

Preliminary results of the correction of metatarsus adductus associated with severe hallux valgus

Resultados preliminares da correção de metatarso aduto associado a hálux valgo grave

Leonardo Fernandez Maringolo¹, Vinícius Felipe Pereira¹, Eduardo Souza Maciel¹, Danilo Oliveira¹, Nacime Salomão Barbachan Mansur¹, Lucas Furtado da Fonseca¹

1. Escola Paulista de Medicina, Universidade Federal de São Paulo, São Paulo, SP, Brazil.

ABSTRACT

Objective: Although hallux valgus is a common diagnosis and there are different well-described techniques for its correction, the presence of this deformity associated with a diagnosis of metatarsus adductus is relatively uncommon, and there is no consensus regarding surgical treatment. The objective of this study was to evaluate the preliminary radiographic results of angular corrections obtained in a series of cases of the surgical treatment of severe hallux valgus associated with adduction of the metatarsal bones, following the technique proposed herein.

Methods: Retrospective data were collected from the medical records and pre- and postoperative radiographs of patients subjected to Lapidus arthrodesis combined with lateral rotation osteotomy at the bases of the second and third metatarsals. The following angular measurements were performed before and after surgery: hallux valgus angle, intermetatarsal angle, and the degree of adduction of metatarsal bones (measured by Sgarlato's and Engel's angles). The mean follow-up period was 18 months (16-24 months).

Results: The mean hallux valgus correction angle was 31° (19-53°), and the mean intermetatarsal correction angle was 5.771° (2-9°). Regarding the forefoot adduction, the mean correction angle measured by the Sgarlato technique was 15.57° (12-21°) and by the Engel technique was 15.71° (10-22°). All of the measured angles decreased significantly in the postoperative assessment.

Conclusion: Lapidus arthrodesis combined with rotational osteotomy at the bases of the second and third metatarsals proved to be effective for correcting the adduction of the metatarsals, allowing for the alignment of the first metatarsal and consequent correction of the deformity.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Metatarsus varus; Hallux valgus; Osteotomy; Foot joints.

RESUMO

Objetivo: Apesar de o hálux valgo ser um diagnóstico comum e existirem diferentes técnicas bem descritas para a sua correção, a presença desta deformidade associada ao diagnóstico de metatarso aduto é relativamente incomum e não há consenso para o tratamento cirúrgico. O objetivo deste trabalho é avaliar os resultados radiográficos preliminares das correções angulares obtidas em uma série de casos de tratamento cirúrgico de hálux valgo grave associado à adução dos ossos metatarsais, seguindo a técnica proposta.

Métodos: Foram coletados, retrospectivamente, dados dos prontuários e radiografias pré e pós-operatórias dos pacientes submetidos à artrodese de Lapidus associada à osteotomia de rotação lateral nas bases dos segundo e terceiro metatarsos. Realizaram-se as seguintes mensurações angulares pré e pós-operatórias: ângulo de valgismo do hálux, ângulo intermetatarsal, grau de adução dos ossos metatarsais (mensurado pelos ângulos de Sgarlato e de Engel). O período de seguimento médio dos pacientes foi de 18 meses (16-24 meses).

Resultados: A correção média do valgismo do hálux foi 31° (19-53°) e do ângulo intermetatarsal foi 5,71° (2-9°). Com relação à adução do antepé, a correção média mensurada pelo método de Sgarlato foi 15,57° (12-21°) e pelo método de Engel foi 15,71° (10-22°). Todas mensurações angulares apresentaram diminuição significativa na avaliação pós-operatória.

Work performed at the Escola Paulista de Medicina, Universidade Federal de São Paulo, São Paulo, SP, Brazil.

Correspondence: Leonardo Fernandez Maringolo. Av. Antonio Segre, 347 - Jardim Brasil, Jundiaí, SP, Brazil - CEP: 13201-843.

E-mail: leoepr73@yahoo.com.br

Conflicts of interest: none. **Source of funding:** none.

Date received: December 21, 2018. **Date accepted:** March 17, 2019. **Online:** March 31, 2019.



