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Original Article

Percutaneous Intra-articular Chevron Osteotomy (PeICO): clinical and radiographic outcomes

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Abstract

Objective: Hallux valgus (HV) is a complex deformity with several surgical treatments described, and percutaneous methods are increasingly used. The objective of the study was to evaluate the clinical and radiographic outcomes of patients with mild or moderate HV submitted to surgical treatment using the Percutaneous Intra-articular Chevron Osteotomy (PeICO) technique.

Methods: A retrospective case series of 15 patients (18 feet) diagnosed with mild or moderate HV submitted to surgical treatment by the PeICO technique. Clinical variables analyzed were pain using the visual analog scale (VAS), function using the American Orthopaedic Foot and Ankle Society (AOFAS), personal satisfaction, and surgical complications. Radiographic parameters measured in the pre-and postoperative were hallux valgus angle (HAV), intermetatarsal angle (AIM), sesamoids position, and osteotomy consolidation.

Results: The mean follow-up time was 14 months. There was an improvement in clinical outcomes, with a mean increase in AOFAS of 31.1 and a reduction of 5.6 in VAS, with significant differences between the pre-and postoperative values ($p < 0.001$). There was also a significant radiographic correction in the HVA and AIM ($p < 0.001$). The most common complication observed was screw removal in three cases (16.6%).

Conclusion: The PeICO technique presented excellent radiographic correction, clinical improvement, high personal satisfaction, and low complication rate when used for the surgical treatment of mild or moderate hallux valgus.

Level of Evidence IV; Cases series; Retrospective Study.

Keywords: Hallux valgus; Minimally invasive surgical procedures; Reproducibility of results; Treatment outcome.

Introduction

Hallux valgus (HV) is a complex deformity in which a lateral deviation of the hallux is associated with a medial deviation and pronation of the first metatarsal[1]. Despite the various surgical techniques described in the literature to treat this pathology, there is still no consensus on the best approach. In the last decade, minimally invasive surgery (MIS) has been improved and has shown promising results in treating HV[2,3].

Distal open Chevron osteotomy is accepted as a well-established method for correcting mild to moderate HV[4]. Despite the several publications presenting good clinical and radiographic results of this classic approach, there are reports of complications related to soft tissue healing[5].

The MIS approach for treating HV proved to be a safe and effective method. In addition to providing adequate correction of forefoot deformities, MIS provides greater postoperative comfort, lower pain intensity, and lower risk of healing-related complications[6]. Due to these advantages, some osteotomies used for the open surgical treatment of HV have been adapted to the MIS[7]. Del Vecchio et al.[8] recently developed the classic Distal open Chevron technique for the

Study performed at the Rede Mater Dei de Saúde, Belo Horizonte, MG, Brazil.

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minimally invasive approach, the Percutaneous Intra-articular Chevron Osteotomy (PeICO). The PeICO is an intracapsular percutaneous "V" osteotomy of the first metatarsal (1MT) with an angle of 90º at its apex in the center of the head of the 1MT and fixed with screws. The only difference between the PeICO technique and the classic Chevron osteotomy is the access approach. In addition to maintaining the advantages of Chevron osteotomy, PeICO is performed minimally invasively, causing less aggression to the soft tissue. The anatomical bases of PeICO were performed through a cadaveric study, increasing the credibility of the procedure. In addition, the authors who described the technique published excellent clinical and radiographic results through a case series of patients with VH treated using the PeICO technique. Despite the promising results, the procedure is still recent, and more studies are needed to corroborate the findings and evaluate the effectiveness and reproducibility of the technique.

The objective of the study is to evaluate the clinical and radiographic outcomes of patients with mild or moderate HV submitted to surgical treatment using the PeICO technique. We hypothesize that the technique demonstrates good correction capacity in the studied population and improves pain and function.

Methods

The study was approved by the Institutional Research Board and followed the guidelines of good clinical practice and the Declaration of Helsinki. All included patients read and signed the informed consent form. We retrospectively evaluated 15 patients (18 feet) diagnosed with mild or moderate HV submitted to the PeICO technique between December 2019 and August 2020. The patients were operated on by the authors, who have training and experience in minimally invasive foot and ankle surgery.

