

# Modified Lapidus Arthrodesis: Rate of Nonunion in 227 Cases

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*Several studies of Lapidus arthrodesis have commented on the rate of nonunion (ranging from 3.3% to 12.0%), although these figures are based on relatively small patient populations. This study retrospectively reviewed the medical records and radiographs of 211 consecutive patients (32 men, 179 women; mean age, 46.9 years) who received modified Lapidus arthrodesis for forefoot pathology in 227 feet. In all cases, the procedure was performed using joint curettage with subchondral plate preservation and screw fixation. Patients remained nonweightbearing for 6 to 8 weeks and were monitored for a minimum of 6 months postoperatively. Nonunion was seen in 12 (5.3%) of the 227 feet that underwent modified Lapidus arthrodesis. (The Journal of Foot & Ankle Surgery 43(1):37–42, 2004)*

Key words: arthrodesis, hallux valgus, metatarsocuneiform joint, Lapidus, nonunion

The role of the hypermobile first ray in forefoot pathology has gained attention recently as the popularity of the Lapidus arthrodesis procedure has reemerged. Insufficiency of the first ray has been implicated in the development of hallux valgus, hallux limitus, and lesser metatarsal overload (1–9). Several publications evaluated functional outcomes of Lapidus arthrodesis and reported favorable results and patient satisfaction (1, 4, 10–12). Nonetheless, the known complications of nonunion, malunion, shortening, transfer metatarsal overload, dorsal drift, intercuneiform diastasis (1, 2, 4–9, 12–14), and increased postoperative convalescence may have deterred the use of this procedure for correction of hallux valgus. Reported rates of nonunion range from 3.3% to 12% (1, 5, 10, 12, 14, 15), but these figures are based on relatively small patient populations.

These reports may also vary in methods of joint preparation (curettage versus wedge resection) and technique of fixation, including use of screws, pins, and plates (1, 5, 10, 12, 14, 15). The objective of this article is to establish a nonunion rate in a large patient population by using the curettage technique, a consistent method of fixation, and a standardized postoperative protocol.

## Materials and Methods

Medical charts, electronic databases, and radiographs were retrospectively reviewed for 308 consecutive patients (324 feet) who had modified Lapidus arthrodesis performed from April 1999 through May 2003. The surgical technique, technique of joint preparation, method of fixation, and postoperative management were applied similarly for each patient by 4 different surgeons (L.A.F., J.E., S.M.R., G.A.H.). Only patients who had a minimum of 6 months postoperative follow-up were included in this study. Further inclusion criteria were Lapidus arthrodesis with joint curettage and screw fixation as described in the surgical technique. Patients who had simultaneous rearfoot osseous procedures were excluded because they often required longer immobilization than 6 to 8 weeks. To accurately assess the nonunion rate of the Lapidus arthrodesis procedure, particularly in determining when to initiate weightbearing, the Lapidus had to dictate postoperative management. Indications for the procedure were a hypermobile first ray resulting in symptomatic hallux valgus, hallux limitus, lesser metatarsal overload, or first metatarsocuneiform arthrosis.

The retrospective review was implemented to identify those patients who had a delayed union or nonunion from

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**FIGURE 1** Lateral radiograph of nonunion at the first metatarsocuneiform joint, evidenced by broken hardware.

modified Lapidus arthrodesis. Radiographic and clinical assessments were performed by the surgeons at 2 weeks, 6 weeks, 3 months, and 6 months postoperatively. These data were then reviewed by the principal investigator (S.P.). Delay or failure to unite was identified at clinical and radiographic follow-up. Failure of osseous healing at the fusion site after 6 weeks, broken hardware, or both indicated delayed union (Fig. 1). Failure of osseous healing on radiographs was defined as notable lucency or widening, sclerosis, broken hardware, or lack of trabeculation at the fusion site. Successful fusion on radiographs was defined as consolidation of the arthrodesis site with obliteration of the joint space. If broken hardware was not evident, but notable lucency was seen at the fusion site, the patient's condition was treated as delayed union: prolonged nonweightbearing was initially prescribed, followed by external bone stimulation. If delayed union persisted for 3 months without any evidence of radiographic improvement, the patients were considered to have nonunion.

