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Original Article

Fourth generation minimally invasive osteotomy with rotational control for hallux valgus: a case series

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Abstract

Objective: Demonstrate the clinical and radiographic results of patients with hallux valgus (HV) treated by a fourth generation minimally invasive technique with rotational control of the first metatarsal.

Methods: Twenty-two patients were included in the study. All patients were women, with 14 right and eight left feet, with a mean follow-up of 15 months (12–18). The radiographic parameters evaluated were the hallux valgus angle (HVA), the intermetatarsal angle (IMA), the sesamoid displacement (Hardy Clapham), and the shape of the lateral edge of the first metatarsal head. The American Orthopaedic Foot and Ankle Score (AOFAS) score, visual analog scale (VAS), and complications were also evaluated.

Results: The HVA improved from the preoperative (26.8°) to the postoperative (4.2°) and the IMA from 13.2° to 2.7°. Regarding sesamoids, in the preoperative, three patients were grade 6, 10 were grade 5, and nine were grade 4. In the postoperative, ten patients were grade 2, and 12 were grade 1. In the preoperative, the lateral edge of the first metatarsal head was intermediate type in 18 patients and round type in four patients. In the postoperative, all patients were classified as angular type. The mean AOFAS increased from 45 to 91 points, and the mean VAS decreased from 6 to 1. The most common complication was surgical scar adherence in four patients.

Conclusion: The fourth generation minimally invasive technique with rotational control presented triplanar correction of the HV deformity. In addition, it provided pain improvement and functional gain with a low rate of complications.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Hallux valgus; Bunion; Minimally invasive surgery; Percutaneous surgery; Triplanar osteotomy; Pronation.

Introduction

Hallux valgus (HV) has been treated as a biplanar deformity with the classic varus deviation of the first metatarsal and associated proximal phalanx valgus[1-3]. Over the years, with the intensification of studies and a better understanding of its physiopathology, it was understood that it is a complex triplanar deformity, also the first metatarsal pronation[2-4].

All components of the deformity must be addressed to achieve success in the surgical treatment, correcting the hallux valgus angle (HVA), the intermetatarsal angle (IMA), and the first metatarsal pronation[3-7]. There are open surgical techniques that directly address these components and achieve a three-dimensional correction[8-10]. Thus far, no percutaneous technique that adequately corrects the first metatarsal pronation has been validated.

Currently, percutaneous osteotomies to correct HV are divided into four generations[11]. In the fourth generation, osteotomy of the first metatarsal neck is transverse and addresses the rotational component indirectly[11]. The only percutaneous technique described in the literature that directly addresses rotational control through a specific guide was described by Nunes and Baumfeld[12]. To date, no case series in the literature evaluating the results of this technique has been published.

Study performed at the Clínica COTE Brasília, Brasília, DF, Brazil.

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The objective of this study is to demonstrate the clinical and radiographic results of patients with HV treated by a fourth generation minimally invasive technique with rotational control of the first metatarsal.

Methods

A case series including 22 patients diagnosed with moderate to severe HV submitted to fourth generation minimally invasive osteotomy with direct rotational control. All patients were submitted to surgery by surgeons specialized in foot and ankle and minimally invasive technique in two tertiary centers from January 2021 to June 2022. The study was approved by the institutional review board and all patients signed the informed consent form and agreed to be included in the study.

Inclusion criteria were patients diagnosed with moderate to severe HV (HVA > 20 and IMA > 11)(13), sesamoid displacement grade ≥ 4 according to Hardy and Clapham classification(14), and intermediate or round shape of the lateral edge of the first metatarsal head as described by Okuda et al.(15). Exclusion criteria were arthrosis of the hallux metatarsophalangeal joint, rheumatological, neurological and vascular disorders, patients who failed to follow the postoperative protocol or who missed a minimum follow-up of 12 months.

All patients were evaluated clinically and radiographically in the pre-and postoperative, with a mean follow-up of 15 months (12–18). Clinical evaluation included the American Orthopaedic Foot and Ankle Score (AOFAS)(16) for the forefoot and the visual analog pain scale (VAS)(17). All complications were documented. Radiographic evaluation was obtained in the anteroposterior (AP) and lateral views with weight-bearing. The HVA, IMA, sesamoid displacement, and the shape of the lateral edge of the first metatarsal head were evaluated. The sesamoid position was evaluated according to the tibial sesamoid position described by Hardy and Clapham(14). Pronation was evaluated according to the classification of Okuda et al.(15). This classification is based on the lateral edge of the first metatarsal head on AP radiographs with weight-bearing. The lateral edge of the first metatarsal head can be classified as angular (type A), intermediate (type I), or round (type R). Type A corresponds to no or mild pronation up to 20°(15). Type I corresponds to moderate pronation between 20° and 30°, and type R corresponds to pronation of 30° or over(15). Two orthopedic foot and ankle surgeons trained and not involved in the surgical procedure performed radiographic evaluation.

Surgical technique

The surgical procedure was performed according to the description of Nunes and Baumfeld (12).

The equipment used was: Beaver blade, Shannon cutter 2×10 mm; Wedge cutter 3.1; High torque and low rotation motor, C-arc fluoroscopy, cannulated screws, and a specific guide for rotational control.

The patient was submitted to spinal anesthesia and sedation and was positioned in the supine position with the feet hanging freely at the end of the table and supported by fluoroscopy.

Pin introduction in the rotational guide

The rotational guide was positioned on the first metatarsal to ensure the proximal component stays under the medial cuneiform and the distal component under the first metatarsal head. Through the rotational guide, pins were inserted into the medial cuneiform and metatarsal head. In the medial cuneiform, the pin must be inserted at the 0º mark. The distal pin was inserted into the first metatarsal head through the rotational guide to be corrected, according to preoperative planning (correction of 10°, 20°, or 30° was possible) (Figure 1).

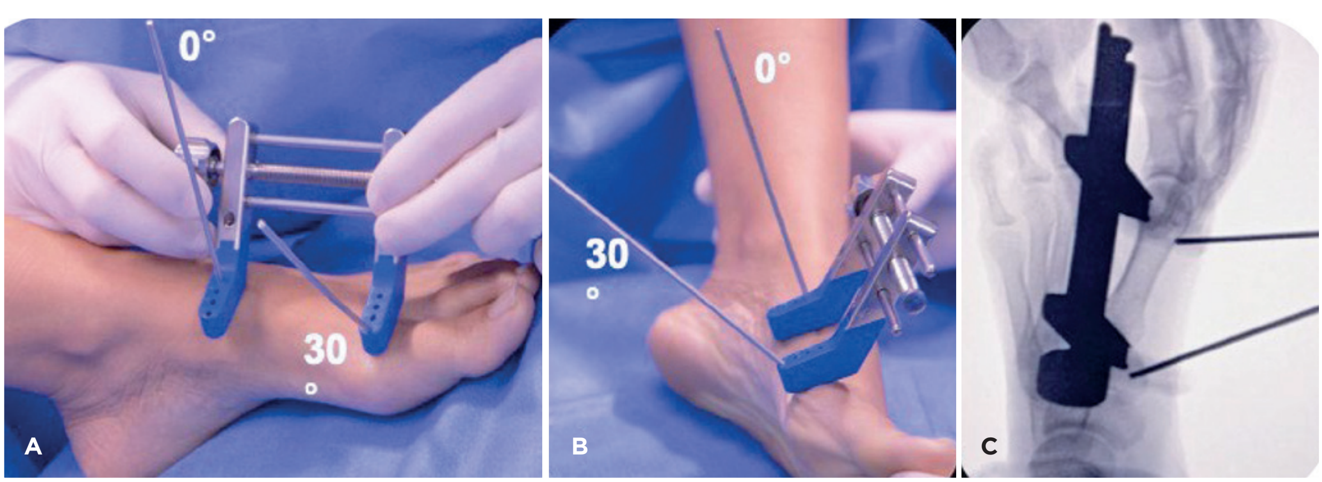

Figure 1. Introduction of rotational pins.

For patients classified type I lateral edge of the first metatarsal head, a correction of 20° was performed, and for type R, a correction of 30°. After the insertion of the pins, the guide was removed.

First metatarsal osteotomy

Through an extracapsular portal, the distal metaphysis-diaphyseal transition of the first metatarsal was established using a beaver blade. Then, a transverse osteotomy was performed using a Shanon cutter 2 x 10 mm (Figure 2).

Reducing and fixation maneuver

The next step was to place two guide wires for 4.0 mm cannulated screws only on the proximal fragment, leaving the metatarsal head free (Figure 3). After introducing the guide wire into the proximal fragment, it proceeded to the reduction maneuver. The first step of reduction is the lateral displacement of the first metatarsal head, which is performed by introducing a blunt instrument into the medullary canal of the first metatarsal (Figure 4).

The second step of reduction was rotational correction. The proximal and distal rotational pins must be fitted back into the rotational guide at the 0° mark. For this to occur, the distal rotational pin previously inserted in the metatarsal head in the rotation to be corrected must be rotated until it reaches the 0° mark in the rotational guide (Figure 5). After the rotational correction of the previously inserted guide wires, only proximal osteotomy fragments were advanced by fixing the distal fragment (Figure 6). The fixation was completed with the introduction of two 4.0 mm cannulated screws (Figure 7). After fixing, the rotational guide and its pins were removed. Through the distal screw portal, the medial diaphyseal prominence was removed with the Shannon cutter 2 x 10 mm (Figure 8).

Akin osteotomy

Akin osteotomy was performed by a mid-axial portal on the medial edge of the proximal phalanx with the Shannon cutter 2 x 10 mm. Then, bone debris removal was performed with abundant saline irrigation. The procedure was completed by closing the surgical incisions and applying a padded dressing and adhesive tape (Figure 9).

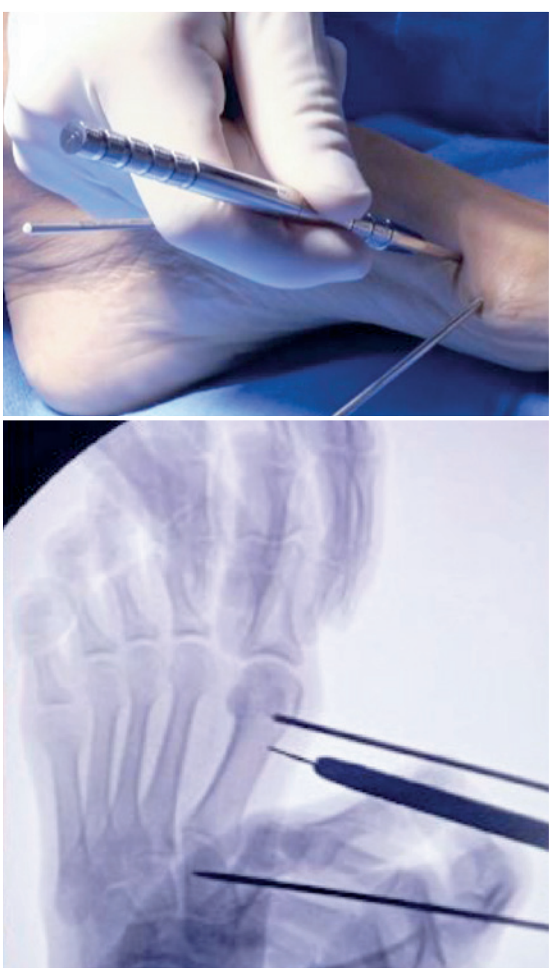

Figure 2. Beaver incision for transverse extracapsular osteotomy.

Figure 3. Positioning of guide wires.

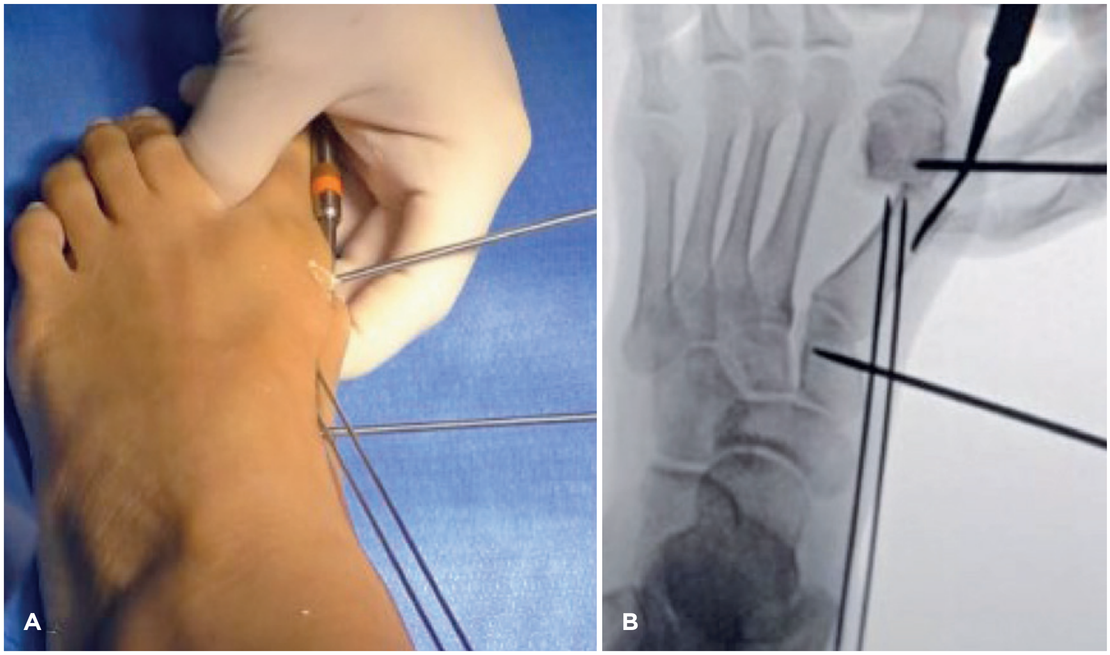

Figure 4. Lateral displacement of the metatarsal head.

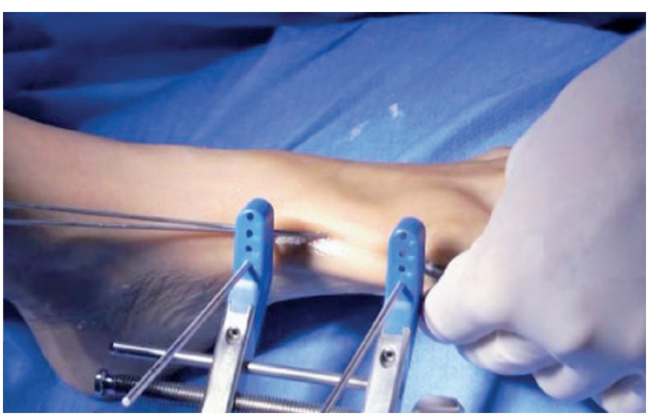

Figure 5. Rotational correction.

Figure 6. Advance of guide wires to distal fragment.

Postoperative protocol

1. Partial support using orthopedic sandals with rigid soles and crutches for six weeks.
2. After the first week, the surgical dressing is replaced with band-aids applied to the portals.
3. Active and passive exercises for the hallux range of motion started in the first week and intensified in the follow-up according to the evolution of the patient.
4. After the sixth week, patients could wear conventional shoes with a wide anterior chamber and rigid soles.
5. Radiographic control was performed at 2, 6, and 12 weeks, and 6 and 12 months.

Statistical Analysis

The SPSS 26 (2019), Minitab 21.2 (2022), and Microsoft Excel 2010 for statistical analysis were used. All variables followed a normal distribution, tested by the Shapiro-Wilks

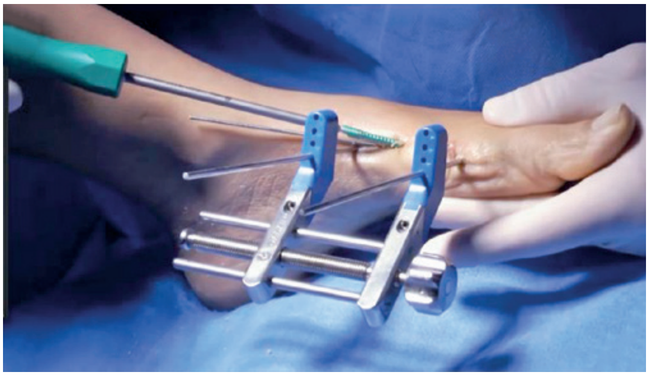

Figure 7. Fixation with two 4.0 mm canullated screws.

Figure 8. Removal of the medial diaphyseal prominence.

test[18]. Student t-test[19] was applied to compare the variables. Variables with a p-value < 0.05 were considered statistically significant.

Figure 9. Pre-and postoperative correction by the fourth generation minimally invasive osteotomy technique with rotational control.

Results

The 22 patients were female, and the mean age was 44 (33–60). Fourteen surgeries were performed on the right foot and eight on the left, with a mean follow-up of 15 months (12-18).

The comparison of the pre-and postoperative radiological variables is shown in Table 1. There was a statistical difference between the pre-and postoperative values of HVA and IMA. Regarding sesamoids, in the preoperative, three patients had grade 6, ten grade 5, and nine grade 4. In the postoperative, ten patients had grade 2 and 12 grade 1. In the preoperative, the lateral edge of the first metatarsal head was type I in 18 patients and type R in four patients. In the postoperative, all patients were classified as type A.

Table 2 shows the pre-and postoperative comparison of clinical variables. There was a statistical difference between the pre-and postoperative values of AOFAS in the forefoot and VAS.

The most common complication was scar adherence, present in four patients. In addition, two other patients reported discomfort with the synthesis material, which needed removal. No cases of infection, pseudoarthrosis, recurrence, or fracture of the medial cortical of the proximal fragment were identified.

Table 1. Pre-and postoperative radiological variables

Variables	Preoperative (mean)	Postoperative (mean)	p-value
HVA	26.8°	4.6°	0.0054*
IMA	13.2°	2.7°	0.0043*

HVA: Hallux Valgus angle; IMA: Intermetatarsal angle
*Statistically significant

Table 2. Mean AOFAS and VAS in the pre-and postoperative

Variables	Preoperative (mean)	Postoperative (mean)	p-value
AOFAS	45	91.1	0.0014*
VAS	6	1	0.0027*

[AOFAS: American Orthopaedic Foot and Ankle Score; VAS: Visual Analog Pain Scale
*Statistically significant.

Discussion

First metatarsal pronation is present in 87% of patients with HV. The importance of its correction is associated with a decrease in the recurrence rate[3,5,20]. There are several ways to evaluate first metatarsal pronation. The best method described in the literature is computed tomography with weight-bearing through the alpha angle[3,21]. Despite being an efficient method, it is not available in all medical centers. Radiography is a more available method that indirectly demonstrates the first metatarsal rotation through the sesamoid position[14,22] and the lateral edge of the first metatarsal head[15].

Radiographic evaluation of first metatarsal pronation is still a controversial method and topic of discussion. Some authors studied the lateral edge of the first metatarsal head and described it as a reliable radiographic method to evaluate the internal first metatarsal rotation[5,15,23]. This indirect radiographic evaluation provides approximate values and should be used only in patients without signs of arthrosis of the hallux since osteophytes may impair the evaluation of the lateral edge of the first metatarsal head[4]. Given this, our study used the lateral edge of the first metatarsal head to calculate the rotation to be corrected and excluded patients over 60 years and those with signs of arthrosis of the hallux metatarsophalangeal or gleno-sesamoid joint. Another indirect radiographic way that can be used to evaluate rotation correction is sesamoid reduction. A strong relationship between high values of first metatarsal pronation with sesamoid classified Hardy Clapham grades 4 and 7 was demonstrated[24].

Some authors have described a technical tip for correcting the first metatarsal rotation using a Kirschner wire attached to the first metatarsal head, using the sesamoid position as a reference[25]. Although it is a good alternative when we do not have a rotational control guide available, it is a subjective technique, as it depends on the surgeon's experience and is based on a fluoroscopic intraoperative image without foot weight-bearing. In addition, the foot's position during fluoroscopy can significantly influence the sesamoid position[1,26,27]. In our study, the rotation to be corrected was evaluated preoperatively, and the rotation correction was controlled intraoperatively through a specific guide. We believe this makes this method more reliable and reproducible, as in the last follow-up of this study, all patients had sesamoid displacement classified as Hardy and Clapham between grade 2 and 1, and the lateral edge of the first metatarsal head grade 0 and 1

The power of correction by percutaneous techniques has already been well established. In a recent case series, 60 patients corrected using the minimally invasive Chevron Akin (MICA) technique were evaluated, which was able to correct the HVA from 41.2° to 11.6°, while the IMA reduced from 17.1° to 6.9°[28]. Another study with a follow-up of two years showed a reduction of HVA from 30.4° to 10.2°[29]. In our study, the correction power was similar, with a reduction of HVA from 26.8° to 4.6º, while the IMA from 13.2° to 2.7°.

An advantage of minimally invasive surgery is the early improvement of pain. Lee et al. conducted a randomized prospective study of 50 patients comparing the clinical and radiographic outcomes of surgical treatment of HV with percutaneous Chevron osteotomy with conventional open osteotomy[30]. The result showed that pain during the acute postoperative phase was statistically lower in the subgroup treated with percutaneous surgery [30]. In addition, Keppler et al. demonstrated a great improvement in VAS from 8.2 to 1.2 at the follow-up of two years in patients treated with the MICA technique[31]. In our study, the findings were similar, with a final mean VAS of only 1 point.

Regarding clinical criteria, several studies reported significant improvement in patients' function[32,33]. Nunes et al. reported preoperative AOFAS of 42.8 and 90 in the postoperative, and Jowett and Bedi obtained an improvement in AOFAS from 56 to 87 points in the postoperative of 106 patients[28,34]. Our series showed a similar improvement, with preoperative and postoperative AOFAS of 45 and 91.1, respectively.

Our study had some minor complications. In four cases (19%) scar adherence was observed in the medial access of the first metatarsal neck. We believe this occurred because this region has little subcutaneous tissue, and the surgical wound mobilization was not performed properly in the postoperative. There were only two cases (9%) with discomfort in the synthesis material needing removal. Other studies show higher incidences of this type of complication, with rates of up to 16%[28].

This study has several limitations. There was a short follow-up time that may be not sufficient to evaluate some complications, especially the recurrence. A greater number of participants with a control group would increase the reliability of the result. The first metatarsal rotation was evaluated by a radiographic method that provides approximate values. The ideal would be the use of computed tomography with weight-bearing. Despite these limitations, this is the first case series in the literature to describe a case series of percutaneous technique that directly addresses the rotation correction of the first metatarsal by evaluating the sesamoid position and the lateral edge of the first metatarsal head.

Conclusion

The fourth generation minimally invasive technique with rotational control used in this study to correct HV deformities presented pain improvement and functional gain with a low rate of complications. In addition, it could perform a three-dimensional correction of the deformity.

Authors' contributions: Each author contributed individually and significantly to the development of this article: GAN *(https://orcid.org/0000-0003-4431-5576), and RR *(https://orcid.org/0000-0002-7411-9720) Conceived and planned the activity that led to the study, wrote the article, participated in the review process; PFSD *(https://orcid.org/0000-0001-7584-8290) Data collection, bibliographic review; GFF *(https://orcid.org/ 0000–0001-8032–3077), and TLL *(https://orcid.org/ 0000–0002-4167–7427), and TBS *(https://orcid.org/0000-0001-9244-5194) Wrote the article, participated in the review process;. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID) .

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