

Radiological Assessment of Postoperative Changes Following Lapidus Procedure for the Treatment of Hallux Valgus

Abdulaziz Almaawi*, Sara Albqami, Marwam Zamzami, Mohammed Aladhayani, Salem Alshahrani and Mohammed Alsahil

Department of Orthopedic Surgery, College of Medicine, King Saud University, Riyadh, Saudi Arabia

Corresponding author:

Dr. Abdulaziz Almaawi, Department of Orthopedic Surgery, College of Medicine, King Saud University, Riyadh, Saudi Arabia, E-mail: aalmaawi@ksu.edu.sa

Abstract

Context: Hallux valgus is considered the most common pathological cause of pain among adults. There are multiple surgical approaches for its treatment, Therefore, to know the effectiveness of each technique in accordance to our population, they have to be analysed. **Aims:** The aim of this study was to radiologically assess postoperative changes after the Lapidus procedure from weight-bearing anteroposterior and lateral radiographs. **Settings & Design:** To analyze the effectiveness of the Lapidus procedure in our setting, we will use a retrospective cohort design to collect the data. Outcomes are defined as reduced calculated angles on radiograph images in King Saud University Medical City. **Methods & Material:** Data of all patients who underwent a modified Lapidus procedure between 2015 and 2019 were collected from multiple centers. All angles (hallux valgus angle, intermetatarsal angle, calcaneal pitch angle, Meary's angle, and tibial sesamoid position) were measured both preoperatively and postoperatively. **Statistical Analysis Used:** Data will be analyzed according to appropriate statistical methods *via* Statistical Package for Social Studies (SPSS 22; IBM Corp., New York, NY, USA). **Results:** A total of 100 Lapidus procedures in 89 patients were reviewed. There were 78 unilateral procedures and 11 bilateral procedures with a mean follow-up period of 2 years. The mean hallux valgus correction angle between the preoperative and postoperative follow-up radiographs was 21.7° ($p < 0.001$). The average decrease in the intermetatarsal angle was 7.5° ($p < 0.001$; 95% confidence interval (CI), (6.8–8.3)). The correction angle Meary's angle mean was 0.2 ($p < 0.721$; CI, (-1.3–0.9)). The average increase in the calcaneal pitch angle was 3.8° ($p < .001$). The average decrease in the LaPorta classification was 2.9 units ($p < .001$; CI, (2.6–3.3)). Postoperatively, no patients were in the LaPorta group 6 or 7. **Conclusion:** In the Lapidus procedure, the first tarsometatarsal joint derotational arthrodesis produced good radiologic correction on flexible Hallux Valgus. In addition, the LaPorta classification showed a significant decrease and proper positioning of sesamoids postoperatively, which is a predictor for good results and a decrease in recurrence.

Keywords: Hallux valgus; Lapidus procedure; Foot and ankle; First tarsometatarsal joint derotational arthrodesis; Chevron osteotomy; Orthopedic surgery

Introduction

Hallux valgus is one of the most frequent deformities affecting the forefoot. [1-4] It usually presents as an irreversible abnormality, [5-7] where the 1st metatarsal bone is shifted medially or adducted and the phalanx is shifted laterally or abducted, [8-11] Such a deformity can affect the alignment of the 1st metatarsophalangeal joint (metatarsophalangeal joint) and attenuation of the medial collateral and the medial capsule along with the plantar flexor, leading to translation of the sesamoid bones, laxity, hypermobility, and instability; eventually, it might disrupt the gait when severe. [3,10,12,13]

The overall prevalence of hallux valgus in Saudi Arabia was 43%; the prevalence of hallux valgus in men and women was 30.7% and 49.2%, respectively. [14] In another study on 100 female participants, it was found that 39% of patients not only had hallux valgus but also had bilateral hallux valgus. [15]

In hallux valgus, the pain has been found to be linked to and located at the forefoot, with a higher incidence rate in females than in males. Pain affects lifestyle and daily activities. It was also noted that severe hallux valgus could lead to a high chance of falling due to changes in gait biomechanics. [3,9,16-21]

