The Journal of Foot & Ankle Surgery 62 (2023) 905–911

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

What Do Patients Report Regarding Their Real-World Function Following Triplane Metatarsophalangeal Joint Arthrodesis for Hallux Valgus?

ARTICLE INFO

Level of Clinical Evidence: 4

Keywords:
biplanar plating
fusion
rotation

ABSTRACT

First metatarsal phalangeal (MTP) joint arthrodesis has been employed for decades for pain related to arthritis and other associated abnormalities. Despite the commonality of the procedure there continues to be questions regarding functional expectations following the procedure especially when employed for correction of hallux valgus deformity. We surveyed 60 patients who had a tri plane MTP joint arthrodesis at mean 28.4 months (median 27.8) regarding their activities of daily living and sports activity through a direct conversation. Secondary endpoints assessed were return to activity, deformity correction and arthrodesis healing rate based on chart review and weightbearing radiographs. The primary outcomes showed robust return to all activities of daily living with 96.7% able to walk without restrictions and or pain, 98.3% were able to walk at a normal pace and 95% responded that loss of motion of their big toe did not affect their daily function. Regarding return to sports all patients that participated in sports before surgery resumed participation after with a trend toward increased sports activity. Early return to walking in a fracture boot was noted in this cohort at mean 4.1 days, return to athletic shoe at mean 6.3 weeks and full unrestricted activity at mean 13.3 weeks with no non-unions identified on radiographic or clinical exam. Deformity correction of the typical components of hallux valgus deformity was similar to previously published studies. This data set supports the hypothesis that patients undergoing first MTP joint arthrodesis can expect rapid and full return to activities of daily living and sports with a low complication rate.

Hallux valgus (HV) is a multifaceted deformity of the forefoot that can provoke aberrant motion around joints of the midfoot and forefoot (1-3). When unaddressed, the abnormal foot mechanics associated with HV can precipitate excessive wear and attrition on the cartilage of the first metatarsophalangeal (MTP) joint, leading to erosion and ultimately painful degenerative joint disease (DJD). This compound deformity of HV and DJD is an excellent indication for first MTP joint arthrodesis. While techniques and fixation constructs for this procedure may vary, the goals remain the same; pain relief, deformity correction and improved gait function. For optimal results, anatomic reduction of the hallux in all cardinal body planes and functional alignment of the first metatarsophalangeal joint is a priority for patients to return to activity with minimal restrictions.

Some active patients are reluctant to undergo a first MTP joint arthrodesis procedure due to fears of loss of activity. It is an interesting dichotomy that many of the studies reporting on MTP joint arthrodesis report an extremely high satisfaction rate among patients after the procedure (4-8), yet there is still a fear of the procedure among patients and in some cases surgeons as well. Studies consistently demonstrate decreased pain following the first MTP joint arthrodesis. Pain relief would theoretically allow for more natural progression of weight transfer through the first ray during the gait cycle and therefore improve function. This is supported by comparative studies of first MTP joint arthrodesis and alternative procedures, which have reported decreased stability of the first ray and decreased first ray weight transfer and less favorable function and longevity when compared to MTP joint arthrodesis (9,10). Gibson and Thomson identified that only 40% of weight is born through the hallux after an arthroplasty procedure of the first MTP joint, compared to 80% after an arthrodesis procedure (9). Likewise, a kinematic study by Defrino et al found a significantly shorter stride length and mild reduction in ankle joint torque and plantarflexory power at toe-off when compared to the contralateral, unaffected limb (11). There seems to be a disconnect between patient perception on their ability to return to activity following MTP arthrodesis and the potential to return to activity and exercise that is published in the literature.

Similar to patient misconceptions associated with first MTP joint arthrodesis, surgeons have had a traditional bias against fusion as a viable option for situations other than hallux rigidus and salvage. Again, there is a prevailing thought that MTP joint arthrodesis will prevent the patient from participating in an active lifestyle. A study by Pinney et al was performed by asking a group of foot surgeons about a specific case scenario including a patient suffering from severe HV deformity (12). Their results demonstrated that only 25% would choose the first MTP joint arthrodesis. In addition to fears that patients may not retain a normal and functional gait postoperatively, further fallacies include the inability to appropriately reduce deformities of the first ray by performing an isolated first MTP joint arthrodesis, including intermetatarsal angle (IMA) and frontal plane rotation. In reality there are multiple studies that show consistent deformity correction including IMA, HVA and frontal plane position without the use of ancillary procedures (13,14).

