Foot and Ankle Surgery 25 (2019) 507–510

Contents lists available at ScienceDirect

Foot and Ankle Surgery

journal homepage: www.elsevier.com/locate/fas

Hallux valgus interphalangeus: reliability of radiological assessment

Ihab Hujazi[a,*], Rafik Yassa[a], Hannah Sevenoaks[a], Mahdi Khalfaoui[a], Jim Barrie[b]

[a] North West Deanery, United Kingdom
[b] Trauma and Orthopaedics Department, Royal Blackburn and Burnley Hospitals, East Lancashire Hospitals Trust, United Kingdom

ARTICLE INFO

Article history:
Received 17 September 2017
Received in revised form 5 March 2018
Accepted 19 March 2018

Keywords:
Hallux
Valgus
Interphalangeus
Reliability

ABSTRACT

Background: Reliable radiographic measurement of hallux valgus interphalangeus (HVI) deformity has a role in guiding surgical management. HVI can be assessed using:

- Hallux interphalangeal angle (HIA).
- Distal articular set angle (DASA).
- Proximal to distal phalangeal articular angle (PDPA).

The aim of the study is to investigate the reliability of these radiological parameters.
Methods: Seventy foot radiographs in patients pre and post hallux valgus corrective surgery were assessed by 3 observers. HVI was assessed using the radiological measurements described above. Two-way random, single measure intra-class correlation coefficients were calculated to assess agreement.
Results: Inter-observer reliability showed good agreement for DASA [ICC = 0.77(0.61–0.88)], and excellent for HIA [ICC = 0.92(0.85–0.96)] and PDPA [ICC = 0.91(0.84–0.96)]. Intra-observer reliability was excellent for all angles; DASA [ICC = 0.88 (0.76–0.95)], HIA [ICC = 0.94(0.86–0.97)] and PDPA [ICC = 0.83(0.65–0.92)].
Conclusions: Reliability is good to excellent among these three radiological techniques for assessing HVI. The HIA and PDPA are slightly more reliable.

1. Introduction

Hallux valgus interphalangeus (HVI) is a deformity of the first ray, characterised by valgus angulation of the distal phalanx on the proximal phalanx. It is considered present if the hallux interphalangeus angle exceeds 10° [1–4]. Recent epidemiological studies suggest a high prevalence of HVI in patients presenting to foot and ankle surgeons [5].

HVI can present as an isolated deformity, it has been described in the adolescent population without traumatic precipitant and can develop after trauma to the interphalangeal joint [6,7]. More commonly, however it is seen in combination with hallux valgus deformity. Strydom et al. demonstrated that a hallux valgus interphalangeus deformity (>10°) was seen in 56% of patients with hallux valgus angulation greater than or equal to 15°, and HVI contributed significantly, with a positive linear relationship to total valgus deformity of the hallux.

The concept of correcting the total valgus deformity of the hallux has led to the practise of addressing both the hallux valgus angulation via osteotomy and soft tissue procedures, but also the hallux valgus interphalangeus deformity, most commonly via medial closing wedge osteotomy of the proximal phalanx and fixation (Akin osteotomy) [8–10].

Reliable radiographic measurement of hallux valgus interphalangeus deformity therefore has a role in guiding surgical management decisions, assessing post-operative outcomes, and building a robust evidence base for ongoing practise.

There have been studies that determine the reliability of radiological measurements in the context of hallux valgus, showing good inter-observer and intra-observer reliability for many of the commonly utilised parameters [11–19].

These studies, showed good reliability of measurements such as hallux valgus angle, intermetatarsal angle when measured on weight bearing radiographs of feet, in a variety of patients with and without clinically diagnosed hallux valgus deformity. Both D'Arcangelo and Menz et al. demonstrated that these

* Corresponding author at: 25 Wrenswood Drive, Worsley, Manchester, M28 7GS, United Kingdom.
E-mail address: hujazi@doctors.org.uk (I. Hujazi).

https://doi.org/10.1016/j.fas.2018.03.005

measurements correlate well with non-radiographic clinical severity scores of the deformity e.g. Manchester scale [20].

Of these studies, five included reliability analysis of measurement angles of hallux valgus interphalangeus deformity specifically. Three looked at the hallux interphalangeus angle [13,14,17] and two looked at both the hallux interphalangeus angle and the distal articular set angle [16,19].

