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Arthrodesis of Ipsilateral Hallux Metatarsophalangeal and Interphalangeal Joints

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Abstract

Background: Arthrodesis of the ipsilateral hallux metatarsophalangeal (MTP) and interphalangeal (IP) joints may be required for severe arthritis or deformity at both joints. The purpose of this study was to review outcomes of ipsilateral first MTP and IP joint arthrodesis.

Methods: Twenty feet were identified, for which the diagnosis was rheumatoid arthritis in 14, failed hallux valgus surgery in 5, and hallux rigidus in 1. The IP arthrodesis was performed first in 6 feet; MTP first in 8 feet; and both joints simultaneously in 6 feet. Median follow-up was 28 months (range 12-94). Medical records and radiographs were reviewed. American Orthopaedic Foot & Ankle Society (AOFAS) score and patient satisfaction were determined.

Results: Although all of the MTP arthrodeses healed, 8 of 20 feet (40%) failed to heal at the IP arthrodesis. The rate of IP nonunion was 17% (1/6) with IP arthrodesis first, 50% (4/8) with MTP arthrodesis first, and 50% (3/6) with simultaneous arthrodesis. Four of 8 IP nonunions were symptomatic. Subsequent surgery was required in 11 feet (55%), including repair of IP nonunion in 3 feet, hardware removal in 4, revision MTP malunion in 2, wound debridement in 1, and soft tissue reconstruction in 1. Median hallux AOFAS score for the cohort increased from 25 to 68. Eighteen feet resulted in patients who were very satisfied or satisfied with minor reservations. Neither AOFAS score nor satisfaction trended toward association with IP union.

Conclusion: Ipsilateral arthrodesis of the hallux MTP and IP joints was challenging because of high rates of reoperation and IP nonunion, the latter of which was likely related to increased mechanical stress on the IP joint with immobilization of the MTP joint. Despite the high IP nonunion rate, IP nonunion did not predict patient-reported outcome. Fibrous ankylosis was an acceptable clinical outcome in many cases.

Level of Evidence: Level IV, case series.

Keywords: hallux, MTP, IP, fusion

Introduction

Isolated hallux metatarsophalangeal (MTP) arthrodesis is a commonly performed procedure with generally excellent results, including low rates of nonunion and high rates of satisfaction for multiple indications.[2,6-8] Isolated hallux interphalangeal (IP) arthrodesis is less commonly performed, but not unusual, and outcomes have similarly been mostly satisfactory, with union rates up to 90% with newer fixation techniques.[4,10,11]

Ipsilateral arthrodesis of the hallux MTP and IP joints is rare, though it may be required for arthritis or deformity at both joints, most commonly in rheumatoid arthritis.[1,8] The incidence of these cases may be declining, as is the incidence for rheumatoid forefoot reconstruction in general, because of the widespread use and efficacy of disease-modifying antirheumatic drugs (DMARDs). Disease of both the MTP and IP joints can develop not only as a result of rheumatoid and other inflammatory arthritides but also as a result of the complications or late effects of prior surgery. Patients who

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Table 1. Demographics.

	Mean ± SD or n (%)
Age, y, mean ± SD	59 ± 15
Sex	
Male	0 (0)
Female	20 (100)
Laterality	
Left	12 (60)
Right	8 (40)
Pathology	
Rheumatoid arthritis	14 (70)
Failed prior hallux valgus surgery	5 (25)
Hallux rigidus with interphalangeal arthritis	1 (5)

undergo arthrodesis of the hallux MTP joint or IP joint for any indication (including hallux valgus, hallux rigidus, neuromuscular deformity, inflammatory arthritis, posttraumatic arthritis, or failed arthroplasty) can subsequently develop degeneration or deformity at the adjacent joint as a result of the increased mechanical stress on the articular segment.[6-8] In support of this phenomenon, Fitzgerald et al[7] found that MTP arthrodesis angle is associated with the rate of subsequent IP arthritis. IP arthritis may also be part of a constellation of secondary effects of any prior surgery that causes deformity or diminished motion of the first MTP joint. Depending on the timing of presentation and degeneration of each joint, patients might undergo either simultaneous arthrodesis or sequential arthrodesis in either order.