Conclusão: A artrodese de Lapidus associada à osteotomia rotacional da base dos segundo e terceiro metatarsos mostrou-se efetiva para correção da adução dos metatarsos, possibilitando o alinhamento do primeiro metatarso e consequente correção da deformidade.

Nível de Evidência IV; Estudos Terapêuticos; Série de Casos.

Descritores: Metatarso varo; Hálux valgo; Osteotomia; Articulação intermetatarsal.

How to cite this article: Maringolo LF, Pereira VF, Maciel ES, Oliveira D, Mansur NSB, Fonseca LF. Preliminary results of the correction of metatarsus adductus associated with severe hallux valgus. *Sci J Foot Ankle*. 2019;13(1):63-9.

INTRODUCTION

Hallux valgus is one of the most common foot deformities. The prevalence of this pathology is estimated at 23% among individuals aged 18 to 65 years and 35.7% among individuals over 65 years of age. The pathogenesis of hallux valgus deformity is complex, and surgical treatment plays a central role in its treatment, with more than 100 different surgical techniques having been described⁽¹⁾.

Correction of the hallux valgus angle can be achieved through proximal, intermediate, and distal osteotomies of the first metatarsal, with lateralization of the distal fragment and consequent reduction of the hallux valgus angle and intermetatarsal angle⁽²⁾.

The presence of metatarsus adductus may be a risk factor for the development of hallux valgus⁽³⁾. A study conducted in 2014 analyzed 230 weight-bearing radiographs of the feet of patients diagnosed with hallux valgus and found a 35% incidence of metatarsus adductus. The data from that study suggest that patients with metatarsus adductus are 3.5 times more likely to develop hallux valgus⁽⁴⁾.

The identification of metatarsus adductus deformity is of great importance in the evaluation and surgical planning of hallux valgus. Adduction of the metatarsals is related both to the development of hallux valgus and to the postoperative recurrence of this deformity, especially when addressed alone^(5,6,7).

The presence of metatarsus adductus reduces the interval between the first and second metatarsals, a feature that can be verified by the low intermetatarsal angle, despite the severe hallux valgus. Thus, the area for the lateral displacement of the first metatarsal head is reduced, which precludes the surgical treatment of hallux valgus by traditional methods^(6,8).

Although hallux valgus is a common diagnosis and there are different well-described techniques for its correction, the presence of this deformity associated with a diagnosis of metatarsus adductus is relatively uncommon, and there is no consensus regarding surgical treatment in this case⁽⁷⁾.

The objective of this study was to evaluate the angular corrections obtained in a series of cases of severe hallux valgus associated with metatarsus adductus that were surgically treated through Lapidus arthrodesis combined with lateral rotation osteotomy at the bases of the second and third metatarsals, following the technique proposed herein.

METHODS

This study was approved by the Research Ethics Committee with registration in the Brazil Platform under CAAE number: 89703118.9.0000.5505.

The included data were collected from the medical records of patients who underwent surgical treatment of severe hallux valgus that was associated with metatarsus adductus by Lapidus arthrodesis combined with lateral rotation osteotomy at the bases of the second and third metatarsals between October 2016 and May 2017.

The inclusion criteria were as follows: preoperative diagnosis of severe hallux valgus (dislocation of the medial sesamoid >100%)^(9,10) and preoperative diagnosis of metatarsus adductus (Sgarlato's angle >15°)⁽¹¹⁾.

The full weight-bearing anteroposterior radiographs were taken of both feet simultaneously, with the X-ray beam centered between the feet in the first metatarsophalangeal joint and with a cephalic inclination of 10 to 15°. The radiographs were taken before and 3 months after surgery.

The radiographs were analyzed to perform angular measurements. The forefoot adduction was measured using two different techniques-Sgarlato's⁽¹²⁾ (Figure 1) and Engel's⁽¹³⁾ techniques (Figure 2). The normal value of Sgarlato's angle was considered to be from 0 to 15°, and the severity of metatarsal adduction was classified as mild (15-19°), moderate (20-25°) or severe (>25°)⁽¹¹⁾.

Materials: The study included 7 patients who were operated on using the technique described below. All patients were female, with a mean age of 63.42 years (52-72 years). The sample comprised five right feet and two left feet.

