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# Return to Sports and Physical Activities after Minimally Invasive Distal Linear Metatarsal Osteotomy for Hallux Valgus

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**Abstract**

**Background:** The minimally invasive distal linear metatarsal osteotomy（DLMO）procedure for hallux valgus has achieved good clinical outcomes comparable with those obtained by conventional surgical techniques. We evaluated participation in specific sports and physical activities with respect to clinical outcomes among patients with hallux valgus who underwent DLMO.

**Methods:** This retrospective study involved 28 patients who underwent DLMO for hallux valgus for May 2010 to February 2020. The return to sports and physical activities was assessed using a newly developed sports activity questionnaire and the International Physical Activity Questionnaire-Short Form. Clinical outcomes were assessed using the Japanese Society of Surgery of the Foot（JSSF）hallux scale.

**Results:** Twenty-one patients（75%）were active in a sports activity preoperatively and/or postoperatively, and these 21 patients participated in 17 different sports activities. Four in 5 patients who performed a sports activity preoperatively were able to return to their sports activity postoperatively. The total metabolic equivalent-minutes per week and physical activity categories were not significantly different between the preoperative and postoperative periods. The changes in the JSSF scores showed no associations with the changes in the sports activity participation level or return to sports activity.

**Conclusions:** Patients were able to continue participation in sports activities, and the physical activity showed no change. These findings suggest that DLMO is a viable treatment option for hallux valgus in active patients.

**Key words: hallux valgus, sports activity, physical activity, distal linear metatarsal osteotomy**

## Introduction

In recent years, minimally invasive surgery for hallux valgus has become popular and has shown results comparable with those of more conventional open techniques [1), 2)]. Advantages of minimally invasive surgery include a reduced operative time, less postoperative pain, a lower risk of wound complications, and greater cost-effectiveness [3)]. Several studies have shown that subjective results after orthopaedic surgery are largely dependent on meeting patients' preoperative expectations [4), 5)]. This indicates that setting realistic expectations for the postoperative period affects functional outcomes. However, research regarding the outcomes of hallux valgus with respect of athletic activity is sparse [4)]. One study showed that patients with hallux valgus who underwent the modified Lapidus procedure returned to various sports and physical activities postoperatively [4)]. The minimally invasive distal linear metatarsal osteotomy（DLMO）procedure achieves effective correction of hallux valgus and good clinical outcomes [6)-8)]. However, the effect of this procedure on participation in specific sports and physical activities remains unclear.

The present study was performed to evaluate participation in specific sports and physical activities

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by patients with hallux valgus who underwent DLMO and to compare this participation with clinical outcomes and the Japanese Society of Surgery of the Foot (JSSF) hallux scale. Our hypothesis was that patients would be able to participate in various sports and physical activities postoperatively, and that these outcomes would be associated with the JSSF hallux scale score.

## Materials and Methods

### 1. Patients

This study was approved by our institutional review board, and informed consent was obtained from all the patients. All patients who underwent DLMO for hallux valgus from May 2010 to February 2020 by three fellowship-trained foot and ankle orthopaedic surgeons were identified. The primary indications for DLMO were all levels of severity (mild to severe), no hypermobility of the first tarsometatarsal joint, and no evidence of degenerative joint diseases at the first metatarsophalangeal/tarsometatarsal joint. The inclusion criterion was follow-up at our hospital for more than 1 year after surgery. The exclusion criteria were a history of surgical intervention on the foot, a history of foot and/or ankle fracture, or concomitant metatarsal osteotomies.

Thirty-six patients met the inclusion and exclusion criteria. Of these, 28 patients (43 feet) were reached for follow-up and consented to participate in the study. The response rate was 77.8%. The patients' mean age at the time of surgery was 51.4 ± 18.8 years (range, 20–82 years); 1 (3.6%) patient was male and 27 (96.4%) were female. The patients' mean height was 157.7 ± 7.5 cm (range, 141.5–171.5 cm), mean weight was 55.9 ± 6.7 kg (range, 39.7–69.8 kg), and mean body mass index was 22.5 ± 2.3 kg/m$^2$ (range, 16.8–26.9 kg/m$^2$). The mean postoperative follow-up time was 33.8 ± 21.5 months (range, 12.0–72.0 months) after surgery.

