

Return to Sports and Physical Activities After First Metatarsophalangeal Joint Arthrodesis in Young Patients



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Abstract

Background: Arthrodesis of the first metatarsophalangeal (MTP) joint has been shown to be effective in alleviating pain and correcting deformity in hallux rigidus. However, outcomes in specific sports and physical activities remain unclear. The aim of this study was to assess sports and physical activities in young patients following first MTP joint arthrodesis and to compare these results with clinical outcomes.

Methods: Patients between ages 18 and 55 years who underwent MTP arthrodesis were identified by review of a prospective registry. Fifty of 73 eligible patients (68%) were reached for follow-up at a mean of 5.1 (range, 2.2–10.2) years with a mean age at surgery of 49.7 (range, 23–55) years. Physical activity was evaluated with a previously developed sports-specific, patient-administered questionnaire. Clinical outcomes were evaluated with the Foot and Ankle Outcome Score (FAOS).

Results: Patients participated in 22 different sports and physical activities. The most common were walking, biking, weightlifting, swimming, running, and golf. Compared to preoperatively, patients rated 27.4% of activities as less difficult, 51.2% as the same, and 21.4% as more difficult. Patients returned to 44.6% of preoperative physical activities in less than 6 months and reached their maximal level of participation in 88.6% of physical activities. Ninety-six percent of patients (48/50) were satisfied with the procedure regarding return to sports and physical activities. Improvements in the FAOS Symptoms subscore were associated with increased postoperative running and walking duration, and improvements in FAOS Pain subscores were associated with greater patient satisfaction.

Conclusion: Patients were able to participate in a wide variety of sports and physical activities postoperatively. Some patients reported increased difficulty, but were nonetheless satisfied with the procedure regarding physical activity participation. These findings suggest that first MTP joint arthrodesis is a reasonable option in young, active patients, and may be used to guide postoperative expectations.

Level of Evidence: Level IV, retrospective case series.

Keywords: hallux rigidus, arthrodesis, metatarsophalangeal, sports, physical activities

Introduction

Arthrodesis of the first metatarsophalangeal (MTP) joint is a well-established procedure to treat pain, functional impairment, and deformity in conditions including hallux rigidus, hallux valgus, hallux varus, or other degenerative, neuromuscular, or inflammatory conditions that may lead to advanced degeneration of the first MTP joint. It is most frequently performed for late stage hallux rigidus, or as a salvage procedure after failure of other joint-preserving approaches.²⁵ Degenerative arthritis of the first MTP joint, known as hallux rigidus, is reported in 2.5% of patients

older than 50 years and is the most common location for arthritis in the foot.¹⁴ Although the results of several studies

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indicate a mean age at onset of approximately 50 years,^{9-11,24} it is also a relatively common condition in younger patients, with one study reporting a mean age of onset at 43 years.⁵ Although studies of first MTP arthrodesis have shown good to excellent results, with union rates ranging from 90% to 100%^{3,6,12,28,29} and significant improvement in functional outcome scores,³⁻²⁷ the current literature available is based on an average older age^{3,7-27} and is difficult to apply to younger patients that may have increased physical demands. In the authors' experience, younger patients with advanced first MTP joint arthritis are often hesitant to undergo first MTP joint arthrodesis, and treating surgeons are often hesitant to offer it, because of concerns of hindering athletic capabilities. Following failed conservative management, operative treatment of hallux rigidus in younger patients or athletes primarily consists of cheilectomy, with first MTP joint arthrodesis considered to be a potential limitation to sports and physical activities postoperatively due to reduced motion of the first MTP joint.^{15,22} These patients may thus continue with ineffective conservative measures, or a less invasive operative intervention with suboptimal results, in order to avoid arthrodesis. However, patients with significant first MTP joint degenerative changes and midrange of motion pain typically have poor results following cheilectomy and are often subsequently recommended for first MTP joint arthrodesis as a result.³⁻⁷

There is a paucity of literature that specifically investigates sports and physical activity outcomes of first MTP joint arthrodesis,^{3,8} and none in a subset of younger patients. Prior studies used questionnaires with a limited number of sports and physical activities and did not evaluate extent of involvement in the activities or patient satisfaction with sport and physical activity participation, all of which may be important to patients considering the procedure. As preoperative expectations in orthopedic surgery have been found to significantly influence outcomes,^{1,19,20,23} it is important to better inform patients in order to set expectations.

