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THE LAPIDUS PROCEDURE

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The purpose of this article is to present the authors' experience and clinical results when using the Lapidus procedure for the primary repair of hallux abducto valgus deformity. Many foot surgeons have used this procedure for correction of cavus deformity, flatfoot deformity, medial column instability, or as a salvage procedure for hallux abducto valgus. Many authors have described the procedure as technically difficult, biomechanically unsound, and plagued with complications. These individuals support their views with evidence that Lapidus himself abandoned the procedure. Dr. Kelikian once stated that the failure of a procedure does not always condemn the procedure. Occasionally, it is necessary to condemn the surgeon. We would like to offer our findings, our surgical technique, and our postoperative regimen using the Lapidus procedure, as a primary procedure, in the properly selected patient.

HISTORY

There is an abundance of literature on the deformity of hallux valgus. Kelikian has stated that well over 100 procedures have been described for surgical correction of this condition.[12] Arthrodesis of the first metatarsocuneiform joint has been advocated as a primary procedure for addressing hallux valgus and metatarsus primus adductus since the early 1900s.

Although Paul Lapidus has been credited for popularizing this procedure, Albrecht in 1911 was the first to initially describe a lateral closing wedge with an arthrodesis of the first met-cuneiform joint. Because his original paper was published in the Russian literature, his work wasn't acknowledged until Albrecht worked with Lapidus at The Hospital for Joint Diseases in New York.[1, 12] The first publication in the English journals occurred in 1925 when Walter

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Truslow described a biplanar first cuneiform wedge resection for arthrodesis and correction of metatarsus primus adductus.[12, 24]

By 1932 Lapidus was a junior member at the New York Hospital for Joint Diseases, under the guidance of Samuel Kleinberg. Kleinberg published his procedure experience using the first metatarsal-cuneiform arthrodesis for hallux valgus repair. His technique was virtually analogous to Albrecht's, with the addition of resection of the lateral base of the first metatarsal. He wrote "Frequently there is a shoulder or projection of the bone on the outer side of the first metatarsal or the inner side of the base of the second metatarsal, which interferes with the free motion of the first metatarsal and has to be removed."[12, 13]

Lapidus published his original article in 1934, followed by a series of publications advocating first metatarsocuneiform fusion for the deformity he noted as metatarsus primus varus. In his original paper his technique was very similar to that of Albrecht and Kleinberg, but Lapidus also roughed the adjacent aspect of the second metatarsal base to induce intermetatarsal fusion. He summarized by saying that this procedure is most useful in an "atavistic" or "weak" foot and that by addressing the deformity at the apex he felt was the metatarsal-cuneiform joint (MCJ), the first metatarsal was corrected and served as a medial buttress that helped to prevent pronation and deformity.[12, 14] In subsequent articles, Dr. Lapidus admitted that, although his procedure was useful in properly selected cases, proper patient selection was important.[15, 16]

Since Lapidus' work, arthrodesis of the metatarsocuneiform joint and its modification were published by Armstrong (1937),[2] Hue and Thyes (1938),[10] and Wissel (1952).[25] Durman, in 1957, combined first MCJ fusion with a medially based wedge osteotomy of the first metatarsal head. The resected wedge of bone was then used as medially based autogenous bone graft at the arthrodesis site.[7, 8]

Giannestras, in 1973, used a transcortical K-wire fixation between the first and second metatarsal to prevent the common complication of elevation of the first metatarsal. Additionally, he used the resected medial exostosis of the first metatarsal head as bone graft at the arthrodesis site.[4, 8] A retrospective analysis of 47 fusions in 33 patients was performed by Maguire in 1973. He concluded that this procedure had some advantages over metatarsal osteotomies and that nonunion, if it occurred, was in the region of a normal joint and was not necessarily considered a complication.[4, 17] An article by Robert Rutherford in a 1974 issue of the *Journal of the American Podiatric Association* was the first to describe the use of a compression screw for fixation at the arthrodesis site. He emphasized the need for stability to help obliviate hypermobility of the first ray.[21]

In 1976, Goldner and Gaines performed first MCJ arthrodesis as a primary procedure for severe juvenile hallux abductovalgus (HAV) deformity. They advocated the procedure when the angle between the first metatarsal and first cuneiform was greater than 30 degrees, and particularly when the first metatarsal was considerably shorter than the second.[4, 9] Butson, in 1980, published his study utilizing a procedure similar to the technique of Giannestras. He also used the resected exostosis from the first metatarsal as an autogenous graft to maintain first ray length, but immobilized the patient postoperatively for a longer period of time.[3]

