Interobeserver and Intraobserver Reproducibility of Hallux Valgus Angular Measurements and the Study of a Linear Measurement

Jose Veiga Sanhudo, Joao Ellera Gomes, Marcelo Costa Rabello and Giuseppe Delucca

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〈 Clinical Research 〉

Interobeserver and Intraobserver Reproducibility of Hallux Valgus Angular Measurements and the Study of a Linear Measurement

Jose Veiga Sanhudo, MD,
Joao Ellera Gomes, MD, PhD,
Marcelo Costa Rabello, MS,
and Giuseppe Delucca, MD

Abstract: Background. *The intermetatarsal angle (IMA), the hallux valgus angle (HVA), and the lateral sesamoid malalignment in relation to the first metatarsal are among the most commonly employed parameters to estimate the severity of the deformity. The aim of this study was to compare HV angular measurements and a linear measurement among 4 observers to determine its intraobserver and interobserver reliability, to find out whether this linear measurement technique is more reproducible than those already-described angular measurements.* Methods. *The IMA, the HVA, and the distance between the lateral cortex of the first metatarsal and the lateral cortex of the lateral sesamoid bone were measured from 50 standing, nonoperated hallux valgus feet. Radiographs were shuffled and reforwarded to the observers at a minimum interval of 30 days for a new measurement.* Results. *When considering 2° of difference as significant, IMA and HVA measurements were not precise, showing low reproducibility for both intraobserver and interobserver assessment. Regarding the distance between the first metatarsal lateral cortex and the lateral sesamoid lateral cortex, when considering differences greater than 2 mm as significant, we observed higher precision and higher reproducibility.* Conclusions. *Angular measurements of hallux valgus deformity in anteroposterior standing radiographs that are manually performed with a goniometer are not precise and have low reproducibility. The linear measurement of the distance between the lateral cortices of the first metatarsal head and the lateral sesamoid demonstrated higher precision and higher reproducibility, and may be a cheap form to assess the correct indication of a distal osteotomy.*

Levels of Evidence: *Diagnostic, Level II*

Keywords: bunions; forefoot; toe; midfoot; foot surgery techniques; diagnostic and therapeutic techniques

Introduction

Hallux valgus is the most common adult forefoot deformity, and its treatment is directed—in association with other factors—by the severity of the deformity.[1-5] The intermetatarsal angle (IMA), the hallux valgus angle (HVA), and the lateral sesamoid malalignment in relation to the first metatarsal are among the most commonly used parameters to estimate the severity of the deformity and to recommend the indicated surgical technique. Many studies, however, demonstrated the low reproducibility of these measurements.[1-13] The aim of this study was to compare hallux valgus

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DOI: 10.1177/1938640012457939. From the UFRGS, Porto Alegre, Brazil (JVS, JEG, GD), PUCRS, Porto Alegre, Brazil (MCR). Address correspondence to Jose Veiga Sanhudo, UFRGS, Rua Ramiro Barcelos 2350, Porto Alegre, 90630020, Brazil; e-mail: jsanhudo@ceotrs.com.br.

angular measurements and a linear measurement among 4 observers to determine its intraobserver and interobserver reliability in order to find out whether this linear measurement technique is more reproducible than the already-described angular measurements.

Method

The IMA, the HVA, and the distance between the lateral cortex of the first metatarsal and the lateral cortex of the lateral sesamoid bone were measured from 50 standing, nonoperated hallux valgus feet (Figure 1A and B). Angular measurements have been based on the recommendations of Hardy and Clapham[14] and from the Research Committee of the American Orthopedic Foot and Ankle Society.[8] Measurements were manually performed using goniometers by 4 evaluators with different levels of experience: a final-year medical student, a second-year resident in orthopaedics and traumatology, a specialist in orthopaedics with foot and ankle subspecialty, and an associate professor of orthopaedics and traumatology. All measurements were carefully erased from the X-rays after the recording. Radiographs were shuffled and reforwarded to the observers at a minimum interval of 30 days. Patient identification was blocked in all radiographic exams during measurements. As the radiographic measurement is a part of hallux valgus routine evaluation, an informed consent was not required in this study.

Results

When considering 2° of difference as significant, IMA and HVA measurements were not precise, showing low reproducibility for both intraobserver and interobserver assessment. Despite the lack of a statistically significant difference between the 2 IMA intraobserver measurements of all observers, there was a high percentage of differences above 2°. This percentage was 66.9% for observer I, 63.5% for observer II, 35.7% for observer III, and 48.1% for observer IV. As for the interobserver evaluation for IMA, the percentage of differences above 2° was 71.2% between observers I and II, 71.2% between observers I and III, 51.9% between observers I and IV, 59.6% between observers II and III, 33.8% between observers II and IV, and 80.8% between observers III and IV.

In the intraobserver evaluation of HVA, the percentage of differences above 2° was 66.9% for observer I, 71.2% for observer II, 50% for observer III, and 59.6% for observer IV. As for the interobserver evaluation for HVA, the percentage of differences above 2° was 73.1% between observers I and II, 67.3% between observers I and III, 76.9% between observers I and IV, 71.2% between observers II and III, 66.9% between observers II and IV, and 53.8% between observers III and IV.