The aim of this study was to examine the effect first MTP joint arthrodesis has on younger patients' participation in specific sports and physical activities using a physical activity and sports-specific questionnaire, which has been used in previous studies of patients undergoing foot and ankle surgery.^{17,18} In addition, we aimed to correlate sports and physical activity outcomes with clinical outcome scores from a validated patient-reported outcomes measure, the Foot and Ankle Outcome Score (FAOS).¹⁶ Our hypotheses were that the majority of younger patients would be able to return to their preoperative level of participation in sports and physical activities, and that patients with better postoperative clinical outcomes as measured by FAOS scores would have better return to sports and physical activities. These findings may help better determine the effects of first MTP joint arthrodesis on sports and physical activity

participation in order to guide expectations and counsel patients accordingly.

Methods

This was a single center, retrospective study. The study protocol was approved by the Foot and Ankle Registry Steering Committee at the investigators' institution. Subjects were identified from an institutional review board-approved foot and ankle registry at the investigators' institution. The registry includes patient demographic, clinical, and operative data from 8 foot and ankle fellowship-trained orthopedic surgeons. A search of the registry was performed using the Current Procedural Terminology (CPT) code for arthrodesis of the hallux MTP joint (28750) among patients who received surgery between October 2006 and December 2014, and operative notes were reviewed to identify eligible patients. Inclusion criteria were first MTP joint arthrodesis, age between 18 and 55 years at time of surgery, and a minimum 2-year follow-up. Exclusion criteria included concomitant metatarsal osteotomies, midfoot or hindfoot fusions, and inflammatory, systemic, or other musculoskeletal disease that would otherwise impact physical activity participation, as well as patients with malunion or nonunion after first MTP arthrodesis, as we aimed to assess postoperative sports and physical activity participation in those with successful union. Patient charts and radiographs were assessed to determine grade of arthritis at presentation.³ Eligible patients were contacted by the investigative team for follow-up.

Seventy-three patients were identified who met the inclusion and exclusion criteria. Fifty patients were reached for follow-up and were consented to be included in this study, yielding a response rate of 68%. The mean age at the time of surgery was 49.7 (range, 23-55) years. Thirty-four percent of patients were male (17/50) and 66% female (33/50). All patients presented with grade III or IV hallux rigidus. The average follow-up time was 5.1 (range, 2.2-10.2) years.

Operative techniques varied by surgeon, but all used either a plate and screw construct or independent screw construct, which have been previously described.⁸ Postoperative management also varied by surgeon, with some allowing for immediate weight-bearing and others deferring weight-bearing until 6 weeks postoperatively. Because this cohort only included patients who achieved union and a prior study found no difference in functional outcomes between these operative techniques,⁸ we did not stratify our cohort based on the technique.

Sports and Physical Activities

Sports and physical activity participation were evaluated with a retrospective physical activity and sports-specific Sports Questionnaire (SQ) that was emailed to patients at follow-up. This questionnaire was developed with the aid of

a clinical epidemiologist and has been used as an assessment tool in previous studies following foot and ankle surgery.^{11,12} The SQ asked whether patients participated in any of 14 common sports and physical activities pre- and postoperatively. These included a mixture of low impact activities (bicycling, golf, swimming, walking) and high impact activities (basketball, dance/aerobics, football, hockey, lacrosse, running, soccer, squash, tennis, weightlifting).^{4,13} Patients could also list up to 3 of the most important sports and physical activities they participated in, including ones that were not included in the list (referred to subsequently as “patient-specific physical activities”). Given the duration of follow-up and likelihood of recall bias, the level of preoperative participation in sports and physical activities was not reported. For postoperative patient-specific activities, patients were asked the number of sessions of participation per week, the duration of time spent per session, the number of months it took to return to the sport after surgery, and the amount of time it took to reach the maximal level of activity, or if they felt they never achieved their maximal level. Patients were also asked whether each patient-specific physical activity was currently more difficult, less difficult, or the same level of difficulty as preoperatively. Only activities that were performed preoperatively were included in the difficulty assessment as any activities that were only started postoperative could not be adequately compared to preoperative. Finally, patients were asked whether or not they were satisfied overall in regard to postoperative return to sports and physical activities. Each patient’s postoperative level of physical activity was subsequently categorized, based on a modification of a previous classification system²⁶: grade 0, sedentary (0 hours of physical activity/week); grade 1, moderately active (greater than 0-5 hours of physical activity/week); grade 2, highly active (greater than 5-10 hours of physical activity/week); or grade 3, extremely active (greater than 10 hours of physical activity/week).

