Intraoperative Evaluation of Medial Intercuneiform Instability Following Lapidus Arthrodesis: Intercuneiform Hook Test

Justin J. Fleming, DPM

INTRODUCTION

More than 150 surgical procedures have been previously described in the management of hallux valgus. As a result, there is significant overlap with surgical management in patients with specific clinical and radiographic findings. However, there is consensus in the surgical management of hallux valgus in the presence of medial column hypermobility. The procedure of choice in this setting involves fusion of the first tarsometatarsal joint, routinely described as the Lapidus arthrodesis. Initially described, the Lapidus arthrodesis involved the removal of cartilage from the first tarsometatarsal joint, decortication of the bases of the opposing surfaces of the first and second metatarsal, and the utilization of the resected medial eminence of the first metatarsal head as autogenous bone graft between the decorticated facing surfaces of the first and second metatarsal bases (1).

With significant advances in internal fixation and joint preparation techniques, outcomes with this procedure have improved significantly. As a result, this procedure is routinely offered to patients with confidence as the definitive correction for this pathology. This confidence is derived from the rationale that unlike bunionectomies that are performed distal to the first tarsometatarsal joint, this technique addresses the pathology at the apex of the deformity, the center of rotation of angulation (CORA), without altering the natural geometry of the first metatarsal (2). Furthermore, it serves to permanently eliminate the motion potentially implicated in this pathology. It is unclear why there has not been standardization regarding the routine use of the intermetatarsal screw, (i.e., some practitioners describe this technique utilizing screws placed only from posterior and anterior or vice versa directed within the sagittal plane, where others routinely augment the correction with screws placed from medial to lateral in the coronal plane with similar overall outcomes.)

The tarsometatarsal joint and its proximal counterparts derive their primary stability through a complex system of dorsal, plantar, and intermediate interosseous ligaments. These ligaments have been extensively studied and defined (4, 5). The articulations have relatively little independent osseous stability, with principal stability derived from the locking keystone mechanism of the second metatarsal joint as well as through these ligamentous structures. Three sets of interosseous ligaments, which correspond to the first, second, and third cuneometatarsal spaces have also been described. The first cuneometatarsal ligament, also known as Lisfranc's ligament, is the strongest of the 3 interosseous ligaments and is critical in maintaining stability in the midfoot (6, 7). However, there is no interosseous connection between the first and second metatarsal bases.

In a series of 5 studies, Christensen et al described the biomechanics of the first ray in a cadaver model. His results demonstrated that arthrodesis of the first metatarsocuneiform joint combined with intercuneiform fusion limited first ray motion to a greater extent than other isolated medial column fusions. Naviculocuneiform joint range of motion was shown to decrease with combined first metatarsal cuneiform fusion and intercuneiform fusion (8). For this reason, stabilization of the intercuneiform joints following Lapidus arthrodesis may be beneficial in controlling excess motion that remains, and conferring additional stability that is not inherent in this area. The majority of the literature concentrates on sagittal plane motion of the medial column; however, no report exists that attempts to objectively or clinically evaluate the transverse plane motion between the medial and central columns despite it being understood that instability in the medial column is often multiplanar (9).

In this article, a relatively objective method of determining the presence of transverse plane instability is discussed. The incidence of this instability in our cohort will be presented, and tips are offered that may reduce variability in outcomes, improve reproducibility, and ultimately reduce the rates of recurrence with this durable procedure.

PATIENTS AND METHODS

Following institutional review board approval, patients were selected from archived records of operations performed at Aria Health Systems, Philadelphia, Pennsylvania by the author with the Current Procedural Terminology (CPT) code 28297 representing the Lapidus bunionectomy. We reviewed all preoperative and postoperative radiographs and operative reports. Intercuneiform instability was recorded as evidenced by fluoroscopic intraoperative testing, operative documentation, and the subsequent placement of the intermetatarsal screw. Inclusion criteria included patients who underwent the Lapidus as a primary procedure, patients 18 years or older, and the ability to provide consent. Exclusion criteria included patients younger than 18 years, any patient unable to provide consent, or revision surgery for a previous bunionectomy. We previously placed the intermetatarsal screw without intermetetarsal arthrodesis however, loss of reduction and screw pullout occurred with an undesirable frequency. As a result, we sought to include only patients in whom the intermetatarsal screw was utilized, intermetatarsal arthrodesis was performed concurrently.

The primary author performed a total of 38 Lapidus bunionectomies in 34 patients from May 2007 to May 2010 over a period of 36 months. All patients presented preoperatively with long-standing symptomatic deformities, which had failed conservative therapy (Figure 1). None of the patients in our study had undergone any previous surgical correction of their deformity. All patients underwent distal soft tissue rebalancing and first tarsometatarsal joint (TMTJ) arthrodesis with a first to second intermetatarsal base "spot-weld" fusion as originally described (1, 10).

Weight-bearing preoperative intermetatarsal angles were measured by the author manually on printed hard copies of computed radiographs utilizing a tractograph. This investigator was not blinded to the outcome of the study. These measurements were also performed by another physician who was blinded to the first measurements but not the outcome of the study. All additional measurements were performed by the author. All measurements were performed by each of these investigators on 2 separate occasions to ensure consistency.

