

The Modified Lapidus Fusion

Timo Schmid, MD, Fabian Krause, MD*

KEYWORDS

- Hallux valgus • Modified Lapidus procedure • Metatarsocuneiform fusion
- Technique

KEY POINTS

- Due to its very proximal correction site and long lever arm, the Lapidus fusion, modified or not, is a powerful technique to correct hallux valgus deformities.
- The disadvantages are a high complication rate and a long postoperative rehabilitation period. Therefore, it is currently only performed in 5% to 10% of all hallux valgus deformity corrections.
- Lapidus fusion remains an important procedure, especially in moderate to severe deformities with intermetatarsal angles more than 14°, hypermobility of the first ray, arthritis of the first tarsometatarsal joint (TMTJ), and recurrent deformities.
- Every surgeon dealing with forefoot deformities encounters cases when the Lapidus procedure is a viable option.

INTRODUCTION: NATURE OF THE PROBLEM

In 1911 and more than 20 years before Lapidus published his technique, Albrecht¹ first described a first metatarsocuneiform fusion for correction of hallux valgus deformity. In 1925, Truslow² introduced the term, *metatarsus primus varus*, pointing out that the primary deformity of the hallux valgus in these cases is located at the proximal end of the first ray. He stated that any operative procedure that does not incorporate the correction of the deformity at its proximal origin is unscientific and inadequate. In 1932, Kleinberg³ identified the obliquity of the first TMTJ and the consequent adduction of the first metatarsal as the ultimate cause in the etiology of hallux valgus.

It was not until 1934 that Lapidus described his technique. And although Lapidus himself stressed that he did not introduce a new principle, it is his name that is closely connected to the procedure.⁴

The original technique consisted of an arthrodesis of the first cuneiform-metatarsal joint and the first intermetatarsal joint. The fixation was achieved by simply sewing the

Department of Orthopaedic Surgery, Inselspital, University of Berne, Freiburgstrasse, Bern 3010, Switzerland

* Corresponding author.

E-mail address: fabian.krause@insel.ch

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joint capsules with catgut. Later, fixation by crossed screws was introduced by Clark and colleagues⁵ and led to a modified technique without intermetatarsal fusion.

Despite Truslow's statement, the original or the modified Lapidus technique is done in barely 10% of all hallux valgus corrections. This is likely due to a longer postoperative rehabilitation period and a higher complication rate as opposed to other techniques, particularly more distal procedures. The Lapidus procedure is a technically demanding operation: with its long lever arm, the procedure is prone to over- or under-correction and nonunion.⁶

INDICATIONS/CONTRAINDICATIONS

According to most investigators, a distal bunion procedure is thought insufficient when the intermetatarsal angle exceeds 15° (Table 1). Any type of proximal metatarsal osteotomy or the more proximal tarsometatarsal arthrodesis is preferred in these cases.

Hypermobility of the first ray in the TMTJ, as originally suggested by Morton in 1928,⁷ continues to be an important indication. Proper measurement of this instability remains, however, difficult. Plantar gapping of the first TMTJ on a lateral weight-bearing radiograph seems to be a reliable sign. Clinical evaluation is highly subjective, however, and objective measurement with external calipers is inconvenient in daily practice.^{8,9}

Hallux valgus deformity with accompanying arthritis of the first TMTJ can be treated by one single procedure with a Lapidus fusion.

Recurrence after hallux valgus correction is a difficult situation for both patient and surgeon. The Lapidus procedure can provide good correction and high satisfaction rates in this setting.^{10,11}

Because the epiphysis of the basis of the first metatarsal contributes to approximately 50% of the length growth of the first ray,¹² a juvenile hallux with open epiphysis is a contraindication.

Potential athletic activity has to be taken into consideration, because only 30% of athletes with a stiffened first ray return to their preoperative level of activity after a metatarsocuneiform fusion. In contrast, 75% of the more sedentary patients achieve this goal.¹³ Arthritis of the adjacent joints (eg, first metatarsophalangeal joint [MTPJ])

Table 1 Indications/contraindications		
	Indications	Comments
Frequent	Moderate to severe deformity Hypermobility of the first ray Generalized hyperlaxity	Intermetatarsal angle >15° Plantar gapping of TMTJ 1 on lateral radiograph Beighton score >5
Rare	Recurrent hallux valgus Juvenile hallux valgus TMT 1 arthritis	Satisfaction rate 80% Only when growth plate is closed
	Contraindications	Comments
Absolute	Arthritis of the first MTPJ Juvenile hallux valgus	Open growth plate
Relative	Short first metatarsal Young active patient Smoker	Consider bone block interposition Only 30% achieve preoperative activity level Higher nonunion rate

and naviculocuneiform) is a relative contraindication because the restricted motion and the enlarged lever arm may lead to an aggravation of a preexisting arthritis.