Clinical Outcomes

Clinical outcomes were evaluated with the Foot and Ankle Outcome Score (FAOS). The FAOS is a patient-administered questionnaire that evaluates 5 subscales: Pain, Symptoms, Activities of Daily Living (ADLs), Sport and Recreation, and Quality of Life (QoL). Each subscale is analyzed independently with values normalized to obtain a value from 0 to 100, with 0 being the worst and 100 being the best outcome. The FAOS has been validated for use in various foot and ankle conditions, including hallux rigidus.^{16,21}

Statistical Analysis

Descriptive statistics are presented as means and ranges for continuous variables and medians and ranges for categorical variables. Linear models were used to determine associations

between FAOS subscores and sport participation, including the number of sessions of participation per week, the duration of time spent per session, whether the physical activity was rated as more difficult, less difficult, or the same level of difficulty postoperatively as preoperatively, and satisfaction with surgery regarding current physical activity participation. Generalized estimating equations (GEEs) were used to assess the association between changes in physical activity difficulty and physical activity impact level. All statistical analyses were conducted using R 3.5.1, an open source statistical software (<https://www.r-project.org>), with a level of significance of $P < .05$.

Results

Sports Questionnaire

Patients reported participation in 21 different sports and physical activities, with 169 total preoperative physical activities and 189 total postoperative physical activities. Preoperatively, 34.3% (58/169) of physical activities were high-impact, and postoperatively 34.9% (66/189) were high-impact. The highest participation reported both pre- and postoperatively was in walking, biking, swimming, weightlifting, running, and golf. No physical activities were discontinued from pre- to postoperatively, but 21 new physical activities were initiated (Table 1).

Patients returned to 44.6% of physical activities (83/186 reported) in less than 6 months, to 21.5% (40/186 reported) between 6 and 9 months, to 19.9% (37/186 reported) between 10 and 12 months, to 8.6% (16/186 reported) between 13 and 18 months and to 5.4% (10/186 reported) between 19 and 24 months. Patients reached their maximal participation levels in 88.6% of physical activities (160/176 reported), which was achieved in 26.1% of physical activities (46/176 reported) in less than 6 months, 23.3% (41/176 reported) in 6 to 9 months, 13.1% (23/176 reported) in 10 to 12 months, 13.6% (24/176 reported) in 13 to 18 months, 9.1% (16/176 reported) in 19 to 24 months, and 3.4% (6/176 reported) in greater than 24 months (Figure 1). The median time to return to physical activity was 6 to 9 (range, <6 to 24) months, and the median time to reach their maximal physical activity levels was 9 to 12 (range, <6 to >24) months. Patients spent a median of 6.5 (range, 0-21.5) hours per week exercising postoperatively, with a median of 9 (range, 0-29) sessions per week and a median of 30 (range, 15 to 120) minutes per session. All patients but one (98%, 49/50) participated in sports or physical activities pre- and postoperatively: 1 patient (2%) was sedentary, 21 patients (42%) were moderately active, 12 patients (24%) were highly active, and 16 patients (32%) were extremely active (Table 2).

Compared to preoperatively, 27.4% (46/168) of patient-specific physical activities were rated as improved in

Table I. Preoperative and Postoperative Sports and Physical Activities^a.

