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Distal metatarsal mini-invasive osteotomy for the iatrogenic metatarsalgia. Retrospective study of a serie of cases

Cirugía metatarsal mínimamente invasiva en la metatarsalgia iatrogénica. Serie de casos retrospectiva

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Keywords:

Podiatric surgery, Weil´s osteotomy, complications, minimally invasive surgery, Weil iatrogenesis, distal metatarsal minimal invasive osteotomy (DMMO), plantar loading, AOFAS score.

Abstract

Introduction: Weil osteotomy and its subsequent modifications are currently the most common techniques of choice for the treatment of metatarsalgia by open surgery, whereas intracapsular capital osteotomy is a minimally invasive surgery (MIS). The objective of this work is to assess the efficacy of metatarsal capital osteotomies using MIS in reintervention of complications derived from the Weil technique and its variants.

Patients and methods: An observational descriptive retrospective study of a cohort of 20 feet in 18 cases that underwent surgery with 48 Weil-type metatarsal osteotomies. These underwent 34 minimally invasive metatarsal osteotomies as a rescue technique during the period between 2010 and 2018. As an evaluation method, the pre- and postoperative maximum metatarsal pressure (kPa) was measured and the patient completed the American Orthopaedic Foot and Ankle Society AOFAS questionnaire for lesser metatarsals and interphalangeal joints after the intervention.

Results: Statistically significant data were obtained, both in decreased maximum postoperative pressure (with an average of < 83.28 kPa; $p < 0.001$) and on the AOFAS scale, with an average percentage increase of 48.5 points after MIS.

Conclusion: This article provides data that supports the use of metatarsal MIS as a validated technique for the reoperation of complications derived from a Weil osteotomy.

Palabras clave:

Cirugía podológica, osteotomía de Weil, complicaciones, cirugía mínimamente invasiva, Iatrogenia Weil, osteotomía metatarsal distal mínimamente invasiva, presiones plantares, escala AOFAS.

Resumen

Introducción: La osteotomía de Weil y sus posteriores modificaciones son hoy en día las técnicas mayoritarias de elección para el tratamiento de la metatarsalgia mediante cirugía abierta, mientras que la osteotomía capital intracapsular lo es de la cirugía mínimamente invasiva (CMI). El objetivo de este trabajo es valorar la eficacia de las osteotomías capitales metatarsales mediante CMI en la reintervención de complicaciones derivadas de la técnica Weil y sus variantes.

Pacientes y métodos: Se realizó un estudio observacional, descriptivo y retrospectivo, de una cohorte de 18 casos, con 20 pies intervenidos en los que se habían practicado 48 osteotomías metatarsales tipo Weil y se encontraron complicaciones posquirúrgicas. En estos casos se practicaron, como técnica de rescate, 34 osteotomías metatarsales mínimamente invasivas durante el periodo comprendido entre 2010 y 2018. Como método de evaluación se midió la presión máxima metatarsal pre y posquirúrgica (KPa), así como la cumplimentación por parte del paciente del cuestionario para metatarsianos menores y articulaciones interfalángicas de la American Orthopaedic Foot and Ankle Society (AOFAS), tanto previamente como seis meses después de la intervención.

Resultados: Obtuvieron datos estadísticamente significativos tanto en la disminución de la presión máxima posquirúrgica (con un promedio de 83.28 KPa; $p < 0.001$) como en la escala AOFAS, consiguiendo un incremento porcentual medio de 48.5 puntos tras la intervención CMI.

Conclusiones: En el presente artículo se aportan datos que apoyan el uso de la CMI metatarsal como técnica válida para la reintervención de complicaciones derivadas de una osteotomía de Weil.

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INTRODUCTION

Metatarsalgia is one of the foot disorders with the highest prevalence in clinical practice. Its surgical approach, always complex, has experienced an exponential leap in recent decades thanks to the introduction of the Weil osteotomy[1] and its subsequent modifications. As studies on these techniques proliferate, they give us an image of an osteotomy that is highly valued by the authors who practice it, although they admit that there are obscure points in their approaches, which generate complications with relatively high incidence rates[2]. On the other hand, for the surgical realignment of the metatarsal parabola, there is minimally invasive surgery (MIS). Its evolution has also been meteoric and parallel to open surgery techniques, but based on different precepts: minimal alteration of the soft supporting structures of the joint, absence of internal fixation and early support.

