Radiographic validation of the Manchester scale for the classification of hallux valgus deformity

H. B. Menz and S. E. Munteanu1

Objectives. Hallux valgus is a common orthopaedic condition affecting elderly people. Grading the severity of the condition commonly involves obtaining measurements from radiographs, which may not be feasible or necessary in some clinical or research settings. Recently, a non-invasive clinical assessment tool (the Manchester scale), consisting of four standardized photographs, has been developed; however, its validity has not yet been determined. Therefore, the objective of this study was to determine the validity of this tool by correlating Manchester scale scores with hallux valgus measurements obtained from radiographs.

Methods. Weight-bearing dorsoplantar foot radiographs were obtained from 95 subjects (31 men and 64 women) aged 62–94 yr (mean 78.6, S.D. 6.5), and measurements of the hallux abductus angle, intermetatarsal angle and hallux interphalangeal abductus angle were performed. These measurements were then correlated with the Manchester scale scores (none, mild, moderate or severe).

Results. The Manchester scale score was highly correlated with hallux abductus angle (Spearman's ρ = 0.73, P < 0.01) and moderately associated with intermetatarsal angle (ρ = 0.49, P < 0.01) measurements obtained from radiographs. Analysis of variance revealed significant differences in mean hallux abductus angles [F(3) = 119.99, P < 0.001] and intermetatarsal angles [F(3) = 29.56, P < 0.001] between the four Manchester scale categories.

Conclusions. These findings indicate that the Manchester scale provides a valid representation of the degree of hallux valgus deformity determined from radiographic measurement of hallux abductus angle and intermetatarsal angle. We therefore recommend the use of this instrument as a simple, non-invasive screening tool for clinical and research purposes.

Key words: Aged, Hallux valgus, X-ray measurement.

Hallux valgus is a common condition in which the first metatarsophalangeal joint becomes progressively subluxed, leading to lateral deviation of the hallux, medial displacement of the distal end of the first metatarsal and bony enlargement of the first metatarsal head (often referred to as a ‘bunion’) [1]. Numerous factors have been implicated in the aetiology of the condition, including muscle imbalances, inherited structural variations in the alignment of the metatarsals, flatfoot and ill-fitting footwear [2, 3]. The prevalence of the condition increases with age, and community studies have reported that between 12 and 56% of people aged over 65 yr are affected [4–8]. In older people, the presence of severe hallux valgus has been shown to impair balance [9] and gait patterns [10], and two prospective studies have indicated that hallux valgus is an independent risk factor for falls [11, 12].

Although hallux valgus is generally regarded as being one of the most common orthopaedic foot conditions, its true prevalence is difficult to ascertain due to variations in the case definitions used across different studies. In community-based epidemiological investigations, hallux valgus is often documented as simply being present or absent [4–8]. Such an approach is clearly inadequate, as a broad spectrum of deformity exists, and differences in the severity of the deformity are likely to be functionally significant. From a radiographic perspective, hallux valgus is generally considered to be present when the angle formed between the longitudinal bisections of the first metatarsal and proximal phalanx (often referred to as the hallux abductus angle) is greater than 15° [13, 14]. More detailed classifications of the deformity have been proposed for presurgical planning purposes, which consider not only the hallux abductus angle but also the degree of displacement of the sesamoids and the level of osteoarthritic change within the first metatarsophalangeal joint [15]. However, because it is not always feasible or necessary to obtain radiographs to grade the severity of hallux valgus, there exists a need for a simple yet valid grading scale for clinical and research applications.

Previously reported techniques for non-radiographic categorization of hallux valgus have included tracing around the foot [16] and tape measures of forefoot girth [17, 18]; however, the validity of these approaches is questionable. In response to the limitations of previous techniques, Garrow et al. [19] developed the Manchester scale, a clinical tool consisting of photographs of feet with four levels of hallux valgus: none, mild, moderate and severe (Fig. 1). This standardized set of photographs was selected from a larger set of 22 photographs, based on the consensus opinions of 12 experienced foot specialists. Both intratester and intertester reliability of grading hallux valgus using this approach have been found to be excellent, with κ values of 0.77 and 0.86, respectively, suggesting that it is a useful tool for clinical and research purposes [19, 20]. However, it has not yet been established whether this approach is valid; i.e. whether the grading of hallux valgus using this technique accurately represents the

Musculoskeletal Research Centre, Faculty of Health Sciences and 1Department of Podiatry, School of Human Biosciences, La Trobe University, Bundoora, Victoria, Australia.

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Correspondence to: H. B. Menz, Musculoskeletal Research Centre, School of Physiotherapy, Faculty of Health Sciences, La Trobe University, Bundoora, Victoria 3086, Australia. E-mail: h.menz@latrobe.edu.au

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underlying osseous deformity of the first metatarsophalangeal joint. Therefore, the aim of this study was to evaluate the validity of the Manchester scale by correlating the photographic classifications to angular measurements obtained from foot radiographs.