Postoperatively, the patients were immobilized in a short-leg non-weight-bearing Jones posterior splint. After suture removal, patients were placed in a non-weight-bearing short-leg cast until union was confirmed radiographically, typically around 6 weeks (Figure 2). Radiographic union was defined as 3 united cortices on the dorsoplantar and lateral foot radiographs. If radiographic evidence of healing was noted, then the patient was permitted to begin protected weightbearing in a walking boot and transitioned into a sneaker with orthotic inserts over the next month. Patients were encouraged to participate in a supervised physical therapy at this time. Patients were generally followed postoperatively at weeks 1, 2, and 6, and then at 3 months, 6 months, and finally at 1 year postoperatively. Patients were radiographically evaluated at each of these follow-ups. Weightbearing prior to radiographic union was not permitted in this patient population. Hardware was not removed postoperatively unless hardware failure or symptomatic prominence was present. Patient demographics are detailed in Table 1.

The data were procured and stored on a microcomputer for subsequent analysis. All statistical analyses were performed using SAS software, version 9.2 (SAS Institute).

Figure 1. Hallux abducto valgus deformity preoperative and postoperative dorsoplantar radiographs. An adjunctive plantar plate repair and Weil osteotomy is evident at the second metatarsal head.

Figure 2. Posterior ankle bump.

Descriptive statistics including means, SDs, and ranges were calculated for each variable, in addition to comparative statistics in the form of the paired and unpaired student's *t*-test where appropriate.

All procedures were performed in the supine position under general anesthesia with supplemental regional anesthesia. Hemostasis was accomplished with a well-padded thigh tourniquet. We recommend a thigh tourniquet instead of the midcalf or ankle because these can negatively influence the trajectory of the drill hole for the first screw (from the medial cuneiform into the first metatarsal) by elevating the surgeon's arm, resulting in a shorter proximal to distal screw length than desired. A bump behind the ankle can assist with plantarflexion of the foot in order to facilitate screw placement (Figure 3). A single dorsomedial incision was utilized in all cases.

Following distal soft-tissue capsulotendon rebalancing involving tenotomy of the adductor hallucis and release

Table 1. Patient demographics (38 feet in 43 patients)

Patient	Sex	Age (years)	Side	Intercuneiform instability	Intercuneiform fixation	Preoperative Intermetatarsal Angle (º)	Postoperative Intermetatarsal Angle (º)	Complications
1	F	64	L	Y	1^{st} to 2^{nd} metetatarsal	25	8	None
			R	Y	1^{st} to 2^{nd} metetatarsal	24	6	Hardware failure, revisional medial column plating
2	F	53	L	N	None	18	9	None
			R	N	None	18	7	None
3	F	20	L	Y	1^{st} to 3^{rd} metetatarsal	20	8	None
			R	Y	1^{st} to 3^{rd} metetatarsal	16	9	None
4	F	20	L	Y	1^{st} to 2^{nd} metetatarsal	17	8	None
			R	Y	1^{st} to 2^{nd} metetatarsal	18	8	None
5	F	33	L	N	None	15	8	None
6	M	20	L	Y	1^{st} to 2^{nd} metetatarsal	16	9	None
7	F	63	L	N	None	15	9	None
8	F	44	L	Y	1^{st} to 2^{nd} metetatarsal	20	8	None
9	F	66	L	N	None	16	8	None
10	M	64	L	Y	1^{st} to 2^{nd} metetatarsal and medial plate	22	8	Nonunion, revisional medial column plating with calcaneal autograft
11	F	50	L	Y	1^{st} to 2^{nd} metetatarsal	18	6	None
12	F	53	R	Y	1^{st} to 2^{nd} metetatarsal	18	6	None
13	F	38	R	Y	1^{st} to 2^{nd} metetatarsal	18	7	None
14	F	47	R	N	None	17	6	None
15	F	45	R	Y	1^{st} to 2^{nd} metetatarsal	20	10	Hallux varus revised with endobutton
16	F	54	R	Y	1^{st} to 2^{nd} metetatarsal	17	9	Asymptomatic hardware failure
17	F	48	R	N	None	18	8	None
18	F	53	L	N	None	20	9	None
19	F	45	L	Y	1^{st} to 2^{nd} metetatarsal	10	6	None
20	F	61	R	N	None	16	8	None
21	M	55	L	Y	1^{st} to 2^{nd} metetatarsal	18	8	None
22	F	33	R	Y	1^{st} to 2^{nd} metetatarsal	17	8	None
23	F	38	L	Y	1^{st} to 2^{nd} metetatarsal and medial plate	19	8	None
24	F	53	R	Y	1^{st} to 2^{nd} metetatarsal	18	9	None
25	F	23	R	Y	1^{st} to 2^{nd} metetatarsal	22	6	Hardware failure with Austin revision
26	F	41	L	N	None	14	10	None
27	F	51	L	Y	1^{st} to 2^{nd} metetatarsal	20	7	Hallux varus revised with endobutton, then fusion
28	M	27	L	Y	1^{st} to 2^{nd} metetatarsal	19	8	None
29	F	22	L	Y	1^{st} to 2^{nd} metetatarsal	15	8	None
30	F	55	R	Y	1^{st} to 4^{th} metatarsals	14	8	None
31	F	46	R	Y	1^{st} to 2^{nd} metetatarsal	12	6	None
32	F	48	R	Y	1^{st} to 2^{nd} metetatarsal	18	7	None
33	F	36	R	Y	1^{st} to 2^{nd} metetatarsal	13	8	None
34	F	49	L	Y	1^{st} to 2^{nd} metetatarsal	15	8	None

