The Journal of Foot & Ankle Surgery 53 (2014) 397–404

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Original Research

Descriptive Quantitative Analysis of Hallux Abductovalgus Transverse Plane Radiographic Parameters

Andrew J. Meyr, DPM, FACFAS [1], Adam Myers, DPM [2], Jane Pontious, DPM, FACFAS [3]

[1] Assistant Professor, Department of Podiatric Surgery, Temple University School of Podiatric Medicine, Philadelphia, PA
[2] Private Practice, Kaiser Permanente Southern California, Redlands, CA
[3] Associate Professor, Department of Podiatric Surgery, Temple University School of Podiatric Medicine, Philadelphia, PA

A R T I C L E I N F O

Level of Clinical Evidence: 5
Keywords:
hallux abductovalgus
hallux abductus angle
intermetatarsal angle
radiographic analysis
tibial sesamoid position

A B S T R A C T

Although the transverse plane radiographic parameters of the first intermetatarsal angle (IMA), hallux abductus angle (HAA), and the metatarsal-sesamoid position (MSP) form the basis of preoperative procedure selection and postoperative surgical evaluation of the hallux abductovalgus deformity, the so-called normal values of these measurements have not been well established. The objectives of the present study were to (1) evaluate the descriptive statistics of the first IMA, HAA, and MSP from a large patient population and (2) to determine an objective basis for defining “normal” versus “abnormal” measurements. Anteroposterior foot radiographs from 373 consecutive patients without a history of previous foot and ankle surgery and/or trauma were evaluated for the measurements of the first IMA, HAA, and MSP. The results revealed a mean measurement of 9.93°, 17.59°, and position 3.63 for the first IMA, HAA, and MSP, respectively. An advanced descriptive analysis demonstrated data characteristics of both parametric and nonparametric distributions. Furthermore, clear differentiations in deformity progression were appreciated when the variables were graphically depicted against each other. This could represent a quantitative basis for defining “normal” versus “abnormal” values. From the results of the present study, we have concluded that these radiographic parameters can be more conservatively reported and analyzed using nonparametric descriptive and comparative statistics within medical studies and that the combination of a first IMA, HAA, and MSP at or greater than approximately 10°, 18°, and position 4, respectively, appears to be an objective “tipping point” in terms of deformity progression and might represent an upper limit of acceptable in terms of surgical deformity correction.

Hallux abductovalgus (HAV) is a structural deformity of the first metatarsophalangeal joint that is most often defined using radiographs in the transverse plane. Although numerous objective parameters can be calculated, measurement of the first intermetatarsal angle (IMA), hallux abductus angle (HAA), and metatarsal sesamoid position (MSP) have formed the basis of preoperative procedure planning and postoperative surgical evaluation.

However, most authoritative sources and texts with respect to the etiology, evaluation, and management of HAV (1–19) either have not cited a specific work for the reported “normal” value of these measurements or have referred to 1 of a small sample of epidemiologic studies of the deformity (20–26). Primary among the latter is the report by Hardy and Clapham (20) in 1951 on the hallux valgus deformity. They reported a mean measurement of the first IMA and HAA of 8.5° and 15.5°, respectively, in 252 control feet and 13.0° and 32.0°, respectively, in 165 feet affected by HAV (20). They also noted that 90% of the control feet had a MSP of position 3 or less, and 88% of experimental feet had a MSP of position 4 or greater. However, that study was not without several significant methodological limitations presented in the “Discussion” section of our report.

The objectives of the present study were to evaluate the descriptive statistics of the first IMA, HAA, and MSP in a large population, and, second, to attempt to determine an objective basis for defining “normal” versus “abnormal” measurements.

Patients and Methods

The radiographs of patients from the Temple University Foot and Ankle Institute were used for the present investigation. Included in the present study were consecutive patients who had undergone radiographic evaluation with at least a weightbearing anteroposterior foot radiograph. Excluded from the present study were any patient with a history of foot and ankle surgery or acute foot and ankle trauma.

