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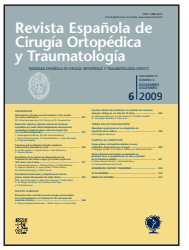

ORIGINAL PAPERS

Results at 3 years of Regnauld's technique for the treatment of hallux valgus and hallux rigidus in 147 cases

A. Santamaría-Fumas*, J. Muriano-Royo, A. Ruiz-Nasarre, V. Adamuz-Medina, V. Vega-Ocaña, X. Bial-Vellvè, M. Delclos-Hartwig and J. Girós-Torres&

Department of Orthopedic and Trauma Surgery, L'Hospitalet General Hospital, L'Hospitalet de Llobregat, Barcelona, Spain

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KEYWORDS
Regnauld;
Hallux valgus;
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Distal articular set angle

Abstract
Purpose: To assess radiological, clinical and functional results at 3 years' evolution of patients subjected to surgical correction of hallux valgus and hallux rigidus by means of the Regnauld technique.
Materials and Methods: This is a descriptive retrospective study of 131 patients and 147 cases operated through the Regnauld technique between 2003 and 2006. One hundred and one females and 30 males were reviewed; 16 cases were bilateral. Mean age was 70 years. Mean follow-up was 3 years. Additional surgical maneuvers were used in 73 cases. Before and after surgery, an assessment was made of the patients' clinical and functional status using both the AOFAS and a subjective scale; measurements were taken of the metatarsophalangeal (MTP), intermetatarsal (IM) and distal articular set angles (DASA).
Results: The degrees of correction achieved were 16.6° for the MTP angle, 2° for the IM angle and 1.7° for the DASA angle. Scores on the AOFAS scale improved from 39.6 to 85.4 points. On the subjective scale, 25%of cases rated their result as excellent, 68%as good and 2%as poor. As far as complications were concerned, there were 4.7%recurrences, 2% instances of moderate pain with no cases of hallux rigidus, hallux varus or infection. There were no reoperations.
Conclusions: The technique makes it possible to shorten the first phalanx, correct rotations, reduce the MTP and DASA angles, preserve the joint's congruence and integrity los MTPA y DASA and regain its function.

*Corresponding author.
E-mail: 35618asf@comb.cat, 35618asf@comb.es (A. Santamaría-Fumas).

PALABRAS CLAVE
Regnauld;
Hallux valgus;
Hallux rigidus;
Ángulo articular distal

Resultados de la técnica de Regnauld para el tratamiento del hallux valgus y el hallux rigidus en 147 casos a los 3 años

Resumen
Objetivo: Evaluar los resultados radiológicos, clínicos y funcionales a los 3 años de evolución en pacientes intervenidos quirúrgicamente para la corrección del hallux valgus y el hallux rigidus mediante la técnica de Regnauld.
Material y método: Estudio descriptivo retrospectivo de 131 pacientes (147 casos) intervenidos mediante la técnica de Regnauld entre los años 2003 y 2006. Se revisaron 101 mujeres, 30 varones, 16 bilaterales. Edad media de 70 años. Seguimiento medio de 3 años. Se asociaron otros gestos quirúrgicos en 73 casos. Antes y tras la cirugía se valoró el estado clínico y funcional con el test de la escala AOFAS (American Orthopaedic Foot & Ankle Society) y se midieron los ángulos metatarsofalángico (AMTF), intermetatarsal (IM) y DASA (*distal articular set angle* 'ángulo articular distal').
Resultados: Corrección del AMTF: 16,6°, del IM: 2° y del DASA: 1,7°. La puntuación en la escala AOFAS mejoró de 39,6 a 85,4.
Resultados: En la escala subjetiva, las valoraciones fueron excelentes (25%), buenas (68%), aceptables (5%) y malas (2%).
Resultados: En el 4,7% hubo recidivas; en el 2% hubo dolor moderado, sin casos de hallux rigidus, hallux varus ni infección; no hubo ninguna reintervención.
Conclusiones; Los resultados a medio plazo son satisfactorios, con un bajo porcentaje de complicaciones. La técnica permite acortar la primera falange, corregir rotaciones, reducir los AMTF y DASA, mantener la congruencia y la integridad articular y recuperar su funcionalidad.

Introduction

The last few years have seen an evolution in the surgical techniques used for treatment of hallux valgus (HV) and hallux rigidus (HR)[1,2]. The growing interest shown by the orthopedic departments of Spanish hospitals in foot and ankle conditions and the setting up of specific units to treat them have spurred research into and application of new techniques.

