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Original Article

Reproducibility of the point connection technique for measuring hallux valgus angles using a smartphone application

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Abstract

Objective: A) To evaluate the reliability of a new technique for the measurement of both intermetatarsal and hallux valgus angles. B) To evaluate whether this technique can be performed with the aid of a smartphone application.

Methods: Preoperative radiographs of 30 patients were evaluated by four observers, two experienced surgeons and two surgeons in training. They performed measurements of the intermetatarsal angle and hallux valgus angle using the classical method and using the new method, both employing a goniometer and a smartphone application. Analysis of agreement was done by quantifying the raw agreement and calculating the intraclass correlation coefficient (ICC).

Results: The hallux valgus angle presented excellent agreement (ICC>0.80) both using the traditional method and the point connection method, while the intermetatarsal angle presented a very good agreement (0.60<ICC≤0.80) in both methods.

Conclusion: The point connection technique showed good concordance rates when measured by smartphone applications, although it did not prove to be superior to the traditional one.

Level of Evidence II; Diagnostic Study; Development of Diagnostic Criteria.

Keywords: Hallux valgus; Radiography; Reproducibility of results; Smartphone.

Introduction

Hallux valgus (HV) is one of the most common chronic foot pain complaints in the practice of a foot and ankle specialist[1]. It is represented by a lateral deviation of the hallux towards the other toes and a medial deviation of the first metatarsal, evolving with pronation of the first metatarsal and metatarsophalangeal subluxation[2]. The severity of these deformities, associated with other factors, is determinant for the choice of treatment[3-5].

The gold standard for diagnosing HV is obtaining weight-bearing anteroposterior and lateral view radiographs of the foot. In the anteroposterior view, the hallux valgus angle (HVA), the intermetatarsal angle (IMA), and the position of the tibial sesamoid in relation to the anatomic diaphyseal axis of the first metatarsal are measured.

According to Coughlin's classification, a mild deformity is characterized by an HVA of less than 20°, an IMA of less than 11°, and a lateral subluxation of the sesamoid of up to 50%. A moderate deformity is defined by an HVA of 20º to 40°, an IMA of less than 16°, and a subluxation of 50–75%. Finally, a severe deformity is defined by an HVA greater than 40°, an IMA greater than 16°, and a lateral subluxation greater than 75%[2].

The HVA measurements have proven to be very important in assessing the severity of the disease, therefore, the standardization of methods with good inter- and intraobserver reproducibility becomes imperative. Parameters to be followed in measurements of HVAs were defined in a publication issued by the American Orthopaedic Foot and Ankle Society (AOFAS) in 2001. The IMA measurement uses the diaphyseal

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axes of the first and second metatarsals. To define the HVA, at first the axis of the first metatarsal is traced, followed by the axis of the proximal phalanx of the hallux, the angle formed between these two lines is then evaluated.

Although these parameters have become widespread and widely used by foot and ankle surgeons, some studies have shown that the reproducibility of these measurements when performed manually or by computerized programs may be low[(6-9)].

In 2016, Seo et al.[(10)] proposed a new way to measure HVAs. This technique is based on using a different reference point connection and showed good inter- and intraobserver reproducibility in IMA and HVA measurements.

Considering that printed radiographs are currently losing space to digital radiographs and that smartphone applications have become an alternative to speed up the measurement of angles in clinical practice, it is essential to also validate new measurement techniques in digital methods.

The objective of this study is to evaluate the reproducibility of this new technique for the measurement of IMA and HVA comparing it with the traditional technique. In addition, we aim to evaluate whether the described technique can be used both manually and in smartphone applications.

Methods

This study was approved by the Ethics and Research Committee of our institution and was conducted by our team of experts.

