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Original Article

A new minimally extended distal Chevron osteotomy (MEDCO) with percutaneous soft tissue release (PSTR) for treatment of moderate hallux valgus

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ABSTRACT

Purpose: Surgical treatment of moderate hallux valgus (HV) onwards by Chevron osteotomy and all variants described to date including the recent extended distal Chevron osteotomy (EDCO), yields improvable outcome but with recurrence rate. A new modification of this technique is needed to achieve better results.
Methods: 34 consecutive female patients suffering from moderate HV underwent a new minimally extended distal Chevron osteotomy (MEDCO) with percutaneous soft tissue release (PSTR). Outcome was assessed using pre-post operative VAS-Pain, AOFAS Hallux Score and radiological measurements. Mean age was 53.7 years, follow-up 2.7 years and satisfaction score 8.
Results: VAS improved from 7 to 1 ($p < 0.001$) and AOFAS score from 64 to 90.7 ($p < 0.001$). Comparing postoperative HV and intermetatarsal (IM) angles of previous studies (either employing a Chevron osteotomy alone or a double Chevron-Akin) with our results, an improvement from 15.6/14.8 to 9.1 and 8.2 /8.8 to 5.6 respectively ($p < 0.05$) was achieved. Complication and recurrence rates were both 5.8%, lower than the documented rates of other techniques.
Conclusion: The modified technique in the present study was found to be a more effective and reliable method of correcting hallux valgus when compared to other previous procedures. It provides a higher level of satisfaction and excellent outcomes with low complication and recurrence rates. Furthermore, the percutaneous lateral incision improved the cosmetic results by avoiding formation of a dorsal first web space scar. Medial incision is also shorter than the one used for EDCO.
Level of evidence: Level IV, case series.

1. Introduction

Chevron V-shaped osteotomy of the distal first metatarsal has been advocated by many authors for the treatment of HV, but when used in moderate cases onwards frequent complications and patient dissatisfaction have been reported, mainly due to undercorrections, subsequent displacements, technical errors, and/or recurrences [1–4].

To improve this, different variants have been developed over time, the most recent being the EDCO that implies a greater length of the plantar arm of the osteotomy with the purpose of increasing the displacement potential. However, several recently reported studies showed a higher rate of complications and recurrences due to more aggression approach in dealing with the tissues [5–8].

The aim of the present study was to evaluate for the first time, to the best of our knowledge, a new modification of the technique. Efficacy, patient satisfaction and complications of a quadriplanar, large

Abbreviations: HV, Hallux valgus; AOFAS, American Orthopedic Foot and Ankle Society; IM, intermetatarsal; MTP, Metatarsophalangeal; IP, Interphalangeal; VAS, visual analogue scale; DMAA, distal metatarsal articular angle; PPAA, proximal phalangeal articular angle; EDCO, extended distal chevron osteotomy; MEDCO, minimally extended distal chevron osteotomy; PSTR, percutaneous soft tissue release

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displacement MEDCO along with a PSTR, and an Akin osteotomy if needed, for the correction of moderate HV in adults, using the AOFAS scale and radiological measures before and after a 2-year postoperative follow-up period were analyzed. The authors believe that this combination of techniques may be advantageous and the purpose of this study was to present the procedure and its results.

2. Materials and methods

Between September 2015 and May 2016, 34 consecutive female patients suffering from symptomatic moderate HV [9] (34 feet) underwent the aforementioned technique by a single surgeon (corresponding author).

The inclusion criteria were: preoperative 1–2 IM angle between 11 and 16 degrees, HV angle between 20 and 40 degrees, no prior foot surgery, minimum follow-up of 2 years, age greater than 30 years, symptomatic HV deformity and failed previous conservative management of at least 3 months. Exclusion criteria were previous foot surgery, rheumatoid arthritis, hypermobility of the first tarsometatarsal joint (i.e. displacement greater than 4 degrees in the sagittal and 8 degrees in the transverse planes) [10], severe associated ankle or foot deformities and vascular or neurological diseases.

