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A new surgical procedure for hallux limitus treatment

Double-V osteotomy on the base of the proximal phalanx of the hallux

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Abstract

The purpose of this study was to evaluate the effectiveness of the new Double-V osteotomy of the first metatarsophalangeal joint (1[st]MPJ) in patients with hallux limitus (HL).

A study of 66 patients was performed, 33 patients were treated Cheilectomy and 33 were treated Double-V. All patients underwent an assessment of the passive mobility of the 1[st]MPJ before the procedure, reevaluated 12 months later evaluating dorsiflexion, plantarflexion, and patients status using both the American Orthopaedic Foot and Ankle Society (AOFAS) for Hallux Metatarsophalangeal–Interphalangeal Scale.

In comparing the improvement achieved regarding the increase of mobility obtained with surgical treatment, the feet operated with procedure Double-V gained significant degrees of movement increased in all analyzed parameters ($P < .05$). We achieved 13.33° more than average in dorsiflexion motion and 2.12° more than average in plantarflexion with regard to the feet that were operated with Cheilectomy procedure. Double-V scores on the AOFAS scale improved significantly ($P = .000$) 91.48 points postoperative, while with the following Cheilectomy only 79.30 points.

This new surgical technique, easy to perform and with low complexity in surgical execution and a minimum of complications, produces better clinical and functional results that Cheilectomy alone.

Abbreviations: 1[st]MPJ = first metatarsophalangeal joint, HL = hallux limitus, HR = hallux rigidus.

Keywords: Cheilectomy, Double-V osteotomy, hallux limitus

1. Introduction

The hallux limitus (HL) has been defined as the limitation of the mobility of the first metatarsophalangeal joint (1[st]MPJ). It was first described by Davies-Colley in 1887. He suggested the term "hallux flexus" because (5 cases, all of them young men) presented flexion of the proximal phalanx, extension in the distal phalanx, inflammation and stiffness at the 1[st]MPJ.[1]

Nilsonne, in 1930,[2] classified HL in 2 groups: the primary and secondary forms. The primary form is seen in adolescents and attributed primarily to a long first metatarsal. The secondary form is identified in older patients, and it is due to degenerative joint changes, hallux abducto valgus deformity, trauma, septic joint, or other types of arthritides. Patients with a functional or primary HL have a normal amount of dorsiflexion in the nonweight-bearing condition. However, when the foot is loaded, a decreased range of motion at the 1[st]MPJ is apparent. Patients with a structural or secondary HL have limited range of motion in both the loaded and unloaded patients.[3]

HL and hallux rigidus (HR) can be classified based on clinical assessment, radiographic findings, or a combination of both. It is generally accepted that the different between these 2 pathologies is in its own definition. HR is defined as that deformity where the 1[st]MPJ no is able to reach a degree of dorsiflexion of more than 10°.[4,5]

Numerous surgical procedures for HL at the proximal phalanx of great toe have been proposed for the HL treatment. Cheilectomy, the cylindrical Akin, Valenti procedure, Watermann procedure, and the Regnauld enclavement has been one of the methods used to bridge the proximal phalanx of the hallux and/or decompress the 1[st]MPJ. The purpose of these procedures is to obtain a few millimeters of space on the 1[st]MPJ, shortening the proximal phalanx of the great toe. However, there have been very frequently observed excessive shortening leading to overload at the lesser metatarsals for several years. We used a procedure with minimal shortening that increases the amount of the 1[st]MPJ and, the clinical and functional aspects of HL are corrected or improved.

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The purpose of this study was to evaluate the effectiveness of the new surgical procedure (Double-V osteotomy) of the 1stMPJ for the treatment of HL.