Arthrodesis of both the hallux MTP and hallux IP joints is rare compared with arthrodesis of either joint in isolation. Consequently, much less has been published regarding the outcomes of such procedures.[5,9,12] A general biomechanical concern is that arthrodeses on either side of an intercalary segment are more likely to result in increased biomechanical stress on the fusion construct, potentially contributing to nonunion on one side or the other. The purpose of this study was to review the results of ipsilateral arthrodesis of both the hallux MTP and hallux IP joints, including minimum 1-year follow-up and patient-reported outcomes for all patients. We hypothesized that the rate of nonunion would vary depending on the order of arthrodesis (MTP first vs IP first vs MTP and IP simultaneously).

Methods

Patients

Consecutive patients having undergone both hallux IP and hallux MTP joint arthrodesis, either simultaneously or sequentially, were identified through a retrospective review of medical records at our institution. A total of 20 feet in 19 patients were identified, all of which were included in the study population (**Table 1**). All of the patients were female; the average (± SD) age was 59 (±15) years. Diagnoses included rheumatoid arthritis in 14 feet, failed prior hallux valgus surgery in 5 feet, and hallux rigidus with IP arthritis in 1 foot. In 6 feet, the IP arthrodesis was performed first; in 8 feet, the MTP arthrodesis first; and in 6 feet, the IP and MTP arthrodeses simultaneously. Median follow-up was 28 months (range 12-94 months).

Operative Technique

In cases of sequential arthrodesis, MTP arthrodesis was routinely performed as follows: A dorsal approach to the first MTP joint was performed; the joint surface was debrided of osteophytes, cartilage, and subchondral bone; and rigid internal fixation was achieved through 2 parallel 3.5-mm cortical screws directed from dorsal-proximal to plantar-distal. Screw heads were countersunk using a burr to reduce subcutaneous prominence and to prevent fracture of the dorsal cortex (Figure 1A and B). Patients were nonweightbearing for 4 weeks followed by weightbearing-as-tolerated for 4 weeks in a postoperative shoe. Of note, all 6 of the patients who first underwent IP arthrodesis underwent subsequent MTP arthrodesis with this technique at our institution. However, of the 8 patients who first underwent MTP arthrodesis, 6 underwent MTP arthrodesis with this technique at our institution, whereas 2 had presented to our institution with their MTP joints already arthrodesed and hardware already removed.

In cases of sequential arthrodesis, IP arthrodesis was routinely performed as follows: A dorsal approach to the first IP joint was performed; the joint surface was debrided of osteophytes, cartilage, and subchondral bone; and rigid internal fixation was achieved with 1 or 2 screws placed from distal to proximal across the joint. (Figure 1C and D). Patients were weightbearing-as-tolerated for 4-5 weeks in a postoperative shoe. Of note, all 8 of the patients who first underwent MTP arthrodesis underwent subsequent IP arthrodesis with this technique at our institution. However, of the 6 patients who first underwent IP arthrodesis, 3 underwent IP arthrodesis with this technique at our institution, whereas 3 had presented to our institution with their IP joints already arthrodesed. Of these latter 3 patients, 2 patients had already had hardware removed, whereas 1 had 2 pins in place.

In cases of simultaneous arthrodesis, IP and MTP joint exposure and preparation was performed as in cases of sequential arthrodesis, but fixation varied. Two of 6 cases were fixed with 2 longitudinal screws crossing both the MTP and IP joints; 2 cases were fixed with 1 longitudinal screw crossing the MTP and IP joint and an additional screw crossing the MTP joint only; 1 case was fixed with 1 longitudinal screw and 1 K-wire crossing the MTP and IP joints; and 1 case was fixed with 2 screws crossing the MTP joint and 1 screw crossing the IP joint (Figure 1E and F). Patients were nonweightbearing for 4 weeks followed by weightbearing-as-tolerated for 4 weeks in a postoperative shoe.

