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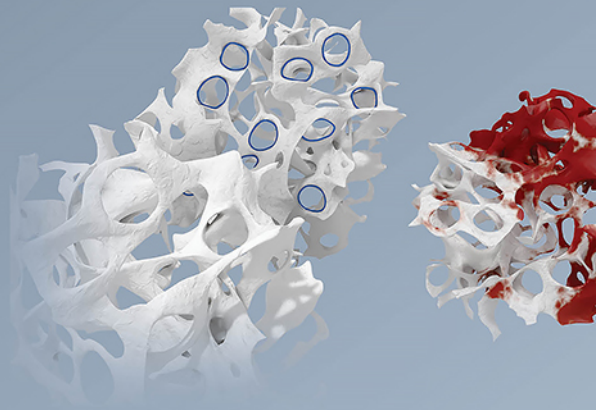
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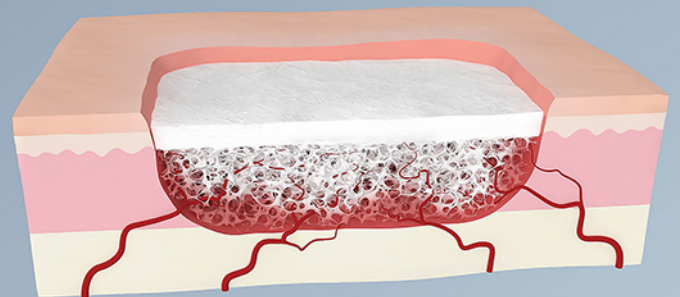
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## ORIGINAL ARTICLE

# Effectiveness of the Lapidus plate system in foot surgery: A PRISMA compliant systematic review

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## Funding information

Spanish Ministry of Science and Innovation, Grant/Award Number: PID2019-108009RB-I00

## Abstract

Lapidus arthrodesis is an established standard procedure to correct various foot surgery problems and hallux limitus, hypermobility of the first ray, hallux abductus valgus, and symptomatic lesser metatarsal. After decades, many fixation methods in the orthopaedic surgery industry have been developed for decreasing complications and improving this technique. The aim of this PRISMA compliant systematic review is to analyse the effectiveness of several lapidus plate systems in foot surgery. We have carried out the first systematic review of the relevant published literature so as to systematically evaluate the scientific knowledge available now on this association, assigning predefined eligibility criteria. Fourteen studies were selected which had an overall of 738 cases. The first tarsal metatarsal joint and hallux valgus were treated by the application of different types of Lapidus plate system. The optimal level of the fixation in these procedures is related with the type and system insertion place of the plate with or without screw in each specific foot disease. There is an insufficient number of studies about the effectiveness of the different types of Lapidus plate system in foot surgery, and there is a need to increase outcomes knowledge on the level of the fixation, sort of the system, and insert place in foot surgery.

## KEYWORDS

arthrodesis, bone-implant interface, foot, hallux

## Key Messages

- We have evaluated the effectiveness of several lapidus plate systems in foot surgery
- Insufficient effectiveness of types of Lapidus plate system for treatment foot surgery
- The increase of outcomes knowledge of Lapidus plate system in foot surgery plays a key to control foot health

## 1 | INTRODUCTION

Lapidus arthrodesis may be considered as a first-line intervention is an established procedure of choice commonly to correct various foot surgery problems as well as hallux limitus, hallux valgus, hallux varus, hindfoot deformity, hypermobility of the first ray, metatarsal adductus, and symptomatic lesser metatarsal,<sup>1-5</sup> because this surgical technique can re-establish the biomechanical characteristics of the first ray alignment in three planes motion.<sup>6</sup>

After decades, these foot problems are known as an essential public health condition, related with the increase of this high prevalence, influence negative in the quality of life and the increase of orthopaedic foot surgery that is related to pain at the low back, hip, knee and osteoarthritis in the first ray joint, balance disturbance and danger of falls.<sup>7-11</sup>