Table 1 shows the preoperative severity of the hallux valgus deformity according to the classification proposed by Mann⁽¹¹⁾. Table 2 classifies the preoperative severity of the adduction of the metatarsals⁽¹¹⁾ as explained above.

Statistical analysis: Student's t-test for paired data was used to compare the preoperative angle values with those measured on the postoperative follow-up. A p-value <0.05 was considered statistically significant. The analyses were performed using SPSS 22.0.

Surgical technique

For the treatment of severe hallux valgus associated with metatarsus adductus, arthrodesis of the first tarsometatarsal joint (lapidus) associated with rotational osteo-

tomy at the bases of the second and third metatarsals were performed according to the following steps:

1. Release of the distal lateral contracture of the hallux
2. Medial exostectomy
3. Preparation of the first tarsometatarsal joint for arthrodesis
4. Oblique osteotomy at the bases of the second and third metatarsals to correct the adduction of the metatarsals
5. Reduction of the first tarsometatarsal joint and arthrodesis with correction of the varus deformity of the first metatarsal
6. Fixation of the oblique osteotomies of the second and third metatarsals after lateral rotation
7. Weil osteotomy with release of the lateral collateral ligament of the second and third toes to correct the metatarsophalangeal subluxation of the small toes

The surgery was performed under spinal anesthesia, starting with a lateral incision in the first interdigital space to release the sesamoid-metatarsal ligament and tenotomy



Figure 1. Sgarlato's angle: traditionally defined as the angle between the longitudinal axis of the forefoot (a) and the longitudinal axis of the midfoot (b). The first is represented by the axis of the 2nd metatarsus, while the midfoot axis is defined as the perpendicular line (c) between the medial border (d) and the lateral border (e) of the midfoot. The medial border extends from the medial ends of the talonavicular joints to the first tarsometatarsal joint; the lateral border extends from the lateral ends of the calcaneocuboid joints to the cuboid (5th metatarsal) joints⁸.

Source: author's personal archive.



Figure 2. Engel's angle is the angle formed between the longitudinal axis of the intermediate cuneiform (a) and the axis of the second metatarsal (b)⁹.

Source: author's personal archive.

of the adductor hallucis. We then initiated medial access at the height of the first metatarsophalangeal joint to perform capsular reconstruction and medial exostectomy.

The next step was the preparation for arthrodesis of the first tarsometatarsal joint. The joint was completely exposed, and the entire articular cartilage was removed. At this time, it was still not possible to correct the varus deformity of the first metatarsal because there was no space for lateral translation due to the adduction of the lateral metatarsals.

The metatarsals of the central column were approached through a dorsal incision between the bases of the second and third metatarsals. After bone exposure, osteotomy was performed with a sagittal saw under fluoroscopic guidance. We began the osteotomy 1cm distal to the midfoot joint with 45° inclination, in the proximal-to-distal and dorsal-to-plantar directions, which made it possible to use screws perpendicular to the focus of the osteotomy for fixation. The main difficulty of this surgical step was to perform the osteotomy such that lateral rotation occurred without flexion or extension of the distal fragment.

Next, Lapidus arthrodesis was reduced so that the first metatarsal remained aligned with the medial cuneiform and was provisionally fixed with two 2.0-mm Kirschner wires. Due to this maneuver, the lateral rays rotated laterally. The Lapidus arthrodesis was fixed with two 3-mm cannulated screws and a 2.8-mm plate, and the lateral metatarsals were fixed with two 2-mm screws after fluoroscopic position confirmation.

After realignment of the metatarsals, we observed an imbalance of the parabola of the forefoot due to shortening of the first ray. Thus, Weil osteotomy was performed in the second and third metatarsals, with shortening and small lateral translation of the metatarsal head, in addition to release of the lateral collateral ligament to correct the abduction of the smaller toes. In 2 cases, the patients had irreducible deformities on the fourth toe, and thus, we performed the same procedure in this ray. The Weil osteotomy was fixed with one 2.0-mm screw.

