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Original Research

What Do Patients Report Regarding Their Real-World Function Following Concurrent Arthrodesis of the First Tarsometatarsal and First Metatarsophalangeal Joints

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ABSTRACT

First metatarsal phalangeal joint and the first Tarsometatarsal arthrodesis have both been used for deformity correction and treatment of pain and arthritis. Concomitant arthrodesis of the first metatarsophalangeal and first tarsometatarsal joints (Double First Ray Arthrodesis) has rarely been described. We surveyed 29 patients who underwent double first-ray arthrodesis for primary or revision correction of hallux valgus. A custom questionnaire was used to assess their activities of daily living and sports activity at a mean follow-up of 19.6 months (median 18.4 months). Secondary endpoints were return to activity, deformity correction, and arthrodesis healing rate. The primary outcomes showed an excellent return to activities of daily living with 96.6% of patients capable of walking as much as they liked after surgery at a normal pace. About 96.6% reported they felt that their surgery was successful, they had no pain, and the loss of motion at the joint fusion sites did not affect their ability to perform daily activities. Protected walking in a fracture boot was initiated at a mean (SD) of 9.8 (9.9) days. Return to an athletic shoe occurred at a mean (SD) of 44.2 (11.7) days. Full unrestricted activity was at a mean (SD) of 105.2 (19.3) days with 65% of the patient group reporting that their recovery was easier than expected. There was 1 nonunion and no other complications. This data set supports the hypothesis that patients undergoing double first-ray arthrodesis can return to activities of daily living and sports with and low complication rate.

Hallux valgus (HV) with degenerative joint disease (DJD) is a common indication for first MTP joint (MTP) arthrodesis. While techniques and fixation constructs for this procedure vary, the surgical goals are to provide pain relief, correct deformity, and improve gait function. Many studies report consistent pain relief, high satisfaction, and robust return to activity after MTP fusion (1-8). Return to normal activities of daily living (ADLs) have been reported, including going up and down stairs, squatting, picking up objects, as well as sporting and recreational activities (1,6-9) and subjective improvement in the shoes worn by patients (6,7,10,11) Many surgeons consider fusion superior to replacement arthroplasty because comparative studies suggest there is decreased stability of the first ray, decreased first ray weight transfer, less favorable function, and questionable longevity when replacement is compared to MTP joint arthrodesis (11,12).

Accurate alignment of the first ray joint is a priority for patients to return to full activity. There are multiple studies that show consistent deformity correction of hallux valgus following MTP arthrodesis including reduction of the intermetatarsal angle (IMA), hallux valgus angle (HVA), and frontal plane position of the first metatarsal without the use of ancillary procedures (6,13-16). However, there are cases in which full correction of the three-dimensional positions of the first ray cannot be restored with MTP arthrodesis alone. These cases involve a stiff or non-mobile proximal first ray, a severe first intermetatarsal angle, malunion from previous procedures, and tarsometatarsal (TMT) joint

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derangement from arthritis or nonunion. Osteotomy has been described in conjunction with MTP arthrodesis to obtain additional correction but is not commonly utilized (17). When there is previous surgery at the TMT, nonunion at the TMT and/or advanced arthritis at the first TMT, a second proximal fusion can be advantageous. This approach of segmental joint fusion (MTP and TMT double fusion) has rarely been described in the foot and ankle literature (18). We have used this approach of combining first MTP and TMT arthrodesis consistently in situations in which an isolated arthrodesis at the MTP did not provide complete correction or when there were other proximal abnormalities such as arthritis, malunion, and nonunion. Some surgeons are concerned that multisegmental arthrodesis may impair ADLs and recreational sports activity. We have noted that these patients are able to return to most activities with minimal limitations.

The goal of this study was to report patient responses to a questionnaire assessing their activity and satisfaction after multisegmental arthrodesis of the first MTP and first TMT joints. We hypothesize that patients will have minimal limitations of daily function and their subjective acceptance of the procedure will be high.