Impact	Sport	Preop. No. of Participants (%)	Postop. No. of Participants (%)	Preop. to Postop. Change
Low	Walking ^b	41 (82)	46 (92)	+5
Low	Biking ^b	25 (50)	29 (58)	+4
Low	Swimming ^b	19 (38)	22 (44)	+3
High	Weightlifting ^b	19 (38)	20 (40)	+1
High	Running ^b	12 (24)	12 (24)	0
Low	Golf ^b	12 (24)	12 (24)	0
High	Dancing/Aerobics ^b	9 (18)	11 (22)	+2
High	Tennis ^b	9 (18)	10 (20)	+1
High	Basketball ^b	5 (10)	6 (12)	+1
High	Football ^b	1 (2)	3 (6)	+2
High	Soccer ^b	2 (2)	3 (6)	+1
Low	Skiing	3 (3)	3 (6)	0
Low	Yoga	3 (3)	3 (6)	0
Low	Elliptical	2 (2)	2 (2)	0
High	Squash ^b	1 (2)	1 (2)	0
Low	Rowing	1 (2)	1 (2)	0
Low	Horseback riding	1 (2)	1 (2)	0
Low	Pilates	1 (2)	1 (2)	0
Low	Hiking	1 (2)	1 (2)	0
Low	Ice skating	1 (2)	1 (2)	0
Low	Cross-country skiing	1 (2)	1 (2)	0
Total	21	169	189	+20

Abbreviations: preop. = preoperative; postop. = postoperative.

^aPatients could indicate participation in multiple sports and physical activities.

^bSports and physical activities provided on Sports Questionnaire.

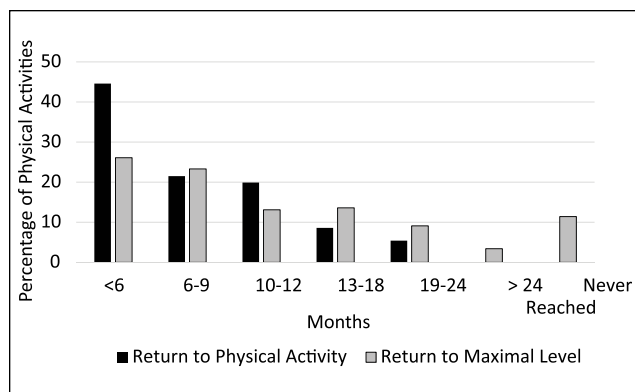


Figure 1. Time to return to physical activities and maximal participation level.

difficulty, 51.2% (86/168) as the same in difficulty, and 21.4% (36/168) as more difficult (Table 3). Changes in physical activity difficulty level were not associated with physical activity impact level ($P = .55$). Reasons for increased difficulty were described by 16 patients (32% of the study cohort) (Table 4). However, all of these patients were satisfied with the surgery in regards to participation in sports and physical activities.

Ninety-six percent of patients (48/50) were satisfied with their surgery in regard to sports and physical activities, with 38% (19/50) very satisfied, 30% (15/50) satisfied, 28% (14/50) somewhat satisfied, and 4% (2/50) dissatisfied. Of the 2 patients who were dissatisfied, one had pain in her foot, and the other cited pain and calluses between the first and second toes.

Functional Outcomes

All FAOS subscores showed significant improvement from pre- to postoperative. Pain improved by 34.2 points (49.9-84.1, $P < .001$), Symptoms by 13.7 points (64.1-77.8, $P < .001$), activities of daily living by 22 points (67.0-89.0, $P < .001$), Sport and Recreation by 29.8 points (38.7-68.5, $P < .001$), and quality of life by 43.2 points (20.7-63.9, $P < .001$).

Associations Between FAOS and Sports Questionnaire

There were no associations found between pre- to postoperative changes in FAOS subscores and total postoperative sessions of physical activities per week or total weekly physical activity participation times. Changes in the FAOS

Table 2. Postoperative Physical Activity Grades.

Grade	Hours of Exercise/Week	No. of Patients	% of Study Cohort (n = 50)
0 (sedentary)	0	1	2
1 (moderately active)	>0 and ≤5	21	42
2 (highly active)	>5 and ≤10	12	24
3 (extremely active)	>10	16	32

Table 3. Changes in Physical Activity Difficulty.