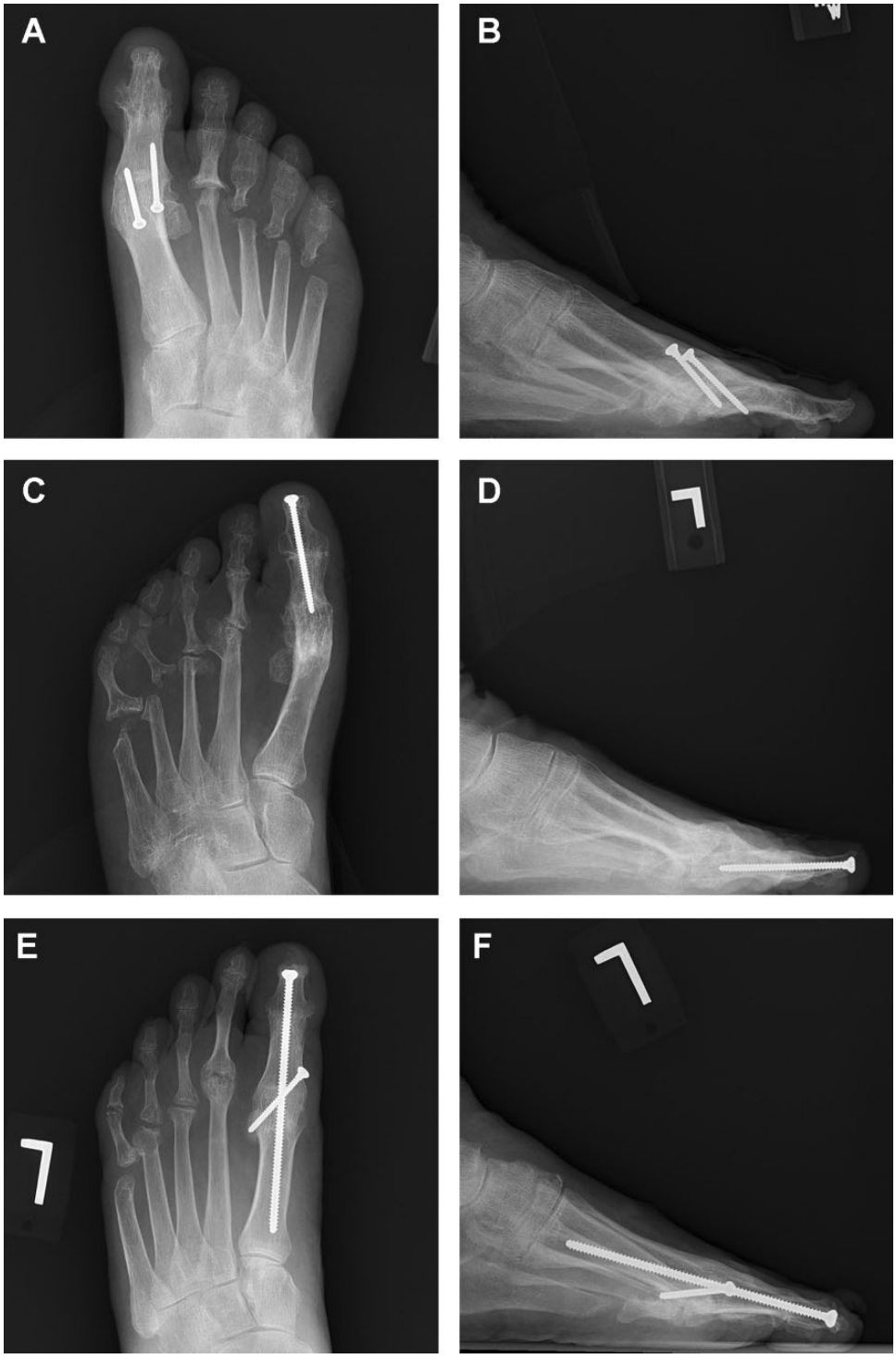

Figure 1. Example constructs for arthrodesis of ipsilateral hallux metatarsophalangeal and interphalangeal joints. (A-B) Arthrodesis of the metatarsophalangeal joint following arthrodesis of the interphalangeal joint. (C-D) Arthrodesis of the interphalangeal joint following arthrodesis of the metatarsophalangeal joint. (E-F) Simultaneous arthrodesis of the interphalangeal and metatarsophalangeal joints.

