

# Radiographic Evaluation of Intermetatarsal Angle Correction Following First MTP Joint Arthrodesis for Severe Hallux Valgus

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## Abstract

**Background:** Arthrodesis is a standard operative treatment for symptomatic arthritis of the first metatarsophalangeal (MTP) joint. Patients with degenerative joint disease (DJD), severe hallux valgus, and metatarsus primus varus may also require fusion of the first MTP joint. An important question in the latter group of patients is whether a proximal first metatarsal osteotomy is required, in addition to the first MTP joint fusion. Our hypothesis was that patients with severe hallux valgus and metatarsus primus varus, treated with first MTP joint arthrodesis alone, would have correction of the first-to-second intermetatarsal angle (1-2 IMA) and hallux valgus angle (HVA) to near population norms, without the addition of a proximal first metatarsal osteotomy.

**Methods:** Preoperative and postoperative radiographs of 19 feet, in 17 patients, with preoperative IMA greater than 15 were analyzed. Weight-bearing radiographs were divided into pre- and postoperative cohorts. Three independent reviewers measured these radiographs and mean 1-2 IMA and HVA were calculated. Mean follow-up was 10 months.

**Results:** The mean preoperative 1-2 IMA was 19.2 degrees (15.6-24.3). The mean preoperative HVA was 48.5 (36-56.6). The mean postoperative values for 1-2 IMA and HVA were 10.8 and 12.3 degrees, respectively. The mean change in IMA was 8.3 degrees and in the hallux valgus angle was 36.4 degrees. The differences between pre- and postoperative measurement for both angles were statistically significant ( $P < .001$ ). Seven of 19 (37%) feet were corrected to an IMA of less than 9 degrees (normal), whereas in 15/19 feet the postoperative IMA was 12.3 degrees or less. The postoperative HVA was less than 15 degrees in 15/19 (79%) feet.

**Conclusion:** This pre- and postoperative radiographic analysis of patients with severe bunion deformity demonstrated that HVA and 1-2 IMA were acceptably corrected without the addition of a proximal first metatarsal osteotomy.

**Level of Evidence:** Level III, retrospective comparative series.

**Keywords:** intermetatarsal angle correction, hallux valgus angle, joint arthrodesis, MTP joint

## Introduction

Hallux valgus is a progressive deformity of the first metatarsophalangeal joint most commonly seen in women in the 4th to 6th decade of life.<sup>4</sup> Although there are many potential causes, including genetics, restrictive shoe wear, rheumatoid arthritis, and neuromuscular disease, the common pathway is a varus deformity of the metatarsal with valgus deformity through the first MTP joint and pronation of the great toe.<sup>2-4,6,7</sup> Operative correction of the deformity is indicated to relieve pain and improve shoe wear. The operative goals are restoration of the anatomy to near population norms to prevent recurrence of the progressive deformity. Recurrent deformity may, in part, be caused by a laterally displaced pull of the flexor, extensor, and adductor tendons.

Three angles (HVA, IMA, and distal metatarsal articular angle [DMAA]) are commonly evaluated when determining

the best operation for a symptomatic bunion. The hallux valgus angle (HVA) measures the amount of valgus at the first MTP joint. The first-to-second intermetatarsal angle (1-2 IMA) evaluates the severity of metatarsus primus varus. The DMAA assesses the relationship of the articular surface of

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the first ray to its metatarsal shaft. Relative normal values for these vary in the literature, but accepted norms are as follows: HVA less than 15 degrees,<sup>8</sup> 1-2 IMA approximately 9 degrees,<sup>8</sup> and DMAA from 0 to 15 degrees.<sup>4</sup> Severe bunions are defined in the literature as having an HVA of greater than 40 degrees and a 1-2 IMA greater than 15 to 16 degrees.<sup>2,12</sup>

The goal of the present study was to evaluate those patients with severe bunions who underwent first MTP arthrodesis for radiographic correction of the 1-2 IMA and the HVA. We hypothesized that after MTP fusion, the deforming forces of the hallux flexor, extensor, and adductor tendons would be converted to a corrective force across the more proximal first TMT, correcting the 1-2 IMA. We specifically postulated that the majority of patients with severe bunions undergoing first MTP joint arthrodesis would have a correction in the 1-2 IMA and HVA, which would be close to the accepted population norms of 9 degrees and less than 15 degrees respectively.

