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Maintenance of Correction of the Modified Lapidus Procedure With a First Metatarsal to Intermediate Cuneiform Cross-Screw Technique

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Abstract

Background: Recurrence of deformity remains a concern when fusing the first tarsometatarsal joint for correction of hallux valgus (HV). A recently described construct adds an additional point of fixation from the plantar medial first metatarsal to the intermediate cuneiform. The purpose of this study was to determine the maintenance of correction of the first and second intermetatarsal angle, hallux valgus angle, and tibial sesamoid position after undergoing a first tarsometatarsal joint arthrodesis using the proposed construct.
Methods: A radiographic review was performed of patients with HV treated with a first tarsometatarsal joint arthrodesis with the addition of a cross-screw intermediate cuneiform construct. Three observers reviewed radiographic data, including preoperative weightbearing, first weightbearing, and final weightbearing plain-film radiographs. Initial improvement and maintenance of intermetatarsal angle, hallux valgus angle (HVA), and tibial sesamoid position were evaluated radiographically. A total of 62 patients met inclusion criteria and were included in the study. Mean follow-up time was 9.3 months (SD 6.7).
Results: Bony union was achieved in 60 of 62 patients (96.7%). Two of 62 patients required revision surgery as a result of recurrence (3.3%). Final mean improvement of the intermetatarsal angle (IMA) was 6.8 degrees (±2.9 degrees), HVA was 14.8 degrees (±7.5 degrees), and tibial sesamoid position was 2.4 (±1.4) positions. Mean loss of IMA correction was 1.5 degrees (±1.6), HVA was 2.9 degrees (±4.8 degrees), and tibial sesamoid position was 0.8 (±0.8).
Conclusion: This study showed that the cross-screw intermediate cuneiform construct for first tarsometatarsal joint arthrodesis had a good union rate, a low complication rate, and maintained radiographic correction.
Level of Evidence: Level IV, retrospective case series.

Keywords: bunion, hallux valgus, Lapidus, arthrodesis, recurrence

Introduction

The treatment of hallux valgus (HV) has evolved as surgeons better understand the etiology and biomechanics of the deformity. Many different operative treatments and techniques have been used. Generally, the accepted procedure for moderate to severe HV with instability of the first ray has been a correctional arthrodesis of the first tarsometatarsal joint (TMTJ).[1,3,9,13,15,18,19,22,24] Originally described in 1911, but later made popular in 1934 by Paul Lapidus, fusion of the first TMTJ has proved to be an effective procedure in the treatment of HV.[15,24] Fusion of the first TMTJ provides stability of the medial column and maintains long-term correction of primary or recurrent HV.[1,3,9,13,18,19,22]

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Figure 1. Final weightbearing radiographs of the (A) cross-screw intermediate cuneiform (CSIC) construct as well as the (B) modified CSIC construct with “1 to 2” spot welding and fixation.

There has been debate over the most effective hardware construct for the first TMTJ fusion. The successful use of different incisional approaches, joint preparation techniques, and hardware constructs have been reported in the literature.[1,8,9,22] The original Lapidus procedure was fixated with chromic gut suture between the first and second metatarsal bases; however, new fixation constructs including screw and plate applications are now typical.[7,15] Hansen described a 2-screw fixation construct across the first TMTJ that has been successful, but there are reports of nonunion with this construct.[2,5,6,9,11,23] Recently, Galli et al[9] compared the sagittal plane motion of the traditional 2-cross-screw fixation construct with an added point of fixation from the plantar medial first metatarsal into the intermediate cuneiform. This cadaveric study demonstrated a decrease in motion at the first TMTJ with the additional intermediate cuneiform fixation point. This construct would ideally lead to improved union rates and decreased splaying or “springing open” of the intermetatarsal angle.[9] This described construct is termed the cross-screw intermediate cuneiform (CSIC) construct for the purpose of this study. At our institution, we routinely use the CSIC along with a standard dorsal medial locking plate construct. In some cases, we have also incorporated an additional screw from the first metatarsal base into the second metatarsal shaft (1-2 intermetatarsal [IM] screw) (Figure 1). The goal of this additional screw is to increase the stability, aid in fusion between the first and second metatarsal bases, and decrease recurrence.