The most commonly assessed angle was the angle between the long axis of the two phalanges of the hallux, the hallux interphalangeus angle (Fig. 1a). These studies showed a reasonable level of intra and inter-observer reliability for this angle with intra-class correlation co-efficients (ICC) ranging from 0.66 to 0.98 [13,14,16,17,19].

The distal articular set angle is measured between a line perpendicular to the longitudinal axis of the proximal phalanx and a line delineating the orientation of the proximal phalangeal base articular surface (Fig. 1b). Balding and Sorto published a radiological study in 1985 popularising the use of this angle, after initially being described by Piggott in 1960 [21,22]. Of the studies listed above, reasonable inter and intra-observer reliability for measurement of the distal articular set angle was found (ICC ranging from 0.72 to 0.82). [N.B Lee et al. refer to the distal articular set angle as PPAA.]

However, these studies measured angles in radiographs of non-operated feet in either normal volunteers or patients presenting with clinically diagnosed hallux valgus, with no reliability analysis of their application to post-operative imaging. Furthermore, there have been no reliability analyses of another angle utilised in our department to assess interphalangeus deformity, the proximal to distal phalangeal articular angle. This is the angle between the effective articular surface of the proximal and distal articular ends of the proximal phalanx of the hallux (Fig. 1c). It is unclear when this angle was first described, however it has been adopted by other authors to assess HVI [23].

The aim of the study is to investigate the reliability of measurements of these three angles, (hallux interphalangeus angle, distal articular set angle and the proximal to distal phalangeal articular angle) in the assessment of hallux valgus interphalangeus in both the preoperative and post-operative radiographs.

2. Material and methods

This retrospective observational radiological study was approved by our local research and development department.

2.1. Selection criteria

We included all the patients who underwent hallux valgus correction osteotomy for hallux valgus deformity, at East Lancashire NHS Trust, between March 2015 and March 2016 under the care of the senior author. The data for these patients was obtained from the logbook of the senior author operating register.

2.2. Exclusion criteria

Patients with previous foot fractures, congenital malformation, and tumours that could cause foot deformities.

2.3. Imaging and measurement protocols

All radiographs of the foot used standard dorso-plantar view of the foot with a 100-cm source to image distance, 15° of cephalic angulation of the tube, and the foot placed in the centre of the X-ray beam, at exposure factors of 1.4–0.8 mAs and 66–60 kV.

The software used to view the images was Siemens Syngo Plaza PACS system Version 2.0.0 (10.135.118.79). PACS measurement tools were used to obtain the required measurements.

Three observers (Orthopaedic Registrars) were trained and instructed to review the images and record the following measurements: hallux interphalangeal angle, distal articular set angle and proximal to distal phalangeal articular angle as per Fig. 1 and according to published references [4,21,23]. These measurements were then repeated four weeks later, with the observers blinded to their previous measurements as illustrated in Fig. 2.

2.4. Statistics & data analysis

Two-way random, single measure intra-class correlation coefficient (ICC with 95% confidence intervals) was calculated to assess for absolute agreement between the three observer's measurements of the three angles to determine inter-observer reliability for both operated and non-operated feet radiographs. Intra-observer reliability was also analysed for duplicate repeated measures on each radiograph at separate time points.

We calculated the prior sample size to determine the minimum number of patients required based on reliability testing. In this study, the ICCs were used for reliability testing at a target value 95%. We calculated the sample size to be 35 radiographs.