This study focuses on the group of Iatrogenic metatarsalgias[3], which can be summarized as the failure of central metatarsal osteotomies (indication vs. technique)[4], causing recurrence or transfer of metatarsalgia, either due to little or excessively corrective technique or due to the non-intervention of a certain metatarsal. Iatrogenic metatarsalgia presents as the main symptoms pain and inflammation, as well as hyperkeratosis or helomas due to the excessive increase in pressure in one or more points of the forefoot caused by the discrepancy in length and / or alignment in the frontal plane obtained after the intervention[5].

For the treatment of metatarsalgia, conservative treatment will be the first approach option and it will be aimed at redistributing forefoot loads through plantar orthoses. The conservative treatment is associated with oral anti-inflammatory drugs, local infiltrations and physical therapy. Failure of the bloodless treatment requires proposing a surgical alternative that aims to re-establish the length and position of the metatarsal heads that are overloaded. The Weil technique with its different modifications (triple, double layer, tilt up, tilt down)[6,7], with or without fixation, has now become the surgical option of choice for open surgery, displacing other techniques that act at different levels of the metatarsal, such as, for example, the Golfard-type basal osteotomy or the Helal-type diaphyseal osteotomy[8]. However, despite the good performance that is deduced from the different articles consulted[9-13], 80-85 % of good or excellent results, the authors also refer a percentage of unsatisfactory resolutions. These are the selected cases from our clinical practice, and in which this work aims to influence from a minimally invasive approach.

This article does not pretend to be a comparison between open techniques or minimally invasive surgery[14,15]; it is intended to expose how to approach iatrogenic cases with a MIS approach, the results obtained with the approach and why it could be an excellent rescue option for patients to take into account even for surgeons who perform open surgery when it generates complications. Barouk values DMMO as an interesting option for the treatment of recurrent metatarsalgia, although it clarifies that it needs to be evaluated through studies, such as the one we presente here[16].

PATIENTS AND METHODS

Type of study

An observational, descriptive, retrospective and multicentric study was carried out in individuals diagnosed with iatrogenic metatarsalgia after surgical intervention with Weil-type osteotomy (one or more rays of the same foot), performed by surgeons belonging to the Spanish Association for Minimally Invasive Foot Surgery AEMIS. It was carried out respecting the principles of the Declaration of Helsinki.

Study population

The inclusion criteria for the study were patients who underwent central metatarsal surgery using the Weil technique or its modifications and who had to be subsequently reoperated due to complications thereof and a minimally invasive approach was chosen. Patients who had undergone central metatarsal surgery by techniques other than Weil or its modifications or who had undergone open surgery techniques were excluded.

Surgical technique

Surgery was performed under loco-regional anesthesia of the affected metatarsal in cases in which there were no other associated techniques or with an ankle block in cases in which there were more than one metatarsals affected following the technique described by Nieto et al.[17].

A minimally invasive surgical intervention was performed with a capital osteotomy in one or more metatarsals as well as other associated MIS techniques for the correction of digital misalignment or floating fingers present in the selected patients. Associating for its resolution: incomplete phalangeal osteotomies (ODI), complete phalangeal osteotomies, arthrodesis, arthroplasties, flexo-extensor tenotomies and capsulotomies; The cases in which previous procedures had been performed in the Hallux and the cases in which it was necessary to intervene at the level of the first ray were also recorded.

Using a dorsal approach to the metatarsal, a 2mm skin incision was made with a Beaver scalpel with blade No. 64. It was deepened by detaching the planes and the incision was projected into the capsule until reaching the surgical neck of the metatarsal, under fluoroscopic control. The Shannon Isham straightflute 2.0 x 12mm drill was introduced laterally in the case of the left foot or medially in the right feet, with a dorsal-distal plantar-proximal (DDPP) angle of 45^0 in the surgical neck of the metatarsal. Once positioned, the particularity of this intervention lay in the presence of osteosynthesis

Figure 1. Positioning of the drill at 45° at the surgical neck level, calibrating that there is no conflict with the osteosynthesis material when performing the osteotomy.