**Methods**

**Subjects**

The study sample comprised 95 retirement village residents (31 men and 64 women) aged 62-94 yr (mean 78.6, s.d. 6.5) who were recruited as part of a larger study of lower limb risk factors for falls. Residents were deemed ineligible for the study if they had very limited mobility (i.e. were unable to ambulate household distances without an assistive device) or were cognitively impaired (defined as a score of <7 on the Short Portable Mental Status Questionnaire) [21]. The Human Studies Ethics Committee at La Trobe University and the Radiation Advisory Committee of the Victorian Department of Human Services gave approval for the study, and written informed consent was obtained from all subjects prior to their participation. All X-ray procedures were performed according to the National Health and Medical Research Council of Australia guidelines [22].

**Manchester scale assessment**

To determine the severity of hallux valgus using the Manchester scale, life-size versions of the photographs in the original publication were printed and laminated (Fig. 1). Subjects stood on an elevated platform and were instructed to walk in place for a few steps and then stand in a relaxed position. The examiner placed the photographs alongside subjects' weight-bearing feet, and selected which photograph most closely resembled their degree of hallux valgus [20]. The severity of hallux valgus for both feet was then documented as no deformity (grade 1), mild deformity (grade 2), moderate deformity (grade 3) or severe deformity (grade 4) [19].

**Fig. 1.** The Manchester scale. (A) No deformity (grade 1); (B) mild deformity (grade 2); (C) moderate deformity (grade 3); (D) severe deformity (grade 4). Diagram adapted from Garrow et al. [19].
Radiographic assessment

Weight-bearing dorsoplantar radiographs were obtained with the subject standing in the same manner as described above. Each radiograph was then placed on a horizontally positioned X-ray viewing box, and covered with overhead transparency film. Using a 1-mm thick non-permanent overhead transparency marking pen, the following angles were determined (Fig. 2). The hallux abductus angle (A) was the angle formed between a longitudinal bisection of the first metatarsal (using a line constructed between a bisection of the head of the first metatarsal and a bisection of the base of the first metatarsal [23]) and a longitudinal bisection of the proximal phalanx; the intermetatarsal angle (B) was the angle formed between longitudinal bisections of the first and second metatarsal shafts; and the hallux interphalangeal abductus angle (C) was the angle formed between longitudinal bisections of the proximal phalanx and distal phalanx.

To determine the test–retest reliability of these measurements, 1-month retests were performed on 20 randomly selected subjects without reference to previously recorded values. A 1-month retest period was considered to be long enough for the examiner to be unable to recall previous observations. To determine intertester reliability, each of the authors measured the same subset of subjects independently.

Statistical analysis

Measurements obtained from right and left feet were pooled for statistical analysis, resulting in a sample size of 190 feet. Although this approach is not always appropriate in clinical studies [24], it was considered to be acceptable in this investigation for two reasons. Firstly, the severity of hallux valgus is frequently asymmetrical, and in clinical practice it is often necessary to assess right and left feet individually. Secondly, the main conceptual and statistical problems associated with pooling data occur when inferences are made to individual patients on the basis of paired measurements. Because the objective of this study was simply to correlate clinical and radiographic measurements of hallux valgus deformity and not to make inferences regarding individual patients, the unit of analysis was considered to be a foot rather than a subject.

All analyses were performed using SPSS Release 11.5 for Windows (SPSS, Chicago, IL, USA). To determine the retest reliability of the radiographic measurements, intraclass correlation coefficients (ICCs) (3,1) [25] and 95% limits of agreement [26] were calculated. To determine the degree of association between Manchester scale scores and radiographic measurements, Spearman’s ρ correlation coefficients were calculated. To determine whether there were significant differences in mean radiographic measurements for each of the four Manchester scale categories, a one-way analysis of variance was used. Post hoc comparisons were performed using Bonferroni-adjusted t-tests.

Results

Manchester scale scores

Frequencies of the Manchester scale scores for right and left feet are shown in Table 1. The grading of hallux valgus was asymmetrical in 35 subjects. Manchester scale scores were significantly associated with gender, women exhibiting more severe hallux valgus on both right ($\chi^2 = 11.26, P < 0.05$) and left ($\chi^2 = 9.86, P < 0.05$) feet.

Reliability of radiographic measurements

Mean (± s.d.) values for each of the radiographic parameters at test and retest, along with intraclass correlation coefficients (3,1) and 95% limits of agreement, are shown in Table 2. The three radiographic measurements demonstrated very high test–retest reliability, with ICCs between 0.87 and 0.99, and narrow 95% limits of agreement.

