Original article

Radiologic analysis of hindfoot alignment: Comparison of Méary, long axial, and hindfoot alignment views

T. Neri, R. Barthelemy, Y. Tourné

Background: Among radiographic views available for assessing hindfoot alignment, the antero-posterior weight-bearing view with metal cerclage of the hindfoot (Méary view) is the most widely used in France. Internationally, the long axial view (LAV) and hindfoot alignment view (HAV) are used also. The objective of this study was to compare the reliability of these three views.

Hypothesis: The Méary view with cerclage of the hindfoot is as reliable as the LAV and HAV for assessing hindfoot alignment.

Material and methods: All three views were obtained in each of 22 prospectively included patients. Intra-observer and inter-observer reliabilities were assessed by having two observers collect the radiographic measurements then computing the intra-class correlation coefficients (ICCs).

Results: The intra-observer and inter-observer ICCs were 0.956 and 0.988 with the Méary view, 0.990 and 0.765 with the HAV, and 0.997 and 0.991 with the LAV, respectively. Correlations were far stronger between the LAV and HAV than between each of these and the Méary view. Compared to the LAV and HAV, the Méary view indicated a greater degree of hindfoot valgus.

Discussion: Intra-observer reliability was excellent with both the LAV and HAV, whereas inter-observer reliability was better with the LAV. Excellent reliability was also obtained with the Méary view. Combining the Méary view to obtain a radiographic image of the clinical deformity with the LAV to measure the angular deviation of the hindfoot axis may be useful when assessing hindfoot malalignment. A comparison of the three views in a larger population is needed before clinical recommendations can be made.

Level of evidence: II, prospective study.

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1. Introduction

Among the radiographic views specifically designed to assess hindfoot alignment, the hindfoot alignment view (HAV) or Saltzman view [1] and the long axial view (LAV) [2] are widely used. Both these views visualise the calcaneus and tibia without superimposition of other foot and ankle bones. In comparative studies [3], both views exhibited good intra-observer and inter-observer reliabilities, although inter-observer reliability was better for the LAV. These views have been proven useful for guiding the surgical correction of hindfoot malalignment [4,5] and for positioning ankle arthrodesis [6].

The Méary antero-posterior weight-bearing view with metal cerclage of the hindfoot is less popular internationally but is the most widely used view in France [7]. The Méary view provides a good radiographic image of the clinical deformity but has not been validated as a hindfoot alignment assessment tool in studies providing a high level of evidence. Furthermore, no study has compared the reliability of the LAV, HAV, and Méary view.

The objective of this study was to compare the inter-observer and intra-observer reliabilities of the LAV, HAV, and Méary’s view with cerclage of the hindfoot. Our working hypothesis was that the Méary view was as reliable as the LAV and HAV for assessing hindfoot alignment.

2. Material and methods

2.1. Population

A prospective single-centre study was conducted between September 2014 and May 2015 at the Clinique du Mail radiology
office in Grenoble, France. The required sample size was estimated as described by Walter et al. [8,9]. To maximise statistical power, the unit for the sample size estimation was the patient and not the foot. Assuming a minimum intra-class coefficient (ICC) of 0.70 (H0: \( \rho_0 = 0.70 \)) and an expected ICC of 0.9 (H1: \( \rho_1 = 0.90 \)), with the alpha risk set at 0.05, the number of patients needed to obtain 80% power was 18 (36 feet). For the statistical analysis, the unit was the foot.

We included 22 patients who underwent a radiological assessment of the hindfoot because of an ankle and/or hindfoot disorder (ankle instability, \( n = 9 \); pes plano-valgus, \( n = 5 \); or hindfoot pain with a lesion of the tibialis posterior or spring ligament, \( n = 8 \)). Exclusion criteria were as follows: unavailability of all three radiographic views, history of foot and/or ankle surgery or trauma, inflammatory disease, and ongoing growth.

### 2.2. Radiographic techniques

A Méary view, LAV, and HAV of both feet was obtained in all patients. The settings were as follows: 75 kv, 40 mAs, 150 ms, and 150 cm source-to-film distance.

