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Original Article

Reverdin-Isham modified vs MICA for moderate hallux valgus: A comparative study

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Abstract

Objective: To compare clinical, functional, and radiographic results of the modified minimally invasive Reverdin-Isham (RImod) and minimally invasive Chevron-Akin (MICA) techniques in the treatment of moderate hallux valgus.

Methods: Retrospective comparative study of 81 feet (38 MICA, 43 RImod) with moderate hallux valgus (IMA ≤ 18°, HVA ≤ 40°). Pre- and postoperative evaluations (6 months) included the AOFAS score, intermetatarsal angles (IMA) and hallux valgus angle (HVA), and fibular sesamoid subluxation (FSS). Statistical analysis used Student's t and Wilcoxon's tests, with adjustment for bilateral testing.

Results: Both groups demonstrated significant improvement ($p < 0.001$) in AOFAS (MICA: 37.9 ± 12.6 to 90.95 ± 8.1; RImod: 40.47 ± 13.1 to 93.4 ± 6.5), IMA (MICA: 14.9 ± 2.1° to 10.0 ± 3.0°; RImod: 14.4 ± 2.1° to 10.0 ± 2.8°), HVA (MICA: 31.3 ± 6.1° to 11.8 ± 5.7°; RImod: 29.0 ± 5.8° to 11.0 ± 4.4°) and FSS (MICA: 89% to 53%; RImod: 82% to 51%). There was no statistically significant difference between the techniques for functional gain ($p = 0.98$), IMA correction ($p = 0.43$), HVA ($p = 0.30$), or FSS ($p = 0.41$). The complication rate was 21.1% for MICA and 9.3% for RImod ($p = 0.149$), with different profiles: MICA presented problems with implants and recurrence, while RImod had cases of nerve injury and malunion.

Conclusion: RImod and MICA are effective for the correction of moderate hallux valgus, with comparable clinical and radiographic results. Both techniques demonstrated significant clinical and radiographic improvements, with functional gains in AOFAS score and substantial angular corrections in HVA, IMA, and FSS.

Level of Evidence III; Comparative Retrospective Study.

Keywords: Hallux valgus; Minimally invasive surgery; Chevron-Akin; Modified Reverdin-Isham.

Introduction

Hallux valgus (HV) is one of the most prevalent deformities of the forefoot, characterized by lateral deviation of the hallux and medial deviation of the first metatarsal (M1), often associated with pain, calluses, and difficulties in wearing shoes[1,2]. Its etiology is multifactorial, involving genetic, biomechanical, and environmental aspects[1,2]. Surgical treatment is indicated for patients refractory to conservative management, aiming to correct the deformity, relieve pain, and improve function[1].

In recent decades, minimally invasive surgery (MIS) of the foot, also known as percutaneous surgery, has emerged as a promising alternative to traditional open techniques for HV treatment[3]. Theoretical advantages include less tissue trauma, smaller incisions, less postoperative pain, faster recovery, and shorter surgical time[4]. However, the literature still lacks high-level evidence studies that directly compare different percutaneous techniques[4,5].

The original Reverdin-Isham technique, described by Isham[5] as a modification of the Reverdin osteotomy[6], aims to realign the joint surface and correct the angle. However, instability of the M1 osteotomy is a concern[7]. To address this issue, a modification of the Reverdin-Isham technique, known as Modified Reverdin-Isham (RImod), was described

Study performed at the Hospital Universitário de Taubaté, Taubaté, SP, Brazil.

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in 2021 and incorporates an oblique cut in the neck of M1 with a bony step[7]. This modification aims to provide greater stability to the osteotomy, allowing lateral displacement of the metatarsal head for proper correction of the deformity, without the routine need for internal fixation[7].

In parallel, the minimally invasive Chevron-Akin (MICA) technique represents an evolution of percutaneous Chevron osteotomy. Originally, Chevron osteotomy described by Austin and Leventen[8], is a "V" osteotomy on the neck of M1, with lateral displacement of the head. Vernois and Redfern[4,9] demonstrated the percutaneous Chevron technique with fixation by two screws, increasing stability and allowing greater displacement of the metatarsal head, making it applicable even for more severe deformities[9].

