Clinical Research

The Modified Subcapital Metatarsal Osteotomy in the Treatment of Hallux Valgus Recurrence

Andrea Scala, MD, Massimo Cipolla, MD, Silvana Giannini, MD, PhD, and Giulio Oliva, MD

Abstract: *The purpose of the present study is to illustrate the use of a modified subcapital metatarsal osteotomy (MSMO) in the treatment of hallux valgus (HV) recurrence. The article reports the clinical and radiological outcomes of a cohort of 52 consecutive patients presenting with recurrent HV, treated with MSMO. A total of 52 patients (54 feet) underwent operations between May 2010 and November 2015. The mean time of follow-up was 2.5 years (range 5.5-1.0 years), and the mean age was 49 years (range 22-76 years). The patient cohort comprised 46 female and 6 male patients. The results of this research show that MSMO is a reliable technique for the correction of HV recurrence. The postoperative radiographic assessments show a statistically significant postoperative improvement of the HV angle ($P < .05$) and the intermetatarsal angle ($P < .05$). The postoperative position of the tibial sesamoid was significantly improved ($P < .1$). The distal metatarsal articular angle was improved ($P < .001$), though assessment may be affected by the previous operations performed on the first metatarsophalangeal joint. The statistical analysis shows that the postoperative American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal-Interphalangeal Scale parameters were significantly improved ($P < 0.001$). Results of this study indicate that the minimally invasive MSMO is effective in restoring anatomical alignment and improving patient outcomes in recurrent cases of HV.*

Levels of Evidence: *Level III: Case-control study*

Keywords: distal first metatarsal osteotomy; foot surgery; hallux valgus; metatarsalgia; osteosynthesis

Introduction

The complication rate in hallux valgus (HV) surgery ranges between 10% and 55%.[1] HV failure has a multitude of causes, and the procedure for revision surgery can be difficult to determine.[2-7] Rates of recurrence vary in the literature, from 2.7% to 16%.[7-9] Common causes of recurrent HV are inadequate selection of patients, inappropriate selection of the procedure to be performed, inappropriate intraoperative technique, or incomplete initial correction.[2-4]

> "Even the best-performed procedure can be compromised by the uncontrolled stresses that occur at the osteotomy site during the first phase of healing."

Surgical treatment of HV recurrence should be directed to neutralize the predisposing factors.[2-6] The revision surgery should use a technique at least as powerful as that of the primary operation. Even the best-performed procedure can be compromised by the uncontrolled stresses that occur at the osteotomy site during the first phase of

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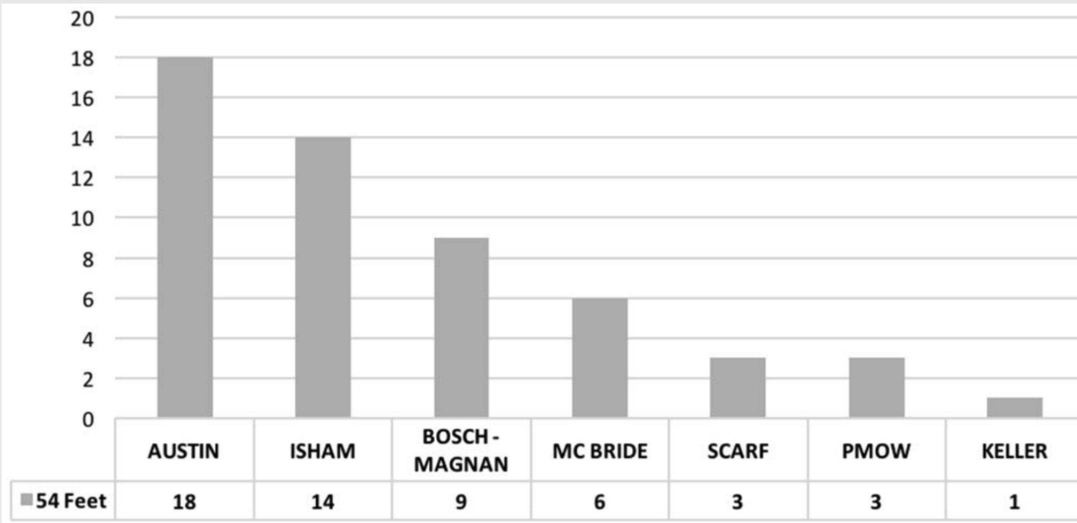
Figure 1.