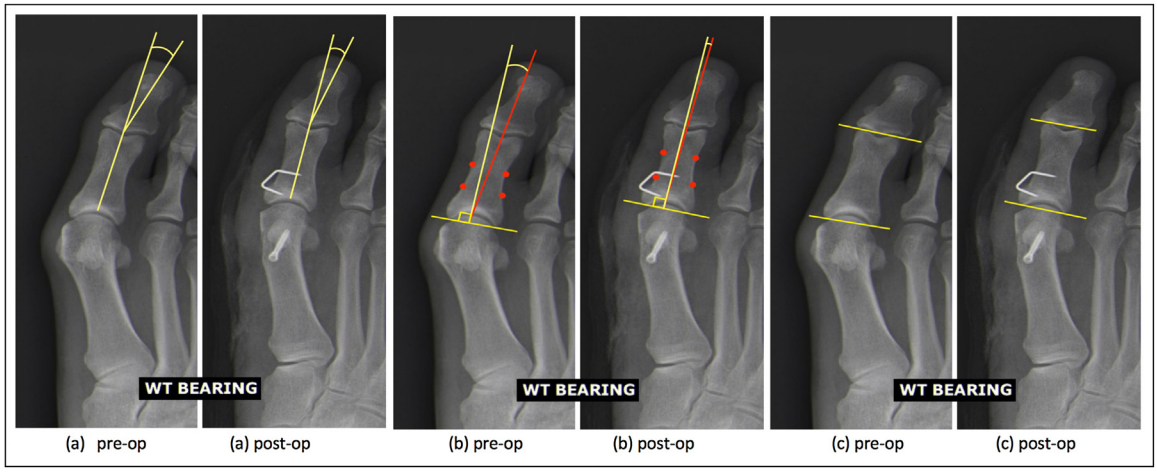

Fig. 1. Illustration of the method of measurement of the three angles studied before and after surgical management: (a) hallux interphalangeus angle, (b) distal articular set angle, (c) proximal to distal phalangeal articular angle.

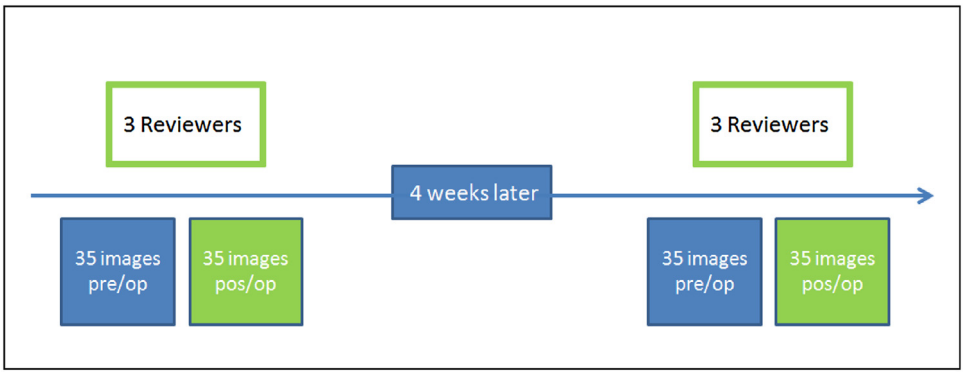

Fig. 2. Flowchart of study protocol.

3. Results

A total of 70 radiographs from 28 patients were included in the study (7 patients with bilateral radiographs). The 35 feet were x-rayed at two separate time points; pre and post hallux valgus surgery. There were 4 males and 24 females (M: 14%, F: 86%), with a mean age of 54 years (range 20–80).

17 patients underwent Chevron osteotomy; out of them fifteen had an adjunct Akin osteotomy, while 18 patients underwent SCARF osteotomy and all of them had an adjunct Akin osteotomy.

Inter-observer reliability was acceptable in the assessment of distal articular set angle measurement in the pre and post-operative radiographs (ICC 0.63 and 0.68) respectively. The inter-observer reliability of hallux interphalangeus angle (ICC pre op 0.83, post op 0.86) and proximal to distal phalangeal articular angle measurements (ICC pre op 0.80–post op 0.83) were both excellent in the pre and post-operative radiographs respectively (Table 1).

Intra-observer reliability was also acceptable for each of the angles measured, ICC (95% CI) for each of the 3 observers (Table 2).

4. Discussion

Hallux valgus deformity is one of the most common musculo-skeletal disorders in the orthopaedic foot and ankle clinic. A recent survey in the United Kingdom suggested that 28.4% of adults have hallux valgus deformity [24].

It occurs frequently with a medial deviation of the first metatarsal bone, a deformity on the phalangeal bone and interphalangeal joint, and pronation with sesamoid subluxation.

A thorough knowledge and understanding of the pathologic conditions present with hallux valgus deformity is essential to offer the correct surgical treatment as it is not an isolated joint deformity, but rather a complex deformity of the first ray often associated with hallux valgus interphalangeus (HVI) deformity.

It is essential to assess the HVI deformity in the preoperative stage to consider offering surgical correction with a medial closing wedge osteotomy and fixation (Akin Osteotomy) [10].

Many studies have evaluated radiological inter-observer and intra-observer reliability in hallux valgus assessment [11,25–27]. This is the first study to evaluate the radiological assessment of hallux interphalangeus deformity measurements in radiographs of operated and non-operated feet in patients with hallux valgus deformity.