2. Materials and methods

This study included 66 feet who underwent surgery with decreased mobility of the 1stMPJ (HL); without angular deviations in the transverse plane of the first ray. None of them had previous surgery of the forefoot. Two groups of patients: 33 feet were treated using a unilaterally Cheilectomy at Miraflores Clinic (Seville, Spain) and 33 were treated using a Double-V in Valero's Clinic (Zaragoza, Spain). A descriptive analysis of surgical procedures from January 2009 to December 2012 is presented. The follow-up ends July 2014, with a mean of 29.85 months follow up (±6.20) to Cheilectomy and 30.58 to Double-V (±5.47).

This research followed the principles and standards of the Declaration of Helsinki of 1975, last revised in Seoul in 2008. They have respected the principles of confidentiality and patient autonomy.

Patients were informed of his injury, diagnosis, and treatment. Informed consent was given.

The Ethical Committee of Aragón (CEICA), Institutional Review Board of the Government of Aragón, approved the study.

Average age, clinical symptoms, and preoperative radiologic findings were similar for the 2 groups. All patients underwent an assessment of the passive mobility of the 1stMPJ before the procedure, reevaluated 12 months later this mobility, evaluating dorsiflexion, plantarflexion, and range of total movement. For measurement of dorsiflexion and plantarflexion of the 1stMPJ, the fulcrum of the goniometer was attached at the midpoint of the first metatarsal head. The fixed arm on the bisector of the first metatarsal shaft and the moving on the bisector of the first phalanx on the medial side of hallux, with the patient in supine position with the knee flexed.

Preoperative and 12 months after surgery, an assessment was performed on the patients. It was compared to the range of dorsiflexion motion of the 1stMPJ, plantarflexion, the range of mass movement and the American Orthopaedic Foot and Ankle Society (AOFAS) for Hallux Metatarsophalangeal–Interphalangeal Scale score preoperative and postoperative and gained degrees (increase degrees) in dorsiflexion and plantarflexion totals obtained as well as the score of the AOFAS between both procedures. Two groups of researchers, separately, took measurements pre- and postsurgery. Statistical significance of $P < .05$ is assumed. Before analysis, test of Kolmogorov–Smirnov and test of Shapiro–Wilk was realized to check the variables follow the normal distribution. Only the variable "dorsiflexion" pre- and postsurgical and the variable "range" pre- and postsurgical had the criteria of normality. For these variables we applied Student *t* test for samples related to compare each surgical procedure preoperative and postoperative and Student *t* test for 2 independent samples to compare the surgical results between both procedures. To the rest of variables we used nonparametric Wilcoxon test before and after of the surgical procedure and of Mann–Whitney *U* test to compare the procedures.

We used the SPSS 17.0 software to perform a statistical analysis of data, doing a descriptive analysis with mean and standard deviation.

The 33 patients were operated unilaterally Cheilectomy; 15 males and 18 females with an average age of 46.20 years (range 23–77 years old). The 33 patients were operated unilaterally Double-V, 12 males and 21 females with an average age of 46.36 years (range 24–65 years old) (Table 1).

Table 1

Patients data.

	Double-V			Cheilectomy		
	Frequency	Mean age	σ	Frequency	Mean age	σ
Male	12	44.08	11.45	15	46.20	11.90
Female	21	47.67	11.87	18	46.33	15.18
Total	33	46.36	11.67	33	46.27	13.58

2.1. Cheilectomy: Surgical procedure

Cheilectomy, involving resection of the dorsal osteophytes and lateral–medial margins of the first metatarsal head, as well as the dorsal edge of the base of the proximal phalanx. Cheilectomy is

Figure 1. Double-V osteotomy: Radiographic and schematic representation of the location of the osteotomy.