Sport	Less Difficult (%)	Same (%)	More Difficult (%)	Total
Walking	20 (45)	11 (25)	13 (30)	44
Biking	4 (14)	19 (66)	6 (21)	29
Swimming	0 (0)	22 (100)	0 (0)	22
Weightlifting	4 (20)	12 (60)	4 (20)	20
Golf	4 (36)	4 (36)	3 (27)	11
Running	6 (55)	4 (36)	1 (9)	11
Basketball	1 (17)	4 (67)	1 (17)	6
Dancing/aerobics	1 (20)	3 (60)	1 (20)	5
Tennis	2 (50)	2 (50)	0 (0)	4
Soccer	2 (67)	1 (33)	0 (0)	3
Yoga	1 (33)	1 (33)	1 (33)	3
Football	1 (50)	1 (50)	0 (0)	2
Elliptical	0 (0)	0 (0)	2 (100)	2
Rowing	0 (0)	1 (100)	0 (0)	1
Horseback riding	0 (0)	1 (100)	0 (0)	1
Pilates	0 (0)	0 (0)	1 (100)	1
Hiking	0 (0)	0 (0)	1 (100)	1
Ice skating	0 (0)	0 (0)	1 (100)	1
Cross country skiing	0 (0)	0 (0)	1 (100)	1
Total physical activities	46	86	36	168
% of physical activities	27.4	51.2	21.4	100

Symptoms subscore were significantly associated with session duration of walking and running ($P = .04$ for both), with a greater improvement in the FAOS Symptoms subscore associated with increased duration per session. There were no associations found between session durations of cycling, swimming, or weightlifting and changes in any FAOS subscale ($P > .05$). There were no associations found between FAOS subscores and changes in activity difficulty. Pre- to postoperative changes in the FAOS Pain subscore were associated with satisfaction with surgery regarding sports and physical activities, with greater improvements in Pain associated with greater satisfaction ($P = .03$).

Discussion

The purpose of this study was to investigate participation in specific sports and physical activities in a younger patient cohort after first MTP joint arthrodesis. We found that patients were able to reach their maximal level in 9 of 10

physical activities postoperatively and experienced no change in difficulty or an improvement in 4 of 5 physical activities. No physical activities were discontinued postoperatively, and patients reported initiating several that they had not participated in preoperatively. Patients were highly active after surgery, with 1 in 3 spending more than 10 hours on physical activities a week and 1 in 4 participating in between 5 and 10 hours of physical activities a week. All patients except 2 were satisfied with their surgery in regard to sports and physical activities. A greater improvement in the FAOS Symptoms subscore was associated with greater durations of walking and running per session, and a greater improvement in the FAOS Pain subscore was associated with a higher satisfaction rate. There were no associations between changes in FAOS subscores and changes in physical activity difficulty.

In contrast to previous studies of first MTP joint arthrodesis, the current work evaluated a younger, more active cohort of patients. While the average age of our cohort at the time of surgery was 49.7 years, the maximum age

Table 4. Reasons for Increased Physical Activity Difficulty.^a

Reason for Increased Difficulty	No. of Patients	% of Cohort
Stiffness	8	16
Pain	8	16
Change in gait or balance	8	16
Swelling	2	4
Difficulty with footwear	2	4
Lack of confidence	2	4
Uncomfortable hardware	1	2
Weakness	1	2
Out of shape	1	2

^aA total of 16 patients (32% of the cohort of 50) provided reasons for increased physical activity difficulty.

included was only up to age 55 years. Thus all patients at final follow up were a maximum of 65 years or younger given our maximum 10 year follow up. Prior studies examining patient participation in sports and physical activities all had an average patient age greater than 54 years, with inclusion of patients up to age 79 years, and thus examined an older cohort of patients. Another novel aspect of the current study was the utilization of a questionnaire that specifically examined return to sports and physical activities and the associated changes in difficulty, as well as the number of sessions per week and time spent per session for individual physical activities. It also evaluated the duration of time it took to return to the activity, to reach maximal participation levels, and patient satisfaction specifically regarding postoperative sports and physical activities. These specific metrics are unique to this study and will allow for improved counseling of patients regarding expectations, as well as confirm previous findings adding strength to the literature with use of a more rigorous outcome tool. Moreover, we assessed correlations in physical activity participation with a validated clinical outcomes measure, the FAOS. In these ways, the current study is the first to provide a comprehensive analysis of patient participation in sports and physical activities after first MTP joint arthrodesis.