The Lapidus procedure recently came back into vogue over the last eight to ten years as numerous articles have been published in orthopedic and podiatric literature. In 1987, Clark, Veith, and Hansen reported on a long-term retrospective review of 32 feet, using their modified procedure. The authors employed A.O. principles of fixation, using two-screw compression fixation across the arthrodesis site. A high recurrence rate in their patient population prompted

these authors to use dual screw fixation. In addition, a lateral and plantar wedge osteotomy at the first MCJ was performed, removing the articular surfaces and a minimal amount of bone. Iliac bone graft was interposed when clinically indicated to prevent a short first ray.[6]

Sangeorzan and Hansen reported their retrospective analysis at Harborview Medical Center in 1989. They evaluated 40 feet preoperatively and postoperatively. They also used multiscrew fixation, bone graft (autogenous) when indicated, and emphasized plantarflexion of the first ray during the procedure. They used 3.5 mm cortical screws across the first MCJ and from the first metatarsal into the second cuneiform primarily to ensure "rotational stability" of the arthrodesis site and not to induce fusion of the first and second metatarsals.[4, 23]

Two publications in the recent podiatric literature reviewed the Lapidus procedure. Saffo et al reported a 5-year retrospective analysis. They reported 54 procedures on 44 patients. The procedure they described emphasized minimal bone resection to prevent shortening, and more importantly, stressed the plantarflexion of the first metatarsal. This could be achieved by either a plantarly based wedge or plantar transposition of the first metatarsal at the first MCJ and was considered paramount to the success of the procedure. Fixation employed was primarily with K-wires or Steinman pins. Descript surgery technique and multiple interoperative pearls were discussed.[4, 22] Also, Hernandez et al in 1989 published an article explaining the proper indications and reasoning for choosing the Lapidus procedure.[11]

In 1990, Mauldin and colleagues published an intriguing modification, incorporating an inlay block of bone after achieving corrected position of the first metatarsal. A modified McBride bunionectomy is performed, followed by mobilization of the first MCJ. The first metatarsal was manipulated in a more lateral position as a 9/64 Steinmann pin was used for fixation. Finally, a medial rectangular trough was performed across the first MCJ and subsequently firmly packed with autogenous bone chips followed by the inlay cortical graft.[18]

Myerson has published two recent articles on metatarsal-cuneiform arthrodesis for hallux abducto valgus and metatarsus primus varus. In his 1990 publication he describes a procedure similarly. Myerson utilizes two-screw fixation but does not employ interpositional bone graft to prevent shortening of the first metatarsal. He advocates plantarflexion of the first metatarsal by bone resection and advises against transposing the first metatarsal plantar. This creates a step-off and increases the technical difficulty of fixation placement.[19] In 1992 Myerson et al published an article which was a long-term, retrospective study of sixty-seven procedures in 53 patients. The authors modified the previously described technique in Myerson's 1990 publication. Instead of resecting a biplanar wedge at the first MCJ, the authors removed only the lateral and plantar articular cartilage, leaving the medial aspect of the joint intact. Manipulation of the first metatarsal in the adducted and plantarward attitude was performed prior to insertion of the screw fixation. This modification allowed the metatarsal to be repositioned with little if any bone resection.[20]

The most recent article on the lapidus arthrodesis was written by Chang and Ruch in 1994. The authors' indications were primarily for midfoot stabilization in cases of Lis Franc arthrodesis, Charcot reconstruction and medial column fusion. The technique evaluated four different forms of fixation with the use of mechanical stress apparatus. The authors concluded that a 1/3 semitubular A.O. plate placed medially with a 4.0 mm interfragmental screw directed from plantar-distal provided the greatest amount of strength when medial column stability is critical.[5]