The Lapidus procedure should be used cautiously in smokers because smoking has proved to negatively influence the union rate.

Even with accurate joint denudement, there is shortening of the first ray. Therefore, a preexistent short first metatarsal is a relative contraindication. With a bone block interposition, a surgeon can overcome this shortening.^{6,14}

SURGICAL TECHNIQUE/PROCEDURE

Preoperative Planning

Prior to the Lapidus procedure, a complete and thorough history, clinical examination, and radiographic work-up are mandatory. The following points are useful to determine whether a Lapidus procedure is a good option:

- Pain at the medial Lisfranc joint indicating Lisfranc arthritis, general hyperlaxity, an older sedentary patient, and recurrence after previous hallux valgus correction support a Lapidus procedure.
- Pain in the first MTPJ indicating first MTPJ arthritis, an athletic activity, and nicotine abuse should lead to consideration of other options.
- Clinical examination aims to detect a first ray hypermobility or a generalized hypermobility. Morton first described how to test the first TMTJ instability: with the patient sitting, the knee flexed and the ankle in neutral position, one hand stabilizes the lateral 4 metatarsals, whereas the other hand moves the first ray from dorsomedial to plantar-lateral. The mobility is compared with the contralateral side.⁷ This subjective method, however, was shown invalid.¹⁵ To more objectively quantify hypermobility, external calipers, like the Klaue device, may be used.¹⁶ With this device, the first metatarsal head was elevated 9.3 mm (± 1.9 mm) in patients with a hallux valgus as opposed to 5.4 (± 1.4 mm) in the control group in a clinical study.

Intractable plantar keratoses underneath the second metatarsal head or on the dorsum of the first metatarsal head also indicate first TMTJ instability. The measurement of this instability, however, remains imprecise and subjective.

- General joint laxity can be estimated with a Beighton score, which consists of 9 stability assessments: ability to put the hands flat on the ground with straight knees (1 point), hyperextending both elbows (each 1 point) and knees (each 1 point), and bending both thumbs back on the front of the forearms (each 1 point) and both little fingers 90° to the back of the hands (each 1 point).¹⁷ A score of 5 or more indicates significant ligamentous instability.
- Tenderness under palpation and passive motion indicates arthritis of the first TMTJ and the first MTPJ.
- Radiographic work-up consists of weight-bearing dorsoplantar and lateral radiographs. A severe deformity with an intermetatarsal angle greater than 15° and arthritis of the first TMTJ on the dorsoplantar view supports a Lapidus procedure. In contrast, a short first metatarsal, an open growth plate, and arthritis of the first MTP joint are contraindications. Regarding first ray hypermobility, Morton⁷ stated that bony hypertrophy of the second metatarsal indicates instability of the first TMTJ, but Grebing and Coughlin¹⁸ were not able to confirm this finding. No association of second metatarsal shaft width and medial cortical hypertrophy with hallux valgus, first ray mobility, or first metatarsal length was seen.

Normally, the first metatarsocuneiform joint is orientated slightly medial, but occasionally it may have an excessive degree of medial inclination. This leads to

a metatarsus primus varus deformity, and a hallux valgus deformity is more common.^{2,19-22}

In approximately 8% of patients, an os intermetatarsaleum is present.⁸ It is often accompanied by a rigid first tarsometatarsal articulation that blocks reduction of the 1 to 2 intermetatarsal angle by distal soft tissue repair or distal metatarsal osteotomy and may indicate a Lapidus procedure.

- In approximately 20% of cases of moderate to severe hallux valgus deformity, a gap of the plantar aspect of the first TMTJ on the lateral view is seen that is associated with hallux valgus or first metatarsocuneiform joint instability.^{8,9,23} It is obvious in a majority of cases and an objective sign for the often-quoted first ray instability.

Authors' Preferred Technique

The patient is placed in a supine position, sometimes with a bolster under the ipsilateral buttock allowing correct rotation of the foot. Appropriate visualization and safe dissection are ensured either by a sterile Esmarch rubber bandage at the ankle level or a tourniquet inflated to 350 mm Hg at the thigh.

- The first TMTJ is approached through a 5-cm longitudinal incision centered over the dorsomedial aspect of the joint. The accompanying distal soft tissue procedure is performed via a 3- to 4-cm longitudinal incision centered between the first and second MTPJs and a 3- to 4-cm longitudinal incision on the medial aspect of the first MTPJ.