Previous studies have indicated poor reliability in certain radiological measurement of hallux valgus deformity. For example, the distal metatarsal articular angle offered poor inter and intra-observer reliability along with assessments of the first ray metatarsal phalangeal joint congruity [11,25].

Our study demonstrates that the assessment of hallux interphalangeus deformity via the three selected angles is generally reliable. We found that the angle measurements based off articular margins (distal articular set angle and proximal to distal phalangeal articular angle) offered reasonable reliability. We thought it is important to assess these angles, which require measurement of joint surfaces in the first metatarsal phalangeal joint, in light of the questionable reliability of DMAA measurements. We suspect that the usual concavity of the articular margins assessed (proximal and distal articular surfaces of the proximal phalanx) in the angles we studied, makes for an easier and more reproducible measurement, certainly when compared to the commonly convex distal metatarsal articular surface.

In this study, the hallux interphalangeus angle and proximal to distal phalangeal articular angle had the highest intra/inter-observer reliability in pre and post-operative stages with ICC value greater than 0.75, while the distal articular set angle was inferior in

Table 1
Inter-observer reliability (intra-class correlation coefficient) in measurement of angles in pre and post operative radiographs.

	Pre operative radiographs	Post operative radiographs	Inter-observer reliability
Distal articular set angle	0.63	0.68	Good
Hallux interphalangeus angle	0.83	0.86	Excellent
Proximal to distal phalangeal articular angle	0.80	0.83	Excellent

Table 2
Intra-observer reliability (intra-class correlation coefficient) of measurement of angles across all radiographs.

	Observer 1	Observer 2	Observer 3
Distal articular set angle	0.66	0.77	0.84
Hallux interphalangeus angle	0.81	0.86	0.91
Proximal to distal phalangeal articular angle	0.75	0.87	0.88

comparison in both the intra and inter-observer reliability. The reasons behind the relative inferiority of the distal articular set angle are unclear. Comparison with our data with the literature suggests comparability with the distal articular set angle data and hallux interphalangeus angle results. With no previous reliability analysis with which to compare our proximal to distal phalangeal articular angle results showed excellent reliability. There remains no stand out consistently reliable angle for use in the assessment of HVI across the literature, but our study is the first to include post-operative imaging. We consider the relative inferiority of the distal articular set angle an interesting observation, in view of it essentially being a combination of the two other measurements i.e. a measurement of both a longitudinal axis (of the proximal phalanx) and an articular margin (proximal margin of the proximal phalanx).

4.1. Limitations

The measurements used in this study focus only on the angular deformities of HVI in the transverse plane as assessed on plain dorso-plantar weight bearing radiographs. Both hallux valgus and hallux valgus interphalangeus are complex three-dimensional deformities and the interpretation of plain film radiographs in these patients must be done with caution.

Our cohort of patients included only those with hallux valgus deformity who underwent corrective surgery. We therefore cannot draw any conclusions on the reliability of these measurements in the wider population.

This study did not focus on correlation between the radiographic measurements, clinical deformity and the intra-operative management because of the retrospective nature of the study.

5. Conclusion

Hallux interphalangeus angle and proximal to distal phalangeal articular angle measurements of hallux valgus interphalangeus have excellent intra and inter-observer reliability, both pre and post hallux valgus surgery. The distal articular set angle has lesser agreement within and between observers but remains at acceptable levels.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors declare that they have no conflict of interest.