## Methods

The University Institutional Review Board approved a retrospective study of patients who underwent first MTP joint fusion for severe hallux valgus deformity at the outpatient surgery center. All surgeries were performed by the senior author. Standard internal fixation methods were used during the operative procedures. Patients were identified by searching the database of the senior author for the CPT code 28750, which is arthrodesis of the first MTP joint. This initial search produced more than 300 patients. These patients were initially screened by measuring the HVA and 1-2 IMA and only those with IMA greater than 15 were included in the study. Nineteen total feet (17 patients) met the criteria for severe hallux valgus based on having a 1-2 IMA greater than 15 degrees and thus were included for analysis. Seven left and 12 right feet were included. Mean follow-up was 10 months.

Digital radiographs (weight-bearing anteroposterior views) were collected and sorted into "preoperative" and "postoperative" folders and subfolders (by patient name). After removal of all identifying information from each radiograph, each subfolder was randomly assigned a unique identifying code so that the pre- and postoperative radiographs of the same patient could not be identified by the reviewers. All radiographs were analyzed by 3 independent reviewers at different levels of training (third-year orthopedic resident, fourth-year orthopedic resident, and orthopedic foot/ankle staff). At the completion of the review process, the identifying code was broken and all recorded measurements were transferred to a master spreadsheet and analyzed.

Each independent review of radiographs consisted of measurements made on weight-bearing anteroposterior radiographs of the foot using the digital angle measurement



**Figure 1.** (A and B) Patient with significant correction of the 1-2 IMA and HVA angles postoperatively after a first MTP fusion. No proximal osteotomy was needed to achieve a 10-degree correction in the 1-2 IMA. HVA, hallux valgus angle; 1-2 IMA, first-to-second intermetatarsal angle; MTP, metatarsophalangeal.

tool on the Phillips I-site PACS software. Two measurements were obtained from each pre- and postoperative radiograph: the hallux valgus angle (HVA) and the 1-2 IMA. The films measured were weight-bearing films obtained preoperatively, and once weight bearing was allowed postoperatively. Our protocol was to obtain non-weight bearing films to evaluate for healing with weight bearing films being obtained first around 3 months postoperatively. The 1-2 IMA was obtained by drawing lines down the center of both the first and second metatarsal shafts. The angle between these 2 lines was calculated by the PACS software. The HVA was measured between the previously drawn line down the first metatarsal and a second line down the center of the proximal phalanx shaft. This angle was again calculated using the PACS software (Figure 1). All recorded measurements are shown in Table 1. The angles for the 3 reviewers were then averaged to give a mean 1-2 IMA and HVA. Statistical analysis was performed using SPSS statistical software (IBM, Inc, Armonk, NY). Descriptive statistics were calculated on combined observer measurements and were reported as the mean value  $\pm$  standard error of the mean (SEM). A paired Student *t* test was used to compare preoperative and postoperative values. A value of  $P < .05$  was considered significant for all comparisons.

**Table 1.** Average Measured HVA and 1-2 IMA for Each Patient in the Study.<sup>a</sup>

Patient	Side	Preoperative		Postoperative	
		IMA	HVA	IMA	HVA
Foot 1	L	16.7	36	8.0	8.0
Foot 2	R	24.3	56.7	12.3	12.0
Foot 3	L	17.3	45.3	10.3	5.0
Foot 4	R	16.7	41.0	11.0	10.0
Foot 5	R	15.7	50.7	7.3	16.0
Foot 6	L	17.3	40.3	13.3	12.7
Foot 7	R	21.3	42.7	16.7	15.3
Foot 8	R	16.0	42.0	13.3	9.7
Foot 9	R	17.0	53.7	9.0	24.0
Foot 10	R	19.0	57.7	10.0	13.3
Foot 11	L	21.3	55.0	6.3	13.3
Foot 12	R	19.3	41.7	11.3	13.7
Foot 13	R	23.0	51.0	10.0	7.0
Foot 14	L	19.7	46.3	9.0	8.7
Foot 15	L	21.3	39.7	12.3	5.0
Foot 16	R	18.7	55.3	9.0	20.3
Foot 17	L	16.0	54.0	7.7	14.7
Foot 18	R	22.3	56.3	13.7	7.7
Foot 19	R	22.7	56.3	16.0	16.7
Average		19.3	48.5	10.9	12.3

Abbreviations: HVA, hallux valgus angle; 1-2 IMA, first-to-second intermetatarsal angle; MTP, metatarsophalangeal.

<sup>a</sup>With only a first MTP fusion, we were able to achieve an 8.3-degree correction in the 1-2 IMA.