Figure 2. We perform distal finger traction to verify that the osteotomy has been completed.

material close to the osteotomy. Under fluoroscopic control, the surgeon ensured that there was no conflict between the drill and the screw. Modifying angulation and / or level of the osteotomy when necessary (Figure 1).

The osteotomy started from the surgical neck location with 45^0 angulation, it was executed by means of oscillating movements of the motor (DDPP), without losing the angulation, at low revolutions with a 4: 1 reducer handpiece, making the cut in reciprocating motion until the completion of the half the metatarsal; at this moment the tail of the motor was tilted until it was located in the plantar cortex and, from this position, it was ascended following the cut line already created until the lack of resistance was noticed at the dorsal level, which indicates that the cut has been completed. In the case that greater shortening is needed, it is possible to extend the osteotomy with a second pass. It was subsequently verified under fluoroscopic control that displacement of the fragments occurred when pulling the intervened finger distally (Figure 2).

Once the planned metatarsal osteotomies had been completed, which should always be the first surgical gesture programmed for the alignment of the radius, if there were other residual misalignments such as floating finger, the rest of the MIS procedures were continued sequentially, from proximal to distal; ODI osteotomies and complementary digital alignment techniques, which contribute to the reduction of the negative forces exerted by the finger against the metatarsal and to its alignment.

The bandage was made using non-woven adhesive tissue digital ties, also called sterilized non-woven. If other associated procedures were performed, the relevant bandages for those techniques were applied (Figure 3). Fixation with cohesive bandage and postsurgical shoe was completed. Postoperative dressings followed the usual protocol, with weekly changes of the dressing until consolidation of the fracture was observed with the formation of bone callus. The patient had to walk during this period always with a rigid sole surgical shoe, allowing immediate loading after the intervention.

Figure 3. Post-surgical bandage with non-woven tape ties.