A retrospective observational study was conducted where 30 preoperative, weight-bearing anteroposterior radiographs of patients undergoing HV surgery at our institution between January 2018 and December 2019 were reviewed. The sample calculation was based on previous literature[(7,8,10)]. These radiographs were taken with the beam centered on the midfoot, with a 20° inclination from vertical in the sagittal plane and a focus-film distance of 100 cm[(11)]. Four observers, two experienced foot and ankle surgeons and two foot and ankle surgery residents, performed the IMA and HVA measurement using the traditional technique validated by AOFAS and the new point connection technique. These techniques were performed both manually, using a goniometer, and digitally, using the TraumaCadTM software system (TraumaCad, Petach-Tikva, Israel)[(12)]. This application is used in the surgical planning of several orthopedic pathologies and has easy-to-use tools for angle measurement (Figure 1).

The conventional method for measuring the IMA uses the diaphyseal axes of the first and second metatarsals, while the HVA measurement uses the axis of the proximal phalanx and the axis of the first metatarsal. To find the axis of the first metatarsal, one must connect a point equidistant from both cortices located 1–2 cm distal to the tarsometatarsal joint with another point located 1–2 cm proximal to the metatarsophalangeal joint. The same is done to find the second metatarsal axis, and the angle is measured between these two lines. The axis of the proximal phalanx is found by connecting the equidistant points of the cortices, located 0.5–1 cm proximal to the interphalangeal joint and 0.5–1 cm distal to the metatarsophalangeal joint[(11)].

The new method of connecting points is performed by marking a point on the most medial portion of the head of the first metatarsal connecting with a point positioned on the most medial, prominent, sclerotic portion of the base of the first metatarsal. A point is then marked on the most prominent and medial portion of the second metatarsal head and on the most medial and sclerotic portion of the base of the second metatarsal. The angle formed between these two lines is the IMA (Figure 2). The axis of the proximal phalanx, on the other hand, is found by drawing a straight line connecting the most medial and prominent point of the proximal phalanx at the interphalangeal joint with a more prominent and medial point at the head of the first metatarsal. The angle formed between this line and the axis of first metatarsal is the HVA[(10)] (Figure 3).

Figure 1. Image of the TraumaCad (TraumaCad, Petach-Tikva, Israel) application interface used to measure angles.

Figure 2. Point-connection measurement of the IMA using two lines as the longitudinal axis of the first metatarsal (A) and the longitudinal axis of the second metatarsal (B).

Figure 3. Point connection measurement of the HVA using two connecting lines as the longitudinal axis of the proximal phalanges (A) and longitudinal axis of the first metatarsal (B).

Statistical analysis

From the collected measurements, a database was built and analyzed using computational resources of the programs R version 3.6.3 (The R Foudation, Indianapolis, Indiana, USA) and SPSS, Statistical Package for the Social Science, version 22.0 (IBM Corp., Armonk, New York, USA) and using the application Microsoft Excel® 2015 (Microsoft Corporation, Redmond, Washington, USA).

For sample characterization and descriptive analysis of the behavior of variables, measurements obtained by the two methods were synthesized using boxplots, calculation of descriptive statistics (mean, median, standard deviation, coefficient of variation, and proportions of interest), simple frequency distributions, and cross tables. All analyses were done globally, by level of expertise of evaluators, and by evaluator individually.

The analysis of agreement between both paired measurements was done by quantifying the raw agreement (percentage of cases with variation D = difference between both measurements = 0) and by calculating the intraclass correlation coefficient (ICC). The ICC expresses the proportion of total variability that is due to inter-unit variability. When evaluating the agreement between two measurements, as is the case in this paper, ICC can be interpreted as a measure of agreement that finds the degree of distance of both measurements from the 45-degree straight line, where there should be perfect agreement, since both measurements should be equal. Since we are only interested in the two measurements under analysis, the one measured by the application and the one measured by the traditional method, ICC was calculated using the mixed-effects model ANOVA (two-way mixed model) and the study interest was 'consistency analysis,' as recommended by Shrout and Fleiss[13]. The ICC classification of agreement will be based on Weir's classification[14]:

$0.00 \leq ICC \leq 0.20$ = poor agreement;

$0.20 < ICC \leq 0.40$ = fair agreement;

$0.40 < ICC \leq 0.60$ = good agreement;

$0.60 < ICC \leq 0.80$ = very good agreement;

$0.80 < ICC \leq 1.00$ = excellent agreement.