All patients were assessed pre and postoperatively using the AOFAS Hallux MTP-IP clinical rating system [11] by an independent observer not involved in the study. Pre and postoperative VAS scores were also recorded. Additionally, patients were asked to rate their overall postoperative satisfaction on a scale of 1–10.

Anteroposterior and lateral weightbearing radiographs of the foot were made preoperatively and at the final follow-up. Another observer not involved in the study measured HV angle, 1–2 IM angle, DMAA and PPAA. The MTP and 1–2 IM angles were measured using the method described by Miller [1]. DMAA and PPAA were measured as described by Coughlin [2].

As with comparable studies, the recurrence of HV was defined as an HV angle of more than 15 degrees [3,4]. Similarly, union was considered when bone bridging was observed on the 4 cortices on the radiographic views and malunion when the metatarsal osteotomy consolidated with an angular deviation.

All procedures performed in this study were in accordance with the ethical standards of our institutional research committee and with the Code of Ethics of the World Medical Association (1964 Helsinki declaration) and its later amendments or comparable ethical standards. A written consent has been obtained accordingly.

2.1. Statistical analysis

SPSS version 20.0 computer software was used for the statistical study.

The differences between the clinical and radiographic variables collected pre and postoperatively were analyzed using the Wilcoxon signed-rank test.

A search for a statistically significant link between the results and the age of participants was explored using the Mann–Whitney U test.

Finally, a comparison of the results with previous published literature was performed using the Mann–Whitney U test.

Using a variance in the reference group of 5.8 and a minimum value of the difference to be detected between two means of 1.5, with a confidence level of 0.05, the statistical power obtained was 84%.

2.2. Surgical technique

With the patient in supine position, under loco-regional anesthesia (popliteal block) and with a pneumatic tourniquet inflated at 100 mmHg higher than systolic pressure, a longitudinal 5 cm medial skin and capsular incision was made, providing exposure for both osteotomies in case Akin procedure is needed. If it is anticipated that Akin

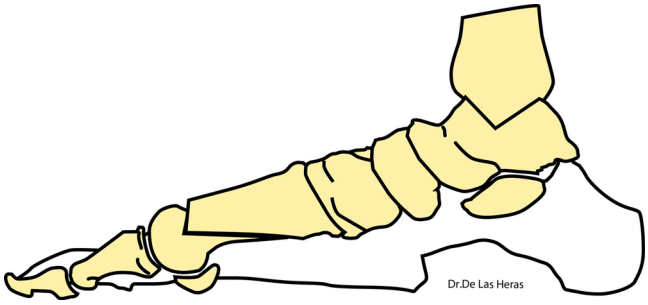

Fig. 1. Drawing showing the distal metatarsal osteotomy from lateral view.

Fig. 2. Photo illustrating the distal metatarsal osteotomy before lateral displacement.

osteotomy will not be necessary, the incision is only 3 cm. The medial eminence was resected beginning just medial to the bottom of the sagittal sulcus.

A lateral release procedure consisting of a percutaneous adductor tenotomy with a Beaver 64 blade is made. The blade is inserted parallel to the joint in intraarticular position over the lateral capsular ligamentous structures. The phalangeal insertion of the tendon is divided on the plantar aspect of the joint, forcing the hallux into varus until you get the distinct feeling of adductor tenotomy [12,13]. The adductor tendon is not detached from the lateral sesamoid.

A reverse L-shape osteotomy with a longer plantar arm and a shorter dorsal arm is performed starting approximately 10–12 mm proximal to the MTP joint line as recommended by Helmy [14], but unlike Helmy the vertex of the osteotomy was placed 3 mm above the center of the metatarsal head with the dorsal cut half way between 1 and 2 o'clock and the plantar cut between 4 and 5 o'clock in relation to the longitudinal axis of the metatarsal, for a right foot. The shape of the osteotomy achieves what it has been called a MEDCO, formed by a dorsal

Fig. 3. Photo illustrating the distal metatarsal osteotomy after lateral displacement.

cut of 5 mm and a plantar cut of 2 cm approximately, which has not been described in the literature to date, to the best of our knowledge. This conformation of the osteotomy is the ideal in terms of achieving better results with few complications. The osteotomy is angled in a plantar lateral direction to additionally plantarflex the capital fragment as recommended by Selner [15], usually at 20 degrees (Figs. 1–3). The dorsal cut is angled proximally, shortening the bone slightly [15,16]. In cases of an abnormal DMAA, an additional medial wedge can be resected on the dorsal arm [14]. A translation of the capital fragment up to 50% of the metatarsal width was performed, unlike what is suggested in the literature and consistent with Stienstra [17] (Fig. 4).