Although the traditional sentiments regarding first MTP joint arthrodesis would predict loss of function after fusion, robust return to

1067-2516/$ - see front matter
https://doi.org/10.1053/j.jfas.2023.04.015

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 (4,15). Furthermore, studies have shown a subjective improvement in the shoes worn by patients after first MTP joint arthrodesis (10,11). The goal of this study was to gather additional patient data to assess real world function after a first MTP joint arthrodesis. Many studies have demonstrated the success of a first MTP joint arthrodesis in eliminating pain and reducing deformity, and while there are some reports assessing patients' everyday function and gait more data is needed to gain a complete understanding of the expectations for daily function. A robust data set of functional analysis of patients who have first MTP joint arthrodesis for HV will help to clarify expectations for ADLs and return to sports activities. We hypothesize that after a first MTP joint arthrodesis 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) approval was obtained, 103 patients who underwent triplanar first MTP joint arthrodesis between June 2018 and December 2020 at a single institution were identified using common procedural terminology (28750) in the practice electronic health record (EHR). All procedures were performed by 1 of 2 surgeons (MD, PD) to maintain consistency regarding fusion preparation, positioning, and fixation construct. Patients were included in the present study on the basis of having intermetatarsal angle (IMA) > 10° and/or hallux valgus angle (HVA) >15°, surgeon-identified indications for arthrodesis, age 18 to 80 years, clinical follow up available for at least 12 months postoperatively, and willingness to answer the Post-Operative Functional and Satisfaction Questionnaire (Table 1) via phone call; a survey developed by the authors for the purposes of the present study. Exclusion criteria included the presence of diabetes mellitus with complications or neuropathy, previous infection on the operative foot, revision or previously failed first MTP joint arthrodesis, and documented neuropathy of any etiology.

After patients were identified, patient demographics were recorded via a retrospective chart review that was completed by a 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 correction, changes in osseous foot width (OFW) and healing of the arthrodesis site. Successful arthrodesis was defined as appropriate radiodensity and lack of lucency at fusion and screw interface by the radiologist, combined with lack of clinical motion obtained from chart review. After patient agreement to participate and informed consent were completed, a prospective functional survey was performed via phone conversation by a non-employee research assistant. Results were logged in a secure database and evaluated by a contracted biostatistician. The survey included 43 questions: 11 questions regarding satisfaction with procedure performed; 16 questions regarding activities of daily living; 6 questions regarding the patient's current health; and 10 questions regarding sports activity.

Table 1
General questions regarding outcomes

	Better	Worse	Same
Does your foot feel better, worse, same after your surgery?	56	1	3
Does your foot look better, worse, same after your surgery?	53	3	4
Does your foot function better, worse, same after your surgery?	42	4	14
Was your recovery from surgery harder or easier than you expected?	28	7	25

The surgical technique was consistent for all patients included in this study. A dorsal incision was utilized just at the medial margin of the extensor hallucis longus tendon and dissection was full thickness with the medial and lateral soft tissue flaps raised subperiosteal. A complete circumferential release of the first metatarsophalangeal joint was done in all patients to promote mobility for 3 plane correction. The fibular sesamoid was removed if it interfered with deformity correction. Joint surface preparation was done manually removing all cartilage and all subchondral bone from the joint surfaces. The fusion site was contoured in a cup and cone fashion with the metatarsal head contoured so that the margins of the prepared head were flush with the shaft circumferentially. The hallux was manually adducted and rotated in a supination direction to obtain alignment of the hallux and to reduce the IMA. Neutral frontal plane rotation to slight supination of the hallux was the goal. We have found that this triplane manipulation is important to drive correction of the IMA from a distal to proximal force application. Sagittal plane position was assessed with the foot firmly loaded in a simulated weightbearing position using a rigid stainless steel tray. Full loading of the first metatarsal head was confirmed followed by assessing hallux position. The hallux interphalangeal joint (HIPJ) was positioned approximately 2mm off the simulated weightbearing surface with the plantar pulp of the toe just touching the plate. Temporary fixation consisted of an axial smooth wire and a dorsal oblique wire. Reduction of the IMA, HVA and frontal plane rotation was directly observed and confirmed on fluoroscopy. Final fixation was a biplanar plate construct with 2 small plates and 8 locking screws (Treace Medical Concepts, Ponte Vedra Beach FL) placed at 90° to each other, one plate dorsal medial and one plate dorsolateral (Fig. 1). Hardware composition was titanium, with screw diameters measuring 2.7mm and lengths varying between 12 and 14 mm. No interfragmentary screws were utilized. Two layer closure was completed and light compression bandage applied. No splints, casts or external stabilization devices were used. Patients were allowed heel weightbearing for the first 3 to 4 days with the foot bandaged and using an assistive device. At approximately day 4 the patients bandages were removed and they were transitioned to a tall fracture boot and allowed low impact activity throughout the day. Showering was allowed after day 4.

Results

Eighty-two of the initial103 patients met inclusion/exclusion criteria. Of the patients included, 60 went on to participate in the Post-Operative Functional and Satisfaction Questionnaire (73 feet, 13 bilateral MTP fusions). Mean age of the included patients was 61.6 years (range 41.9-75.4 years). Most patients were female (52/60, 86.7%). There was a near-even distribution between left (27/60, 45%) and right feet (33/60, 55%). Nicotine use was recorded for 8/60 patients (13.3%). Severity of baseline degenerative joint disease to the first MTP joint was variable; 34 (56.7%) had mild disease, 15 (25%) had moderate disease, and 11 (18.3%) had severe disease based on the radiologists assessment. Fifteen (24%) patients reported a history of previous foot surgery.

Most of the patients in this study did not have significant medical history; 6 (10%) had controlled diabetes mellitus (defined as stable blood sugars and without systemic complications), 1 (1.7%) patient reported immunosuppression therapy, while the other 2 (3.3%) reported a diagnosis of rheumatoid arthritis. Preoperatively, 14 (23%) patients had pain plantar to the second or third metatarsal heads, while 53 (88.3%) exhibited symptoms of pain with first MTP joint range of motion.