The ICC was analyzed by the confidence interval at the 95% level and the significance of ICC was evaluated by the F test. The agreement found was considered significantly good when every value within the confidence interval of ICC at the 95% level was at least comparable to the 'good agreement' level, that is, when the lower limit of the agreement coefficient confidence interval at the 95% level was greater than 0.40.

The analysis of agreement between both measurements was done inter-rater and intra-rater. Additionally, in order to evaluate if the angle was independent of the rater's expertise, the agreement by rater level (resident or specialist) was analyzed. All analyses were performed at a 5% significance level, and details of the methodology can be obtained in Medronho et al.[15] and Weir[14].

Results

As shown in Table 1, when evaluating the HVA by the traditional method in global analysis, not discriminating the evaluator, the agreement between the HVA measured using a goniometer and the HVA measured using the application was significant and excellent (ICC=0.84).

When evaluators were discriminated by level of expertise, the HVA evaluated by the traditional method with a goniometer and using the application showed no statistically significant difference (p-value=0.654). However, there was a significant difference between the residents measurements of the HVA (p-value=0.013), as well as a lower ICC compared to that found in measurements by specialists.

By evaluating the HVA by the new method in a global analysis, not discriminating the evaluator, the agreement measured by ICC is excellent (ICC=0.84) and statistically significant.

When evaluators were discriminated by level of expertise, by measuring the HVA using the new method, there was no significant difference between the residents measurements (p-value=0.286), and significant ICC values referring to excellent or very good agreement were found. The specialists, on the other hand, showed a significant difference between their measurements using a goniometer and the application (p-value=0.003).

By evaluating the IMA using the traditional method not discriminating the evaluator, the agreement between the IMA measurement using a goniometer and the application was very good and statistically significant (ICC=0.60) (Table 2).

Considering only the specialists, no significant difference was found between the measurements of the IMA using the traditional method with a goniometer and with the application (p-value=0.722); besides, a very good agreement was found (ICC=0.71). However, when it comes to resident evaluators, a lower level of agreement was found, with an ICC lower than that found with the specialists (ICC=0.52).

Table 1. Concordance analysis for the HVA measurements using different instruments: goniometer and smartphone application

Method	Evaluator	Tool	Mean	Median	SD	VC	ICC	AC	p-value*
TM	Resident 1	GN	30.1	29.0	10.1	0.33	0.76	6.7%	**0.017**
		App	27.4	28.0	7.0	0.25	(0.52-0.88)		
	Resident 2	GN	27.9	28.0	7.4	0.27	0.79	10.0%	0.344
		App	27.1	26.0	6.5	0.24	(0.60-0.89)		
	Residents Global	GN	29.0	28.0	8.8	0.31	0.77	8.3%	**0.013**
		App	27.3	26.0	6.7	0.25	(0.63-0.86)		
	Specialist 1	GN	28.1	26.5	8.4	0.30	0.94	3.3%	0.051
		App	27.1	25.0	7.5	0.28	(0.87-0.97)		
	Specialist 2	GN	28.2	28.0	8.5	0.30	0.88	13.3%	0.417
		App	28.8	28.0	8.0	0.28	(0.77-0.94)		
	Specialists Global	GN	28.1	27.5	8.4	0.30	0.91	8.3%	0.654
		App	27.9	27.0	7.7	0.28	(0.85-0.95)		
	Global	GN	28.6	28.0	8.6	0.30	0.84	8.3%	**0.020**
		App	27.6	26.5	7.2	0.26	(0.77-0.88)		
PC	Resident 1	GN	35.6	34.0	8.4	0.24	0.87	6.7%	0.511
		App	36.1	35.0	7.8	0.22	(0.75-0.94)		
	Resident 2	GN	35.4	34.0	7.7	0.22	0.68	10.0%	0.405
		App	36.3	36.0	6.3	0.17	(0.44-0.84)		
	Residents Global	GN	35.5	34.0	8.0	0.23	0.79	8.3%	0.283
		App	36.2	35.5	7.1	0.20	(0.67-0.87)		
	Specialist 1	GN	36.6	35.5	7.5	0.21	0.97	16.7%	0.719
		App	36.5	35.0	7.9	0.22	(0.93-0.98)		
	Specialist 2	GN	33.3	33.0	7.8	0.23	0.82	16.7%	**0.000**
		App	36.2	36.0	7.6	0.21	(0.47-0.93)		
	Specialists Global	GN	35.0	35.0	7.8	0.22	0.89	16.7%	**0.003**
		App	36.3	35.5	7.7	0.21	(0.80-0.94)		
	Global	GN	35.2	34.0	7.9	0.22	0.84	12.5%	**0.009**
		App	36.3	35.5	7.4	0.20	(0.77-0.89)		

