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Development of Multidimensional Nil Hallux Valgus Scale: a reliability and validity study

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Objective: The aim of this study was to develop a disease-specific multidimensional hallux valgus (HV) scale, as well as to establish the validity and reliability thereof.

Methods: The 14-item Multidimensional Nil Hallux Valgus Scale was developed. The scale has a score range of 0–60, with higher score indicating increased HV symptoms, complaints, and functional disorder. Among the patients referred to our clinic with HV diagnosis based on anterior-posterior non-weight-bearing radiography of the affected foot, 129 feet of 66 patients (63 bilateral, 3 unilateral) were included in the study. In clinical evaluations of these HV patients, American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal Joints Scale (AOFAS-MTF-IF), Manchester Scale, and Short Form 36 Health Survey (SF-36) were used to test the validity and reliability of the new scale.

Results: From factor analyses, it was observed that the items clustered in 5 factors, which explained 73.2% of the variance. Floor and ceiling effects were observed to be within normal limits (floor effect: 3.1%; ceiling effect: 0.8%). The Cronbach's alpha level related with the overall internal consistency of the scale was estimated as 83.3%, and the Cronbach's alpha for the subheadings of the scale varied between 33.9% and 74.2%. High correlation was observed regarding test-retest reliability of the scale.

Conclusion: This newly developed scale allows for the holistic evaluation of HV including the condition-specific parameters and is a valid and reliable scale that can be conveniently used by health care professionals.

Keywords: Deformities; Hallux Valgus; reliability; scales; validity.

Level of Evidence: Level II, Diagnostic Study.

Hallux valgus (HV) is a common condition, appearing as the inclination of the great toe (hallux) towards the second toe, starting from the first metatarsophalangeal (MTP) joint. Medial deviation of the first metatarsal and lateral deviation with internal rotation through the longitudinal axis of the big toe occur in HV.[1–4]

HV is quite common in all age groups, and depending on the severity of the condition, it may adversely affect health-related quality of life (HRQOL) with several complaints, such as dissatisfaction with the appearance of the foot, difficulty in shoe selection, gait disturbance and thus limitation of daily activities, arch pathologies, nail disorders, and occurrence of bunions and calluses.[5] The most commonly used method and the gold standard

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for HV deformity assessment is angular measurement of the first MTP joint using anterior-posterior X-ray imaging.[6] Pre- and post-treatment measurement of the first MTP joint angle using a universal goniometer is a common method utilized by physiotherapists for treatment planning and evaluation of the outcome, respectively.[7] However, these measurements only indicate the angular severity of the deformity. The Manchester Scale, which depends on the comparison of the appearance of the concerned foot with the photographs of 4 feet with varying levels of HV deformity, is another oft-used subjective assessment tool.[8] Later, the Manchester-Oxford Foot Questionnaire, which is a patient reported outcome measure, was developed.[9] In the assessment of ankle- and foot-related problems, there exist several tools in the literature, each of which is tailored to different problems and/or different patients or age groups, and presents the problems using different parameters. Foot Function Index,[10] Foot and Ankle Outcome Score,[11] Foot Posture Index,[12] Foot Posture Index-6 for pediatric patients,[13] Foot and Ankle Ability Measurement,[14] and American Orthopaedic Foot and Ankle Society (AOFAS) clinical rating scale, which also includes exclusive scales for the toe and forefoot, are tools that are commonly used.[15] To determine the effects of foot-related problems such as HV on HRQOL, several other scales such as the Short Form 36 Health Survey (SF-36) and Nottingham Health Profile are implemented.[16,17] A detailed investigation of the assessment tools listed above indicates that most of these tools depend on patients' subjective evaluations of their own findings and limitations, some of these tools are not pathology-specific, and the ones that are capable of identifying the pathology are not capable of assessing several important parameters of the deformity. Radiographic method is used more frequently than the other methods and provides information regarding the condition of the joints, but it requires standard position of the feet, as well as technical knowledge and experience. Additionally, none of the aforementioned assessment tools are pathology-specific in rating HV deformity.

