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A New Technique to Increase Reliability in Measuring the Axis of Bone

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ABSTRACT

Measuring bone angles is an important method for diagnosing disease and predicting the prognosis in orthopedics. Traditionally, the angle is measured using lines drawn manually and adjusted by the naked eye. The purpose of the present study was to propose new methods to measure the bone angles formed by the axes of the calcaneus with good reliability and low operational error. The 2 new methods used linear regression analysis of the points inside and on the "envelope" line. The traditional method used the vector of the lines drawn for calculation. Digital radiographs of the lateral view of the feet from 51 patients were collected, and the angles were measured using these 3 methods. Next, we analyzed the reliability, differences, and correlations of these 3 methods. The intra- and interobserver comparisons revealed significant differences between the results of the 2 new methods and those of the traditional method. In addition, the new methods had greater reliability and better intra- and interobserver correlations than did the traditional method. We suggest that these 2 new methods to measure bone axis should be added to the Picture Archiving and Communication System to obtain more reliable and standardized data in clinical practice and for future research purposes.

Measuring the bone angle is an important method to determine the severity of bone disease and predict the prognosis in orthopedics. The bone angle is conventionally measured by surgeons drawing 2 lines on the radiograph. The radiograph can be either on plain film or, more recently, on the Picture Archiving and Communication System (PACS® imaging software; McKesson Radiology, San Francisco, CA). Usually, surgeons draw the lines instinctively rather than scientifically. This practice can introduce operational error. To our knowledge, few studies have reported on the intra- and interobserver reliability of measuring the bone angle (1–6).

Several angles are important in the diagnosis of the cavus foot, such as Hibbs' angle and Meary's angle (7,8). Hibbs' angle is formed by the intersection of 2 lines drawn through the axis of the calcaneus and the first metatarsal bone. Meary's angle is formed by the intersection of 2 lines drawn through the long axis of the talus and first metatarsal bone (Fig. 1) (7). These 2 angles are important to diagnose the cavus foot (7,8). However, the measurements have usually been subjective and are highly operator dependent.

To reduce operational error, an objective measuring method is needed. We hypothesized that, using linear regression analysis, the new methods would be more reliable than the traditional method. The aim of the present study was to develop a scientific method to measure the axis of the bone on plain radiographs and evaluate the reliability of this method. Because the bone axis is so important to provide an accurate diagnosis in orthopedics, we chose the axis of the calcaneal bone, which has an irregular shape, to test the reliability of our measurements.

Materials and Methods

We studied 2 new methods to measure the axis of bone. First, we recorded numerous points at the edge of the bone and linked them together to create an "envelope." The first method uses linear regression analysis of the area inside the envelope, the vector area (Va). The second method uses linear regression analysis of the points of the envelope, the vector envelope (Ve). We used a traditional method, the axis from freehand drawing, the vector axis (Ax), for comparison (Fig. 2). The linear regression analysis used was the least squares approach, which determines the best fitting line by minimizing the sum of squared errors.

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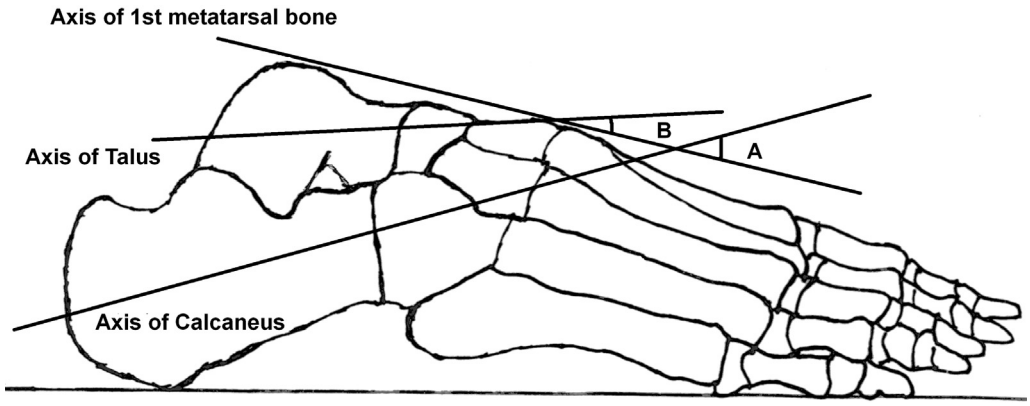