Patients and Methods

After institutional review board (IRB) exemption was obtained, 29 patients who underwent combined first MTP and TMT joint arthrodesis (multi-segmental arthrodesis) between March 2019 and May 2022 at 4 institutions and performed by 5 surgeons were identified in the individual practice electronic health record systems (EHR). The patients all had hallux valgus deformity that was complicated by arthritis at the first MTP, along with either a stiff, immobile first ray with or without arthritis at the TMT, or the need for revision of a failed first ray procedure necessitating a TMT arthrodesis. Inclusion criteria included patients between the ages of 18 and 80 years with clinical follow-up available for at least 12 months after the procedure and having a willingness to answer the post-operative functional and satisfaction questionnaire via phone call. The call was performed by a contracted research assistant who is independent of any of the surgeons' practices. The questionnaire used was developed by several of the authors and used in a previous study looking at function after isolated MTP fusion published in 2023 (8). Exclusion criteria included the presence of diabetes mellitus with complications or neuropathy, previous infection on the operative foot, documented neuropathy of any etiology, and patients who underwent hindfoot and ankle reconstructive procedures at the same time.

After the patients were identified, patient demographics were recorded from a retrospective chart review that was completed by the contracted research assistant. Baseline and final radiographic evaluation were performed by an independent, board-certified radiologist for assessment and comparison of pre- and postoperative IMA, HVA, osseous foot width (OFW), and healing of the arthrodesis sites. Successful arthrodesis was defined as appropriate radiodensity and lack of lucency at the arthrodesis sites and the screw interfaces, combined with lack of clinical motion obtained from chart review. After the patient agreement to participate and informed consent were completed, a functional questionnaire was administered via phone conversation by the research assistant. Results were logged in a secure database and evaluated by a contracted independent biostatistician. The survey included 43 questions: 11 questions regarding satisfaction with the procedure performed; 16 questions regarding activities of daily living; 6 questions regarding the patient's current health; and 10 questions regarding sports activity.

The surgical technique was consistent for all patients included in this study. The preparation technique for both the MTP and TMT involved full-thickness dissection and complete removal of cartilage and subchondral bone followed by fenestration. Positioning of the first ray at both the TMT and MTP prioritized full three-dimensional correction of the first metatarsal and the hallux. The proximal segment was corrected first and the first TMT was stabilized in anatomic position with the intermetatarsal angle approaching zero degrees, neutral frontal plane rotation, and neutral sagittal plane position. The hallux and first MTP were positioned and fixated second. The hallux frontal plane position was set with the nail plate parallel to the ground. The transverse plane position was in line with the first metatarsal. The sagittal plane position of the hallux was set using a sterile plate to fully load the foot with the ankle joint at 90 degrees and the subtalar joint approximating a neutral position. A 2 mm spacer between the plantar proximal phalanx head and the simulated weightbearing surface set the dorsiflexion angle of the phalanx relative to the ground. Using this method, the plantar pulp of the toe was just touching the plate. Reduction of the IMA, HVA, and frontal plane rotation was confirmed with the use of fluoroscopy. Temporary fixation consisted of two wires at each joint. Final fixation was a biplanar titanium locking plate construct with two small plates and 8 locking screws at each arthrodesis site (Treace Medical Concepts, Ponte Vedra Beach FL). At each respective joint, 2 plates were placed at approximately 90° to each other, one plate dorsomedial and one plate dorsolateral. (Figs. 1 and 2). No interfragmentary screws were utilized. Two-layer closure was completed, and light compression bandage was applied. A temporary splint was applied based on surgeon's preference. Patients were allowed heel weightbearing immediately as tolerated with the foot bandaged and using an assistive ambulatory device. Patient's bandages were removed at their first postoperative evaluation, and they were instructed to walk with a tall fracture boot, and they were allowed to participate in low-impact activity throughout the day. Showering was permitted after the initial bandage removal.

Results

Twenty-nine patients met inclusion/exclusion criteria and went on to participate in the post-operative functional and satisfaction questionnaire. Six of the patients underwent multisegmental arthrodesis on both feet. Of those undergoing bilateral procedures, the second side was performed after adequate bone and soft tissue healing was achieved on the first side. Mean age of the patients was 59.7 years (range 17-77 years). Twenty-five (86.2%) patients were female and 4 (13.8%) were male. One patient had controlled diabetes and 2 patients reported active nicotine use. None of the patients had peripheral neuropathy. Ten (34.5%) patients had undergone previous first-ray surgeries and had presented for revision surgery. Twenty (69.0%) patients had additional procedures performed at the time of the combined first MTP and TMT joint arthrodesis. Procedures were limited to associated forefoot pathologies such as hammertoes and tailor's bunions, as well as gastrocnemius recessions for equinus deformity. Patients who underwent hindfoot and ankle reconstructive procedures were not included in the study. Formal postoperative physical therapy was not required for any of the patients studied.