Finally, an Akin phalangeal osteotomy is performed in the usual manner [18] keeping in mind the preoperative PPAA, so as to achieve a postoperative PPAA of approximately 0 degrees (Fig. 5). If preoperative PPAA is nearly normal Akin osteotomy is not usually needed, so the surgery can be planned in advance with the prior measurement of angles.

Both osteotomies can be fixed with a cannulated double threaded 2.7 mm screw in a perpendicular direction (Figs. 6–8).

2.3. Postoperative management

Patient is discharged the day after the operation. A compression dressing was applied postoperatively at the first web space for 2 days. Then the dressing is removed and replaced by a ready-made silicon spacer for 2 more weeks. A postoperative flat hard sole shoe is allowed on the day after surgery and is continued for 3 weeks. Regular shoes afterwards. Weightbearing is allowed from the first day after surgery.

3. Results

The average age at the time of surgery was 53.7 ± 10.5 (range, 36–71) years. All patients were examined in each visit and no patient was lost during the follow-up period. The mean follow-up was 2.7 ± 0.2 (range, 2.3–3.0) years and the average patient satisfaction score was 8 ± 1.8 on a scale of zero to 10 (range, 3–10).

18 feet (52.9%) were on the right side and 16 (47.1%) were on the left. Preoperative osteoarthritis of the MTP joint was present in 6 feet (17.6%), and 23 of them (67.6%) were congruent (nonsubluxated).

Outcomes are presented in Table 1. VAS improved from a mean value of 7 ± 1.8 points (2 to 10) preoperatively to 1 ± 1.5 (0 to 5) at the final follow-up ($p < 0.001$). The total AOFAS score significantly improved from 64 ± 12.3 (34 to 85) to 90.7 ± 9.6 69 to 100) with $p < 0.001$. All AOFAS subscores achieved a statistically significant improvement excluding IP joint movement and MTP-IP joint stability, with $p < 0.001$ for all except MTP joint movement ($p < 0.001$).

The average preoperative HV angle was 28.7° ± 5.6° (range, 20° to 40°), the IM angle 12.2° ± 2.5° (range, 8° to 16°), the DMAA 8° ± 3.9° (range, 3° to 17°) and the PPAA 6.5° ± 3.3° (range, 3° to 15°). At final follow-up HV angle was 9.1° ± 5.2° (range, 2° to 22°), IM angle was 7.3° ± 2.5° (range, 3° to 11°), DMAA was 5.3° ± 2.6° (range, 0° to 10°) and PPAA was 1° ± 3.5° (range, −4° to 10°), with a mean final correction of 19.6°, 5°, 2.7° and 5.5° respectively ($p < 0.001$).

After comparison of patients who were less than 50 years old to patients 50 years old or older, no significant differences between the two age groups regarding VAS, AOFAS or Radiographic Angles were found, except postoperative HV angle, which was greater in the older group ($p = 0.027$) (Table 2).

A summary of radiographic results of previous literature compared to our study is shown in Tables 3 and 4. In studies involving distal

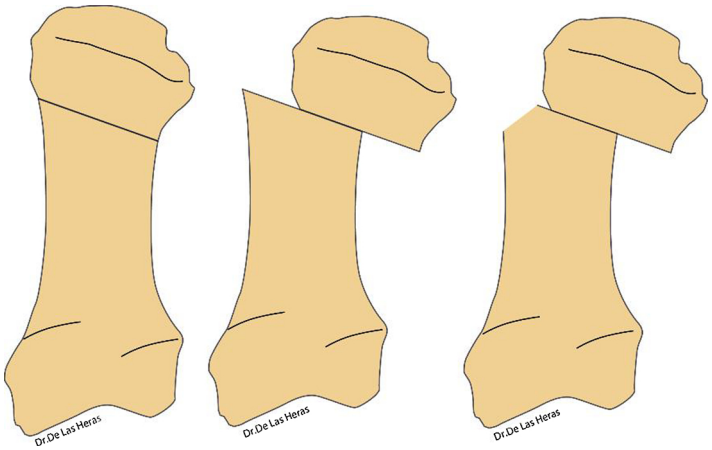

Fig. 4. Drawing showing the distal metatarsal osteotomy from AP view.