A detailed description of all parameters of the HV deformity is needed to guide healthcare professionals with regard to treatment options and to present the outcomes of conservative and surgical treatments. To attain this, a pathology-specific objective multidimensional assessment tool capable of evaluating all symptoms, findings, and parameters other than angular severity is needed.

The primary aim of the present study was to develop a pathology-specific multidimensional scale to assess hallux valgus deformity in all concomitant parameters. In addition, the present study aimed to investigate the consistency of the subsections of the scale, to test its validity against radiographic measurement—the gold standard—and to test the reliability of the scale by comparing it with other assessment tools whose validity and reliability have been previously established.

Patients and methods

Development of the Multidimesnional Nil Hallux Valgus Scale

The Multidimensional Nil Hallux Valgus Scale was developed based on the scale development stages described by Guyatt et al.[18] Foot-and ankle-related popular valid assessment tools used in HV were analyzed. The content of the scale was grouped according to the relevant parameters, and the first draft of the scale was produced. The draft was analyzed by an expert panel composed of a physiatrist and 4 physiotherapists and revised several times following recommendations. The revised first draft with 21-item was administered to 60 patients with HV. The scale with 14-item was administered to 58 Turkish patients, and the point weights of the subheadings of the scale were revised accordingly.

Following the approximately 3-year revision processes, the final version of the 14-item Multidimensional Nil Hallux Valgus Scale was developed.[19] In the scale, perceived maximum pain was evaluated using Visual Analog Scale, and the measurements were recorded.[20] Passive first MTP joint extension range of motion, passive first MTP joint abduction loss of range of motion, and first MTP joint adduction angle in static position were measured using a universal goniometer.[21] These 3 angular values were recorded for the affected foot. Scores for 4 other concomitant parameters were also recorded: great toe active abduction movement, medial longitudinal arch drop, distal phalanx rotation, and hallux valgus interphalangeus. Scores of 6 parameters were recorded: walking distance without pain, pain during push-off, avoidance of daily activities, avoidance of social activities, discomfort with shoes, and dissatisfaction with foot appearance. The total score range of the scale was set between 0 and 60. Increasing score indicated an increase in symptoms, complaints, and functional problems.

The study included 129 feet (63 bilateral, 3 unilateral) of 66 patients with an age range of 17–74 years who were referred to our clinic with a diagnosis of HV (Figure 1). In calculating the number of participants, the criteria used for the development of the scale were considered.[22] Patients with cognitive, mental, and psychological problems and/or severe infection were excluded from the study. Patients' age, gender, BMI, and direction of the foot with HV were recorded. All patients were