For many years, few surgical techniques such as those proposed by Dabies-Collety[3], Keller[4,5], Brandes[6] or Lelièvre[7] were used to address practically all cases[8]. Currently there has been a significant change in attitude. Indications, orientations and preoperative planning have undergone a significant evolution with the calculation of the metatarsophalangeal (MTP) angle, the intermetatarsal (IM) angle, the proximal articular set angle (PASA), the proximal articular set angle (PASA), the distal articular set angle (DASA), the consideration of the digital and metatarsal formulae[9] and the availability of specific radiographic views, all of this supplemented by the drawing up and application of specific treatment protocols.

The purpose of this study is to demonstrate the validity of the Regnauld technique for the treatment of HV and HR through a descriptive retrospective analysis of the results obtained at 3 years' follow-up in a group of 147 cases treated with this procedure, used either in isolation or in conjunction with other surgical maneuvers.

Materials and Methods

We hereby present a descriptive retrospective study of 147 cases in 131 patients affected by HV and HR, operated between 2003 and 2006 by means of the Regnauld technique.

Inclusion criteria were as follows: patients older than 40 years of age with the clinico-radiographic exam revealing HV not derived from any other disease (except HR) and an MTPA angle smaller than a 40° or grade II HR. Patients were operated following the Regnauld technique between 2003 and 2006, with a minimum follow-up of 2 years.

Exclusion criteria were as follows: patients under 40 years of age with a clinical-radiographic diagnosis of HV secondary to other diseases, with circulatory or infectious problems, a MTPA higher than 40°, HV of grade i, iii or iv, or with less than 2 years' follow-up.

The initial sample was made up of 204 cases. Once the patients' clinical records were reviewed, those who strictly complied with the inclusion criteria were selected. The final study group therefore shrank to 147 patients, which included those subjects for whom a primary HV-inducing disease had been ruled out. In this manner, cases in which the hindfoot problem was originated in the ankle, the hindfoot and other sites were eliminated from the study and patients were treated for their primary disease in accordance with the established protocols. Patients with adult flatfoot, calcaneus fracture sequelae with talipes calcaneovalgus or neurodegenerative diseases, among

others, were not initially eligible for isolated hindfoot surgery and were excluded.

A total of 131 patients were included in the final study, 16 of them (12.2%) operated of both feet at different surgical sessions. The sample comprised 101 females (77%), of whom 12 were bilateral cases, and 30 males (23%), of whom 4 were bilateral cases. Mean age at surgery was 70 years (range: 40-82 years). Causes for treatment were HV in 111 cases (76%) and HR in 36 cases (24%). Mean follow-up was 2.9 years con with an interval of 2-3 years and a half.

The same standardized surgical technique was used in all cases; four experienced surgeons carried out the procedures.

This technique requires a significant learning curve and presents few differences with that described by Dr. Regnauld in 1968 (fig. 1)[10-13]. After a traditional approach to the first metatarsophalangeal (MTP) joint, an osteotomy is made at the proximal metafisodiaphyseal junction of the first phalanx (P1) of the first ray. Subsequently the distal medullary canal is perforated and a bone plug is created on a level with the proximal fragment; the shape, size and specific characteristics of the bone plug will depend on the characteristics of the patient's phalanx, his/her DASA and his bone stock quality. The bone plug is press-fitted into the P1 medullary canal. We did not suture the plantar plate to the soft tissues or fix it transosseously to P1 as suggested by Badulescu and Blatter[14], because in our opinion reduction of the first metatarsal (M1) to its original position over the sesamoids is achieved through the combination of 3 surgical maneuvers.

—A wide external capsule release is performed in all cases following the P1 osteotomy and before press-fitting the bone plug through a medial approach to the space between the distal end of M1 and the proximal end of P1.
—Increase of the MTP joint space when shortening the phalanx with the osteotomy.
—Capsule plication that maintains the reduction of the head of M1 over the sesamoids[15].

In cases where DASA is greater than 10°, we suggest performing an oblique or medially wedged osteotomy, which will enable a reduction of 2 to 3°. Fixing the distal end of the proximal phalanx to the soft tissues and press-fitting the bone plug will result in the proximal and distal P1 joint surfaces being parallel to each other. Subsequently, the capsule is plicated, the surgical wound closed and a metatarsal strip applied.

When there are alterations of the IM, PASA or DASA angles, metatarsalgias or other associated hindfoot conditions, the necessary techniques must be performed to correct them through a proximal, diaphyseal, distal or Akin (or double) osteotomy, among others. As regards the IM angle, the treatment guidelines of our Department regard an IM angle smaller than 9° as normal; capsule placation is considered sufficient to correct IM angles between 9 and 11°; for IM angles between 11 and 14° a Chevron distal metatarsal osteotomy is recommended; for angles between 14 and 18° a Scarf osteotomy[9] is indicated; for angles between 18 and 22° an osteotomy of the base of M1 is suggested, and for IM angles greater than 22° either a double osteotomy or a Lapidus technique is performed[16-18]. Associated metatarsalgias are treated by simple, double or triple, fixed or unfixed Weil-type subcapital osteotomies[9,19,20] or a metatarsal base osteotomy, depending on the results of prior study and planning.