Table 2. IP Nonunion Rate, by Order of Arthrodesis.

	Total patients	IP nonunions	IP nonunion rate (%)
Overall	20	8	40
IP arthrodesis first	6	1	17
MTP arthrodesis first	8	4	50
Simultaneous arthrodesis	6	3	50

Abbreviations: IP, interphalangeal; MTP, metatarsophalangeal.

Radiographic Outcomes

Radiographic evaluation was performed using weightbearing anterior-posterior, lateral, and oblique views of the foot. Joints were assessed for bridging bone and implant stability to determine arthrodesis. Arthrodesis angles of the MTP and IP joints were determined on both the anterior-posterior and lateral views.

Clinical Outcomes

AOFAS hallux score was completed for each patient at each clinic visit. The following complications were documented from the patient's postoperative course: nonunion; thromboembolic events; and subsequent procedures including for painful hardware, malunion, wound healing problems, nonunion, and infection. Nonunion was defined as a lack of bridging bone and/or evidence of implant instability on plain film radiography. Thromboembolic events included either deep vein thrombosis or pulmonary embolism prompting systemic treatment. A subsequent procedure for a wound healing problem was defined as wound dehiscence without gross purulence, osteomyelitis, or the need for a prolonged course of postoperative antibiotics. A subsequent procedure for infection was defined as evidence of deep abscess, sinus tract, and/or osteomyelitis that prompted return to the operating room, with or without the subsequent use of a prolonged course of antibiotics. A subsequent procedure for painful hardware was defined as a procedure for removal of hardware in the absence of nonunion or infection. A subsequent procedure for malunion was defined as a procedure performed for an unacceptable arthrodesis angle at either the IP or MTP joint that resulted in pathologic pressure either at a location on the hallux or due to transfer of pressure to another ray. Patients also completed a questionnaire of subjective satisfaction in which they were asked to designate their feelings about their operative interventions as very satisfied, satisfied with minor reservations, satisfied with major reservations, or not satisfied. Patients were also asked if, knowing the full operative course and outcome, they would undergo the procedure again. The use of custom shoes and custom orthotics were noted. In patients who had not radiographically united, a history of pain at the nonunited segment or pain on examination with stress placed across the nonunited segment was used to classify symptomatic vs asymptomatic nonunion.

Analysis

The study was underpowered for statistical comparisons among the groups regarding the temporal order of MTP vs IP arthrodesis procedures. Thus, the data were analyzed as a case series and only descriptive statistics are reported. For continuous variables, the Shapiro-Wilk test was used to determine whether data were normally distributed with the level of significance set at .05. For follow-up duration, the test rejected the null hypothesis that the data were normally distributed; hence, results are reported as medians and ranges. For age and radiographic angles, the test failed to reject the null hypothesis that the data were normally distributed; hence, results are reported as means and standard deviations. The AOFAS scoring system is nonparametric by nature; hence, the Shapiro-Wilk test was not applied to this outcome and results were reported using medians and ranges.

Results

Nonunion

Of the 20 feet included in the study, none developed nonunion of the MTP joint. In contrast, 8 (40%) developed nonunion of the IP joint. The rate of IP nonunion was 17% (1 of 6) with IP arthrodesis first, 50% (4 of 8) with MTP arthrodesis first, and 50% (3 of 6) with simultaneous arthrodesis (Table 2). Of the 8 patients with IP nonunion, 4 (50%) were symptomatic at the IP joint. Two of the patients with symptomatic nonunion had subsequent removal of hardware, 1 had subsequent IP revision arthrodesis resulting in subsequent union, and 1 had no further surgery.

Among the 14 feet in patients with rheumatoid arthritis, IP nonunion occurred in 5 patients (36%). Among the 6 feet in patients without rheumatoid arthritis, IP nonunion occurred in 3 patients (50%).