In this way, many fixation methods in the orthopaedic surgery industry have been developed to increase effectiveness and decrease worrisome complications such as malunion, nonunion, and metatarsal shortening to improve this technique's outcomes.<sup>12</sup>

Thus, many modifications in the Lapidus procedure have been performed maybe to the technical problems related to the fixation and the surgical procedure methods, in order to improve the findings and to decrease complications during all this time.<sup>6</sup>

Several research studies showed rates up to 25%<sup>12</sup> related to conditions in orthopaedic foot surgery mistake concerns associated with: (a) inadequate internal fixation, (b) low joint preparation, (c) wound postoperative care, (d) large incision with aesthetically may not be nice to the patient, (e) stress on surrounding joints, (f) nonweight bearing long period and (g) inadequate patient selection (smokers, nutritional status, bone quality).<sup>6,13,14</sup>

To date, there have not found investigations analysing the concerns to improve these several and fundamental problems related to the Lapidus arthrodesis procedure is unclear.

Our hypothesis that is few the clinical trials and studies about the effectiveness of the various Lapidus plate system in foot surgery.

This PRISMA compliant systematic review aims to analyse the effectiveness of several Lapidus plate systems in foot surgery.

## 2 | MATERIALS AND METHODS

### 2.1 | Design

This PRISMA compliant systematic review was recorded in the International Prospective Register of Systematic

Reviews on health sciences associated topics,<sup>15</sup> file number CRD42021237437.

### 2.2 | Search strategy

An electronic search was carried out in the MEDLINE and Web of Science using keywords and controlled vocabulary terms (i.e., medical sub-heading [MeSH] terms). Keywords include Lapidus plate system terms (arthrodesis, bone-implant interface, hallux, foot) and treatment-related terms (Lapidus plate system, Lapidus procedure, first metatarsocuneiform arthrodesis, foot surgery). Our search protocol strategy realised can be revised in the Supplementary info.

Besides, this review period was set during the last 10 years, and all research available in these two databases until February 2021 was included. We considered manuscripts reporting completed randomised clinical trials and controlled clinical trials published in international peer-reviewed papers. All references included in these papers published in Spanish or English were revised and restringing the evaluate and these languages.

Besides, special attention was used on the electronic search in two databases, to be assured to include all relevant research, even though at the risk of identified irrelevant information that would afterward have to be removed.

### 2.3 | Inclusion and exclusion criteria

We applied the selection of these inclusion and exclusion criteria to determine which investigations were incorporated in the systematic review related to used different types of Lapidus plate system. The selection of variables included were: (a) randomised clinical trials and controlled clinical trials of the last 10 years, (b) cases of patients or fresh-frozen human cadavers, (c) various foot problems, (d) type intervention on foot, (e) different plate system, (f) selection of the system insertion place, (g) outcomes measures, (h) time of follow-up, (i) efficacy level of the fixation, and (j) studies written in Spanish or English.

Disregarded criteria included were: (a) observational studies with sawbones anatomical models or finite element method, (b) letters, commentaries, expert opinions, editorials, and other non-original studies, and (c) research published in other languages different from Spanish or English.<sup>15</sup>