### Surgical Technique

A longitudinal incision was placed from the first cuneiform to the base of the proximal phalanx of the hallux. Proximally, the incision curved laterally to avoid the dorsomedial cutaneous nerve and to gain more central exposure over the first metatarsocuneiform joint. The remainder of the incision was medial to the extensor hallucis longus tendon. The first metatarsophalangeal joint was addressed first: the hypertrophic medial eminence, if present, was resected, and the conjoint adductor tendon in the first interspace was resected. The dorsomedial cutaneous nerve was identified and medially retracted. The first metatarsocuneiform joint was exposed through a transverse capsulot-

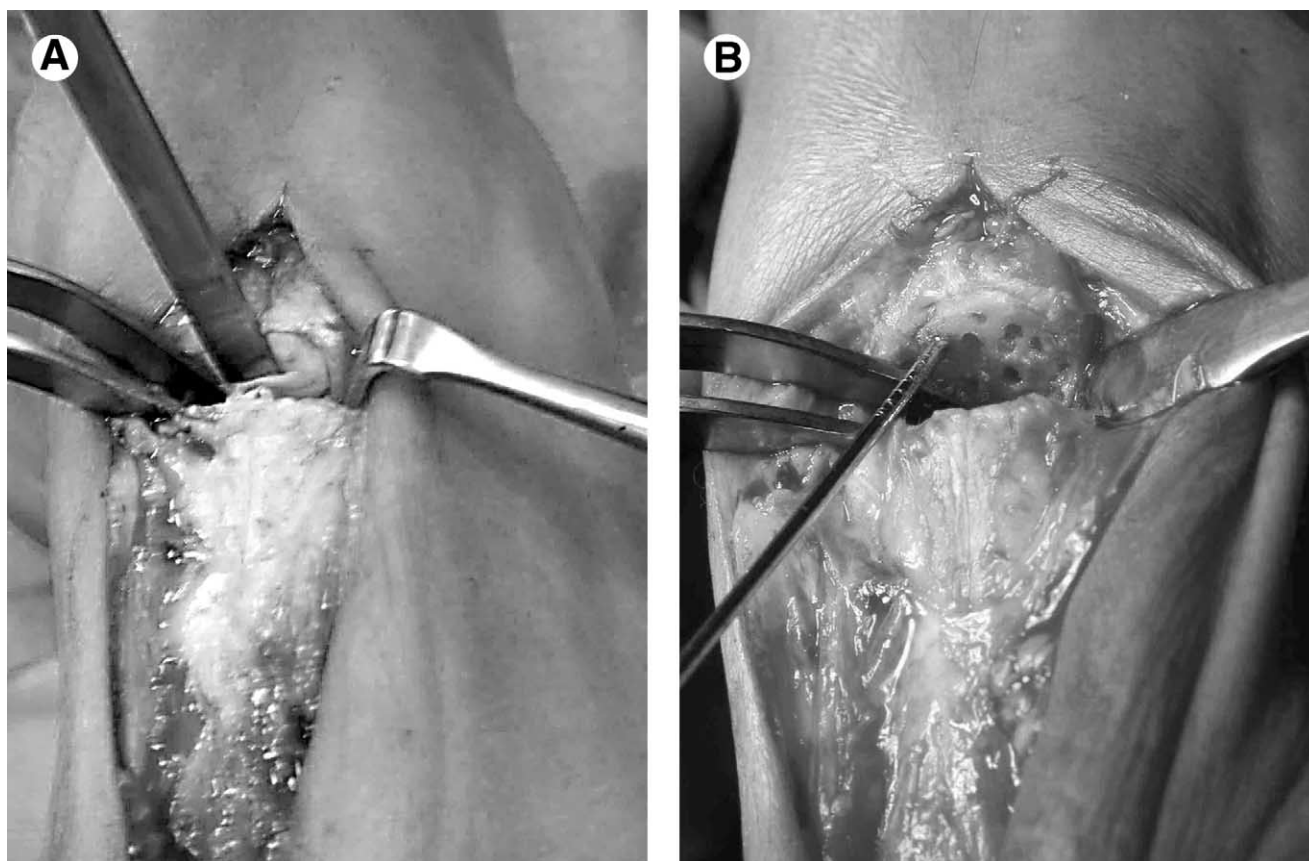
omy. The cartilage was denuded with a sharp osteotome, leaving the subchondral plate intact (Fig. 2A). A laminar spreader was inserted to gain access to the cartilage at the deeper part of the joint. The joint, approximately 3 cm deep, was visualized to ensure adequate removal of the deeper cartilaginous surfaces (10, 11, 16). The subchondral bone was fenestrated and scalloped to promote bleeding (Fig. 2B).