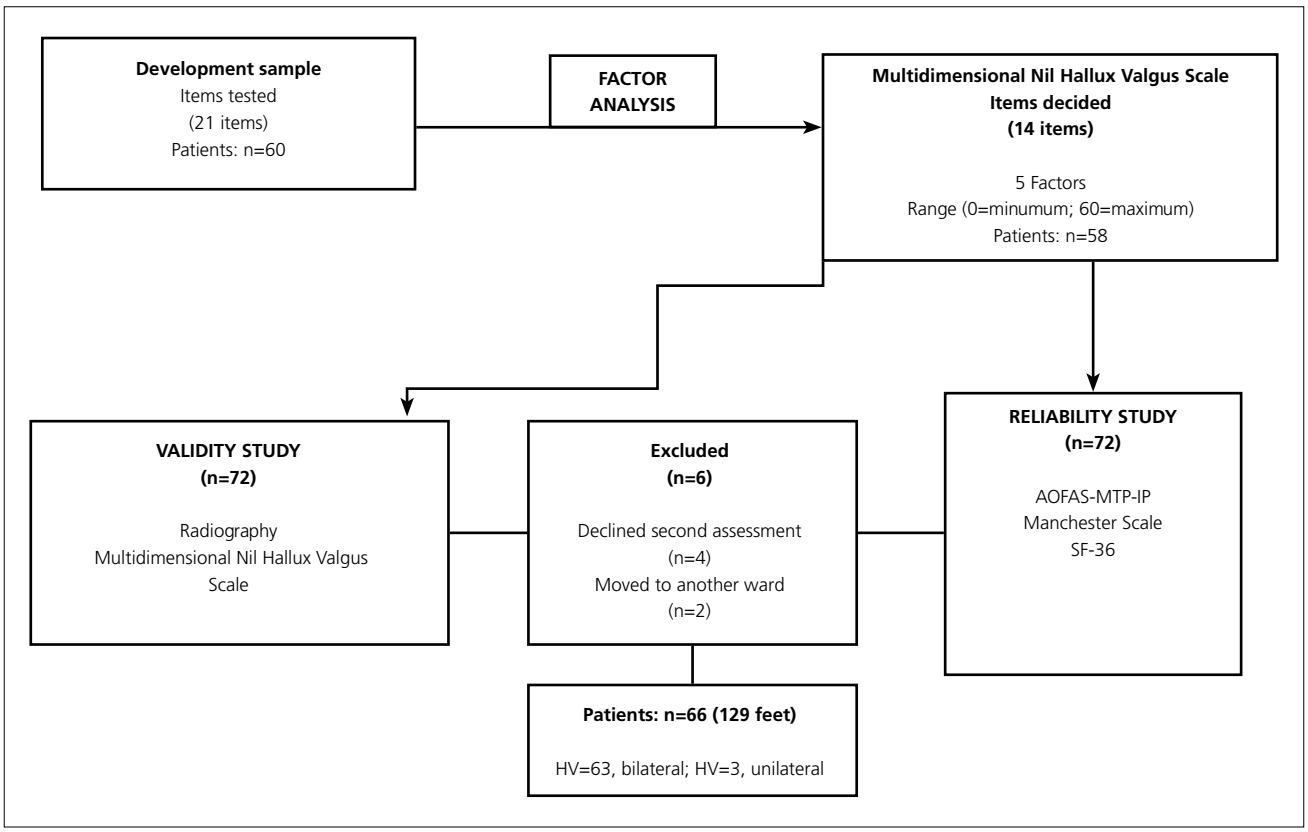

Fig. 1. Consort diagram. HV: Hallux valgus; AOFAS-MTP-IP: American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal Joints Scale; SF-36: Short Form 36 Health Survey.

evaluated using American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal Joints Scale (AOFAS-MTF-IF), Manchester Scale, SF-36, and the Multidimensional Nil Hallux Valgus Scale.

AOFAS-MTF-IF is a scale including 100 items in 3 categories: pain, function, and alignment. This scale is clinician-administered, with higher scores indicating better function.[23] The Manchester Scale is an assessment tool which uses images to classify HV deformity in 4 groups: 0=no deformity; 1=mild deformity; 2=moderate deformity; and 3=severe deformity.[8] SF-36 is used to evaluate HRQOL in 8 subscales: physical function, physical role, emotional role, social function, mental health, energy/vitality, pain, and general health perception. The score range of each subscale is 0–100, with a higher score indicating better health condition.[24,25] For patients with bilateral deformity, all scales except SF-36 were administered on both feet.

Using the angle measuring feature of RadiAnt DICOM Viewer® free software (version 2.0.9 for Windows), the first MTP angle, first and second intermetatarsal angles (IMA), and first interphalangeal (IPA) angle were measured on standard radiographic images of the patients. To verify test-retest reliability, the same researchers repeated all measurements for the same patients in 7–10 days following completion of the first measurements. Required permissions were obtained from the institution's Non-invasive Research Ethics Committee, and signed informed consent forms were obtained from all patients.

