



Fusion of the First Metatarsophalangeal Joint: Precontoured or Straight Plate?



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ABSTRACT

Precontoured, low-profile plates with fixed dorsiflexion angles are becoming increasingly popular for first metatarsophalangeal joint fusion. We have concerns that the routine use of a precontoured plate can lead to excessive clinical dorsiflexion. The aim of our study was to investigate the relationship between the first metatarsophalangeal joint dorsiflexion intramedullary angle and the angle formed at the dorsal cortices where the plate is applied. We hypothesized that the dorsal cortical angle was significantly less dorsiflexed than the intramedullary angle. We measured both angles on lateral weightbearing radiographs of 40 consecutive individuals presenting with forefoot symptoms. The results demonstrated that the mean dorsal cortical angle was significantly smaller (mean 0.2° plantarflexion) compared with the intramedullary angle (mean 10.6° dorsiflexion; $p < .001$). The interobserver and intraobserver reliability of both the intramedullary and the dorsal cortical measurements was very good. In conclusion, the dorsal cortical angle is, on average, 10.8° smaller than the intramedullary angle, with a mean angle of almost 0°. This finding should be considered when selecting plates for first metatarsophalangeal joint fusion.

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Arthrodesis of the first metatarsophalangeal (MTP) joint is the reference standard for the treatment of end-stage osteoarthritis, rheumatoid arthritis, and revision of failed treatment of hallux valgus surgery (1–3). Several methods have been described for achieving fusion, including 1 or 2 compression screws (4–6), a combination of plates and screws (7,8), and intramedullary nails and staples (3,9).

The correct fusion position is crucial. The hallux should be sufficiently dorsiflexed to allow for heel rise during the terminal stance phase of gait. However, excessive dorsiflexion will prevent effective toe off and distribution of pressure, potentially leading to difficulty with shoe wear and rubbing of the dorsum of the toe. Pain and arthrosis can occur in the interphalangeal joint owing to the constant hyperflexed position that develops in an attempt to contact the floor. Similarly, failure to load the hallux because of its extended position

can lead to pain under the metatarsal head and sesamoids owing to transfer of loading to these points (10). Excessive plantarflexion, however, can cause the patient to vault over the toe during gait or experience irritation at the tip of the toe.

A review of the published data revealed that the recommended position of the fused first MTP joint is believed to be 20° to 25° of dorsiflexion of the proximal phalanx in relation to the first metatarsal axis (10–12), and this is measured using an intramedullary (IM) technique (Fig. 1). Precontoured plates have become increasingly popular for MTP joint fusion and can offer added stability (7). The currently marketed plates are precontoured to variable angles (0° to 14°) of dorsiflexion. Our experience has been that precontoured plates invariably need to be straightened to achieve an optimal clinical position for fusion (Figs. 2 to 5).

We were interested in the relationship between the first MTP joint intramedullary (IM) angle and the angle formed at the dorsal cortices, where the plate is applied, which to our knowledge has not been previously described. We hypothesized that the dorsal cortical (DC) angle was significantly less dorsiflexed than the IM angle. Our primary aim was to measure and compare these 2 angles in a retrospective study of newly referred patients presenting with forefoot symptoms.

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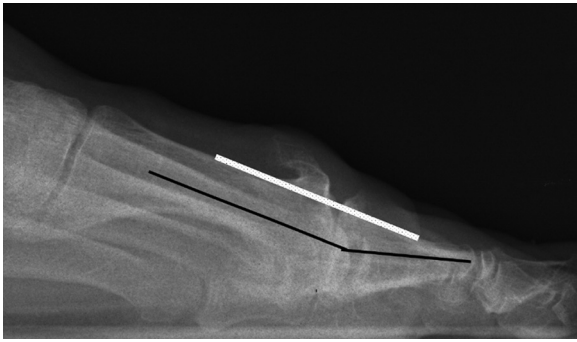


Fig. 1. Angular relationship between the metatarsal and proximal phalanx using the intramedullary technique (black line) and dorsal cortices (white line) in weightbearing.