Subsequent Procedures

Subsequent procedures on the ipsilateral hallux were performed in 11 feet (55%). These included 3 of the 4 feet noted above to have symptomatic IP nonunions, 4 feet with painful hardware, 2 feet with symptomatic MTP malunions, 1 foot with wound healing problems, and 1 foot with infected hardware (but successful arthrodesis). The 4 feet with painful hardware underwent uneventful hardware removal. One of the feet with a symptomatic MTP malunion had been placed in an unsatisfactory amount of plantarflexion and the other in a combination of plantarflexion and varus. Both were successfully treated with osteotomy and fixation. The foot with a wound healing problem underwent plastic surgery intervention. The foot with infected hardware underwent hardware removal and debridement.

Table 3. Patient-Reported Outcomes.

		Self-Reported Satisfaction				
	Total Patients, n	Very Satisfied, n (%)	Satisfied With Minor Reservations, n (%)	Satisfied With Major Reservations, n (%)	Not Satisfied, n (%)	Would Do It Again, n (%)
Overall	20	11 (55)	7 (35)	0 (0)	2 (10)	16 (80)
IP union	12	7 (58)	4 (33)	0 (0)	1 (8)	11 (92)
IP nonunion	8	4 (50)	3 (38)	0 (0)	1 (13)	5 (63)

Abbreviation: IP, interphalangeal.

Table 4. Median AOFAS Score (Range).

	Preoperative	Postoperative	Change
Overall	25 (0-67)	68 (38-85)	+41 (–3 to +65)
IP union	31 (5-37)	71 (47-85)	+41 (–3 to +65)
IP nonunion	15 (0-49)	68 (38-72)	+41 (+18 to +62)

Abbreviations: AOFAS, American Orthopaedic Foot & Ankle Society; IP, interphalangeal.

Table 5. Mean Arthrodesis Angles in Degrees (± Standard Deviation).

	MTP Valgus	IP Valgus	MTP Extension	IP Flexion
Overall	9 (±6)	6 (±7)	16 (±10)	7 (±10)
IP union	11 (±6)	3 (±6)	17 (±9)	7 (±10)
IP nonunion	7 (±5)	10 (±8)	14 (±12)	7 (±11)

Abbreviations: IP, interphalangeal; MTP, metatarsophalangeal.

Patient-Reported Outcomes and AOFAS Score

Overall, patients reported being very satisfied for 11 feet (55%), satisfied with minor reservations for 7 feet (35%), satisfied with major reservations for 0 feet (0%), and not satisfied for 2 feet (10%). These proportions were relatively similar between the groups with IP union vs IP nonunion (Table 3). Overall, patients reported they would do it again knowing their full operative course and outcome for 16 of 20 feet (80%).

Of the 2 patients who reported being not satisfied, 1 had an MTP arthrodesis for hallux rigidus and then developed symptomatic IP arthritis. This patient had a subsequent IP arthrodesis that developed a symptomatic nonunion. The other patient who was not satisfied had failed 3 previous bunionectomies and had her IP arthrodesis performed prior to her MTP arthrodesis. Although she achieved successful union of her IP joint, she had a plantarflexion malunion of her MTP joint that required revision, as noted above.

The hallux scale of the AOFAS score increased from a median (range) preoperative value of 25 (0-67) to a median postoperative value of 68 (38-85). The preoperative and postoperative AOFAS scores were relatively similar for both the union and nonunion groups (Table 4).

Shoe Wear

At final follow-up, 18 of 19 patients routinely used over-the-counter shoes whereas 1 patient used custom, prescription shoes. The patient who used custom shoes had rheumatoid arthritis and had successful union of both the MTP and IP joints. She reported being very satisfied with the procedure and that she would do it again. Eight patients (42%) routinely used a custom orthotic.

Arthrodesis Position

The mean (± standard deviation) MTP position at final follow-up was 9 degrees valgus (±6) and 16 degrees extension (±10). The mean IP position at final follow-up was 6 degrees valgus (±7) and 7 degrees flexion (±10). The MTP and IP positions were all relatively similar between the IP union and nonunion groups (Table 5).