The following day, patients were discharged from hospital walking full weight bearing with an orthopedic shoe with a semi-rigid insole. They were called for an appointment at 7 days for inspection of the wound and suture removal. At 3 weeks active motion of the first MTP joint was begun. A new follow-up visit was organized at 4 weeks where x-rays were taken; the orthopedic shoe was withdrawn. Follow-up was completed at 3, 6, 12 months and at 2 and 3 years from surgery.

Indications and contraindications of the Regnauld technique are described in table 1.

Patient age is not a contraindication since the Regnauld technique keeps the MTP joint of the first ray intact and congruent.

The complications[21] that could ensue as a result of an erroneous indication or application include:

– Should the first ray be shortened in excess, the final digital formula would be considered a Grecian foot. If

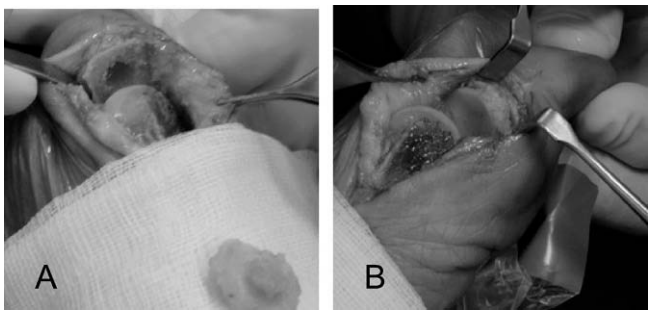

Figure 1 Surgical technique. A) Bone plug is ready for insertion. B) Press-fit introduction and final result prior to capsule plication.

Table 1 Current indications and contraindications of the Regnauld technique

Indications
1. Egyptian foot
2. Irreducible hallux valgus with a MTP angle <40°
3. Grade II hallux rigidus
4. Hallux valgus in osteoporotic patients
Contraindications
1. Disrupted circulation
2. Active infection
3. Hallux valgus with MTP angle > 40°
4. Grade I, II or IV hallux rigidus
5. Short P1

P1: first phalanx of the first toe; MTP: metatarsophalangeal angle.

these patients present with an index minus metatarsal formula, secondary insufficiency of the first ray could result in transfer metatarsalgia if no action is taken as regards the lesser rays[9].

—If when performing the P1 osteotomy a proximal fragment is resected with little bone stock, the bone plug created will be insufficient and secondary displacements or a dissociation could appear in the proximal end of P1.

It should not be forgotten that every case is unique and only individualized study of each case will make it possible to choose most suitable technique from the vast amount of possibilities available.

X-ray study was carried out on the basis of front and profile weight-bearing views. In patients with metatarsalgia a Roig-Puerta view was taken to assess the alignment of the metatarsal heads[18].

Before surgery and iat subsequent follow-up visits measurements were made of the MTP, IM, PASA and DASA angles; the metatarsal and digital formulae were determined and the presence of hyperkeratosis identified. The degree of x-ray healing of the P1 osteotomy was classified as either complete x-ray integration or lack of x-ray integration.

In order to determine the clinico-functional results, all patients were interviewed. The AOFAS (American Orthopaedic Foot and Ankle Society) HV scale[22] (table 2) was used at all pre- and post-operative follow-up visits. Results were considered excellent if the score on the AOFAS scale was higher than 93 points, good if they were between 83 and 92 points, acceptable if they were between 66 and 82 points and poor if under 66 points.

In order to subjectively assess the patients' degree of satisfaction and acceptance of the outcome of their del surgical procedure, they were asked to answer the following question: "How would you rate your current health status?" The possible answers were "excellent", "good", "fair" and "poor."

The data obtained were processed and analyzed by means of the SPSS statistical package. The association between qualitative variables was analyzed with the chi square test or with Fisher's Exact Test, if the patient did not meet the minimum effective levels expected. The result was considered significant when p was equal to or higher than 0.05.

Table 2 AOFAS Hallux Valgus Score[22]