Given the need for comparative evidence, this retrospective study evaluates patients with moderate HV (intermetatarsal angles (IMA) ≤ 18° and hallux valgus angle (HVA) ≤ 40°)[10], comparing the clinical, functional, and radiographic results of the RImod and MICA techniques, contributing to the understanding of their relative effectiveness and assisting clinical decision-making.

Methods

Study design and context

This is a longitudinal retrospective observational study (before-after) and a comparative study between two groups, conducted through the review of medical records and imaging exams of patients with moderate HV. Patients underwent MIS between 2012 and 2024 in different services.

The study compared the results of RImod and MICA techniques: Potential biases due to inclusion of data from different centers and authorship of the RImod technique will be discussed as limitations.

Eligibility criteria

Patients with moderate HV refractory to conservative treatment, with a minimum postoperative follow-up of six months, were included. The classification of moderate HV was defined by a HVA ≤ 40°, according to the criteria of Coughlin and Mann[11] and IMA ≤ 18° in accordance with the criterion adopted by De Prado et al.[10], which establishes this value as the upper limit to indicate distal percutaneous techniques of the M1, an approach also used in Bauer et al.[12] study.

Patients with previous surgery on the first radius of the foot, peripheral vascular diseases, rheumatological diseases, active infections, acute fractures, or incomplete data that prevented analysis were excluded from the study.

Sample

The final sample consisted of 81 operated feet, divided into two groups:

- MICA group (n = 38 feet):
- MICA only: 15 feet
- MICA + associated procedures at other radius: 23 feet

Of these 23 feet, 19 feet required metatarsal osteotomies (Distal Metatarsal Metaphyeal Osteotomy (DMMO)), and eight feet had smaller toe claws that were realigned.

- RImod group (n = 43 feet):
- RImod + Aikin: 20 feet
- RImod + Aikin + associated procedures at other radius: 23 feet

Of these 23 feet, 20 feet required metatarsal osteotomies (DMMO), 13 had smaller toe claws that were realigned, and one foot had correction of overriding second toe.

Data collection and evaluated variables

Demographic (sex, age, side of the foot operated) and clinical (postoperative complications) data were collected from medical records. Functional and radiographic evaluations were performed preoperatively and in the sixth postoperative month.

The variables evaluated included:

- American Orthopaedic Foot & Ankle Society (AOFAS): functional score that assesses pain, function, and hindfoot, midfoot, and forefoot alignment (0-100 points, where 100 is the best result)[13].
- The weight-bearing radiographs were performed in anteroposterior (AP) and lateral views. Radiographic measurements were performed by a single evaluator (unblinded), using digital software.
- IMA: measured on weight-bearing AP radiographs (degrees).
- HVA: measured on weight-bearing AP radiographs (degrees).
- Fibular sesamoid subluxation (FSS): evaluated on weight-bearing AP radiographs, according to Coughlin and Mann's classification[11]. FSS was visually categorized into quartiles and grouped into Grades I, II, and III for analysis.

Surgical procedures

All surgeries were performed by surgeons experienced in MIS techniques.

- MICA group: The MICA technique involved a "V" osteotomy on the neck of the M1, with lateral displacement of the head and fixation with screws, associated with Akin osteotomy (Figure 1).
- RImod group: The RImod technique consisted of an oblique cut in the neck of M1 with a bony step to lateralize the metatarsal head, providing greater stability without the routine need for internal fixation and Akin osteotomy (Figures 2 and 3).

Associated procedures were allowed in both groups and will be considered potential confounding factors in the discussion.