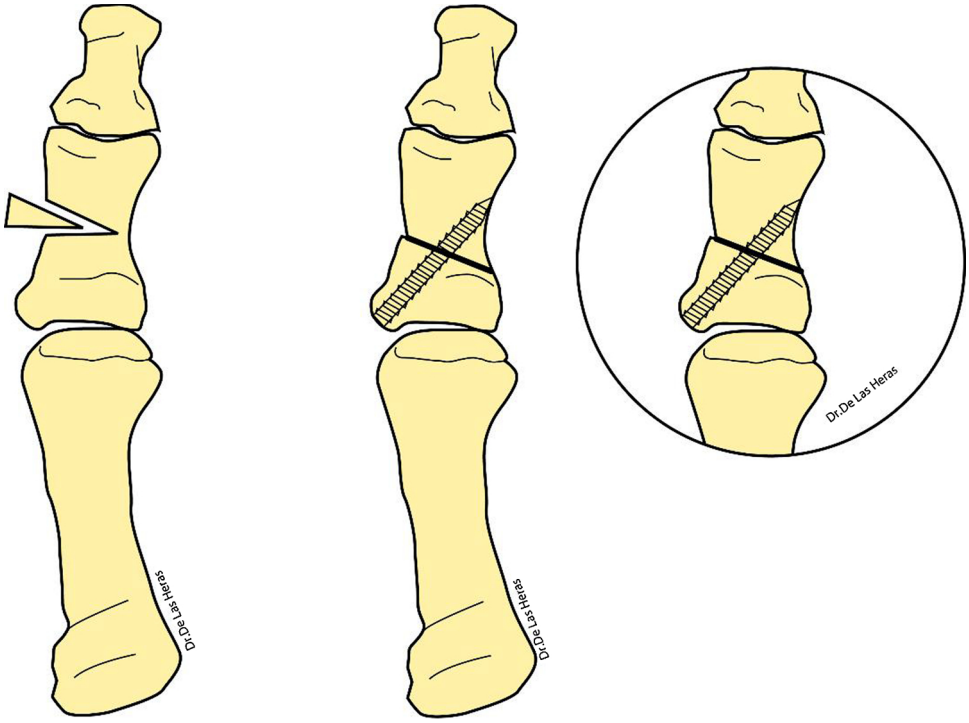

Fig. 5. Drawing showing the phalangeal osteotomy from AP view.

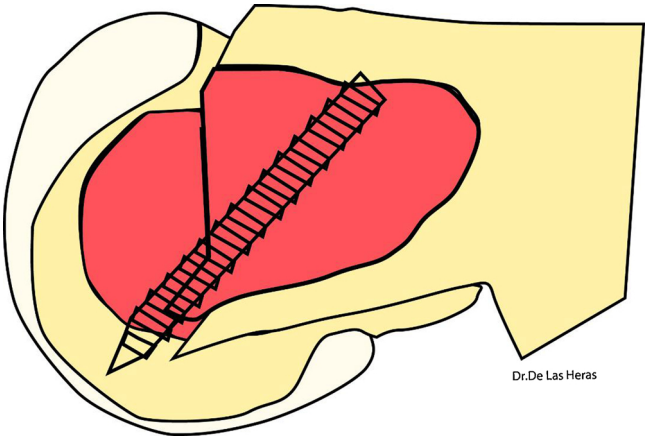

Fig. 6. Drawing showing the distal metatarsal osteotomy fixed with a screw from lateral view.