The aim of this study was to determine the angular correction of the first and second intermetatarsal angle (IMA), hallux valgus angles (HVA), and tibial sesamoid position (TSP) after undergoing fusion of the first TMTJ with the CSIC construct. The effect of adding an additional screw from the base of the first metatarsal to the base of the second metatarsal was also evaluated as means of correction and maintenance. We hypothesized that the CSIC with a dorsal medial locking plate construct would provide acceptable outcomes in maintained correction and that the addition of the 1-2 IM screw would improve the maintenance of correction.

Methods

A single-center chart and radiographic review was performed of all patients with HV treated with fusion of the first TMTJ with CSIC fixation (with or without an additional 1-2 IM screw) by the senior author (C.H.). The study period was from June 2016 to May 2018. Potential study subjects were identified on the basis of current procedural terminology (CPT) codes for first TMTJ arthrodesis (28740). Only patients who underwent first TMTJ arthrodesis for a primary diagnosis of HV or bunion were studied. Patients were included if they were older than 18 years, underwent primary HV correction with the CSIC, and locking plate fixation construct (with or without a 1-2 IM screw), and had complete preoperative and postoperative clinical and radiographic data. Patients were excluded if they were younger than 18 years, had a different fixation construct, were undergoing revision surgery, had a previous infection at the operative site, had incomplete clinical or

Figure 2. Intraoperative photograph illustrating reduction of the intermetatarsal angle with the use of Windlass mechanism and a tenaculum clamp around the first and second metatarsal heads. Note that the tenaculum clamp is placed within distal incisions.

radiographic data, or underwent concomitant procedures that would alter the normal first TMTJ arthrodesis postoperative course. Electronic medical records were reviewed and the following data were extracted: age, sex, body mass index, preoperative diagnoses, length of follow-up, complications, and adjunctive operative procedures. Three observers independently reviewed radiographic data, including preoperative weightbearing, first weightbearing (4 ±1 weeks), and final weightbearing plain-film radiographs of all patients who met the inclusion criteria. The IMA, HVA, and TSP according to the Hardy classification[12] for all 3 intervals were recorded with observers blinded to each other's work. Complications were recorded, including recurrence, nonunion, painful hardware, wound healing problems, infection, and unplanned return to the operating room. Adjunctive procedures were performed at the primary surgeon's discretion. These procedures included distal soft tissue and capsular balancing procedures at the first metatarsophalangeal joint (MTPJ), Silver ostectomy, Akin, lesser digital and metatarsal deformity correction, and posterior muscle group lengthening. Surgeries were excluded if they were revision arthrodesis or procedures that were part of an adjunctive major deformity correction such as a flatfoot or cavus foot reconstruction.

Sixty-two total patients were identified and included within the study period with a mean follow-up time of 9.3 months (SD 6.8). Patients who underwent the procedure from June 2016 to September 2017 (n = 45) had the standard CSIC construct. Patients who underwent the procedure from October 2017 to May 2018 (n = 17) received an additional 1-2 IM screw. Preoperative films were used if they were within 3 months of the surgery, and postoperative weightbearing radiographs were obtained at 4 ± 1 weeks, 8 ± 2 weeks, 12 ± 2 weeks, 18 ± 4 weeks, 26 ± 4 weeks, 52 ± 12 weeks, and the final follow-up visit.

Operative Technique

All surgeries were performed by a single fellowship-trained foot and ankle surgeon. First, a 2-cm incision was placed in the first interspace at the level of the first MTPJ. This incision was used to perform a sequential lateral release of the soft tissues at the first MTPJ. The authors generally released only the superficial fibers of the deep transverse intermetatarsal ligament and the lateral sesamoid suspensory ligament. The hallux and sesamoids were evaluated and, if needed, a complete release was performed. This incision was left open and later used during reduction of the first TMTJ and IMA.

