



Reduction of Intermetatarsal Angle after First Metatarsophalangeal Joint Arthrodesis in Patients with Hallux Valgus

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ABSTRACT

We present a radiographic review of 94 patients who underwent first metatarsophalangeal joint arthrodesis. The main focus of our review was to assess the change in the intermetatarsal angle (IMA). The change in the IMA was measured for the entire group and for 2 subgroups (IMA 11° to 15° and IMA >15°). The results of the angular measurements for the total data set were as follows: mean preoperative first IMA, 15.32° (range 11° to 24°), mean postoperative IMA, 9.88° (range 3° to 18°), and mean change in IMA of 5.44° (range -2° to 13°; $p < .001$). Group 1, with an IMA of 11° to 15°, included 52 patients, with a mean change in the IMA of 4.21° (range -2° to 9°; $p < .001$). Group 2, with an IMA greater than 15° (range 16° to 24°), included 42 patients, with a mean change in the IMA of 6.83° (range 2° to 13°; $p < .001$). The change in the preoperative to postoperative IMA in group 1 compared with that in group 2 was statistically significant ($p < .001$). The results of the present study have confirmed the observations of previous investigators that arthrodesis of the first metatarsophalangeal joint for hallux abducto valgus deformity results in a reduction of the IMA and that a proportionately larger reduction can be expected when the IMA is larger.

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First metatarsophalangeal joint (MTPJ) arthrodesis is widely accepted in the practice of foot and ankle surgery and can be effective in providing correction for a variety of deformities and disorders related to the first metatarsophalangeal joint and first ray. Angular and rotational deformities can be addressed, as well as joint subluxation, dislocation, and hallux varus. It is also effective for pain relief in hallux rigidus, salvage for failed implant arthroplasty, and the arrest of any inflammatory or infectious process. It has been noted by multiple investigators that correction of metatarsus primus adductus or the first intermetatarsal angle (IMA) occurs in conjunction with first MTPJ fusion (1–8). In addition, several investigators have suggested a proportionate reduction of the IMA for larger deformities (1,2). It is readily intuitive that hallux abducto valgus can be alleviated and the correction maintained with fusion. However, a reduction in the IMA is not as easily understood.

Our purpose was to observe the reduction of the IMA when first MTPJ fusion was performed in a large series of patients with a wide range of first IMAs. We believed this information would better define

the reduction of the first IMA that can be expected postoperatively after first MTPJ fusion and further clarify the indications and whether secondary procedures could be needed to correct metatarsus primus adductus.

Patients and Methods

A retrospective review was performed of all patients undergoing primary first MTPJ arthrodesis performed by 1 of us (M.F., P.D., J.C.W.) from January 2007 to June 2012. The institutional review boards of both Des Moines University and Sanford Health approved the present review. A medical information confidentiality agreement was executed for all authors. The inclusion criteria for the present review included primary first MTPJ arthrodesis without adjunctive first ray procedures, adequate preoperative and postoperative (>3 months after the procedure) dorsoplantar weightbearing radiographs available, and a measured preoperative IMA greater than 11.0°. Patient age ranged from 24 to 86 years. Only procedures performed by the 3 of us using the same surgical technique were included. Additional exclusion criteria were revision arthrodesis or fusion performed for a failed implant or osteotomy procedure. The clinical findings that supported the indication for fusion included decreased first MTPJ range of motion, painful MTPJ range of motion, crepitation, instability, deformity, increased circumferential prominence of the joint, and/or radiographic findings consistent with osteoarthritis.

Weightbearing dorsoplantar radiographs were used to evaluate the preoperative IMAs. The same measurements were taken postoperatively when the patients were able to bear full weight and demonstrated solid clinical and radiographic union. The longitudinal bisectors of the first and second metatarsals were used to establish the IMA. Angular measurements were performed by 1 of us (P.D.). The radiographic records were a combination of digital and plain film records and all were measured manually

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using a drafting protractor. A comparison of the change in the mean preoperative and postoperative IMAs using the entire data set was performed using IBM SPSS Statistics for Windows, version 19.0, data analysis software (IBM, Armonk, NY). The data were analyzed using a 1-way analysis of variance test with 95% confidence intervals. Two subsets were then evaluated separately. The first group included patients with a preoperative IMA of 11° to 15° and the second group those patients with a preoperative IMA greater than 15°. This was also evaluated using a 1-way analysis of variance test.