The index procedure in cases of hallux valgus recurrence treated in this series (n = 54 feet in 52 patients).



healing. Instability at the first tarsometatarsal joint is considered a negative risk factor for osteotomy consolidation.[7-10]

Fusion of the first metatarsophalangeal joint (MTPJ)[11] and fusion of the first tarsometatarsal joint (Lapidus procedure)[12] have been advocated as stable and definitive solutions in cases of HV recurrence. In many cases of HV recurrence, these 2 fusion techniques may be considered more invasive and demanding than required to achieve correction, with secondary impacts on the patient's recovery, motion, and function. In this series of patients, the surgeon determined that minimally invasive surgery (MIS) with modified subcapital metatarsal osteotomy (MSMO) would be more appropriate. The potential advantages of this MIS technique include reduced surgical time, minimal soft-tissue disruption with preservation of blood supply, accelerated postoperative recovery, preserved range of motion, and enhanced cosmesis as a result of adequate correction being achieved through a smaller surgical incision.[13] In the present series, the minimally invasive MSMO offers a solution to HV recurrence in patients with fragile soft tissues and compromised bone stock resulting from previous surgical insults.

Patients and Methods

The present study is aimed at determining the efficacy of correction of the MSMO in a cohort of 52 patients presenting with recurrent HV consecutively treated by 1 of 2 surgeons (AS and MC). The patients underwent MSMO from May 2010 to November 2015. The mean time of follow-up was 2.5 years (range 5.5-1.0 years), and the mean age was 49 years (range 22-76 years). The series includes 46 female and 6 male patients. Two of the 52 patients, both female, underwent bilateral MSMO (54 procedures). Procedures were performed, and functional outcome data were collected from the patients' medical records at the authors' institutions with study approval of the authors' institutional review boards.

The previous surgical procedures, reported in the patients' medical records, are summarized in Figure 1. Recurrences following Austin Chevron techniques[14,15] occurred in 18 feet. Isham percutaneous[16-18] recurrences were reported in 14 feet; minimally invasive distal metatarsal (MT) osteotomy (Bosh-Magnan)[19-24] recurrences were reported in 9 feet; Silver-McBride recurrences were reported in 6 feet; Scarf recurrences[25] were reported in 3 feet; proximal medial opening wedge[26,27] recurrences were reported in 3 feet; and Keller recurrence[28] was reported in 1 foot.

Additional surgical procedures were performed in association with MSMO in 42 cases (77.7%) cases. Akin osteotomy[29] was performed in 11 cases (20.37%). Lesser MT ray realignment by means of Weil osteotomy was performed in 17 cases (31.4%).[9,30-32] A total of 14 feet (25.92%) underwent gastrocnemius lengthening.[30]

The inclusion criteria for the surgical treatment of HV recurrence with MSMO were the following clinical settings: pain localized on the medial and plantar side of the first ray; metatarsalgia of lesser rays; malalignment and deformity of the first MT ray; malalignment and deformity of the phalanx of the hallux; instability of the first MTP joint; and problems wearing shoes as a result of recurrent HV. Conservative treatment consisting of nonsteroidal anti-inflammatory drugs, shoe wear modification, and the use of orthotics had previously failed after 6 or more months of treatment in all patients.

Exclusion criteria included patients who did not obtain postoperative radiographs per protocol and patients who did not complete postoperative American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal-Interphalangeal Scale (AOFAS forefoot score) surveys prior to November 2016. Additional exclusion criteria include severe degenerative changes of the first MTPJ, hallux rigidus, severe stiffness and fibrosis of the first MTPJ, significant contracture caused by surgical scars, severe instability of the medial tarsal-cuneiform joint, and metatarsus adductus. Surgeons excluded patients with hyperlaxity conditions, inflammatory arthritis, and neuromuscular conditions

Outcome Assessment

The patients' AOFAS forefoot scores[33,34] were determined preoperatively by the 2 orthopedic surgeons (AS and MC). A chart review was performed to assess patient demographics, previous surgical procedures, and associated preoperative forefoot deformity. The 2 orthopedic surgeons (AS and MC) gathered data from the medical records and acted as outcome assessors at the time of the follow-up. The AOFAS forefoot scores of the 52 patients (54 feet) who participated in the final follow-up were determined postoperatively by the 2 orthopedic surgeons (AS and MC).

Radiological Measurements

Preoperative radiological assessments consisted of a standard dorsoplantar view, taken at an angle of 20°, a lateral weight-bearing view, and an oblique view. A plantar view of the foot was taken to evaluate the sesamoids and the plantar aspect of the first MTPJ.

Measurements were performed by 2 radiologists (SG and GO) who measured the intermetatarsal angle (IMA), the HV angle (HVA), and the distal metatarsal articular angle (DMAA). The position of the tibial sesamoid (TS) was measured on an anteroposterior radiograph, on a scale from 1 to 7, as described by Hardy and Clapham.[38] The 2 radiologists were "blinded" to the study, and the patients underwent the routine radiological forefoot protocol, regardless of study participation.

The 2 radiologists were asked to grade the severity of the recurrent HV into 3 categories: mild, moderate, and severe recurrent HV.[31,35-41] All patients who underwent MSMO for recurrent HV underwent the same set of radiographic assessments at 1 month, 3 months, and 6 months postoperatively. The radiological assessments were then repeated yearly. At the time of the final follow-up prior to November 2016, all study participants who had obtained the radiographs per protocol were included for statistical analysis.[31,42-45]

The radiologists (SG and GO) were then asked to grade the outcome of the revision procedure. The imaged feet that had undergone MSMO were allocated to mild, moderate, and severe grades. All radiological assessments and measurements were electronically performed, using the picture archiving and communication system of their professional institutes.