Fig. 7. AP view X-ray showing the technique used. Preoperatively, 1 month and 2 years postoperatively.

Fig. 8. Lateral view X-ray of the same patient as shown in Fig. 1. Preoperatively, 1 month and 2 years postoperatively.

chevron osteotomy alone the average preoperative HV angle was 27.9°, and postoperative HV angle was 15.6°. Preoperative IM angle was 13° and postoperative IM angle was 8.2° (Table 3). In studies where a conventional double Chevron-Akin osteotomy was employed the

Table 1
Clinical and radiological results.

	Preoperative[a]	Final follow-up[a]	Variation[a]	*p*-Value[b]
VAS	7 ± 1.8 (2–10)	1 ± 1.5 (0–5)	6 ± 1.8 (1–8)	< 0.001
AOFAS				
Total	64 ± 12.3 (34–85)	90.7 ± 9.6 (69–100)	26.7 ± 12.3 (−4 to 46)	< 0.001
Pain	26.5 ± 4.9 (20–30)	35.3 ± 5.1 (30–40)	8.8 ± 7.3 (0–20)	< 0.001
Activity	5.8 ± 2.5 (0–10)	8.5 ± 1.8 (4–10)	2.7 ± 2.7 (−6 to 7)	< 0.001
Footwear	6.2 ± 2.5 (0–10)	9.1 ± 2.3 (0–10)	2.9 ± 2.8 (−5 to 5)	< 0.001
MTP movement	6.2 ± 3.7 (0–10)	8.4 ± 2.4 (5–10)	2.2 ± 3 (0–10)	0.001
IP movement	4.8 ± 0.9 (0–5)	4.8 ± 0.9 (0–5)	0 ± 0 (0–0)	1.000
MTP-IP stability	4.7 ± 1.2 (0–5)	5 ± 0 (5–5)	0.3 ± 1.2 (0–5)	0.157
Callus	3.5 ± 2.3 (0–5)	5 ± 0 (5–5)	1.5 ± 2.3 (0–5)	0.002
Alignment	6.3 ± 3.8 (0–15)	14.6 ± 1.7 (8–15)	8.3 ± 3.4 (0–15)	< 0.001
ANGLES				
HVA[c]	28.7 ± 5.6 (20–40)	9.1 ± 5.2 (2–22)	19.6 ± 4 (12–27)	< 0.001
IMA[d]	12.2 ± 2.5 (8–16)	7.3 ± 2.5 (3–11)	5 ± 2 (3–9)	< 0.001
DMAA	8 ± 3.9 (3–17)	5.3 ± 2.6 (0–10)	2.7 ± 3.2 (0–10)	< 0.001
PPAA	6.5 ± 3.3 (3–15)	1 ± 3.5 (−4 to 10)	5.5 ± 2.3 (0–10)	< 0.001

[a] Mean ± standard deviation (range).
[b] Wilcoxon signed-rank test related to comparison between preoperative and follow-up examination (significant differences when $p < 0,05$).
[c] Hallux Valgus Angle.
[d] Intermetatarsal Angle.

Table 2
Comparison of current population results according to different age group.

	< 50 years old (n = 17)[a]	≥50 years old (n = 17)[a]	p-Value[b]
PREOP VAS	6.8 ± 2 (2–10)	7.3 ± 1.5 (5–10)	0.399
POSTOP VAS	0.9 ± 1.6 (0–5)	1.1 ± 1.5 (0–5)	0.602
PREOP AOFAS TOTAL	67.5 ± 10.1 (35–85)	60.6 ± 13.5 (34–78)	0.170
POSTOP AOFAS TOTAL	91.4 ± 7.9 (77–100)	90 ± 11.2 (69–100)	0.790
PREOP HVA	27.4 ± 5.1 (20–36)	30 ± 5.8 (22–40)	0.231
POSTOP HVA	7.1 ± 4.2 (3–21)	11.1 ± 5.5 (2–22)	0.027
PREOP IMA	12.8 ± 2.4 (10–16)	11.6 ± 2.5 (8–16)	0.181
POSTOP IMA	5.3 ± 2.1 (3–9)	5.8 ± 2.1 (3–11)	0.420
PREOP DMAA	7.9 ± 4.2 (5–17)	8.2 ± 3.8 (3–16)	0.765
POSTOP DMAA	5.5 ± 2.1 (3–10)	5.1 ± 3 (0–9)	0.711
PREOP PPAA	5.9 ± 1.3 (4–8)	7.1 ± 4.4 (3–15)	0.612
POSTOP PPAA	−0.1 ± 2 (−4 to 3)	2.1 ± 4.3 (−3 to 10)	0.160