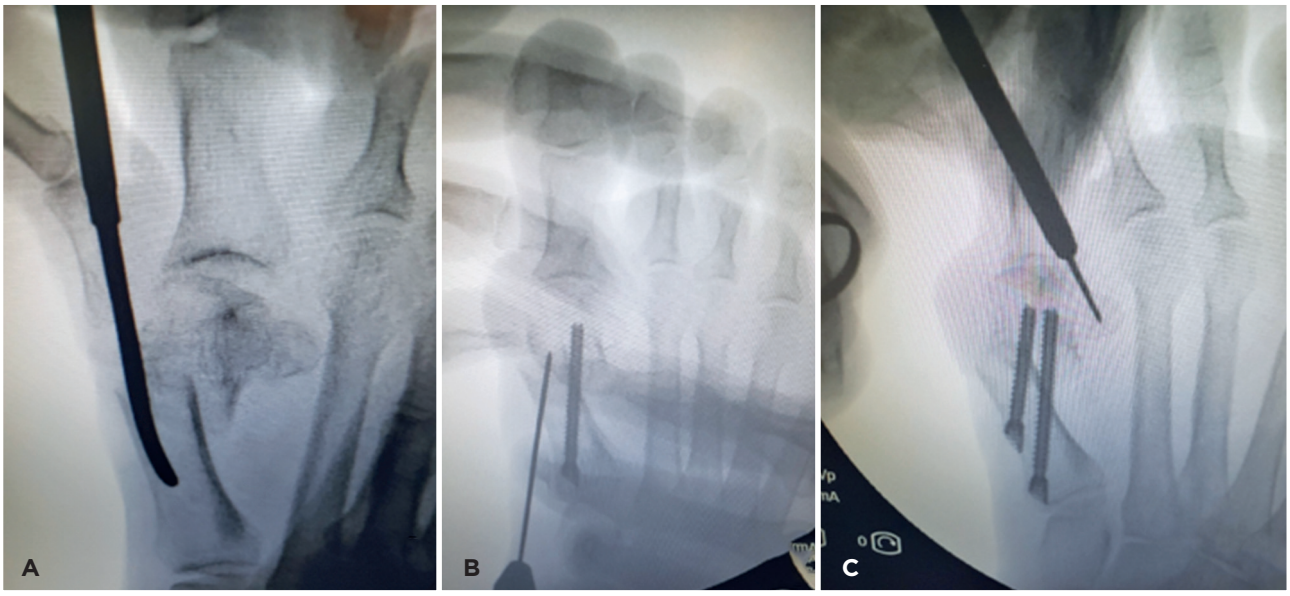

Figure 1. Intraoperative radiographs of the MICA technique. (A) The lateral displacement of the first metatarsal head, (B) the guidewire passage of the second screw, (C) osteotomy already fixed, preparing to perform the tenotomy of the adductor of the hallux.

Figure 2. (A-B) Clinical and radiographic image showing the moderate hallux valgus, (C-D) clinical image and radiography after RImod technique.

Postoperative period

The postoperative protocol included initial immobilization and progressive rehabilitation, with immediate weight-bearing in both techniques.

Weekly dressings were performed at the outpatient clinic for four weeks; thereafter, patients performed their own dressings at home from weeks 4 to 8 in both techniques. During this period, patients were instructed to wear a rigid-sole sandal full time for the first two months.

Control radiographs were performed in the first, fourth, and eighth postoperative weeks.

Statistical analysis

Data were organized and analyzed using Stata software (version 17.0, StataCorp LLC, College Station, TX, USA). Continuous variables were described by mean and standard deviation (SD). The normality of the data distribution was verified by the Shapiro-Wilk test. For preoperative comparisons

between groups, Student's t-test was used for continuous variables with normal distribution, or the Mann-Whitney U test for non-parametric variables. For pre- vs. postoperative comparisons within each group, the paired t-test was used for continuous variables with a normal distribution, or the Wilcoxon test for non-parametric variables. To compare the differences (Δ = post-pre) between the groups, the Student's t-test for independent samples or the Mann-Whitney U test were used. The FSS variable (Grades I-III), being an ordinal categorical variable, was analyzed using non-parametric tests (Wilcoxon for intra-group comparisons and Mann-Whitney U or ordinal regression models for inter-group comparisons). For the bilateral adjustment, inferential estimates were calculated with adjustment for cluster per patient (ID), reducing the risk of overestimation of significance due to non-independence of observations. A significance level of $p < 0.05$ was adopted in all analyses.