The peripheral rim of subchondral bone was preserved to retain as much length as possible and to provide added stability for internal fixation (17). In most cases, the first metatarsal can be reduced in the transverse and sagittal planes by simply "dialing in" the amount of correction. In a foot with a medially angulated or atavistic cuneiform, the lateral aspect of the joint was planed or feathered to accommodate appropriate correction of the deformity with a small sagittal saw, osteotome, or burr. The joint was fixed with two 3.5-mm cortical screws placed across the fusion site in lag fashion: The first screw was placed axially from the dorsomedial surface of the first metatarsal base to the plantar surface of the medial cuneiform. This screw was usually 45 to 50 mm in length. The second screw was placed from the dorsal aspect of the medial cuneiform to the plantar lateral aspect of the first metatarsal. This screw was usually 36 to 45 mm long. If the first ray was judged to still be hypermobile, a third lag screw may be placed from the medial base of the first metatarsal to the second cuneiform.

Patients having modified Lapidus arthrodesis were placed into a modified Jones compression splint for 10 to 14 days, at which time sutures were removed. A short-leg non-weightbearing cast was applied for 4 more weeks. Non-weightbearing radiographs of the foot were taken when the patients returned for follow-up examination at 6 weeks postoperatively. The patients were routinely advanced to a removable walking boot, with partial weightbearing for 2 weeks followed by full weight bearing for another 2 weeks in the walking boot. At 10 weeks postoperatively, the patients were advanced to regular supportive shoes with gradual return to regular activities as tolerated. Follow-up visits and weightbearing radiographs of the foot were repeated at 3 and 6 months postoperatively.

### Results

A total of 211 patients (32 men: mean age, 51.4 years; range, 15 to 79 years; 179 women: mean age, 46.1 years; range, 11 to 68 years) were included in the study. The number of procedures contributed by the 4 surgeons ranged from 49 to 57. The procedures simultaneously performed on the ipsilateral foot are listed in Table 1. Of the 211 patients (227 feet) who received modified Lapidus arthrodesis, 14 had delayed union (Table 2). Fusion later occurred in 2 of these 14 feet after they were treated with prolonged immo-



**FIGURE 2** Intraoperative photographs of first metatarsocuneiform joint during modified Lapidus arthrodesis that shows dorsal view of: (A) resection of cartilage with small osteotome and (B) fenestration of subchondral plate.

**TABLE 1** Procedures performed on the ipsilateral foot in 227 patients receiving modified Lapidus arthrodesis

Procedures	Number Performed
Lapidus alone	108
Hammertoe correction	129
Gastrocnemius recession/tendo-Achillis lengthening	54
Lesser metatarsal osteotomy	43
Distal first metatarsal osteotomy	9
Akin	5
Tendon transfer	3
Exostectomy of anterior ankle	1
Syndactylism	1

bilization (5.5 months for 1, and 6 months for the other) and application of an external bone stimulator. The remaining 12 feet (5.3%) had nonunion (Fig. 3); 2 feet were asymptomatic, and 10 were symptomatic, requiring further treatment. Each surgeon treated at least 1 patient with nonunion. At last follow-up, 7 of these 10 underwent revision arthrodesis, 1 was awaiting revision, and 2 declined further surgery despite their symptoms. Of the 12 patients with nonunion, 4 were noncompliant with their postoperative

instructions to remain nonweightbearing. In addition, 2 of these 4 patients were active cigarette smokers. Revisional procedures were performed by using autogenous bone graft from the iliac crest, distal tibia, or calcaneus. Six of 7 revisions went on to successful union (Fig. 4). The other patient went on to asymptomatic nonunion. Two patients with nonunion had loss of correction, and both required revision.

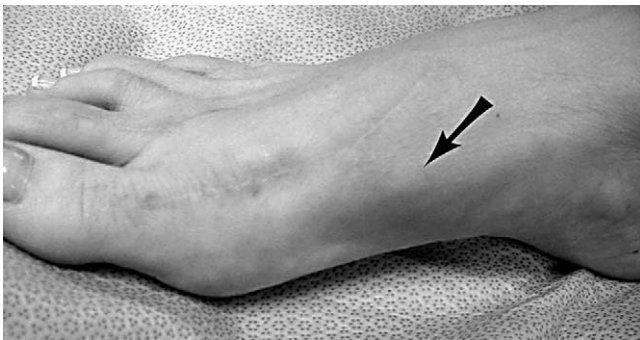
## Discussion

The Lapidus procedure has evolved since 1934, when Paul Lapidus first reported his experience with arthrodesis of the first metatarsocuneiform joint (16). Most modifications today use the AO principles of rigid internal fixation, and limit arthrodesis to the first metatarsocuneiform joint. Still, methods of preparing joint surfaces, fixation techniques, use of bone grafts, and postoperative management vary greatly (1, 2, 5, 7, 10–12, 14, 18). Many publications describe methodology and outcomes of the Lapidus procedure, and most of these articles report favorable radiographic and clinical results (1, 2, 5, 10–12, 14). In a recent