We identified 9 additional ancillary procedures performed at the time of first MTP joint arthrodesis in our population (n = 35 concomitant procedures total). Hammertoe correction was the most common

ancillary procedure performed (n = 16), followed by lesser MTP joint release (n = 11). Other procedures recorded included flexor tendon release (n = 10), gastrocsoleal recession (n = 6), fifth metatarsal head remodeling (n = 4), lesser digit proximal interphalangeal joint fusion (n = 2), fifth metatarsal distal osteotomy (n = 2), second MTP joint bone resection (n = 2), and soft tissue mass removal (n = 1).

Fifty-four (90%) of patients did not require formal postoperative physical therapy. One (1.7%) patient suffered from postoperative infection, which was treated successfully with oral antibiotics. There was an isolated case (1, 1.7%) of subsequent secondary surgical intervention, performed for removal of hardware at the patient's request.

Mean baseline HVA, IMA, and OFW were 27.0° (range −15.6° to 53.7°), 13.8° (range 7.5°-20.7°), and 9.8 cm (range 7.8-12.2 cm), respectively. Postoperative HVA improved 13.7° on average (range −40.8° to 17.2°), with a mean HVA of 13.3° (range 1.6°-26.6°). IMA decreased by 3.4° postoperatively (range −9.3° to 4.1°), to a mean of 10.3° (range 5.3°-19.1°). A mean reduction in OFW of 0.7 cm (range −3.4 to 1.2) was also observed. Mean OFW was identified as 9.2 cm postoperatively (range 5.6-11.2 cm).

Patients began protected weightbearing in a tall fracture boot at a mean of 4.1 days postoperatively (median 4; range 1-6). Mean time to weightbearing activity in athletic shoes was 6.3 weeks (median 6.3; range 5.1-7.9), and mean time until full return to activity was 13.3 weeks (median 12.2; range 6.7-64.9). All patients (100%) met criteria for fully healed arthrodesis of the first MTP joint at an average of 9.8 months. Prevalence of pain plantar to the second or third metatarsal heads improved from 23% (14/60) to 3% (2/60) postoperatively.

Post-Operative Function and Satisfaction Questionnaire and final postoperative radiographic examination were performed at mean 28.4 months (median 27.8; range 13.2-45.7) and 9.8 months (median 9.2; range 2.1-25.4) after index procedure, respectively. The results of the Post-Operative Function and Satisfaction Questionnaire are reported in Tables 1-7 and Figs. 2-5. Primary endpoint results for return to function were as follows: 93% (n = 53) of respondents reported they felt better after the surgery and 1.7% (n = 1) stating they felt worse. About 88.3% (n = 53) of respondents felt their foot looked better after surgery and 5% (n = 3) responded worse. Total 98.3% of patients did not require medication or other treatments for symptoms after surgery (n = 59) (Table 2). About 91.7% of patients stated that pain never limits their postoperative activity (n =55) with 6.7% admitting sometimes having activity restrictions (n = 4). About 96.7% of patients stated they could walk as much as they liked after surgery (n = 58), 98.3% could walk at a normal pace and 98.3% of patients could walk up and down stairs comfortably (n = 59). When the participants were asked if the loss of motion of their big toe affected their ability to do normal activity, 95% responded "no" (n = 57). About 91.7% of the respondents never had trouble doing regular leisure activities (n = 55), and 8.3% responded sometimes (n = 5). About 83.3%

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?	59	0	1

Table 3
Questions regarding ADLs

	Yes	With Limitations	No	N/A
If you worked before your surgery, can you do your previous job after your surgery?	38	1	0	21
Were you able to **kneel before** your foot surgery?	39	16	4	1
Are you able to **kneel after** your foot surgery?	43	15	1	1
Were you able to **squat before** your foot surgery?	36	16	3	5
Are you able to **squat after** your foot surgery?	44	9	3	4
Were you able to stand on **tip toes before** your foot surgery?	31	24	4	1
Are you able to stand on **tip toes after** your foot surgery?	33	17	9	1

Table 4
Questions regarding ADLs

	Yes	No	N/A
Are you able to wear a variety of **shoes** after your foot surgery?	50	10	0
Were you able to **walk** at a normal pace **before** your foot surgery?	19	41	0
Are you able to **walk** at a normal pace **after** your foot surgery?	59	1	0
Are you able to **walk as much as you like after** your foot surgery?	58	2	0
Were you able to go **up and down stairs** comfortably **before** your foot surgery?	51	8	1
Are you able to go **up and down stairs** comfortably **after** your foot surgery?	60	0	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?	3	57
Do you consider your foot surgery successful?	56	4
Would you have the surgery again knowing what you know now?	56	4
Would you recommend this surgery to a friend or family member	57	3