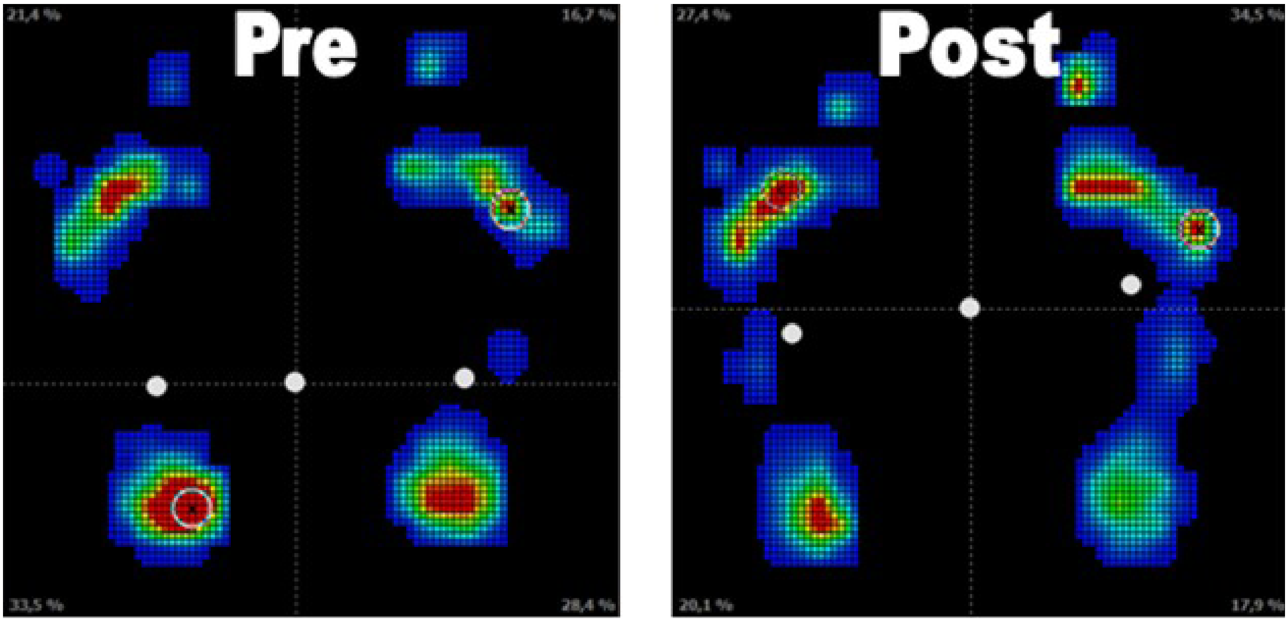

Figure 4. Biomechanical study in static stance. The redistribution of loads can be seen at the metatarsal level in the right foot. Located at the M4 level, the point of maximum pressure preoperatively, disappearing in the postoperative analysis at 6 months of MIS with capital osteotomies of M3 and M4.

Data collection

All data were obtained by the main author of the study (P.D.B.). This data included the medical records of the interventions carried out in five collaborating centers, in the period included in the study from 2010 to 2018. Surgical data included: sex, age, operated foot, months after Weil surgery, if Hallux and / or digital surgery was associated in the operation, the location of the Weil osteotomy and the podobarometric measurement of overload.

The variables collected as postsurgical complications were: if there was post-Weil digital misalignment, if there was a limitation of phalangeal metatarsal mobility, the presence of post-intervention hyperkeratosis, recurrence of metatarsalgia and transfer metatarsalgia. In the second intervention performed to reverse the complications, the following parameters were collected: location of the MIS osteotomies, if the Hallux was intervened, if there was an associated digital MIS, and post-surgical podobarometric measurement.

To evaluate the results obtained before and after surgery, a static study was carried out with a podobarometric platform, preoperatively and six months after discharge from the intervention. The maximum preoperative and postoperative pressure at the level of the operated metatarsal was assessed, measured in kPa (Figure 4).

The patient responded to the questionnaire based on the AOFAS scale for minor metatarsals and interphalangeal joints before and 6 months after surgery[18].

Analysis of data

Before performing the inferential statistics, compliance with normality was verified for the variables "Maximum preoperative pressure" and "Maximum postoperative pressure" (both measured in KPa.) As well as for "AOFAS" in the pre and post-test (valued in percentages). The Shapiro-Wilk statistic was applied to verify compliance with normality. Since for the two AOFAS measurements (pre and post-test) compliance with normality was verified, the Student's t test was applied for related groups to detect possible differences between the pre and post-test. On the other hand, in the case of the Pressure variable, the normality of the distribution of the scores cannot be assumed in the pretest, so the non-parametric test (or free distribution) equivalent to the Student's t test was applied for related samples, i.e. the Wilcoxon test. In both cases, the mean and the median were calculated as measures of central tendency, and the standard deviation as a measure of dispersion. Additionally, the minimum and maximum scores obtained by the participants were reported for each variable. The analysis was performed using the SPSS version 22 software (IBM Corp, Armonk, USA).

RESULTS

A series of 18 patients was obtained, 20 feet operated with 48 Weil-type metatarsal osteotomies to which 34 minimally invasive metatarsal osteotomies were performed as a rescue technique. The sample for the present investigation was 16 women (80 %) compared to 4 men (20 %). The average age was 59 years (DT = 17.22), with a maximum age of 84 and a minimum of 23 years, the most frequent age (mode) being 73 years. Table I collects information from the whole study sample.

The Wilcoxon test was applied to verify the possible pressure differences between the pre and post test offered by the descriptive statistics at both measurement moments (Table II). The results showed a decrease (Zw = -3.92; p <.001) in the maximum preoperative pressure (Average = 216.66) compared to the postoperative one (Average = 133.38) with an average decrease in maximum pressure of 83.28 KPa.

The Student's t test was performed for groups related between the pre and post test for the AOFAS variable (Table III). The results of this test showed a significant percentage increase in the post-test compared to the pre-test (respective percentages, in averages, of 88.25 and 39.75; t (19) = -18.90; p <.001). Specifically, there was an average increase of 48.50 percentage points ((95% CI) = -53.87 and -43.13, for the difference). More than half of the sample exceeded 90% in the post test, when in the pretest only 62% was reached as the maximum value.