### 2. Operative procedure

The patients were placed in the supine position, and a thigh tourniquet was applied. A 2.0-cm skin incision was centered over the medial aspect of the first metatarsal neck. The periosteum was elevated and carefully spared, and the intended osteotomy site was visualised. A 2.0-mm Kirschner wire was manually inserted in a retrograde manner from the wound to the medial side of the great toe; it was then pushed back to the intended osteotomy site, along the medial aspect of the first metatarsal head in a subperiosteal position until the blunt tip reappeared in the wound. The osteotomy was performed with an oscillating saw at the subcapital level in a single plane perpendicular to the first metatarsal shaft axis. Lateral translation of the metatarsal capital fragment was undertaken. Under fluoroscopic and direct guidance, the Kirschner wire was introduced into the medullary canal of the first metatarsal shaft and fixed to the metatarsal base.

### 3. Postoperative management

Weight-bearing on the heel in a stiff-soled postoperative shoe was allowed on the first postoperative day. The Kirschner wire was removed at 6 weeks postoperatively, and the patients were allowed to wear normal shoes thereafter. Nonimpact sports and activities were commenced at 3 months postoperatively. The patients were allowed to participate in all sports and activities at 6 months postoperatively.

### 4. Sports and physical activities

Outcome evaluation consisted of two self-administered patient questionnaires; a newly developed sports activity questionnaire (SAQ) and the International Physical Activity Questionnaire-Short Form (IPAQ-SF).

The SAQ asked patients whether they participated in any of 13 different sports and activities preoperatively and postoperatively. It also allowed patients to list any sports and activities they participated in preoperatively and/or postoperatively, including any not listed in the SAQ. The patients were asked about their postoperative participation level in the sports activity compared with preoperatively. The IPAQ-SF asked about three specific types of physical activity: walking, moderate-intensity activities, and vigorous-intensity activities. It also asked about the duration (in minutes) and frequency (in days) of each activity. The IPAQ-SF was used to calculate the metabolic equivalent (MET), which was classified into one of three physical activity categories (low, moderate, or high). Outcome evaluation was measured preoperatively, 1 year postoperatively, and at the final follow-up.

### 5. Clinical assessment

Objective clinical results were assessed using the Japanese Society of Surgery of the Foot (JSSF) hallux scale. The JSSF hallux scale is scored from 0 to 100, and higher scores indicate better clinical outcomes. The JSSF hallux scale was administered preoperatively, 1 year postoperatively, and at the final follow-up.

### 6. Radiographic assessment

A weight-bearing anteroposterior (AP) radiograph was obtained preoperatively, 1 year postoperatively, and at the final follow-up. Radiographic angular parameters

in the AP view, including the hallux valgus angle (HVA) and intermetatarsal angle (IMA) were measured using conventional methods. The HVA was measured in the AP radiographs as the angle between the longitudinal axes of the first metatarsal and proximal phalanx. The longitudinal axis of the first metatarsal was defined as the line connecting the centre of the proximal articular surface of the first metatarsal to the centre of the first metatarsal head. The IMA was measured as the angle between the longitudinal axes of the first and second metatarsals.

**7. Statistical analysis**

Statistical analyses were performed using SPSS software version 23.0 (IBM Corp., Armonk, NY, USA). We used conventional statistical tests to compare the preoperative, 1-year postoperative, and final follow-up outcomes. The physical activity category in the IPAQ-SF was analysed with the Kruskal–Wallis test. The physical activity category was coded as follows: 1 for low–level activity, 2 for moderate–level activity, and 3 for high–level activity. The JSSF score, HVA, IMA, and total MET-minutes per week were analysed with the repeated-measures analysis of variance. Differences in the JSSF score between patients who did and did not return to sports were assessed with the Mann–Whitney U tests and two-sample t test. Changes in the difficulty of sports activities were assessed in a similar manner. Statistical significance was set at $p \leq 0.05$.

## Results

**1. Sports and physical activities questionnaires**

Patients participated in 17 different sports activities consisting of 34 total sports activities preoperatively, 31 total sports activities 1 year postoperatively, and 27 total sports activities at the final follow-up. The highest participation among the three periods was found in walking (Table 1). Twenty-one of the 28 patients (75%) were active in sports activity preoperatively and/or postoperatively. Of these, 16 patients (76.2%) returned to sports activity, 3 (18.8%) did not returned to sports activity, and 2 (12.5%) started a new sports activity. The mean time until return to sports activity was 7.2 ± 4.5 months (range, 1–18 months).