Regarding the distance between the first metatarsal lateral cortex and the lateral sesamoid lateral cortex, when considering differences greater than 2 mm as significant, the percentage of intraobserver disagreement was 13.5% for observer I, 19.2% for observer II, 17.3% for observer III, and 0% for observer IV. As for the interobserver evaluation of that distance, the percentage of differences at greater than 2 mm was 21.2% between observers I and II, 13.5% between observers I and III, 7.7% between observers I and IV, 17.3% between observers II and III, and 3.7% between observers III and IV. Variables were described as means and standard deviation. For intraobserver comparison, Student's *t* test was used for paired samples. When comparing interobservers, the analysis of variance for repeated measurements was applied. Student's *t* test for paired samples, and Bonferroni's *P* value correction for type I error were used in case of statistical significance. Both methods presented the same significant differences. The adopted level of significance was set at 5% ($P \leq .05$), and the analyses were performed with the version 18.0 of SPSS (Statistical Package for Social Sciences) software.

Figure 1.

(A) Weight-bearing anteroposterior radiograph of the foot showing the angular measurements studied (intermetatarsal angle and hallux valgus angle). (B) Weight-bearing anteroposterior radiograph of the foot showing the linear measurement studied. It represents the amount of head displacement required to cover the lateral sesamoid.

Discussion

Hallux valgus angular measurements are the most common parameters used to establish severity of deformity and to determine the correction yielded by the surgical treatment. Although some studies do confirm its use, several reports have demonstrated that hallux valgus angular measurement does have little reproducibility and is unreliable.[6,7,10,12,13,15] The difficulty in drawing an axis of nontubular bones from the first and second rays is, undoubtedly, one of the strongest responsible for the low reproducibility of the aforementioned angular measurement techniques. Resch et al[13] observed that the linear measurement may be more easily achieved than angular measurements, but the authors had studied a linear measurement different from the one we had studied. The linear measurement assessed in this study aims to directly determine the lateral displacement from the metatarsal head that is necessary to reestablish an anatomical sesamoid–metatarsal relationship at the first ray. Coughlin and Freund[7] assessed the reliability of HVA, IMA, and the distal metatarsal articular angle between 24 orthopaedic surgeons. Twenty-five anteroposterior standing feet radiographs were measured on 3 occasions with a minimum interval of 6 weeks. Authors reached the conclusion that the distal metatarsal articular angle reliability is questionable, but HVA and IMA measurements are reliable. Nonetheless, it should be stressed that the authors had reckoned as consistent angular measurements with differences of up to 5°, which, in practical terms, may create controversy.[7] Piqué-Vidal et al[12] compared manually performed hallux valgus angular measurements with measurements made by computer-based software (Autocad). Assessed angular values included HVA, IMA, distal metatarsal articular angle, and hallux valgus interphalangeal angle. A total of 176 anteroposterior radiographs of feet with hallux valgus were assessed. Manual measurements were performed by an orthopaedic surgeon with a goniometer, and computer-based measurements were performed by a seasoned computer technician. Authors observed that Autocad angular measurements were more reliable than those manually performed using a goniometer.[12] Farber et al[10] also compared IMA and HVA goniometer measurements with Magic View software computer measurement, and considered 2° as a significant difference. The computer-based measurement was more reliable, showing HVA interobserver agreement was 81% on the computer-based measurement and 66% on the manual measurement.[10] Condon et al[6] studied the measurement reliability of the first IMA in hallux valgus among 10 observers of varying experience. Ten anteroposterior feet radiographs were measured on separate occasions. The margin of error in measuring the angle was ±3.6° with 95% confidence interval. They observed that experience does not improve reliability, and that measuring twice the radiograph twice and averaging the two values can reduce the error.[6] The American Orthopaedic Foot and Ankle Society appointed an ad hoc committee to evaluate the methods of measurement in quantifying hallux valgus angle and to make recommendations.[8] They recommended the placement of reference points 1 to 2 cm to the articular surface on the first and second metatarsal and 0.5 to 1.0 cm to the articular surface on the proximal phalanx of the hallux and the use of standard protractor instead of a goniometer. They observed that the protractor does not require an estimated center of rotation and eliminates a double source of error, which can occur when the 2 arms of a goniometer are used, and also observed that the protractor have 1° increment as opposed to 2° increments of the goniometer, which may increase the method's accuracy.[8]

As the surgical treatment aim consists of approximating the distal end of the first metatarsal to the distal end of the second metatarsal, the first metatarsal thickness, along with the length of the first and second rays should be taken into account, but these are not considered in any described assessment. Harper[16] demonstrated that in distal osteotomies a correction of 1° of the IMA for each millimeter of lateral head displacement of the first metatarsal is achieved, and Badwey et al[17] demonstrated that the maximum advisable displacement of the first metatarsal head in distal osteotomies is 5 mm in females and 6 mm in males. Based on the principle that the head ought to be repositioned over the sesamoid bones, it is admissible that the distance between the lateral cortices of the first metatarsal and the lateral sesamoid must not be greater than 5 mm, so that the anatomical reestablishment is achieved and that a distal osteotomy may be indicated. In those cases, an alternative treatment form should be attempted. The study of reproducibility and reliability of this linear measurement allows the evaluation of its use in the assessment of hallux valgus deformity severity and helps guide an eventual surgical treatment based on the corrective ability of distal osteotomies.

Conclusions

Angular measurements of hallux valgus deformity in anteroposterior standing radiographs that are manually performed with a goniometer are not precise and have low reproducibility. The linear measurement of the distance between the lateral cortices of the first metatarsal head and the lateral sesamoid demonstrated higher precision and higher reproducibility and may be a low-cost alternative to assess the correct indication of a distal osteotomy. FAS

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