Metatarso-phalangeal and inter-phalangeal scale of the first digit (100 points)	
Pain (40 points)	
1. None	40
2. Mild, occasional	30
3. Moderate	20
4. Severe, almost always present	0
Function (45 points)	
Activity limitations	
1. No limitation	10
2. No limitation of daily activities	7
3. Some limitations of daily activities including recreational and leisure activities	4
4. Severe limitation of daily and recreational activities	0
Footwear requirements	
1. Fashionable, conventional shoes, no insert	10
2. Comfort footwear, shoe insert	5
3. Modified shoes or brace	0
Metatarsophalangeal joint motion (dorsiflexion plus plantarflexion)	
1. Normal or mild restriction (at least 75° of motion)	10
2. Moderate restriction (30 to 74°)	5
3. Severe restriction (less than 30°)	0
Interphalangeal joint motion (plantar flexion)	
1. No restriction	5
2. Severe restriction (less than 10°)	0
Metatarsophalangeal and interphalangeal joint stability	
1. Stable	5
2. Unstable or able to dislocate	0
Callus related to metatarsophalangeal or interphalangeal joints	
1. No callus or asymptomatic callus	5
2. Asymptomatic callus	0
Alignment (15 points)	
1. Good, hallux well aligned	15
2. Fair, some degree of malalignment	8
4. Poor, obvious symptomatic malalignment	0

Results

The total number of patients included in the study was 131: 101 females (77%), 12 of them operated for both feet, and 30 men (23%), 4 of these bilateral. The final number of cases recorded was 147. In bilateral cases, the feet were approached one at a time, with a mean of 6.8 months elapsing between both surgeries.

Additional surgical maneuvers were associated to the Regnauld technique in 73 cases: in 23 cases a Chevron-type distal osteotomy was performed (fig. 2), in 11 cases a proximal osteotomy of the base of M1 (fig. 3), in one case a diaphyseal Scarf osteotomy, in 5 cases a double proximal-distal osteotomy and in 15 cases a subcapital osteotomy of the M2, M3 or M4 heads. In 18 cases it was necessary to approach the lesser rays as there were instances of clawtoe or hammertoe: 5 cases were treated with extensor tenotomy, 3 with flexor-extensor tenotomy, 7 with resection arthroplasty and extensor tenotomy, and 3 with arthrodesis of the MTP joints, of the proximal interphalangeal and distal interphalangeal joints with 1.6 mm wires (MTP dislocation or subluxation).

Radiographic results

The results of the radiographic parameters were calculated using the changes observed in the MTP, IM and DASA angles between the pre-op situation and the follow-up review (table 3).

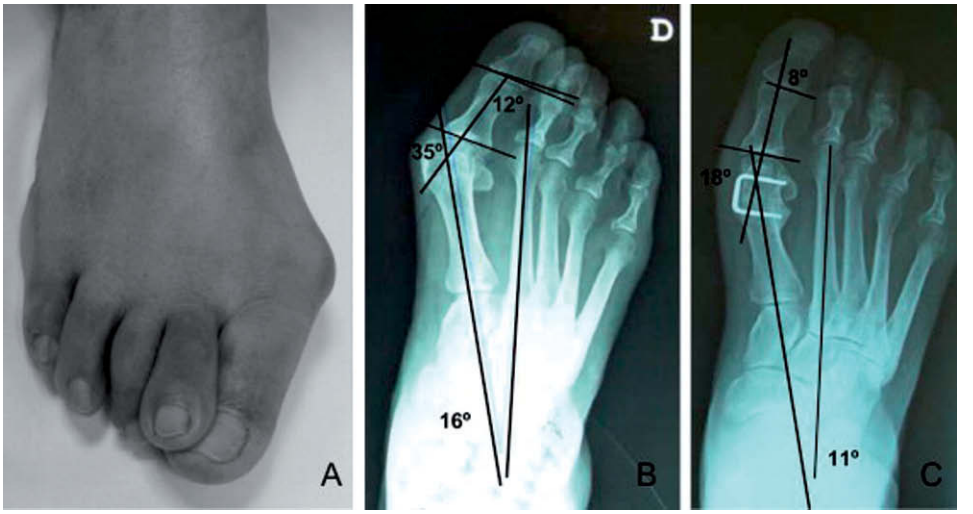

Figure 2 A) 65-year-old woman, right foot. B) Pre-op radiographic study. C) Surgical technique associated to the Regnauld technique: distal osteotomy. Final evolution at 2 years with a 17° improvement in the metatarsophalangeal, a 5º improvement in the intermetatarsal angle and a 4º improvement in the distal articular angle. Scale of the American Orthopaedic Foot and Ankle Society: 93 points, excellent subjective assessment.