References

[1] Sorto L., Balding M, Weil L, Smith S. Hallux abductus interphalangeus: etiology, x-ray evaluation and treatment. J Am Podiatry Assoc 1976;66(June (6)):384–96.
[2] Daw SW. An unusual type of hallux valgus (two cases). Br Med J 1935;580.
[3] Gentili A, Masih S, Yao L, Seeger L. Pictorial review: foot axes and angles. Br J Radiol 1996;69(October (826)):968–74.
[4] Karasick D, Wapner K. Hallux valgus deformity: preoperative radiologic assessment. Am J Roentgenol 1990;155(1):119–23.
[5] Strydom A, Saragas N, Ferrao P. A radiographic analysis of the contribution of hallux valgus interphalangeus to the total valgus deformity of the hallux. Foot Ankle Surg 2017;23(March (1)):27–31.
[6] Grawe B, Parikh S, Crawford A, Tamai J. Hallux valgus interphalangeus deformity: a case series in the pediatric population. Foot Ankle Surg 2012;18 (March (1)):4–8.
[7] Shimizu A, Watanabe S, Kamada K, Tsuboi I, Yamamoto H. Hallux valgus interphalangeus following osteochondral fracture of the proximal phalanx: a case report. Foot Ankle Int 2005;26(November (11)):994–6.
[8] Akin O. The treatment of hallux valgus: a new operative procedure and its results. Med Sentin 1925;33:678–9.
[9] Duke H, Newman L, Bruskoff B, Daniels R. Hallux abductus interphalangeus and its relationship to hallux abducto valgus. J Am Podiatry Assoc 1982;72 (12):625–8.
[10] Arnold H. The akin procedure as closing wedge osteotomy for the correction of a hallux valgus interphalangeus deformity. Oper Orthop Traumatol 2008;20 (6):477–83.
[11] Coughlin M, Freund E. The reliability of angular measurements in hallux valgus deformities. Foot Ankle Int 2001;22(5):369–79.
[12] Saltzman C, Brandser E, Berbaum K, DeGnore L, Holmes J, Katcherian D. Reliability of standard foot radiographic measurements. Foot Ankle Int 1994;15(December (12)):661–5.
[13] Bryant A, Tinley P, Singer K. A comparison of radiographic measurements in normal, hallux valgus, and hallux limitus feet. J Foot Ankle Surg 2000;39 (1):39–43.
[14] Menz H, Munteanu S. Radiographic validation of the Manchester scale for the classification of hallux valgus deformity. Rheumatology 2005;44(August (8)):1061–6.
[15] Saro C, Johnson D, Martinez de Aragón J, Lindgren U, Felländer-Tsai L. Reliability of radiological and cosmetic measurements in hallux valgus. Acta Radiol 2005;46(January (8)):843–51.
[16] D'Arcangelo P, Landorf K, Munteanu S, Zammit G, Menz H. Radiographic correlates of hallux valgus severity in older people. J Foot Ankle Res 2010;16 (September (3)):20.
[17] Srivastava S, Chockalingam N, El Fakhri T. Radiographic angles in hallux valgus: comparison between manual and computer-assisted measurements. J Foot Ankle Surg 2010;49(6):523–8.
[18] Shima H, Okuda R, Yasuda T, Jotoku T, Kitano N, Kinoshita M. Radiographic measurements in patients with hallux valgus before and after proximal crescentic osteotomy. J Bone Joint Surg Am 2009;91(June (6)):1369–76.
[19] Lee K, Ahn S, Chung C, Sung K, Park M. Reliability and relationship of radiographic measurements in hallux valgus. Clin Orthop Relat Res 2012;470 (September (9)):2613–21.
[20] Garrow A, Papageorgiou A, Silman A, Thomas E, Jayson M, Macfarlane G. The grading of hallux valgus. The Manchester scale. J Am Podiatr Med Assoc 2001;91(February (2)):74–8.
[21] Balding M, Sorto L. Distal articular set angle. Etiology and x-ray evaluation. J Am Podiatr Med Assoc 1985;75(December (12)):648–52.
[22] Piggott H. The natural history of hallux valgus in adolescence and early adult life. Bone Joint J 1960;42(4):749–60.
[23] Dixon A, Lee L, Charlton T, Thordarson D. Increased incidence and severity of postoperative radiographic hallux valgus interphalangeus with surgical correction of hallux valgus. Foot Ankle Int 2015;36(August (8)):961–8.
[24] Roddy E, Zhang W, Doherty M. Prevalence and associations of hallux valgus in a primary care population. Arthritis Care Res 2008;59(6):857–62.
[25] Chi T, Davitt J, Younger A, Holt S, Sangeorzan B. Intra-and inter-observer reliability of the distal metatarsal articular angle in adult hallux valgus. Foot Ankle Int 2002;23(8):722–6.
[26] Condon F, Kaliszer M, Conhyea D, O'Donnell T, Shaju A, Masterson E. The first intermetatarsal angle in hallux valgus: an analysis of measurement reliability and the error involved. Foot Ankle Int 2002;23(8):717–21.
[27] Resch S, Ryd L, Stenström A, Johnsson K, Reynisson K. Measuring hallux valgus: a comparison of conventional radiography and clinical parameters with regard to measurement accuracy. Foot Ankle Int 1995;16(May (5)):267–70.