All patients were evaluated for medical and anesthesia concerns before surgery, and all patients provided informed consent for the procedure. The procedures were performed with the patient in the supine position. General or local anesthesia with sedation was used, depending on patient preference and/or the medical concerns noted in the patient's medical history or if adjunctive procedures were to be performed that necessitated a specific form of anesthesia. The incision was consistently made from the midshaft of the proximal phalanx to the midshaft of the first metatarsal, parallel and immediately adjacent to the extensor hallucis longus tendon. The incision was continued to the level of the joint capsule, ensuring that all neurovascular structures were protected. Minimal subcutaneous separation was performed to preserve the perforating blood supply. A dorsal capsular incision was made in line with the skin incision, and the capsule was reflected off the distal first metatarsal head and the proximal phalanx base. All connections and adhesions of the sesamoid apparatus were released from the metatarsal head. Next, all cartilage and the subchondral plate were resected from the head of the first metatarsal using a rongeur. The metatarsal head was shaped into a convex cone. Next, all cartilage and the subchondral plate were resected from the proximal phalanx base using an aggressive cutting power burr. This was fashioned into a concave cup shape, mirroring the convexity of the first metatarsal head. The phalanx was impacted on the head of the metatarsal and the joint temporarily fixated with a 0.062-in. Kirschner wire with the hallux in a slightly dorsiflexed position, abducted parallel with the second digit, and without varus or valgus rotation. A variety of fixation methods were used, including crossing screws, an axial screw and dorsal locking plate, and multiplanar locking plates. The capsule and skin were then closed. The patients were allowed to ambulate immediately postoperatively with an ankle-immobilizing boot with full weight on the heel. The patients were allowed to return to an athletic shoe at approximately 5 to 6 weeks postoperatively, when solid clinical and radiographic union had been documented.

Results

A total of 256 patients were identified who had undergone arthrodesis of the first MTPJ from January 2007 to June 2012. Of these, 94 patient met the inclusion criteria, including an IMA greater than 11°, complete radiographic records, and nonrevision surgery. All patients underwent surgery by 1 of us (M.F., P.D., J.W.). The surgical incision and dissection, joint preparation, and postoperative course were consistent for all patients. A variety of fixation methods were used, including crossing screws, axial screw and dorsal locking plate, and multiplanar locking plates.

The results of the angular measurements for the total data set were as follows: mean preoperative IMA, 15.32° (range 11° to 24°); mean postoperative IMA, 9.88° (range 3° to 18°); and mean change in IMA, 5.44° [range -2° to 13°; $F(1,93) = 391.95, p < .001$]. Group 1, with an IMA of 11° to 15°, included 52 patients, with a mean change in the IMA of 4.21° (range -2° to 9°; $p < .001$). Group 2, with an IMA greater than 15° (range 16° to 24°), included 42 patients, with a mean change in the IMA of 6.83° (range 2° to 13°; $p < .001$). The analysis of the change in the preoperative to postoperative IMA in group 1 compared with that in group 2 was statistically significant [$F(1,92) = 26.68, p < .001$].

Discussion

Arthrodesis of the first MTPJ provides correction of a wide variety of deformities and derangements of the first MTPJ. In our experience, many benefits are offered by first MTPJ arthrodesis. First and foremost, arthrodesis produces permanent correction of both hallux valgus and metatarsus primus adductus, with an extremely low likelihood of revision surgery. This is a distinct advantage for patients with first MTPJ arthrosis associated with hallux valgus. Patients with instability, joint laxity, or severe contracture are also good candidates. Second, when treating hallux abducto valgus with associated degenerative arthritis, the central joint pain and that caused by sesamoid derangement are both addressed, producing more

consistent overall pain relief. Third, arthrodesis preserves the weightbearing function of the hallux and produces more consistent hallux purchase than other joint destructive methods such as resection arthroplasty or implantation (9).

A question that many foot and ankle surgeons have regarding using first MTPJ fusion for hallux abducto valgus is whether the IMA needs to be addressed with concurrent procedures to provide adequate deformity correction. Previous studies have documented a reduction in the IMA after isolated fusion. Mann and Katcherian (1) noted a reduction in the IMA with first MTPJ arthrodesis and stated that the change in the IMA was directly proportional to the preoperative IMA. Sung et al (2) reviewed 58 cases of first MTPJ arthrodesis and reported a mean preoperative angle of 14°, with a mean postoperative angle of 9.7°. They also noted a proportionate improvement of the IMA according to the severity of the deformity. In a similarly designed review of 69 cases, Pydah et al (3) noted a change from 13.1° preoperatively to 8.6° postoperatively. Cronin et al (4) and Coughlin et al (5) both noted changes in the IMA from preoperatively to postoperatively of 16.65° to 8.67° and 17.3° to 11.2°, respectively. Other investigators have also reported a reduction in the IMA (6–8).

The results from our case series of 94 procedures, which included a comparison of small and large preoperative IMAs, have confirmed a larger mean reduction in the postoperative IMA in those with an IMA greater than 15° compared with those with an IMA of 11° to 15° when fusion is used for metatarsus primus adductus ($p < .001$). These values were chosen to determine the thresholds for the groups because we believed they fairly represented the conventional cutoff between a mild to moderate bunion and a more severe bunion. These data have further clarified the hypothesis that even in cases of a large IMA, it is unnecessary to address the first metatarsal with proximal procedures.