Ethical aspects

The study was approved by the Institutional Review Board. As this is a retrospective review, the data were analyzed anonymously, preserving patient confidentiality.

Results

A total of 81 feet with moderate HV (MICA: n = 38; RImod: n = 43) were evaluated. The sample, composed predominantly of middle-aged and older women, was operated on in different services, with a mean follow-up of 28.1 months (minimum of six months and maximum of more than six years). The mean postoperative follow-up time was 30.3 months in the MICA group and 26.2 months in the RImod group.

Sample characteristics (preoperative data)

The groups had comparable demographic characteristics and preoperative parameters (clinical, functional, and radiographic).

In the MICA group, the preoperative AOFAS score was 37.9 ± 12.6 points, the mean IMA was 14.9 ± 2.1°, the HVA was 31.3 ± 6.1°, and the FSS of the hallux was estimated at 0.89 ± 0.18 (≈ 89%), a value compatible with severe (Grade III) displacement of the fibular sesamoid. In the RImod group, the preoperative AOFAS was 40.47 ± 13.1 points, the IMA was 14.4 ± 2.1°, the HVA was 29.0 ± 5.8°, and the mean FSS was 0.82 ± 0.22 (≈ 82%), also within the severe profile.

These data indicate that, although the patients were classified as having moderate HV based on IMA and HVA, from the point of view of the sesamoid position (Coughlin and Mann's criterion[11]), most of the feet had a radiographic pattern compatible with Grade III (severe) of lateral subluxation (Table 1).

Intragroup comparison (pre- vs postoperative)

In the intragroup analysis (paired sample t-test), a statistically significant improvement was observed in all evaluated parameters – AOFAS, IMA, HVA, and FSS – in both MICA and RImod groups (Table 2).

In the MICA group:

- The AOFAS score increased from 37.9 ± 12.6 to 90.95 ± 8.1 ($p < 0.001$), with a mean gain of 53.0 ± 13.9 points.
- The IMA decreased from 14.9 ± 2.1° to 10.0 ± 3.0° ($p < 0.001$), with a mean difference of 4.9 ± 2.9°.
- The HVA decreased from 31.3 ± 6.1° to 11.8 ± 5.7° ($p < 0.001$), with a mean reduction of 19.4 ± 5.8°.
- The FSS, expressed as lateral displacement, decreased from 0.89 ± 0.18 (≈ 89%, Grade III to 0.53 ± 0.30 (≈ 53%, mean Grade II), with a mean reduction of 0.36 ± 0.29 (36 ± 29%, $p < 0.001$).

In the RImod group:

- The AOFAS score increased from 40.47 ± 13.1 to 93.4 ± 6.5 ($p < 0.001$), with a mean gain of 52.9 ± 13.9 points.

Figure 3. (A) Radiograph showing the moderate hallux valgus, (B) intraoperative radiograph demonstrating the point of onset of osteotomies, (C)radiograph after the RImod technique with lateral displacement of the metatarsal head and entry point of the tenotomy, (D) intraoperative radiograph showing the final result.

- The IMA decreased from 14.4 ± 2.1° to 10.0 ± 2.8° ($p < 0.001$), with a mean difference of 4.4 ± 2.8°.
- The HVA decreased from 29.0 ± 5.8° to 11.0 ± 4.4° ($p < 0.001$), with a mean reduction of 18.0 ± 6.3°.
- The FSS ranged from 0.82 ± 0.22 (≈ 82%, Grade III/severe) to 0.51 ± 0.25 (≈ 51%, Grade II/moderate), with a mean reduction of 0.31 ± 0.29 (31% ± 29%, $p < 0.001$).

These findings demonstrate that both MIS techniques provided significant functional improvement and consistent radiographic correction, with a reduction in FSS from severe (Grade III) to moderate (Grade II) (Table 2).