A dorsal medial incision was used just medial to the extensor hallucis longus tendon to expose the first TMTJ. A pin distractor allowed for joint exposure, and manual joint preparation was performed by curettage. Care was taken to preserve the cortical bone edges in order to maintain length of the first ray. The subchondral surfaces were aggressively fenestrated with a small drill bit (2.7-mm) and a curved osteotome. Decortication of the opposing surfaces of the first and second intermetatarsal articulation was then performed in order to achieve a "spot weld" fusion between the first and second metatarsal bases.

A 2-cm incision was then made over the medial aspect of the first MTPJ in a linear fashion. An elliptical capsulotomy was performed exposing the metatarsal head. Any prominent medial eminence was resected with a saw or rongeur.

Using the previous first interspace incision, a large reduction clamp was placed around the head of the first and second metatarsal. Before closing the IMA, any frontal plane deformity of the first metatarsal was addressed and the hallux was placed in a neutral position within the frontal plane. While engaging the Windlass Mechanism, the IMA was reduced using the tenaculum clamp, and intraoperative fluoroscopy confirmed osseous reduction (Figure 2). Temporary guidewire fixation was then placed from the medial base of the first metatarsal, across the first TMTJ, and into the intermediate cuneiform (Figure 3). Care was taken not to violate the second TMTJ. A 4.0-mm cannulated screw was then placed in lag fashion (Figure 4). This unique screw placement allowed for a force vector that

Figure 3. Intraoperative radiograph of the guidewire for the cannulated cross-screw intermediate cuneiform construct from the plantar medial first metatarsal into the intermediate cuneiform.

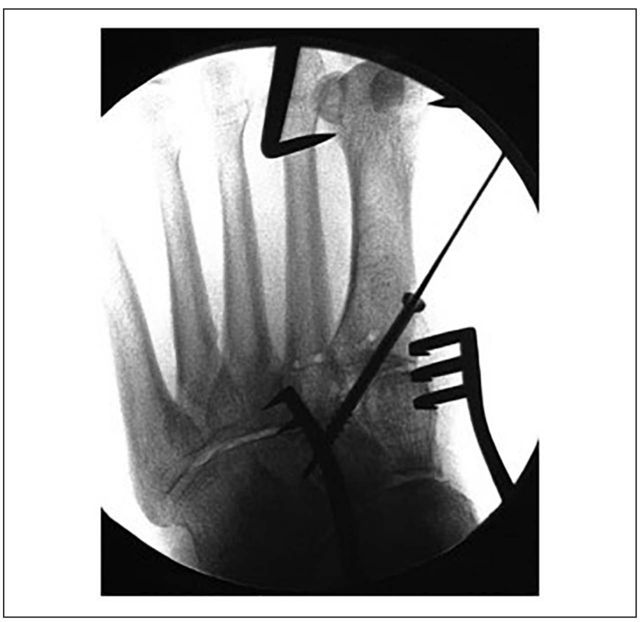

Figure 4. Intraoperative radiograph of 4.0-mm cannulated cross-screw intermediate cuneiform screw inserted in lag fashion from the plantar medial aspect of the first metatarsal into the intermediate cuneiform.

Figure 5. Intraoperative radiograph demonstrating guidewire placement for the first-to-second intermetatarsal screw. The wire is placed between the bases of the first and second metatarsals, parallel to the tarsometatarsal joints.

Figure 6. Intraoperative radiograph demonstrating the use of a dorsal medial locking plate for the final fixation construct.

closed the first IMA as well as increased stability in the construct.[9] For the 1-2 IM screw, a guidewire was then placed from the base of the first metatarsal into the base of the second metatarsal that was parallel to the TMTJ. A 4.0-mm screw was then placed (Figure 5). A fully threaded screw was placed to hold the reduction, or a lag screw could be placed to further reduce the IMA if needed. A dorsal or medial locking plate was then placed across the first TMTJ for added stability and fixation (Figure 6). The reduction tenaculum was removed and any remaining correction at the first MTPJ was completed. This was done with further sequential lateral release, medial capsular balancing, and/or an Akin osteotomy as needed. A layered closure was then performed.