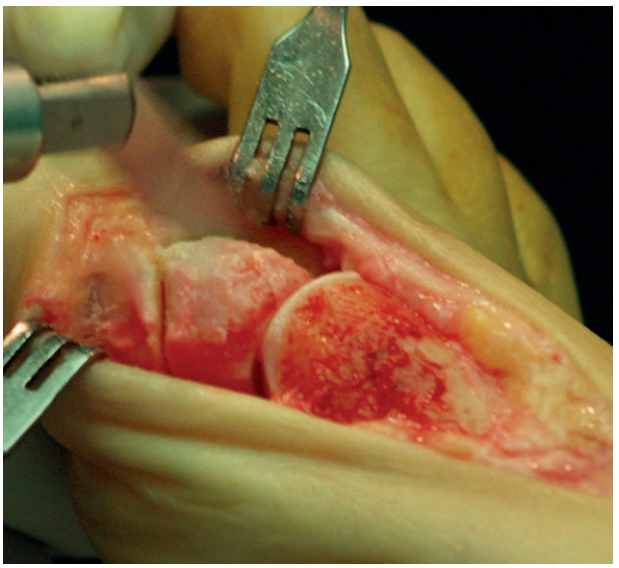

Figure 2. Intraoperative image showing the location of the Double-V osteotomy.

an appropriate method for grades I and II of HL, without sesamoid disease.

The advantages of Cheilectomy include early range of motion and rapid decrease in clinical symptoms. The most important disadvantage is not addressing the etiology. Patients with advance HL are not suitable for Cheilectomy.

2.2. Double-V: Surgical procedure

We believe that genuine indication of this procedure is the presence of HL as a result of excessive length of the proximal phalanx of great toe. Although it has been established that a cause of HL excessive length of the first metatarsal, inasmuch as the goal of intervention is to decompress the 1stMPJ, whatever the size of the metatarsal and/or the proximal phalanx, many of the types of HL, including iatrogenic etiology, can benefit from this technique.

A longitudinal incision of the skin and subcutaneous tissues was made from the dorsomedial aspect, parallel to the longitudinal extensor hallucis tendon, of the 1stMPJ. The capsule was longitudinally opened to expose the base of the proximal phalanx and metatarsal head, and the joint was exposed.

A power saw was used to respect the lateral, medial, and dorsal metatarsal eminences. Lateral osteophytes or osteophytes on the base of proximal phalanx were also removed.

The surfaces were smoothed using a Joseph nasal rasp (beaver-tail) or a drill, in order to achieve proper gliding of the boney surfaces.

Double osteotomy was performed in the shaped of a V, exactly at the anatomical neck of the base of proximal phalanx of the hallux, with distal vertex and an angle between 85° and 105° perpendicular to the plane of the joint, removing a wedge-shaped chevron to the proximal third of the proximal phalanx of the hallux to shorten its length (Figs. 1 and 2).

This osteotomy provides an excellent approximation and stability of the fragments. The alignment must ensure contact with the 2 bone surfaces (stabilization with Kirschner wires) or, better yet, compression between the fragments of bone (with screw) (Figs. 3 and 4).

Figure 3. Postoperative radiography showing the fixation of the osteotomy with a cannulated screw.

Elimination contact between the first metatarsal head and base of the phalanx, increasing the space between the 2 facet joints, is the purpose of this procedure. Therefore, from our personal experience over a decade of practicing this surgical technique, in some cases, we make a distal capsulotomy in the form of "L", which allows a subsequent coating of the metatarsal head and the "purse stringing" of the spindle-shaped capsule, which is usually sufficient to achieve the aim of achieving a pseudoarthrosis and the ultimate aim of preventing recurrence of HL by contact between the bone surfaces.

Postoperative management of this procedure requires passive joint mobilization as early as possible, usually at 4 or 5 weeks. We achieved a good passive mobilization of the 1stMPJ in a relatively short time with proper rehabilitation.