Multiple risk factors have been associated with hallux valgus. Pes planus has been found to be the most important risk factor [22,23] wherein there is an increase in the pressure over the medial plantar side of the first ray, which also contributes to a decrease

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in the range of motion of the metatarsophalangeal joint. [24] Additionally, shoe wear, [25] particularly high heels, which increases the load over the 1st metatarsal bones, increases the load on the forefoot by 30%–47% depending on the heel height. [26-30] Hallux valgus occurs at higher rates among the elderly population. [8,18,31,32] Moreover, many risk factors have also been linked to hallux valgus, such as family history, genetics, ligaments laxity [33-35] and Body Mass Index (BMI). [17,36]

A variety of procedures have been recommended, one of which is the Lapidus procedure. The Lapidus procedure is mainly indicated for moderate to severe hallux valgus with first meta tarsophalangeal joint subluxation, hypermobility of the first tarsometatarsal joint, or ligamentous laxity, as well as in the treatment of recurrent hallux valgus. This procedure aims to correct the position and rotation of the 1st metatarsal. This can be achieved by reducing the intermetatarsal angle, which alters and changes the rotation and position of the metatarsals, [37,38] including the correction of the sesamoid complex. The relocation of the 1st metatarsal over the sesamoid bones with frontal plane rotation is an important factor in the success of the procedure. [39]

The purpose of our study was to review the radiographic changes in the foot after undergoing the Lapidus procedure.

Patients and Methods

This was a retrospective observational study on the radiological review of patients who underwent the Lapidus procedure between 2015 and 2019. The inclusion criterion was all patients who underwent the Lapidus procedure during the inclusion time regardless of their age, sex, and comorbidities; these characteristics shown in Table 1. Our exclusion criteria were any patient who previously underwent any hallux valgus procedure, those with a restriction of range of motion of the 1st metatarsophalangeal joint, and those with any signs that indicated degenerative changes. All data were extracted from the electronic databases of the King Saud University Medical City (KSUMC), Specialized Medical Center (SMC) and Dallah Hospital's, Dr. Sulaiman Alhabib Medical Center. Radiologic

measurements were obtained from different imaging systems: Centricity™ in King Saud University Medical City (KSUMC), Sectra™ in Dallah Hospital, Isite™ in Specialized Medical Center (SMC), and PACs™ in Dr. Sulaiman Al Habib Medical Center.

IRB approval was provided by the Institutional Review Board (IRB) at KSUMC, and the patients' consent was waived as per our IRB regulations for retrospective studies.

The diagnosis and classification of hallux valgus and its severity rely on angular measurement from anteroposterior and lateral weight-bearing radiographs. [40] The severity of hallux valgus can be determined by the hallux valgus angle, which is the angle created by a line that bisects the 1st hallux and another line that bisects the 1st metatarsal. [41] In addition, the intermetatarsal angle, which is an angle created by the 1st and 2nd metatarsal, indicates a widening between the 1st and 2nd metatarsal bones. [42] A severe hallux valgus deformity is when the hallux valgus angle is greater than 40° and the intermetatarsal angle is greater than 16°. [43]

The hallux valgus angle and intermetatarsal angle were measured from the standing foot anteroposterior images. The calcaneal pitch angle and Meary's angle (angle between the longitudinal axes of the talus and the 1st metatarsal) were measured from the lateral weight-bearing images. The tibial sesamoid position relative to the 1st metatarsal bisector was assessed from a standing foot anteroposterior X-ray through the LaPorta classification, ranging from grade 1 (normal position) to grade 7 (most laterally translocated). [44]

All measurements and data collection were performed in accordance with the guidelines of the American Orthopedic Foot and Ankle Society Ad Hoc Committee on Angular Measurements reference. Of a total of 100 procedures, 93 procedures were performed in female patients (93%) and 7 were in males (7%). Our patients had a mean age of 40.7 years. All demographic data of the patients are included in Table 1.