A release of the adductor tendon and the transverse metatarsal ligament is carried out in the first web space. The lateral MTPJ capsule is perforated with several puncture wounds and disrupted by medial angulation of the toe. Medially, the joint capsule is prepared and opened horizontally and the medial bony eminence is removed. The removal of the eminence is a standard step with a resection of 2 to 4 mm in width, superior more than inferior, and without violating the medial sesamoid groove.

The joint capsule of the first TMTJ is approached retracting the extensor hallucis longus tendon laterally. The joint is opened dorsally and medially. If a fusion of the bases of the first and second metatarsal is planned, the joint is approached via the interval between the extensor hallucis longus and brevis tendons. Care has to be taken not to harm the neurovascular bundle (the dorsalis pedis artery and deep peroneal nerve).

- The joint is exposed with 2 Hohmann retractors to protect the anterior tibial tendon on the medial side and the neurovascular bundle on the lateral side. With an osteotome and a small curette, the articular cartilage is completely removed. The joint is sinusoidal-shaped and 30 mm in height. Therefore, removing all cartilage of the plantar lateral aspect can be somewhat difficult. A small lamina spreader or a Kirschner wire distractor is useful to better expose the most plantar part of the joint. By resection of a small plantar and laterally based wedge, better correction of excessive valgus and mild plantar flexion is achieved (**Fig. 1**). Alternatively, a minimal saw cut at the articular surface of the cuneiform with a small plantar and laterally based wedge can be done if the first metatarsal is not already short.
- For a fusion of the first intermetatarsal joint, the corresponding articular surfaces are also prepared (as discussed previously). During this dissection, the penetrating branch of the dorsalis pedis artery has to be protected. Usually the authors prefer the modified Lapidus technique with simple fusion of the first

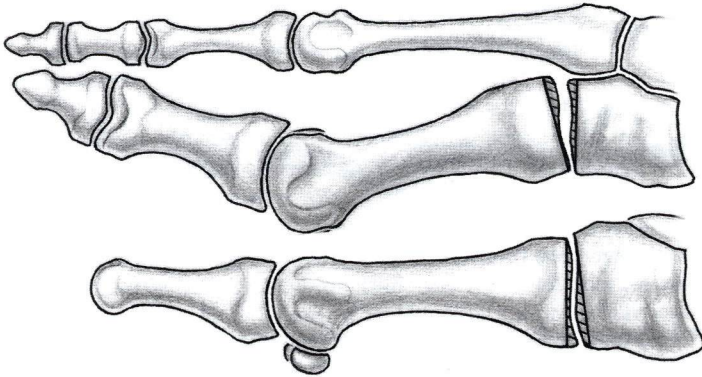


Fig. 1. By resection of a small plantar and laterally based wedge, better correction of excessive valgus and mild plantar flexion is achieved.

TMTJ and only perform this intermetatarsal arthrodesis in cases of a nonunion or presence of an os intermetatarsaleum.

- The subchondral bone is opened by feathering with an osteotome and multiple 1.5-mm drill holes on both sides of the arthrodesis.
- The joint is gently manipulated from a dorsomedial to a plantar lateral position, thus respecting the joint's biomechanical axis. The first metatarsal is then reduced to close the intermetatarsal angle. Generally, there is a tendency to undercorrect the metatarsal plantarflexion. Too much dorsiflexion of the first ray may lead to transfer metatarsalgia of the second ray. If appropriate plantarflexion cannot be achieved, the plantar lateral aspect of the joint should be revascularized to ensure that the joint is correctly prepared. It is relatively easy to leave residual cartilage or bony fragments on the plantar lateral of the joint aspect, which impede correct positioning. Local bone graft obtained from the medial MTP joint eminence may be placed into the arthrodesis site if there are any defects present. The correct alignment and rotation is fixed with a preliminary Kirschner wire. It is imperative that this be checked both clinically and fluoroscopically.

Fixation with 2 crossed 3.5-mm lag screws is usually sufficient. A notch at the entry point of the distal screw prevents a fracture of the dorsal proximal cortex of the first metatarsal (**Fig. 2**). Without the notch, the screw lever the metatarsal cortex dorsally when cortical contact of the screw head forces it upwards. For the notch, a triangle of six 2.5-mm drill holes is created and the cortex surrounded by the drill holes is removed with a rongeur (**Fig. 3**). The medial cuneiform has a width of

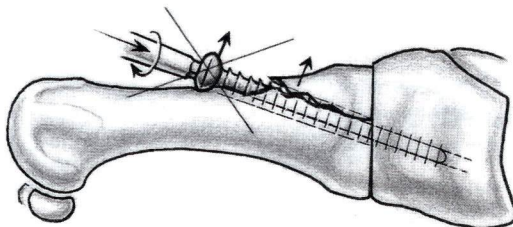


Fig. 2. A notch at the entry point of the distal screw prevents a fracture of the dorsal proximal cortex of the first metatarsal.