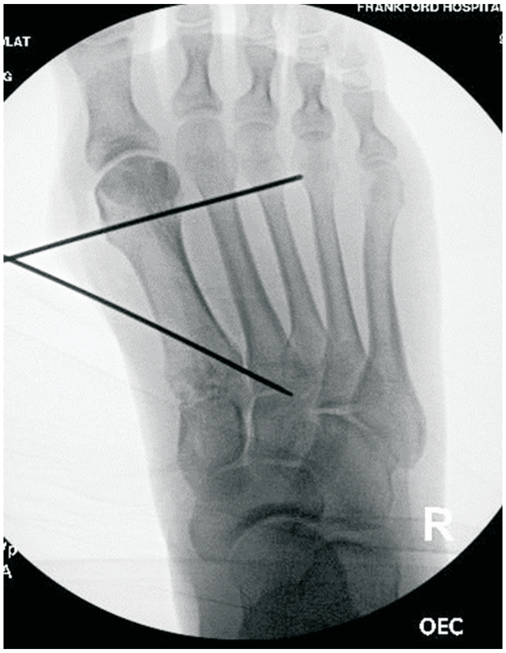


Figure 3. Intraoperative temporary fixation.


Figure 4. Frontal plane view of the anatomic deformity-free hallux where the hallux nail plate is parallel to the second digit nail plate when viewed anatomically from distal to proximal.

of the fibular sesamoidal suspensory ligament, the first tarsometatarsal joint was exposed. A longitudinal periosteal incision in line with the original skin incision was extended proximally overlying the first tarsometatarsal joint, and the dorsal and medial capsular tissues reflected. Care was taken not to disrupt the dorsal ligaments adjoining the medial cuneiform and second metatarsal base, the dorsal intercuneiform ligament, and the naviculocuneiform ligaments. A one-quarter inch osteotome was utilized to release the plantar capsule, with care taken not to disrupt the flexor hallucis longus tendon just deep to the plantar capsule. Distraction was facilitated with a specialized laminar spreader.

Joint preparation was performed with the combination of osteotomes, curettes, rongeurs, and small power burrs to minimize shortening while fenestrating the subchondral bone plate until pinpoint bleeding occurred. At this time the intermetatarsal angle was manually reduced by transverse plane rotation of the first metatarsal. This sometimes left a small defect at the medial aspect of the arthrodesis site, which was later backfilled with local autogneous or cancellous allograft. Transverse plane reduction was confirmed fluoroscopically with either of the following: 1) the visual reduction of the intermetatarsal angle, ideally at a clinically slightly greater angle than parallel to the second metatarsal; 2) a tibial sesamoid position >4; or 3) contralateral weight-bearing films that demonstrated radiographic parody to the transverse plane reduction of the operative foot, presuming there was no deformity on the contralateral foot.

Contralateral weight-bearing foot radiographs were obtained for all cases preoperatively. Sagittal plane reduction was confirmed fluoroscopically with either of the following: the parallel bisection of the talar head and neck on the lateral view was directly in line with the parallel bisection of the first metatarsal also on the lateral view, or contralateral weight-bearing films that demonstrated radiographic parody to the sagittal plane reduction of the operative foot, presuming there was no deformity on the contralateral foot. Frontal plane reduction was confirmed clinically when the hallux nail plate was parallel to the second digit nail plate when viewed anatomically from distal to proximal (Figure 4). To obtain this position, valgus rotation of the first metatarsal was corrected with a varus rotation of the first metatarsal until the previously mentioned nail plates were parallel. Sagittal and frontal plane correction was performed as needed.

After sagittal, transverse, and frontal plane position were confirmed clinically, temporary fixation was achieved with a 1.6 mm Kirschner wire inserted from the first metatarsal neck into the second metatarsal neck. An additional 1.1 mm Kirschner wire was then placed from the dorsal aspect of the first metatarsal base to the dorsal intermediate cuneiform to prevent frontal plane displacement during screw application (Figure 5). The arthrodesis site was then back filled with allogeneic cancellous mulch when necessary and fixated with two 3.5 mm fully-threaded bicortical screws inserted in lag fashion. The first screw was placed under fluoroscopic guidance from the dorsal aspect of the medial cuneiform into the plantar lateral aspect of the first metatarsal shaft. To ensure appropriate length, the drill bit was started at the level of naviculocuneiform ligaments, lateral to midline. The initial lateral to midline starting point serves to facilitate the maintenance of the initial transverse plane reduction achieved. The drill hole for second screw was placed midline of the first metatarsal shaft 2 cms distal to the arthrodesis site, aiming towards the navicular tuberosity, and paralleling