TM: Traditional Method; PC: Point Connection Method; SD: Standard Deviation; VC: Variation Coefficient; ICC: Intraclass Correlation Coefficient; AC: Absolute Concordance; * Student's T-Test.

When the IMA was evaluated by the method of connecting points not discriminating the evaluator, the agreement between measurements made by goniometer and by the application was very good (ICC=0.76), with no statistically significant difference between measurements (p-value=0.235).

When the level of expertise was discriminated, the IMA measured by the new method showed no significant difference neither between residents (p-value=0.803) nor between specialists (p-value=0.068). However, specialists showed an excellent agreement (ICC=0.83), while residents showed a very good agreement (ICC=0.71) (Table 2).

When evaluating the agreement between the measurements of the HVA by the traditional method and by the point connection method, both using a goniometer and the application, in all analyses (global analysis, not discriminating the evaluator, within the group of specialists and within the group of residents, and for each evaluator individually) the agreement measured by ICC was not significant (lower limit of the confidence interval smaller than 0.40). Furthermore, it presented a significant difference among measurements (p-value less than 0.001) (Table 3).

When evaluating the agreement between measurements of the IMA by the traditional method and by the point connection method, we had a very good agreement using the goniometer (ICC=0.68). When it comes to the application, despite presenting a very good agreement (ICC=0.65), it did not show statistical significance (lower limit of the confidence interval smaller than 0.40) (Table 4).

Discussion

Angular measurement is an indispensable tool in the classification and surgical planning of HV. However, traditional techniques have often shown low reproducibility[6-8]. In view of this, the search for new techniques that have greater reproducibility and can also be measured in software and smartphone applications becomes imperative.

Table 2. Concordance analysis for the IMA measurements using different instruments: goniometer and smartphone application

Method	Evaluator	Tool	Mean	Median	DP	VC	ICC	AC	p-value*
TM	Resident 1	GN	13.2	13.0	2.5	0.19	**0.41**	10.0%	0.353
		App	12.6	12.5	3.1	0.25	**(0.07-0.67)**		
	Resident 2	GN	14.8	14.0	3.3	0.22	**0.60**	13.3%	**0.001**
		App	13.0	13.0	3.0	0.23	**(0.20-0.81)**		
	Residents Global	GN	14.0	14.0	3.0	0.22	**0.52**	11.7%	0.353
		App	12.8	13.0	3.0	0.24	**(0.30-0.69)**		
	Specialist 1	GN	13.2	13.0	2.9	0.22	0.79	40.0%	0.612
		App	13.0	13.0	2.6	0.20	(0.61-0.90)		
	Specialist 2	GN	13.8	14.0	2.8	0.20	**0.64**	10.0%	0.943
		App	13.8	13.0	3.1	0.22	**(0.36-0.81)**		
	Specialists Global	GN	13.5	14.0	2.8	0.21	0.71	25.0%	0.722
		App	13.4	13.0	2.8	0.21	(0.56-0.82)		
	Global	GN	13.7	14.0	2.9	0.21	0.60	18.3%	**0.010**
		App	13.1	13.0	2.9	0.23	(0.47-0.71)		
PC	Resident 1	GN	14.9	16.0	3.6	0.24	0.66	13.3%	0.511
		App	15.2	15.0	3.0	0.20	(0.40-0.82)		
	Resident 2	GN	15.6	17.5	3.6	0.23	0.77	13.3%	0.258
		App	15.1	15.0	3.4	0.22	(0.57-0.88)		
	Residents Global	GN	15.3	16.0	3.6	0.23	0.71	13.3%	0.803
		App	15.2	15.0	3.2	0.21	(0.56-0.82)		
	Specialist 1	GN	15.1	15.0	2.4	0.16	0.86	26.7%	0.052
		App	14.4	14.5	2.6	0.18	(0.64-0.941)		
	Specialist 2	GN	14.4	14.0	3.1	0.21	0.80	20.0%	0.850
		App	14.3	14.0	2.9	0.20	(0.62-0.90)		
	Specialists Global	GN	14.8	15.0	2.8	0.19	0.83	23.3%	0.068
		App	14.4	14.0	2.7	0.19	(0.72-0.89)		
	Global	GN	15.0	16.0	3.2	0.21	0.76	18.3%	0.235
		App	14.8	15.0	3.0	0.20	(0.67-0.83)		