Mean baseline HVA, IMA, and OFW were 36.1 degrees (range 18.2-52.2), 15.6 degrees (4.8-23.7), and 10.2 cm (range 8.7-11.9 cm), respectively. Mean postoperative HVA improved by 28.2 degrees (43.7-6.5), with a mean postoperative HVA of 7.4 degrees (range 1.0-15.8). IMA decreased a mean of 9.7 degrees (2.5-15.0), to a mean of 6.0 (range 2.3-11.2). A mean reduction in OFW of 1.3 cm (0.1-2.0 cm) was observed.

Patients began protected weightbearing in a tall fracture boot at a mean of 9.8 days postoperatively (median 4.0; range 1-34). Mean time to weightbearing activity in athletic shoes was 44.2 days (median 41.0; range 31.0-88.0), and mean time to full return to activity was 15.0 weeks (median 6.1; range 6.1-20.1). Twenty-eight (96.6%) patients met criteria for fully healed arthrodesis of the first MTP and TMT joints at an average of 7 months. One patient had a revision of the MTP arthrodesis

Fig. 1. (*A-D*) Pre and postoperative radiographic views following segmental fusion for revision of nonunion and poor initial correction.

site due to a painful nonunion and went on to heal the revision arthrodesis.

Postoperative function and satisfaction questionnaire was administered at a mean of 19.6 months (median 18.4 months). The postoperative questionnaire included questions regarding overall satisfaction, ability to perform activities of daily living (ADL), and questions regarding recreational sports activities. The results of the postoperative function and satisfaction questionnaire are reported in Tables 1–7.

Following the surgical interventions performed, 28 (96.6%) patients reported their feet felt better and 27 (93.1%) reported their foot looked better. Twenty-four (82.8%) reported their foot functioned better with 3 (10.3%) patients reporting the same function and only 1 (6.9%) reporting a worse function. Nineteen (65.5%) of patients reported that their recovery was easier than expected, 3 (10.3%) as expected and 7 (24.1%) harder than expected. Twenty-nine (100%) of patients reported they did not need to take medications for foot pain at the time they answered the questionnaire. Twenty-eight (96.6%) of patients reported they could wear a variety of normal shoes. Twenty-five (86.2%) patients reported that pain in their foot never limits their activities with 4 (13.8%) reporting pain sometimes limits their activity. Twenty-eight (96.6%) of patients are able to walk at a normal pace and are able to walk as much as they like. Twenty-eight (96.6%) patients responded that loss of motion of their big toe has no effect on their ability to perform normal daily activities and 25 (86.2%) have no trouble carrying out regular leisure activities with 4 (13.8%) reporting sometimes having trouble. Twenty-eight patients (96.6%) can comfortably go up and down stairs, 24 (82.8%) can stand on their tip toes, and 28 (96.6%) are able to squat and kneel. Twenty-five patients (86.2%) reported that they could do the same job after surgery that they did before surgery, one of which stated they did the same work, but with some limitations. Of the remaining 4, 3 stated their foot did not interfere with their current work after surgery and one stated occasionally. Twenty-eight (96.6%) of patients considered their foot surgery successful, 26 (89.7%) would recommend the surgery to a friend or family member and 28 (96.6%) would have the surgery again.

Regarding recreational athletic activities; 27 (93.1%) of patients walked for exercise before surgery 29 (100%) walked for exercise after surgery, 4 of 5 patients that ran before surgery were running after and 1 additional patient began running, all of the patients that biked before surgery continued to do so with 3 additional patients that began biking after surgery, 2 patients who golfed before surgery were golfing after surgery, 6 patients did yoga before surgery and 5 were still doing yoga after surgery, 10 patients hiked before surgery and continued hiking after surgery, 12 patients did gym workouts before surgery and continued after surgery, 3 patients played tennis before surgery and all continued after. Twenty-seven (93.1%) reported no loss of ability to do the