Table 6
Questions regarding sports activities

	Yes	No	N/A
Did you **walk** for exercise before surgery	58	2	0
Do you **walk** for exercise after surgery?	58	2	0
Did you **run** before surgery?	9	51	0
Do you **run** after your surgery?	11	0	49
Did you ride a **bike** before surgery?	23	37	0
Do you ride a **bike** after your surgery?	26	0	34
Did you **golf** before surgery?	11	49	0
Do you **golf** after your surgery?	12	0	48
Did you do **yoga** before surgery?	10	50	0
Do you do **yoga** after your surgery?	13	0	47
Did you go **hiking** before surgery?	24	36	0
Do you go **hiking** after your surgery?	26	0	34
Did you do **gym workouts** before surgery	20	40	0
Do you do **gym workouts** after your surgery?	22	0	38
Did you play **tennis** before surgery?	2	58	0
Do you play **tennis** after your surgery?	3	0	57

Table 7
Questions regarding pain and limitations

	Never	Sometimes	Always
Does pain in your foot limit any of your activities after your foot surgery?	55	4	1
Do you have trouble doing regular leisure activities with others?	55	5	0

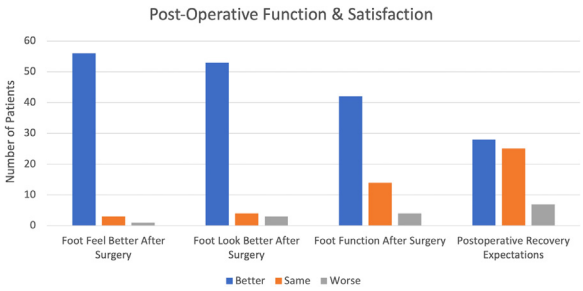

Fig. 1. Pre- versus postoperative appearance, function, and recovery.

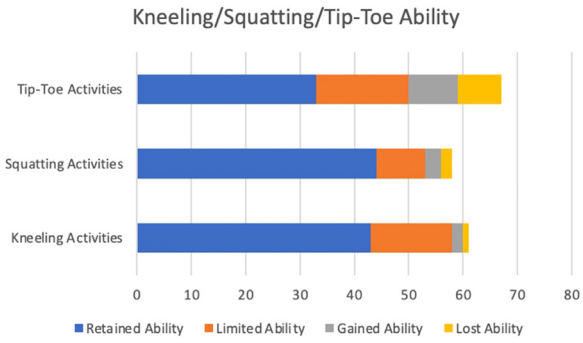

Fig. 2. Postural function.

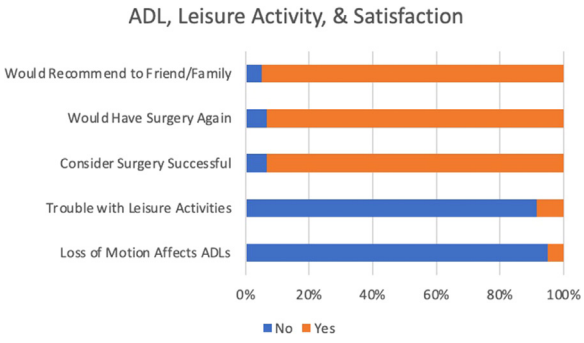

Fig. 3. Activities of daily living (ADL), leisure activities, & patient satisfaction.

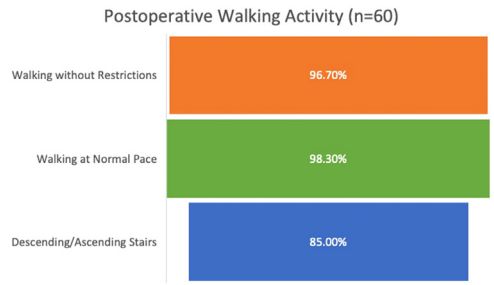

Fig. 4. Walking ability.

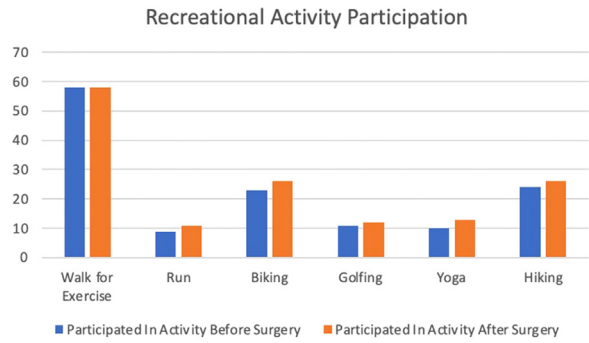

Fig. 5. Participation in recreational activities.

of patients stated they could wear a variety of normal shoes after their surgery (n = 50). When asked if the patients considered their foot surgery successful 93.3% responded "yes" and related that they would undergo the surgery again (n = 56). With regards to postural activities, 43/60 (72%) patients responded they had the ability to kneel postoperatively after undergoing first metatarsophalangeal joint arthrodesis, 15/60 (25%) were able to do so with some limitations. Despite 2 patients not being able to kneel postoperatively, one of these did not have the ability to do so from a preoperative functional standpoint. Similar results were found in our population with respect to their ability to squat postoperatively. Forty-four of 60 (73%) responded they were able to squat, 9/60 (15%) were able to do so with limitations, and 3/60 (5%) responded they were not able to squat postoperatively. Of the patients who were not able to do so, 2 of the 3 patients had lost the ability compared to their preoperative functional capacity. There was a small increase in our population who lost the ability to stand on tip toes postoperatively (13%; n = 8). Nevertheless, 55% of patients acknowledged they could still perform tip toe activity comfortably (n = 33), 28% could do so with limitation (n = 17). One patient who could not do so postoperatively did not have the functional ability for tip toe positional activity preoperatively.