Surgical Technique

The original technique of distal MT osteotomy performed by a minimally invasive approach for the correction of HV (Figure 2A) was conceived and published by Kramer.[19] It has subsequently been popularized by Bosch et al,[20] by Giannini et al,[21,22] and by Magnan et al.[24] The technique has been substantially modified[46] to address concerns with fixation of the distal fragment (Figure 2B).

In this series, the 2 surgeons performed MSMO using the modified technique, with the details of the procedure outlined here. A 15-mm longitudinal skin incision is centered over the medial side of the first metatarsophalangeal head. In the setting of revision surgery for HV recurrence, it is common to find that small remnants of the capsule remain adherent to the skin, and the bone of the first MT head may be osteoporotic and frail, compromised by previous drill holes and implants such as screws, plates, pins, or wires. Following removal of hardware, fluoroscopy is used to localize the neck of the first MT bone. In HV recurrence, it is crucial to position the site of the MSMO 3 to 4 mm proximal to the sesamoid bones in order to cut the bone in the "safe osteotomy zone."[9] This spares the tenuous vascular supply and lowers the risk of avascular necrosis.[32] The periosteum from the neck is not raised, to avoid further tissue stripping. The MSMO osteotomy is performed with a micro sagittal saw. The osteotomy is a single planar cut, perpendicular to the long axis of the first MT bone. On completion of the osteotomy, the first MT head is displaced laterally until a reduction over the sesamoid bones is achieved. At this point, a 1.8- to 2-mm Kirschner wire is introduced through the incision in retrograde fashion through the osteotomy toward the base of the first MT. Care is taken to implant the wire along the medial cortex of the diaphysis to provide rotational and coronal stability that would be lost by placing the wire more centrally in the medullary canal.

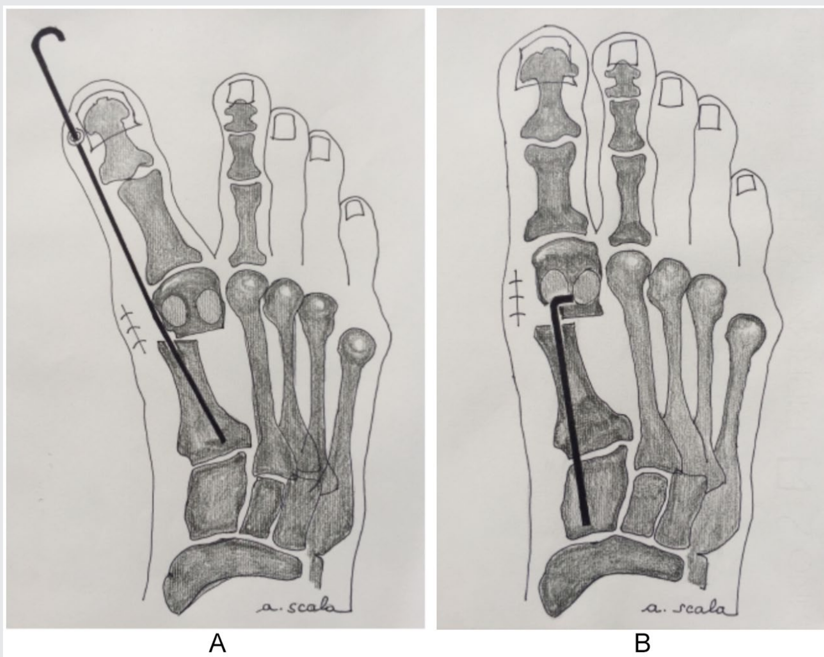
The proximal tip of the wire is advanced into the medial cuneiform, to achieve greater stability. Fluoroscopy is then used to confirm MT head reduction over the sesamoids.[39] The distal end of the wire is bent at a right angle and cut at the level of the first MT head, leaving a hook 2 to 3 mm in length. The angled tip of the wire is turned laterally and tapped into the head of the first MT to obtain fixation. At this point, the Akin procedure is performed to improve the alignment of the first MT ray, when considered necessary. The lateral aspect of the first MTPJ, is released with a percutaneous procedure using the arthroscopic blade (or a 15 blade).[47] The remnants of the capsule, when present and stout enough for repair, are closed in a "pants over vest" fashion, thus ensuring further stabilization of the MSMO. At the end of the procedure, the operative extremity is dressed in a soft bandage.

Postoperative Care

Patients were instructed to begin immediate mobilization with active and

Figure 2.