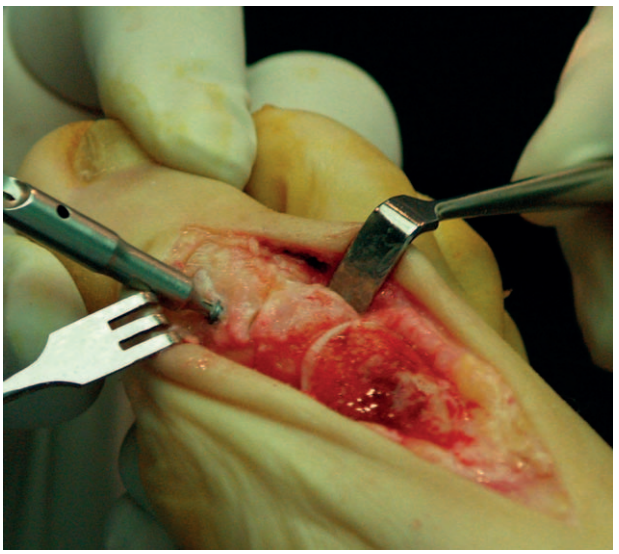

Figure 4. Intraoperative image showing the location of the fixation with cannulated screw Double-V.

3. Results

Both feet operated by the following Cheilectomy procedure as per the Double-V procedure had significant changes ($P < .05$) in the range of motion in dorsiflexion and plantarflexion and range of total movement after the surgical procedure (Tables 2 and 3; Figs. 5 and 6).

However, comparing levels of improvement achieved in the increase of mobility obtained with surgical treatment, the feet operated via procedure Double-V gained significant degrees of movement increased in all 3 analyzed parameters ($P < .05$). You get 13.33° (±13.96°) more than media in dorsiflexion motion, 2.12° (±4.91°) more than half in plantarflexion and 15.39° (±13.81°) of total movement with regard to the feet that were operated by Cheilectomy procedure (Table 4; Fig. 7).

Table 2

Cheilectomy: Dorsiflexion and plantarflexion ranges preoperative and postoperative and statistic significance.

Cheilectomy (N = 33)	Preoperative degrees, μ and σ	Postoperative degrees, μ and σ	Increase degrees, μ and σ	Significance
Dorsiflexion range	30.82° ± 6.03°	46.55° ± 9.93°	15.73° ± 11.92°	0.000
Plantarflexion range	10° ± 3.69°	13.39° ± 3.48°	3.39° ± 3.61°	0.000
Total range	40.82° ± 7.59°	59.7° ± 10.11°	18.88° ± 12.29°	0.000

Table 3

Double-V: Dorsiflexion and plantarflexion ranges preoperative and postoperative and statistic significance.

Double-V (N = 33)	Preoperative degrees, μ and σ	Postoperative degrees, μ and σ	Increase degrees, μ and σ	Significance
Dorsiflexion range	29.36° ± 5.11°	58.42° ± 8.08°	29.06° ± 9.06°	0.000
Plantarflexion range	10.03° ± 3.25°	15.55° ± 3.36°	5.52° ± 2.95°	0.000
Total range	39.39° ± 6.63°	73.67° ± 7.17°	34.27° ± 8.04°	0.000

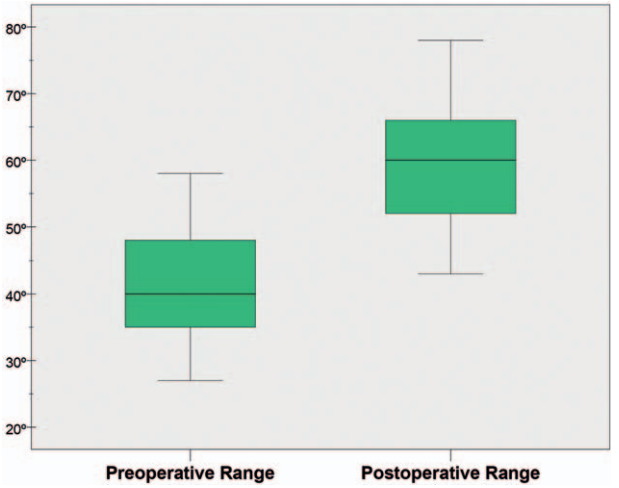

Figure 5. Box-plot showing preoperative and postoperative ranges of Cheilectomy procedure.