**TABLE 2** Type and outcome of treatment in 14 patients who had nonunion after receiving modified Lapidus arthrodesis

Patient	Age (yr)	Complication	Treatment	Results	Additional Procedures	Comments
1	51	Nonunion	Revised with ICBG	Fused	Gastrocnemius recession	—
2	45	Delayed union	Bone stimulator	Fused	Arthrodesis at 2nd PIP joint	—
3	67	Nonunion	Declined further surgery	Nonunion	—	—
4	46	Nonunion	Revised with calcaneal bone graft	Asymptomatic nonunion	2nd HT correction	—
5	61	Nonunion	Revised with ICBG	Fused	2nd HT correction	—
6	58	Nonunion	Revised with calcaneal bone graft and bone stimulator	Fused	—	PWB/smoker
7	55	Nonunion	Awaiting revision	—	Gastrocnemius recession; exostectomy of ankle; 2nd metatarsal osteotomy; 2nd-5th HT correction	—
8	57	Delayed union	Bone stimulator	Fused	Gastrocnemius recession; 2nd-5th HT correction	—
9	35	Nonunion	Revised with ICBG	Fused	—	—
10	63	Nonunion	Revised with tibial bone graft	Fused	2nd HT correction	PWB
11	53	Asymptomatic nonunion	None	—	—	PWB
12	49	Nonunion	Revised with ICBG	Fused	2nd HT correction	—
13	48	Asymptomatic nonunion	None	—	—	PWB
14	55	Nonunion	Declined further surgery	Nonunion	2nd HT correction	—

Abbreviations: HT, hammer toe; ICBG, iliac crest bone graft; PIP, proximal interphalangeal; PWB, premature weightbearing.



**FIGURE 3** Nine-month postoperative photograph of first metatarsocuneiform fusion site that shows the local edema site, which is suggestive of delayed union or nonunion.

review, McInnes and Bouché (10) reported subjective and objective outcomes and showed how good results were associated with 3 factors: adequate reduction of the intermetatarsal angle, first metatarsophalangeal joint dorsiflexion angle  $>45^\circ$ , and proper alignment in the sagittal plane.

Despite the favorable outcomes of the Lapidus arthrodesis, many physicians may hesitate to perform the Lapidus arthrodesis because of the potential complication of nonunion. Published reports have shown a nonunion rate of 3.3% to 12% (1, 5, 10, 12, 14, 15). Sangeorzan and Hansen (5) reported a nonunion rate of 10% for 40 feet in 32 patients. Joint prepa-

ration varied between simple cartilage removal versus removal of a small plantar, laterally based wedge. They used two 3.5-mm cortical screws for fixation. A 3.5-mm cortical screw crossed the first metatarsocuneiform joint to provide compression whereas the second screw served as a derotational screw, crossing from the first metatarsal base to the second cuneiform. The patients were maintained nonweightbearing for 4 weeks and were then placed into a short-leg walking cast until radiographic consolidation was seen. On the basis of high incidence of nonunion, the authors advocated using bone grafts to augment the procedure (5).

Myerson et al (12) evaluated 65 feet in 51 patients with an average follow-up of 28 months. A biplanar wedge was removed, and the arthrodesis site was fixed with two 3.5-mm cortical screws. The first screw crossed the first metatarsocuneiform joint and the second screw was placed from the first to the second metatarsal base. The placement of the second screw allowed reduction of the intermetatarsal angle. The postoperative regimen involved protected weightbearing in a short-leg cast or in a wooden shoe. These authors reported 7 nonunions (9.5%) (12).

Grace et al (14) described 30 Lapidus arthrodeses performed for 23 adolescents, 1 (3.3%) of whom had nonunion. The arthrodesis site was prepared by removing both the cartilage from the first metatarsal base and a laterally based wedge from the medial cuneiform. Various methods were



**FIGURE 4** Six-month postoperative radiographs of Lapidus arthrodesis with autogenous calcaneal bone graft, showing bony union. (A) Dorsal plantar projection. (B) Lateral projection.

used for fixation (including screws, Steinmann pins, and plates), after which the patients remained nonweightbearing for 6 to 8 weeks (14).

Catanzariti et al (1) described the surgical procedure used in 47 feet of 39 patients with a mean age of 43 years. The articular surface of the first metatarsal was resected perpendicular to its long axis, and a laterally based wedge was removed from the articular surface of the medial cuneiform

to reduce the intermetatarsal angle. Fixation was achieved with a screw directed from the dorsal aspect of the base of the first metatarsal in a plantar direction into the medial cuneiform. A second point of fixation was achieved with a screw, Kirschner wire, or Steinmann pin. The first metatarsal was transposed plantarward to compensate for shortening. In some patients, bone graft was used to maintain length. Two (4.36%) of the patients had delayed union, and 3 (6.39%) had nonunion. The patients were nonweightbearing for 6 to 10 weeks (1).