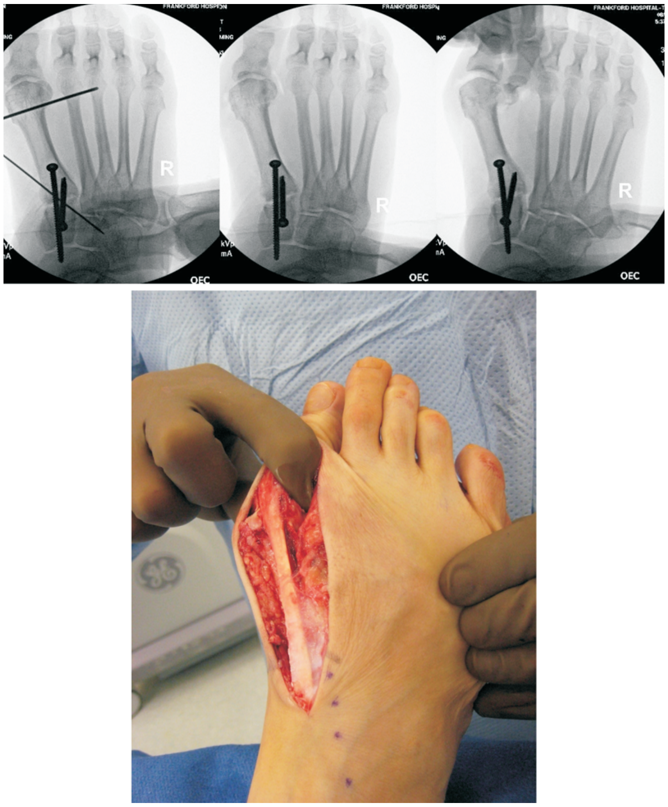


Figure 5. Fluoroscopy demonstrating the intercuneiform hook test performed with the surgeon's finger following fixation of the first tarsometatarsal joint.

the first screw on the dorsoplantar radiographic projection. This screw is also lagged and ideally exits in the plantar medial cortex of the medial cuneiform adjacent to the naviculocuneiform joint. It is not uncommon for these screws to measure approximately 50 mm.

At this point, the fixation was evaluated under fluoroscopy. Once proper positioning and deformity reduction was confirmed, the provisional wires were removed. A bone hook, fracture reduction clamp, or dental pick was then used to carry out an intraoperative intercuneiform hook test. The hook of the instrument was then placed on the distal lateral cortex of the first metatarsal shaft and a medially directed force was applied under fluoroscopic visualization (Figure 6). If widening of the intermetatarsal angle was appreciated as confirmed by a radiographic loss of the achieved transverse plane reduction as discussed above (the visual reduction of the intermetatarsal angle, ideally at a clinically slightly greater angle than parallel to the second metatarsal, a tibial sesamoid position >4, or finally contralateral weight-bearing films that demonstrated radiographic parody to the transverse plane reduction of the operative foot, presuming there was no deformity on the contralateral foot), transverse plane intercuneiform instability was documented.

The intermetatarsal angle was reduced again and stabilized with Kirschner wires and the "diastasis" screw was employed following decortication of the facing sides of the first and second metatarsal bases and additional placement of bone graft ("spot-weld fusion") to assist in the maintenance of the intermetatarsal correction and stabilization of intercuneiform instability. The first perforating artery lies in this area and care must be taken to avoid it. This additional screw is placed in lag fashion from medial to lateral at the proximal one-third of the first metatarsal. This screw commonly purchases several cortices and can be allowed to even engage the lateral cortex of the third metatarsal in patients with lesser bone quality. However purchase of at least 2 cortices is desired and usually sufficient (Figure 7). Alignment was then re-evaluated with special attention to the intermetatarsal angle and alignment of the first

Figure 6. Final placement of diastasis screw engaging multiple cortices.

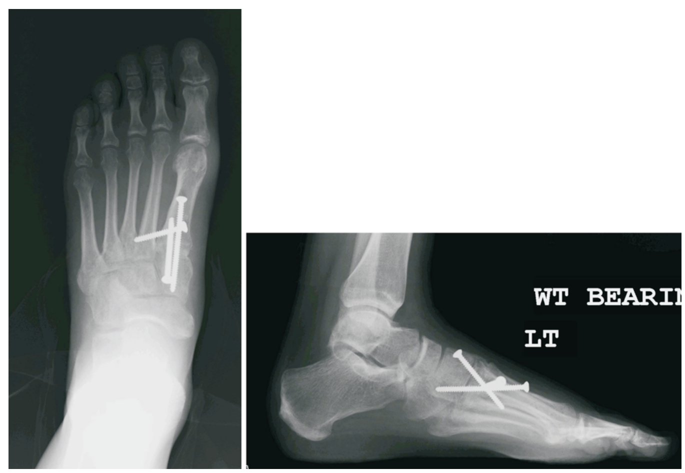


Figure 7. Evidence of radiographic union on postoperative weightbearing dorso-plantar and lateral projections. Appreciate the intermetatarsal spot welding postoperative demonstrating a healed fusion site.

metatarsal. This third screw is quite powerful in its ability to reduce the intermetatarsal angle. Consequently, the surgeon must have a high degree of suspicion for overcorrection with careful scrutiny of the final alignment.