[a] Mean ± standard deviation (range).
[b] Mann–Whitney U test (significant differences when $p < 0,05$).

Table 3
Summary of radiographic results of HV correction with distal chevron osteotomy alone compared to the author's technique.

	Year	Preop HVA[a]	Postop HVA[a]	Preop IMA[b]	Postop IMA[b]
Meier	1985	28.5	21.9	12.6	7.8
Harper	1989	–	–	11.7	6.2
Hirvensalo	1990	31	19	14	9
Bar-David	1991	22.6	8	13.8	5.2
Velkes	1991	32.1	16	13.6	9.3
Johnson	1991	21	11	11	6.5
Klosok	1993	30	21	–	–
Goforth	1993	–	–	12.7	6.8
Hetherington	1993	31.5	14.3	14.2	6.2
Graves	1993	26.5	19	13.2	10.9
Pochatko	1994	–	–	13	8
Donnelly	1994	25	17	12	8
Trnka	1996	30	17.8	13.7	8.1
Mann	1997	23	20	11	11
Chou	1998	22	18	11	9
Trnka	2000	29	18	13	9
Torkki	2001	24.3	17.9	–	–
Nery	2002	25	14	12	8
Schneider	2004	27.6	14	13.8	8.7
Deenik	2007	30	17	13	10
Saro	2007	32	20	14	10
Trnka	2007	29	16	13	9
Oh	2008	34.1	11.1	14.4	7.9
Potenza	2009	28	16	13	7
Corte-Real	2009	28	14	12	7
Lee	2010	29	9	16	12
Choi	2012	29	5	13	5
Radwan	2012	26.1	12.8	12	8.2
Jeuken	2016	30.7	17.1	13.5	7.7
Average		27.9	15.6	13	8.2
Heras	2018	28.7	9.1	12.2	5.6

[a] Mean of Hallux Valgus Angle.
[b] Mean of Intermetatarsal Angle.

average preoperative HV angle was 29°, postoperative HV angle was 14.8°, preoperative IM angle was 13.1° and postoperative IM angle was 8.8° (Table 4). In the present study the calculated angles were 28.7°, 9.1°, 12.2° and 5.6° respectively, which shows a significant improvement in both postoperative values compared to previous studies ($p < 0,05$) (Tables 5 and 6).

The overall recurrence rate was 5.8% (2 cases). No cases of edema at final follow-up was found. A total of 2 complications were reported also (5.8%). There was one case of secondary metatarsalgia due to shortening of the first metatarsal to treat osteoarthritis of the joint, requiring Weil osteotomy of the second and third metatarsals. One developed Complex Regional Pain Syndrome which resolved with medication. No case of nonunion (more than 6 months), avascular necrosis nor malunion developed. No patient in this series had infection.

4. Discussion

Chevron osteotomy is classically contraindicated in cases of severe HV [19] (IM angle greater than 16°) although the new version of the technique could be already indicated as it definitely has much more ability to correct greater deformities. Although it was believed previously that this operation was not indicated in patients older than 50 years [19], clinical results of both VAS and AOFAS from the present study do not show change with the age of the patient. Radiology results, although slightly worse in patients over 50 years, only show a small significant difference in the postoperative HV angle. Therefore, this technique could be used in adults of any age.

Other possible contraindications that have already been outlined are joint osteoarthritis or the presence of a high DMAA. Our technique is able to decompress the joint using both osteotomies and modify the DMAA, for which it is believed that it can also be used in these cases.

This technique achieved excellent clinical and radiological results

Table 4
Summary of radiographic results of HV correction with conventional double Chevron-Akin osteotomy compared to the author's technique.