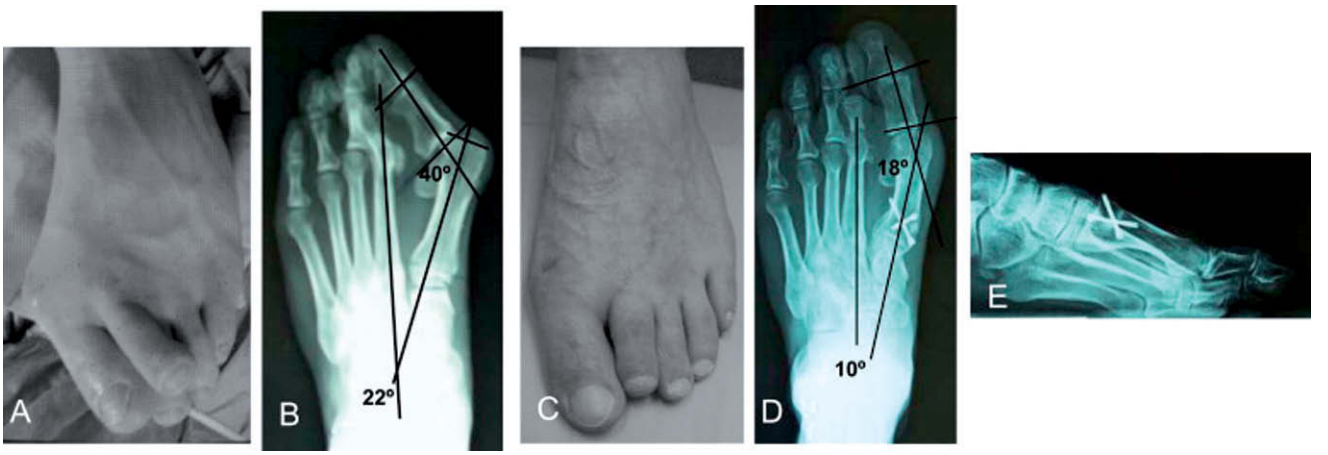

Figure 3 A) 41-year-old male, view of the left foot with pronation of the first toe and overlapping second toe. B) Preoperative x-ray study. C) Surgical technique for Regnauld procedure: proximal osteotomy of the first metatarsal. Final result at 2 years. D) and E) angular corrections; correction of the metatarsophalangeal angle by 22° and of the intermetatarsal angle by 12°. American Orthopaedic Foot and Ankle Society scale: 95 points; excellent subjective evaluation.

Table 3 Radiographic results. Pre- and post-operative values of the metatarsophalangeal, intermetatarsal and distal articular angles

	Pre-op	2 years' post-op	Difference
MTP angle	34.7° (15–40°)	18.1° (12–35°)	16.3°
IM angle	11° (7–25°)	9° (7–15°)	2°
DASA angle	8.2° (0–18°)	6.5 (0–10°)	1.7°

DASA: distal articular set angle; IM: intermetatarsal (angle); MTP: metatarsophalangeal angle.

Metatarsophalangeal angle

Before surgery, mean metatarsophalangeal angle was 34.7° (range: 15-40°). At 4 weeks, the mean angle was 8.1° with a mean initial reduction of 26.6° (76.6%).

At one year from surgery, the MTP angle was measured at 14,7°, with a relapse with respect to the immediate post-op value of 6,6°. In spite of this, a mean reduction of 20º (57.8%) was maintained with respect to the preoperative value.

At 2 years, the final value measured for the MTP angle was 18.1° (range: 12-35°), which constituted an improvement over the initial value of 16.6° (47.8%).

A loss in reduction of 3.4º (18.8%) was observed between the first and the second year's follow-up measurements.

Intermetatarsal angle

Mean preoperative IM angle was 11° (range: 7-25°). At 4 weeks it improved by 3°, achieving a final mean value of 8° the first year. At 2 years only 1° was lost, with a mean final value of 9° (range: 7-15°).

Distal articular angle

Mean preoperative DASA angle was 8.2° (range: 0-18°). Following osteotomy, a correction of 3.2° was achieved at 4 weeks, with a mean value of 5° (39% reduction) at one year. In the second-year follow-up, mean final DASA was 6.5° (range: 0-10°), with a global improvement of 1.7° (20%).

Osteotomy

As regards the evolution of the osteotomy (integration of the bone plug in the medullary canal), 124 cases (85%) presented with complete x-ray incorporation without cortical discontinuities in the successive x-ray views of the phalanx after the third month (figs. 4 and 5). There were 23 cases (15%) of suboptimal incorporation with a discontinuous radio-opaque line at the osteotomy site without secondary displacement or pain. A serial study of the progression from union to pressure of the bone plug onto the medullary canal reamed at the distal end of P1 shows incorporation. At 6 months from surgery the line that signals the boundary of the osteotomy disappeared and at one year a gap appeared all along the phalanx.

Fisher's Exact Test did not find a statistically significant relation between absence of x-ray incorporation and the presence of occasional or moderate pain ($p>0.05$) or with incipient evolution to HR ($p>0.05$). It can be concluded that lack of x-ray incorporation does not increase the likelihood of developing pain or progressing early to HR.