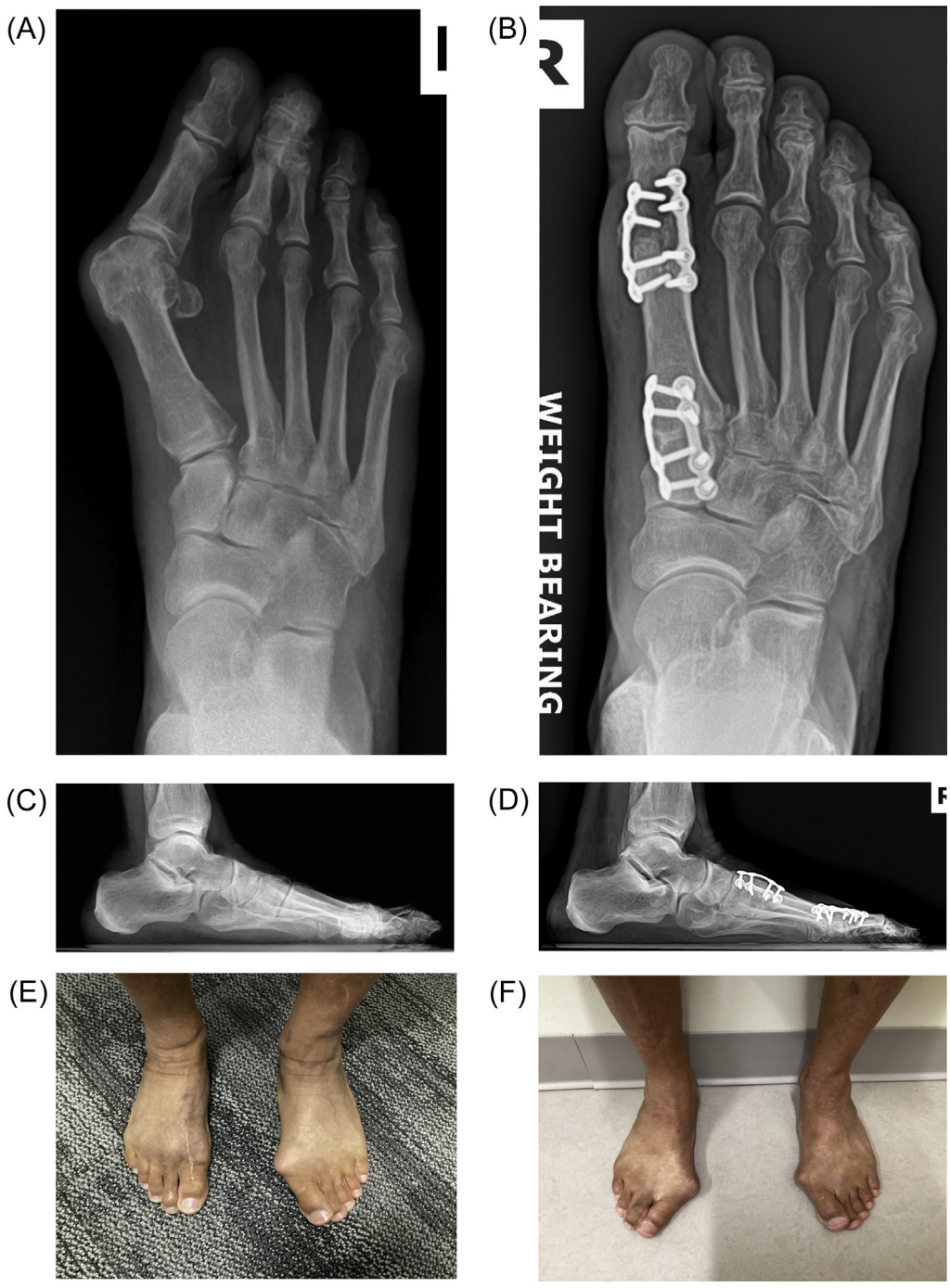

Fig. 2. (*A-F*) Radiographs and clinical photos demonstrating preoperative and postoperative appearance and radiographic correction.

sports that they had done before surgery. One patient could not perform a lunge and 1 patient reported not being able to dance en pointe during ballet. Thirteen (44.8%) of patients reported starting new sports activities after surgery including bowling, pickleball, skating, and rowing and 28 (96.6%) stated they were satisfied with their surgical outcome related to performing recreational sports activities.

Complications included one patient who had a nonunion at the MTP arthrodesis site. The patient who experienced the nonunion had no early complications or reported events. The patient went on to have a revisional first MTP arthrodesis using biplanar plating with the introduction of a nonstructural bone graft following the removal of the original hardware and preparation of the corresponding bone surfaces. No infections or wound healing problems were encountered in this data set.