Data obtained were analyzed using SPSS software (version 21, SPSS Inc., Chicago, IL, USA). Construct validity of the scale was verified via factor analysis. The number of factors was determined based on the eigenvalue-greater-than-one rule. Principal component factor analysis was used as the factor extraction method. Varimax rotation was performed to maintain proper factorization. Internal consistency of the whole scale as well as each subscale, which was formed by factor analysis, was presented via Cronbach's alpha coefficients.[22] Reliability of the scale was presented as test-retest correlation coefficient, and Spearman's correlation coefficient was used. The correlations of the scale with other scales and angular measurements were presented as Spearman's correlation coefficient. Floor and ceiling effects on the score distribution of the scale were calculated. Significance level for all analyses was set at $p<0.05$.

Results

Demographic data of the participants are presented in Table 1.

Based on the factor analysis results, items attending to similar parameters were observed to be clustered in 5 factors, which explained 73.2% of the variance. The factors in which the 14 items of the scale were clustered and factor weights are presented in Table 2.

Mean, standard deviation, and minimum and maximum values that were obtained by factor analysis of the values obtained for the affected feet of the patients for all items of the scale are presented in Table 3.

Floor and ceiling effects were observed to be in an acceptable level (floor effect: 3.1%; ceiling effect: 0.8%). Internal consistency among the items was presented as Cronbach's alpha coefficient. While the Cronbach's alpha coefficient for the entire scale was 83.3%, internal consistency of the subscales ranged between 33.9% and 74.2%.

The correlation analyses performed to verify the test-retest reliability of the scale showed that all 5 subscales demonstrated high test-retest reliability (Table 3).

Regarding correlation of the present scale with other scales, the items under Factors 3 and 5 did not correlate significantly with the pain subscale of AOFAS. All other subscales and total scores correlated with the subscales of AOFAS. Except for Factor 5 of the Multidimensional Nil Hallux Valgus Scale and Physical Total Score, all parameters and total scores showed negative significant correlation, but Mental Total Score showed no correlation. These negative correlations are because lower AOFAS and SF-36 scores indicate better functions, while in the Multidimensional Nil Hallux Valgus Scale, higher scores indicate negative functions. Positive correlation was observed between the Manchester Scale and this newly developed scale in all subscales and total scores.

Radiographic measurements of the first MTPA and IMA, which were used for validity verification, were positively correlated with the total score and all subscales, except for Factor 5. No significant correlation of IPA values with the subscales of the newly developed scale was found except for Factor 2 and the total score (Table 4).

Table 1. Demographic characteristics.

	n	%	Mean±SD	Min–Max
Sex				
Female	58	87.9		
Male	8	12.1		
Involved side				
Unilateral	3	4.5		
Bilateral	63	95.5		
Age				
Female			42.8±17.2	17–74
Male			32.5±17.5	21–68
Total			41.6±17.4	17–74

SD: Standard Deviation; Min: Minimum; Max: Maximum.

Table 2. Factor items.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Pain severity	0.687				
Walk distance without pain	0.725				
Pain during push-off	0.811				
Avoidance of daily activities because of great toe pathology	0.772				
Avoidance of social activities because of great toe pathology	0.731				
Difficulty in shoe choice / discomfort with shoe		0.633			
Dissatisfaction with foot appearance		0.863			
Passive first metatarsophalangeal joint extension range of motion goniometric measurement			0.683		
Loss of first metatarsophalangeal joint abduction range of motion goniometric measurement			0.861		
First metatarsophalangeal joint adduction angle at static position			0.496		
Insufficiency in great toe active abduction movement				0.558	
Flat foot				0.910	
Distal phalanx / nail rotation					0.674
Hallux valgus interphalangeus					0.793
Eigenvalues	5.384	1.514	1.218	1.128	1.004
Variance percent	38.5	10.8	8.7	8.1	7.2
Internal consistency	0.742	0.713	0.710	0.467	0.339

Table 3. Descriptive statistics and test-retest correlations of the scale of the total scale and subscores.