A. The original Bosh-Magnan procedure is illustrated. After the distal osteotomy is carried out, the first MT head is laterally displaced, reducing the IMA angle. The hallux is medially deviated. A percutaneous Kirschner wire (1.8-2.0 mm) is used as a skewer to fix the hallux, the medial aspect of the first MT head, and the first MT shaft. The operated hallux is taped in a varus position for 4 to 6 weeks while first MTPJ range of motion is prohibited because of the temporary fixation. After wire removal, deformity would recur if adequate bone healing had not occurred. B. The modified distal subcapital MT osteotomy is illustrated. Osteotomy of the first MT is performed, lateral displacement of the first MT head is obtained, and the IMA reduced. In contrast to the Bosh-Magnan technique, the Kirschner wire is introduced through the minimally invasive incision into the proximal fragment of the first MT shaft and across the TMT joint into the medial cuneiform. At the level of the osteotomy, the wire is cut, shaped into a hook and turned laterally, toward the first MT head to achieve a permanent, internal, stable fixation that protects against recurrence or varus collapse. The proximal tip of the wire is tapped into the medial cuneiform to grant more stability to the construct. Immediate range of motion of the MTPJ is allowed.



Abbreviations: MT, metatarsal; IMA, intermetatarsal angle; MTPJ, metatarsophalangeal joint; TMT, tarsometatarsal.

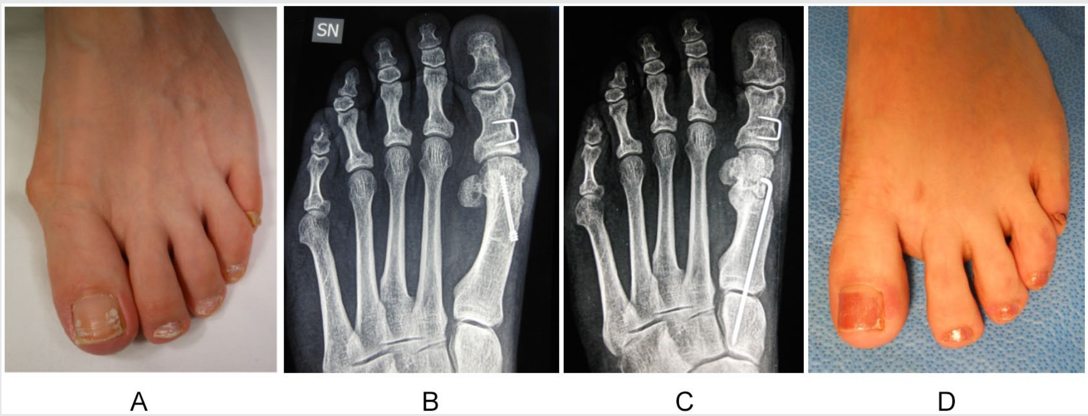
passive range of motion of the hallux[48] and were weight bearing, as tolerated with crutches, in postoperative sandals for 2 weeks with instructions to ice and elevate the extremity while resting. Then, 15 days after the operation, the suture was removed and the patient was allowed to wear comfortable shoes. One month after the operation, the first postoperative radiographic assessment was performed to assess stability of correction, and the patient was allowed to return to work and drive a car. At the end of the third month, a radiographic assessment was performed to again check reduction and assess for bone callus formation. The patient was allowed to gradually return to sport activities. The radiographic assessment was repeated after 6 months and every year after the operation.

Results

The recurrent cases of HV were classified preoperatively and postoperatively into 3 different categories based on radiographic parameters: mild deformity, defined by an IMA of less than 13° and HVA of less than 20°; moderate deformity, defined by an IMA greater than 13° and an HVA less than 30°; moderate deformity was also considered an IMA greater than 13° and HVA greater than 30°; and severe deformity, defined by an IMA greater than 20° and an HVA greater than 40° (Figures 3 and 4). Preoperative versus postoperative severity grades were analyzed using the χ^2 test and test of proportions (Table 1). Preoperatively, 18 (33%) feet were graded as mild, 28 (52%) feet were graded as moderate, and 8 (15%) feet were graded as severe. On the basis of the postoperative radiographic findings, 48 (89%) feet were graded as mild, and 6 (11%) feet were graded as moderate. None of the feet that underwent MSMO procedures met the definition of severe deformity. Preoperative and postoperative comparisons demonstrate

Figure 3.

A. Recurrent hallux valgus after an Austin chevron procedure. B. The preoperative radiographic dorsoplantar view shows that the HVA and IMA are not corrected. The sesamoids are subluxated. C. The postoperative radiographic dorsoplantar view after the modified subcapital metatarsal osteotomy (MSMO) shows improved HVA and IMA. Position of the sesamoids is improved. D. Cosmetic appearance of the hallux after the MSMO procedure.



Abbreviations: HVA, hallux valgus angle; IMA, intermetatarsal angle.

Figure 4.