Patients over 18 years of age who had symptomatic HV classified as mild or moderate and who had pain for at least six months without improvement with conservative treatment (adaptation of shoes and anti-inflammatory medication) were included. The degree of deformity was based on the hallux valgus angle (HVA), intermetatarsal angle (IMA), and the sesamoids position through anteroposterior (AP) radiographic analysis of the foot with support, according to the classification of Mann and Coughlin[1] (Table 1). Exclusion criteria were previous surgery in the hallux, symptomatic arthritis of the metatarsophalangeal (MTP) joint of the hallux, concomitant deformities of the hind and midfoot that required surgical treatment, and rheumatological and neurological diseases.

The preoperative clinical evaluation consisted of the hallux scale of the American Orthopedic Foot and Ankle Society (AOFAS)[9] and the visual analog scale (VAS)[10]. In the last evaluation, patients answered the AOFAS, VAS, and satisfaction with the procedure using the Coughlin scale (excellent, good, regular, bad, or very bad).

Radiographic evaluation was obtained at 6, 12, 24, and 48 weeks postoperatively. The variables evaluated were HVA, IMA, the sesamoids position, radiographic consolidation, migration of synthesis material, loss of reduction, and recurrence of the deformity.

Surgical technique and postoperative care

Under spinal anesthesia and sedation, patients were positioned in the supine position with their feet hanging, with the operated foot supported on the image intensifier without the use of a tourniquet. We use specific instruments for the percutaneous technique, such as the scalpel blade and cutters.

The portal (P1) was performed at the limit between the proximal 1/3 and distal 2/3 of the 1MT head, followed by the dorsomedial release of the joint capsule (Figure 1). Then, a 2.0mm Kirschner wire was inserted percutaneously in the medial region of the distal phalanx of the hallux up to the level of the MTP joint (Figure 2A), the wire served to maintain the temporary reduction of the osteotomy. Next, a 2.0 mm Shannon-type drill was inserted into the 1MT head in the medial-lateral direction, creating the apex of the osteotomy (Figure 2B). Then, the dorsal limb was created at a 10º to 20º angle, proximal to the axis of the 1MT.

Table 1. Hallux valgus classification, according to Mann and Coughlin, 1996

	Normal	Mild	Moderate	Severe
HVA	< 15	< 20	< 40	> 40
IMA	< 9	< 11	11–16	> 16
Sesamoid position		< 50%	50%–75%	> 75%

HVA: Hallux valgus angle; IMA: Intermetatarsal angle.

Figure 1. Portal P1.

The plantar limb was performed at a 90º angle to the dorsal limb and parallel to the ground, ending the osteotomy. The next step was to perform the lateral translation of the 1MT head (up to 50%), introducing an angular instrument through the portal P1 (Figure 3) in the midline of the metatarsal to avoid angular deviation in the sagittal plane (it is important at this moment to perform fluoroscopic control in the profile of the foot). Through a dorsomedial portal (P2 - approximately 15mm proximal and 3mm dorsal to P1), we inserted the screw guidewire in the dorsal-medial to plantar-lateral direction, forming a 45º angle in the AP view (Figure 4).

The fixation was performed using a 3.0mm conical screw (Figure 5). The remaining bunion resection was performed by the P2 portal using a 3.0mm wedge-type drill. Finally, through a dorsolateral portal in the MTP joint (P3), the tenotomy of the adductor of the hallux was performed, and lateral capsulotomy displacing the hallux medially promoting

Figure 2. (A) Insertion of Kirschner wire. (B) Position of the osteotomy cutter.

Figure 3. Lateral head translation.

Figure 4. Temporary stabilization of osteotomy with a guidewire.

a varus and introducing the scalpel with the lateral cutting face and deeply. Ultimately, we performed copious irrigation through the portals to remove bone debris and suture the portals using nylon 4.0.

The dressing was changed weekly until the fourth week by the medical team, keeping the hallux positioned in varus for the first two weeks and neutral for the remaining. From then on, the patient should use a silicone toe spacer until the sixth week after surgery, when the first radiographic control was performed (Figures 6 and 7). Then, an immediate full load with rigid sandals was released for six weeks, and after this period, the patient was allowed to wear the shoes of their choice. There was no prescription for physiotherapy, and the patients were instructed to perform passive hallux flexion and extension from the second week postoperatively.