Financial Disclosure: None reported.
Conflict of Interest: None reported.
Address correspondence to: Andrew J. Meyr, DPM, FACFAS, Assistant Professor, Department of Podiatric Surgery, Temple University School of Podiatric Medicine, 8th at Race Street, Philadelphia, PA 19107.
E-mail address: ajmeyr@gmail.com (A.J. Meyr).

http://dx.doi.org/10.1053/j.jfas.2013.04.004

Table 1
Descriptive statistics of hallux abductovalgus radiographic parameters

Descriptive Statistical Measure	First IMA (n = 373)	HAA (n = 373)	MSP (n = 373)	Engel's Angle (n = 373)
Mean ± SD	9.93 ± 2.97	17.59 ± 8.87	3.63 ± 1.20	23.90 ± 5.94
95% CI	9.63–10.23	16.69–18.49	3.51–3.75	23.30–24.50
Range	2.60–31.80	0.30–59.10	2.0–7.0	3.7–40.3
Median	9.60	16.40	4.0	24.0
Interquartile range	8.10–11.80	11.5–22.60	3.0–4.0	20.25–27.5
Skewness	1.348	0.772	0.521	−0.186

Abbreviations: HAA, hallux abductus angle; IMA, intermetatarsal angle; MSP, metatarsal sesamoid position; SD, standard deviation.

All radiographs were taken using a standard technique in the angle and base of gait, performed by 1 of 2 radiologic technicians with a combined 50 years of clinical experience (27). The purpose of the angle and base of gait is to radiographically represent the structure of the foot during weightbearing midstance. The angle of gait was defined as the degree of abduction or adduction of the foot from midline during gait, and the base of gait was defined as the distance between both heels during the gait cycle. At our facility, the patient was positioned into the angle and base of gait by the radiology technician after an observation of gait and stance. The radiographic measurements were made by 1 of us (A.M.) using computerized digital software (Opal-RAD PACS, Viztek, Garner, NC), which measured to a precision of 0.1°. Four measurements were recorded from each standard weightbearing anteroposterior radiograph, including the first IMA, HAA, MSP, and Engel's angle (27–31). The anteroposterior radiograph was defined as the film placed in a horizontal position flat on the orthoposer with the tube head angulated 15° from vertical, directed posteriorly, and aimed at the second metatarsocuneiform joint. The first IMA was defined as the angular relationship between the bisectors of the first and second metatarsal shafts. The bisectors were determined by individually identifying the proximal and distal midpoints of the diaphyseal–metaphyseal junctions and then forming a line connecting the 2 points (28–30). The HAA was defined as the angular relationship between the bisectors of the first metatarsal and hallux proximal phalanx shafts (28–30). The MSP was measured on a 7-point scale, as described by Hardy and Clapham (20). Engel's angle was defined as the angular relationship between the bisectors of the second metatarsal shaft and the intermediate cuneiform (31).

After taking the radiographic measurements, the data were stored in a personal computer for subsequent statistical analysis. All statistical analyses were performed using Statistical Analysis Systems software, version 9.2 (SAS Institute, Cary, NC). Descriptive statistics were calculated for each parameter and consisted of the mean, median, standard deviation (SD), 95% confidence interval (CI), range, interquartile range, and skewness. Each parameter was then individually depicted graphically on a histogram and normal Q–Q plot to assist in evaluation of the normalcy of the data population.

Determining the normalcy of a data population can be both a challenging and a subjective, but also a critically important, exercise. A normally distributed (or parametric) population is 1 in which approximately 68% of the data is found within 1 SD of the mean and approximately 95% of the population is found within 2 SDs of the mean (32–39). This has important consequences in terms of both data reporting and comparative statistical analysis within medical studies. Generally, descriptive data from parametric populations are more appropriately reported in terms of the mean and SD, with CIs used to further describe the precision of the mean. Descriptive data from nonparametric populations are more appropriately reported in terms of the median and interquartile range. Furthermore, given a common comparative study design used within the field of foot and ankle surgery (e.g., comparing preoperative and postoperative radiographic parameters), data from parametric populations should be analyzed with certain specific comparative statistical tests (i.e., the Student *t* test). Other specific statistical tests are more appropriately used if the data are not normally distributed (i.e., the Wilcoxon signed rank test) (39).