Cheilectomy scores on the AOFAS scale improved significantly ($P = .000$) from 64.30 (±9.98) points preoperative to 79.30 (±8.80) points postoperative (Table 5). As far as complications were concerned, there were 3 cases recurrences (decrease dorsiflexion range), 4 cases it had limitations for recreational activities, 2 cases required foot inserts and the use of comfortable shoes, and one case of moderate permanent pain. No cases of HR, hallux varus, infection and/or stress fractures. There are no other complications from the surgical procedure.

Double-V scores on the on the AOFAS scale improved significantly ($P = .000$) 68.21 points (±14.65) preoperative to 91.48 points (±7.80) postoperative (Table 6). The complications, in 1 case, is moderate recurrence of HL (reduction of the dorsiflexion range won with the procedure from 72° to 65°), 2 cases relate (occasional) mild pain, in 1 case it had limitations for recreational activities and 1 case required the use of comfortable shoes. No cases of HR, hallux varus, infection, and/or stress fractures. There are no other complications from the surgical procedure.

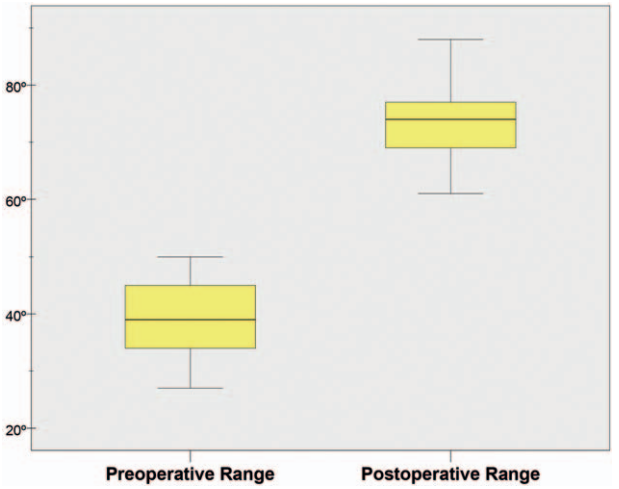

Figure 6. Box-plot showing preoperative and postoperative ranges of Double-V procedure.

Table 4

Increase degrees with every surgical procedure, differences obtained between both procedures and statistical significance.

Increase degrees	Cheilectomy, μ and σ	Double-V, μ and σ	Difference, μ and σ	Significance
Dorsiflexion	15.73°±11.92°	29.06°±9.06°	13.33°±13.96°	0.000
Plantarflexion	3.39°±3.61°	2.52°±2.95°	2.12°±4.91°	0.004
Total	18.88°±12.29°	34.27°±8.04°	15.39°±13.81°	0.000

The comparison of postoperative AOFAS score scale between the 2 procedures was significant ($P = .000$) obtaining 12.18 points higher on average for the group of Double-V.

4. Discussion

For years, there has been and there continuous to be a controversy about the kinematics of the 1stMPJ.[6] Payne et al[7] suggested the term HL when there is less than 65° of dorsiflexion at the 1stMPJ. Cohn and Kanat[8] argue that, in its origin, the term HL was used to define a deformity of the first toe, with limitation of its dorsiflexion function but not important enough to cause stiffness. Palladino[9] proposed the term HL when there is less than 65° of extension at the 1stMPJ. In our study the average correction obtained from the limitation of dorsiflexion with Double-V procedure is 29.06° achieving or approaching the normal pattern of dorsiflexion in most cases (mean: from 29.36° preoperative from 58.42 postoperative).

With regard to radical procedures for the treatment of HL, Regnauld[10] procedure, one of the most common, has the following disadvantages and complications:

1. It is a difficult technically to perform and often causes postoperative pain.
2. Detachment of the abductor and adductor of the hallux.
3. Delayed union and, in some cases, avascularization.