TABLE 1 Main characteristics of the included studies

	Cases	Foot problem	Intervention	Type of the system	System insertion place	Outcomes measures	Follow up fixation	Level of the fixation
Garas et al (2018)	10	First tarsal metatarsal joint	Arthrodesis of the first tarsal metatarsal joint	Total compression plate system with or without a 3.5-mm locking Screw (OrthoPro, Salt Lake City, Utah)	Medially first tarsometatarsal	-Tekscan FlexiForce A201 Variable Resistance Sensors - Fluoroscopy	12 h	-Optimal (3.5-mm locking screw) -Medium (without a 3.5-mm locking screw)
Cotom & Baker (2017)	16	First tarsal metatarsal joint	Arthrodesis of the first tarsal metatarsal joint	-Low-profile system locking Lapidus plate (Arthrex, Naples, Florida) with a 4.5-mm cannulated screw -Plantarily applied locking plate (Arthrex, Naples, Florida) with a 4.0-mm compression screw	-Medially plate with a plantar interfragmentary screw -Plantar approach with intraplate lag screw placement	-8871 Servo Hydraulic Materials Testing System (Instron, Canton, Massachusetts)	None	-Optimal (medially plate) -Medium (plantarily plate)
Gutteck et al (2018)	126	Hallux Valgus	Osteosynthesis of the first tarsal metatarsal joint	Darco, Wright Medical® (Germany GmbH)	Plantar plate osteosynthesis	-Digital measuring system PACS -Emed I-x400 sensor plate (Novel GmbH, Munich)	12 mo	Optimal (plantarily plate)
Cotom et al (2013)	10	First tarsal metatarsal joint	Arthrodesis of the first tarsal metatarsal joint	Arthrex®_ LPS Lapidus plate (Arthrex, Naples, Florida) with a 4.5-mm cannulated PIFS	-Medial side of the locking plate with an intraplate compression screw -Medial side of the locking plate with a plantar interfragmentary screw 4.5-mm cannulated	-8871 Servo Hydraulic Materials Testing System (Instron, Canton, Massachusetts) -OriginPro, version 8, software (OriginLab, Northhampton, Massachusetts)	None	-Optimal (interfragmentary screw) -Medium (intraplate compression screw)
Menke et al (2011)	21	Hallux abducto valgus Metatarsus primus varus, Metatarsocuneiform instability	Metatarsocuneiform arthrodeses	Interfragmental lag screw and a Darco locking H-plate	Medial to slightly plantar-medial Metatarsocuneiform	Radiographs	16.76 mo	Sufficient
Garas et al (2018)	10	first tarsal metatarsal joint	Arthrodesis of the first tarsal metatarsal joint	Total Compression Plate System with or without a 3.5-mm locking Screw (OrthoPro, Salt Lake City, Utah)	Medially first tarsometatarsal	-Tekscan FlexiForce A201 Variable Resistance Sensors -Fluoroscopy	12 h	-Optimal (3.5-mm locking screw) -Medium (without a 3.5-mm locking screw)

(Continues)

TABLE 1 (Continued)

Cases	Foot problem	Intervention	Type of the system	System insertion place	Outcomes measures	Follow up	Level of the fixation
Cotom & Baker (2017)	16 first tarsal metatarsal joint	Arthrodesis of the first tarsal metatarsal joint	-Low-profile system locking Lapidus plate (Arthrex, Naples, Florida) with an 4.5-mm cannulated screw -Plantarily applied locking plate (Arthrex, Naples, Florida), with a 4.0-mm compression screw	-Medially plate with a plantar interfragmentary screw -Plantarily applied plate with intraplate lag screw placement	-8871 Servo Hydraulic Materials Testing System (Instron, Canton, Massachusetts)	None	-Optimal (medially plate) -Medium (plantarily plate)
Gutteck et al (2018)	126 Hallux Valgus	Osteosynthesis of the first tarsal metatarsal joint	Darco, Wright Medical® (Germany GmbH)	Plantar plate osteosynthesis	-Digital measuring system PACS -Emed I-x400 sensor plate (Novel GmbH, Munich)	12 mo	Optimal (plantarily plate)
Cotom et al (2013)	10 First tarsal metatarsal joint	Arthrodesis of the first tarsal metatarsal joint	Arthrex®_ LPS Lapidus plate (Arthrex, Naples, Florida) with a 4.5-mm cannulated PIFS	-Medial side of the locking plate with an intraplate compression screw -Medial side of the locking plate with a plantar interfragmentary screw 4.5-mm cannulated	-8871 Servo Hydraulic Materials Testing System (Instron, Canton, Massachusetts) -OriginPro, version 8, software (OriginLab, Northampton, Massachusetts)	None	-Optimal (interfragmentary screw) -Medium (intraplate compression screw)
Menke et al (2011)	21 Hallux abducto valgus Metatarsus primus varus, Metatarsocuneiform instability	Metatarsocuneiform arthrodeses	Interfragmental lag screw and a Darco locking H-plate	Medial to slightly plantar-medial Metatarsocuneiform	Radiographs	16.76 mo	Sufficient