In 16 patients, the sports activity participation level was compared with that preoperatively. Of these 16 patients, 7 (43.8%) reported decreased difficulty, 7 (43.8%) reported no change in difficulty, and 2 (12.5%) reported increased difficulty postoperatively.

The total MET-minutes per week was 2560.8 ± 2308.1

**Table 1. Preoperative and postoperative sports activities.**

| Sport | Preop. No. of participants | 1-year postop. No. of participants | Final follow No. of participants | Discontinued Postop. | Started Postop. | Change |
|---|---|---|---|---|---|---|
| Walking[a] | 14 | 13 | 13 | − 3 | 2 | − 1 |
| Swimming[a] | 6 | 3 | 2 | − 4 | 0 | − 4 |
| Aerobics | 2 | 2 | 2 | 0 | 0 | 0 |
| Badminton[a] | 2 | 0 | 1 | − 1 | 0 | − 1 |
| Dancing[a] | 2 | 0 | 0 | − 2 | 0 | − 2 |
| Running[a] | 1 | 3 | 1 | 0 | 0 | 0 |
| Tennis[a] | 1 | 1 | 1 | 0 | 0 | 0 |
| Table tennis | 1 | 1 | 1 | 0 | 0 | 0 |
| Golf[a] | 1 | 1 | 1 | 0 | 0 | 0 |
| Halberd | 1 | 1 | 1 | 0 | 0 | 0 |
| Hiking[a] | 1 | 1 | 1 | − 1 | 1 | 0 |
| Bicycling[a] | 1 | 1 | 0 | − 1 | 0 | − 1 |
| Softvolley | 1 | 0 | 0 | − 1 | 0 | − 1 |
| Gym training | 0 | 2 | 1 | 0 | 1 | 1 |
| Yoga | 0 | 1 | 1 | 0 | 1 | 1 |
| Bowling | 0 | 1 | 1 | 0 | 1 | 1 |
| Total | 34 | 31 | 27 | − 13 | 6 | − 7 |

Abbreviations: preop., preoperative/preoperation; postop., postoperative/postoperation.
[a]Sports activities provided on sports activity questionnaire

(range, 99–9630) preoperatively, 2509.5 ± 2660.1 (range, 99–13038) at 1-year postoperatively, and 2504.8 ± 2261.7 (range, 99–7038) at the final follow-up. The total MET-minutes per week were not significantly different among the three periods (Table 2). The physical activity categories were also not significantly different among the three periods (Table 2).

**2. JSSF scores**

The mean total score and pain, function, and alignment subscores of the JSSF scale improved from the preoperative to postoperative period ($p < 0.001$). The total score improved by 29.8 points, the pain subscore improved by 14.0 points, the function subscore improved by 9.2 points, and the alignment subscore improved by 6.7 points from preoperatively to the final follow-up (Table 3). The change in the total score and each subscores of the JSSF scale showed no associations with the change in sports activity participation level (Figure 1) or return to sports activity (Figure 2).

**3. Radiographic outcomes**

The mean HVA and IMA were significantly improved from the preoperative to postoperative period ($p < 0.001$). The mean HVA improved by 18.3° and the mean IMA improved by 6.0° from preoperatively to the final follow-up (Table 3).

## Discussion

The major findings of this study are that 84.2% of patients were able to return to sports activity at a mean time of 7.2 months postoperatively and that the total MET-minutes per week, which reflected the physical activity, showed no significant change. These findings suggests that the DLMO does not affect the return to sports activity in active patients. The sports activity participation level showed the same or decrease difficulty in 87.6% of patients, and the radiographic measurements and clinical outcomes were significantly improved from preoperative to postoperatively.