For the Méary view, a flexible malleable lead wire was passed under the heel then wrapped up on either side around the malleolus (Fig. 1) [7]. The X-ray beam was horizontal, along the axis of the second metatarsal, parallel to the floor, and centred on the middle of the ankle. The cassette was placed behind the two heels, perpendicularly to the direction of the beam.

The HAV was obtained with the patient standing on both feet, positioned parallel to each other, on a radiolucent cassette-holding box with a Plexiglas surface. The beam was angled 20° to the floor and pointed at the middle of the ankle. The field of exposure
Fig. 4. Méary antero-posterior weight-bearing view with metal cerclage of the hindfoot: angular measurement of hindfoot alignment. A. The green line is the anatomical axis of the tibia. B. The red line runs through the middle of the footprint of the hindfoot (delineated by the metal cerclage) and the middle of the talus.

Fig. 5. Hindfoot alignment view. A. Angular measurement of hindfoot alignment. B. Determination of the most distal point of the calcaneus.
included half the tibia down to the calcaneus (Fig. 2) [1]. The cassette was positioned perpendicular to the beam, i.e., inclined 20° from the vertical.

For the LAV, the beam was at a 45° angle to the floor and pointed at the middle of the ankle. The field of exposure included the distal two-thirds of the tibia down to the calcaneus (Fig. 3). The cassette was horizontal, flat on the floor [2].

2.3. Foot position

For all three views, the patient was in the bipodal stance with the body weight evenly distributed between the two lower limbs, in a natural position. To minimise the influence of foot position on the measurement values, thus allowing comparisons to other studies and within this study, widely accepted, predefined foot positions were used [10,11]. For the LAV and HAV, the feet were about 80 mm apart and in slight internal rotation so that the medial edges of the two feet were parallel to each other. For the Méary views, the feet were in the natural position (in slight external rotation). Despite this difference in foot position across views, we decided to obtain each view in the standardised manner described in the literature, in order to reflect everyday practice.

2.4. Angular measurements on radiographs

Inter-observer reliability was evaluated by having two senior observers (RB and TN) measure the hindfoot alignment angles independently of each other. For the assessment of intra-observer reliability, one of the observers (TN) measured the angles again 7 days after the first measurement session. Hindfoot alignment was assessed based on the angle formed by the anatomical axis of the tibia and the longitudinal axis of the calcaneus [12–14].

On the Méary view, the hindfoot alignment angle was measured as illustrated in Fig. 4 as the angle formed by the anatomical axis of the tibia (green line) and the line running through the middle of the footprint of the hindfoot (delineated by the metal cerclage) and the middle of the talus (red line). On the HAV (Fig. 5), one of the lines defining the hindfoot alignment angle was drawn through the most distal point of the calcaneus resting on the floor (red dot) and the point at the intersection of the tangent to the talar dome with the axis of the tibia (red line). The other line defining the angle was the tibial axis (green line) [1,14,15]. Finally, on the LAV, the hindfoot alignment angle was formed by the calcaneal axis (red line) and the tibial axis (green line) (Fig. 6) [3,15,16]. The calcaneal axis was defined by two points: one of the points was on the horizontal line 7 mm proximal to the most distal part of the calcaneus and divided into a 40%/60% ratio, where the 40% segment started at the lateral side; and the other point was the middle of the horizontal line 30 mm proximal to the most distal part of the calcaneus. On all three views, hindfoot alignment could be neutral (0°), in valgus (positive angle value), or in varus (negative angle value).

2.5. Statistical analysis

The hindfoot alignment angle was measured on each of the three views for each study foot. The data were entered into a secure Microsoft Excel® file (Microsoft Corp., Redmond, WA, USA). Statistical analyses were performed using SPSS software (Statistical Package for the Social Sciences, IBM, Armonk, NY, USA).