FIGURE 1 Flowchart of the included studies describing Lapidus plate system in foot surgery

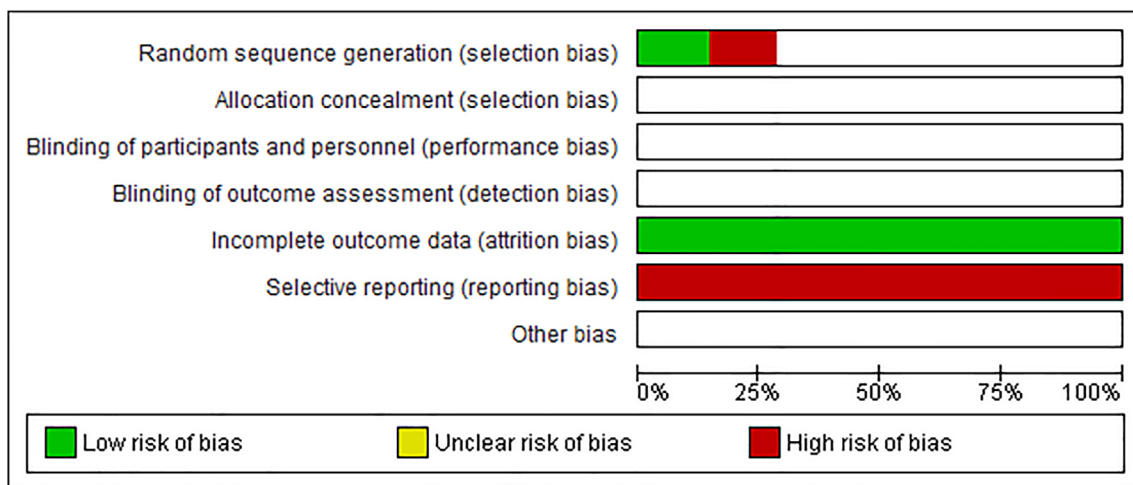
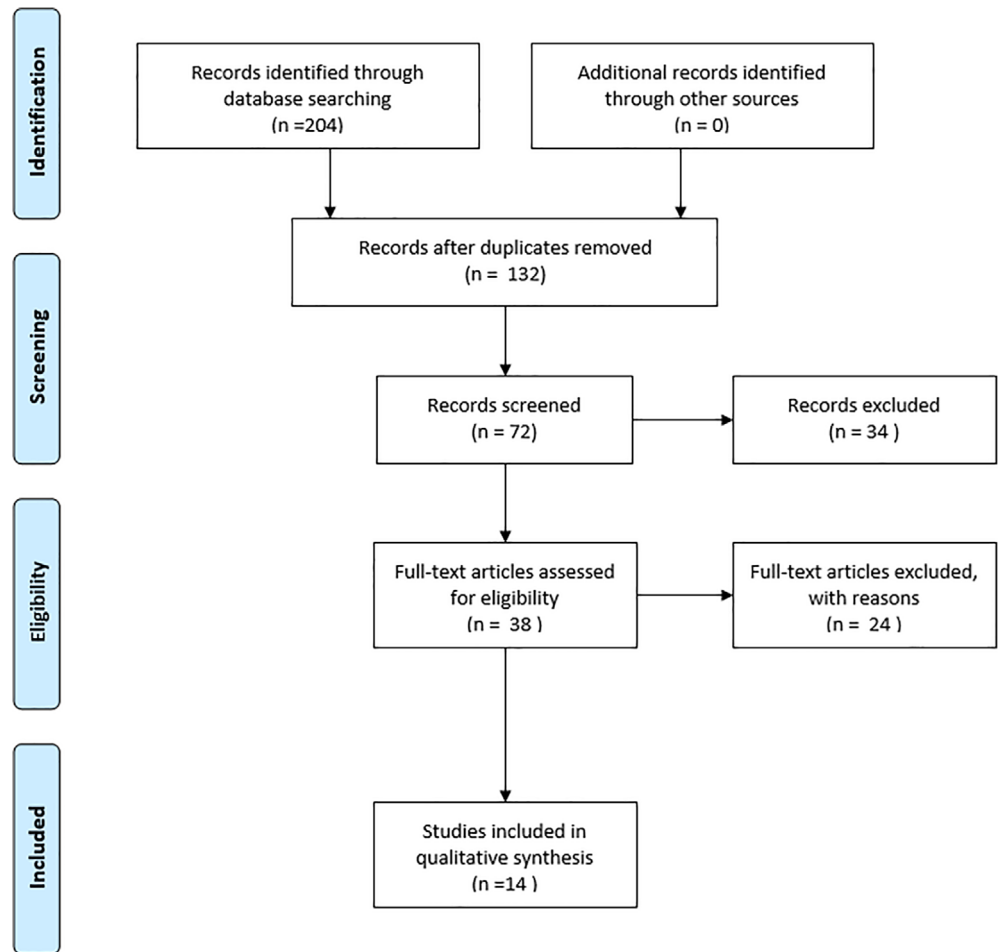