In total, 87% of patients who returned to sports activity experienced the same or decreased difficulty in their postoperative sports activity compared with the preoperative difficulty level. Few studies have focused on the change in the participation difficulty of sports activity associated with return to sports activity [4),9)]. MacMahon et al. [4)] examined the change in sports and

**Table 2. Preoperative and postoperative physical activities.**

| | | Preoperatively | 1-year postop. | Final follow-up | *p* value |
|---|---|---|---|---|---|
| Total MET-min/week | | 2560.8 ± 2308.1 | 2509.5 ± 2660.1 | 2504.8 ± 2261.7 | 0.99 |
| Category | High | 10 | 7 | 7 | 0.225 |
| | Moderate | 9 | 14 | 13 | |
| | Low | 9 | 7 | 8 | |

Data are given as mean ± standard deviation or number of patients.
Abbreviation: MET, metabolic equivalents; postop, postoperatively

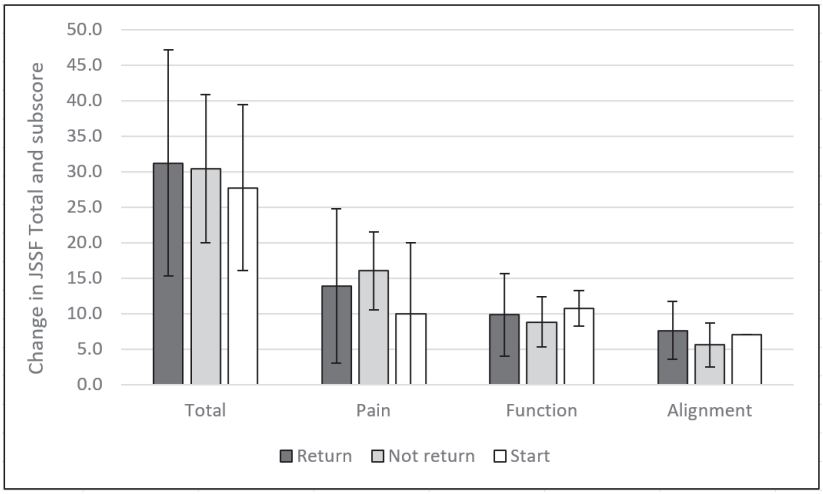


**Figure 1.** Mean preoperative to postoperative changes in JSSF total score and subscores stratified by ratings of return to sports from preoperative to postoperative period. Error bars indicate 95% confidence intervals. There were no associations with return to sports. JSSF, Japanese Society of Surgery of the Foot.

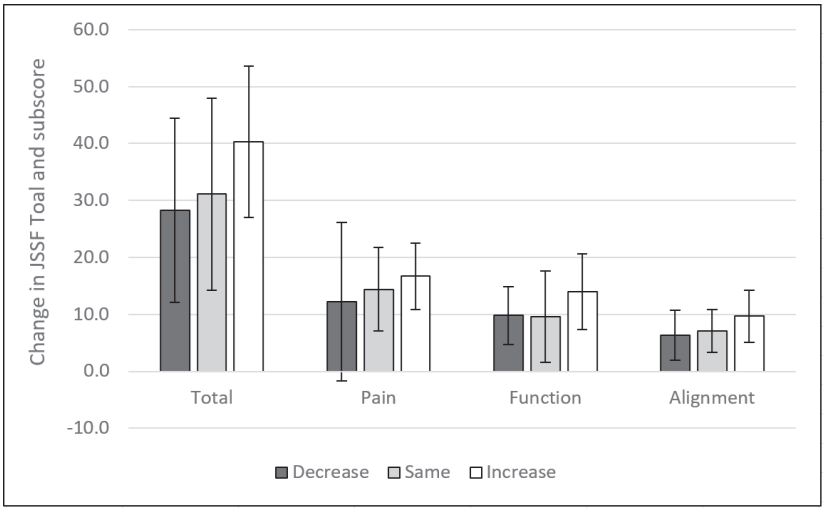


**Figure 2.** Mean preoperative to postoperative changes in JSSF total score and subscores stratified by ratings of preoperative to postoperative change in difficulty of physical activity. Error bars indicate 95% confidence intervals. There were no associations with changes in the difficulty of physical activity. JSSF, Japanese Society of Surgery of the Foot.