In patients with alterations in the distal metatarsal articular angle (>6°), we performed biplanar chevron osteotomy to correct the deformity. In addition, patients with an altered interphalangeal angle (>14°) were corrected with Akin osteotomy.

In the postoperative period, the patients were immobilized with an orthotic boot and restricted from weight-bearing on the operated limb for 6 weeks. The suture was removed 3 weeks after surgery, at which point motor physical therapy was started. Progressive partial weight-bearing was initiated on the 6th week, and the patient used the orthotic boot until the 8th week.

Patients were released to return to activities of daily living after being comfortable with the use of shoes with hard soles, around the 12th postoperative week.

Table 1. Preoperative classification of the hallux valgus severity⁽¹¹⁾

Patient	HVA	IMA	Smith	Classification
1	60	13	3	Severe
2	48	12	3	Severe
3	57	14	3	Severe
4	38	14	3	Severe
5	34	14	3	Severe
6	40	13	3	Severe
7	30	12	3	Severe

HVA: hallux valgus angle; IMA: intermetatarsal angle; Smith classification^(9,10).
 Source: Prepared by the author based on the results of the research.

Table 2. Preoperative classification of the metatarsus adductus severity⁽¹¹⁾

Patient	Sgarlato	Classification
1	30	Severe
2	33	Severe
3	28	Severe
4	40	Severe
5	20	Moderate
6	40	Severe
7	28	Severe

Sgarlato: adduction angle of the forefoot measured by the Sgarlato technique⁽¹²⁾.
 Source: Prepared by the author based on the results of the research.

RESULTS

The mean follow-up period was 18 months (16-24 months). The hallux valgus angle decreased on average by 31° (19-53°), decreasing from a mean of 42.9° before surgery to a mean of 12.9° after surgery. Using Student's t-test for paired data, we found that the mean valgus values in the postoperative period were significantly lower than the mean values in the preoperative period (p=0.001) (Table 3).

The intermetatarsal angle showed an average correction of 5.71° (2-9°), decreasing from a mean of 13.11° to 7.44° in the postoperative period. Using Student's t-test for paired data, we found a significant decrease in the values after surgery (p=0.001) (Table 3).

Regarding the forefoot adduction, we found that the mean values of Sgarlato's angle after surgery (29.99°) were significantly lower than the mean values before surgery (14.33°) ($p < 0.001$), with a mean correction of 15.57° (12-21°) (Table 3).

Using Engel's technique, the mean angular decrease was 15.71° (10-22°), from 33.3° to 17.6° in the postoperative period, with significantly lower values measured after surgery ($p < 0.001$) (Table 3).

Table 4 shows the angular correction obtained with the proposed treatment for the 7 cases included in the study. Figure 3 illustrates one of the cases, showing the weight-bearing radiographs taken of the patient before and after surgery.

The main postoperative complaints were diffuse swelling in the forefoot and difficulty moving the hallux and small toes in the first 6 weeks. No recurrence was diagnosed until the last assessment, and there have been no complications to date.

Table 3. Comparison of preoperative and postoperative angular measurements

	HVA		IMA		Sgarlato		Engel	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	43.9	12.9	13.1	7.4	29.9	14.3	33.3	17.6
SD	11.5	3.8	0.9	2.5	6	6.2	6.8	5.3
p	=0.001		=0.001		<0.001		<0.001	

HVA: hallux valgus angle; IMA: intermetatarsal angle; Sgarlato: adduction angle of the forefoot measured by the Sgarlato technique⁽¹²⁾; Engel: adduction angle of the forefoot measured by the Engel technique⁽¹³⁾; SD: standard deviation; p: p-value.

Source: Prepared by the author based on the results of the research.

Table 4. Pre- and postoperative values of the angular measurements of the foot

	HVA		IMA		Sgarlato		Engel	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	60	7	13	4	30	15	34	19
2	48	14	12	8	33	18	38	22
3	57	16	14	12	28	10	36	14
4	38	16	14	6	40	24	43	25
5	34	15	14	8	20	8	22	11
6	40	14	13	6	40	18	30	20
7	30	8	12	8	28	7	30	12
Mean	43.9	12.9	13.1	7.4	29.9	14.3	33.3	17.6

HVA: hallux valgus angle; IMA: intermetatarsal angle; Sgarlato: adduction angle of the forefoot measured by the Sgarlato technique⁽¹²⁾; Engel: adduction angle of the forefoot measured by the Engel technique⁽¹³⁾.