Clinico-functional results

The AOFAS scale was used for the clinico-functional assessment; mean pre-op value was 39.6 points (range: 19-49). Subsequent measurements showed the following result (table 4):

At one month from the procedure the AOFAS score increased by 25.7 points with respect to the previous value (the initial score was 39.6 points and the final one was 65.3). At 6 months the increase was of 38.6 points (range: 39.6- 78.2) and at one year it was 49.9 points (range: 39.6-89.5). At 2 years from surgery, a slight decrease was observed, to 85.4 points. This decrease is attributable to the 7 cases where the MTP angle relapsed: 5 of them after surgery with the Regnauld technique with no additional maneuvers, one case further to a proximal Chevron-type osteotomy and one following a double osteotomy. Mean relapse in these cases was10°. None of them presented pain on ambulation or limitation of normal joint balance.

Two-year results on the AOFAS scale, broken down into the different categories (pain [40 points], function [45 points] and alignment [15 points]), show the following:

Pain

Mean score at 2 years was 37.2 points. Thirty-four cases (23% of total) presented with occasional pain that varied as a function of the type of footwear worn. Three cases (2%) complained of moderate pain at the end of the day that abated with analgesics and rest. In these 3 cases, the MTP angle did not relapse but patients had severe restrictions of MTP joint motion with a reduction of joint space, which

Figura 4 Evolution of the osteotomy of one single case. A) 10 days. B) 4 weeks. C) 2 years post-op. Note progressive incorporation.

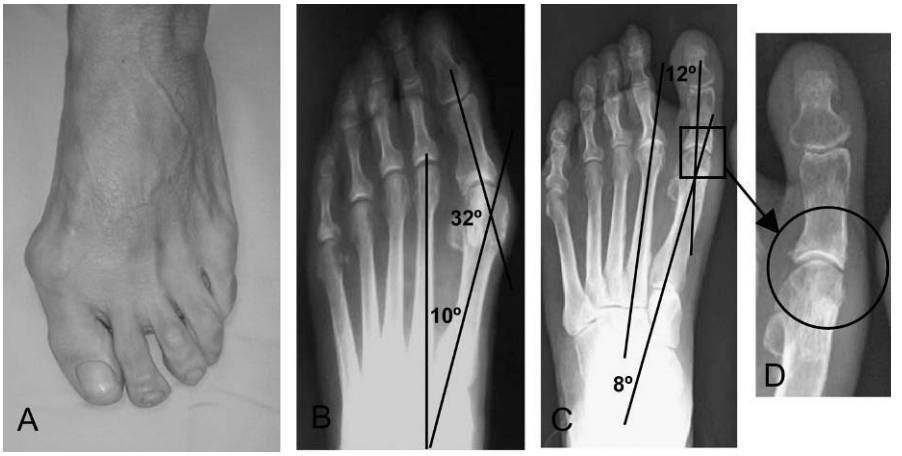

Figure 5 72-year old male. A) Macroscopic left foot view. B) Pre-op radiologic study. C) Final evolution at 2 years. D) Union of osteotomy site.

Table 4 Clinico-functional assessment results

	2 years' post-op
Pain	37.2
Function	33.6
Activity limitations	7.2
Footwear	4
Metatarsophalangeal joint motion	8
Interphalangeal joint motion	4.5
Stability	5
Callus	4.9
Alignment	14.6
Total	85.4

AOFAS (American Orthopaedic Foot and Ankle Society) score[22] at 2 years from the procedure.

seemed to indicate early progression to HR (fig. 6). None of the cases had severe pain on a daily basis.

($p<0.015$), so that the greater the pain the higher the likelihood of early progression to HR.

Function

Mean value at 2 years was 33.6 points. One-hundred thirty seven cases (93%) reported the existence of limitations of sports activities but not of occupational or recreational activities. If the term "sport activity" is taken to include the performance of physical exercise of intermediate intensity the authors of this paper consider that, given the mean age of the patients in the sample, this data is not really too significant for the final analysis of results. Ten patients (7%) went back to their normal sports activities without limitations; these were the youngest patients in the sample.

Sixteen cases (11%) still wore conventional fashionable shoes with no insoles; as in the previous case, these were also the youngest patients in the sample. Eighty-seven cases (59.2%) wore comfortable footwear with an insole, and 44 cases wore orthopedic shoes; these 44 patients were those with MTP angle relapse (7), occasional pain (34) and moderate pain and early progression to HR (3).

With respect to MTP joint motion, 93 cases (63%) had a normal or mildly restricted range of motion; 51 cases (35%) presented with a moderate restriction (range: 30-74°) and 34 reported occasional pain. Three cases (2%) had a severely restricted range of motion (less than 30° flexion-extension) and moderate pain. Fisher's Exact Test analysis of MTP joint motion (limitation of motion) and early progression to HR showed a statistically significant relationship between both ($p<0.045$), so that the greater the restriction to motion the higher the likelihood of early progression to HR. Comparison of the results by means of a chi square test of the restriction of MTP joint motion and pain variables was statistically significant ($p<0.001$).