**Table 3. JSSF scores and radiographic measurements preoperatively, 1-year postoperatively, and at final follow-up.**

| | Preoperatively | 1-year postop. | Final follow-up |
|---|---|---|---|
| JSSF scores | | | |
| Total | 66.7 ± 9.7 | 94.8 ± 10.1 | 96.5 ± 8.6 |
| Pain | 24.5 ± 7.2 | 36.6 ± 7.9 | 38.5 ± 4.3 |
| Function | 34.7 ± 3.7 | 43.8 ± 3.3 | 43.9 ± 3.8 |
| Alignment | 7.4 ± 2.2 | 14.8 ± 1.2 | 14.1 ± 2.4 |
| Radiographic measurements | | | |
| HVA (°) | 32.7 ± 6.9 | 14.1 ± 5.5 | 14.4 ± 5.8 |
| IMA (°) | 15.4 ± 3.0 | 9.1 ± 2.2 | 9.4 ± 2.3 |

Data are given as mean ± standard deviation.
Abbreviations: JSSF, Japanese Society of Surgery of the Foot; HVA, hallux valgus angle; IMA, intermetatarsal angle; postop, postoperatively

physical activity difficulty in patients who underwent the Lapidus procedure for hallux valgus. They reported that the sports and physical activity participation level was less difficult than preoperatively in 29% of patients, the same level of difficulty in 52% of patients, and more difficult in 19% of patients. Naal et al. [9] examined the sports ability after surgery in patients who underwent total ankle arthroplasty. They reported that the sports ability was worse after surgery in 8 patients (7.9%), remained unchanged in 27 (26.7%), and improved in 66 (65.4%). However, no study has investigated the change in the difficulty of returning to sports activity after DLMO for hallux valgus. This outcome may be beneficial for patients who wish to participate in sports activities after DLMO.

In the present study, nearly half of patients experiences decreased difficulty in postoperative sports activity. This suggests that their sports performance levels were reduced because of the presence of hallux valgus. Several studies have shown that patients with moderate or severe hallux valgus had a worse functional status in terms of physical activity [10), 11)]. Nishimura et al. [10)] reported that the maximum walking speed was slower in patients with moderate-severe hallux valgus group than in those with no or mild hallux valgus. Cho et al. [11)] showed that participants with moderate or severe hallux valgus had a significantly worse foot health function status and poorer self-assessment of their foot condition. In addition, Abdalbary et al. [12)] reported that women with moderate hallux valgus deformity experienced increased the hallux plantarflexion and abduction strength, toe grip strength, and ankle dorsiflexion range of motion after treatment. These studies suggest that moderate or severe hallux

valgus is related to a decreased sports performance level. Our outcome suggests that patients with hallux valgus may improve their sports performance level by undergoing DLMO.

In this study, one in five patients who performed a sports activity preoperatively were unable to return to their sports activity. The inability to return to a sports activity was not associated with changes in the clinical outcome. This suggests that the physical activity limitation for surgery was minor and that the return to sports activity was not associated with surgery. One study showed that the reason for an inability to return to sports activity may be a lifestyle change or social reason unassociated with the surgery [5]. Lifestyle changes or social reasons might have also impacted the patients' outcomes in the present study. However, we were unable to evaluate lifestyle changes and social reasons because these data were unavailable in this retrospective study.

Historically, distal metatarsal osteotomy has been indicated for correction of mild to moderate hallux valgus deformities. DLMO has recently achieved good clinical and radiographic outcomes comparable with those obtained by open surgical techniques in the management of mild to severe hallux valgus [7),8),13),14)]. The present study demonstrated that radiographic measurements (HVA and IMA) and clinical outcomes (JSSF scores) were significantly improved at the 1-year postoperative and final follow-up evaluations compared with the preoperative values.

The present study has several limitations. First, because it was retrospective study, there may been response bias in which patients with worse outcomes did not respond to follow-up, although there was a high response rate of 78%. Second, there may have been recall bias in which patients did not accurately remember their relative participation levels and physical activities. Finally, the number of patients was limited. Therefore, accumulation of more cases is necessary to confirm a return to sports activity in patients who have undergone DLMO for hallux valgus.

In conclusion, this is the first study to assess participation in specific sports and physical activities after DLMO for hallux valgus. Patients were able to continue participation in sports activities, most had equal or decreased difficulty in their sports activity after surgery, and their physical activity showed no change. This suggests that the procedure is a viable treatment option for hallux valgus in active patients. The findings in this study will facilitate more effective discussions between surgeons and patients regarding postoperative expectations in sports and physical activities following DLMO for hallux valgus.

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