Patients and Methods

We reviewed the lateral, weightbearing radiographs of 40 feet in 40 consecutive patients (21 females [52.5%] and 19 males [47.5%]) presenting to the senior authors' (J.C., R.R.E.) foot and ankle clinic from September to December 2012. The mean age of these patients was 47 (range 24 to 65) years. The inclusion criterion was patients referred with forefoot symptoms. Patients were excluded if they had previously undergone forefoot surgery or if they had inflammatory arthropathy that could potentially lead to cortical erosion or joint subluxation.

As stated, the primary aim of the present study was to determine the relationship between the DC and IM angles at the first MTP joint. To this end, all radiographs were stored electronically on our Picture Archiving and Communications System, and the angle measuring tools of the Picture Archiving and Communications System workstation were used to determine the angles of interest. The DC angle was measured on the lateral, weightbearing foot radiograph as the angle formed by the intersection of the line parallel to the dorsal cortex of the first metatarsal and the line parallel to the dorsal cortex of the proximal phalanx of the hallux in the sagittal plane. The IM angle was measured on the lateral, weightbearing foot radiograph as the angle formed by the intersection of the line parallel to the long axis of the medullary canal of the first metatarsal and the line parallel to the long axis of the proximal phalanx of the hallux (Fig. 1). In keeping with our secondary aim of determining the reliability of the radiographic angles, all the measurements were performed by 2 of us (K.E., R.R.E.), and 1 of us (R.R.E.) repeated 20 of these measurements 1 week after the initial measurements were made. Subsequently, the intraobserver and interobserver reliability scores were calculated using the intraclass correlation coefficient (ICC). All the data were analyzed using Microsoft Excel 2007® (Microsoft Corp, Redmond, WA) software. Because our data did not display a normal distribution, the Wilcoxon signed ranks test was used to compare the values obtained using the 2 measurement methods, and $p \leq .05$ (5% probability of the null hypothesis) was considered statistically significant for all the tests. Because ours was a retrospective study, institutional review board approval was not required as long as the protected health information remained protected; therefore, the patient identities were kept private.

Results

The mean IM angle was $10.6^\circ \pm 4.7^\circ$ (range -0.1° to $+17.2^\circ$) of dorsiflexion, and the mean DC angle was $-0.2^\circ \pm 4.7^\circ$ (range -11.8°



Fig. 2. Clinical photograph showing an excessively dorsiflexed first metatarsophalangeal joint fusion, with resulting interphalangeal joint hyperflexion and failure of the toe to contact the floor.



Fig. 3. Clinical photograph showing marked callosity under the metatarsal head resulting from excessive dorsiflexion of the metatarsophalangeal joint.

to $+7.6^\circ$) of dorsiflexion. This difference was statistically significant ($p < .001$). The mean difference between the DC and IM angles was $10.8^\circ \pm 3.0^\circ$ (range 2.1° to 17.9°). The ICC scores showed that the methods used to measure the DC and IM angles were reliable between the observers (ICC 0.95 and 0.99, respectively), indicating very good agreement between the angles measured by the 2 different surgeons. Similarly, the intraobserver reliability for the DC and IM angles was also good (ICC 0.98 and 0.98, respectively), indicating very good agreement between the angles measured by the same surgeon on 2 different occasions 1 week apart.

Discussion

The results from the present study confirm our hypothesis that the DC angle is significantly less dorsiflexed compared with the IM angle of the first MTP joint, as measured in the sagittal plane on the lateral weightbearing radiograph of the foot. The conical shape of the proximal phalanx influences the relationship between the intramedullary and dorsal cortical angles at the first MTP joint (12). We have confirmed and formally measured this relationship, which to our knowledge has not been previously reported. Our results showed a wide range in the measured IM angle at the first MTP joint (approximate range 0° to 17°), with a mean average angle measurement of $10.6^\circ \pm 4.7^\circ$. We, therefore, caution against routinely relying on the recommended dorsiflexion of 20° to 25° as described in the historical data. The present study has demonstrated that a clinically and statistically significant difference of approximately 11° exists between the DC and IM angles, and we believe this should be considered during first MTP joint fusion surgery to achieve an

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