Statistical analysis

Statistical analysis was performed using the R software[11]. Continuous variables were measured through descriptive statistics by the mean, minimum, and maximum, and the Shapiro test was used for their distribution[12]. Categorical variables were described by their proportion.

The analysis of continuous variables between the pre-and postoperative was performed using the paired Wilcoxon signed rank test (non-parametric variables distribution) and the paired Student's t-test (parametric variables distribution). Pearson's Chi-square test was used to compare categorical variables[13]. A p-value ≤ 0.05 was adopted as the level of statistical significance.

Results

Fifteen patients were included, totaling 18 feet. Most patients were female (10), representing 66%. The mean age of the patients was 49 years (range 30–62), and the mean follow-up time was 14 months (range 12–18). The distribution regarding laterality was equal between the right and left feet. In thirteen feet (72.7%) the HV was classified as moderate.

The clinical and radiographic evaluation can be seen in Table 2. The clinical outcomes showed statistically significant differences between the pre-and postoperative values, with a mean increase in AOFAS of 31.1 and a reduction of 5.6 in VAS.

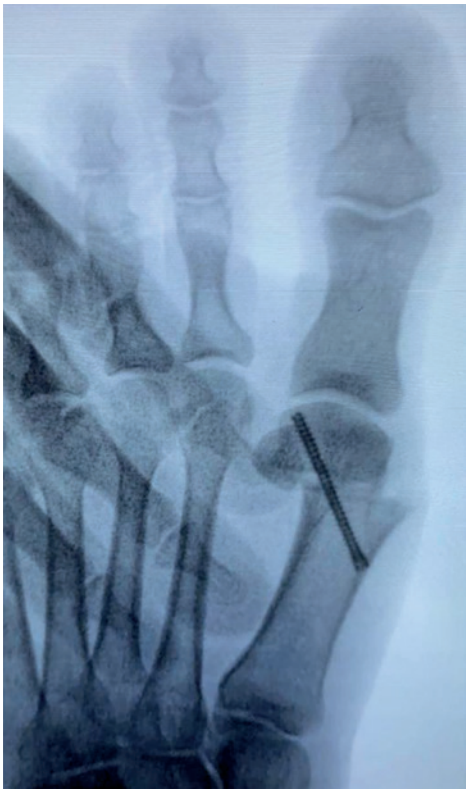

Figure 5. Fixing with a conical screw.

Figure 6. (A) Preoperative radiograph in AP. (B) Preoperative radiograph in profile.

Regarding personal satisfaction with the surgical result, according to the Coughlin score[14], 80% of patients considered the final result excellent and 20% good. No patient considered the final result regular or bad.

There was also a statistically significant difference in the pre-and postoperative radiographic analyses ($p < 0.001$), observing a mean reduction in HVA of 15.8º and IMA of 6.3º. The pre-and postoperative sesamoids position is described in Table 3. Osteotomy was consolidated in all cases.

No patient had a superficial or deep infection, skin complications, necrosis, or surgical wound dehiscence. There were no transfer metatarsalgia, hallux varus, necrosis, or vicious head consolidation in the sagittal plane. Because it is an intra-capsular osteotomy, a higher degree of stability and, therefore, a lower chance of undesirable deviations is inferred.

Figure 7. (A) Six weeks postoperative radiograph in AP. (B) Six weeks postoperative radiograph in profile.

Complications

The most common complication was screw removal in three cases (16.6%) due to local discomfort. The synthesis material was removed, when necessary, after a minimum of six months and with the osteotomy consolidated through radiographic analysis. There was complete remission of symptoms after the procedure. Two patients (10%) had medial dorsal cutaneous nerve neurapraxia, which improved spontaneously during follow-up. There were no major complications or need for surgical revision.

Discussion

Our study presented the clinical and radiographic results of a case series of patients with mild to moderate HV submitted to surgical treatment using the PeICO technique. There was a radiographic improvement with HVA and IMA reduction and the sesamoids position. In addition, clinical outcomes were favorable, with significant improvement in pain and increased quality of life, according to the VAS scale and AOFAS score. The most common complication was screw removal in three patients (16.6%).