Fig. 6.

Questions regarding sports and exercise activity revealed a high level of function after MTP arthrodesis. All patients who walked for exercise preoperatively were able to do so postoperatively. Fifty-eight of 60 (96.7%) patients stated they could walk as much as they wanted postoperatively and 2 (3.3%) responded that they were not able to walk as much as they wanted. The pace of walking activities seemed to improve in the majority of the included patient population; 68.3% reported they were able to walk at a normal pace after surgery despite not being able to preoperatively (n = 41), 30% reported retaining their ability to walk at a normal pace both pre- and postoperatively (n = 18), and 1.7% admitted loss of normal walking pace from pre- to postoperatively (n = 1). Patient reported function and participation in sports activities increased for running (9 increased to 11; 122%), biking (23 increased to 26; 113%), golfing (11 increased to 12; 109%), yoga (10 increased to 13; 130%), and hiking (24 increased to 26; 108%). Fifty-eight of 60 (96.3%) of the group were satisfied with their return to sports activities.

A vast majority of patients related that loss of first MTP joint motion did not affect their ability to perform their ADLs (n = 57; 95%), while 5% did feel limited ability to perform ADLs (n = 3). Similarly, 91.7% reported never having trouble doing regular leisure activities with others (n = 55), while the remaining 8.3% did admit to sometimes experiencing difficulty doing so (n = 5). These findings were comparable to patient subjective success, with 93.3% believing their surgery was successful (n = 56). Complementary to these findings, 93.3% expressed that they would undergo the surgery again (n = 56), and 95% stated they would recommend this surgery to a friend or family member (n = 57). With regards to patients' perception of ease of recovery, 28/60 (46%) stated recovery was easier than expected, 25/60 (41.7%) responded that recovery was as expected and 7/60 (7%) found the recovery harder. Thirty-eight of 39 (97.4%) of patients that worked before surgery could do their previous job after surgery with one patient working but with

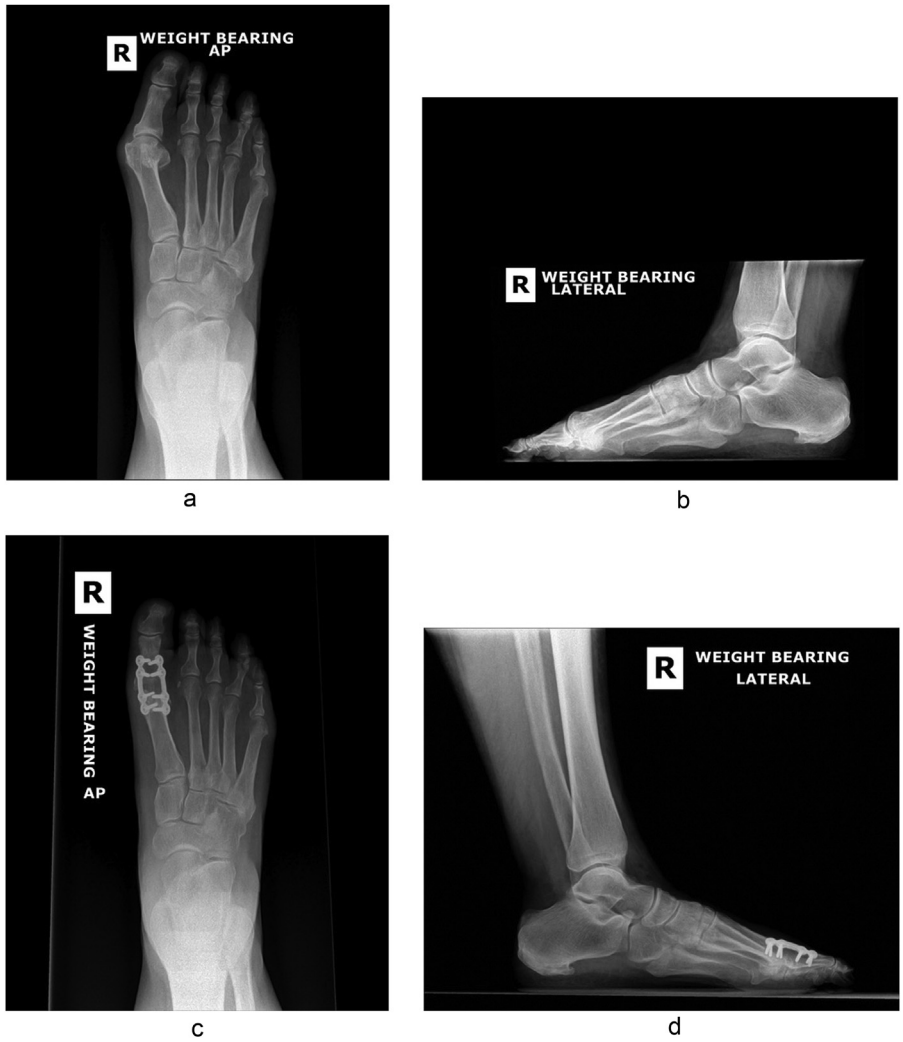

Fig. 6. Radiographs demonstrating preoperative (*A*) AP and (*B*) lateral and postoperative (*C*) AP and (*D*) lateral foot with triplanar first MTP joint arthrodesis using biplanar plating. Note the reduction of the IMA, HVA and frontal plane rotation of the hallux.

limitations. Fifty of 60 (83.3%) of patients responded that they could wear a variety of normal shoes after surgery.