Discussion

In this cohort that underwent multisegmental first-ray arthrodesis, we demonstrated a robust patient ability to perform ADLs and recreational sports activities. Twenty-eight (96.6%) of the patients within our cohort were able to perform ADLs without significant issues and reported that they were satisfied with their return to sports activities

Table 1
General questions regarding outcomes

	Better	Worse	Same
Does your foot feel better, worse, same after your surgery?	28	0	1
Does your foot look better, worse, same after your surgery?	27	2	0
Does your foot function better, worse, same after your surgery?	24	2	3
	As expected	Easier	Harder
Was your recovery harder or easier than expected?	3	19	7

Table 2
Question regarding medications after recovery

	No	Regularly	Occasionally
Do you have to take any medications for pain related to the surgical site in your foot now?	29	0	0

Table 3
Questions regarding ADLs

	Yes, Without Limitations	Yes, With Limitations	No	N/A
Are you able to *kneel after* your foot surgery?	24	4	0	1
Are you able to *squat after* your foot surgery?	26	2	0	1
Are you able to stand on *tip toes after* your foot surgery?	15	9	5	

Table 4
Questions regarding ADLs

	Yes	No	N/A
Are you able to wear a variety of *shoes* after your foot surgery?	28	1	0
Are you able to *walk* at a normal pace *after* your foot surgery?	28	1	0
Are you able to *walk as much as you like after* your foot surgery?	28	1	0
Are you able to go *up and down stairs* comfortably *after* your foot surgery?	28	1	0

Table 5
Questions regarding overall satisfaction

	Yes	No
Do you feel the loss of motion of your big toe affects your ability to perform your daily activities?	1	28
Do you consider your foot surgery successful?	28	1
Would you have the surgery again knowing what you know now?	28	1
Would you recommend this surgery to a friend or family member	26	3

Table 6
Questions regarding sports activities

	Yes	No
Did you walk for exercise before surgery	27	2
Do you walk for exercise after surgery?	29	0
Did you run before surgery?	5	24
Do you run after your surgery?	5	24
Did you ride a bike before surgery?	8	21
Do you ride a bike after your surgery?	11	18
Did you golf before surgery?	2	27
Do you golf after your surgery?	2	27
Did you do yoga before surgery?	6	23
Do you do yoga after your surgery?	5	24
Did you go hiking before surgery?	10	19
Do you go hiking after your surgery?	10	19
Did you do gym workouts before surgery	12	19
Do you do gym workouts after your surgery?	12	19
Did you play tennis before surgery?	3	26
Do you play tennis after your surgery?	3	26

after surgery. Patients were also pleased with the appearance of their feet compared to preoperatively and did not report the need for medications to control pain at the time of completing the questionnaire. Notable facts regarding this patient group are that 10 (34.5%) patients had undergone previous first ray surgeries and were presenting for revision and 6 of the patients underwent bilateral multisegmental fusion of the first ray. It is interesting that in this complicated patient cohort, the final result was a high level of function with daily activities as well as with return to work and with recreational sports.

Isolated triplane first MTP joint arthrodesis for HV can be an effective means of surgical treatment in the setting of concomitant first MTP degenerative joint disease. Desandis et al (19), demonstrated a significant reduction in difficulty with the performance of daily activities; noting that patients stated their feet looked better, felt better, and they were satisfied with the outcome. Jones et al (1) noted following surgery a high percentage of patients were able to return to a satisfactory level of sport and physical activity.

Table 7
Questions regarding pain and limitations

	Never	Sometimes	Always
Does *pain* in your foot limit any of your activities after your foot surgery?	25	4	0
Do you have trouble doing regular leisure activities with others?	25	4	0

When an isolated first MTP arthrodesis is not able to achieve adequate deformity correction, such as in cases when there is proximal TMT arthritis, malunion or nonunion of the first metatarsal segment, a multisegmental "double" arthrodesis can provide a means for complete deformity correction. Based on our patient-reported function data, we believe multisegmental arthrodesis with appropriate alignment is safe and effective. When comparing the results of multisegmental arthrodesis presented here to those results published for isolated MTP arthrodesis, the patient function and satisfaction is very similar. There have been concerns raised that multisegmental arthrodesis could be "too stiff" and prevent an active lifestyle. We have found that our patients with a combined first MTP and first TMT arthrodesis function very similarly to the result expected after an isolated MTP fusion (8).