Quantitative variables were described as mean ± SD. Intra-observer and inter-observer reliabilities were assessed by computing the intra-class correlation coefficients (ICCs) separately for each view. The ICC values were compared to the theoretical minimum value of 0.7, using a one-tailed test with alpha set at 0.05. The 95% confidence interval (95% CI) was computed for each ICC value. Pearson’s correlation coefficient was used to assess corre-

![Fig. 6. Long axial view: hindfoot alignment is measured as the angle between the anatomical axis of the tibia (green line) and the axis of the calcaneus (red line).](image)

Table 1

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<th>Mean ± SD</th>
<th>Range</th>
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<tr>
<td>Méary</td>
<td>6.09 ± 0.21</td>
<td>−2.8° to 20.2°</td>
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<tr>
<td>HAV</td>
<td>0.21 ± 0.22</td>
<td>−14.8° to 13.9°</td>
</tr>
<tr>
<td>LAV</td>
<td>0.73 ± 0.10</td>
<td>−14.7° to 15.6°</td>
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Méary: Méary radiographic view (antero-posterior weight-bearing view with metal cerclage of the hindfoot); HAV: hindfoot alignment view; LAV: long axial view.

lations between angular measurements obtained using different views. Student’s t-test was applied to evaluate the significance of the Pearson’s correlation coefficient values. The foot was the unit for these analyses. ICC values greater than 0.7 were taken to indicate good reliability and those greater than 0.9 excellent reliability.

3. Results

3.1. Population

Of 35 selected patients, 22 (44 feet) were included. There were 12 females and 10 males with a mean age of 48.5 ± 22.0 years (range, 17–79 years). Varus hindfoot deformity was noted bilaterally in 7 patients and unilaterally in 1 patient and valgus hindfoot deformity bilaterally in 6 patients and unilaterally in 2 patients. Hindfoot alignment was normal in the remaining 6 patients. The reason for obtaining radiographs of the hindfoot were lateral ankle instability (n = 7), hindfoot pain (n = 6), suspected posterior ankle impingement syndrome (n = 2), tibio-talar osteoarthritis (n = 3), pes plano-valgus (n = 2), and fibular tenosynovitis (n = 2).

3.2. Mean hindfoot angle values

The mean hindfoot angle value was highest on the Méary view. The mean difference was +5.88° vs. the HAV and +5.36° vs. the LAV (Table 1).
3.3. Intra-observer and inter-observer reliability assessments

The intra-observer and inter-observer ICC values were 0.956 and 0.988 for Méary’s view, 0.990 and 0.765 for the HAV, and 0.997 and 0.991 for the LAV, respectively (Table 2).

Comparing the ICC values to the theoretical value of 0.7 showed that intra-observer reliability was excellent with all three views ($P < 0.001$). Inter-observer reliability, in contrast, was excellent only with the Méary view and LAV ($P < 0.001$).

3.4. Correlations among radiographic views

Table 3 reports the correlation coefficient values between the means of the values obtained using the three views (values for the two sides, values obtained by the two observers, and values obtained twice by the same observer). The mean values obtained by both observers showed significant correlations across the three radiographic views. Nevertheless, the correlation between the values on the HAV and LAV was considerably stronger (Pearson coefficient, 0.889) compared to the correlations between the values on the Méary view and on the LAV (0.635) or HAV (0.661).

4. Discussion

The results reported here indicate excellent intra-observer reliability of the angular measurement of hindfoot alignment with all three radiographic views. Inter-observer reliability, in contrast, was better with the LAV and Méary view than with the HAV. Reliability of angular measurements of hindfoot alignment seemed similar with the Méary view and LAV. This excellent reliability supports the use of the Méary view and LAV for the radiographic assessment of hindfoot malalignment.

Our data are original, as no previous studies have compared the reliability of the Méary view, LAV, and HAV. Nevertheless, despite the preliminary sample size estimation, the number of patients was too small to determine the normal range of radiographic hindfoot angular measurements or the exact indications of each radiographic view in clinical practice. Another source of bias that limits the representativeness of the results is that all patients initially sought medical advice for foot or ankle symptoms.