FIGURE 2 Risk of bias graph in the studies included. (1) Green (low risk), (2) white (unclear risk) and (3) red (high risk)

### 2.4 | Synthesis of information and management of search results

Two expert reviewers checked the search results in this Lapidus plate system in foot surgery (D.L.L. and J.B.L.)

and if there were doubts about something, any research regarding the inclusion and exclusion criteria, this was clear up by accord us of all authors. All references added were manually evaluated, and those articles that might be incorporated were also reviewed and obtained.

Study	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Barp 2017					+	-	
Baxter 2015					+	-	
Cotton & Vora 2013	-				+	-	
Cotton 2013					+	-	
Cotton 2017					+	-	
Dayton 2019	-				+	-	
Guttek 2013					+	-	
Guttek 2015					+	-	
Guttek 2018					+	-	
Kameel 2018	+				+	-	
Kios 2011					+	-	
Kios 2013					+	-	
Menke 2011					+	-	
Roth 2014	+				+	-	

FIGURE 3 Risk of bias summary in the studies. (1) Green (low risk), (2) white (unclear risk), and (3) red (high risk)

We recuperated the self-same information related to all articles resulting from the PRISMA declaration, using a standardised rule associated only with a present Table 1 with common fields for every paper. We showed information from every single research in an evidence table with qualitative information, and a global conclusion has been realised. The risk of bias assessment in the systematic review was analysed using the tool Review Manager (RevMan) of The Cochrane Library, v.5.3. It has not been possible to perform a meta-analysis because of the principal heterogeneity of the incorporated studies.

### 3 | RESULTS

#### 3.1 | Summary of the investigations included

Figure 1 shows up the flowchart of the information published in the articles related to the Lapidus plate system in foot surgery retrieved.

Complete 14 research studies fulfilled all the inclusion criteria. Most of the records evaluated were articles on randomised clinical trials and controlled clinical trials. The major part of the papers corresponded to measurements of cases of patients, with eight and fresh-frozen human cadavers, with six studies in each and all information is shown in Table 1.

Finally, the risk of bias was analysed in 14 research studies. Only two studies recorded a low risk in random sequence generation. All studies showed an unclear risk of bias in terms of: (a) allocation concealment, (b)

blinding of participants and personnel, (c) blinding of outcome assessment, (d) selective reporting, and (e) other bias. The incomplete outcome data were the low bias in these studies. All information are shown in Figures 2 and 3.