CLINICAL PRESENTATION

Criteria to be considered when choosing the Lapidus procedure are many. The question is often asked, "Why perform a Lapidus procedure when the same can be accomplished with a base wedge osteotomy?" This is by no means true. Patient selection for Lapidus arthrodesis does not necessarily require a large intermetatarsal angle. It is not uncommon for the author to perform a Lapidus on a patient with a ten to twelve degree intermetatarsal angle. Although it is true that patients with extremely high intermetatarsal angles are well-suited to a Lapidus procedure, those with small intermetatarsal angles may also be candidates for this procedure. Hypermobility of the first ray is a primary indicator when selecting the Lapidus procedure. Hypermobility has often been questioned. How do you measure it? Is it important? Does it really exist? Vern Inman noted that with regard to first ray motion 10% of the first ray's range-of-motion is at the first metatarsal cuneiform joint and 90% is at the navicular cuneiform joint. This may be true in patients with a rectus foot; however, it has been the authors' experience through cadaveric research that as hallux abducto valgus deformity increases and the axis of motion changes, the location of motion within the first ray also increases. We have found that in patients with moderate to severe hallux abducto valgus deformity, the amount of motion within the first ray is divided equally between joints. Therefore, it is the authors' opinion that as the axis of motion of the first ray deviates with increasing deformity, so does the apex of the deformity, precisely to the metatarsal cuneiform joint. Hypermobility is not a measurable entity; however, it can be assessed clinically by loading the foot to neutral position and moving the first ray dorsally and plantarly and noting its relationship to the second ray. Any excessive deviation dorsally with regard to the second ray would constitute hypermobility.

Many patients with hallux abductus valgus deformity present with a sub second metatarsal head lesion, or metatarsalgia associated with the second metatarsal. Often these patients demonstrate hypermobility that is leading to redistribution of weight-bearing forces from the first metatarsal to the second. Despite the intermetarsal angle, this type of patient is a candidate for a Lapidus procedure. Fusion of the metatarsal cuneiform joint with the first ray plantarflexed helps to realign the first metatarsal, thereby distributing weight back to the first ray and alleviating second metatarsal symptomatology.

Patients suffering from hallux limitus or hallux rigidus that have maintained some joint articular surface are also candidates for a Lapidus procedure. Plantarflexing and shortening the first metatarsal will decompress the first MPJ, increase range of motion and alleviate symptomatology.

Other indications include splay foot deformity requiring forefoot reconstruction, metatarsus adductus repair with Berman Gartland, isolated pain at the first metatarsal cuneiform joint, or as a medial column stabilizing procedure.

RADIOGRAPHS

Evaluation of standard weightbearing radiographs are a vital part of the preoperative assessment of hallux valgus deformity. The severity of the hallux abductus angle, the intermetatarsal angle, sesamoid position, and metatarsus adductus angle should be measured prior to surgery.[19] It is also prudent to correlate the congruity of the first MPJ and relative length of the first and second metatarsals with the clinical examination. The relative elevation of the first

metatarsal to the second metatarsal on lateral radiograph may be determined by divergence of the dorsal cortices and by sagittal plane joint breaching with plantar gapping at the first metatarsocuneiform joint.[4] Hypermobility of the first ray has been suggested to be expressed radiographically as cortical hypertrophy of the second and third metatarsal shaft secondary to excessive weightbearing.[4] Degenerative joint disease and periarticular osteophytic proliferation at the first metatarsal cuneiform joint can also be reliable signs of hypermobility. Evaluation of the lateral condyle of the base of the first metatarsal should also be noted because this prominence is resected as part of the procedure. The so-called addivistic cuneiform, in the authors' experience, is a radiographic anomaly and not necessarily a true structural entity seen intraoperatively. Preoperative radiographs help determine the possible size and length of a screw that will avoid screw threads across the fusion site and avoid peripheral joint spaces proximally.

THE PROCEDURE

Regional anesthesia along with intravenous sedation is most commonly used for this procedure; however, general anesthesia may also be used. An ankle pneumatic tourniquet is routinely used. Numerous incisional approaches have been described and are dependent on the type of fixation chosen. Screw fixation is generally the choice of the author, and therefore we routinely use a long curvolinear incision, originating just proximal to the first metatarsal cuneiform joint, and extending distally across the first metatarsalphalangeal joint. It is important to begin the most proximal portion of the incision at the most extreme dorsal portion of the joint to aid in visualization when joint resection is required. A more medial incision aids in easier resection at the joint; however, the disadvantages of a medial incision include difficulty in obtaining internal fixation as well as the inability to resect the lateral base of the first metatarsal which allows for lateral displacement and will be discussed later. A two-incisional approach has also been described and also provides fine exposure; however, it is recommended to only use this incisional approach if K-wire or Steinman pin fixation is being used. The two-incisional approach combines a 3 cm incision proximally over the first metatarsal cuneiform joint dorsally and a 3 cm to 4 cm dorsal medial incision over the first metatarsal phalangeal joint.