Fig. 1. Angle measurement related to the axis of bone. Hibbs' angle (angle A) is measured using 2 lines drawn through the axis of the calcaneus and first metatarsal bone. Meary's angle (angle B) is measured using 2 lines drawn through the long axis of the talus and first metatarsal bone.

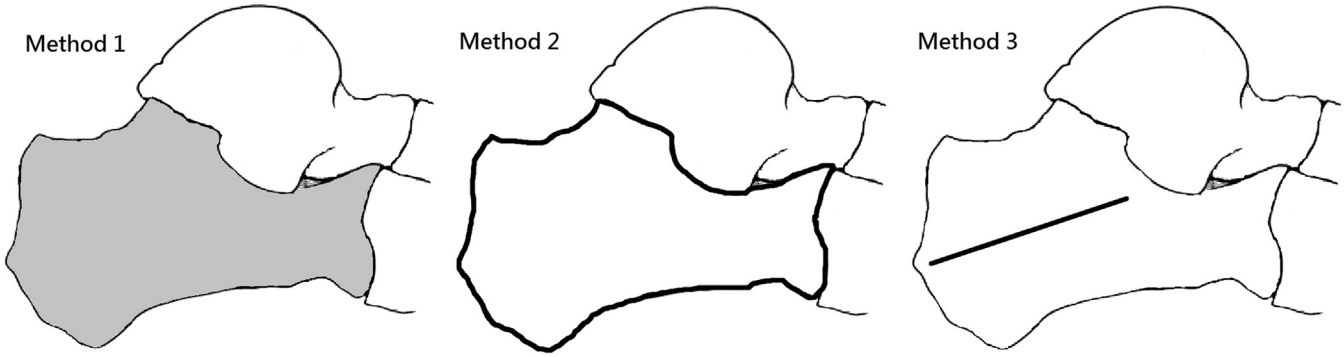

Fig. 2. The 3 methods we used to determine the axis of bone are illustrated. Method 1: vector area. We calculated the vector by integrating the vector of the whole area we had prespecified. Method 2: vector envelope. We calculated the vector by integrating the vector of the envelope of the area we had prespecified. Method 3: vector axis (Ax). The traditional method in which the vector line is drawn using the Picture Archiving and Communication System.

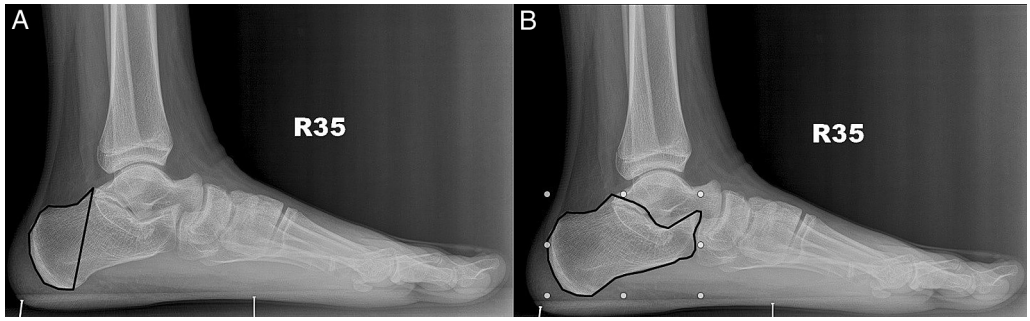

Fig. 3. (*A* and *B*) The use of our software to mark the margin of the calcaneus on lateral plain radiographs of the right foot. We used the mouse to delineate the edge of the whole area of the calcaneus. Next, these pixels were input to Excel for linear regression analysis.