A. Clinical appearance of a hallux valgus recurrence after an Austin Chevron procedure. B. The preoperative radiographic dorsoplantar view shows that the HVA and IMA are not corrected. The sesamoid bones are subluxated. C. The postoperative radiographic dorsoplantar view after the modified subcapital metatarsal osteotomy (MSMO) shows improved HVA, IMA, and sesamoid position. D. Postoperative clinical appearance of the forefoot after the MSMO.

a significant difference in the HV severity grade deformity before and after MSMO procedure, with statistical significance achieved with both the χ^2 test and test of proportions. The percentage of patients with moderate deformity before the operation (52%) was reduced to 11% after treatment. The majority of the sample (89%) was classified as an aligned hallux or a mild HVA deformity after MSMO procedure, demonstrating the effectiveness of the operation (Table 1).

The efficacy of correction of the MSMO as well as the concordance of the assessments of the 2 radiologists (SG and GO), was evaluated through a 2-way repeated-measures analysis of variance (ANOVA; Table 2). The 2-way repeated-measures ANOVA did not show any statistically significant difference between the 2 radiologists for each of the 4 radiological measurements. The *P* values corresponding to the radiological measurements were always greater than 0.05 (IMA *P* value = .83; DMAA *P* value = .17; HVA *P* value = .50; TS *P* value = .97).

Table 1.

Recurrent Hallux Valgus Severity (n = 54 Feet in 52 Patients) Compared With Postoperative MSMO Outcomes.[a]

	Pre	Post
Mild	18	48
Moderate	28	6
Severe	8	0
Total	54	54
	Statistics	***P* Value**
χ^2 Test	35.9	$P < .005$[b]
Test of proportions	35.1	$P < .005$

Abbreviation: MSMO, modified subcapital metatarsal osteotomy.
[a]The preoperative recurred hallux valgus grading of severity (n = 54 feet in 52 patients) was compared with MSMO postoperative outcomes. The preoperative and postoperative radiographic assessments were statistically analyzed using a χ^2 test, computing *P* values by 2000 Monte Carlo simulations and a test on the proportions (probabilities of success) of the 2 groups.
[b]*P* value obtained in a χ^2 test using Monte Carlo analysis.

The *P* values highlighted the concordance of the radiological measurements, independently collected by the 2 radiologists (SG and GO; Table 2). The effect of the MSMO procedure on the series (54 feet out of 52 patients) of recurrent HV was scrutinized by means of the 2-way repeated-measures ANOVA (Figure 5). The postoperative radiological assessments showed a statistically significant improvement in all 4 radiological measurements (DMAA *P* value = .02, IMA *P* value = 9.51e-16, HVA *P* value < 2e-16, TS *P* value = 8.63e-09; Figure 5).

Before the operation, the IMA angle was greater than or equal to 12° in 25% of the patients and greater than or equal to 14° in 50%. After the operation, the IMA angle was less than or equal to 6° in 25% of the patients and less than or equal to 8° in 50%, with a mean percentage decrease of 42.8% (percentage – percentage; Figure 5). Before the operation, 75% of the patients had an HVA angle higher than 22°, whereas after the MSMO procedure, the HVA angle was lower than 14.2° in 75% of the patients (Figure 5). The TS position was improved by 40% (this may need clarification). The median DMAA angle was 18° before the operation, whereas after the MSMO procedure, the DMAA was less than or equal to 12° in the majority of patients (Figure 5).

The patients of the survey were administered the AOFAS forefoot score[31,38] by the 2 surgeons (AS and MC) who performed the surgical procedures. The AOFAS forefoot score includes 8 different items, which are divided into 3 subscales: pain, function, and alignment. These were completed by the series participants before the operation and after the MSMO procedure. The Wilcoxon-Mann-Whitney test was used to evaluate the AOFAS forefoot score results. The postoperative AOFAS score showed a statistically significant improvement from the preoperative scores when analyzed as an overall score (*P* = 8.01e-17) as reported in Figure 6.

The Wilcoxon-Mann-Whitney test also showed a significant difference between preoperative and postoperative values for each item of the AOFAS scores. The *P* values of the score items are reported in Figure 6. For each item, the median postoperative score was significantly improved. Specifically, statistically significant improvement of function was found after the MSMO procedure in function, joint motion, stability, and foot wear (function *P* value = 1.13e-08; joint motion *P* value = 6.02e-08; stability *P* value = 1.12e-09; foot wear *P* value = 4.24e-07). Reported results also showed improvement in pain score (preoperative median 20; postoperative median 30; *P* value = 3.68e-09) and alignment score (preoperative median 0, postoperative median 15, *P* value = 1.14e-10; Figure 6).