IP joint motion was complete in 134 cases (91%), and 13 cases (9%) presented with a severe restriction with associated pain; 3 of these were cases showing an incipient progression to HR.

MTP joint stability was acceptable in all cases.

Three cases presented with an asymptomatic callus; these were the same patients that reported moderate pain.

The 93 cases with no limitation of motion were asymptomatic and, of the 54 patients that presented with limitation of motion, 37 reported pain; these differences were statistically significant ($p<0.01$).

Alignment

Mean value at 2 years was 14.6 points. At 2 years, 139 cases (95%) presented with a well-aligned HV and 8 cases (5%) showed slight asymptomatic deviation. There were no cases of malalignment or evident and symptomatic deviation.

An analysis of the cases showing malalignment at the end of follow-up revealed no correlation between the pain experienced by the patients and the said malalignment.; these differences were statistically significant ($p<0.02$).

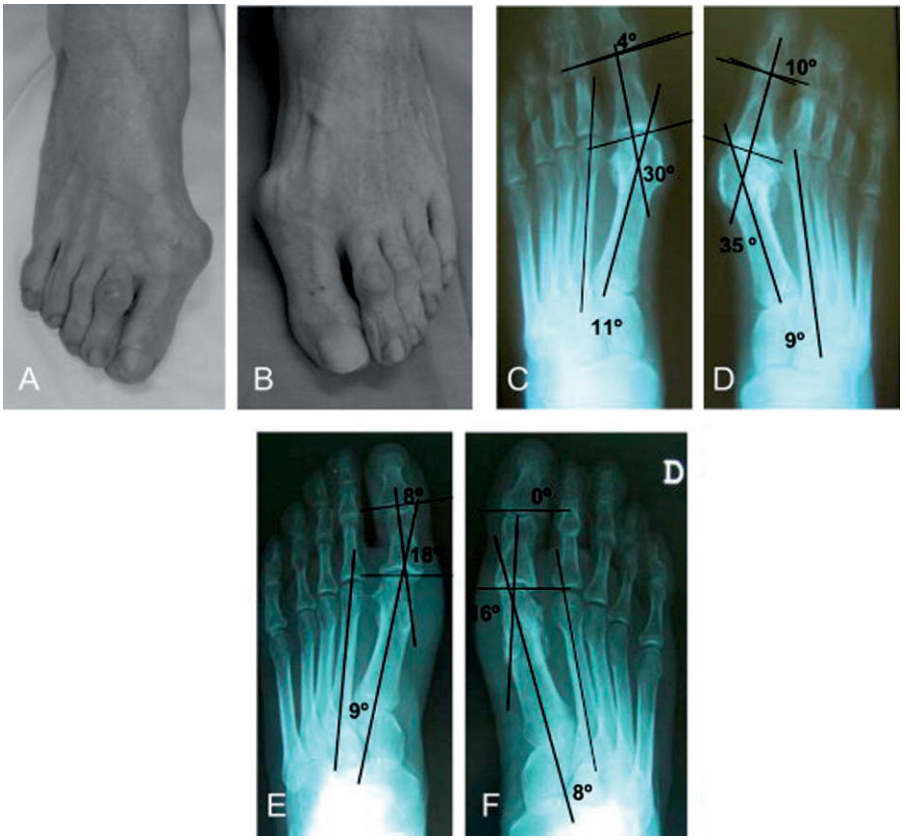

Figure 6 72-year old woman, bilateral. Macroscopic view and preoperative radiographic study. A) Right foot: hallux rigidus. B y C) Left foot: hallux valgus. D) Right foot: hallux rigidus. E) 2 years' follow-up. Note incipient development of hallux rigidus in the left foot. F) 2 years' follow-up. American Orthopaedic Foot and Ankle Society Scores: 90 points for the right foot: and 72 points for the left foot. Subjective evaluation for the right foot: excellent; left foot: acceptable.

Subjective evaluation

The subjective assessment of results was carried out by asking the question: "How would you rate your current status if it were to be permanent?". Thirty-seven patients (25%) rated it as excellent and 100 cases (68%) as good; 7 cases (4.7%) said it was acceptable. These were the patients where the MTP angle had relapsed; they rated their current status as acceptable not because of the pain but because of the cosmetic HV relapse. Three patients (2%) defined their status as poor with nondaily moderate pain.

Complications

Seven 7 cases (4.7%) presented with a relapse of the MTP angle at 2 years with nearly preoperative values. Mean value of relapses was 10° with a mean MTP angle of 30° (range: 25-35°). Three of the (2%) reported moderate pain and following physical examination and an x-ray study revealed incipient progression to HR. In spite of this, patients claimed they had experienced a significant improvement with respect to their previous condition and did not wish to undergo further surgery. The cases that relapsed reported more pain than those that did not; these differences were statistically significant ($p<0.01$).

