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Cross-sectional study to evaluate radiological parameters in hallux rigidus

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Abstract

Backgound: Hallux rigidus (HR) is a common condition with X-rays used to evaluate its pathology, grade joint changes and to inform treatment.
Method: A cross-sectional study was undertaken to evaluate radiological foot parameters in HR. In 110 subjects (180 feet) aged 18–70 years (mean 52 years) standard weight-bearing X-rays were examined using dorsal plantar and lateral views.
Results: Seventy (64%) subjects had bilateral HR and 73 (66%) were female. The mean onset of HR (denoted by first metatarsophalangeal (MTP) joint restriction/pain) was 44 (14–68 years) years and median HR duration was 6 years (1–33 years). Flat or chevron-shaped metatarsal heads presented in 131 (73%) feet and a history of first MTP joint trauma in 22% (74% of whom had unilateral HR). In 74% of feet hallux abductus interphalangeus angle (HAI°) was greater than normal (≤10°). Correlations between first MTP joint narrowing and sclerosis ($r = 0.76$, $p = 0.01$) and increased HAI° and first MTP joint narrowing ($r = 0.34$, $p = 0.01$) was found. The mean hallux equinus angle of 11° was outside the normal range (16–18°). Abnormal sesamoid morphology presented in 117 (65%) feet (30% irregular or hypertrophic). Proximal sesamoid displacement was greater than that seen in non-HR. Metatarsus primus elevatus was within normal range (≤8 mm) in 160 (89%) feet. The first metatarsal was longer than the second metatarsal in 66 (37%) feet although the first metatarsal was longer than the third metatarsal in 131 (73%) feet and may be responsible for altered forefoot function in HR.
Conclusions: HR was associated with female gender, bilateral involvement, older age groups, flat or chevron-shaped metatarsal head, longer proximal phalanx, increased HAI° and a first metatarsal longer than the third metatarsal. For radiological parameters to be considered valid for inclusion in a classification of HR their content validity needs to be established by formal research.

Keywords: Hallux rigidus; Radiological; Parameters; X-ray

1. Introduction

Hallux rigidus (HR) describes the clinical and radiological findings of both limited motion and associated degenerative arthritis of the first metatarsophalangeal (MTP) joint. Objective measurements form the basis of the scientific process and are critical to the understanding of a pathological change [1]. The most common objective evaluation of HR has been by radiological measurement [1]. The magnitude and pattern of first MTP and metatarsosesamoid joint wear in HR differ from other first MTP joint pathologies such as hallux valgus due to the different kinematic patterns and overall biomechanical properties [2].

This study aimed to identify the radiological parameters associated with HR evaluated from dorsal plantar (DP) and lateral views of the foot in order to determine radiological content validity (how comprehensively a system evaluates the problem it is assessing) for HR. In addition to the first MTP joint a variety of other radiological foot parameters linked to HR were examined.

2. Methods

An observational, cross-sectional study was undertaken. This involved a quantification of specific variables applied

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Table 1
Exclusion criteria

Hallux valgus-rigidus (intermetatarsal angle ≥12°)
Severe multiple forefoot deformities
Significant trauma sustained to foot/leg in previous 12 months
Neuropathy
First ray/forefoot surgery (including digital/excluding soft tissue)
Morton's neuroma affecting any inter-metatarsal space
Septic arthritis of first MTP joint
Inflammatory arthritides
Neuromuscular disorders
Insulin-dependent Diabetes Mellitus
Hypermobility syndromes
Long-term steroid use
History of severe peripheral vascular disease
Metabolic bone disease

to a sample of subjects with varying severity. It was undertaken to evaluate radiological parameters in HR subjects (age range 18–70 years) with varying degrees of restricted first MTP joint dorsiflexion <65° (measured with a standard full-circle plastic goniometer, calibrated to 1° increments) with either pain, deformity or both. 180 standard pre-operative weight-bearing X-rays were randomly selected and examined (94 plain, 86 digital). DP and lateral views of both feet (exclusion criteria permitting) were used. Ethical approval (Leicestershire, Northants, Rutland) was obtained, subjects gave informed consent and a pilot study was undertaken.

Careful preliminary examination of subjects' clinical notes was undertaken to remove those possessing criteria of exclusion (Table 1). An invitation letter and study information sheet was sent to suitable subjects giving them time for consideration prior to inclusion in the study. Detailed exclusion criteria were used to reduce unwanted variables.

The body mass index (BMI) for each subject was documented to determine its effect on the radiological parameters.

2.1. Radiological technique

To ensure the best possible comparability of X-rays, standard weight-bearing views were taken and rigid protocol adherence was followed.

The technique used followed guidelines laid down by the Research Committee of the American Orthopaedic Foot and Ankle Society [3]. Positioning of the feet and tube-head angle were the same for individual and bilateral X-rays (a standard radiological protocol was used). The only parameter that differed was where the X-ray beam was centered in the tarsus. For DP views the X-ray beam was directed at 15° from the vertical (craniocaudal angled) and aimed centrally between the feet, centred on the navicular. On individual feet it was centered on the intermediate cuneiform [4]. In each case the feet were parallel, side by side and in line. Angle and base of gait was not used. It was considered that this may vary between subjects and it was considered that these different positions may introduce unwanted variables between subjects making comparison between feet difficult. Film focus distance was 100 cm; the kilovoltage and milliamperage were set at 55 and 6.3, respectively [5,6]. For lateral views a horizontal tube-head angulation of 90°, mediolateral-directed beam, centered on lateral cuneiform with the film vertically placed, parallel to the second metatarsal [5].

2.2. Radiological evaluation

X-rays were evaluated and interpreted using one of two standardized methods:

(1) A film marker and plastic goniometer (1° increments for angles, 1 mm increments for length) on plain film with a clear acetate sheet to protect it.
(2) A digital workstation with high-resolution monitor computer picture archiving communication system (PACS) using a web image browser (Visage) to display lossless JPEG images for diagnostic interpretation.

Computerized X-ray measurement was undertaken in two centres while hand measured X-rays were evaluated in one other. The use of two methods enabled evaluation and comparison of the techniques.

2.3. Radiological parameters

These were evaluated (Table 2) by one examiner to eliminate inter-observer error.

2.4. Radiological protocol

2.4.1. First MTP joint width

Two methods were used:

(1) Joint space narrowing between bone end plates (not osteophyte bridging) was objectively graded as: none,

Table 2
Radiological measurements

Area assessed	Radiological criteria
First MTP joint	Narrowing, symmetry, presence and severity of osteophytes, subchondral sclerosis, subchondral cysts, loose bodies
Hallux	Proximal/distal phalanx length ratio, HAI°, IPJ OA, equinus°
Sesamoids	Type and shape, metatarsal/sesamoid joint space. Distance between metatarsal head and proximal edge of sesamoids. Inter-sesamoid distance
First metatarsal	Head shape. Length compared to second and third metatarsals. First metatarsal/proximal phalanx length ratio. Sagittal plane position, first M-C joint position/angle/joint sag
General features	MAA, lateral talus–first metatarsal angle. Transverse plane angulation second MTPJ, N-C joint sag, medial/intermediate cuneiform diastasis and gross alterations in tarsal morphology

HAI° = hallux abductus interphalangeus angle, M-C = metatarso-cuneiform, MAA = metatarsus adductus angle, N-C = navicular-cuneiform.