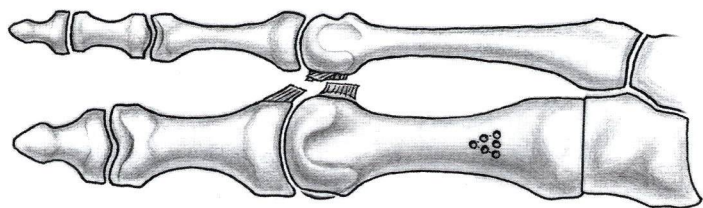


Fig. 3. For the notch, a triangle of six 2.5 mm drill holes is created and the cortex surrounded by the drill holes is removed with a rongeur.

approximately 1.5 cm. Appropriate aiming of the drill is crucial to correctly place the screws and to avoid violation of the intercuneiform joint. Drilling parallel to the medial border of the foot helps direct the drill in axis of the cuneiform. A 3.5-mm gliding hole is created. To allow more lateral correction of the first metatarsal, the 2.5-mm drill can then be directed in the cuneiform slightly more medially than the gliding hole (**Fig. 4**). A second screw is inserted from proximal to distal, aiming distally for the lateral plantar first metatarsal cortex. The screws should not cross within the fusion but rather distally to it, thus adding rotational stability. Dorsiflexion of the first MTPJ while inserting the screws improves compression at the arthrodesis site by tensioning the plantar fascia.

- The capsular tissues on the medial MTPJ are double-breasted for satisfactory alignment of the hallux. At this point, the deformity should be fully corrected. Any correction with dressings is not sufficient to prevent long-term recurrence. If there is residual deformity, the surgeon needs to ascertain the reason for this through clinical and flourescopic examination. Providing the arthrodesis has been fixed in the correct position, the most common reason is hallux interphalangeus. In this situation, an Akin osteotomy can be performed.
- The incision is then closed in layers. A compression dressing and a below-knee cast are applied.

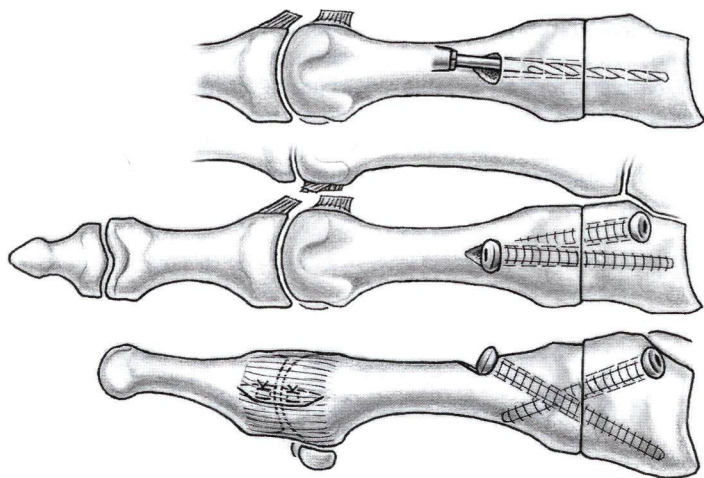


Fig. 4. A 3.5-mm gliding hole is created. To allow more lateral correction of the first metatarsal, the 2.5 mm drill can then be directed in the cuneiform slightly more medially than the gliding hole.

POSTOPERATIVE CARE

A compression dressing is removed 1 to 2 days after surgery and a below-knee cast is applied for 8 weeks. Patients are kept non-weight bearing for 4 weeks. The authors keep patients 10 to 20 kg partial weight bearing for the next 4 weeks.²⁴ Patients are then allowed transition to full weight bearing in regular shoes after this 8-week period of cast immobilization. In order to ensure progression of healing, the authors obtain dorsoplantar and lateral radiographs after 4 and 8 weeks.