Lapidus procedures were performed by three surgeons working simultaneously at these institutes. All surgeons had undergone foot and ankle fellowship training in North America and similarly performed the procedure. The Lapidus procedure was performed by fusing the 1st tarsometatarsal joint while correcting the intermetatarsal angle. Under fluoroscopy guidance, the 1st metatarsal head is restored back onto the sesamoids, and the hallux is derotated and straightened, with attenuation of the medial joint capsule along with modified McBride procedure. [45]

The analysis was performed using Statistical Package for Social Sciences version 22.0 software (SPSS Inc., Chicago, IL, USA). Categorical data were expressed using frequency and

Table 1: Baseline characteristics of respondents.

Variable	Category	%
Side	Left	43
	Right	57
Gender	Male	7
	Female	93
Smoker	No	100
	Yes	0
Diabetes	No	92
	Yes	8

Table 2: Effect of operation on radiologic parameters.

Parameter	Preoperative	Postoperative	Mean difference (95% CI)	P-value
Hallux valgus angle	33.2 ± 8.0°	11.5 ± 7.4°	21.7° (19.9° to 23.5°)	<0.001
Intermetatarsal angle	14.4 ± 3.3°	6.8 ± 3.7°	7.5° (6.8° to 8.3°)	<0.001
Calcaneal pitch angle	17.7 ± 6.8°	21.5 ± 6.8°	-3.8° (-4.9° to -2.6°)	<0.001
Meary's angle	5.5° ± 4.1°	5.7° ± 4.4°	-0.2° (-1.3° to 0.9°)	0.721
Sesamoid position (LaPorta position)	5.6 ± 1.5	2.7 ± 1.3	2.9 (2.6 to 3.3)	<0.001

percentage. Chi-square and Fischer's exact tests were used to compare the categorical data for the two groups. We assumed statistical significance when the p-value was less than 0.05.

Results

In this study, we reviewed 100 laparoscopic procedures in 89 patients. Among the participants, there were 78 unilateral procedures and 11 bilateral procedures with a two-year mean follow-up period [Table 1 and Table 2].

In terms of adjunct procedures, 51 patients (51%) underwent gastrocnemius/Achilles elongation, and one patient underwent Weil osteotomy (1%). There were no reports of infection or nonunion. There was one reoperation (1%) due to broken screws. The mean hallux valgus correction angle between the preoperative and postoperative follow-up radiographs shown in Table 2 was 21.7 ($p < 0.001$). The mean Meary's angle was 5.5°

preoperatively and 5.7° postoperatively, with a mean change of 0.2° ($p < 0.721$; CI, (-1.3–0.9)). The average increase in the calcaneal pitch angle was 3.8° ($p < 0.001$). The average decrease in the intermetatarsal angle was 7.5° ($p < .001$; CI, (6.8–8.3)) [Figure 1].

The LaPorta classification was used to measure the rotational correction of the 1st metatarsal along its longitudinal axis. The average decrease in the LaPorta classification was 2.9 units ($p < 0.001$; CI, (2.6–3.3)). Postoperatively, no patients were in the LaPorta group 6 or 7. [Figure 2–Figure 5]



Figure 1: Radiologic results. Radiologic parameters (Hallux valgus angle) studied from the preoperative and 6-week postoperative AP radiographs.



Figure 2: Radiologic results. Radiologic parameters (intermetatarsal angle) studied from the preoperative and 6-week postoperative AP radiographs.



Figure 3: Radiologic results. Radiologic parameters (Meary's angle) studied from the preoperative and 6-week postoperative weight bearing radiographs.



Figure 4: Radiologic results. Radiologic parameters (calcaneal pitch) studied from the preoperative and 6-week postoperative weight bearing radiographs.