The incision is then deepened distally at the first MPJ. The extensor hallucis brevis tendon is identified and transected. Dissection medially is not extensive unless an osteotomy is planned distally to realign the cartilage. This is not routinely done. Dissection laterally includes an extensive lateral release of the conjoint tendon of the adductor hallucis and a capsolotomy is performed at the plantar one-half of the joint capsule. An inverted "L" incision is made dorsally in the joint capsule with one arm of the "L" extending plantarly at the medial aspect of the joint but proximal to the joint.

The head of the first metatarsal is freed from soft tissue to allow for adequate resection of the dorsal medial exostosis as well as appropriate release of the sesamoid apparatus. Once this has been completed attention is directed to the proximal portion of the wound where the incision is deepened. The extensor hallucis longus tendon must be retracted laterally. If the EHB tendon is identified, it may be isolated and removed from the wound totally. The first metatarsal cuneiform joint can be identified with a 25-gauge needle. An incision is then made at the most extreme dorsal portion of the joint. Dissection proximal

and distal should be adequate enough to allow for good exposure of the joint that aids in resection. Dissection in this area medially and laterally is best obtained with a freer elevator as well as with a #15 blade. Once adequate exposure is obtained, it is recommended that the lateral base of the first metatarsal be resected from a dorsal to plantar direction. Resection of this condyle makes it much easier to displace the metatarsal laterally and obtain IM correction. It is important when resecting this condyle not to be overzealous and resect so much bone as to leave little surface for bone-to-bone apposition as well as enough bone surface for internal fixation. One must also keep in mind that when resecting this condyle, the metatarsal must be held in a rectus position to avoid resection in an oblique fashion. This mistake is easily made if the metatarsal is held in a varus or valgus attitude.

Resection of the joint begins at the metatarsal base and is made parallel and just distal to the articular cartilage. Resection of the cuneiform is then carried out, again, just proximal to the articular surface but with minimal wedging laterally to allow for IM correction (Fig. 1*A* and *B*).

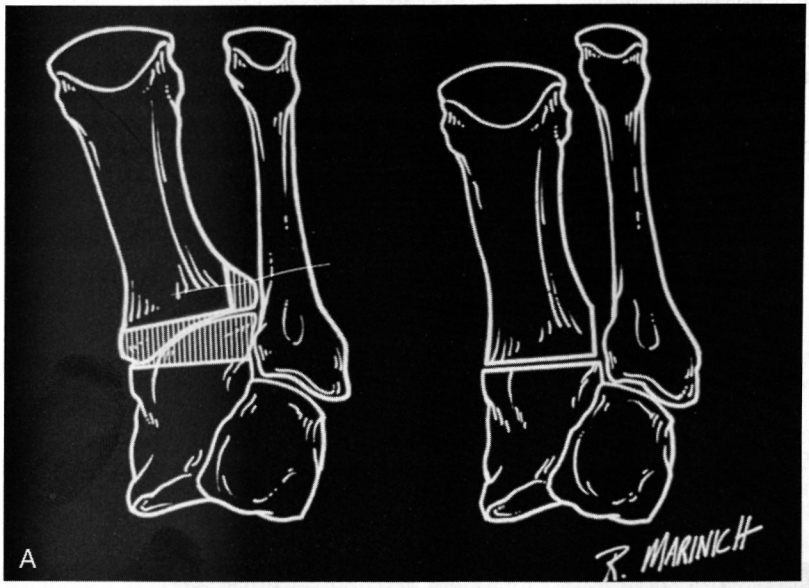
Once articular surfaces have been resected, numerous fenestrations are made on each side at the fusion site with a 1.5 mm drill bit to promote osseous bleeding and fusion (Fig. 2).