In a study by DeFrino et al of 9 patients with a mean age of 56 (range, 38-72) years who underwent first MTP joint arthrodesis, gait analysis and pedobarography were performed preoperatively and at a mean follow-up of 34 months. Six of the 9 patients had no limitations in activity, and all patients who participated in running preoperatively returned to it postoperatively, although the number of these patients was not given.⁷ This is consistent with our findings that most patients were able to participate in a variety of sports and physical activities postoperatively, including running, and that most achieved a maximal level of physical activity. They concluded that a first MTP joint arthrodesis establishes a more normal plantar pressure pattern, and that despite the patterns of gait changes, patients seemed to be

compensating well.⁷ Similarly, our findings suggest that first MTP joint arthrodesis is a feasible treatment option for athletic patients, either recreationally or at a higher level, as most may be able to compensate adequately for biomechanical changes or pain at that joint.

Brodsky et al also looked at the effects of first MTP joint arthrodesis on gait. They performed gait analysis on 23 patients with a mean age of 58.0 ± 9.5 years preoperatively and at least 1 year after the procedure, and found increases in maximal ankle push-off power and single-limb support time on the operated extremity, as well as a decrease in step width, concluding that first MTP joint arthrodesis leads to objective improvement in propulsive power, weightbearing ability of the foot, and stability during gait.² Although we did not perform functional testing, these findings could explain the high rate of postoperative participation in sports and physical activities in our cohort. However, 8 patients in our study noted decreased gait and balance that made some physical activities more difficult, indicating that some patients do not experience this functional improvement. Nonetheless, they were still satisfied with the procedure regarding sports and physical activities, suggesting that other improvements outweighed this consideration.

Few studies have investigated the effect of first MTP joint arthrodesis on specific sports and physical activities. Brodsky et al evaluated the effects of the procedure with a parallel screw fixation technique on activities of daily living and recreational sports and exercise in 53 patients with a mean age of 54.2 (range, 21-79) years at a mean follow-up of 44 months. They administered a questionnaire that assessed walking, stair climbing, and return to work and specific recreational activities, including jogging, golfing, hiking, and tennis. They found improved functional outcomes in patients, with the majority being able to return to physical activities, including 75% to jogging and tennis, 80% to golfing, and 92% to hiking.³ Other postoperative physical activities reported by patients included snow skiing in 2 patients, waterskiing in 1 patient, and softball in 1 patient. Ninety-four percent of patients said that they would have the surgery again. This is similar to findings in our study, in which all patients participating in running, tennis, golfing, and hiking returned to them postoperatively. However, their assessment of participation in sports and physical activities did not include the time to return to them, nor the extent of postoperative participation. Moreover, these results were not correlated with a validated clinical outcome score, as in our study.

De Sandis et al⁸ assessed 53 patients with a mean age of 58.8 (range, 38-75) years who underwent isolated first MTP joint arthrodesis with either a plate and screw or independent screw construct at a mean follow-up of 3.3 years. They utilized a similar questionnaire as Brodsky et al, which assessed patient function in using stairs, walking, skiing, jogging,

running, treadmill, yoga, golf, hiking, tennis, elliptical, and biking. A majority of patients found those physical activities either improved or the same as preoperatively, similar to our study. That study divided their cohort into a younger and older age group based on the median age of 60.5 years. Their younger group was still older than the mean of the current study and had a mean age of 52.1 (range, 28-60). They found no differences in functional outcomes between the older and younger groups, with 23% of younger patients and 26% of older patients experiencing some limitations in daily and athletic activities. However, they did not assess differences between age groups in regard to specific sports and physical activities. Similar to that study, we found increases in all FAOS subscores from pre- to postoperatively. Moreover, we assessed associations of FAOS subscores with physical activity participation and found that patients with greater improvement in the FAOS Pain subscore had greater durations of walking and running sessions, suggesting that these physical activities are particularly affected by preoperative pain from hallux rigidus, and that first MTP joint arthrodesis is effective in relieving this pain to improve participation in them.