Source: Prepared by the author based on the results of the research.

DISCUSSION

Although we found several studies on the prevalence and radiographic methods for evaluating hallux valgus associated with metatarsus adductus, there are few studies on the combined management of these pathologies. There is only one study available that proposes a protocol to be followed for the correction of both deformities⁽⁷⁾, but it is based on a series of only four cases. In that study, the authors present a surgical protocol similar to that used in our study, but Sharma and Aydogan added a calcaneal osteotomy as one of the initial steps of surgery. The results of the angular corrections were quite satisfactory in the previous study, as was also found in our investigation.

In addition to the severity of hallux valgus, several other factors should be considered for the surgical planning of hallux valgus associated with metatarsus adductus, such as the adduction angle of the metatarsals, deformities of the small toes, metatarsalgia, alteration of the distal metatarsal articular angle, and interphalangeal valgus⁽¹⁴⁾. Such evaluations are important because they are related to patient satisfaction⁽⁷⁾ and the possibility of recurrence^(4,16,17), as was demonstrated in the present study because there has been no recurrence to date.



Figure 3. Weight-bearing anteroposterior radiograph of the foot of one of the patients showing the preoperative deformity and postoperative deformity correction.

Source: author's personal archive.

For the diagnosis of adduction of the metatarsals, the Sgarlato technique is the most widely accepted and used. The Engel technique was popularized due to its simplicity and ease of measurement when compared to the more traditional technique of Sgarlato et al.⁽¹⁵⁾. As there is no consensus in the literature on the best way to measure metatarsal adduction, we chose to perform this assessment using the two angles mentioned above.

In 2015, Aiyer et al. confirmed that the postoperative recurrence of hallux valgus was substantially higher in patients who had an associated diagnosis of metatarsus adductus compared to the group without this deformity, when only the first ray was addressed⁽¹⁶⁾. This finding supports the hypothesis, supported by other studies^(4,17), that the adduction of metatarsal muscles increases the risk of recurrence and suggests that the association of hallux valgus with metatarsus adductus should be addressed jointly, addressing the lateral rays to allow correction of the first ray. This fact was demonstrated in our study by the significant postoperative improvement of the hallux valgus angle, without recurrence of the deformity in the postoperative follow-up period.

Due to the adduction of the lateral rays, there is a restricted space for lateral translation of the first metatarsal head, which limits the power of correction of any isolated osteotomy of the first metatarsal⁽¹⁶⁾. This reduction of the intermetatarsal angle requires that we approach the lateral metatarsals to make room for correcting the varus of the first metatarsal; otherwise, it becomes impossible to align the first metatarsal with the medial cuneiform. This correction was evidenced in the present study by the significant decrease in the forefoot adduction angles.

In a retrospective study with 19 patients diagnosed with severe metatarsus adductus treated with different techniques, the authors concluded that modified Lapidus arthrodesis led to a lower rate of recurrence of hallux valgus compared to isolated distal osteotomies of the first metatarsal, but only when performed together with realignment arthrodesis of the proximal joints of the second and third metatarsals and distal metatarsal osteotomies⁽¹⁸⁾. In our study, we chose to perform osteotomy at the base of the metatarsals of the central column due to the larger amount of metaphyseal bone and for maintaining mobility in the midfoot joints. Thus, we were able to abduct the approached rays, allowing the alignment of the first metatarsal with the medial cuneiform and the consequent significant improvement of the angular measurements.

The present study has some limitations, such as the small number of patients, the absence of a comparison group, and a short follow-up time. However, the findings indicate a possible treatment for hallux valgus when it is associated with metatarsus adductus, given the observed improvement of the hallux valgus angle and adduction angle of the metatarsals achieved following the proposed method.

CONCLUSION

The results show that Lapidus arthrodesis combined with rotational osteotomy at the bases of the second and third metatarsals allowed correcting the metatarsus adductus deformity associated with severe hallux valgus, leading to a significant improvement in the hallux valgus angle and the adduction angle of the metatarsals.