Intermetatarsal angle correction is then performed with the goal of correction to zero degrees. The entire first metatarsal is then displaced plantarly on the cuneiform to achieve plantarflexion. The fusion site is then temporarily fixated with two distally threaded guide wires that are used with the Synthes 4.0 mm cannulated screw set. The first guide wire is placed dorsally in the base of the first metatarsal approximately 1.5 cm distal to the fusion site. The guide wire is then directed from distal to proximal and slightly plantar with attention being paid not to deviate laterally, but instead to attempt to purchase solid bone in the medial portion of the medial cuneiform. The second guide wire is then placed from the medial aspect of the base of the first metatarsal approximately 1.5 cm distal to the fusion site and angled from distal medial to proximal lateral into the medial cuneiform and avoiding the intermediate cuneiform. Once the temporary guide wires are in place, each is countersunk and corresponding 4.0 mm cannulated Synthes self-tapping, self-drilling screws are placed across the fusion site (Fig. 3*A* and *B*). Intraoperative radiographs or fluoroscopy is obtained to evaluate screw placement. Once it has been determined that no screw threads are crossing the fusion site and that screw length is satisfactory, the guide wires are removed.

Closure of the wound is then carried out in layers with capsulorrhaphy work done at the first metatarsal phalangeal level. A compressive dressing of the Jones type or unnaboot application is achieved and the foot is then placed in a posterior splint.

There are a number of intraoperative decisions that are made that help to determine a successful result. When performing this procedure on children with a growth plate present, .062 Kirshner wires or 5/64 Steinmann pin fixations may be substituted for screw fixation, providing excellent results.

Much debate has been given to the advantage of curettage technique of the joint compared to resection to avoid shortening of the metatarsal. It has been the authors' experience that shortening of the first metatarsal postoperatively is irrelevant, so long as the entire metatarsal has been plantarflexed. Second metatarsal head lesions and metatarsalgia are a result of metatarsus primus elevatus and not necessarily first ray shortening. Resection of the joint allows for easier



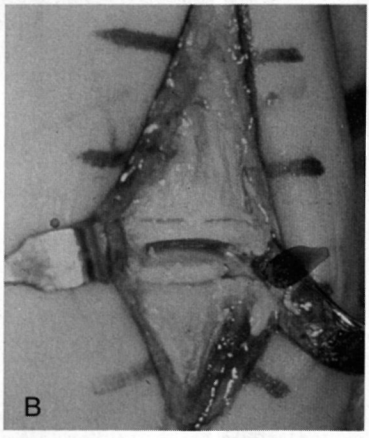


Figure 1. *A,* Schematic demonstrating resection base lateral condyle, resection base first metatarsal, and resection distal cuneiform with wedge for IM correction. (Courtesy of Dr. Alan Catanzanti.) *B,* Intraoperative of schematic.

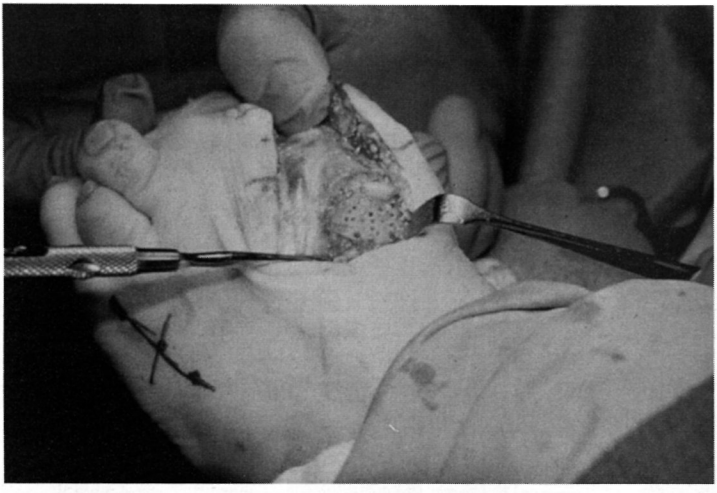


Figure 2. Intraoperative demonstrating 1.5 mm drill fenestrations.