There are several limitations to this study. The Sports Questionnaire was administered retrospectively, so there may have been recall bias, with patients incorrectly recalling their participation in sports and physical activities. We aimed to minimize this by excluding specific preoperative participation data from analysis, such as the number of sessions per week or minutes per session, that may have been more difficult to recall, and focused on postoperative participation in physical activities, as well as preoperative to postoperative comparisons regarding return to physical activities and difficulty. There may also have been response bias, in which patients with worse outcomes did not respond. However, the response rate was high, likely leading to good generalizability of the results. In addition, the Sports Questionnaire is not a validated tool; however, it was developed with a clinical epidemiologist with the aim of describing participation in specific sports and physical activities and has been used in prior studies.^{17,18} Patients in this study underwent first MTP joint arthrodesis from 8 foot and ankle surgeons, each with different operative techniques and postoperative protocols, which may have contributed to variability in outcomes; however, a previous study reporting on functional outcomes of these 2 techniques with different postoperative protocols reported no significant differences between them.⁸ Moreover, the number of different surgeons makes these findings applicable to a wider range of surgeons and patients. Another limitation is that there was no comparison group of patients that underwent a cheilectomy for a similar grade of hallux rigidus. However, cheilectomy is indicated for mild to moderate hallux rigidus, whereas first MTP joint arthrodesis is the gold standard for severe hallux rigidus, and suboptimal outcomes with cheilectomy have previously been shown when performed for advanced-stage hallux rigidus.^{6,14}

In conclusion, this study adds to previous studies suggesting that first MTP joint arthrodesis results in good functional outcomes and return to physical activities in patients, particularly in younger, more active ones. The majority of patients in our study were able to return to a wide variety of physical activities and sports within a year, as well as to their maximal level of participation and were satisfied with their outcomes in this respect. Activities that were found to be similar or less difficult for the majority, included walking, bicycling, swimming, weightlifting, running, golf, basketball, dance/aerobics, tennis, soccer, rowing, horseback riding, and football. Some patients that participated reported increased difficulty postoperatively or were not able to return to their maximal levels of participation, which indicates that first MTP joint arthrodesis may lead to athletic limitations in some cases. Activities that were found to be more difficult postoperatively included the elliptical, Pilates, hiking, ice skating, and cross country skiing. Yoga was found to be equivocal. Nonetheless, all patients but 2 were satisfied with the outcomes of the procedure regarding postoperative participation in physical activities. These findings may be beneficial for patient counseling and aid in decision making for this procedure, as well as in advising patients regarding expectations for participation in physical activities postoperatively.

Declaration of Conflicting Interests

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References

1. Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KDJ. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? *Clin Orthop Relat Res.* 2010;468(1):57-63.
2. 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(2):162-165.
3. Brodsky JW, Passmore RN, Pollo FE, Shabat S. Functional outcome of arthrodesis of the first metatarsophalangeal joint using parallel screw fixation. *Foot Ankle Int.* 2005;26(2):140-146.
4. Clifford PE, Mallon WJ. Sports after total joint replacement. *Clin Sports Med.* 2005;24(1):175-186.
5. Coughlin MJ, Shurnas PS. Hallux rigidus: demographics, etiology, and radiographic assessment. *Foot Ankle Int.* 2003;24(10):731-743.
6. Coughlin MJ, Shurnas PS. Hallux rigidus: grading and long-term results of operative treatment. *J Bone Joint Surg Am.* 2003;85(11):2072.