Redundant capsule of the first metatarsophalangeal joint was then debulked to ensure appropriate soft tissue balance. Frequent medial exostectomy of the first metatarsal is not required, but generally the medial aspect was decorticated to encourage capsular readherence. Layered wound closure was then performed.

RESULTS

A total of 38 Lapidus procedures were performed on 34 patients over a 36-month period from May of 2007 to May of 2010. All participants had preoperative and postoperative weight-bearing radiographs. The mean ± SD preoperative and postoperative intermetatarsal angular measurements for all feet were 17.61 ± 2.97 (range 10-25) and 7.79 ± 1.09 (range 6-10), respectively. This difference was statistically significant with a paired student *t*-test ($P < 0.0001$). A total of 28 (73.68%) of the 38 feet demonstrated transverse plane intercuneiform instability for which the diastasis screw was employed. The 28 feet with the intercuneiform instability presented with a mean ± SD preoperative intermetatarsal angle of 17.89 ± 3.25 (range 10-25) and a mean ± SD postoperative intermetatarsal angle of 7.68 ± 1.09 (range 6-10). This difference was statistically significant with a paired student *t*-test ($P < 0.0001$). The 10 feet without intercuneiform instability presented with a mean ± SD preoperative intermetatarsal angle of 16.80 ± 1.93 (range 14-20) and a mean ± SD postoperative intermetatarsal angle of 8.10 ± 1.10 (range 6-10). This difference was statistically significant with a paired student *t*-test ($P < 0.0001$).

No difference was observed in the mean preoperative intermetatarsal angles of patients with and without intercuneiform instability with the unpaired student t-test (17.89 versus 16.80; $P = 0.3251$), nor was a difference observed in the mean postoperative intermetatarsal angles of patients with and without intercuneiform instability with the unpaired student *t*-test (7.68 versus 8.10; $P = 0.3022$).

Mean follow up was 1.5 years (range 1-3.5 years). Of the 34 patients, 30 were female and 4 were male. There were 19 right and 19 left feet. The mean patient age was 44.4 years (range 20-66 years).

Radiographs demonstrated hardware-related failures in 3 (7.89%) feet. The mode of hardware failure in all 3 was a loss of purchase or pull out of the intermetatarsal screw (Figure 8). In 2 of 3 hardware failures, loss of initial intermetatarsal correction was identified early in the postoperative course. One recurrence was identified at 6 weeks postoperatively due to premature ambulation and noncompliance and the second at approximately 5 months postoperatively. Both were accompanied with recurrence of the deformity. The former was revised with repeat debridement, autogenous bone grafting of the intermetatarsal spotweld site, and augmentation with a medially-based plate. The second was approached with a Chevron osteotomy. The third failure was clinically asymptomatic and underwent no additional surgery. Thus of 38 Lapidus procedures, 2 feet (5.26%) required revision for clinically symptomatic recurrence.

Figure 8. Diastasis screw pullout with symptomatic loss of reduction.

Additional complications included 2 feet (5.26%) that developed hallux varus deformity postoperatively. One subsequently required first MTPJ fusion to correct the deformity after a salvage attempt with an endobutton device failed to reduce pain (Figure 9). The second was successfully treated with an endobutton device (Figure 10).

Radiographic union across the first tarsometatarsal joint was visualized in 37 (97.37%) of 38 after the index procedures. One case (2.63%) progressed to an aseptic nonunion despite the addition of a medially-based locking plate intraoperatively as a result of longstanding preoperative osteoporosis. This patient eventually required revisional surgery requiring autogenous bone grafting and progressed to union with maintenance of the operative reduction. Our total reoperation rate was 15.79%.

Four patients (11.76%) underwent bilateral procedures. In none of these patients was intercuneiform instability present unilaterally. Thus among these 4 patients; 3 had documented evidence of intercuneiform instability and required intermetatarsal stabilization whereas 1 patient did not. All recurrences and complications occurred in patients with documented intercuneiform instability. There were no recurrences or complications in patients where intercuneiform instability was absent.

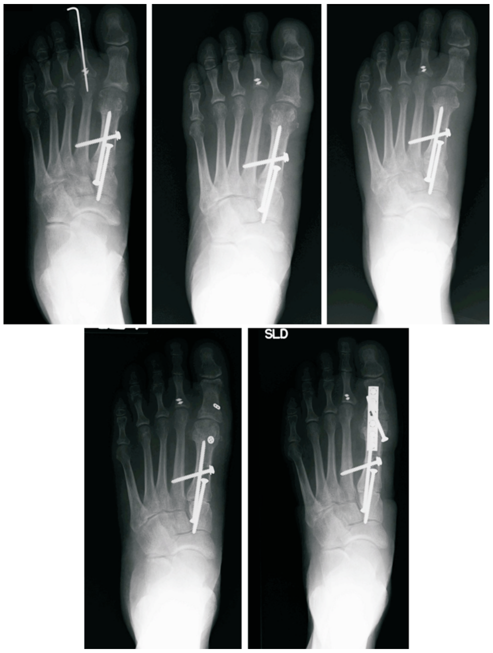


Figure 9. First metatarsophalangeal joint fusion for symptomatic hallux varus following Lapidus arthrodesis after failed salvage with an endobutton device.