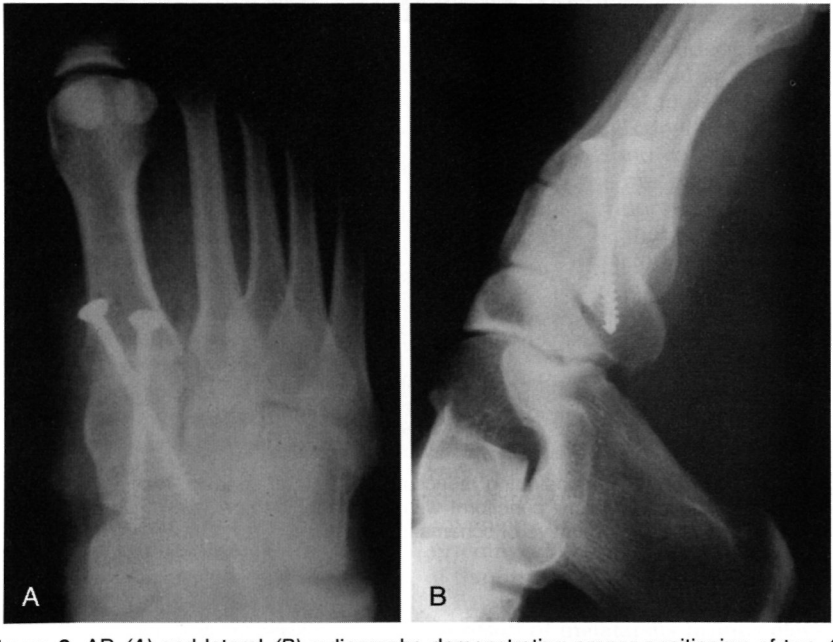


Figure 3. AP *(A)* and lateral *(B)* radiographs demonstrating proper positioning of two 4.0 mm cancellous screws. Note plantarflexed position of first metatarsal on lateral view.

reduction of the intermetatarsal angle and provides more surface area for bony apposition when plantarflexing the metatarsal on the cuneiform.

Bone grafting should be reserved for cases that have failed due to nonunion or malalignment and require filling of a void or reestablishment of length to the medial column. Bone grafting is generally not indicated when the Lapidus is an initial primary procedure.

Inherent to the procedure is the ability to correct deformity in three planes. One advantage over other procedures is the ability to correct metatarsus primus varus or valgus in the frontal plane. Often the central crista at the head of the first metatarsal is deviated in the frontal plane, and when the sesamoids are realigned, they do not function properly within their sesamoidal groove because of this crista rotation. The Lapidus procedure also allows for rotation of the entire metatarsal to correct this problem.

POSTOPERATIVE COURSE

Control of edema, immobilization and nonweightbearing is started immediately post operation. The patient is maintained in a compressive dressing with a posterior splint and three-point nonweightbearing with crutches or walker. At 1 week the dressing is changed, wound examined, and again placed in a compressive-type dressing with splintage. The dressing is changed after the 2nd postoperative week, at which time the stitches are removed. A below-the-knee cast is then applied and nonweightbearing with crutches is continued. First metatarsal phalangeal joint range of motion exercises are started at home beginning the second postoperative week. The patient is then seen during the sixth to eighth postoperative week at which time the cast is removed, radiographs obtained and clinical assessment is made. Partial weightbearing in a surgical shoe with an unnaboot compression dressing is started if clinical and radiographic signs indicate. Radiographic union may not be evident for months. Clinical evaluation is most important, assessing pain and stability. If 1 week of partial weightbearing is well-tolerated, progression to full weightbearing in a jogging shoe is begun.

Serial radiographs are needed only if bone graft has been used or if some type of complication needs monitoring. In the case of bone grafting, nonweightbearing should be maintained until bony union is evident and clinical signs and symptoms correlate with healing.

Edema of the midfoot, rearfoot, or ankle is a frequent finding at 8 to 12 weeks postoperatively in the Lapidus patient. Control of this edema is by means of antiembolic compression stockings and oral steroid therapy. The patient should be informed that this transient edema resolves uneventfully.

Radiographs obtained following return to weightbearing may demonstrate some metatarsus primus elevatus on a lateral view. It has been the authors' experience that this temporary condition is due in part to weakening of the peroneous longus tendon following resection of the metatarsal cuneiform joint. This condition generally will resolve itself over time with increased activity and eventual strengthening of the peroneal tendon. Occasionally, physical therapy directed at strengthening of this tendon may be indicated. Stiffness of the first metatarsal phalangeal joint is usually not encountered because the plantarflexed and shortened position of the first metatarsal acts to decompress the joint. A number of authors have stated that long-term follow-up of these patients may demonstrate proximal midfoot and rearfoot joint pathology; however, there is

no literature to support this claim and the authors have not witnessed this phenomenon.

RESULTS

The best evidence to support the long-term success of the Lapidus procedure comes from a study done by Saffo et al at our institution in 1989. A 5-year analysis of the Lapidus procedure was performed, and 44 patients comprising 54 procedures were evaluated. The average age was 45 years, ranging from 13 to 64. Minimum follow-up consisted of 1 year with a maximum follow-up of 5 years. Eighty-four percent of the patients studied believed that the surgery adequately addressed their complaint. Eighty-two percent of the patients rated the surgery as excellent or good. Most patients who were unsatisfied were primarily unhappy with concomitant procedures, not with the Lapidus itself.