	Mean±SD	Min–Max	Correlation	p
Factor 1	8.0±6.1	0–22	0.485	<0.001
Factor 2	3.5±2.2	0–6	0.908	<0.001
Factor 3	3.6±3.2	0–15	0.944	<0.001
Factor 4	3.0±1.6	0–7	0.831	<0.001
Factor 5	1.3±1.3	0–6	0.841	<0.001
Total	19.4±10.8	2–51.4	0.953	<0.001

SD: Standard Deviation; Min: Minimum; Max: Maximum.

Table 4. Correlations between the new scale and HV angle, AOFAS-MTP-IP clinical scale, and SF-36.

		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Total
AOFAS	Pain	-0.589**	-0.467**	-0.162	-0.212*	-0.010	-0.531**
	Function	-0.636**	-0.402**	-0.308**	-0.372**	-0.290**	-0.628**
	Alignment	-0.369**	-0.339**	-0.386**	-0.331**	-0.323**	-0.470**
SF-36	PTS	-0.712**	-0.577**	-0.478**	-0.313*	-0.133	-0.744**
	MTS	-0.140	-0.146	-0.065	-0.082	-0.164	-0.146
Manchester Scale		0.357**	0.393**	0.516**	0.449**	0.209*	0.513**
Radiography	First MTPA	0.376**	0.608**	0.403**	0.375**	0.137	0.503**
	IMA	0.285**	0.522**	0.264*	0.234*	0.124	0.389**
	IPA	-0.125	-0.295**	-0.199	-0.172	-0.112	-0.238*

*p<0.05, **p<0.01.
HV: Hallux valgus; AOFAS-MTP-IP: American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal Joints Scale; SF-36: Short Form 36 Health Survey; PTS: Physical Total Score; MTS: Mental Total Score; First MTPA: First metatarsophalangeal angle, IMA: Inter-metatarsophalangeal angle; IPA: Interphalangeal angle.

Discussion

The present study details a newly developed, easy-to-use (by virtually all healthcare professionals), practical, multidimensional, pathology-specific, and comprehensive (including all parameters of the condition) scale for the evaluation of hallux valgus.

Among the assessment methods, radiographic assessment—which is assumed to be the most reliable and the most preferred method by clinicians—presents the joint and bone deformities in a two-dimensional medium, but it does not allow for the assessment of individual functional incompetencies.

The Manchester Scale is one of the popular pathology-specific tools to assess HV deformity. While it is a valid and reliable tool, it depends exclusively on the appearance of the foot. The Manchester-Oxford Foot Questionnaire was subsequently developed. Although it is relatively more detailed, it is patient-reported and primarily pain-based, similar to the Foot Function Index.[9] Pain in HV increases with functions requiring movement of the first MTP joint. Depending on structure of the deformity, degeneration on joint surfaces, decrease in joint gap, and loss of movement may occur. Thus, pain decreases with increasing impairment.[5] The AOFAS-MTF-IF scale also does not include HV-related causative or concomitant parameters.

However, the Multidimensional Nil Hallux Valgus Scale, with it subscales, involves all pathology-specific parameters, from pain level to nail rotation. Via factor analysis results, it can be understood that the 5 items are easy to use, and the newly developed scale total and subgroup scores can be compared with similar scales in the literature. In the scale, which was developed for multidimensional assessment of HV deformity, items assessing similar parameters were observed to be clustered in the same subscale. Considering the factor weight values and the descriptive data of these factors, floor and ceiling effects in all subscales were found to be at an acceptable level. Verified test-retest reliability of the subscales showed that results of the scale would not be greatly affected by repeated assessment of the same patient or by the differences between practitioners. That the total score of the scale as well as the scores of each subscale were found to be correlated with several scales with established reliability and validity shows the validity of the newly developed scale. These results indicate that the Multidimensional Nil Hallux Valgus Scale is a pa-