Most investigators recommend non-weight bearing in the first 6 to 8 weeks after the procedure. Newer and stronger implants may provide more primary stability and, therefore, allow a shorter period of immobilization or immediate partial weight bearing postoperatively. Even full weight bearing 2 weeks after the procedure was described to have no adverse effects on alignment or the rate of osseous union.²⁵⁻²⁷ Nevertheless, in biomechanical studies, most of these locking plates failed to demonstrate a stronger fixation than the crossed screw technique.^{5,28-30} The downside of locking plates is the amount of hardware present in an area with little subcutaneous tissue. It is the authors' belief that locking plates have a greater potential for necessity of hardware removal. Even 2 crossed screws, however, cause implant-related problems in up to 20%.³¹

Because of the poor ratio of the long metatarsal lever arm and the small fusion surface, the authors do not recommend that patients be permitted to weight bear at an earlier stage. This cautiousness is supported by higher nonunion rates in several studies with early weight bearing as well as higher nonunion rates in simultaneous bilateral Lapidus fusion.^{6,32}

Therefore, the classic construct of 2 crossed screws and an immobilization of 6 to 8 weeks still seems the gold standard. The authors' experience with this approach is generally good, and patients accept the longer period of cast immobilization and walking on crutches without complaints.

COMPLICATIONS AND MANAGEMENT

- The most common complication after a Lapidus procedure is nonunion. Rates from 2% to 10% are reported in the literature. In simultaneous bilateral operations, the rate even raises up to 33%.⁶ Approximately 50% of the patients with nonunions are symptomatic and require revision.³³ Smoking is proved to have a major impact¹¹; therefore, smoking is a relative contraindication for a Lapidus procedure in heavy smokers. Patients are informed about these risks and asked to stop or at least cut down smoking, but the authors do not cancel the surgery unless it is a revision surgery.

Table 2
Complications and management

Complications	Frequency (%)	Of Note
Nonunion	2-10 ^{5,6,13,14,24,32,35,38-40}	Simultaneous bilateral operation: 33% ⁶ Symptomatic in 50% ³³
Transfer metatarsalgia	4-5 ^{11,41}	Due to malalignment/shortening
Malunion	0-10 ^{6,32,36}	
Hallux varus	0-16 ^{39,40}	Mostly caused by excessive lateral release of the MTPJ 1
Recurrence	0-16 ^{6,11,14,32,34,39,42}	

Table 3 Outcomes		
Outcome	Rate/Range	Of Note
Reduction of HV angle	10°–22° ^{10,32,34,36,40}	
Reduction of IMT 1–2 angle	6°–9° ^{10,32,34,36,40}	
Patient satisfaction rate	74%–96% ^{3,5,32,34,42,43}	When performed after recurrence: 81% ¹¹ Depending on ¹³ reduction of first intermetatarsal angle, first MTPJ dorsiflexion >45°, and proper sagittal alignment
Shortening of the first ray	2.9 mm–8 mm ^{6,11,13,37,41,44}	Management: 5–10 mm: plantarflexion of the first ray >10 mm: Weil osteotomies of second/third ray >20 mm: lengthening with bone graft
Subjective foot stiffness	8%–18% ^{5,32,36}	
Prolonged pain/swelling	Up to 16% ⁴¹	Usually subsides after 3 mo

- In the presence of a painful nonunion, the authors recommend revision with autologous cancellous bone graft interposition and strong fixation, including fusion of the basis of the first and second metatarsals as originally described by Lapidus.
- Malalignment typically results in shortening and dorsiflexion of the first metatarsal and may lead to transfer metatarsalgia of the second and/or third rays.^{14,34,35} It occurs in up to 10% of the cases.³⁶ It is, therefore, essential that accurate joint preparation is performed and that excessive wedges are not taken from the joint. Interposition of the resected medial eminence helps to prevent significant shortening if there is already a relatively short metatarsal or excessive bone has been resected.³⁷ A shortening of less than 5 mm with correct position usually does not cause problems. For shortening of 5 to 10 mm, a slight plantarflexion of the first metatarsal suffices to prevent problems. In cases of more than 10 mm, shortening metatarsal osteotomies (eg, Weil osteotomy) of the second and third toe can prevent transfer metatarsalgia. In cases of 20-mm and more first metatarsal shortening, however, a reconstruction of the first ray with a tri-cortical bone graft is used to adequately restore the correct length (Tables 2 and 3).¹⁰

SUMMARY

- The idea of the modified Lapidus procedure is to correct the hallux valgus where the primary deformity, the metatarsus primus varus, occurs.
- The Lapidus procedure is the most proximal site for forefoot correction and, therefore, offers more power than all metatarsal osteotomies.
- Accounting for 5% to 10% of all hallux valgus corrections, the modified Lapidus procedure is currently mainly used in severe deformities, deformity recurrences, first metatarsocuneiform arthritis, and hypermobility of the first ray.

- Because of its power and the demanding surgical technique, the procedure is prone to complications, which occur in approximately one-fourth of patients.
- With an appropriate surgical technique, good results can be expected, even when used for revision cases.
- Fixation with crossed screws and immobilization for 6 to 8 weeks still seem to be the gold standard.

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