By contrast, the Double-V procedure has the following advantages:

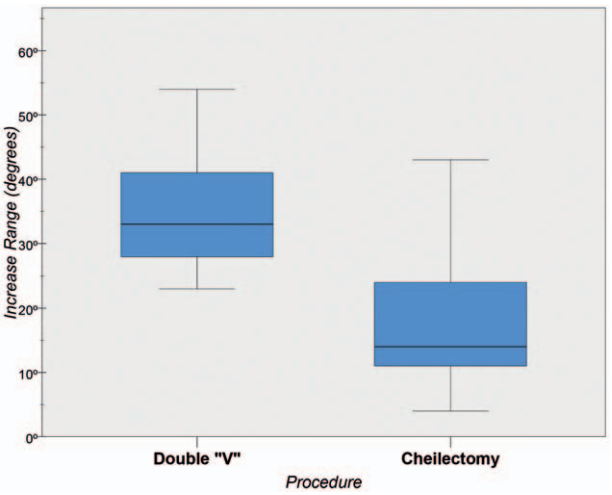

Figure 7. Box-plot showing increase degrees with each procedure: Double-V and Cheilectomy.

Table 5

Cheilectomy: AOFAS Hallux Metatarsophalangeal–Interphalangeal Scale.

Cheilectomy	Preoperative points, μ and σ	Postoperative points, μ and σ	Significance
Pain (40 points)	22.42±8.67	34.24±5.01	0.000
Function (45 points)	33.15±4.79	35.55±4.71	0.024
Activity limitation	8±1.78	8.12±1.90	
Footwear requirements	6.66±3.22	8.03±2.48	
MPJ motion	4.84±0.87	5±0.00	
IP motion	5±0.00	5.60±1.65	
MPJ stability	5±0.00	5±0.00	
Callus related to hallux	3.63±2.26	3.78±2.17	
Alignment (15 points)	8.73±1.85	9.52±0.87	0.012
Total (100 points)	64.30±9.98	79.30±8.80	0.000

IP = interphalangeal, MPJ = metatarsophalangeal joint.

1. Technique is easy to perform (simple and secure fixation) that requires minimal resection of bone and does not require overly sophisticated instruments.
2. The design of the osteotomy as a "hinge" that respects the plantar cortex and cartilage, safeguarding the insertion of the flexor hallucis brevis.
3. Minimal postoperative disability. The recovery that is required is limited, and walking is possible immediately after surgery, with post-surgical shoes. The patient is returned to its normal life early, in about 6 weeks and normal shoes can be used.
4. Good aesthetic and functional results (minimum shortening and maximum respect for joint function), especially in the right indicated: HL/HR.

We believe that the treatment precedes arthroplasty procedures and 1stMPJ arthrodesis.[11–13] These procedures, including variants that allow a "pseudo-arthrosis" or "interposition arthroplasty" with an acceptable functionality[10,14,15] have their fair indication in the HR.

The Valenti[16] procedure is more radical in nature and does not seem to completely solve the problem of HR, but may do so in some cases of HL, providing greater advantage as respect for the intrinsic muscles of the first ray.[17,18] The failure of this procedure is obvious, since, as it is limited to the dorsal aspect, not acting on the plantar quadrant of the 1stMPJ.

The advantages of Cheilectomy include early range of motion, rapid decrease in clinical symptoms and obviates the need for

Table 6

Double-V: AOFAS Hallux Metatarsophalangeal–Interphalangeal Scale.