TM: Traditional Method; PC: Point Connection Method; SD: Standard Deviation; VC: Variation Coefficient; ICC: Intraclass Correlation Coefficient; AC: Absolute Concordance; *Student's T-Test.

In this study, we evaluated the reproducibility and inter-rater agreement of a new method for measuring HVAs both using a goniometer and a smartphone application.

In the analysis of results found, we observed that the HVA measurements present excellent agreement (ICC>0.80) both using the traditional method and the point connection method. However, taking into account the level of expertise of evaluators, specialists showed better agreement using the traditional method, while residents showed better agreement using the point connection method. This result is probably due to a greater familiarity of specialists with the traditional method for radiographic evaluation of their patients.

As for the IMA, the agreement between measurements using both the traditional method and point connection method was very good (0.60<ICC≤0.80). Furthermore, when the level of expertise of evaluators was discriminated, residents showed lower agreement results in both the traditional and point connection methods.

This study also compared the agreement of values found using both measurement methods. As for all analyses of HVA values, we found a significant difference between measurements and a non-significant agreement. This result corroborates the results found in the original study describing the new method issued by Seo et al.[10], where there was a greater difference in HVA when comparing both methods, especially in cases where there was subluxation of the hallux metatarsophalangeal joint.

Observing the agreement of IMA values between the analyzed methods, both showed a very good agreement with the use of a goniometer and with the use of the application, and the latter did not show statistical significance. As in the original study, IMA values showed a higher agreement between the methods in relation to the HVA, although both HVA and IMA showed higher values in the new method[10].

Table 3. Concordance analysis for the HVA measurements using different methods: traditional method and point connection method