Comparison between techniques (MICA group vs RImod group)

In the intergroup comparison (t-test of independent samples), no statistically significant differences were observed between the MICA group and the RImod group in any of the variables analyzed (Table 3):

- Functional gain (AOFAS difference)
  - MICA group: 53.0 ± 13.9
  - RImod group: 52.9 ± 13.9
  - p = 0.98
- IMA correction (pre-post difference)

Table 1. Sample characteristics and preoperative parameters of the MICA and RImod groups

Variables	MICA group (n = 38 feet)	RImod group (n = 43 feet)
Age (years), mean ± SD	54.0 ± 13,1	57.0 ± 12.8
Female (%)	89.5%	83.7%
Operated side (R/L)	52.6% R / 47.4% L	55.8% R / 44.2% L
Pre- AOFAS, mean ± SD	37.9 ± 13.0	40.5 ± 13.1
Pre- IMA (°), mean ± SD	14.9 ± 2.1	14.4 ± 2.1
Pre- HVA (°), mean ± SD	31.3 ± 6.1	29.1 ± 5.9
Pre lateral sesamoid (%), mean ± SD[1]	89 ± 18	82 ± 22

[1]Pre lateral sesamoid: Fraction (0-1.00) of the lateral displacement of the fibular sesamoid in relation to the axis of the first metatarsal, converted into percentage (0%-100%). For interpretation according to Coughlin and Mann, it was considered: < 50% compatible with Grade I (mild); 50%-75% with Grade II (moderate) and > 75% with Grade III (severe).

Table 2. Pre- and postoperative comparison of functional and radiographic variables in the MICA and RImod groups

Variables	Group	Preop (mean ± SD)	Postop (mean ± SD)	Difference (pre-post) (mean ± SD)	p intragroup	Unit
AOFAS	MICA	37.9 ± 12.6	90.95 ± 8.1	53.0 ± 13.9	< 0.001	points
AOFAS	RImod	40.47 ± 13.1	93.4 ± 6.5	52.9 ± 13.9	0.001	Points
IMA	MICA	14.9 ± 2.1	10.0 ± 3.0	4.9 ± 2.9	< 0.001	degree
IMA	RImod	14.4 ± 2.1	10.0 ± 2.8	4.4 ± 2.8	< 0.001	degree
HVA	MICA	31.3 ± 6.1	11.8 ± 5.7	19.4 ± 5.8	< 0.001	degree
HVA	RImod	29.0 ± 5.8	11.0 ± 4.4	18.0 ± 6.3	< 0.001	degree
Sesamoid (%)	MICA	80 ± 20	50 ± 30	36 ± 29	< 0.001	%
Sesamoid (%)	RImod	80 ± 20	50 ± 20	31 ± 29	< 0.001	%

AOFAS: American Orthopaedic Foot & Ankle Society; IMA: Intermetatarsal angle; HVA: Hallux valgus angle. Sesam: Fraction (0-1.00) of the lateral displacement of the fibular sesamoid in relation to the axis of the first metatarsal, converted into percentage (0%-100%). For interpretation according to Coughlin and Mann, it was considered: < 50% compatible with Grade I (mild); 50%-75% with Grade II (moderate) and > 75% with Grade III (severe). Paired sample t-test; $p < 0.05$ considered significant.

Table 3. Pre- postoperative differences (Δ) between the MICA and RImod groups

Variables	Groups	Difference (pre-post) (mean ± SD)	p intragroup	Unit
AOFAS	MICA	53.0 ± 13.9	0.98	points
	RImod	52.9 ± 13.9		
IMA	MICA	4.9 ± 2.9	0.43	degree
	RImod	4.4 ± 2.8		
HVA	MICA	19.4 ± 5.8	0.30	degree
	RImod	18.0 ± 6.3		
Fibular sesamoid (displacement)	MICA	36% ± 29%	0.41	%
	RImod	31% ± 29%		

Δ = pre- postoperative value. Independent samples t-test; $p < 0.05$ considered significant.

