



Intrareader and Interreader Reliability of Radiographic Measurements in Hallux Valgus

João David Costa*, Maribel Gomes, Miguel Rocha, Fernando Macedo,
João Lucas, Carlos Vilela and João Moura

Hospital Senhora da Oliveira, Guimarães, Portugal

*Corresponding Author: João David Costa, Hospital Senhora da Oliveira,
Guimarães, Portugal.

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Costa, et al.

Abstract

Background: Hallux valgus (HV) is one of the most frequent pathologies of the forefoot. Diagnosis and treatment depend on several factors. To evaluate patients with HV measurements of hallux valgus angle (HVA) and intermetatarsal angle (IMA) by traditional midaxial method are the most common strategies used nowadays. Therefore, it is important to study interreader reliability (IRR) of both angles on pre- and post-operative.

Purpose: Determine intrareader and interreader reliability of HVA and IMA both pre-operative and postoperative.

Methods: A sample of 48 patients (55 feet) was selected from the patients above the age of 18 years, with hallux valgus, who underwent osteotomy of the first metatarsal in an orthopedics' department. All had weight-bearing pre-operative and post-operative anterior-posterior (AP) and lateral X-rays performed. Three readers measured HVA and IMA both pre-operative and post-operative using the traditional midaxial method. To ensure the uniformity of the measurement technique the 3 readers evaluated eight training cases together. All readers repeated 20% of the measurements after one week. Intraclass Correlation Coefficient (ICC) were obtained.

Results: For IMA pre- and post-operative ICC were .779 and .773, respectively. For HVA pre- and postoperative ICC were .798 and .932. Standard error of measurement was considerably below mean values for both angles on both moments. Intrareader reliability results showed very high reliability.

Conclusions: IRR was high (>.700) for both HVA and IMA on pre-operative and post-operative. However, results showed an advantage of HVA when compared with IMA, considering higher IRR and better precision of the estimates.

Keywords: Hallux Valgus; Radiographic Measurements; Hallux Valgus Angle; Intermetatarsal Angle; Interreader Reliability

Introduction

The hallux valgus consists of a progressive deformity in which the hallux deviates laterally, resulting in the medial prominence of the head of the first metatarsus [1]. This is one of the most frequent pathologies of the forefoot, with an overall prevalence of 23% in the population aged 18 to 65 years and 35% in the population over 65 years. The prevalence increases with age and is also higher in female patients (30%) when compared to male patients (13%) [2].

Etiologically, it is considered to be a multifactorial pathology. The genetic component is an important factor in the development of hallux valgus, since many of the patients report a family history. It is also proven that the abnormal anatomy of the foot, the use of high heels, as well as inflammatory diseases can be related to the appearance of the deformity [3-5]. This deformity can manifest

in several ways, although, in most cases, the first manifestation of hallux valgus is pain in the forefoot, associated with functional disability, often related to supine position and use of tight shoes [6].

In addition to the clinical history and associated symptoms, imaging tests, especially radiography, play an important role in diagnosis, in the study of deformation's severity and in treatment selection [7]. The radiographic evaluation must include the evaluation of general radiographic parameters and the evaluation of several bone angles involved in this deformity [8-12]. Weightbearing face and profile radiographs must be obtained, since the presence or absence of weight can alter the degree of metatarsal's axial rotation and consequently affect the angle measurements [13].

The assessment of the hallux valgus severity can be done by measuring several parameters. The two most frequently used

angles are the hallux valgus angle (HVA) and the intermetatarsal angle (IMA). The HVA is the angle formed by the intersection of the longitudinal axis of the hallux's proximal phalanx and the longitudinal axis of the first metatarsal (figure 1). The normal value is approximately 15° and many authors consider values above 15° to be pathological [14-17]. The IMA is the angle formed by the intersection of the longitudinal axis of the first metatarsal with the longitudinal axis of the second metatarsal (Figure 1). This angle is evaluated as pathological for values above 9° [14-17]. Multiple methods are available for assessing hallux valgus angles. Traditionally, longitudinal axes of bones are used to draw intersecting lines, allowing the angle measurement.



Figure 1: Weightbearing dorsoplantar foot radiograph. HVA is formed by the intersection of line b (longitudinal axis of the proximal phalanx) with line d (longitudinal axis of the first metatarsal), while IMA is formed by the intersection of line d with line e (longitudinal axis of the second metatarsal). [18].

The measurements of HVA and IMA are used for diagnosis, election of surgical procedures and radiographic evaluation of treatment results, therefore, it is important to guarantee a high reliability of the measurement techniques, both before and after surgery, in order to ensure uniform treatment and follow-up of patients with hallux valgus. For that reason, the main objective of this study is to assess intrareader and interreader reliability of measurement of HVA and IMA in preoperative and postoperative periods.

Methods type of study

Observational, longitudinal, retrospective, analytic study.