Figure 10. Endobutton management for symptomatic hallux varus.

DISCUSSION

Recurrent deformity and loss of correction is most frustrating following hallux valgus repair, particularly in a patient who has undergone the protracted postoperative course associated with the Lapidus arthrodesis. There have been numerous previously speculated etiologies, however proximal instability occurring through chronic attenuation of intercuneiform ligaments from long-standing hallux valgus has not been explicitly described (11). To date, there have been no published reports objectively evaluating this proximal intercuneiform instability nor have there been reports that cite this condition as a possible etiology for primary or recurrent hallux valgus deformity after surgery. We sought to highlight the importance of intraoperative assessment and the prevalence of intercuneiform instability in patients with moderate to severe intermetatarsal angles.

The utilization of intermetartasal fixation with a “derotational screw” is not a new concept (1, 10, 12). Coetzee et al (13) in 2003 demonstrated the reliability and effectiveness of the Lapidus arthrodesis in appropriately-selected patients after failed hallux valgus surgery (13). In this study, 1 screw was placed from the medial cuneiform into the first metatarsal. A second screw was inserted from the medial aspect of the first metatarsal into the base of the second metatarsal to close the intermetatarsal gap securely.

In the Coetzee et al study (13), each case was prospectively followed for 24 months. The American Academy of Orthopedic Surgeons Foot and Ankle Society (AOFAS) Hallux Metatarsophalangeal-Interphalangeal Scale was used to evaluate each patient’s satisfaction. Their results demonstrated satisfaction rates improved from 47.6 to 87.9 points. There was a decrease in the visual analog pain scale from 6.2 to 1.4. Both mean hallux valgus angle and intermetatarsal angle decreased significantly, from 37.1 degrees to 17.1 degrees and from 18 degrees to 8.6 degrees, respectively. They rated 77% of the 26 being very satisfied, 4% satisfied, and 19% being somewhat satisfied. No patients in their study were dissatisfied. Complications reported included 3 nonunions. There were no cases of hallux varus. Coetzee further pointed out that the first to second metatarsal screw following first tarsometatarsal fusion eliminated any rotation or translation of the first ray, thus lessening the chance of recurrence.

The pathogenesis of intercuneiform instability we suspect occurs secondary to absence of ligamentous restraint between the first and second metatarsals in the presence of hallux valgus. Attenuation of the intercuneiform ligaments occurs with long-standing adduction of the first metatarsal. Persistent strain and increasing deformity render these ligaments insufficient. Traditional techniques of hallux valgus repair fail to address this problem. Intercuneiform diastasis, which may at times be difficult to appreciate on routine dorsoplantar foot radiographs due to the dynamic nature of the pathology, has an additive effect on the first intermetatarsal angle and on the overall magnitude of the deformity.

The pathology is analogous to stage IV posterior tibial tendon dysfunction in which the posterior tibial tendon and the hindfoot ligamentous support lose mechanical strength.

Once the subtalar joint has achieved maximum eversion (pronation), the valgus forces are directed on the next proximal structure, the deltoid ligament. In this scenario, the deltoid ligament fails and leads to proximal instability in the form of ankle valgus.

We present intercuneiform instability as another cause, which has been previously unrecognized. Following Lapidus arthrodesis of the first metatarsal cuneiform joint, an additional "diastasis" screw with intermetatarsal fusion is helpful in assisting to maintain the intermetatarsal correction and stabilization of intercuneiform instability.

Lagaay et al reported a total reoperation rate of 8.19%, with a 2.92% recurrence rate, 2% nonunion rate, and a 0.29% hallux varus rate following the Lapidus Arthrodesis (14). Despite the absence of an intermetatarsal screw, their outcomes appear better than ours until you take into account that our 3 recurrences were seen in patients with documented weight-bearing noncompliance. Our 2.63% nonunion rate was slightly higher, and our hallux varus rate was higher.

Our data demonstrated that intercuneiform instability was present in 73.68% of our cohort who underwent Lapidus arthrodesis for symptomatic hallux valgus deformity. The importance of the intercuneiform joint as a potential cause of hallux valgus is demonstrated by the fact that loss of intermetatarsal correction occurred intraoperatively and even postoperatively after temporary stabilization of the first tarsometatarsal site and after union of the first tarsometatarsal arthrodesis site occurred, respectively. Furthermore, all recurrences were associated with loss of purchase of the "diastasis" screw, highlighting the utility of the intermetatarsal fusion rather than simple intermetatarsal screw placement.