Complications

The postoperative complications[2-5,9] can be summarized as follows:

- One superficial cellulitis (1.85%): A female patient, 29 years old, developed a superficial infection of the surgical site after removal of sutures. The patient was treated with systemic antibiotics and local antibiotic and antiseptic preparations for 6 weeks, ambulated with crutches for 6 weeks, and went on to complete healing.
- Two hallux varus (3.70%): The hallux varus deformities did not require treatment.
- Three cases of first MTPJ stiffness (5.55%) were found.
- Three delayed unions (5.55%): All cases healed within 1 year from the MDMO. Risk factors for nonunion and delayed union in these patients included smoking, hypothyroidism, and multiple prior surgeries. One female patient (76 years old) was an active smoker. Hypoxia caused by cigarette smoking can lead to aberrant bone healing at an osteotomy site.[2-4] One female patient (36 years old) had a diagnosis of hypothyroidism. One female patient (53 years old) had undergone 2 bunionectomies prior to the MSMO.
- One painful migration of hardware (1.85%): In a male patient (41 years old) worker, the Kirschner wire

Table 2.

Statistical Analysis of Intraobserver Radiographic Measurements of Recurrent Hallux Valgus Patients, Treated With MSMO.[a]

		Df	Sum Square	Mean Square	*F* Value	Pr(>*F*)
IMA	Pre-Post MSMO	1	934.7	934.7	75.866	9.51e-16***
	Radiologist	1	0.6	0.6	0.045	.831
	Pre-Post MSMO × Radiologist	1	4.2	4.2	0.340	.560
	Residuals	208	2562.6	12.3		
DMAA	Pre-Post MSMO	1	387	386.7	5.380	.0213*
	Radiologist	1	136	135.9	1891	.1706
	Pre-Post MSMO × Radiologist	1	17	17.0	0.236	.6274
	Residuals	208	14 952	71.9		
HVA	Pre-Post MSMO	1	5985	5985	84.802	<2e-16***
	Radiologist	1	32	32	0.448	.504
	Pre-Post MSMO × Radiologist	1	64	64	0.904	.343
	Residuals	208	14 680	71		
TS	Pre-Post MSMO	1	41.51	41.51	35.998	8.65e-09***
	Radiologist	1	0.00	0.00	0.001	.973
	Pre-Post MSMO × Radiologist	1	1.58	1.58	1371	.243
	Residuals	208	239.84	1.15		

[a]Results of 2-way repeated-measures ANOVA on intermetatarsal angle (IMA), distal metatarsal articular angle (DMAA), hallux valgus angle (HVA), and the position of the tibial sesamoid (TS). The efficacy of the modified subcapital metatarsal osteotomy (MSMO) procedure (Pre-Post MSMO), the effect of the 2 independent radiologists' assessments (Radiologist), and the interaction between these 2 variables are reported. The absence of statistically significant differences in the radiological assessments denotes the concordance between the 2 radiologists. *Significance at the 10% level; **significance at the 5% level; ***significance at the 1% level. Abbreviations: df, degrees of freedom.

displaced distally 18 months after the MSMO procedure. The wire was removed in day surgery.

- One broken hardware (1.85%): In a male patient (34 years old) who was an amateur soccer player, the hardware failure was incidentally noted during routine radiographic follow-up. The patient did not endorse any symptoms related to hardware failure.
- Three transfer metatarsalgias (5.55%) were seen.

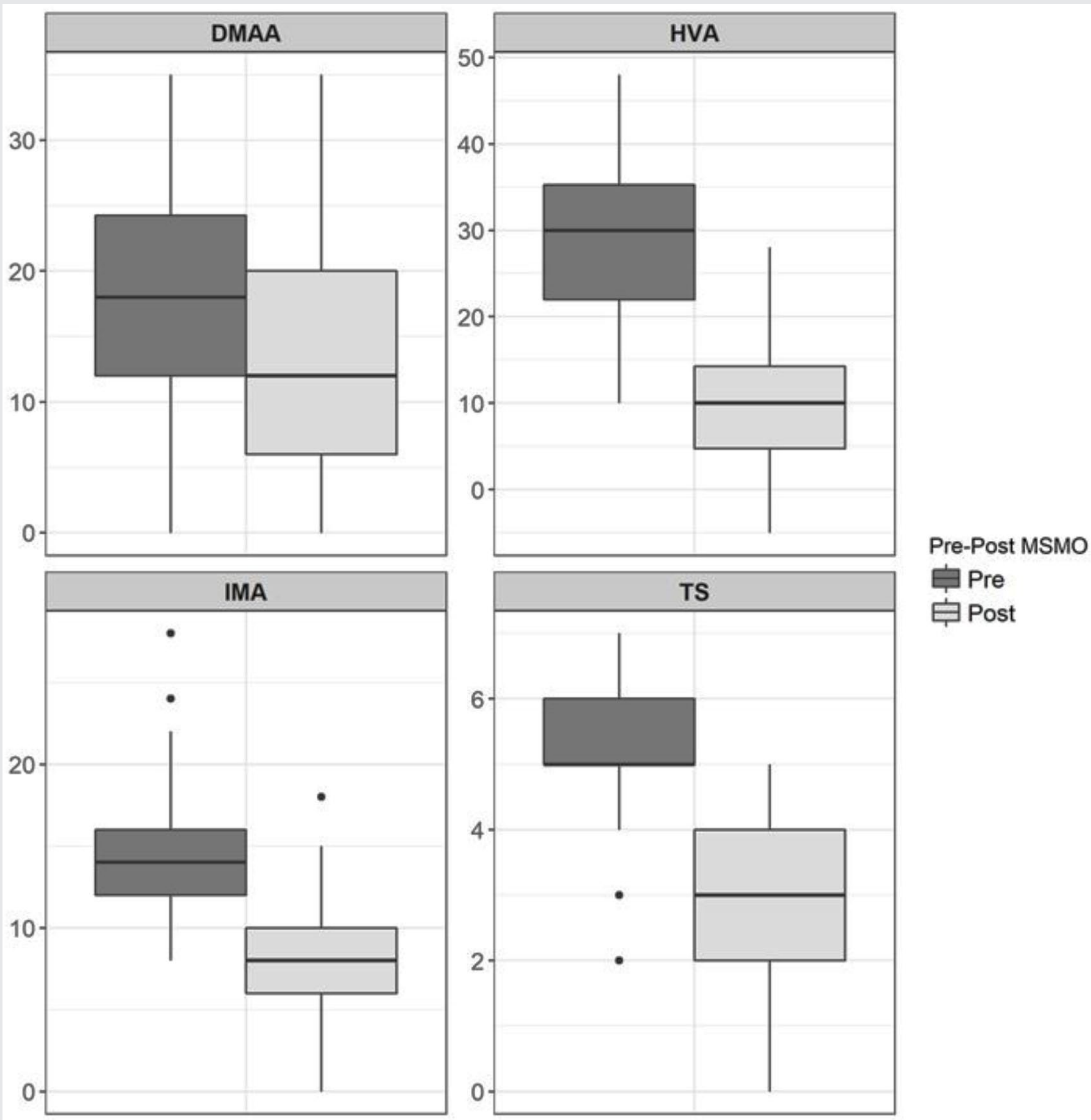
In the present series, there are no reported cases of Complex Regional Pain Syndrome, persistent pain at the first MTPJ, or avascular necrosis of the first MT head.[2-4,40]