Mean (± s.d.) values for each of the radiographic parameters for the two examiners, along with intraclass correlation coefficients (3,1) and 95% limits of agreement, are shown in Table 3. Hallux abductus angle and intermetatarsal angle demonstrated high intertester reliability (ICCs 0.87 and 0.96, respectively), although the reliability of hallux interphalangeal abductus angle was only moderate (ICC 0.77).
Relationship between Manchester scale scores and radiographic measurements

The Manchester scale scores were strongly associated with the hallux abductus angle ($\rho=0.73$, $P<0.01$). Weaker associations were found between the Manchester scale scores and the intermetatarsal angle ($\rho=0.49$, $P<0.01$) and hallux interphalangeal abductus angle ($\rho=-0.25$, $P<0.01$). Mean values for the hallux abductus angle, intermetatarsal angle and hallux interphalangeal abductus angle ($\pm 95\%$ confidence intervals) for each of the four Manchester scale categories are shown in Figs 3–5.

The one-way analysis of variance revealed a significant relationship between the Manchester scale score and the hallux abductus angle $[F(3) = 119.99, P<0.001]$. Bonferroni post hoc comparisons revealed significant differences in mean hallux abductus angles between all four Manchester scale groups, with the exception of the ‘none’ vs ‘mild’ comparison. Finally, the analysis of variance revealed a significant relationship between the Manchester scale score and the hallux interphalangeal abductus angle $[F(3) = 9.89, P<0.001]$. Bonferroni post hoc comparisons revealed a significant difference in the mean hallux interphalangeal abductus angle in the ‘severe’ group compared with the ‘none’, ‘mild’ and ‘moderate’ groups, indicating that subjects with severe hallux valgus had a smaller degree of interphalangeal abductus.

Discussion

The purpose of this study was to determine the validity of grading the severity of hallux valgus deformity using a set of standard photographs (the Manchester scale) by correlating the clinical grading scores with angular measurements obtained from radiographs. The first consideration when interpreting these results is the accuracy of the gold standard radiographic measurements. Test–retest reliability of each of the measurements was found to be very high, with ICCs between 0.87 and 0.99. More importantly, the
The intermetatarsal angle ranged from 0 to 6°. Although subjects with more pronounced hallux valgus demonstrated greater variability and some degree of overlap between the 'severe' group and the 'none', 'mild' and 'moderate' groups. The Manchester scale scores are highly correlated with hallux abductus angle measurements obtained from radiographs. Furthermore, the mean hallux abductus angles varied significantly between each of the four Manchester scale categories, indicating a clear separation between the four groups. It can be concluded from these results that the Manchester scale is a valid tool for measuring the hallux abductus angle.

The findings reported here indicate that the ordinal grading of hallux valgus deformity using the Manchester scale is highly correlated with hallux abductus angle measurements obtained from radiographs. Furthermore, the mean hallux abductus angles were found to differ significantly between each of the four Manchester scale categories, indicating a clear separation between the four groups. It can be concluded from these results that the Manchester scale is a valid measure of the hallux abductus angle. Although also significantly correlated with Manchester scale scores, the 95% confidence intervals for the intermetatarsal angle demonstrated greater variability and some degree of overlap between the 'none' and 'mild' categories (Fig. 4). This suggests that, although subjects with more pronounced hallux valgus had, on average, a larger intermetatarsal angle, the Manchester scale score could not be considered to be as accurate an indicator of this parameter, particularly for less severe forms of the condition. The hallux interphalangeal abductus angle demonstrated a weak negative correlation with the Manchester scale score, indicating that the position of the distal phalanx relative to the proximal phalanx makes a very minor contribution to the visual determination of hallux valgus severity. Figure 5 shows that this correlation is primarily due to the markedly smaller hallux interphalangeal abductus angle in the 'severe' hallux valgus group, which is likely to be due to the distal phalanx being forced into a less abducted position due to compression against the second toe.

Despite the strong association with hallux abductus angle, it needs to be considered that, like any clinical tool, the Manchester scale has a number of limitations. Perhaps the most significant limitation is that the grading of hallux valgus severity is based primarily on the degree of abduction of the hallux relative to the first metatarsal. Although this parameter is the most obvious manifestation of the condition and is also likely to be the most functionally significant, other components of hallux valgus, such as sesamoid displacement, frontal plane rotation and range of motion, are not considered. A second limitation is that although there were significant differences in the mean hallux abductus angle between all Manchester scale grades, the total range of values slightly overlapped for the 'none' and 'mild' groups, indicating that differentiation between milder levels of deformity may not always be accurate. Finally, although it has considerable merit as a clinical screening tool, the Manchester scale with its four levels may not be precise enough for some applications, such as presurgical planning or evaluating the effects of clinical interventions.

The use of standard photographs to grade disease severity has been employed in a range of disciplines, such as dermatology [34, 35], ophthalmology [36, 37] and rheumatology [38]. Such an approach has numerous benefits in that it is low-cost and non-invasive, requires minimal training, and the results obtained can be easily compared across different settings. The results of this study indicate that the Manchester scale is a valid tool for grading hallux valgus deformity. Based on these findings, in conjunction with the high inter- and intrater reliability reported previously in the literature, the Manchester scale can be recommended for both clinical and research purposes where a simple, non-invasive grading of hallux valgus is required.

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