Published rates of nonunion vary greatly (1, 5, 10, 12, 14, 15). Making accurate conclusions is difficult when rates are reported from small patient populations with varying approaches and means of fixation. In our study of 227 cases, the rate of nonunion was 5.3%. Of these 12 cases, 4 occurred in patients who were noncompliant with postoperative instructions for nonweightbearing. Therefore, 8 cases of nonunion (3.6%) occurred in patients who were compliant with postoperative management. These results suggest that a small percentage of nonunion is inherent in the procedure despite appropriate surgical technique, fixation, and patient compliance.

Preparation of the joint surfaces for fusion may be a significant factor that determines the outcome of the procedure. The curettage technique used by the authors preserves the subchondral plate. Ray et al (17) showed that maintaining the subchondral plate increased stability substantially at the arthrodesis site and limited dorsal migration of the screws. After the subchondral plate is removed, only the metaphyseal bone remains in the medial cuneiform. The chance of dorsal migration of the screw increases when loads are applied (17). This technique also preserves the joint contour, which, in turn, reduces rotational and shear forces at the arthrodesis site (17). In a retrospective study, Myerson et al (12) noted that, toward the end of their study, the joint surfaces were prepared by using the curettage technique because of dissatisfaction with malunion and shortening. Our study supports the idea that maintaining the subchondral plate increases stability. In cases in which nonunion occurred, only 2 of 12 (16.7%) lost correction of the first ray.

In addition to preparation of the joint surfaces, placement of the screws may also be important for union. Two screws that cross the joint in the sagittal plane resist cantilever loads applied to the first metatarsal during midstance (17). Orientation of screw placement allows the force to be dispersed through the length of the screws. The orientation of the screws also maximizes the amount of compression across the arthrodesis site. In cases in which intraoperative transverse or sagittal hypermobility is noted after the standard fixation, the intercuneiform joint may require fusion, although inserting a third screw from the medial base of the first metatarsal to the second cuneiform has been recom-

mended to provide a greater load to failure and bending moment (17).

Patient selection and appropriate postoperative treatment are essential factors for obtaining successful union. Patients must be thoroughly educated about the necessity of strict nonweightbearing and the length of time they must remain immobilized. Others have implied that premature weightbearing may affect union rate (10). In reviewing the literature, we noted that postoperative regimens consisting of weightbearing earlier in the postoperative course led to higher rates of nonunion (5, 12).

Several limitations to our study include its retrospective design, in which initial clinical and radiographic assessments were performed by the primary surgeon, thus leaving the potential for intraobserver bias. Another limitation of our study is that we did not evaluate the role of cigarette smoking on nonunion rate. The adverse effects of smoking on bone healing are well documented (19). For this reason, we try to avoid performing this procedure in the subset of patients who smoke. In describing use of the Lapidus arthrodesis in 26 patients with recurrent hallux valgus, Coetzee et al (15) reported 3 cases of nonunion (11.5%), each of which occurred in a cigarette smoker. The authors (15) concluded that cigarette smoking should be considered a relative contraindication to the procedure. Reporting on 32 feet, McInnes and Bouché (10) similarly noted 5 cases of nonunion (12%) and 2 cases of delayed union (6.25%). Three of the 5 patients with nonunion were asymptomatic. The 2 symptomatic patients smoked cigarettes, and 1 was prematurely weightbearing at 2 weeks postoperatively (10). Although these findings may be incidental, we speculate that our nonunion rate might have been higher if we had performed this operation more often in cigarette smokers.

Patients were observed for at least 6 months. We believed that this period allowed sufficient time to determine whether the arthrodesis site had fused or failed. Patients received more than 6 months of follow-up observation if they had clinical or radiographic signs of delayed union or other symptoms related to the operation. Length of follow-up did not seem to influence results of this study.

Although no surgeons' procedures are exactly alike, each of the 4 surgeons in this study used similar surgical techniques according to the principles mentioned. Similar rates of nonunion in each surgeon's patient cohort suggest a limited sample bias in this entire series of patients.

## Conclusion

The modified Lapidus arthrodesis is a popular method for addressing pathology associated with an insufficient first ray. The current study reports a favorable nonunion rate for

this procedure in a large patient population. Three principles—joint curettage, subchondral plate preservation, and rigid screw fixation—may provide increased stability at the arthrodesis site.

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