- MICA group: 4.9 ± 2.9°
- RImod group: 4.4 ± 2.8°
- p = 0.43

- HVA Correction (pre-post difference)
  - MICA group: 19.4 ± 5.8°
  - RImod group: 18.0 ± 6.3°
  - p = 0.30
- FSS reduction (Δ Sesamoid)
  - MICA group: 0.36 ± 0.29 (36 ± 29%)
  - RImod group: 0.31 ± 0.29 (31 ± 29%)
  - p = 0.41

Thus, there was no evidence of statistical superiority of one technique over the other regarding functional gain (AOFAS), angular correction (IMA, HVA), or FSS in the postoperative period (Table 3). In both groups, the mean lateral FSS was reduced from severe (Grade III) to moderate (Grade II), with no statistically significant difference between the techniques regarding the magnitude.

Postoperative complications directly related to osteotomies were evaluated and categorized for both groups (Table 4). In the MICA group (n = 38), eight patients (21.1%) had at least one complication related to the surgical procedure. In the IRmod group (n = 43), four patients (9.3%) had complications directly related to osteotomies. Statistical analysis showed no statistically significant difference in the overall complication rate between the two techniques (p = 0.149, Fisher's exact test).

In the MICA group, the most frequent complications were Complex Regional Pain Syndrome (CRPS) (n = 2; 5.3%), recurrence/hypocorrection (n = 2; 5.3%), and implant problems (screw) (n = 2; 5.3%). A fracture of the medial cortex of the proximal metatarsal fragment was observed in one patient (2.6%), requiring removal of one of the screws, and a soft-tissue complication (skin necrosis) in another (2.6%).

In the RImod group, complications were less frequent. One case of CRPS (2.3%), one of soft tissue complication (prolonged residual edema, 2.3%), one of nerve injury (superficial fibular neuropraxia, 2.3%), and one of malunion/malposition (slight plantar flexion of the head of the M1, 2.3%) were recorded. None of the specific complications showed a statistically significant difference between the groups (p > 0.05 for all individual comparisons).

Discussion

This study compared the RImod and MICA techniques for moderate HV. Both techniques demonstrated significant improvements in AOFAS, HVA, IMA, and FSS, with no statistical differences between groups.

In the present study, the AOFAS score showed a mean improvement of 53.0 ± 13.9 points in the MICA group and 52.9 ± 13.9 points in the RImod group, with no statistically significant difference between the groups.

Carvalho et al.[14] and Xavier et al.[15], in retrospective studies using the MICA technique in moderate and severe HV, reported a mean preoperative AOFAS score of 43.97/45, with improvement of 90 points, similar to that found in the present study.

We observed in the literature a few studies that evaluated the RImod technique for HV correction. However, numerous studies were found that applied the classical Reverdin-Isham technique to correct HV, such as Bauer et al.[12], who observed a significant increase in postoperative AOFAS score, with 89% patient satisfaction. The systematic review and meta-analysis by Sanchís-Soria et al.[16], which analyzed 554 patients and 643 feet submitted to Reverdin-Isham osteotomy, also identified a mean improvement of 36.89 points in the AOFAS, corroborating the effectiveness of the technique. In this study, the RImod technique presented a gain greater than 50 points, surpassing the studies that presented the original technique[12,16,17], possibly due to the greater stability of the modified osteotomy[7].

The HVA correction was expressive in both groups: in the MICA group, the mean reduction was 19.5° while in the RImod group the reduction was 18.0°, results similar to the Vernois and Redfern study in the description of the MICA technique[4].

The IMA correction showed a mean reduction of 4.9° (MICA) and 4.4° (RImod), indicating a good realignment of the first radius.

Table 4. Distribution of postoperative complications by surgical technique

Complication	MICA (n = 38)	RImod (n = 43)	p
CRPS	2 (5.3%)	1 (2.3%)	0.617
Recurrence/hypocorrection	2 (5.3%)	0 (0.0%)	0.239
Implant problems	2 (5.3%)	0 (0.0%)	0.239
Osteotomy-related fracture	1 (2.6%)	0 (0.0%)	0.469
Soft tissue complication/wound healing	1 (2.6%)	1 (2.3%)	1.000
Nerve injury	0 (0.0%)	1 (2.3%)	0.469
Malunion/malposition	0 (0.0%)	1 (2.3%)	0.469
Total of patients with complication	8 (21.1%)	4 (9.3%)	0.149

CRPS: Complex Regional Pain Syndrome. Values expressed as n (%). Fisher's exact test used for all comparisons. p < 0.05 considered statistically significant.