Based on our cohort we offer these recommendations:

1. The best method for stabilizing intercuneiform instability is still unclear and long-term studies and further investigation are required to determine what procedure is best to address this pathology.
2. The intercuneiform hook test should be performed routinely following the first tarsometatarsal arthrodesis for bunion correction, as it was present in approximately 75% of our population.
3. The possibility for recurrence in bunionectomies that address the deformity via shaft and head procedure should be lent realistic expectations as they may miss a more proximal pathology if not appropriately investigated.
4. There appears no correlation with intermetatarsal angle and intercuneiform instability.
5. Consideration should be given to routine intermetatarsal "spot welding" as a preemptive solution to reduce the likelihood of hardware failure and recurrence.
6. The addition of the "diastasis" screw may cause an overcorrection of the intermetatarsal angle and increase the propensity for hallux varus. Careful radiographic scrutiny should be employed intraoperatively alongside careful clinical investigation postoperatively.

We posed the following potential queries with our study and sought to offer potential answers to our readers:

If the instability exists at the intercuneiform joint then why is the problem not treated at this level? Prior attempts at stabilization at the intercuneiform joint have not been successful. This may occur for several reasons: Bone density in the lesser tarsus is not high as the metatarsal segments, and the thick cortical walls of the metatarsals provide greater screw purchase and pull out strength to resist hardware failure. Additionally, an intermetatarsal screw placed distal to the intercuneiform joint mechanically provides greater degree of mechanical stability and resists "splaying" of the first and second metatarsals and ultimately the intercuneiform articulation.

Does the addition of this screw increase foot stiffness? Yes, as evidenced by previous research; however we have not found this stiffness clinically relevant and may not be apparent to the patient. Furthermore we believe the achievement and long-term maintenance of the correction is the target end result and in our opinion this marginal increase in stiffness is clinically not appreciable as sagittal plane excursion of the second tarsometatarsal joint is virtually negligible (15).

Are you required to take this screw out? This does not seem to be necessary at least based on the current data and observation.

Have you observed any long-term problems with screw retention? No, despite the fact that the screw is placed across 2 separate bony segments, analogous to the syndesmosis, it appears to be well tolerated. Screw breakage as one might expect has not been observed. This may occur for several reasons: The amount of motion that occurs at the tarsometatarsal joint complex is minimal and arthrodesis of the adjacent joint protects this screw from excessive forces. Additionally, bony "failure" from stress phenomena does not appear to be problematic in the short and intermediate term follow up. Screw failure generally occurs early prior to union of the spot weld site during the first 6 months and appears related to premature weightbearing. In this instance the first tarsometatarsal joint has not yet united and the "diastasis" screw undergoes cyclical loading until screw pullout ensues and secondary loss of correction is identified.

Weaknesses in our study are those inherent in any level IV study. We were constrained by data previously collected and sought to generate a therapeutic study based on this data. None of the study investigators were blinded to the outcome of the study, which lends significant bias specifically with respect to the intermetatarsal angular measurements. However, our study aim was to simply demonstrate this dynamic instability without making any associations to the intermetatarsal angle.

Although there was a seemingly disproportionately high percentage of patients with intercuneiform instability, it was not our objective to imply that the approximately 75% of intercuneiform instability in this study could be extrapolated to a larger population. As this study is largely anatomic in its foundation, there is variation in any population. In other words, a similar study may yield an approximate percentage of 10% of patients with intercuneiform instability. Yet even at 10%, this information potentially offers significant therapeutic and beneficial recommendations.

It is possibly likely that patients with hypermobility have a higher rate of recurrence if the intercuneiform instability is not addressed at the intermetatarsal base primarily at the index procedure. However without a clear method of preoperative measurement, it is virtually impossible to determine the prevalence of transverse plane hypermobility of the first tarsometatarsal joint in the general population as our surgical technique could have potentially destabilized the intercuneiform joint, and iatrogenically creating this instability. Randomized prospective studies would be helpful in determining whether the presence of intercuneiform instability is associated with recurrence.