Discussion

Triplanar first MTP joint arthrodesis for hallux valgus can be an effective means of surgical treatment for hallux abductovalgus in the setting of concomitant first MTP degenerative joint disease. The results from our radiographic review are consistent with previous published reports that have demonstrated excellent deformity correction in all cardinal body planes, including IMA and frontal plane rotation (13,16) and high level of successful healing (no non-unions). Furthermore, patient satisfaction following first MTP arthrodesis was robust in the reported patient group with low complication rates.

The understanding of deformity driven arthritis along with the necessity to correct deformity in all cardinal body planes continues to expand, particularly in the setting of the first MTP joint. A recent study has demonstrated the relationship of hallux valgus and cartilage degeneration of the first MTP (17). In this study, gradation and incidence of lesion formation of the metatarsosesamoid and metatarsophalangeal compartments were analyzed, and a statistically significant correlation was found between the grade of cartilage lesion and the hallux valgus angle. These changes were identified in both the metatarsophalangeal and the metatarsosesamoid joints. More recently, Senga et al corroborated these findings with the analysis of 600+ patients and risks associated with hallux rigidus. Amongst the analyzed possible etiologies of joint pathology investigated in their study, hallux valgus was found to have the highest odds ratio and statistical significance of causality (18). It is clear that reliable methods for correction of HV with concomitant DJD are needed and our results support the utility of triplane MTP arthrodesis in restoring pain free activity to this patient population.

A conglomerate of studies has demonstrated the reduction of HVA and IMA following MTP joint arthrodesis (12,19-22). One systematic review illustrated the ability to correct these parameters evaluating fifteen studies, including 701 first MTP arthrodesis procedures. Mean pre- to postoperative IMA angle correction was 4.36° (preoperative mean 13.7° corrected to 9.4° postoperatively). A secondary subset of 267 patients were analyzed with deformities greater than 15°, and a mean correction of 5.42° was identified (12). The findings of this meta-analysis found statistically significant improvement in hallux valgus deformity correction, suggesting arthrodesis alone can be successfully utilized, even in the setting of an increased IMA. Our results were similar with mean baseline IMA 13.8°, and postoperative IMA improvement of −3.4°, to a mean of 10.3°. As with previous studies the degree of IMA

correction seems to be dependent on the size of the preoperative IMA with larger deformities resulting in greater reported angular correction. We have found that supination of the hallux during positioning has a direct effect on IMA correction and we leveraged this concept in our procedure technique.

Several studies have described patient function regarding ADLs following first MTP joint arthrodesis. Desandis et al demonstrated significant reduction in difficulty performing daily activities, with all subscales of the Foot & Ankle Outcome Scores (FAOS) and the Short Form-12 (SF-12) scores significantly improving postoperatively ($P < 0.05$) in 2 distinct patient populations (≤60 years and >60 years) (23). In their study, patients stated that their feet looked and felt better and they were satisfied with the outcome. A second study of 50 patients analyzed return to sport (4). Over 22 sports were described in the study including: biking, running weightlifting, basketball, and swimming. Following surgery 96% were able to return to sport and ideal physical activity level with satisfaction. A third study analyzed a 62 patient cohort consisting of 27 patients with preoperative hallux rigidus and 35 patients with hallux valgus. Their findings included a mean follow-up of 30 months, postoperative VAS pain score of 6.5, and 95% fusion rate with 3 non-unions who underwent a second surgery (8). Only one patient went on to an unsatisfactory result. Similarly, our study demonstrated a robust patient ability to perform ADLs and sports activities with increases in many of the functional domains surveyed. Notably, patients within our cohort had improved involvement in numerous activities and were able to perform ADLs without restrictions. About 96.7% of our patient group were satisfied with their return to sports activities after surgery. We noted a decrease in submetatarsal pain at the lesser metatarsals from 23% preoperatively to 3% postoperatively. Theoretically, this indicates a restoration of first ray weightbearing and improved gait function reducing lesser metatarsal overload. Patients were also pleased with the appearance of their foot compared to preoperatively and did not report the need for medications to control pain.

Active recovery is desirable for patients and improves their overall satisfaction with their procedure and likely has positive effects on the outcome. Furthermore, recent trends in the literature have demonstrated a lack of negative effects with weightbearing after first MTP joint arthrodesis with a variety of fixation constructs (24-27). 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 4.1 days, returned to an athletic shoe at mean of 6.3 weeks, and were graduated to full unrestricted activity at a mean of 13.3 weeks. Despite this aggressive rehabilitation schedule, no instances of nonunion of the fusion site were found. We attribute the rapid healing to 3 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. The success rate of this surgical method was previously published for application of first ray arthrodesis procedures (28). In that study, 195 total first ray arthrodesis procedures were investigated, with roughly 98% fusion rate at the first MTP joint and 96% fusion rate at the first tarsometatarsal joint.