Although there is not necessarily a functional mathematical formula to determine whether a population has a parametric distribution, analysis of the descriptive statistics can provide some important information with respect to normalcy. We used 2 objectives to evaluate whether the data were normally distributed.

First, if the SD was greater than 50% of the mean and/or if 2 SDs above or below the mean were outside the range, we considered the data to be nonparametric. Second, the data were graphically depicted using both a histogram and a normal Q–Q plot to visualize the data. A parametric population would be expected to have a bell-shaped curve on the histogram and relatively firm adherence to the normal line on a Q–Q plot. Evaluation of a bell-shaped curve on a histogram can be assisted by calculation of skewness, which is generally symmetrically distributed around a mean of 0 for a parametric population. Negative values of skewness represent a skew to the left (left tailed) and positive values a skew to the right (right tailed). Generally, a normally distributed population has a skewness with a range of −1 to 1 (40).

Finally, each parameter was then graphically depicted against each other on a frequency scatter plot and analyzed with a uniform Loess best fit line to further evaluate for relationships among the variables.

Results

A total of 373 feet (179 left feet) in 272 patients (126 males) were included in the present analysis during a 4-month data collection period (November 2010 to February 2011). The patient age range was 13 to 90 years (mean 47.4 ± 15.5). A summary of descriptive data for the measurement of the 4 radiographic parameters is listed in Table 1.

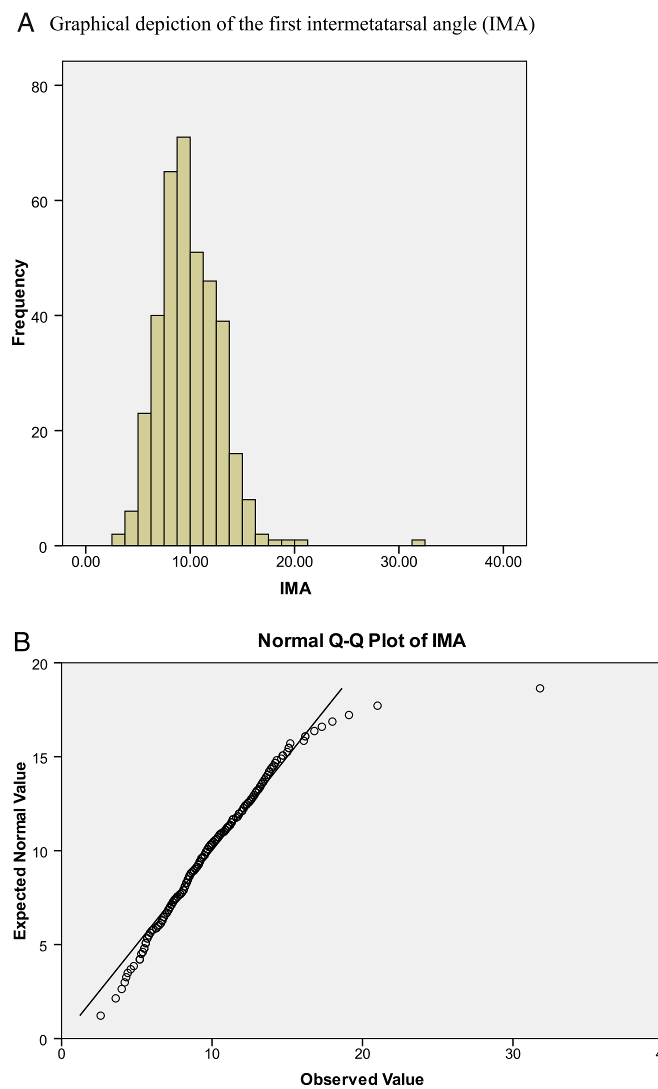

Fig. 1. (*A* and *B*) Graph showing data for first intermetatarsal angle (IMA).