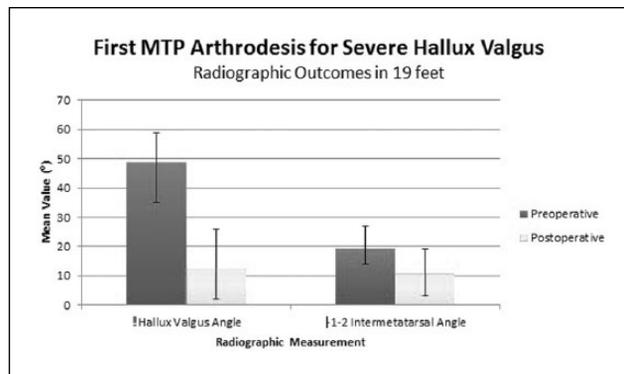
**Results**

The mean preoperative 1-2 IMA was 19.2 degrees (range 15.6-24.3 degrees). The mean preoperative HVA was 48.5 degrees (range 36-56.6 degrees), as seen in Table 1. Results from this study show an average change in the IMA of 8.3 degrees ( $\pm 3.0$  degrees [standard deviation]) and hallux valgus angle of 36.4 degrees ( $\pm 6.4$  [standard deviation]), displayed in Figure 2. Paired *t* test demonstrated that differences between pre- and postoperative measurements for both angles were statistically significant ( $P \leq .001$ ).

Mean postoperative values for 1-2 IMA and HVA were 10.8 and 12.3 degrees, respectively (Table 1). Seven of 19 (37%) feet were corrected to an IMA of less than 9 degrees, which is considered normal,<sup>8</sup> whereas in 15/19 (79%) feet, the postoperative IMA was 12.3 degrees or less. The postoperative HVA was less than 15 degrees in 15/19 (79%) feet.

**Discussion**

In this study, we present the power of the MTP arthrodesis to correct the 1-2 IMA to a normal value almost 40% of the time and to an acceptable level in the vast majority of cases



**Figure 2.** Graph presenting a visual indicator of the average severity of preoperative hallux valgus and the average postoperative deformity that remained. The error bars represent the minimal and maximal preoperative and residual deformity seen.

without the addition of a proximal first metatarsal osteotomy. We believe that after a first MTP fusion, the pull of the flexor, extensor, and adductor tendons is converted from a deforming force to a corrective force to the varus on the first metatarsal. Although an additional osteotomy can improve 1-2 IMA correction even further, these procedures are not without risk. Mann has reported on the potential for malunion and shortening of the first ray after Mau osteotomy leading to transfer metatarsalgia on the lesser metatarsal heads.<sup>9</sup> Nonunion may also occur with any osteotomy. Thus, it is important to determine whether a more proximal procedure adds any benefit. We feel it is not required according to our current findings.

Successful clinical results for patients undergoing first MTP joint arthrodesis can be found throughout the literature. Fusion rates are reported to be from 77% to 100%, with the average being higher than 90%<sup>1</sup> and an overall success rate around 91% for the operation.<sup>11</sup> Coughlin et al reported on patients undergoing MTP fusion for moderate to severe hallux valgus with an average follow-up of more than 8 years.<sup>3</sup> Coughlin reported that 80% of the patients in his study reported excellent results, whereas the remaining 20% reported good outcomes. All patients reported significant pain relief.<sup>3</sup> These findings along with other studies in the literature support the idea that those patients undergoing first MTP fusion have very good clinical results.<sup>6,7</sup>

Recent literature suggests that first MTP arthrodesis alone does not adequately address metatarsus primus varus, thus requiring an additional proximal procedure (Lapidus or Mau osteotomy) to correct the wide first intermetatarsal angle (1-2 IMA).<sup>12</sup> Rippstein et al looked at patients with severe bunions (HVA >40 degrees and a 1-2 IMA >15) who underwent first MTP arthrodesis and a proximal corrective procedure. They showed that by including a proximal procedure with the MTP fusion, they were able to correct the 1-2 IMA to an average of 4.6 degrees, with a mean

correction of 14 degrees.<sup>12</sup> The rationale behind this is that correction of the 1-2 IMA will allow for improved appearance of the foot by decreasing the gapping in the first web-space and allow for more normal shoe wear by decreasing the width of the foot.<sup>12</sup> These authors emphasized that previous studies evaluating 1-2 IMA correction in patients undergoing first MTP fusion included bunions of varying severity.<sup>5,10,12</sup>