DISCUSSION

Surgery of the central metatarsal performed by traditional surgery has experienced a notable increase in recent decades, especially thanks to the Weil technique. Formerly considered interventions with a poor prognosis due to the fact that the techniques that preceded it were highly unstable and whose results in both shortening and elevation of the metatarsal were frequently unpredictable, the Weil technique offered surgeons, for the first time, an osteotomy with which the desired degree of metatarsal shortening could be calculated accurately and reproducibly, which in turn allowed early loading without fear of unwanted displacement of the osteotomy fragments.

The factors that lead to the failure of the Weil are diverse. Born as a technique that solved all the problems that arose when performing previously published osteotomies, its wide dissemination and fast popularization among surgeons worldwide has allowed the publication of a large number of articles that expose a big sample of successes and failures[2,8,10-12,19-23].

From the analysis of the different complications observed and their causes, the thesis can be extracted that it is not such an easy technique to execute, as described by Lowel Scott Weil, due to the technical impossibility of making the cut parallel to the ground as Trnka et al. demonstrated in their cadaver study[24], which leads to excessive plantar flexion of the head when generous shortening of the metatarsal is performed (> 3 mm), generating recurrent metatarsalgias of iatrogenic origin. The different modifications that have arisen to counteract the limitations of the original technique, generate new problems such as the generation of transference metatarsalgias in the triple Weil, due to its dorsiflexor effect as well as shortening[25], and also increase the degree of technical difficulty in its execution.

The technical advantage that the procedure offered to the surgeon of measuring the degree of correction of the length intrasurgically would be affected with the modifications, since correcting in two planes of space could alter the reliability of the measurement.

Determination of metatarsal length intraoperatively in an unloading position is technically difficult and can provide inaccurate data. But even more complex is the measurement of the correction in the frontal plane of one metatarsal with respect to the next regarding the next one with our patient in the supine position on the operating table, and there are pros and cons in the design and planning of these interventions that the scientific literature has not yet been able to clarify. Added to all, this is the ever-present difficulty when planning metatarsal surgery, whatever the technique, regarding how many and which metatarsals should be operated[26-29]. There is no single criteria that is infallible for all cases. That is why, when the taking of the medical history, the examination of the patient, the analysis of the complementary tests and the diagnosis are not correct, the probability that complications will appear increases[30].

From the minimally invasive approach, the pre-surgical approach will be the same as in traditional surgery, with the advantage that it will be the metatarsal itself that is repositioned in the most biomechanically balanced position thanks to the inherently stable design of the osteotomy added to the dorsiflexion effect and coaxial shortening with respect to the diaphyseal axis of the metatarsal that produces the drill step, modifying the position of the metatarsal in the three planes of space[31], with a mean setback described between the articles consulted between 6.4 mm[32] and 4.01 mm[33], a discrepancy that the authors attributed to the number of bur passes in the execution of the osteotomy. Its intracapsular location and the minimal damage suffered by the articular support structures[34], will prevent the displacement of the fragments resulting from the osteotomy to undesired positions, thus being unnecessary their internal fixation with osteosynthesis materials. A sign that there is no interfragmental mobility is the fact that hypertrophic calluses have not been generated in any of the cases in this sample, achieving bone healing by direct healing. The sum of these factors will allow the biomechanical positioning of the metatarsals, due to the action of ground resistance forces, moving the head to a normalized load situation and reconfiguring the metatarsal parabola without having altered the metatarsophalangeal joint or having decreased its range of mobility[30]. The MIS assumes that it is the early postoperative loading that will provide the degree of correction of the metatarsal heads that will finally be obtained, although there is currently a lack of studies that show that this occurs in this way (Figure 5).