	Year	Preop HVA[a]	Postop HVA[a]	Preop IMA[b]	Postop IMA[b]
Mitchel	1991	27	14	11.5	7.1
Tollison	1997	26.7	15.5	13.4	9.6
Basile	2000	22.5	12.5	11.5	7
Lechler	2011	32	14.1	12.2	11.1
Priyadarshi	2015	37	18	17	9
Average		29	14.8	13.1	8.8
Heras	2018	28.7	9.1	12.2	5.6

[a] Mean of Hallux Valgus Angle.
[b] Mean of Intermetatarsal Angle.

Table 5
Comparison of our population median to the average of previous studies median.

	Average previous[c] studies chevron osteotomy alone	Current study[c]	p-Value[d]
Preop HVA[a]	27.9	28.7	0.736
Postop HVA[a]	15.6	9.1	< 0.001
Preop IMA[b]	13	12.2	0.161
Postop IMA[b]	8.2	5.6	< 0.001

[a] Hallux Valgus Angle.
[b] Intermetatarsal Angle.
[c] Median.
[d] Mann–Whitney U test (significant differences when $p < 0,05$).

Table 6
Comparison of our population median to the average of previous studies median.

	Average previous[c] studies double chevron-akin osteotomy	Current study[c]	p-Value[d]
Preop HVA[a]	29	28.7	0.642
Postop HVA[a]	14.8	9.1	0.015
Preop IMA[b]	13.1	12.2	0.375
Postop IMA[b]	8.8	5.6	0.005

[a] Hallux Valgus Angle.
[b] Intermetatarsal Angle.
[c] Median.
[d] Mann–Whitney U test (significant differences when $p < 0,05$).

with no evidence of avascular necrosis. It is our believe that the large displacement [17] and quadriplanar shape [15] of the osteotomy along with the percutaneous adductor tenotomy [13] are responsible of these good results. The minimally extended length of the osteotomy also allows to achieve these large displacements. Moreover, being only half as long as EDCO, it does not compromise the stability of the assembly and avoids extensive exposures which imply more complications, recurrence and instability requiring longer time of nonweightbearing and postsurgical rehabilitation and predisposing dorsal angulation, causing more cases of transfer metatarsalgia [5].

In the present study, a mean postoperative AOFAS value of 90.7 and a low incidence rate of complications, in agreement with scores previously reported using conventional chevron osteotomy was noted [20–25].

However, the surgical technique used in the present study significantly improved the average HV and 1–2 IM angles correction and lower the recurrence rates, in comparison to previous documented studies in which Chevron alone [20–34] or double Chevron-Akin osteotomies are used [35–38].

Limitations of this study include a relatively small sample size. Furthermore, the comparison is made with previous series with different follow-up periods. Therefore, further randomized controlled trials with larger group of patients to confirm these preliminary results are recommended.

Despite these limitations, this study suggests this procedure could be a good alternative to proximal or shaft metatarsal osteotomies in the treatment of moderate HV (especially in cases with radiographic evidence of degenerative arthritis or increased DMAA).

5. Conclusions

Results of a new minimally extended distal Chevron osteotomy (MEDCO) with percutaneous soft tissue release (PSTR) are described in this manuscript and compared with other techniques of previous literature. VAS-Pain and AOFAS Hallux scores along with the calculated radiological measurements improve dramatically after this procedure. The correction of HV and IM angles achieved with this technique is greater than that achieved with former ones, with a statistically significant difference, and the overall recurrence rate is lower. Furthermore, the percutaneous lateral incision improved the cosmetic results by avoiding formation of a dorsal first web space scar and the medial incision is also shorter than the one used for the already described extended distal Chevron osteotomy (EDCO) which also implies more complications and a longer non-weightbearing and post-surgical rehabilitation period than our technique.

Therefore, MEDCO with PSTR was more effective than traditional Chevron osteotomy or its recent variants in terms of correction of the angulation, patient satisfaction, functional capacity and complication or recurrence rate.

Declarations of interest

None.

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Conflict of interest

All authors have nothing to disclose.

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