There are various studies that have evaluated the sagittal plane motion of the first ray. In 2000, Myerson and Badekas (20) described excessive motion at the first TMT as greater than 4 degrees. Roukis and Landsman (21) pointed out that most of the first ray motion is at the navicular cuneiform joint, with this complex providing between 35% and 50% of the total motion. More specifically, Roling et al (22) determined that sagittal plane motion was 50% at the navicular cuneiform joint, 41% at the first tarsometatarsal joint, and 9% at the talonavicular joint. Accordingly, with the first TMT arthrodesis, there is still approximately 50% of the sagittal plane first ray range of motion available. Even more encouraging to our method is Saffo et al (23), stating that the most motion of the first ray occurs at the medial cuneiform navicular joint, accounting for 90% of the motion. We have observed minimal limitations in patient-reported foot function with a combined fusion of the first MTP and first TMT suggesting that the small amount of first ray motion present within this complex can be sacrificed to provide deformity correction and stability. We firmly believe that our good functional results were achieved because of careful attention to the 3-dimensional deformity correction of both the hallux and the first metatarsal. Additionally, none of the patients in this group had fixation between the first and second metatarsals so this likely allowed for continued natural motion between the rays. Studies support excellent function after the first MTP fusion and since the fusion of the first TMT removes only a portion of the first ray motion robust weightbearing function is maintained. The results of this patient survey are similar to the results seen in a previously published report following the isolated first MTP fusion (8).

Active recovery is desirable for patients and improves their overall satisfaction with their procedure and likely has positive effects on the healing of soft tissues and bone, and ultimately influences the overall outcome. Recently, trends in the literature have shown low complication rates with early weightbearing after the first MTP joint arthrodesis with a variety of fixation constructs (15,24-27). In 2011, Roukis et al (26) reported nonunion, malunion, and symptomatic nonunion rates of 5.4%, 6.1%, and 1.8%, respectively in a systematic review of first MTP arthrodesis outcomes. He noted dorsal malalignment as the primary symptomatic complication and a hardware removal rate of 8.5%. Other recent publications looking at union rates of first TMT fusions show a nonunion rate of 0.9% using a biplanar locked plate construct (28). Based on recent literature using modern fixation, both isolated first TMT and first MTP procedures tolerate weightbearing during recovery. The healing rate in this study of multisegmental arthrodesis was similar, with only one nonunion at a single first MTP fusion site, which was successfully revised and went on to heal.

Immediate protected weightbearing protocols were implemented in all patients included in the present study. Patients were encouraged to utilize gait assistive devices such as crutches, canes, or knee scooters until they began low-impact activity in a tall fracture boot at a mean of 9.8 days. They returned to an athletic shoe at a mean of 44.2 days and graduated to full unrestricted activity at a mean of 15.0 weeks. With this accelerated rehabilitation and early weightbearing protocol, there were no instances of nonunion of the first TMT and only one reported nonunion at the first MTP. We attribute the reported healing rates to three concepts: (1) full-thickness dissection which preserves the soft tissue and periosteal blood supply; (2) fusion site preparation with complete removal of the subchondral plate; and (3) multiplanar stability provided by the biplanar plating construct. The success rate of this surgical method, including the same dissection, preparation, and fixation, was previously published for first-ray arthrodesis procedures with a first TMT fusion rate of 96% and first MTP fusion rate of 98% in 195 total first-ray arthrodesis procedures (29). In this group, we found no long-term complications at the time of follow-up, no soft tissue healing issues, and hardware removal in only one patient.

Limitations of our study include those inherent in retrospective data collection. Functional outcome and satisfaction results were collected via a phone-administered questionnaire which could have influenced the patient responses. Our survey is not validated, and although this prevents direct comparison to other data sets, it does not detract from the primary aim of the study to gather patient-reported functional outcomes. Due to the short timeline of the radiological evaluation, we cannot predict potential long-term issues such as adjacent joint arthritis, and further study will be needed to answer this and other questions. Our empirical experience with performing this procedure over the past 8 years has been encouraging but requires further study. Radiographic evaluation bias exists in all studies, and we attempted to control for this by contracting with an independent board-certified radiologist to assess the radiographs.

This review confirms excellent functional results following a combined first MTP and first TMT arthrodesis based on patient-reported surveys. Radiographs and clinical exams demonstrated a high rate of fusion at both joints with robust and consistent deformity correction. The functional survey confirmed a consistent return to activities of daily living with minimal restrictions on quality of life.

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