

# The Metatarsal Axis Deviation Angle: A Novel Angular Measurement for Planning Surgery of Severe Hallux Valgus

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## ABSTRACT

Surgical planning for hallux valgus is a complex procedure. Many angular measurements are described to decide on the correct procedure. Primus metatarsus varus is considered as one of the important factors in the causation and persistence of hallux valgus. Intermetatarsal angle (IMA) has been used to assess the first metatarsal varus. However, we identified a normal IMA in some feet with severe hallux valgus; and these feet had metatarsus adductus. Hence, after further investigations, we propose a new angular measurement to detect axis deviation of the first metatarsal. We have called this the metatarsal axis deviation angle (MADA). We also recommend a basal realignment osteotomy in hallux valgus with the MADA of more than 30°.

**Keywords:** Hallux valgus, Primus metatarsus varus, Surgery.

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## INTRODUCTION

Hallux valgus is a common condition, and surgical correction has remained a challenge over the last 100 years with at least 130 procedures being described.<sup>1</sup> The choice of operation depends principally on the severity of the deformity.<sup>2,3</sup> For mild and moderate deformities, distal osteotomies of the first metatarsal joint, such as the Chevron, Austin, Wilson, or Mitchell techniques are used.<sup>4</sup> A proximal metatarsal osteotomy is recommended for more severe deformities because it allows for a greater degree of correction.<sup>3</sup> This may be at the expense of stability and bony healing. The Scarf osteotomy has gained popularity because of its inherent stability, minimal shortening of the first metatarsal, and ease of internal fixation.<sup>5</sup>

However, these procedures result in a 10% recurrence rate.<sup>6</sup> Radiographic and clinical parameters like hallux valgus angle (HVA), intermetatarsal angle (IMA), distal metatarsal articular angle (DMAA), and tarsometatarsal (TMT) hypermobility have been developed to identify different types of hallux valgus. Severity of each parameter is based on cut-off points and used in algorithms to choose between different surgical procedures.<sup>7,8</sup> Radiographic cut-off points lie between 20 and 40° for HVA, 11 to 20° for IMA, and 10 to 15° for DMAA. Evidence for algorithms is derived from few retrospective studies.<sup>9</sup> Outcomes of other studies do not support the validity of individual features, such as TMT hypermobility, IMA, and DMAA.<sup>10</sup> Randomized controlled trials show no difference in correction between Lapidus and distal osteotomy nor shaft and distal osteotomy.<sup>10,11</sup>

The angle between the first and second metatarsals has long been considered an important factor in the development of hallux valgus. Truslow<sup>12</sup> believed that the increased IMA which he labeled metatarsus primus varus was congenital, and that it inevitably resulted in hallux valgus. In their statistical survey of normal and hallux valgus feet, Hardy and Clapham<sup>13</sup> found that the most consistent correlation in all their data was the association between the severity of hallux valgus and the magnitude of the IMA. Lundberg and Sulja<sup>14</sup> found a similar correlation, but were cautious about interpreting the relationship in etiological terms. Piggot,<sup>15</sup> however, contradicted the widely held belief that metatarsus primus varus was the underlying cause of hallux valgus, noting that some cases of hallux valgus had normal IMAs.

We believe that a normal IMA does not rule out primus metatarsus varus and our novel measurement could address this conundrum.

## OBJECTIVE

As discussed, IMA is considered as an important determinant of hallux valgus severity. But we observed that in feet with an element of metatarsus adductus, the IMA was not as effective. A normal IMA could be present in a patient despite first metatarsal varus, due to varus in the entire forefoot (Fig. 1). This confuses the surgical

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**Fig. 1:** Metatarsus adductus with slightly increased IMA (IMA 13.5°, MADA 47°, HVA 35°)



**Fig. 2:** Normal IMA, but significant first metatarsal varus and severe hallux valgus (IMA 12°, MADA 45°, HVA 32°)

planning process and there is a risk of poorer outcomes. We introduced a new angle to quantify a combined effect of primus metatarsus varus and metatarsus adductus. We have termed this metatarsal axis deviation angle (MADA) (Fig. 2). We hypothesized that this angle correlated better with the severity of hallux valgus. Our research aimed to compare the correlation between IMA and MADA on the severity of hallux valgus.