Table I. Descriptive table of the sample

Cases	Age	Sex	Foot	Months after Weil	Hallux Surgery	Weil	Diagnosis	DMMO	MIS digital	MIS hallux	Maximum pressure pre (KPa)	Maximum pressure post (KPa)	AOFAS pre	AOFAS post
Case 1	34	F	R	16	No	M2 M3 M4	DD >MMTT-F HQ RV	M3 y M4	No	No	246.3	99.2	25	83
Case 2	59	M	L	32	Arthrodesis 1ª MTP	M2 M3	>MMTT-F HQ RV	M3	No	No	223.4	169.3	54	90
Case 3	37	F	L	144	No	M2 M3	DD >MMTT-F HQ RV	M3	2 ODI FP base + ODI FM 3 ODI FP base + ODI FM	No	238.0	160.4	62	82
	37	F	R	132	No	M2 M3	HQ TF	M2	No	No	245.2	153.2	57	90
Case 4	43	F	R	72	No	M2 M3 M4	DD >MMTT-F RV	M2, M3 y M4	2 ODI FP + soft tissue. 3 ODI FP distal, ODI FM + soft tissue. 4 ODI FP, ODI FM + soft tissue.	Akin Tenotomía Extensor	221.3	103.6	42	95
Case 5	53	M	L	108	Scarf + Akin	M2 M3	HQ TF	M3 y M4	2 soft tissue. 3 soft tissue.	No	205.5	129.1	25	73
Case 6	73	F	L	21	No	M2 M3	DD >MMTT-F TF	M4	4ODI FP base + ODI FM	No	245.2	179.0	29	78
	73	F	R	22	No	M2 y M3	DD >MMTT-F HQ RV	M2	2 FP base derotational.	Akin	233.8	150.6	52	95
Case 7	67	F	R	24	Austin	M3 y M4	DD >MMTT-F HQ RV	M2, M4 y M5	2 ODI FP complete FM 3 ODI FP 4 ODI FP 5 FM complete	AKIN.	212.9	98.2	35	100
Case 8	70	F	L	60	Keller	M2 y M3	DD >MMTT-F HQ RV	M2, M3 y M4	2 ODI FP derotational 3 ODI FP ODI FM 4 ODI FP ODI FM 5 FM completa	AKIN	243.9	135.1	37	90
Case 9	63	F	R	64	Austin	M2 M3 M4	DD >MMTT-F HQ RV	M2 y M3	2 complete FP complete FM 3 complete FP complete FM	No	151.9	107.4	40	100
Case 10	68	F	L	12	Austin + Akin	M2 M3	>MMTT-F RV	M2	2 ODI in FP	No	208.3	112.5	32	77
Case 11	62	M	L	33	No	M2 M3 M4	DD >MMTT-F RV	M3 y M4	4 ODI FP base ODI FM	No	233.9	122.8	35	85
Case 12	84	F	L	60	Keller	M3 M4	DD HQ RV	M3	No	No	233.2	99.6	32	95
Case 13	78	F	R	38	Keller	M2 M3 M4	HQ	M3	No	No	224.7	177.5	57	100
Case 14	78	F	R	18	No	M2 M3 M4	DD >MMTT-F RV	M2	Soft Tissue	No	246.3	134.7	37	85
Case 15	67	F	R	26	No	M2 M3	HQ TF	M4	No	No	227.8	157.2	54	90
Case 16	46	M	R	25	No	M2 M3	DD >MMTT-F HQ RV TF	M3 y M4	2 ODI base FP 3 ODI FP base + FP neck 4 ODI FP + arthrodesis IF proximal	Akin	223.1	124.4	22	77
Case 17	23	F	L	22	Silver + Akin	M2 M3 M4	DD HQ RV TF	M2, M3 y M4	2 FP base 3 FP base + FP neck 4 FP	Reverdin	246.2	235.0	38	85
Case 18	73	F	R	28	No	M2 M3 M4	DD >MMTT-F HQ RV	M2, M3 y M4	2 ODI FP base + ODI FM 3 ODI FP base + ODI FP neck 4 ODI FP ODI FM	No	221.4	112.0	30	95

M: male. F: female. R: right. L: left. MTP: metatarsophalangeal. ODI: digital incomplete osteotomy. FP: proximal phalanx. IF: interphalangeal. FM: middle Phalanx. DD: digital deformity. HQ: hiperqueratosis. MMTT-F: metatarsalgia. RV: recurrence.

Table II. Descriptive statistics for maximum pressure KPa (pre and post).