Our present study was created to investigate radiographic correction of the 1-2 IMA and HVA in patients with severe bunions undergoing first MTP fusion. To our knowledge, this subset of patients has not been isolated and studied specifically for correction of HVA and 1-2 IMA. We specifically hoped to address the controversy as to whether a proximal osteotomy is radiographically required after an MTP fusion. We demonstrated that the HVA and the 1-2 IMA can be significantly corrected with first MTP joint arthrodesis, without an additional proximal first metatarsal osteotomy. Our patients had an average correction in the 1-2 IMA of 8.3 degrees and an HVA correction of 36.4 degrees. These corrections allowed for resultant mean angles of 10.8 degrees (1-2 IMA) and 12.3 degrees (HVA), both of which are comparable to results reported by Coughlin et al.<sup>3</sup> Although we did not report clinical results in our present study, our study shows equivalent radiographic results based on postoperative angles when compared to Coughlin et al's study, which reported mostly excellent results.<sup>3</sup>

Pydah et al<sup>10</sup> and Cronin et al<sup>5</sup> both looked at correction of the IMA after first MTP fusion and showed that there was an average correction of 5.44 and 8.22 degrees, respectively. Both of these studies included multiple patients with mild bunions. Fifty percent of patients in the latter study and 55% of the patients in the former had a 1-2 IMA  $\leq$ 15.0 degrees. Our study looked only at severe bunions; thus, all but 1 of our patients had a 1-2 IMA greater than 16 degrees, and all but 1 patient had an HVA greater than 40 degrees. By selecting severe bunions, we hoped to show that if the angles can be corrected in these patients, they should be correctable in almost all patients with lesser deformities. Our mean postoperative 1-2 IMA was acceptable and comparable to previous studies of first MTP joint fusions without proximal osteotomies. The 1-2 IMA was corrected to normal in 39% of feet and to 12.3 degrees or less in 79% of feet.

Our goal was to demonstrate radiographic correction of deformity, but we realize that a major limitation of this study is that this is a retrospective radiographic review that does not analyze clinical results.

## Conclusion

We feel this study demonstrated adequate radiographic correction of the 1-2 IMA after MTP fusion for severe bunions. With a distal fusion alone, we were able to bring

many patients to an acceptable 1-2 IMA angle. We think clinical success is guided by reconstruction of the anatomy and avoiding of complications. Our data shows that in a majority of cases, we recreated acceptable anatomy with less surgery than a combined proximal and distal procedure, thereby decreasing the risk of complications.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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## References

- Coughlin MJ. Arthrodesis of the first metatarsophalangeal joint. *Orthop Rev*. 1990;19(2):177-186.
- Coughlin MJ. Hallux valgus: an instructional course lecture. *AAOS JBJS*. 1996;78(6):932-966.
- Coughlin MJ, Grebing BR, Jones CP. Arthrodesis of the first metatarsophalangeal joint for idiopathic hallux valgus: intermediate results. *Foot Ankle Int*. 2005;26(10):783-792.
- Coughlin MJ, Thompson FM. The high price of high-fashion footwear. In *Instructional Course Lectures, The American Academy of Orthopaedic Surgeons*. Vol. 44. Rosemont, IL: American Academy of Orthopaedic Surgeons; 1995:371-377.
- Cronin JJ, Limbers JP, Kutty S, Stephens MM. Intermetatarsal angle after first metatarsophalangeal joint arthrodesis for hallux valgus. *Foot Ankle Int*. 2006;27(2):104-109.
- Grimes JS, Coughlin MJ. First metatarsophalangeal joint arthrodesis as a treatment for failed hallux valgus surgery. *Foot Ankle Int*. 2006;27(11):887-893.
- Lipscomb PR. Arthrodesis of the first metatarsophalangeal joint for severe bunions and hallux rigidus. *Clin Orthop Relat Res*. 1979;142:48-54.
- Mann RA, Coughlin MJ. Adult hallux valgus. In: Mann RA, Coughlin MJ, eds. *Surgery of the Foot and Ankle*. 6th ed. St Louis: Mosby-Year Book; 1993:167-296.
- Mann RA, Rudicel S, Graves SC. Repair of hallux valgus with a distal soft-tissue procedure and proximal metatarsal osteotomy. A long-term follow-up. *Bone Joint Surg*. 1992;74(1):124-129.
- Pydah SK, Toh EM, Sirikonda SP, Walker CR. Intermetatarsal angular change following fusion of the first metatarsophalangeal joint. *Foot Ankle Int*. 2009;30(5):415-418. <http://dx.doi.org/10.3113/FAI.2009.0415>
- Riggs SA Jr, Johnson EW Jr. McKeever arthrodesis for the painful hallux. *Foot Ankle*. 1983;3(5):248-253.
- Rippstein PF, Park YU, Naal FD. Combination of first metatarsophalangeal joint arthrodesis and proximal correction for severe hallux valgus deformity. *Foot Ankle Int*. 2012;33(5):400-405.