Reported complication rates have consistently been low when evaluating first MTP joint arthrodesis. One systematic review reported no long-term complications in a study group of MTP arthrodesis patients (12). Another study found a complication rate of 3.1% in a cohort including 32 patients (29). Roukis performed a systematic review in 2011 identifying overall nonunion rate after first MTP joint arthrodesis (30). He reported comprehensive nonunion, malunion, and symptomatic nonunion rates of 5.4%, 6.1%, and 1.8%, respectively. He also identified dorsal malalignment as the primary symptomatic malunion position (87.5%), and a rather high rate of hardware removal (8.5%). We report no long term complications in our patient cohort, and all patients in this study achieved osseous fusion within 10 months. There were minimal soft tissue issues in our review (1.7%), and a low hardware removal rate (1.7%).

Limitations with our study include those inherent with retrospective data collection. Functional survey results were collected via a phone administered questionnaire which could have influenced the patient responses. The authors feel that the ease of participating through a phone call with a research assistant rather than face-to-face with a physician visit may have provided a safer environment for improved patient honesty. When comparing data sets between studies it is important to use validated research tools. While our survey is not validated, it was simply designed to give the patients the opportunity to state how they were feeling and functioning after MTP arthrodesis. 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. 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. While this was an industry funded study, there were no financial incentives for the investigators and all funding was for administration of the study as noted in the funding disclosure and, as such, we feel this does not adversely affect our conclusions.

In conclusion, the authors present radiographic, clinical and patient reported functional outcomes for hallux valgus correction with triplane first MTP joint arthrodesis. Radiographs and clinical exams demonstrated 100% fusion with consistent deformity correction. The functional survey showed excellent patient function and quality of life with respect to activity level. Quantitative radiographic deformity correction data, patient qualitative satisfaction, and questionnaire data with a focus on postoperative functional limitations following triplane MTP joint arthrodesis will empower surgeons to further inform patients on post-surgical expectations.

Acknowledgments

The authors would like to thank Deirdra Kile MS, Biostatistician, for statistical analysis, Lisa Kennedy RN, BSN for assistance with data collection and James Choi MD for radiographic analysis.

Supplementary Materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1053/j.jfas.2023.04.015.

References

1. Farzadi M, Sanjari MA, Jalali M, Saeedi H, Kamali M, Movahedi Yeganeh M. Ground reaction force complexity in hallux valgus. Clin Biomech 2021;81:105229.
2. LaPorta GA, Nasser EM, Mulhern JL, Malay DS. The mechanical axis of the first ray: a radiographic assessment in hallux abducto valgus evaluation. J Foot Ankle Surg 2016;55:28–34.
3. Naguib S, Derner B, Meyr AJ. Evaluation of the mechanical axis of the first ray before and after first metatarsal-phalangeal joint reconstructive surgery. J Foot Ankle Surg 2018;57:1140–1142.
4. Da Cunha RJ, MacMahon A, Jones MT, Savenkov A, Deland J, Roberts M, Levine D, Elliot A, Kennedy J, Drakos M, Ellis SJ. Return to sports and physical activities after first metatarsophalangeal joint arthrodesis in young patients. Foot Ankle Int 2019;40(7):745–752.
5. Donegan RJ, Blume PA. Functional results and patient satisfaction of first metatarsophalangeal joint arthrodesis using dual crossed screw fixation. J Foot Ankle Surg 2017;56:291–297.
6. Kuik L, Chmiel J, Jaskólski D, Łuczkiewicz P. Mid-term functional results and failure analysis after first metatarsophalangeal joint arthrodesis. Ortop Traumatol Rehab 2020;22:45–53.
7. Poggio D, de Retana P F, Borda D, Hortua P, Asuncion J, Rios J. Analysis of the clinical score progressions during the first year after first MTPJ fusion. Foot Ankle Int 2010;31:578–583.