Only very few studies of the Méary view are available. However, our results seem consistent with those of previous studies, which found similar angle values and supported the same conclusions regarding the comparison of the LAV and HAV [3]. The lower inter-observer reliability of the HAV may be ascribable to several factors. First, the method described by Saltzman and El-Khoury to determine the calcaneal axis [1] involves identifying the lowest point of the weight-bearing calcaneus. This is a difficult step that has poor reproducibility, particularly between two observers. Second, the projection of the calcaneus is shorter on the HAV than on the LAV. The shorter a segment between two points used to define an axis, the greater the impact of small measurement errors on the determination of that axis.

In keeping with earlier reports, we found that the mean angular measurements of hindfoot alignment differed across radiographic views, ranging from close to 0° on the LAV and HAV to about 6° of valgus on the Méary view [17]. Similarly, values on the LAV and HAV correlated closely with each other and less closely with those on the Méary view. Thus, the LAV and HAV may assess different aspects of hindfoot deformities compared to the Méary view. Several hypotheses, which would require evaluation in additional studies, can be put forward to explain these differences. One hypothesis is that the degree of leg rotation may affect hindfoot alignment measurements [18]. The foot was in the natural position for the Méary view and in slight medial rotation for the LAV and HAV [3]. Johnson et al. [12] found no significant difference in hindfoot alignment between the natural foot position (i.e., with lateral rotation) and the medially rotated position. Our results, in contrast, suggest that medial foot rotation may produce angle values in greater hindfoot varus on projection views, leading to values in greater valgus on the Méary view. Another hypothesis involves the fact that the Méary views were obtained separately for each foot, whereas both feet were imaged simultaneously for the LAV and HAV. This difference may hinder comparison of the views and induce rotation affecting the projection of the hindfoot axes. Finally, a third hypothesis involves the differences in the radiological landmarks used for the three views: the LAV and HAV rely only on projections of bone axes, whereas the Méary view uses both a bony landmark (the talus) and a soft tissue landmark (the heel circled by the wire) [19].

Thus, although the three views investigate the same hindfoot deformities, they are not strictly comparable, as they rely on somewhat different measurement methods [20]. However, they are complementary, with the Méary view apparently quantifying the clinical hindfoot deformity and the LAV characterising the bone malalignment. Further studies are needed to determine the exact indications of each radiographic view when assessing hindfoot abnormalities in everyday clinical practice.

5. Conclusion

Intra-observer reliability is excellent for both the LAV and the HAV, whereas LAV has better inter-observer reliability. The LAV therefore deserves preference over the HAV as a tool for angular measurements of hindfoot malalignment. Measurements on the Méary view with cerclage of the hindfoot seem reproducible.

Although measurements on the three views correlate significantly with one another, the LAV and HAV do not seem to assess the same aspects of hindfoot deformities as does the Méary view. The three views seem helpful and complementary. Nevertheless, further comparative assessments in larger number of patients

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Table 2

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<tr>
<th></th>
<th>LAV</th>
<th>HAV</th>
<th>Méary</th>
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<tr>
<td></td>
<td>ICC [95% CI]</td>
<td>ICC [95% CI]</td>
<td>ICC [95% CI]</td>
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<tr>
<td>Intra-observer</td>
<td>0.997 [0.994–0.998]</td>
<td>0.990 [0.982–0.994]</td>
<td>0.956 [0.919–0.975]</td>
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<tr>
<td>Inter-observer</td>
<td>0.991 [0.983–0.995]</td>
<td>0.765 [0.602–0.862]</td>
<td>0.988 [0.978–0.993]</td>
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ICC: intra-class correlation coefficient; 95% CI: 95% confidence interval; LAV: long axial view; HAV: hindfoot alignment view; Méary: Méary radiographic view (antero-posterior weight-bearing view with metal cerclage of the hindfoot).

* $P < 0.05.

Table 3

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<tr>
<td>LAV vs. HAV</td>
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LAV: long axial view; HAV: hindfoot alignment view; Méary: Méary radiographic view (antero-posterior weight-bearing view with metal cerclage of the hindfoot).
Disclosure

The authors declare that they have no competing interest.

References