Discussion

Several procedures have been described in the literature for symptomatic hallux valgus, such as the Lapidus procedure, modified McBride procedure, distal metatarsal osteotomies, metatarsal shaft osteotomies, Akin osteotomy, proximal metatarsal osteotomies, and hallux joint fusion. [40]

The indications of the Lapidus procedure have been well described in the literature, including the increase in the angulation of the 1st tarsometatarsal joint inclination of $>30^\circ$. Increased mobility of the 1st ray along with instability is also [46-51] an indication. Hallux valgus with pes planovalgus has been considered as an indication for surgical correction with the Lapidus procedure, particularly for hypermobility of the 1st

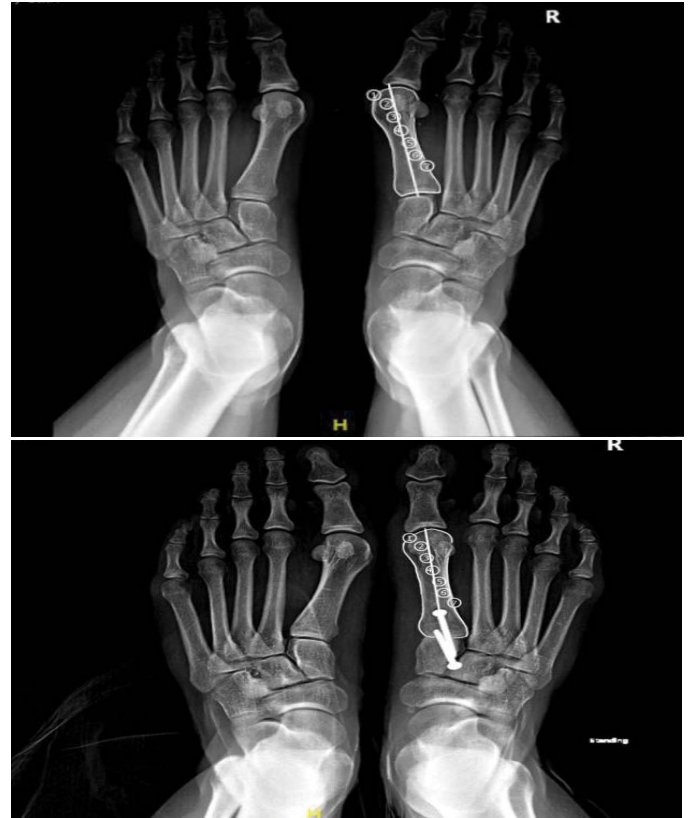


Figure 5: Radiologic results. Radiologic parameters (La porta) studied from the preoperative and 6-week postoperative AP radiographs.

tarsometatarsal joint associated with pes planovalgus. However, the significance and surgical treatment of medial column hypermobility is an area of debate among surgeons. [52,53]

In this procedure, the windlass mechanism of the 1st metatarsophalangeal joint remains intact. [54] The 1st metatarsal rotational correction mimics the peroneus longus function of the foot. [55] First tarsometatarsal joint arthrodesis has shown an improvement in the efficiency of the peroneus longus in stabilizing the medial column. [16] In the method described, the 1st metatarsal head is restored back onto the sesamoids, and the hallux is derotated and straightened, with attenuation of the medial joint capsule along with modified McBride. [45]

The relationship between both Meary's angle and calcaneal pitch and hallux valgus has been described in the literature. Coughlin et al. conducted a study on 118 feet (44% had hallux valgus); there was no statistical significance between both groups in terms of the incidence of pes planus or pes cavus. Saragus et al. reviewed 34 male patients (41 feet) and found similar results. [30,56] Although hallux valgus is not generally associated with the cavus foot, [22] our results demonstrated that the majority of our patients had a positive Meary's angle preoperatively, indicating a more plantar flexion of the 1st tarsometatarsal. According to Klemola et al., eversion of the 1st metatarsal in pes planovalgus will cause lateralization of the sesamoids in a fixed hallux valgus deformity; thus, they only recommend the 1st tarsometatarsal joint derotational arthrodesis for flexible deformities. [54]

In this study, the mean hallux valgus angle correction was 21.7° . Torkki et al. reported a 10° correction of the hallux valgus angle using the chevron osteotomy technique, [57] while Klemola et

al. had relatively close numbers with a mean difference of 19.8° in the hallux valgus angle corrections using the Lapidus procedure [54]