REFERENCES

1. Lapidus PW. The author's bunion operation from 1931-1959. Clin Orthop 1960;16:119-35.
2. Paley D, Herzenberg JE (eds). Osteotomy concepts and frontal plane realignment, Berlin. principles of deformity correction. Springer-Verlag; 2002, p. 99-154.
3. Catanzariti AR. Modified medial column arthrodesis. J Foot Ankle Surg 1993;32:180-8.
4. Castro M, Melao L, Canella C, Weber M, Negrao P, Trudell D, et al. Lisfranc joint ligamentous complex: MRI with anatomic correlation in cadavers. Am J Roentgenol 2010;195: 447-55.
5. Sarrafian SK. Functional anatomy of the foot and ankle: descriptive, topographic, and functional. Lippincott, Philadelphia; 1993.
6. Goossens M, De Stoop N. Lisfranc's fracture-dislocations: etiology, radiology, and results of treatment. Clin Orthop Rel Res 1983;176:154-62.
7. Raikin SM, Elias I, Dheer S, Besser MP, Morrisoin WB, Zoga AC. Prediction of midfoot instability in the subtle Lisfranc injury. J Bone Joint Surg Am 2009;91:892-9.
8. Roling BA, Christensen JC, Johnson CH. Biomechanics of the first ray. Part IV: the effect of selected medial column arthrodeses. a three-dimensional kinematic analysis in a cadaver model. J Foot Ankle Surg 2002;41:278-85.
9. Rush SM, Christensen JC, Johnson CH. Biomechanics of the first ray. Part II: Metatarsus primus varus as a cause of hypermobility. a three-dimensional kinematic analysis in a cadaver model. J Foot Ankle Surg 2000;39:68-77.
10. Butson AR. A modification of the Lapidus operation for hallux valgus. J Bone Joint Surg Br 1980;62:350-2.
11. Perera AM, Mason L, Stephens MM. The pathogenesis of hallux valgus. J Bone Joint Surg Am 2011;93:1650-61.
12. Bednarz PA, Manoli II A. Modified Lapidus procedure for the treatment of hypermobile hallux valgus. Foot Ankle Int 2000; 21:816-21.
13. Coetzee JC, Resig SG, Kuskowski M, Saleh KJ. The lapidus procedure as salvage after failed surgical treatment of hallux valgus. J Bone Joint Surg Am 2003;85:60-5.
14. Lagaay PM, Hamilton GA, Ford LA, Williams ME, Rush SM, Schuberth JM. Rates of revision surgery using chevron-austin osteotomy, lapidus arthrodesis, and closing base wedge osteotomy for correction of hallux valgus deformity. J Foot Ankle Surg 2008;47:267-72.
15. Ouzounian TJ, Shereff MJ. In vitro determination of midfoot motion. Foot Ankle 1989;10: 140-6.

The Precise Instruments You Expect… from the Company You Trust.

Founded in 2006, Delta's focus is providing the finest **Podiatric Instrumentation.** Our customers receive the highest levels of product quality, service, and fair pricing. These three key points give our customers an overall experience that is unforgettable and unrivaled – ***The Delta Experience.***

Quality Instruments

- *Precise designs*
- *Crafted by experts – you'll feel the difference*
- *Extensive range of instruments – the right instruments for your procedure*

Customer Service

- *Personal attention to your instrument needs*
- *Product knowledge*
- *Easy ordering and timely delivery*
- *Repair Service*

Competitive Prices

- *Strong supplier relationships and efficient supply chain keeps prices low*

Show Specials!
Visit Delta's booth for details. Additional 5% discount for PI Faculty!

Available exclusively from Delta!

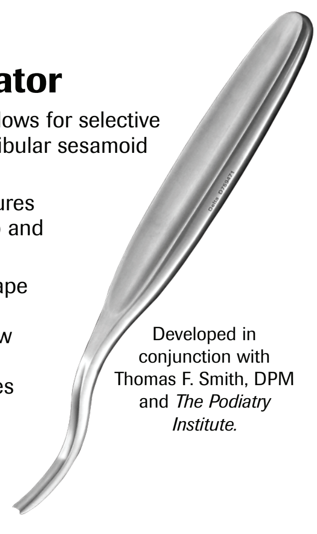
P.I. Fibular Sesamoid Elevator

Narrow and curved shaft allows for selective and precise release of the fibular sesamoid portion of a lateral release.

Concave cutting edge captures capsular layer within the tip and cuts only within the tip.

Contoured to match the shape of the metatarsal head and the fibular sesamoid to allow for the quick and safe access to the specific tissues to be released without excessive exposure.

Part#: D 759 471



Developed in conjunction with Thomas F. Smith, DPM and *The Podiatry Institute.*

Modified Inge Retractor with K-Wire Guides

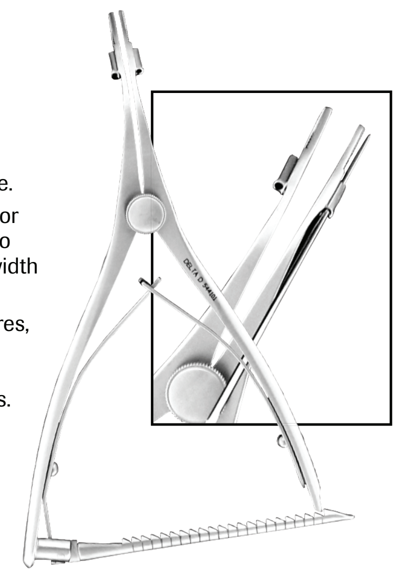
Accommodates up to .062 K-Wire.

Can be used as a distractor and/or retractor. Ratchet graduated up to 35mm to accurately assess the width for bone graft requirements.

Useful in many types of procedures, such as fusions, fractures and nonunions. Narrow tips allow for easy entrance into small incisions.

Serrated tips for secure positioning.

Part#: D 544 101



Delta
Surgical Instruments

Exclusive licensed instrument provider for and proud Silver Sponsor of *The Podiatry Institute.*

THE PODIATRY INSTITUTE

Delta provides royalties to *The Podiatry Institute* on sales of their exclusive instruments. These royalties support ongoing research and development for the improvement of instrumentation and their applications in podiatric surgery.

To place an order call Toll Free 866-390-2226 • Visit us at: *www.deltasurgicalinstruments.com*