Statistic	Preoperative máximum pressure	Postoperative máximum pressure
Mean	216.66	133.38
Median	230.50	131.90
Estándar Deviation	50.71	44.78
Mínimum	22.13	10.36
Maximum	246.30	235.00

For this reason, the need arises to raise the hypothesis that frames this work. Considering that the MIS techniques of metatarsal capital osteotomies are effective in the treatment of mechanical metatarsalgia[30], they should be equally effective in the treatment of iatrogenic metatarsalgia in the case of joints already intervened, despite the fact that their supporting structures could have been weakened by the surgery previously performed.

Because it is the most commonly found technique of choice, cases of iatrogenesis after Weil-type interventions and their modifications were selected, and in most cases it was not possible to know which technique was exactly performed (simple, triple, titl up or down, double layer, etc.). Regarding the inclusion of cases with Hallux operated on in the same Weil surgery, the authors state that they do not alter the results of this study since it focuses on solving recurrences of metatarsalgia, regardless of whether the technique is well executed or not. In the case of Hallux valgus that had failed, they had to be reoperated simultaneously to ensure metatarsal correction. Obtaining similar results, in this sample, whether or not the first radius was acted upon.

Likewise, the behavior of the gastrocnemius should be evaluated, since there are studies that interrelate their shortening with the development of Hallux valgus and metatarsalgia. The pre-surgical performance of the Silfverskiöld test is recommended to assess this factor[16].

Despite these limitations, the positive results obtained after the statistical analysis of the data collected in this study invite us to be optimistic in relation to the hypothesis raised (Figure 6). The yields obtained after performing the Student t test for the values of the AOFAS scale showed an average increase of the scale of 48.50 in percentage points (respective percentages, in averages, 88.25 postoperative

Table III. Descriptive Statistics and paired simple test (Student t) for AOFAS values pre-post.

	Descriptive Statistics				Diferences					
							CI (95)			
Variable	Mean	SD	Min	Max	Mean Difference	SD	Inf Lim	Sup Lim	$t_{(19)}$	p
AOFAS_pre	39.75	12.130	22	62	-48.50	11.48	-53.87	-43.13	-18.90	< 0.001
AOFAS_post	88.25	8.265	73	100						

CI (95 %): confidence interval for mean differences. Inf Lim: inferior limit. Sup Lim: superior limit.

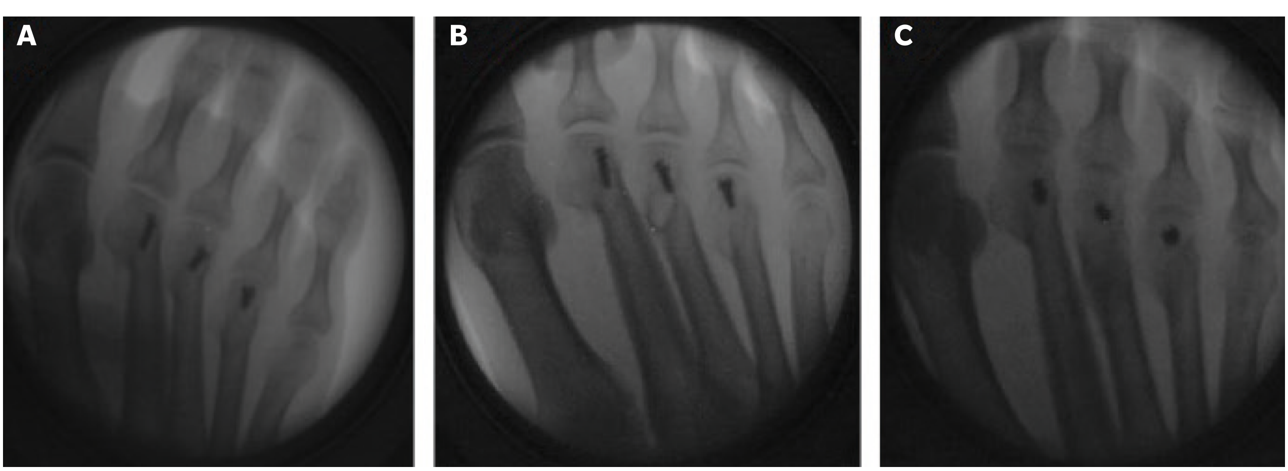

Figure 5. (A) Fluoroscopy prior to the intervention. (B) Fluoroscopy immediately after the intervention. (C) Image of the bone callus already consolidated after revision at six months.