7. 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(6):496-502.
8. DeSandis B, Pino A, Levine DS, et al. Functional outcomes following first metatarsophalangeal arthrodesis. *Foot Ankle Int.* 2016;37(7):715-721.
9. Drago JJ, Oloff L, Jacobs AM. A comprehensive review of hallux limitus. *J Foot Surg.* 1984;23(3):213-220.
10. Easley ME, Davis WH, Anderson RB. Intermediate to long-term follow-up of medial-approach dorsal cheilectomy for hallux rigidus. *Foot Ankle Int.* 1999;20(3):147-152.
11. Feltham GT, Hanks SE, Marcus RE. Age-based outcomes of cheilectomy for the treatment of hallux rigidus. *Foot Ankle Int.* 2001;22(3):192-197.
12. Goucher NR, Coughlin MJ, Kristensen RM. Dislocation of the posterior tibial tendon: a literature review and presentation of two cases. *Iowa Orthop J.* 2006;26:122-126.
13. High-impact sport. In: *McGraw-Hill Concise Dictionary of Modern Medicine*. <http://medical-dictionary.thefreedictionary.com/high-impact+sport>. Published 2002. Accessed May 12, 2015.
14. Ho B, Baumhauer J. Hallux rigidus. *EFORT Open Rev.* 2017;2(1):13-20.
15. Hockenbury RT. Forefoot problems in athletes. *Med Sci Sports Exerc.* 1999;31(7)(suppl):S448-S458.
16. Hogan MV, Mani SB, Chan JY, Do H, Deland JT, Ellis SJ. Validation of the foot and ankle outcome score for hallux rigidus. *HSS J.* 2016;12(1):44-50.
17. MacMahon A, Karbassi J, Burket JC, et al. Return to sports and physical activities after the modified Lapidus procedure for hallux valgus in young patients. *Foot Ankle Int.* 2016;37(4):378-385.
18. MacMahon A, Kim P, Levine DS, et al. Return to sports and physical activities after primary partial arthrodesis for Lisfranc injuries in young patients. *Foot Ankle Int.* 2016;37(4):355-362.
19. Mahomed NN, Liang MH, Cook EF, et al. The importance of patient expectations in predicting functional outcomes after total joint arthroplasty. *J Rheumatol.* 2002;29(6):1273-1279.
20. Mancuso CA, Sculco TP, Wickiewicz TL, et al. Patients' expectations of knee surgery. *J Bone Joint Surg.* 2001;83(7):1005-1012.
21. Negahban H, Mazaheri M, Salavati M, Sohani SM, Askari M, Fanian H. Reliability and validity of the foot and ankle outcome score: a validation study. *Clin Rheumatol.* 2010;29:479-48.
22. Nihal A, Trepman E, Nag D. First ray disorders in athletes. *Sports Med Arthrosc Rev.* 2009;17(3):160-166.
23. Noble PC, Conditt MA, Cook KF, Mathis KB. The John Insall Award: patient expectations affect satisfaction with total knee arthroplasty. *Clin Orthop Relat Res.* 2006;452:35-43.
24. Pontell D, Gudas CJ. Retrospective analysis of surgical treatment of hallux rigidus/limitus: clinical and radiographic follow-up of hinged, silastic implant arthroplasty and cheilectomy. *J Foot Surg.* 1988;27(6):503-510.
25. Tsai J, Raikin SM. First metatarsophalangeal joint arthrodesis. In: Chiodo CP, Smith JT, eds. *Foot and Ankle Fusions: Indications and Surgical Techniques*. Cham: Springer International Publishing; 2018:129-144.
26. Valderrabano V, Pagenstert G, Horisberger M, Knupp M, Hintermann B. Sports and recreation activity of ankle arthritis patients before and after total ankle replacement. *Am J Sports Med.* 2006;34(6):993-999.
27. van Doeselaar DJ, Heesterbeek PJC, Louwerens JWK, Swierstra BA. Foot function after fusion of the first metatarsophalangeal joint. *Foot Ankle Int.* 2010;31(8):670-675.
28. Womack JW, Ishikawa SN. First metatarsophalangeal arthrodesis. *Foot Ankle Clin.* 2009;14:43-50.
29. Yee G, Lau J. Current concepts review: hallux rigidus. *Foot Ankle Int.* 2008;29(6):637-646.