Statistical Methods

To verify the power of correction of the MSMO, the 2-way repeated-measures ANOVA was performed on the 4 radiological measurements. The significant differences between preoperative and postoperative radiological assessments were investigated. These models included a random variable to take into account the natural difference between patients, the preoperative and postoperative MSMO procedure effect, the effect of the 2 radiologists, and the interaction between the 2 radiologists. The preoperative and postoperative MSMO procedure assessments, as a within-subject factor, were also investigated. To determine whether there was a statistically significant difference between the preoperative and

Figure 5.

Comparison between preoperative and postoperative radiological findings: Preoperative radiological measurements of the distal metatarsal articular angle, hallux valgus angle, and intermetatarsal angle and position of the tibial sesamoid compared with postoperative modified subcapital metatarsal osteotomy (MSMO) radiological measurements.



postoperative evaluations of HV deformity severity grade, a χ^2 test and a test of proportions was performed. Because of the small sample size of some elements of the survey, *P* values of the χ^2 test were computed using a Monte Carlo with 2000 simulations.

The effectiveness of the MSMO in the treatment of recurrent HV was assessed for each item of the AOFAS score, surveyed preoperatively and postoperatively. The comparison between the AOFAS score administered preoperatively and postoperatively was performed exploiting the Wilcoxon-Mann-Whitney test.

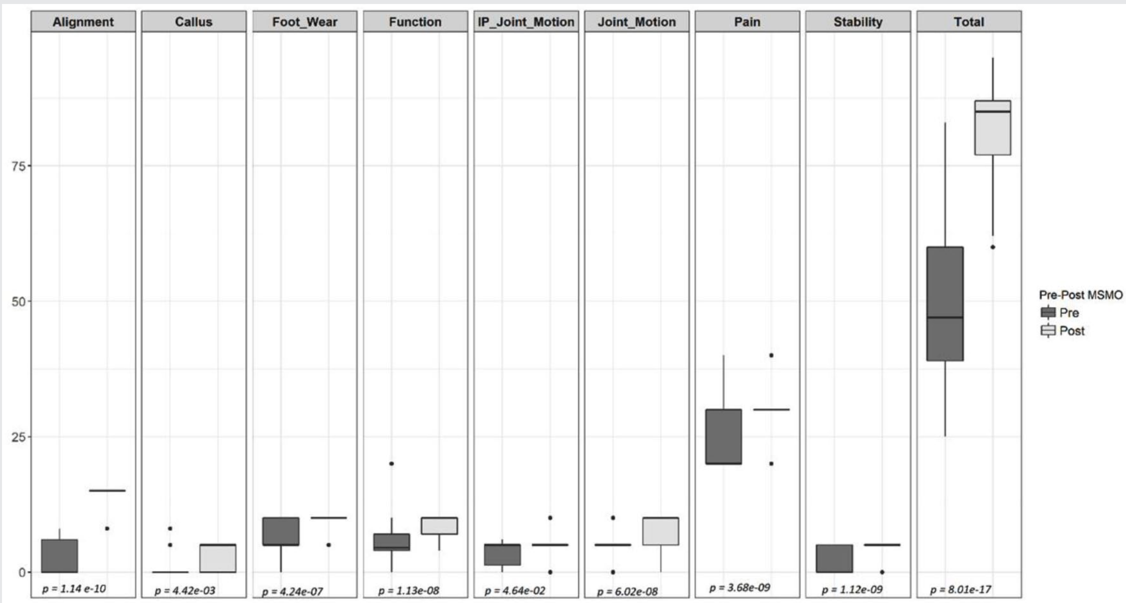
Statistical analysis was performed using the computing environment R (R Development Core Team, 2005). In all the analyses, statistical significance was defined at a 5% level.