Patient selection

Inclusion criteria: A sample was selected from all the patients above the age of 18 years, with hallux valgus, who underwent osteotomy of the first metatarsal (scarf or chevron surgeries) in the Orthopedics' department of HSOG and had pre-operative and post-operative weight-bearing AP and lateral X-rays.

Exclusion criteria

- Patients with other diseases that could cause foot deformities;
- Patients with recent history of foot trauma;
- Patients with previous surgery of the foot and lower extremity;
- Patients with orthopedic hardware in their foot;
- Patients with low-quality x-rays;
- Patients with x-rays without complete inclusion of the forefoot in the field of view;

Data collection

Data collection was done through analysis of informatics' registries relative to the patients who respected the inclusion and exclusion criteria. The data was recorded in a data base to perform a statistical analysis. The data base included age, gender (male; female), affected foot (right; left), pre-operative and post-operative hallux valgus angle and pre-operative and post-operative intermetatarsal angle. Independent measures of pre-operative and post-operative hallux valgus angle and pre-operative and post-operative intermetatarsal angle using the traditional method were conducted by 3 readers (Reader 1 - Orthopedic resident with 2 years of experience; Reader 2 - Orthopedic surgeon with 8 years of experience; Reader 3 - Orthopedic surgeon with 7 years of experience). It was decided that pre-operative measurements would be done based on the anatomic longitudinal axis, while post-operative measurements would be done based on the mechanical axis of the

first metatarsal. Before beginning independent measurements, the 3 readers evaluated eight training cases together to ensure the uniformity of their measurement technique. Each reader was blinded to the other’s results. In order to determine intrareader reliability each one of the 3 readers repeated the measurements of 11 cases (approximately 20% of all cases) with an interval of one week. The data was recorded by each reader in a separated data base (excel) and sent to the main investigator who organized all the information and performed the statistical analysis.

Statistical analysis

For descriptive statistics frequencies (n) and percentages (%) were calculated. Means and standard deviations were calculated for continuous variables after checking for symmetry by calculating and assessing symmetry coefficient [-1;1] and by observing histograms. Normality was checked and confirmed with Shapiro-Wilk test (p > .05) for allowing parametric statistics. Interreader reliability (IRR) and intrareader reliability were assessed with intraclass correlation coefficient (ICC) [19] for pre- and post-surgery assessments with IMA and HVA for the three readers. Intrareader and interreader reliability were classified as minimal (correlation coefficient, 0.90)”. Additionally, it was also calculated the standard error of measurement (SEM) for assessing precision, expressed in the same units of the corresponding scale and a 95% CI for the precision of scores. For this purpose, it is presented the precision for the global mean in each measurement.

Results

A total of 48 patients, 41 (85.4%) females and 7 (14.6%) males, aged between 18 and 88 at surgery date, mean 53.35 (SD = 14.60) were observed totalizing the assessment of 55 feet, 22 (40.0%) left and 33 (60.0%) right sided. Figure 1 shows IMA and HVA mean assessment scores pre and post-surgery. All investigators were consistent when assessing the diminish of the IMA and HVA after surgery.

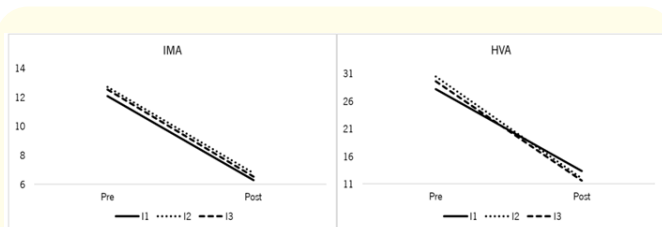


Figure 2: 2a shows IMA and HVA mean assessment scores pre and post-surgery. 2b IMA and HVA mean assessment scores pre and post-surgery.

Inter-rater reliability (IRR) was assessed by calculating intraclass correlation coefficient (ICC) (Table 1). Results showed high and very high IRR. For IMA pre and post-surgery ICC were .779 and .773, respectively. For HVA pre and post-surgery ICC were .798 and .932. Standard error of measurement (SEM) was calculated to measure the precision of individual scores for IMA and HVA. SEM for IMA pre and post-surgery was 4.61 and 3.64, respectively, considerably below mean values, reflecting a moderate to high precision of the estimate; 95% confidence intervals (CIs) for the true IMA score were (3.39; 21.48) for IMA pre and (-0.61; 13.66) for IMA post. For HVA, SEM were also considerably below mean values, SEM = 11.08 (HVA pre-surgery) and SEM = 7.49 (HVA post-surgery), especially for this last one; 95% confidence intervals (CIs) for the true IMA score were (7.69; 51.12) for HVA pre- and (-2.35; 27.03) for HVA post-surgery.