Figure 7. Anteroposterior radiographs at time intervals of (A, D) preoperative, (B, E) first weightbearing and (C, F) final weightbearing for crossscrew intermediate cuneiform (CSIC) construct and the modified CSIC construct with first-to-second "spot welding" and fixation technique.

Table 1. Preoperative and Postoperative Radiographic Data.

Radiographic Finding (n = 62)	Preoperative	First Weightbearing Radiographs	Final Weightbearing Radiographs
IMA, degrees	16.0 (±2.5)	7.6 (±2.8)	9.1 (±3.0)
HVA, degrees	31.7 (±6.2)	13.9 (±6.1)	16.8 (±7.9)
TSP	4.7 (±1.2)	1.6 (±0.8)	2.3 (±1.0)

Abbreviations: HVA, hallux valgus angle; IMA, intermetatarsal angle; TSP, tibial sesamoid position.

All study patients were placed into a nonweightbearing splint for 1 week. Patients were then placed into a boot and allowed to heel-weightbear. At 4 weeks postoperatively, patients began full weightbearing in the boot and transitioned to normal shoe wear as tolerated at 6 weeks postoperation (Figure 7).

Statistical Analysis

Statistical analysis was performed by an independent researcher. Preoperative, first weightbearing, and final radiographic values for IMA, HVA, and sesamoid position were calculated by each observer, and the overall averages

Table 2. Improvement From Preoperative to Final Radiographs, Mean (±SD).

Radiographic Finding (n=62)	Final Improvement From Preoperative to Final Radiographs	Loss of Correction From Initial Weightbearing to Final Radiographs
IMA, degrees	6.8 (±2.9)	1.5 (±1.6)
HVA, degrees	14.8 (±7.5)	2.9 (±4.8)
TSP	2.4 (±1.4)	0.8 (±0.8)

Abbreviations: HVA, hallux valgus angle; IMA, intermetatarsal angle; TSP, tibial sesamoid position.

Table 3. Comparison of Patients With CSIC Construct and Patients With Additional 1-2 IM Screw.[a]

Radiographic Finding	Total (n=62)	1-2 IM Screw (n=17)	CSIC (n=45)	*P* Value
Initial improvement IMA, degrees	8.4 ± 2.4	9.4 ± 2.1	8.0 ± 2.5	.04
Final improvement IMA, degrees	6.8 ± 2.9	8.4 ± 2.2	6.3 ± 2.9	.01
Loss of correction IMA, degrees	−1.5 ± 1.6	−1.0 ± 1.2	−1.7 ± 1.6	.13
Initial improvement HVA, degrees	17.7 ± 7.4	21.4 ± 7.3	16.3 ± 7.0	.02
Final improvement HVA, degrees	14.8 ± 7.5	17.3 ± 8.2	13.9 ± 7.0	.11
Loss of correction HVA, degrees	−2.9 ± 4.8	−4.1 ± 5.3	−2.5 ± 4.6	.22
Initial improvement TSP[b], n (%)				
1 or 2	24 (39)	3 (18)	21 (47)	.01
3	12 (19)	1 (6)	11 (24)	
4	15 (24)	8 (47)	7 (16)	
5 or 6	11 (18)	5 (29)	6 (13)	
Final improvement TSP[b], n (%)				
0 or 1	17 (27)	1 (6)	16 (36)	.02
2	15 (24)	3 (18)	12 (27)	
3	17 (27)	6 (35)	11 (24)	
4 or 5	13 (21)	7 (41)	6 (13)	
Loss of correction TSP[b], n (%)				
−3 or −2	11 (18)	2 (12)	9 (20)	.76
−1	23 (37)	6 (35)	17 (38)	
0	28 (45)	9 (53)	19 (42)	