Authors' contributions: Each author contributed individually and significantly to the development of this article: LFM *(<https://orcid.org/0000-0003-0318-2842>) conceived and planned the activities that led to the study, wrote the article, participated in the review process, approved the final version; VFP *(<https://orcid.org/0000-0002-1005-6089>) wrote the article, interpreted the results of the study; ESM *(<https://orcid.org/0000-0002-8572-7764>) wrote the article, interpreted the results of the study; DO *(<https://orcid.org/0000-0003-1514-8510>) wrote the article participated in the review process; NSBM *(<https://orcid.org/0000-0003-1067-727X>) wrote the article, approved the final version; LFF *(<https://orcid.org/0000-0001-6497-833X>) conceived and planned the activities that led to the study, wrote the article, participated in the review process, approved the final version. *ORCID (Open Researcher and Contributor ID).

REFERENCES

1. Barg A, Harmer JR, Presson AP, Zhang C, Lackey M, Saltzman CL. Unfavorable outcomes following surgical treatment of hallux valgus deformity: a systematic literature review. *J Bone Joint Surg Am.* 2018; 100(18):1563-73.
2. Holmes GB Jr, Hsu AR. Correction of intermetatarsal angle in hallux valgus using small suture button device. *Foot Ankle Int.* 2013; 34(4):543-9.
3. Aiyer AA, Shariff R, Ying L, Shub J, Myerson MS. Prevalence of metatarsus adductus in patients undergoing hallux valgus surgery. *Foot Ankle Int.* 2014;35(12):1292-7.
4. La Reaux RL, Lee BR. Metatarsus adductus and hallux abducto valgus: their correlation. *J Foot Surg.* 1987;26(4):304-308.
5. Bohne W. Metatarsus adductus. *Bull NY Acad Med.* 1987;63(9):835-838.
6. Stephen C. Wan. Metatarsus adductus and skewfoot deformity. *Clin Podiatr Med Surg.* 2006;23(1):23-40.
7. Sharma J, Aydogan U. Algorithm for severe hallux valgus associated with metatarsus adductus. *Foot Ankle Int.* 2015;36(12):1499-503.
8. Dawoodi AI, Prera A. Reliability of metatarsus adductus angle and correlation with hallux valgus. *Foot Ankle Surg.* 2012 Sep;18(3):180-6.
9. Smith RW, Reynolds JC, Stewart MJ. Hallux valgus assessment: report of research committee of American Orthopaedic Foot and Ankle Society. *Foot Ankle.* 1984;5(2):92-103.
10. Nery CAS. Hálux valgo. *Rev Bras Ortop.* 2001;36(6):183-200.
11. Coughlin M, Saltzman C, Anderson R. *Mann's Surgery of the foot and ankle.* 9thed. Philadelphia: Elsevier; 2014. p.155-321.
12. Sgarlato TE. *Compendium of podiatric biomechanics.* San Francisco: California College of Podiatric Medicine; 1971: 381.
13. Engel E, Erlick N, Krems I. A simplified metatarsus adductus angle. *J Am Podiatry Assoc.* 1983;73:620-8.
14. King DM, Toolan BC. Associated deformities and hypermobility in hallux valgus: an investigation with weightbearing radiographs. *Foot Ankle Int.* 2004; 25(4):251-5.
15. Dawoodi AIS, Perera A. Radiological assessment of metatarsus adductus. *Foot Ankle Surg.* 2012;18(1):1-8.
16. Aiyer AA, Shariff R, Ying L, Shub J, Myerson MS. Radiographic recurrence of deformity after hallux valgus surgery in patients with metatarsus adductus. *Foot Ankle Int.* 2016;37(2):165-71.
17. Coughlin MJ. Hallux valgus. *J Bone Joint Surg Am.* 1996;78(6):932-66.
18. Aiyer A, Shariff R, Tracey JA, Myerson MS. Management of hallux valgus deformity in patients with metatarsus adductus. *Foot Ankle Orthop.* 2016;1(1).