Discussion

Different surgical procedures have been described as treatments for recurrent HV deformity: MTPJ arthrodesis after failed Keller-Brandes,[11,28,49,50] proximal crescentic osteotomies,[51] and Scarf

Figure 6.

Preoperative AOFAS score compared with postoperative MSMO AOFAS outcomes. The preoperative American Orthopaedic Foot Ankle Society hallux metatarsophalangeal-interphalangeal subscales are compared with the postoperative AOFAS score related to MSMO outcomes (statistical significative Wilcoxon-Mann-Whitney test).



osteotomy.[52] The Lapidus procedure[12,53-55] was described as the final solution in case of HV recurrence.

Minimally invasive MSMO as a salvage procedure for recurrent HV appears to have comparable results. Modifications of the technique used by Bosh-Magnan[56,57] limit the morbidity and complications associated with the originally described technique. It was not necessary to enlarge the surgical exposure to remove the metalwork of previous procedures.

Two advantages of the modified MSMO are procedural efficiency, because the provisional percutaneous Kirschner wire fixation has been modified to remain as permanent internal fixation, and accelerated rehabilitation. Because the MTPJ is spared and avoids surgical insult, the immediate range of motion after HV correction[58] is permitted, and because removal of hardware is not necessary, a secondary loss of correction and an additional surgical insult requiring a second recovery can be avoided.

In this series, the Akin procedure was frequently used as an adjunct to improve the alignment of the first MT ray, with repair and retention of the slackened capsular structures to further stabilize the first MTPJ medially while releasing tight structures laterally with an arthroscopic blade.

Of note, no avascular necrosis was reported,[59] there are no cases of nonunion, and there was a low recurrence of deformity. The authors attribute this to attention to technical details of the procedure—namely, the placement of the bent wire at the distal level achieves correction of HV alignment while preventing overcorrection to hallux varus deformity. Also, retrograde pinning across the first tarsometatarsal joint provides adequate stability of the construct to allow bone callus formation of the osteotomy.[60] The authors describe fatigue fracture of the proximal end of the k wire, migration of the k wire, and problems related to rotation stability of the osteotomy. These concerns are reported in the complications paragraph.

It cannot be overstated that preservation of the arterial blood supply to the first MT head is paramount with appropriate subcapital site selection for the osteotomy if nonunions and AVN are to be avoided.

Our study has several limitations. It is a retrospective analysis of consecutive cases, with potential for selection bias and surgeon bias because the 2 orthopedic surgeons (AS and MC) who performed the procedures also determined the initial AOFAS forefoot score and the postoperative AOFAS forefoot score at the final follow-up.[31,38,55] Because of the study design, the survey reports the effect of a single surgical procedure and lacks a control group for comparison, Other study weaknesses include the focus of the study on radiographic outcomes without recording or reporting preoperative and postoperative MTPJ range of motion. Additionally, the study did not specifically or fully assess foot-related quality of life and lacked a psychometrically valid and reliable measurement of patient satisfaction. Finally, the study showed that the MSMO procedure did not fully correct first MTPJ congruency or DMMA angle and is not exempt from complications. Although the internal fixation appeared to provide enough stability to the first MT ray in this series, biomechanical studies on cadaveric specimens would help elucidate and quantify the strength of this technique for fixation. Despite the limitations of this investigation, the authors believe that the results of this study should guide future development of prospective cohort studies or randomized controlled trials that focus on a more comprehensive assessment of the value of the MSMO procedure for restoration of alignment and function of the first MTPJ in recurrent HV surgery.

In conclusion, MSMO is an effective treatment in patients with recurrent HV. Evaluation of preoperative and postoperative radiographic parameters shows a statistically significant improvement of the IMA ($P < .05$), HVA ($P < .05$), and position of the TS ($P < .1$). The difficulty encountered in correcting the DMAA angle[35] and restoring the first MTPJ congruency may be attributable to the articular changes caused by previous operations.

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Ethical Approval

Not applicable, because this article does not contain any studies with human or animal subjects.

Informed Consent

Not applicable, because this article does not contain any studies with human or animal subjects.

Trial Registration

Not applicable, because this article does not contain any clinical trials.

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