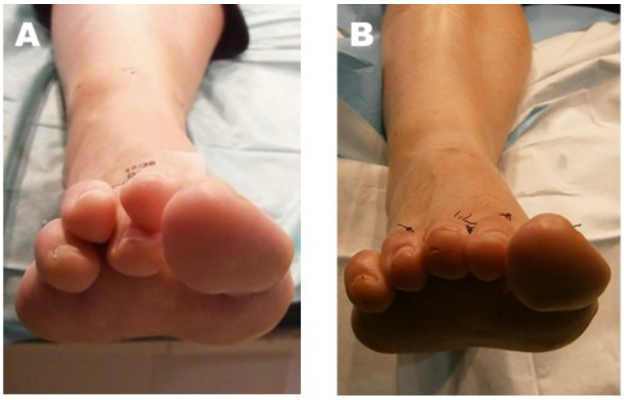

Figure 6. (A) Preoperative image. (B) Correction obtained in the immediate postoperative period.

Figure 7. (A) Recurrent neurovascular heloma under the head of M3 after Weil osteotomy intervention. (B) Total disappearance of hyperkeratosis after CMI performing capital osteotomies of M3 and M4. Six month review.

and 39.75 preoperative; $t(19) = -18.90$; $p < .001$), more than half of the sample exceeded 90 points out of 100 on the scale when in the preoperative evaluation only 62 points were reached as a maximum value.

In turn, for the evaluation of the decrease in the maximum pressure before and after surgery under the Wilcoxon test, a significant reduction was found ($Zw = -3.92$; $p < .001$) with an average decrease in the maximum pressure of 83.28 KPa achieving a mean pressure of 133.38 KPa compared to the pre-surgical mean which was 216.66 KPa.

Highlander et al. in their 2011 bibliographic review, they analyzed 17 impact articles on the Weil technique. They counted 1131 osteotomies, compiling the described complications, being the floating finger with a prevalence of 36% the most common, followed by recurrence in 15%, transfer metatarsalgia in 7%, while the delay of ossification, the non-union and bad union between all reached 3% of the cases[2].

We found similar parameters in post-Weil iatrogenesis in our study, such as: recurrence of metatarsalgia (16 cases), closely followed by Hyperkeratosis (15 cases), post-Weil digital misalignment (14 cases) and lower MTF mobility post Weil (14 cases) that are found together in 66% of the cases, and already at a great distance, the transfer metatarsalgia (5 cases) from which we can theorize, taking into account the limitations of the sample, that the problems that occurred after the intervention could be more frequently caused by the execution of the technique in which we would include: an incorrectly performed osteotomy, an erroneous management of the soft tissues due to deficit or excessive manipulation, infection or an inadequate postoperative period, among others, than by the wrong approach to it: number of operated metatarsals, technique of choice (single, triple, double layer, etc.) and / or degree of planned pre-surgical shortening. They need more data to be able to corroborate this statement.

In the analysis of the time it takes for patients to re-consider metatarsalgia reoperation, a trend towards negative asymmetry was detected in this sample. With a mean of 47.85 ≈ 49 months (SD = 38.98) with a minimum of 12 and a maximum of 144 months, the tendency to shorten the waiting time until reoperation predominates, which is a true reflection of the degree of discomfort generated by this situation (Figure 7).

The limited size of the sample (N = 20), since it is a very specific pathological process within the entire metatarsalgia, which is not representative of all patients operated on with Weil osteotomy, conditions the study and invites us to continue to develop it in the future, since as long as metatarsal surgery exists, iatrogenesis will continue to appear.

In conclusion, we have found in the present study a decrease in the maximum pre-post operative pressure and an average increase of 48.50 in percentage points on the AOFAS scale after the application of CMI osteotomies. These results encourage us to postulate that the minimally invasive metatarsal osteotomy can be an effective method as a salvage surgical alternative in iatrogenesis secondary to the Weil osteotomy and its modifications. This fact must be taken into account by the group of surgeons who perform metatarsal remodeling interventions, either by traditional surgery or by means of MIS.

CONFLICT OF INTERESTS

The authors declare that they have no relevant conflicts of interest in this article.

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