MULTIDIMENSIONAL NIL HALLUX VALGUS SCALE					
Name	Affected Side	**RIGHT** ◯	**LEFT** ◯	Date	
Please use a separate form for each foot.					**Score**
1.					
Pain severity No pain 1 0 ····· 1 Worst pain 10					
Walk distance without pain	**No pain 0**	**500–1000 m 1**	**<500 m 2**	**No walking without pain 4**	
Pain during push-off	**Never 0**	**Sometimes 1**	**Often 2**	**Always 3**	
Avoidance of daily activities because of great toe pathology	**Never 0**	**Sometimes 1**	**Often 2**	**Always 3**	
Avoidance of social activities because of great toe pathology	**Never 0**	**Sometimes 1**	**Often 2**	**Always 3**	
2.					
Difficulty in shoe choice / discomfort with shoe	**Never 0**	**Sometimes 1**	**Often 2**	**Always 3**	
Dissatisfaction with foot appearance	**Never 0**	**Sometimes 1**	**Often 2**	**Always 3**	
3.					
Passive first metatarsophalangeal joint extension range of motion goniometric measurement	**20°–↑ 0 Pain: +2**	**10°–19° 1 Pain: +2**	**1°–9° 2 Pain: +2**	**0° 6**	
Loss of first metatarsophalangeal joint abduction range of motion goniometric measurement	**Full 0 Pain: +2**		**Partial 2 Pain: +2**	**Full limited 6**	
First metatarsophalangeal joint adduction angle at static position	**0°–15° 0**	**16°–29° 1**	**30°–39° 3**	**40°–↑ 6**	
4.					
Insufficiency in great toe active abduction movement	**Normal 0**		**Contraction without movement 2**	**No contraction 3**	
Flat foot	**Normal arch 0**	**Mild 1**	**Moderate 3**	**Severe 4**	**Rigid 6**
5.					
Distal phalanx / nail rotation	**None 0**	**Mild 1**	**Moderate 2**	**Severe 3**	
Hallux valgus interphalangeus	**No 0**		**Yes 1**		
TOTAL SCORE				**Min–Max: 0–60**	

thology-specific, sensitive, and reliable assessment tool. Furthermore, the scale's correlation with radiographic measurements, assumed to be the gold standard, shows that it is a valid assessment tool.

Based on the statistical data of the present study, the scale did not correlate with the Mental Total Score of the SF-36, a finding which may indicate that HV deformity is not perceived to be a significant issue af-

fecting mental health. Surprisingly, no correlation was observed between radiographic measurements and Factor 5 parameters. No correlation of radiographic first MTPA, IMA, and IPA angles with distal phalanx rotation and hallux valgus interphalangeus was observed. The lack of correlation of the first MTPA and IMA with those subscales may be an expected outcome, but the IPA and hallux valgus interphalangeus inquire exactly the same point . This result may be because the IPA may be measured high with radiography, and for the hallux valgus interphalangeus item, the only answer options are Yes or No, and low level hallux valgus interphalangeus existence may have been marked as No. Factor 5 parameters did not correlate with the Physical Total Score of the SF-36, which may be interpreted to mean that the distal joint position of the great toe has a minimal effect on general health status. The lack of correlation of the pain section of the AOFAS scale with Factors 3 and 5, in which parameters related with the angular values and positions of the great toe are addressed, may be interpreted to mean that angular severity/position and pain may not increase in parallel with each other. This result may indicate that pain-based assessment tools of HV, such as the Foot Function Index and Manchester-Oxford Foot Questionnaire, are not sufficiently sensitive. The Manchester Scale is a subjective but pathology-specific assessment tool, which positively correlated with all the subscales and the total score of the newly developed scale.

There are some limitations of the present study. The lack of a valid and reliable disease-specific scale for HV deformity made comparison analysis of the present scale difficult. In addition, some of the patients were not in standard position during foot X-rays. For new users, the present newly developed scale needs to be pre-exercised for inter-rater reliability issues.

In the present study, it was established that the Multidimensional Nil Hallux Valgus Scale is a valid and reliable assessment tool for healthcare professionals in diagnostics, determination of deformity level, presenting the effectiveness of conservative or surgical treatment, assessing HV-related functional status of the patients, and determining their social participation level.

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