Investigator	IMA M (DP)		HVA M (DP)	
	Pre	Post	Pre	Post
Investigator 1 (n = 55)	12.07 (3.80)	6.29 (2.47)	28.14 (8.89)	13.39 (9.80)
Investigator 2 (n = 55)	12.71 (3.09)	6.76 (3.07)	30.46 (8.78)	12.04 (9.76)
Investigator 3 (n = 55)	12.53 (3.70)	6.52 (2.71)	29.61 (8.83)	11.59 (9.86)
ICC	.779	.773	.798	.932
SEM	4.61	3.64	11.08	7.49
95% CI for score precision	(3.39; 21.48)	(-0.61; 13.66)	(7.69; 51.12)	(-2.35; 27.03)

Table 1: Interreader reliability for IMA and HVA regarding pre- and post-surgery assessments.

Descriptive statistics presented as means (M) and standard deviations (SD); 95% CI for score precision calculated as: mean score ±(1.96*SEM).

Intrareader reliability results showed very high reliability for all investigators in all assessments, with a minor exception for investigator 1 on IMA post-surgery.

Investigator	ICC for IMA		ICC for HVA	
	Pre	Post	Pre	Post
Investigator 1 (n = 15)	.951	.675	.987	.983
Investigator 2 (n = 15)	.959	.951	.971	.966
Investigator 3 (n = 15)	.901	.873	.975	.981

Table 2: Intrareader reliability for IMA and HVA regarding pre- and post-surgery assessments.

ICC is presented as measure of intra-rater reliability (two measurements)

Discussion

The measurements of HVA and IMA are used for diagnosis, election of surgical procedures and radiographic evaluation of treatment results [7]. There have been reported many methods for measuring these angles in the last few years with the intention of making the process easier, faster and cheaper. However, the traditional method is still the most used by the majority of the orthopedic surgeons around the world.

For that reason, it is important to understand the reproducibility of this technique, so, the main objective of this study is to determine intrareader and interreader reliability of HVA and IMA on preoperative and post-operative. The mean age of the patients in this sample was 53.35 ± 14.60 years, and 85,4% were women, which was similar to the demographic described in literature [2]. This demonstrates that the database is representative of the general population and for that reason results obtained can be applied in clinical practice.

This study showed high and very high IRR. for IMA pre and post-surgery ICC were .779 and .773, respectively. For HVA pre- and post-surgery ICC were .798 and .932. Other studies have reported IRR for HVA values reaching from .900 to .990 and for IMA ranging from .680 to .940 [18,20-25], which is similar to the findings reported here, with the exception on HVA pre-surgery, that was a little lower in this study. These results suggest high reliability of the instruments. Intrareader reliability was very high for all investigators in all measurements with the exception of investigator 1 on IMA post-surgery.

Overall the results suggest high reproducibility capacity of the instruments. The results from investigator 1 on IMA post-surgery were an unexpected finding. It could be justified by the fact that investigator 1 is the one with the least experience, although Condon et al. assessed the reliability of IMA and concluded that experience did not improve reliability, while a careful technique, the repetition of measurements at least twice and averaging the results could improve reliability [26]. It is also possible that this interfered with interreader reliability results and could be one of the reasons why IMA post-surgery ICC is the smallest of all ICC (.773).

The overall results advocate an advantage of HVA when compared with IMA, considering higher IRR and better precision of the estimates. These findings are consistent with the ones reported by Kyoung Min Lee et al. who concluded that the HVA had the highest ICC when compared with other angles used to evaluate hallux valgus [18].

The relevance of this study relies on the fact that contributes to reinforce previous studies on the same topic, because although some studies have been conducted there is still no consensus on the best assessment technique.

Summarizing, based on the results obtained, it is safe to say that both IMA and HVA on pre-operative and post-operative are very reliable instruments to use in order to choose surgical procedures and do follow-up of the patients with HV.

This study includes a short interval (one week) between the repetition of the measurements by each reader. However, the same interval has been used in previous studies, so it is believed that this interval was long enough to ensure that the readers did not remember their previous results [24,26-28]. The sample size could have been a limitation, because it was possible that there were not a significant number of patients with different disease states (mild, moderate and severe) but as we verified with the measurements it didn't happen. Studies with larger databases and more observers might be relevant to improve the actual evidence.

Conclusion

The high prevalence of hallux valgus associated with its clinical manifestations as well as the patient's cosmetics concerns, give a significant importance to this pathology. For that reason, it is important to optimize its diagnose, treatment and follow-up. In this study we report a high intrareader reliability for all investigators in all measurements as well as high interreader reliability for both HVA and IMA on pre-operative and post-operatives. Although both HVA and IMA were considered reliable, results showed an advantage of HVA when compared with IMA, considering higher IRR and better precision of the estimates. Lastly, the fact that this work and other similar studies report a high IRR shows that both HVA and IMA measurements are reliable, which allows to conclude that these are safe methods to determine treatment and follow-up of patients with HV.

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