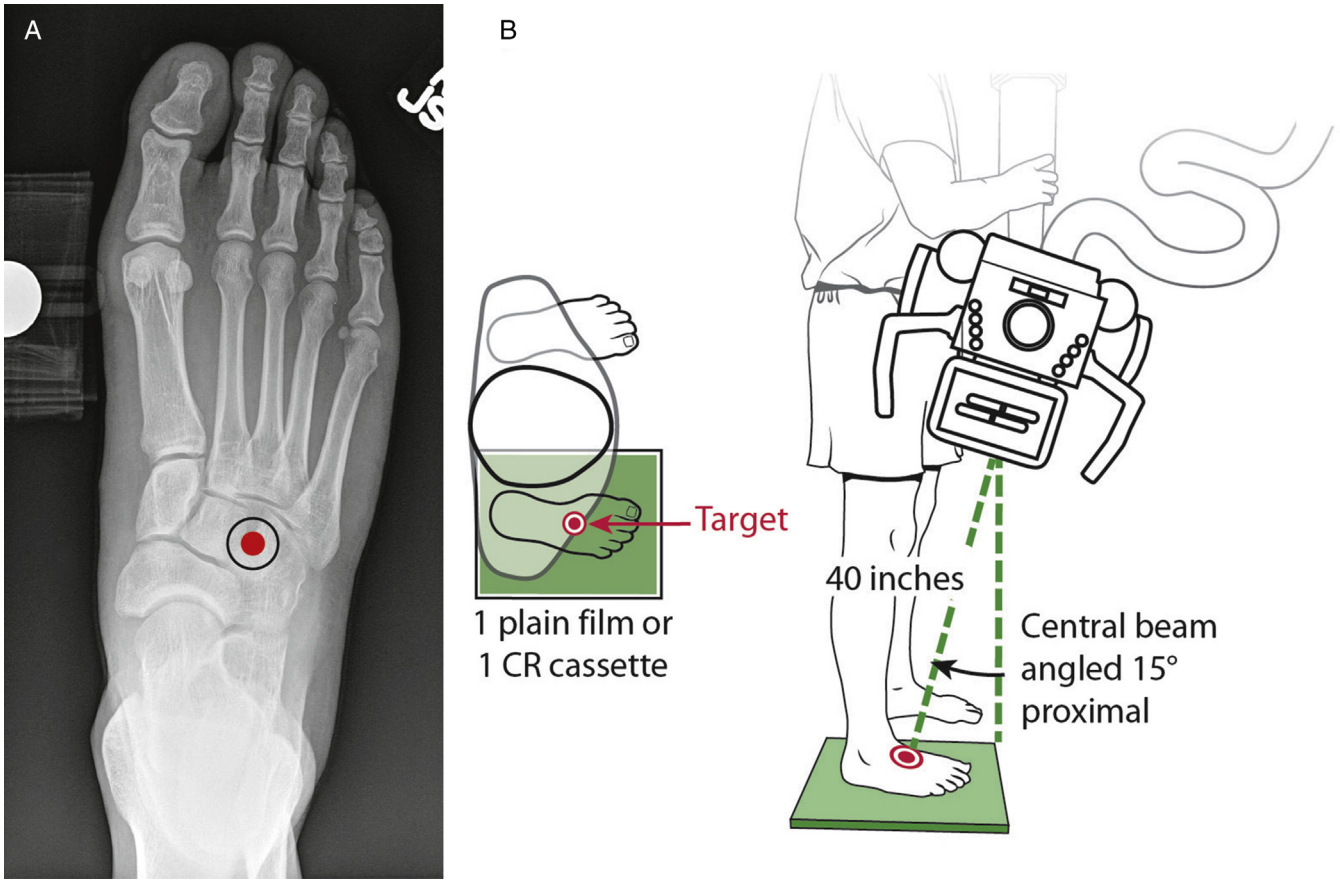

Fig. 1. (*A*) Well-positioned anteroposterior view foot radiograph. The red circle marks the third cuneiform and shows where the central beam should be aimed. (*B*) The cassette is placed on the floor. The patient stands and places their foot on the center of the cassette. The knee should be fully extended. The red circle marks the third cuneiform and shows where the central beam should be aimed. The central beam should be angled 15° proximally. CR, computed radiography. Copyright 2016, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore.

correlations for their data; however, the interobserver reliability could not be determined because 1 physician performed all the measurements (6).

Thomas et al (7) measured the standard radiographic angles of 100 participants (50 males and 50 females) in a healthy patient population with a wide age range (19 to 76 years). They obtained mean radiographic measurements in the adult foot and assessed novel measuring techniques in both right and left feet. The patients were included only on the basis of their medical history without a medical examination. The limitation in their study compared with the radiographic parameters used in our study was the absence of axial radiographs and standard nomenclature (7).

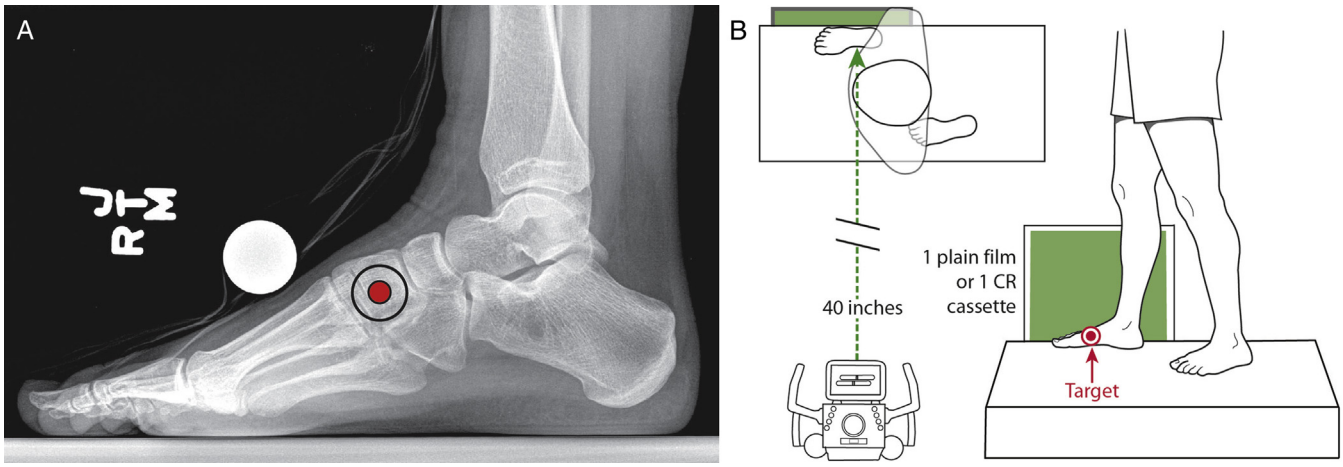

Fig. 2. (*A*) Well-positioned lateral view foot radiograph. The red circle marks the third cuneiform and shows where the central beam should be aimed. (*B*) The central beam is perpendicular to the cassette. While the patient is weightbearing, the lateral aspect of the foot is positioned against the cassette. Note the neutral positioning of the ankle and that the patient has taken a small step backwards with the contralateral foot. The red circle marks the third cuneiform and shows where the central beam should be aimed. CR, computed radiography. Copyright 2016, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore.