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Original Article

Fixation methods of Chevron osteotomy in percutaneous surgery for hallux valgus: a comparative study

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Abstract

Objectives: Evaluate the results of percutaneous surgery for hallux valgus, comparing three fixation methods of Chevron osteotomy of the first metatarsal.

Methods: Seventy-one feet were submitted to percutaneous surgery with Chevron osteotomy between 2017 and 2022; 41 feet were fixed with screws, 18 with two Kirschner wires, and 12 with one screw and one Kirschner wire. Clinical results were evaluated using the American Orthopaedic Foot & Ankle Society (AOFAS) Hallux Metatarsophalangeal-Interphalangeal Score (MTP-IP). Radiographic outcomes included hallux valgus angle (HAV), intermetatarsal angle (IMA), distal metatarsal articular angle (DMAA), and sesamoid displacement (SD). Patients had a mean follow-up of 25 months.

Results: No statistically significant difference was found among the three groups in the AOFAS score ($p < 0.001$). The means of HVA, IMA, DMAA, and SD decreased from preoperative to postoperative in all techniques similarly. Among the total sample, 17 presented some complications. There was no statistically significant difference in complications among the techniques.

Conclusion: Clinical and radiological results of the three fixation methods for percutaneous Chevron osteotomies were equivalent, with no disadvantage regarding radiographic parameters or increased operative complications.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Hallux Valgus; Bunion; Minimally invasive surgery.

Introduction

Hallux valgus (HV) is the main forefoot pathology, where the hallux deviates laterally in valgus, also by a medial deviation of the first metatarsal head, producing a medial bone protrusion in the first metatarsophalangeal joint region[1]. It mainly affects women due to the great influence of narrow footwear and high heels[2].

Conservative treatment may produce pain relief in patients with HV, but is inefficient to correct the deformity[2]. For this reason, surgical intervention is indicated for symptomatic cases, aiming to realign the first ray, keeping the forefoot biomechanically functional[3,4].

Minimally invasive techniques are commonly chosen as surgical interventions[3]. In HV, these techniques stand out for presenting some advantages over conventional techniques, such as allowing outpatient surgeries with local anesthesia and small or punctate incisions, the non-routine use of synthesis material, the release for immediate postoperative ambulation, in addition to presenting a lower incidence of complications with the surgical wound and lower pain intensity after the procedure[4,5].

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

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The Chevron V-osteotomy, described by Austin e Leventen[6] as an open procedure for HV treatment, is a biplanar bone cut on the transverse and vertical planes with lateral displacement, maintaining stability in the vertical plane. The literature shows good results and, therefore, the most-performed technique worldwide[7]. Vernois and Redfern[8] demonstrated percutaneous osteotomy using fixation with screws in severe cases, which guarantees greater stability when the head displacement of the first metatarsal needs to be greater[9]. It is known that in some services, especially in the Unified Health System (SUS), screws are often not available, and other materials, such as Kirschner wires (K-wire), are routinely used as a substitute for fixing osteotomies. However, no studies have compared the results of Chevron osteotomy fixation using different synthesis materials.

Given the lack of evidence as mentioned above, the objective of the study is to:

- Compare the results of three fixation methods (with two screws, with two K-wires, and combined with a screw and a K-wire) in percutaneous Chevron osteotomy of the first metatarsal, based on radiographic parameters of hallux valgus angle (HAV), intermetatarsal angle (IMA), distal metatarsal articular angle (DMAA), and sesamoid displacement (SD) and clinical results using the American Orthopaedic Foot & Ankle Society (AOFAS) scale[10], in the pre-and postoperative;
- Verify the incidence of reduction in fixation among the groups;
- Correlate the incidence of complications and the different synthesis techniques.

Methods

This study was approved by the Institutional Review Board under the number 70032723.4.0000.5501.

From November 2017 to October 2022, 68 patients were selected from the database of an Orthopedics and Traumatology service, totaling 71 feet with symptomatic HV, classified as moderate to severe, submitted to percutaneous Chevron Osteotomy, fixed with cannulated screws 4.0 and 3.0 mm and/or K-wires 2.5 mm. The procedures were performed by three experienced surgeons and service fellows, always under supervision.

Among the 71 feet submitted to the intervention, 41 were fixed exclusively with screws, 18 only with K-wires, and 12 with combined fixation, using a K-wire and a screw. Follow-up ranged from six months to five years and nine months, with a mean of 25 months. The chosen fixation method determined the allocation in the groups (group S, group W, and group SW). It is important to highlight that the decision on the method was guided by the availability of materials in the service, giving preference to screws whenever they were available. Additional procedures performed simultaneously included a Tailor's bunion foot, 34 metatarsalgias, and 23 claw toes.

Patients with mild HV, rheumatoid arthritis, neuromuscular disorders, bone-degenerative changes of the hallux metatarsophalangeal joint, and previous surgeries in the first ray were excluded.

All participating patients were informed about the objectives of the study and signed the Informed Consent Form, a mandatory criterion for participation in the study.

Clinical and radiographic evaluation in all feet were performed individually and subsequently intergroup. The pre-and postoperative radiographic evaluation (in the anteroposterior and lateral profile with weight-bearing) was performed by two orthopedists (fellows), measuring the HAV, IMA, DMAA, and SD. Clinical and functional evaluation was performed according to the AOFAS scale, with responses collected by the senior orthopedist.

Descriptive analyses were performed by a statistical professional. For categorical variables, absolute and relative frequencies were presented, and for numerical variables, summary measures (means and standard deviation). The existence of associations between two categorical variables was verified using Fisher's exact test. The distributions of a categorical variable between two evaluation moments were compared using McNemar's test.

Mixed linear regression models were used to evaluate the effects of time and technique on each dependent variable (AOFAS, HAV, IMA, and DMAA). A significance level of 5% was used for all statistical tests. Analyses were performed using the statistical package SPSS 20.0 and STATA.

Surgical Technique

The surgical technique, already consolidated and published in the literature, was performed as described by Vernois and Redfern[8], and the specific fixation characteristics of each group are detailed below.

In patients in group S, two cannulated screws introduced from medial to lateral were used to stabilize the osteotomy. The proximal screw went through the two cortical of the first metatarsal before reaching the head, making a tricortical fixation. The second screw was positioned distally and parallel to the first (Figure 1).

As described above, the surgical technique for inserting the synthesis material was performed in groups W and SW. In group W, two K-wires of 2.5 mm were used (Figure 2), while in group SW, a K-wire of 2.5 mm and a screw were used, as shown in Figure 3.

Percutaneous release of the lateral soft tissues (adductor tendon of the hallux and lateral capsule) was performed in all patients to minimize the risk of recurrence.

After osteotomy and fixation of the first metatarsal and lateral release, the relevance of performing the Akin osteotomy[11] in the proximal phalanx was analyzed. In most cases (84.5), this osteotomy was performed, except in six cases where proper alignment had already been achieved.

Figure 1. Fixation with two screws: the proximal screw crosses three cortical, while the second, more distal, two cortical.

The incisions were sutured with 4.0 Nylon thread, and the compressive dressing was performed. Weight-bearing was released from the first postoperative day with a rigid sole sandal. The dressing was changed weekly during the first four weeks by the surgical team and the patient or companion for the next two weeks. The k-wires used in groups S and SW were removed six weeks after surgery.

It is important to highlight that the degree of head translation was performed according to the severity (moderate/severe), regardless of the synthesis used.

Results

Considering the information of the 71 feet analyzed, whose mean age was 54 years (ranging from 16 to 80 years), with a predominance of females (89%), the radiographic parameters in the pre-and postoperative period of each group were evaluated, considering the means of HAV, IMA, and DMAA as shown in Table 1 and Figures 4 to 6.

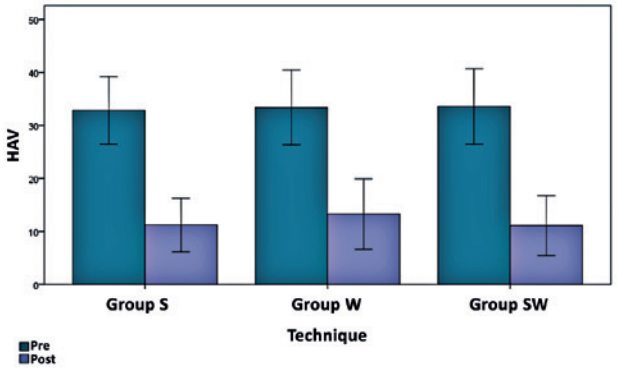
Figure 2. Fixation with K-wires: A: Preoperative radiograph; B: Preoperative clinical image; C: Fixation with K-wires; D: Radiograph with nine postoperative months, showing optimal consolidation; E: Clinical image with six postoperative weeks.

Figure 3. Fixation with K-wire and screw: A: Preoperative clinical image; B: Preoperative radiograph; C, D: Clinical image and radiograph with four postoperative weeks.

Table 1. Summary measures of AOFAS, HAV, IMA, and DMAA by technique

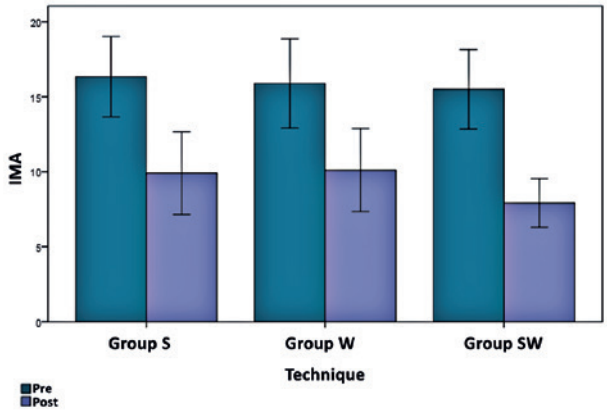
	Technique				p-value		
	Group S (N = 41; 57.7%)	Group W (N = 18; 25.4%)	Group SW (N = 12; 16.9%)	Total (N = 71; 100.0%)	Technique	Period	Technique vs. Period
AOFAS					0.468	< 0.001	0.850
Pre	38.93 ± 12.37	41.89 ± 13.79	43.00 ± 15.92	40.37 ± 13.29			
Post	89.44 ± 10.40	89.78 ± 11.43	93.33 ± 9.17	90.18 ± 10.43			
Post-Pre	50.51 ± 16.75	47.89 ± 18.44	50.33 ± 21.04	49.82 ± 17.71			
HAV					0.905	< 0.001	0.617
Pre	32.83 ± 6.38	33.39 ± 7.05	33.58 ± 7.14	33.10 ± 6.59			
Post	11.22 ± 5.08	13.28 ± 6.66	11.08 ± 5.66	11.72 ± 5.60			
Post-Pre	-21.61 ± 6.92	-20.11 ± 7.71	-22.50 ± 6.57	-21.38 ± 7.02			
IMA					0.580	< 0.001	0.307
Pre	16.34 ± 2.68	15.89 ± 2.97	15.50 ± 2.65	16.08 ± 2.73			
Post	9.90 ± 2.76	10.11 ± 2.76	7.92 ± 1.62	9.62 ± 2.69			
Post-Pre	-6.44 ± 3.12	-5.78 ± 2.96	-7.58 ± 3.92	-6.46 ± 3.23			
DMAA					0.565	< 0.001	0.300
Pre	22.63 ± 7.74	22.56 ± 7.99	20.42 ± 8.03	22.24 ± 7.78			
Post	11.66 ± 4.94	9.61 ± 5.24	12.00 ± 5.62	11.20 ± 5.14			
Post-Pre	-10.98 ± 7.67	-12.94 ± 7.72	-8.42 ± 9.51	-11.04 ± 8.03			

p: descriptive level of the mixed linear model.



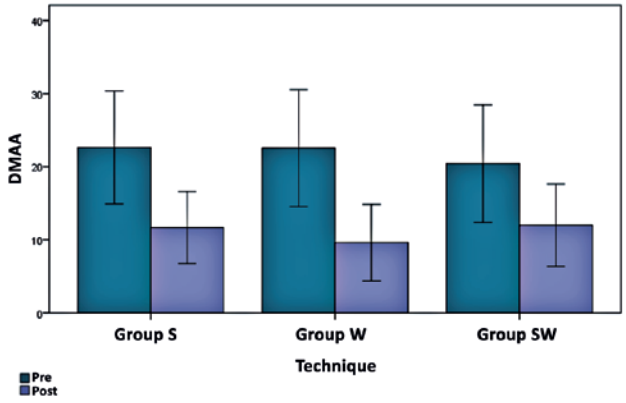
Mean ± SD
Time effect: p < 0.001, Technique effect: p = 0.905, and Technique effect on post-pre variation = 0.617.

Figure 4. HAV means by technique and period of evaluation.



Mean ± SD
Time effect: p < 0.001, Technique effect: p = 0.580, and Technique effect on post-pre variation = 0.307.

Figure 5. IMA means by technique and period of evaluation.



Mean ± SD
Time effect: p < 0.001, Technique effect: p = 0.565, and Technique effect on post-pre variation = 0.300.

Figure 6. DMAA means by technique and period of evaluation.

As for SD, there were no different distributions by technique (p = 0.598). Table 2 shows the position of the sesamoid reached in the postoperative period in the three groups regarding the displacement's improvement, maintenance, or worsening.

Regarding the clinical parameters, an increase in the AOFAS score was observed in all groups when comparing the pre- and postoperative periods, according to Table 3, without presenting a statistical difference among the techniques (Figure 7).

There was no loss of correction in either the immediate or late postoperative period and no loss of the reduction after removing the K-wire in groups S and SW. There was also no difference between the groups regarding the severity of the deformity, percentage of translation, and complications.

Table 2. Position of the sesamoid by technique in the postoperative period

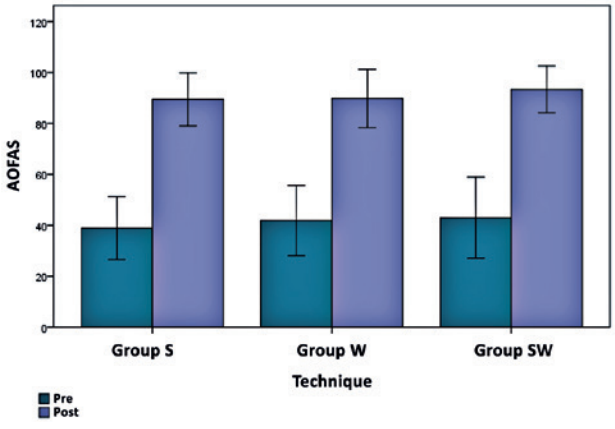
	Technique			p-value
	Group S (N = 41; 57.7%)	Group W (N = 18; 25.4%)	Group SW (N = 12; 16.9%)	
Sesamoid displacement				0.598
Improvement	34 (82.9)	14 (77.8)	11 (91.7)	
Maintenance	7 (17.1)	3 (16.7)	1 (8.3)	
Worsening	0 (0.0)	1 (5.6)	0 (0.0)	

The sum of the percentages may not total 100.0% due to rounding.
p: descriptive level of Fisher's exact test.

Table 3. Pre-and postoperative AOFAS by technique

	Mean	SD	Min	Max	Median	N
AOFAS - pre	**40.37**	**13.285**	**15**	**70**	**39**	**71**
Group S	38.93	12.372	15	65	39	41
Group W	41.89	13.792	25	69	40	18
Group SW	43	15.92	20	70	41	12
AOFAS - post	**90.18**	**10.433**	**49**	**100**	**95**	**71**
Group S	89.44	10.404	53	100	95	41
Group W	89.78	11.425	49	100	92.5	18
Group SW	93.33	9.168	72	100	97.5	12

SD: Standard deviation; Min: Minimum; Max: Maximum.



Mean ± SD
Time effect: p < 0.001, Technique effect: p = 0.468, and Technique effect on post-pre variation = 0.850.

Figure 7. AOFAS means by technique and period of evaluation.

As for complications, no different percentages per technique were found (p = 0.931). Of the total sample, 23.9% had some complications (Table 4). Complications were stratified according to the adapted classification of surgical complications for orthopedic surgery by Clavien-Dindo[12], a system that evaluates the severity of surgical complications.

In group S, the most frequent complications were related to the synthesis material, with three cases of screw migration (Figure 8) and three cases of pain in the screw head. In cases where the screw caused pain, it was removed. In addition, in this group, other complications were observed, such as fracture of the cortical bone, complex regional pain syndrome (CRPS), and a case of recurrence. In total, this group had complications of 26.8%, with classifications, according to Clavien-Dindo, ranging from 2 to 3b (Table 4).

When analyzing group W, a complication rate of 22.2% was observed, also classified from 2 to 3b. As in group S, most of these complications were associated with the synthesis material, with three early removals of one of the K-wires. Of these removals, two were due to proximal migration and one due to pain at its insertion site.

In the SW group, two complications were identified: a case of pain in the screw head, which needed to be removed, and another case of skin necrosis at the incision site, which evolved to complete resolution. These complications accounted for 16% of this group.

Discussion

The minimally invasive Chevron Akin (MICA) technique with percutaneous fixation is indicated in the surgical treatment of HV with moderate and severe deformities. The choice of this technique is due to the greater correction of HV and intermetatarsal angle. These corrections occur due to the head lateral displacement of the first metatarsal, up to 100%, associated with the fixation of this osteotomy[8]. Although some studies show different fixation methods of percutaneous Chevron osteotomy, comparing them is still a matter of discussion.

Table 4. Distribution of complications by group

	Group S (N = 41; 57.7%)	Group W (N = 18; 25.4%)	Group SW (N = 12; 16.9%)	Total	p-value
K-wire/screw removal	3 (7.31%)	1 (5.55)	1 (8.33)	5 (7.04)	**1.000**
Material migration	3 (7.31%)	1 (5.55)	0 (0.0)	4 (5.63)	**1.000**
Cortical bone fracture	2 (4.87%)	1 (5.55)	0 (0.0)	3 (4.22)	**1.000**
CRPS	1 (2.43%)	0 (0.0)	0 (0.0)	1 (1.40)	**1.000**
Skin necrosis	1 (2.43%)	0 (0.0)	1 (8.33)	2 (2.81)	**0.385**
Recurrence	1 (2.43%)	0 (0.0)	0 (0.0)	1 (1.40)	**1.000**
Hallux hypoesthesia	0 (0.0%)	1 (5.55)	0 (0.0)	1 (1.40)	**0.430**
TOTAL	**11 (26.8%)**	**4 (22.2)**	**2 (16.0)**	**17 (23.9)**	**0.931**

CRPS: complex regional pain syndrome.

Figure 8. Complications: A: Proximal screw migration; B: Result after screw removal.

The most available fixing material for performing percutaneous surgeries in the SUS is the K-wires, which have lower costs and higher and easier technical handling[13,14]. However, when screws are available, we choose them, following the classical approach of MICA technique.

Due to the variability of fixation materials, the study was divided into three groups: group S, fixed with screws; group W, fixed with K-wires; and group SW, a screw and K-wire. Due to the retrospective study design, the quantitative distribution of patients into the groups was heterogeneous. Such distribution was based on the choice of fixation material.

Our results corroborated previous findings[15,16], indicating that both K-wire and screw fixation resulted in comparable functional and radiological outcomes. In the analysis performed, the choice of implant did not affect the conduct of the surgical technique, and it was performed according to the severity and specific needs of each case.

There was no loss of correction in the immediate or late postoperative period and after removal of the K-wire. No significant disparities were identified among the groups regarding deformity severity, translation amount, and complication incidence.

Regarding the radiographic angles, there was a reduction in the means in the three techniques. The reductions were similar in the three angles analyzed, showing that all fixation methods were effective in maintaining HV correction. Better results, however, were observed in the HAV and IMA in the SW group (22.5º and 7.58º, respectively) and the DMAA in the group W (12.94º), although without statistical significance among the groups. These results indicate that the mean correction of angles was consistent with the findings of several previous studies[17-24].

As for the DMAA, the mean value obtained was 10.8°. Some studies did not evaluate the referred angle, including the studies by Carlucci et al.[25], Carvalho et al. [22], and Nunes et al. [21], with results similar to ours (8°, 8.5°, and 10.2° respectively). Regarding the sesamoids, there was a significant reduction in severe cases, changing to mild and moderate deformities in the postoperative period. This reduction was observed in the three fixation techniques, indicating their effectiveness. The study by Ferreira et al.[17] showed similar results, with good postoperative correction. However, in the literature, the evaluation of the sesamoid position was not frequently evaluated[18,19,22].

Regarding the AOFAS score, there was a significant functional improvement of the foot after surgery, with an increase in postoperative values in the three groups (mean: 40.4 to 90.2), similar to other studies[19,21,22].

In the total sample, 23.9% of patients had some complications, such as removal of material (Clavien-Dindo 3b), migration of the synthesis material (Clavien-Dindo 2), fracture of the medial cortical (Clavien-Dindo 2), CRPS (Clavien-Dindo 2), skin necrosis (Clavien-Dindo 2), recurrence of HV (Clavien-Dindo 3b), and hallux hypoesthesia (Clavien-Dindo 2) stand out (Table 4). When analyzing the groups separately, a varied distribution of complications was observed, highlighting that most were classified as Clavien-Dindo 2 and 3b in all groups, indicating complications that required observation

or surgical intervention to remove the synthesis material without implying a risk of death or sequelae.

There were no significant differences among the groups. In all of them, the synthesis material was the main motivator of patient's complaints, often requiring their removal, as also evidenced in other studies[18,19,21,22,25]. Despite the eventual removal, there was no interference in the clinical and radiographic results. Another complication observed was the screw migration in 7.3% of the cases, the same reported by Carvalho et al.[22].

In a single case, the deformity recurred late, and the patient was submitted to a new surgical procedure. Hallux valgus recurrence and neuropraxia of the medial dorsal cutaneous nerve are relevant complications to be considered in minimally invasive surgeries. In our analysis and the studies by Nunes et al.[21] and Carvalho et al.[22], a low percentage of such complications was observed. Lewis et al.[18], in a recent study with a two-year follow-up, also reported a recurrence rate of 0.9%.

Armstrong et al.[26] evaluated the results of 69 patients regarding immediate postoperative morbidity, structural correction, and long-term range of motion after fixation with a single K-wire and a cortical screw. They observed that fixation with K-wire and rigid internal screws was effective, presenting good consolidation, low morbidity, and adequate stability.

It is relevant to note that the availability of fixation materials can influence the choice of technique in specific clinical contexts, as in this sample, performed in a public hospital. The significant improvement in the quality of life of patients submitted to minimally invasive surgery to correct HV justifies the continuation of these procedures to correct moderate and severe deformities.

However, we recognize that this study has limitations, including its retrospective design and the heterogeneity in the distribution of patients among the fixation groups. Therefore, future studies with larger samples, adequate randomization, and longer follow-up are needed to provide more robust evidence and guide the choice of fixation technique in the HV treatment.

In summary, based on the results of this comparative study, the three fixation techniques were effective in angular correction and displacement of the sesamoid associated with HV. Most complications were resolved in the short term and did not interfere with correction.

Conclusion

The three fixation methods effectively corrected the angular deformities associated with hallux valgus. The choice among these methods did not significantly influence the clinical and radiological results. Although material-related complications were observed, the groups had no statistically significant differences.

Authors' contributions: Each author contributed individually and significantly to the development of this article: NRX *(https://orcid.org/0009-0005-9113-3902) Conceived and planned the activity that led to the study, wrote the article, participated in the review process; LCRL * (https://orcid.org/0000-0003-1158-2643) data collection, bibliographic review; GARV *(https://orcid.org/0009-0001-1903-3289) formatting of the article, bibliographic review; FPL *(https://orcid.org/ 0000-0002-9888-5614) Interpreted the results of the study, participated in the review process; GB *(https://orcid.org/ 0000-0001-5273-4303) Performed the surgeries; data collection, statistical analysis. LFL * (https://orcid.org/ 0000-0003-1048-7134) MMDC *(https://orcid.org/ 0000-0002-6180-5158) AHSG *(https://orcid.org/0009-0002-8103-2903) https://orcid.org/0009-0002-8103-2903) MFS *(https://orcid.org/0009-0008-3726-775X) LTSC *(https://orcid.org/ 0009-0000-1870-352X). All authors read and approved the final manuscript.*ORCID (Open Researcher and Contributor ID).

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