8. van Doeselaar DJ, Heesterbeek PJC, Louwerens JWK, Swierstra BA. Foot function after fusion of the first metatarsophalangeal joint. Foot Ankle Int 2010;31:670–675.
9. Gibson JN, Thomson CE. Arthrodesis or total replacement arthroplasty for hallux rigidus: a randomized controlled trial. Foot Ankle Int 2005;26:680–690.
10. Kim PJ, Hatch D, Didomenico L A, Lee M S, Kaczander B, Count G, Kravette M. A multicenter retrospective review of outcomes for arthrodesis, hemi-metallic joint implant, and resectional arthroplasty in the surgical treatment of end-stage hallux rigidus. J Foot Ankle Surg 2012;51:50–56.
11. DeFrino PF, Brodsky JW, Pollo FE, Crenshaw SJ, Beischer AD. First metatarsophalangeal arthrodesis: a clinical, pedobarographic and gait analysis study. Foot Ankle Int 2002;23:496–502.
12. Pinney SJ, Song KR, Chou LB. Surgical treatment of severe hallux valgus: the state of practice among academic foot and ankle surgeons. Foot Ankle Int 2006;27:1024–1029.
13. Dayton P, Feilmeier M, Hunziker B, Nielsen T, Reimer RA. Reduction of the intermetatarsal angle after first metatarsal phalangeal joint arthrodesis: a systematic review. J Foot Ankle Surg 2014;53:620–623.
14. DeCarbo WT, Dayton P, Smith WB, McAleer JP, Hatch DJ, Ray JJ, Santrock RD. Triplanar correction for first metatarsophalangeal fusion. J Foot Ankle Surg 2021;60(5):1044–1047.
15. Brodsky JW, Baum BS, Pollo FE, Mehta H. Prospective gait analysis in patients with first metatarsophalangeal joint arthrodesis for hallux rigidus. Foot Ankle Int 2007;28:162–165.
16. Manchanda K, Chang A, Wallace B, Ahn J, Xi Y, Liu GT, Raspovic K, Van Pelt M, Chhabra A, Wukich D, Lalli T. Short term radiographic and patient outcomes of a biplanar plating system for triplanar hallux valgus correction. J Foot Ankle Surg 2021;60:461–465.
17. Bock P, Kristen KH, Kröner A, Engel A. Hallux valgus and cartilage degeneration in the first metatarsophalangeal joint. J Bone Joint Surg Br 2004;86:669–673.
18. Senga Y, Nishimura A, Ito N, Kitaura Y, Sudo A. Prevalence of and risk factors for hallux rigidus: a cross-sectional study in Japan. BMC Musculoskelet Disord 2021;22:786.
19. Coughlin MJ. Arthrodesis of the first metatarsophalangeal joint with mini-fragment plate fixation. Orthopedics 1990;13:1037–1044.
20. Feilmeier M, Dayton P, Kauwe M, Cifaldi A, Roberts B, Johnk H, Reimer R. Comparison of transverse and coronal plane stability at the first tarsal-metatarsal joint with multiple screw orientations. Foot Ankle Spec 2017;10:104–108.
21. Pydah SKV, Toh EM, Sirikonda SP, Walker CR. Intermetatarsal angular change following fusion of the first metatarsophalangeal joint. Foot Ankle Int 2009;30:415–418.
22. Sung W, Kluesner AJ, Irrgang J, Burns P, Wukich DK. Radiographic outcomes following primary arthrodesis of the first metatarsophalangeal joint in hallux abductovalgus deformity. J Foot Ankle Surg 2010;49:446–451.
23. DeSandis B, Pino A, Levine DS, Roberts M, Deland J, O'Malley M, Elliott A. Functional outcomes following first metatarsophalangeal arthrodesis. Foot Ankle Int 2016;37:715–721.
24. Bass EJ, Sirikonda SP. 1st metatarsophalangeal joint fusion: a comparison of nonunion and gender differences between locking and non-locking plating systems. Foot (Edinb) 2015;25:195–199.
25. Besse JL, Chouteau J, Laptoiu D. Arthrodesis of the first metatarsophalangeal joint with ball and cup reamers and osteosynthesis with pure titanium staples radiological evaluation of a continuous series of 54 cases. Foot Ankle Surg 2010;16:32–37.
26. Dalat F, Cottalorda F, Fessy MH, Besse JL. Does arthrodesis of the first metatarsophalangeal joint correct the intermetatarsal M1M2 angle? Analysis of a continuous series of 208 arthrodeses fixed with plates. Orthop Traumatol Surg Res 2015;101:709–714.
27. Roukis TS, Meusnier T, Augoyard M. Nonunion rate of first metatarsal-phalangeal joint arthrodesis for end-stage hallux rigidus with crossed titanium flexible intramedullary nails and dorsal static staple with immediate weight-bearing. J Foot Ankle Surg 2012;51:308–311.
28. Dayton P, Santrock R, Kauwe M, Gansen G, Harper S, Cifaldi A, Egdorf R, Eisenschink J. Progression of healing on serial radiographs following first ray arthrodesis in the foot using a biplanar plating technique without compression. J Foot Ankle Surg 2019;58:427–433.
29. Fazal MA, Wong JH-M, Rahman L. First metatarsophalangeal joint arthrodesis with two orthogonal two hole plates. Acta Orthop Traumatol Turc 2018;52:363–366.
30. Roukis TS. Nonunion after arthrodesis of the first metatarsal-phalangeal joint: a systematic review. J Foot Ankle Surg 2011;50:710–713.

Mindi Dayton, DPM, MHA, FACFAS

Paul Dayton, DPM, MS, FACFAS

Cody J. Togher, DPM, AACFAS

John M. Thompson, DPM, AACFAS
[1] *Bunion Surgery Specialists, Ankeny, IA*
[2] *Orthopedic Foot & Ankle Center, Worthington, OH*

E-mail address: daytonp@icloud.com (P. Dayton).

Financial Disclosure: This study was funded by a grant from Treace Medical Concepts, Ponte Vedra Beach FL. Funding was used for direct costs to administer the survey, statistical analysis, IRB oversight and radiologic services. No practice or personal income was obtained as part of this study.

Conflict of Interest: Authors MD, PD are consultants for Treace Medical Concepts, Ponte Vedra Beach FL and/or receive royalties for intellectual property related to the Lapiplasty system

IRB exemption was received after submission of protocol to WIRB.