Abbreviations: CSIC, cross-screw intermediate cuneiform; HVA, hallux valgus angle; IM, intermetatarsal; IMA, intermetatarsal angle; TSP, tibial sesamoid position.
[a]Values listed are the amount of improvement seen.
[b]Sesamoid position according to the Hardy classification.[12]

were used for each patient. The average loss of correction was calculated by comparing first weightbearing and final weightbearing radiographic values. Differences in continuous demographic, operative, and outcome data between those who received an additional 1-2 IM screw versus those who did not were evaluated using Student *t* test, whereas categorical variables were evaluated using χ^2 or Fisher exact test. Correlations between continuous demographic variables and outcomes were evaluated using the Pearson *r* correlation coefficient. The relationship between categorical outcomes and continuous demographic variables were determined using 1-way analysis of variance or Kruskal-Wallis test. The relationship between the categorical demographic variables and categorical outcomes was determined by Fisher exact test. All tests were 2-sided, and the significance level was $P < .05$.

Results

Bony union was achieved in 60 of 62 patients (96.7%). Some amount of clinical and symptomatic recurrence occurred in 4 of 62 patients (6.4%), but only 2 of 62 patients required a revision bunionectomy as a result of their recurrence (3.2%). One revision was performed at 12 months and the other was performed at 14 months from the initial procedure. Other complications included symptomatic hardware in 3 of 62 requiring removal (4.8%) and a transient neuritis in 2 of 62 patients that resolved with conservative care.

Table 1 shows preoperative and postoperative radiographic data. Average preoperative IMA was 16.0 degrees (±2.5), HVA was 31.7 degrees (±6.2), and TSP was 4.7 (±1.2). Overall IMA improved to a mean of 7.6 degrees

(±2.8) at the first weightbearing radiographs and was a mean of 9.1 degrees (±3.0) at final follow-up. Mean HVA was 13.9 degrees (±6.1) at first weightbearing radiographic evaluation and 16.8 degrees (±7.9) at final evaluation. Mean TSP improved to 1.6 (±0.8) at first weightbearing interval and 2.3 (±1.0) at final follow-up.

Table 2 shows the amount of improvement in the radiographic findings and the average loss of correction at final follow-up. Final mean improvement of IMA was 6.8 degrees (±2.9), HVA was 14.8 degrees (±7.5), and TSP was 2.4 (±1.4) positions. Mean loss of IMA correction was 1.5 degrees (±1.6), HVA was 2.9 degrees (±4.8), and TSP was 0.8 (±0.8) positions.

We also compared the results of patients who underwent an additional 1-2 IM screw with those patients who did not (Table 3). Those patients who received the additional 1-2 IM screw showed significantly improved results in several radiographic findings. Patients with the 1-2 IM screw showed a 1.4 degrees greater initial improvement in IMA (P = .04) and a 5.1 degrees greater initial improvement in HVA (P = .02). Furthermore, 1-2 IM screw patients showed a greater final improvement of IMA 2.1 degrees (P = .01) over those without the 1-2 IM screw. Those patients with the 1-2 IM screw lost an average of 1.0 degree of IMA correction whereas those without lost an average of 1.7 degrees. Although this finding is radiographically significant, we were not able to detect a statistically significant difference (P = .13). The addition of the 1-2 IM screw aided in achieving a "spot weld" between the base of the first and second metatarsal in 65% of the patients compared with 36% of patients without the additional screw (P = .04). Patients with a spot weld between the metatarsal bases showed a 1.3 degree (P = .07) greater final improvement in IMA than those who did not achieve a spot weld. There were no other categorical or continuous data showing a significant relationship with radiographic results (ie, body mass index, age, sex, laterality, etc).

Discussion

Arthrodesis of the first TMTJ has become a common method of correcting moderate to severe hallux valgus.[1,3,5,7,10,13,17-19,24] This procedure has gone through several modifications with advances in hardware choices and specific techniques over time. The use of crossed screws and locking plates across the first TMTJ has been used by multiple authors with good results.[2,5,11,18,19,22] However, nonunion continues to be a complication leading to pain, edema, and possible loss of correction.[9] The proposed CSIC construct has been shown to be safe and effective.[9,21] Galli et al[9] demonstrated increased stability with this added point of fixation, and they suggested the construct may reduce the rate of nonunion. The rate of nonunion in recent literature for the modified Lapidus procedure with varying fixation methods ranges from 0% to 15%.[2,6,14,22] The current study showed a union rate of 97%, which is satisfactory and higher than many reports.