Although a reduction in the first IMA has been consistently observed with first MTPJ fusion (1–8), the mechanism of reduction has not been established experimentally. The most likely explanation has been a spontaneous reduction of the first metatarsal after relief of retrograde force from the hallux pushing the first metatarsal medially. Mann and Katcherian (1) observed that with a valgus position of the hallux, lateral bow stringing of the extensor hallucis longus and flexor hallucis longus tendons occurs and accentuates the valgus position. Over time, the lateral joint capsule and the conjoined adductor tendon contract, pushing the first metatarsal into further adductus. After first MTPJ arthrodesis, bow stringing of the long flexor and extensor tendons is all but eliminated as a deforming force. Also, the conjoined tendon of the adductor hallucis can provide an active corrective force toward the midline of the foot, which would act to decrease the IMA, instead of accentuating the lateral deviation of the hallux. Pydah et al (3) also hypothesized that the laterally directed pull of the adductor tendon on the hallux and metatarsal reduced the IMA angle when the proximal joints were flexible. However, this functional relationship has not been proven experimentally. Cronin et al (4), in a series of 20 cases, noted that 4 of their patients had an additional 4° of improvement from week 6 to the end of the observation period. This suggests some degree of active correction of the IMA, possibly from the adductor muscle pull. We believe that the reduction in the medially directed force from the hallux on the metatarsal is the main reason the IMA decreases. We believe this because the correction can be visualized immediately postoperatively and appears to be maintained consistently on postoperative clinical and radiographic examination. We did not measure the change at multiple intervals postoperatively, making conclusions regarding progressive correction over time impossible from our series.

Flexibility of the proximal first ray articulations would be required for IMA reduction to occur. Hypermobility as it relates to the first ray is a controversial and not well-understood subject. To date, no studies have specifically tested the contribution of proximal first ray mobility

to IMA reduction after MTPJ fusion. We agree in principle with other investigators that motion must be available for IMA correction to occur (3,5). We also believe that some rotational changes could also occur at the first metatarsal cuneiform joint that results in a first ray positional change and that this rotation might be a component of the IMA reduction. In a recent case series, Dayton et al (10) noted transverse plane alignment changes of the first ray after frontal plane rotation of the first ray. Although we had no mechanism to observe rotation in the present series, we raise the possibility that relief of the distal deforming forces allows for spontaneous rotation of the metatarsal in the frontal plane, along with the transverse plane movement. This is a topic that requires additional investigation.

We have noted that lateral ankylosis of the sesamoids prevents reduction of the IMA when fusing the first MTPJ in some cases. We have routinely released the sesamoids from any attachment to the plantar and lateral first metatarsal head from an intracapsular approach while preparing the joint. This allows for more mobility of the first metatarsal to move back laterally over the sesamoids, and we believe this is necessary for IMA reduction. The adductor and flexor tendons should be left intact, because the release is purely intracapsular. We have also routinely prepared the plantar metatarsal articular surface by removing the crista. This has the effect of decompressing the plantar aspect of the joint, which is commonly prominent in hallux abducto valgus with associated degenerative changes.

The present study was limited by its retrospective design and reliance on radiographic records with the inherent inconsistencies. Also, the pre- and postoperative measurements were performed by only 1 of us (P.D.), which could have introduced an observer bias. Although the final measurements were performed on radiographs as early as 3 months postoperatively, we do not believe that this limited our ability to draw conclusions regarding our narrow focus of study (i.e., a reduction in the IMA). We did not set out to observe the healing rates or other surgical outcomes, which would have required a longer follow-up period. Additionally, the short follow-up period prevented us from observing whether the IMA changed significantly over time. This would be an interesting topic for additional investigation. We controlled for a surgical inconsistency bias by having all 3 surgeons use the same technique for incision, dissection, joint release, and joint preparation. Each of the surgeons has worked at the same facility and performed large numbers of first MTPJ fusions in conjunction and, therefore, had intimate knowledge of the surgical technique. This,

however, could not prevent any bias that might have occurred with subtle changes in surgeon technique over time.

In conclusion, in our series of patients undergoing first MTPJ arthrodesis for hallux valgus and metatarsus primus adductus, first MTPJ arthrodesis produced a consistent reduction in the IMA. In addition, a larger decrease in the IMA was noted for the subset of IMAs greater than 15°. This information supports the recommendation that first metatarsal osteotomy is not required as an adjunct procedure to achieve acceptable deformity correction when fusing the first MTPJ for hallux abducto valgus and metatarsus primus adductus.

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