The first published study of the PeICO technique[15] demonstrated only radiographic outcomes. The authors observed a mean reduction in HVA of 25.8º, ranging from 33.9º in the preoperative to 8.1º in the postoperative. The mean preoperative IMA angle was 12.4º to 8.1º (reduction of 4.3º) in the postoperative. Subsequently, Del Vecchio et al.[16] evaluated 114 feet using the PeICO technique, obtaining a mean reduction of 17.1º in HVA and 4.6º in IMA. Our study reproduced these radiographic results with a mean reduction of 15.º in HAV and 6.3º in IMA.

Table 2. Pre- and postoperative clinical and radiographic evaluation

Outcome	Pre (med, min, and max)	Post (med, min, and max)	Difference between pre and post	p-value
HVA	21.2 [15–32]	5.4 [1–9]	15.8	< 0.001
IMA	11.0 [8–14]	4.7 [1–9]	6.3	< 0.001
AOFAS	62 [52–78]	93.1 [80–100]	31.1	< 0.001
VAS	6.3 [5–8]	0.7 [0–2]	5.6	< 0.001

Pre: Preoperative; Post: Postoperative, Med: Median; Min: Minimum; Max: Maximum.

Table 3. Pre-and postoperative sesamoids position

Degree	Preoperative	Postoperative
0	0	15 (83.3%)
I	12 (66.7%)	2 (11.2%)
II	5 (27.8%)	1 (5.5%)
III	1 (5.5%)	0

Statistical analysis using the Chi-square test ($p < 0.001$).

Regarding the clinical outcomes of Del Vecchio et al.[16], they presented a mean increase of 39 points in AOFAS and a mean reduction of 5.3 points in VAS, confirming an improvement in pain and function. Our study also showed similar results, with a mean increase of 39 points in AOFAS and a mean reduction of 5.3 points in VAS. Personal satisfaction with the surgical outcome was also similar between studies, and most patients considered the result excellent.

Another important finding of our case series was evaluating the sesamoids position. The inadequate postoperative sesamoids position is considered a predictive factor for the recurrence of the deformity[17,18]. In our study, 83.3% of patients had a complete sesamoid position at the end of the procedure, which was maintained until the end of follow-up. Despite this, it is important to reiterate that this series evaluated mild and moderate deformities, and most patients had a slight change in the sesamoid position (classified as grade 1) preoperatively.

The main complication of this series was the screw removal, performed in three cases (16.6%) due to local discomfort. Screw removal is a frequent indication in percutaneous procedures for HV correction, ranging from 10%–24%[19,20]. After removal, there was a complete remission of symptoms. Despite the high implant removal rate, using a rigid internal fixation brought excellent radiographic results, and no cases of delayed consolidation or pseudoarthrosis were observed. Some studies of percutaneous osteotomies without fixation or fixed only with flexible wires have reported higher complication rates related to osteotomy consolidation[21].

The mean recurrence rate with chevron osteotomies is 19.1% (range 0%–75.6%)[22]. Recurrence is defined as the clinical development of HV after surgical correction[23]. All patients in our study submitted to the PeICO technique maintained joint consolidation, alignment, and sesamoid position until the end of follow-up, and no recurrences were identified.

Despite the good results obtained, the PeICO technique for mild and moderate HV correction is not free of complications, and the main are screw removal, praxis of the medial dorsal cutaneous nerve, and rigidity of the halux phalangeal metatarsal joint.

This study has several limitations. Firstly, it is a case series with a small sample. In addition, the follow-up period is relatively short, and the lack of a control group limits the comparison with other techniques and a reliable evaluation of the HV recurrence rate.

Conclusion

The PeICO technique presented excellent radiographic correction, clinical improvement, high personal satisfaction, and low complication rate when used for the surgical treatment of mild or moderate hallux valgus. Comparative studies with the open technique and larger sample are needed to consolidate the PeICO technique further.

Authors' contributions: Each author contributed individually and significantly to the development of this article: JMBM *(https://orcid.org/0000-0002-4224-8149), and GFF *(https://orcid.org/0000-0001-8032-3077), and DS Conceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process; RCB *(https://orcid.org/0000-0003-4923-8370); BMB *(https://orcid.org/0000-0003-3712-1247), and RZ *(https://orcid.org/0000-0001-9692-5283) GAN *(https://orcid.org/0000-0003-4431-5576) Participated in the review process. All authors read and approved the final manuscript.*ORCID (Open Researcher and Contributor ID).

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