### 4 | DISCUSSION

To the best of our knowledge, this is a novel systematic review. The first focused on relevant published literature that exclusively evaluates the scientific knowledge available on the effectiveness of Lapidus plate systems in foot surgery.

We have found that Lapidus arthrodesis is a standard procedure of choice to correct the first tarsal metatarsal joint and hallux valgus associated with instability. This is a principal technique for arthrodesis of the first tarsal metatarsal joint. This surgical technique can re-establish the first ray alignments biomechanical characteristics in three planes of motion.<sup>6</sup>

Due to the ostensible heterogeneousness evaluated among cases and interventions performed, relationated to the system insertion place, outcomes measures, and follow-up in the available studies with different types system plate used, the investigations recognised that the investigations included various types of the system of fixation.

Indeed, it was detected that the investigations showed the most level of fixation in this procedure with compression plate system with screws, this manner if help to the immediate weight-bearing, with good clinical and radiographic results in the most of the cases.<sup>16-24</sup>

The majority of these studies showed the optimal system insertion place of the Lapidus plate system in foot surgery is plantar or dorsomedial applied plate combined with the plate system with screws in this procedure seems to provide an excellent option to increase control and avoid the elevation in the first metatarsal joint.

It is necessary for Lapidus plate system selection to consider availability, cost, structural integrity to identify the fixation construct. For that, it must be analysed and contrasted the biomechanical functionality, the size plate system for the patient's to obtain in the foot surgery the more adequate fixation system in each case.

This systematic review highlights some limitations of the low available evidence, consequence to the heterogeneous methods related to these studies, which did not offer the opportunity to carry out a meta-analysis. Furthermore, some investigations included cases of patients while others fresh-frozen human cadavers and differences in the measures of the main characteristics of the included studies.

Finally, the present systematic review gives helpful information to foot and ankle surgery researchers and clinicians regarding the Lapidus plate system's effectiveness. Furthermore, it shows the importance of continuous investigation on this procedure to improve the surgical outcome and the patients' quality of life.

## 5 | CONCLUSIONS

There is an insufficient number of studies about the effectiveness of the different type of Lapidus plate system in foot surgery. There is a need to increase outcomes knowledge on the fixation level, type of the system, insert place in foot surgery.

### ACKNOWLEDGEMENTS

This research was funded by Spanish Ministry of Science and Innovation through the project PID2019-108009RB-I00.

### CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

### AUTHOR CONTRIBUTIONS

**Daniel López-López:** Conceptualization; data curation; formal analysis; investigation; methodology; supervision; writing—original draft; writing—review and editing. **Ricardo Larrainzar-Garijo:** Conceptualization; investigation; methodology; supervision; writing—original draft; writing—review and editing. **Ricardo Becerro De Bengoa Vallejo:** Conceptualization; investigation; methodology; supervision; writing—original draft; writing—

review and editing. **Marta Elena Losa-Iglesias:** Conceptualization; investigation; methodology; supervision; writing—original draft; writing—review and editing. **Javier Bayod López:** Conceptualization; data curation; formal analysis; investigation; methodology; supervision; writing—original draft; writing—review and editing.


### DATA AVAILABILITY STATEMENT

The dataset supporting the conclusions of this article is available in the daniellopez@udc.es in the Research, Health and Podiatry Group. Department of Health Sciences. Faculty of Nursing and Podiatry. Universidade da Coruña, Ferrol, Spain.

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**How to cite this article:** López-López D, Larrainzar-Garijo R, De-Bengoa-Vallejo RB, Losa-Iglesias ME, Bayod-López J. Effectiveness of the Lapidus plate system in foot surgery: A PRISMA compliant systematic review. *Int Wound J*. 2022;19(3):507-514. <https://doi.org/10.1111/iwj.13649>