In another study[7] conducted by our group, where the RImod technique was presented and used in 46 feet, the IMA decreased 4.3º, very close to the results in the present study, which was 4.4º.

Both techniques evaluated in the present study are complete distal osteotomies in which the M1 head is shifted laterally. This displacement alone allows correction of the distal metatarsal articular angle, which is why this parameter was not assessed in the present study[7,15].

Assessment of fibular sesamoid position is an important radiographic parameter for evaluating the quality of HV surgical correction, as FSS reflects the degree of imbalance of the sesamoid apparatus and is a prognostic factor for deformity recurrence[1]. In the present study, both groups demonstrated significant improvement in the fibular sesamoid position in the postoperative period, with no difference between the groups. De Prado et al.[10] reported partial realignment of sesamoids in 62% of cases after the classical Reverdin-Isham percutaneous technique. The realignment of the sesamoid position observed in both techniques in the present study corroborates these findings, suggesting that both the lateral translation of the metatarsal head (MICA) and the reorientation of the joint surface (RImod) contribute to improving the relationship between the sesamoid and the metatarsal groove. Carvalho et al.[14] and Xavier et al.[15] also demonstrated significant improvement in the sesamoid position, corroborating that partial recentralization is a robust marker of good correction and lower recurrence in the medium term.

Postoperative complications directly related to osteotomies were observed in eight patients (21.1%) in the MICA group and in four patients (9.3%) in the RImod group. The profile of complications varied between techniques, which has clinical relevance.

In the MICA group, problems with implants (screw pain, migration, cortical fracture) accounted for 3 of the 8 cases. Carvalho et al.[14] and Xavier et al.[15] also reported a high incidence of pain related to screws (14.28%), often requiring removal.

In the RImod group, the absence of internal fixation eliminates the risk of implant-related complications, an inherent advantage of the technique in terms of its complication profile. However, the stability of osteotomy depends on the integrity of the medial bony step and postoperative compressive dressing, which may represent a limitation in patients with low adherence to treatment.

The infection rate was null in both groups, a result consistent with the literature that reports infection rates for percutaneous foot surgeries ranging from 0% to 3.5%[3,12,17].

The findings of the present study suggest that both techniques are effective for treating moderate HV, and align with the growing evidence base, reinforcing the role of percutaneous techniques in HV therapy.

Limitations

This study has limitations inherent to its retrospective design, including the absence of randomization and blinding of evaluators, which can introduce selection and measurement biases. The sample size, although adequate for a comparative analysis, may be insufficient to detect small differences between groups. In addition, the absence of formal assessment of intraobserver reliability constitutes an additional methodological limitation. Finally, the mean follow-up may be insufficient to detect late complications, such as recurrence of the deformity and transfer metatarsalgia.

Conclusion

This study compared the effectiveness of RImod and MICA techniques in the treatment of moderate HV. Both techniques demonstrated significant clinical and radiographic improvements, with functional gains in AOFAS score and substantial angular corrections in HVA, IMA, and fibular sesamoid position. There was no statistically significant difference between the groups regarding the magnitude of these improvements, validating both techniques.

Authors' contributions: Each author contributed individually and significantly to the development of this article: LLCR *(https://orcid.org/0000-0003-1158-2643) Conceived and planned the activities that led to the study, interpreted the results of the study, and participated in the review process; XNR *(https://orcid.org/0009-0005-9113-3902) Planned the activities that led to the study, interpreted the results of the study, wrote the article, and participated in the review process; LFP *(https://orcid.org/0000-0002-9888-5614) Planned the activities that led to the study, wrote the article, and participated in the review process: VGAR *(https://orcid.org/0009-0001-1903-3289), BG *(https://orcid.org/0000-0001-5273-4303), LLF *(https://orcid.org/0000-0003-1048-7134) and CLTS *(https://orcid.org/0009-0000-1870-352X) Planned the activities that led to the study. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

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