Tool	Evaluator	Method	Mean	Median	SD	CV	ICC	AC	p-value
Goniometer	Resident 1	TM	30.1	29.0	10.1	0.33	**0.71**	**13.3%**	**0.000**
		PC	35.6	34.0	8.4	0.24	**(0.09- 0.90)**		
	Resident 2	TM	27.9	28.0	7.4	0.27	**0.55**	**3.3%**	**0.000**
		PC	35.4	34.0	7.7	0.22	**(-0.10-0.84)**		
	Residents Global	TM	29.0	28.0	8.8	0.31	**0.63**	**8.3%**	**0.000**
		PC	35.5	34.0	8.0	0.23	**(-0.05-0.86)**		
	Specialist 1	TM	28.1	26.5	8.4	0.30	**0.57**	**0.0%**	**0.000**
		PC	36.6	35.5	7.5	0.21	**(-0.07-0.87)**		
	Specialist 2	TM	28.2	28.0	8.5	0.30	**0.78**	**0.0%**	**0.000**
		PC	33.3	33.0	7.8	0.23	**(-0.06-0.94)**		
	Specialists Global	TM	28.1	27.5	8.4	0.30	**0.66**	**0.0%**	**0.000**
		PC	35.0	35.0	7.8	0.22	**(-0.08-0.89)**		
	Global	TM	28.6	28.0	8.6	0.30	**0.65**	**4.2%**	**0.000**
		PC	35.2	34.0	7.9	0.22	**(-0.07-0.87)**		
App	Resident 1	TM	27.4	28.0	7.0	0.25	**0.52**	0.0%	**0.000**
		PC	36.1	35.0	7.8	0.22	**(-0.07-0.84)**		
	Resident 2	TM	27.1	26.0	6.5	0.24	**0.44**	0.0%	**0.000**
		PC	36.3	36.0	6.3	0.17	**(-0.04-0.80)**		
	Residents Global	TM	27.3	26.0	6.7	0.25	**0.48**	0.0%	**0.000**
		PC	36.2	35.5	7.1	0.20	**(-0.06-0.81)**		
	Specialist 1	TM	27.1	25.0	7.5	0.28	**0.54**	0.0%	**0.000**
		PC	36.5	35.0	7.9	0.22	**(-0.03-0.86)**		
	Specialist 2	TM	28.8	28.0	8.0	0.28	**0.54**	0.0%	**0.000**
		PC	36.2	36.0	7.6	0.21	**(-0.09-0.83)**		
	Specialists Global	TM	27.9	27.0	7.7	0.28	**0.53**	0.0%	**0.000**
		PC	36.3	35.5	7.7	0.21	**(-0.08-0.83)**		
	Global	TM	27.6	26.5	7.2	0.26	**0.51**	0.0%	**0.000**
		PC	36.3	35.5	7.4	0.20	**(-0.07-0.82)**		

TM: Traditional Method; PC: Point Connection Method; SD: Standard deviation; VC: Variation Coefficient; ICC: Intraclass Correlation Coefficient; AC: Absolute Concordance; *Student´s T-Test.

Conclusion

According to the results of the present study, the point connection technique showed an excellent ICC for HVA measurement and a very good ICC for IMA measurement. When compared to the traditional method, the new technique was not superior. Regarding the use of the smartphone application, the new method showed it can be measured by this tool with good levels of agreement.

Table 4. Concordance analysis for the IMA measurements using different methods: traditional method and point connection method

Tool	Evaluator	Method	Mean	Median	SD	VC	ICC	AC	p-value
Goniometer	Resident 1	TM	13.2	13.0	2.5	0.19	**0.54 (0.17-0.77)**	26.7%	**0.002**
		PC	14.9	16.0	3.6	0.24			
	Resident 2	TM	14.8	14.0	3.3	0.22	0.71 (0.47-0.85)	43.3%	0.075
		PC	15.6	17.5	3.6	0.23			
	Residents Global	TM	14.0	14.0	3.0	0.22	0.64 (0.40-0.78)	35.0%	**0.000**
		PC	15.3	16.0	3.6	0.23			
	Specialist 1	TM	13.2	13.0	2.9	0.22	**0.68 (-0.06-0.90)**	3.3%	**0.000**
		PC	15.1	15.0	2.4	0.16			
	Specialist 2	TM	13.8	14.0	2.8	0.20	0.80 (0.61-0.90)	50.0%	0.083
		PC	14.4	14.0	3.1	0.21			
	Specialists Global	TM	13.5	14.0	2.8	0.21	**0.73 (0.36-0.87)**	26.7%	**0.000**
		PC	14.8	15.0	2.8	0.19			
	Global	TM	13.7	14.0	2.9	0.21	0.68 (0.43-0.81)	30.8%	**0.000**
		PC	15.0	16.0	3.2	0.21			
App	Resident 1	TM	12.6	12.5	3.1	0.25	**0.63 (-0.08-0.88)**	6.7%	**0.000**
		PC	15.2	15.0	3.0	0.20			
	Resident 2	TM	13.0	13.0	3.0	0.23	**0.70 (0.00-0.90)**	13.3%	**0.000**
		PC	15.1	15.0	3.4	0.22			
	Residents Global	TM	12.8	13.0	3.0	0.24	**0.66 (-0.05-0.88)**	10.0%	**0.000**
		PC	15.2	15.0	3.2	0.21			
	Specialist 1	TM	13.0	13.0	2.6	0.20	**0.71 (0.17-0.89)**	3.3%	**0.000**
		PC	14.4	14.5	2.6	0.18			
	Specialist 2	TM	13.8	13.0	3.1	0.22	**0.60 (0.31-0.78)**	26.7%	**0.049**
		PC	14.3	14.0	2.9	0.20			
	Specialists Global	TM	13.4	13.0	2.8	0.21	**0.64 (0.33-0.78)**	15.0%	**0.001**
		PC	14.4	14.0	2.7	0.19			
	Global	TM	13.1	13.0	2.9	0.23	**0.65 (0.23-0.82)**	14.2%	**0.000**
		PC	14.8	15.0	3.0	0.20			