In a retrospective study by Rink-Brüne on 106 patients, the Lapidus procedure showed a high success rate and reproducible correction in cases of severe hallux valgus with an intermetatarsal angle greater than 15° . Moreover, the author suggested that in patients with first ray hypermobility, the sesamoid position is a better measurement for under correction than the IM angle, irrespective of the type of surgery performed. In addition, patients had an overall mean postoperative sesamoid position of 2.5, which is similar to that in this study, suggesting that the Lapidus procedure can restore joint alignment irrespective of the severity of metatarsus adducts. [58]

The sesamoid position is classified according to LaPorta into 7 grades in relation to the axis of the 1st metatarsal, where the normal is grade 1, grade 7 is the most subluxated position laterally, and grade 4 is considered to be at the center of the shaft. [44] When there is a lateral displacement of the sesamoid bone, it indicates that there is a displacement of the 1st metatarsal to the medial side. Surgical reduction of the sesamoid bone into a more medial position can reduce the whole deformity of the metatarsophalangeal joint, which helps decrease the chance of recurrence. [59] In a study that followed up 88 feet with hallux valgus that underwent first tarsometatarsal joint derotational arthrodesis with a total follow-up of 3–8 years, the Lapidus procedure had a great impact on correcting the tibia-sesamoid bone by decreasing the LaPorta degree by 1.1 units (95% CI: 0.9–1.4; $p < .001$) compared to 2.9 units correction in this study. [60]

In another study with a sample size of 29 patients undergoing the Lapidus procedure, the overall satisfaction rate was 90% (26/29 patients), and 86% (25/29 patients) had satisfaction regarding the cosmetic outcome. [61]

The most common complication in the Lapidus procedure was a recurrence of hallux valgus deformity, [62] along with the shortening of the 1st metatarsal and failure of fixation. [63-65] Lapidus has acknowledged the shortening of the 1st metatarsal and, to avoid this issue, has advised the minimization of cutting in the lateral articular surface of the cuneiform and the 1st metatarsal along with a smaller wedge osteotomy. [13,66] The recurrence rate was low after the Lapidus procedure, in a study by Bennet et al. on 107 feet, of which 13% had a failure of fusion related to implant failure, but only 2% required operative treatment for recurrence. [67] Moreover, in another multicenter study that included 342 patients who underwent the modified Lapidus procedure, the rate of recurrence was found to be 2.92% (10 patients). [68]

There was no nonunion of the first tarsometatarsal joint fusion site reported in our study, even though nonunion usually carries a concern among surgeons. In a multicenter study by Prissel et al., which focused on nonunion following the Lapidus procedure, nonunion was not a common complication. Only 6.5% of the sample size of 367 patients developed a nonunion. In addition, they challenged whether the timing of the weight-bearing had any effect on the union, describing that early weight-bearing within 21 days after surgery does not affect the union. [69] Another study showed the incidence of nonunion after

Lapidus arthrodesis (8.3%) with a sample size of 35 patients. [70] However, Coetze et al. argued that wound complications and smoking are major risk factors for nonunion in the Lapidus procedure. [71]

Although the Lapidus procedure is an effective hallux valgus treatment method that corrects the intermetatarsal angle and the Laporta classification, it does not suit those with degenerative changes or fixed deformities due to the chance of causing lateralization of the sesamoids. [54]

The limitations of the present study were its retrospective nature and the short-term follow-up. In addition, pre- and postoperative evaluation of patient satisfaction was not measured, and there was a lack of a control group to compare other surgical techniques that could have added more value to our study.

Conclusion

The purpose of our study was to report the efficacy of the Lapidus procedure in the correction of the deformity radiologically. The 1st tarsometatarsal joint derotational arthrodesis produced good radiologic results on flexible hallux valgus. In addition, the LaPorta classification showed a significant decrease and proper positioning of the sesamoids postoperatively. We recommend additional studies with a longer follow-up period be conducted to determine the effect of this procedure and the recurrence of Hallux Valgus.

Competing Interests

The authors report no competing (commercial/academic) interests.

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