Discussion

Arthrodesis of the ipsilateral hallux MTP and IP joints may be required for articular damage or deformity at both joints. Depending on the timing of presentation and degeneration of each joint, patients might undergo either simultaneous arthrodesis or sequential arthrodesis in either order. Although isolated hallux MTP arthrodesis[2,6-8] and isolated hallux IP arthrodesis[4,10,11] have been well studied and generally shown to have satisfactory outcomes, much less is known regarding ipsilateral arthrodesis of the MTP and IP joints.[5,9,12] A theoretical concern is that arthrodeses on both sides of an intercalary segment may result in increased biomechanical stress, potentially contributing to nonunion or pain.

The present study summarizes our experience with ipsilateral arthrodesis of both the hallux MTP and hallux IP joints, including minimum 1-year (median 2 year) follow-up and patient-reported outcomes for all patients. Overall, we found a high rate of complication requiring reoperation (55% of feet), a low rate of MTP nonunion (0%), and a high rate of IP nonunion (40%). Notably, the IP nonunion rate was higher for patients undergoing MTP arthrodesis prior to IP arthrodesis (50%) and for patients undergoing simultaneous MTP and IP arthrodesis (50%), compared with patients undergoing IP arthrodesis in the setting of a native MTP joint (17%).

Only 2 prior studies have reported outcomes following arthrodesis of the ipsilateral hallux MTP and IP joints.[9,12] The first was published in 2006 by Mizel et al.[9] These authors reported the results of 7 feet in 5 patients who underwent simultaneous arthrodesis of the hallux IP and MTP joints. These patients included 3 with rheumatoid arthritis and 2 with multiple prior hallux surgeries including hallux valgus correction, cheilectomy, and MTP arthroplasty with a silicone implant. Five feet (3 patients) also underwent Hoffman arthroplasties. No description of their fixation method was provided. The study reported good pain relief and satisfaction and a 100% union rate of both arthrodesis sites by routine postoperative radiographs. A low complication rate was reported with 1 postoperative cellulitis treated with oral antibiotics and 2 patients requiring removal of painful hardware after union was achieved.

The second study examining arthrodesis of the ipsilateral MTP and IP joints was published by Thitiboonsuwan et al in 2018.[12] These authors directly compared their results between 25 patients undergoing isolated IP arthrodesis and 17 patients undergoing IP arthrodesis in the setting of prior MTP arthrodesis. These authors reported an IP nonunion rate of 35% among cases with prior MTP arthrodesis vs only 8% among cases undergoing isolated IP arthrodesis. Moreover, they found a higher rate of other complications in addition to nonunion among patients who had had ipsilateral MTP arthrodesis prior to their IP arthrodesis procedure. The authors concluded that first MTP arthrodesis resulted in slower healing of the IP arthrodesis with associated higher risk for nonunion and other complications.

The results of the Thitiboonsuwan et al[12] study are consistent with the results of the present study in that for both studies, the IP nonunion rate was below 20% without prior MTP arthrodesis, but climbed to greater than 35% when MTP arthrodesis had been previously performed. Thitiboonsuwan et al[12] excluded patients undergoing simultaneous arthrodesis, but we found that patients undergoing simultaneous arthrodesis had an IP nonunion rate that was more similar to those having previously undergone MTP arthrodesis than those who had not. This makes biomechanical sense, if the MTP joint is immobilized—whether through solid prior arthrodesis or recent transarticular fixation to facilitate novel arthrodesis—it increases stress transfer to the adjacent IP joint in both cases.

The Thitiboonsuwan et al[12] study also has several significant limitations. First, the authors required a minimum of only 3 months of follow-up, with a median follow-up of only 9 months. The current study had minimum 12-month and median 28-month follow-up. A number of our complications including the symptomatic plantarflexion malunions of the MTP joint might have only been captured by this longer follow-up period. Second, the current study augments the findings of the study by Thitiboonsuwan et al[12] by the inclusion of patient-reported outcomes, subjective measures of patient satisfaction, and AOFAS scores obtained at final follow-up for all patients.