TM: Traditional Method; PC: Point Connection Method; SD: Standard deviation; VC: Variation Coefficient; ICC: Intraclass Correlation Coefficient; AC: Absolute Concordance; *Student´s T-Test.

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References

1. Vanore JV, Christensen JC, Kravitz SR, Schuberth JM, Thomas JL, Weil LS, et al. Diagnosis and treatment of first metatarsophalangeal joint disorders. Section 1: hallux valgus. J Foot Ankle Surg. 2003;42(3):112-23.
2. Coughlin MJ. Hallux valgus. J Bone Joint Surg Am. 1996;78(6):932-66.
3. Easley ME, Trnka HJ. Current concepts review: hallux valgus part 1: pathomechanics, clinical assessment, and nonoperative management. Foot Ankle Int. 2007;28(5):654-9.
4. Easley ME, Trnka HJ. Current concepts review: hallux valgus part II: operative treatment. Foot Ankle Int. 2007;28(6):748-58.
5. Coughlin MJ, Jones CP. Hallux valgus: demographics, etiology, and radiographic assessment. Foot Ankle Int. 2007;28(7):759-77.
6. Farber DC, Deorio JK, Steel MW. Goniometric versus computerized angle measurement in assessing hallux valgus. Foot Ankle Int. 2005;26(3):234-8.
7. Piqué-Vidal C, Maled-García I, Arabi-Moreno J, Vila J. Radiographic angles in hallux valgus: differences between measurements made manually and with a computerized program. Foot Ankle Int. 2006;27(3):175-80.
8. Panchbhavi VK, Trevino S. Comparison between manual and computer-assisted measurements of hallux valgus parameters. Foot Ankle Int. 2004;25(10):708-11.
9. Pinney SJ, Song KR, Chou LB. Surgical treatment of severe hallux valgus: the state of practice among academic foot and ankle surgeons. Foot Ankle Int. 2006;27(12):1024-9.
10. Seo JH, Ahn JY, Boedijono D. Point-connecting measurements of the hallux valgus deformity: a new measurement and its clinical application. Yonsei Med J. 2016;57(3):741-7.
11. Coughlin MJ, Saltzman CL, Nunley JA. Angular measurements in the evaluation of hallux valgus deformities: a report of the ad hoc committee of the American Orthopaedic Foot & Ankle Society on angular measurements. Foot Ankle Int. 2002;23(1):68-74.
12. Steinberg EL, Shasha N, Menahem A, Dekel S. Preoperative planning of total hip replacement using the TraumaCad™ system. Arch Orthop Trauma Surg. 2010;130(12):1429-32.
13. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. Psychol Bull. 1979;86(2):420-8.
14. Weir JP. Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. J Strength Cond Res. 2005:19(1):231-40.
15. Medronho RA, Bloch KV, Luiz RR, Werneck GL. Epidemiologia. São Paulo: Editora Atheneu; 2019.