Clinical results of the study revealed that 14% of the patients developed subsecond metatarsal head lesions, four percent of which were symptomatic. Four percent of the patients had pseudoarthrosis/nonunion of the arthrodesis site; however, none of these were symptomatic. Evaluation of the subtalar and midtarsal joints revealed no evidence of increased range of motion, pain, or signs of degenerative changes.

The intermetatarsal angle was routinely reduced to zero degrees and the metatarsal declination angle of the first metatarsal was shown to increase by an average of 2 degrees. Average first metatarsal shortening was 6mm; however, as demonstrated earlier, this shortening appeared irrelevant with regard to lesser metatarsal symptomatology.[22]

It is the authors' experience that the technical difficulty and morbidity that has been often associated with the Lapidus procedure can be avoided if judicious preoperative planning and comprehensive postoperative follow-up are achieved.

Hypermobility has been a highlight throughout this chapter and is a common finding in patients selected for this procedure. We have found that hypermobility and laxity of other joints of the foot in these patients are commonplace. Although no studies are published to substantiate the use of orthotic devices in patients with hallux valgus, it has been the authors' experience that these patients are prime candidates and respond well to orthotics postoperatively. To date, the authors have witnessed no recurrent HAV deformities in patients undergoing the Lapidus procedure.

Other authors have reported similar results. Maguire in 1973 reported on 33 patients undergoing a total of 47 Lapidus procedures. Good to excellent results in 80% of the patients were demonstrated. Maguire also found that nonunions were asymptomatic and not necessarily a complication. He also reported the cosmetic results were very good.[17]

Butson reported on 119 procedures in 78 patients with a follow-up of 2 to 16 years. Good to excellent results were demonstrated in 92% of cases with zero incidence of nonunions.[3] Sangeorzan and Hansen in 1989 reviewed 32 patients undergoing 40 operations. A 90% union of the arthrodesis site was reported, and 80% of the procedures were reported as successful.[23]

Myerson in 1992 reported 67 Lapidus procedures in 53 patients. At 28 months follow-up, 77% of patients had total alleviation of symptomatology, 15% were partially relieved, and 8% were not relieved with regard to comfort, pain, cosmesis, and shoewear following surgery. Seven nonunions were reported, one of which was symptomatic.[20]

The literature has supported the use of the Lapidus procedure as a primary procedure for the repair of the hallux valgus deformity. Good to excellent results have been consistently reported. The authors concur with these findings and have concluded that in the properly selected patient, consistent clinical results can be obtained utilizing the Lapidus procedure for primary repair of hallux valgus deformity.

CONCLUSION

The Lapidus procedure has been used at our institution for many years as a primary procedure for the repair of hallux abducto valgus deformity and has provided excellent results.

Indications range from mild to severe intermetatarsal angles, hypermobility of the first ray with or without pain at the metatarsal cuneiform joint, and patients with sub second metatarsal head lesions or metatarsalgia. Other indications include hallux limitus or hallux rigidus, combined forefoot deformities requiring first ray stabilization including splay foot, and metatarsus adductus.

Successful results are dependent on proper patient selection, appropriate and aggressive intraoperative techniques, properly used rigid fixation techniques, and a well-monitored postoperative regimen.

Complications can occur including mal- or nonunion, pseudoarthrosis, under- or overcorrection of the intermetatarsal angle, failure of fixation devices, and sesamoiditis due to excessive plantarflexion of the first metatarsal. All of these are common complications with any hallux valgus repair. These complications are more amenable to repair following Lapidus fusion compared with other metatarsal osteotomy failures, such as the base wedge osteotomy. Technical difficulties with the Lapidus procedure are primarily encountered with resection of the joint due to extensive, plantar, soft-tissue adherence. With proper dissection and exposure this difficulty can be minimized and should not be considered as a negative factor influencing selection of this procedure.

Long-term results of large numbers of patients that have had first metatarsal cuneiform joint arthrodesis have demonstrated excellent results with recurrence of deformity practically nonexistent. The authors believe that the Lapidus is an excellent procedure for the primary repair of hallux abductus valgus deformity and provides excellent long-term results.

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