Double-V	Preoperative points, μ and σ	Postoperative points, μ and σ	Significance
Pain (40 points)	19.70±11.58	36.97±4.66	0.000
Function (45 points)	35.42±4.28	39.94±3.81	0.000
Activity limitation	8.45±2.00	9.63±0.99	
Footwear requirements	8.03±2.48	8.63±2.26	
MPJ motion	5±0.00	5±0.00	
IP motion	5±0.00	6.96±2.48	
MPJ stability	5±0.00	5±0.00	
Callus related to hallux	3.93±2.07	4.69±1.21	
Alignment (15 points)	13.09±3.16	14.58±1.69	0.008
Total (100 points)	68.21±14.65	91.48±7.80	0.000

IP = interphalangeal, MPJ = metatarsophalangeal joint.

healing at an osteotomy site.[19] The disadvantages include not addressing the underlying etiology, potential joint destruction, slippage, or pseudoarticulation at the joint's end range of dorsiflexion. It is not indicated in later stages of the disease.[20] In our study, as indicated in the results, we have had minimal complications.

Other procedures such as Cheilectomy and phalangeal osteotomy have been proposed for the treatment of the HL/HR. Moberg[21] proposes a phalangeal osteotomy that consists of a dorsiflexory wedge osteotomy in the base of the proximal phalanx. Waizy et al presented a series of 46 patients comparing Cheilectomy combined with the Moberg osteotomy. The results were similar although there a was a notable higher grade of satisfaction in the patient group of Cheilectomy plus Moberg osteotomy.[22]

Citron and Neil[23] proposed dorsal wedge osteotomy of the proximal phalanx for HR treatment. O'Malley et al proposed Cheilectomy and phalangeal osteotomy for treatment of HL/HR obtaining the following results: The mean dorsiflexion of the 1stMPJ improved significantly ($P < .05$), by 27.0°, from 32.7° preoperatively to 59.7° postoperatively. The average AOFAS scores improved significantly ($P < .05$) from 67.2 points preoperatively to 88.7 points postoperatively.[24] In our study, which combines the following Cheilectomy with a Double-V osteotomy, we have obtained very similar results: The mean dorsiflexion of the 1stMPJ by 29.36° preoperatively to 58.42° postoperatively and the average of AOFAS scores from 68.21 points preoperatively to 91.48 postoperatively.

We agree with the proposals of Roukis. Cheilectomy with phalangeal dorsiflexory osteotomy for treatment of HR was reported in 11 studies involving a total of 374 procedures. It should be considered as the technique of choice in the surgical treatment of HR, due to the high patient satisfaction and the low incidence of revision surgery after this procedure.[25]

The distal osteotomies of the first metatarsal have been indicated in the surgical treatment of HL/HR. The goal of these osteotomies is to decompress the joint and achieve a plantar displacement of the metatarsal head. However, the general problem with these distal osteotomies is that they cause a relatively important shortening of the first ray, which therefore can cause a secondary metatarsalgia and weight transfer to the central rays, especially in those patients with a metatarsal index minus parabola which is a condition frequently associated with HL/HR.

Haddad[26] published a series of poor results with shortening of the first ray and overload of the sesamoids. It is significant in the systematic review by Roukis[25] that in 93 cases there was a 22.6% rate of revisions and a 30% rate of postoperative metatarsalgia. In this same sense, Kilmartin[27] compared the phalangeal osteotomy to the shortening metatarsal osteotomy in an interesting prospective study, affirming that although neither procedure can be recommended as definitive in the treatment of HL/HR, the phalangeal osteotomy has less complications and a lower grade of patient dissatisfaction.

5. Conclusions

The results of our procedure, with a remarkable relief of the pain (19.70–36.97 points on the AOFAS scale), function improvement (35.42–39.94 points), and alignment (13.09–14.58 points) allows us to say that the Cheilectomy with Double-V osteotomy that we propose in this paper, preceded by a joint cleaning (Cheilectomy) can be a valuable procedure for resolving conservatively HL and postoperative stiffness derived from any of the other procedures used in the treatment of the pathology of the 1stMPJ.

Although the results obtained by this method are promising the first 12 months, with few postoperative complications, being a new procedure we believe that further studies would be needed in the long term to assess whether the changes obtained will be stable and long lasting in the future.

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