Despite the high nonunion rate observed in the present study, patient satisfaction was actually relatively high. Specifically, the rate of patient satisfaction with minor reservations or higher was 90%. Moreover, 80% of patients reported they would have the procedure again. Four of our 8 nonunions were completely asymptomatic. Of the 4 nonunions that were symptomatic, 3 underwent additional procedures in the form of hardware removal (2) or revision arthrodesis (1). At the same time, AOFAS score increased by 41 points in both the IP union and IP nonunion groups. Taken together, these findings suggest that a fibrous nonunion is an acceptable result following IP arthrodesis in many cases.

Our series had 2 plantarflexion malunions of the first MTP joint, one of which also had a component of varus malunion. In cases of isolated MTP arthrodesis, there is some forgiveness toward malunion in that the IP joint can accommodate some of the angular deformity. However, in cases of ipsilateral MTP and IP arthrodesis, the resulting long segment without any joint mobility makes it more difficult for the surgeon to achieve acceptable functional alignment, and even small changes at one arthrodesis site require reciprocal adjustments at the other. Considering the high rate of malunion, the surgeon may need to adjust this complex, multisegment reconstruction at some variance to the standard recommendation of dorsiflexion of 15 to 25 degrees and valgus of 10-15 degrees at the MTP joint[3] because the angle varies with foot posture (cavus vs planus) and proximal deformity, especially in rheumatoid arthritis. When using a flat plate intraoperatively to establish hallux position, the usual technique of aiming for slight elevation and extension of the distal phalanx is more difficult, and with a narrower tolerance. Although arthrodesis position is important in isolated MTP arthrodesis, it becomes even more critical once the accommodative ability of the IP joint is abolished.

In the present series, 14 of the 20 feet developed hallux MTP and IP joint destruction as a result of rheumatoid arthritis, 5 following previous attempted bunion correction, and 1 following MTP arthrodesis for hallux rigidus. Overall, these were complex reconstructive cases, involving multiple deformities, either due to the extensive effects of the rheumatoid arthritis,[1] or due to the revision nature of the procedures. Most of the feet had undergone multiple prior attempts at operative treatment with retained and sometimes broken hardware, leaving an operative field altered by previous incisions and scar tissue and sometimes significant loss of metatarsal and proximal phalangeal bone stock. The series may be skewed toward greater complexity of pathology given both the high rate of rheumatoid patients and the referral nature of the patient population at a tertiary medical center. Reoperation was required in 11 of 20 feet. Difficulty was encountered not only in achieving union of the IP joint but also in achieving satisfactory soft tissue healing and satisfactory osseous alignment over contiguous segments in multiple planes.

The present study has several limitations. First, the sample size is not sufficient to make valid statistical comparisons. Second, these patients have complicated histories with multiple revision procedures and associated foot deformities, making isolation of the effect of MTP and IP arthrodeses difficult. Third, AOFAS score is not a validated patient-reported outcome. This study would be stronger if it used a different patient-reported outcome score. Fourth, union was assessed on plain radiographs rather than by CT scan; this was a retrospective study, and CT scans were not obtained to confirm union as part of our routine clinical protocol. Nevertheless, the present study is by several-fold the longest follow-up of ipsilateral hallux IP and MTP arthrodesis, and also the only such study to collect patient-reported outcomes and AOFAS score.

In conclusion, ipsilateral arthrodesis of the hallux IP and MTP joints was a technically challenging procedure, whether performed simultaneously or sequentially in either order. Special attention should be paid to achieving the best possible position of slight extension and valgus at the MTP joint, as malunions were unforgiving in the setting of double arthrodesis of the first ray. Even with appropriate positioning of the hallux MTP and IP joints, the surgeon should expect a significant rate of complication and reoperation. IP nonunion was more likely in the setting of prior or simultaneous arthrodesis of the MTP joint, compared with isolated IP arthrodesis and a native MTP joint. However, fibrous ankylosis of the IP joint resulted in a satisfactory outcome in some cases. Satisfaction rates in excess of 80% with meaningful improvements in AOFAS score were achieved.

Ethics Approval

Ethical approval for this study was obtained from Baylor University Medical Center (020-018-340952).

Declaration of Conflicting Interests

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