## MATERIALS AND METHODS

58 dorsoplantar feet radiographs were retrospectively evaluated. The cohort included 38 women and 20 men with symptomatic moderate-to-severe hallux valgus. The severity was classified on the basis of HVA. Patients with HVA of more than 25° were included. Exclusion criteria were previous forefoot surgery and any congenital foot deformities requiring treatment. The average age was 35.36 (19–71). The radiographic measurements were made on the picture archiving and communication system. The HVA was calculated between the axis of first metatarsal and the proximal phalangeal axis. The IMA was the angle between the first and second metatarsals. The metatarsus adductus angle (MAA) was calculated by the Engel et al<sup>16</sup> method, as the angle between the axis of second metatarsal and the axis of middle cuneiform. The MADA was calculated as the angle between the axis of first metatarsal and the axis of middle cuneiform. The average HVA was 35.52°. The average IMA was 14.38°. The average metatarsus adductus (MA) angle was 25.87°. The average MADA was 39.83°.

## Statistical Analysis

We analyzed the data using online statistical software (Statistical Package for the Social Sciences). We identified and compared the association of both the IMA and

MADA with the HVA. We also compared the association between the IMA and the MAA. Pearson correlation coefficient was utilized for this purpose.

## RESULTS

The association between IMA and the HVA was weakly positive ( $r = 0.4754$ ). The association between the MADA and the HVA was moderately positive ( $r = 0.6133$ ). The correlation between IMA and MAA was very weakly positive ( $r = 0.1082$ ), while the correlation between IMA and MADA was moderately positive ( $r = 0.5913$ ).

## DISCUSSION

Many angles on dorsoplantar radiographs of the foot have been employed in the study of hallux valgus.<sup>17</sup> However, most have not been useful for the determination of the absolute positions and relationships of the bones. One focus of discussion has been the point of origin of metatarsus primus varus.<sup>17-19</sup> Some studies have found the mean angle of metatarsus primus varus was larger in the patients who had hallux valgus. However, because this angle includes not only the varus angulation of the first metatarsal, but also the valgus angulation of the first cuneiform.<sup>20,21</sup> It is possible that the first cuneiform is in valgus, but there is also a possibility that the entire forefoot is in adduction. In an anatomical study, Haines and McDougall<sup>22</sup> noted that the distal articular surface of the first cuneiform inclined medially in hallux valgus.

Correlation of the clinical deformity, angular measurement, and surgical planning is a contentious issue in hallux valgus surgery. There is good evidence to suggest that varus positioning of the first metatarsal predisposes a hallux valgus deformity. But the quantification of primus metatarsus varus remains far from perfect. The new angle



**Fig. 3:** First metatarsal basal osteotomy as a remedy for MADA >30°

that we describe seems to bridge this gap. In cases where the first metatarsal is in varus despite having a normal IMA, a distal or shaft osteotomy may not provide with adequate correction. In such circumstances, we recommend use of proximal metatarsal osteotomy to achieve better correction and accurate realignment (Fig. 3).

Our study does have some shortcomings. Firstly, ours is a radiological and inferential study design with little clinical correlation and only 58 radiographs. Secondly, we could have included only patients with metatarsus adductus and hallus valgus to better compare the effect of forefoot axis deviation. This would have given a greater statistical validity to the correlation assessment.

## CONCLUSION

The MADA is a measurement that comprehensively indicates the spatial position of first metatarsal in relation to the forefoot axis and quantifies its varus positioning. Of the radiographic measurements available to quantify hallux valgus severity, the MADA had the best correlation in our study. A MADA of 30° or more should be considered abnormal. This reflects the amount of metatarsus varus more effectively than the IMA. It also showed the hallux valgus severity better than the IMA. Both the associations between IMA and HVA and between MADA and HVA were statistically significant ( $p < 0.05$ ). We recommend routine use of the MADA to plan hallux valgus osteotomy. A MADA of more than 30 degrees requires re-alignment of the first metatarsal shaft from its varus position. This was achieved by the metatarsal basal osteotomy in our series.

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