Galli et al[9] also suggested that the orientation of the intercuneiform screw may decrease "springing open" of the first IMA and provide improved radiographic correction. The current study showed acceptable radiographic results with the described construct. From the first weightbearing films to the final follow-up, loss of IMA correction was 1.5 degrees, HVA was 2.9 degrees, and TSP was 0.8. This is comparable to previously reported loss of correction rates for first TMTJ fusion.[10]

The use of a screw from the base of the first metatarsal to the base of the second metatarsal has also been shown to be an effective and safe construct.[1] To the authors' knowledge, this has not been directly compared to a study group without this screw construct. Our study demonstrates the additional screw had a lower loss of correction, with an improved overall radiographic correction. Lapidus described a fusion between the base of the first and second metatarsal and stated that this may help maintain deformity correction.[16] The addition of the 1-2 IM screw had a significantly higher rate of spot weld between the metatarsal bases (P = .04). Achieving a radiographic spot weld between the metatarsal bases trended toward a greater IMA correction (P = .07) and a lower loss of correction (P = .25). We feel the addition of a 1-2 IM screw should be considered in patients where a large amount of IMA correction is needed. The screw can be fully threaded to maintain the already achieved correction, or it can be placed in lag fashion to further correct the IMA, if needed.

Tibial sesamoid position was also evaluated in the current study. It has been shown that there is a significant relationship between reduction of TSP and recurrent deformities.[4,20] Okuda et al[20] showed that incomplete sesamoid reduction can lead to recurrent hallux valgus. The current study demonstrated an average TSP improvement of 2.5 positions. The mean TSP of 2.3 (±1.0) is well within the acceptable postoperative position of 4 or less.[4,20] We understand this measurement is not likely related to the hardware construct, but it is an interesting variable to note. The authors feel the described technique of a small first interspace incision allows for compete release of the lateral sesamoid complex. The medial incision at the first MTPJ allows for medial capsular balancing to assist in relocating the sesamoids. Surgeons should be meticulous in the correction of IMA and HVA; however, optimal balancing of the sesamoid complex is important to long-term success.

Another important finding to recognize from this study is the method of joint preparation used. Joint preparation remains key for maximizing union rates and allowing for adequate deformity correction.[6,17,22] In the current study, the joint surfaces were prepped by cartilage curettage rather than resection to prepare the arthrodesis site. Prissel et al[22] showed that joint preparation with curettage preserves the length of the first ray while allowing for effective correction and high union rates. This study further supports the use of curettage for joint preparation in first TMTJ fusions. Curettage was performed quickly and completely utilizing the above technique.

The current study does have several limitations. First, we noted that bunion correction requires multiple procedures for complete correction. This created many confounding variables that may skew the results. The authors note, however, that it would be nearly impossible to find a cohort where a first TMTJ fusion was the only procedure performed. Next, this study is retrospective which can have inherent bias. Although only complete records were included, the results relied on the accuracy of the documentation. The sample size is relatively small and may consequently be underpowered. The average follow-up time was also variable among the patients with a mean of 9.3 months, which is relatively short. This was attributed to positive clinical outcomes with no further need for follow-up once bony union and patient satisfaction was achieved. This short follow-up, however, could underestimate the loss of correction at long-term follow-up. Finally, there were no subjective scoring systems used. We were unable to add patient satisfaction results as a validated scoring system was not used.

Conclusion

In conclusion, although many constructs have been described for first TMT fusion, the application of the CSIC construct resulted in good clinical and radiographic results. The addition of a first to second intermetatarsal screw allowed for greater IMA correction and greater maintenance of correction at short-term follow-up.

Declaration of Conflicting Interests

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