The results obtained were analyzed in terms of the different surgical techniques used and any subsequent recurrences with no statistically significant differences being found between them ($p>0.005$).

As regards early progression to HR and previous indications (HV or HR), analysis of the results obtained with Fisher's Exact Test did not reveal statistically significant differences between them ($p>0.05$).

No instances of overcorrection or infection were identified.

Discussion

The medical literature contains descriptions of multiple techniques for the treatment of HV, although none of these can be considered the gold standard. The recent growing interest in hindfoot pathology, the development of new techniques and the appearance of new materials will no doubt result in the future availability of more resources to successfully address the challenges posed by hindfoot disease.

The present study seeks to demonstrate the validity of a technique that is more than 40 years old, which can be applied in isolation or associated to other surgical maneuvers.

Table 5 Comparative literature review

	Study	Hanft[17]	Kurian[8]	Daghino[19]
N	147 cases	20 cases	20 cases	69 cases
Mean age	70 years	–	56 years	52 years
Follow-up	2.9 years	2.2 years	3.3 years	4.2 years
Pre-S MTPA	34.7°	34°	29.3°	36°
MTPA reduction	16.3°	14°	16,9°	16°
IMA reduction	2°	4°	2°	2°
MTP angle relapse	4.7%	–	40%	–
Early progression to HR	3%	–	40%	–
Subjective assessment	93%	92%	92%	–
Satisfied patients (%)				

IMA: Intermetatarsal angle; MTPA: metatarsophalangeal angle; MTPA Pre-op MPTA: Pre-operative metatarsophalangeal angle; HR: hallux rigidus; n: total number of cases included in the study.

The authors do not Intend to belittle any of the techniques currently in use, the purpose of this study is to present potential solutions that use less aggressive techniques, do not require the use of osteosynthesis material and do not involve an increase of OR time.

The number of cases presented is acceptable and the percentages of sex, mean age, laterality and clinico-functional and radiographic status prior to surgery are comparable to those described in the medical literature[11,23-26]. Clinico-functional parameters have been evaluated with internationally accepted scores and pre- and postoperative radiographic measurements show results similar to those of other authors.

A literature review identified 3 references to the Regnauld technique (table 5):

The first of these, by Hanft et al[23]. reviewed the results of applying the Regnauld technique at 2 years' follow-up. After a mean follow-up of 2 years (as compared with the 3 years of the present study) the authors achieved a reduction of the MTP angle of 14° (16.3° in this series); in the subjective assessment 93% of patients considered themselves to be satisfied with the procedure. These data are very similar to those presented herein.

Kurian et al[11], presented the results of a series of 20 patients with a mean age lower than that of patients in this study (56 years as compared with 70) y con un longer mean follow-up (3 years and 4 months). Preoperative MTP angle was 29.3° (34.7° in the cases presented herein) and the final correction obtained was of 16.9° and, in line with our series, the IM angle was corrected by 2°. Forty percent of cases suffered a relapse in the MTP angle, without pain. Ninety-two percent of patients said they were satisfied with the procedure and 8 cases (40%) suffered early progression to HR, as compared with 3% in the present study.

In the last publication, Daghino et al[24] compared the Regnauld technique with a first toe osteotomy. Their series was made up of 69 cases with a lower mean age (52 years) and a mean follow-up of years and 3 months. They obtained an improvement of the MTP angle of 16° (from 36° pre-op to 20° post-op) of the IM angle of 2° (from 14 to 12°). These results are comparable to those of the present study.

To summarize, the Regnauld technique offers the following advantages:

- It preserves joint congruence and decreases the risk of early progression to arthritis. In congruent well-preserved MTP joints with no degenerative changes preserving the facet joint of the base of P1 defers progression to osteoarthritis and to HR with respect to the Keller-Brandes-Lelièvre technique, which spontaneously creates a new articulation with a smaller range of motion[21,25,26]. At 3 years' evolution, patients who preserve joint congruence and integrity behave as patients without previous MTP joint surgery.
- It decompresses the MTP joint space of the first toe. Shortening of P1 relieves tension on the as well as the pressure on the articular cartilage of M1 and P1; it also delays the onset of pain due to joint involvement and improves MTP joint motion. This surgical maneuver will help maintain joint congruence thereby reducing de risk of a potential progression to HR.
- It restores or preserves MTP joint function. On discharge, patients can ambulate; at one week, following suture removal, they start a passive exercise program and at 3 weeks start with active motion of the first MTP joint. At 3 months, the majority of patients achieve near-normal joint balance.
- It corrects the DASA angle with either an oblique cut or a medial wedge osteotomy without the need for osteosynthesis. The risk of discomfort, infection, protrusion and loosening is minimized; no new surgery is needed for hardware exchange or removal.
- It allows correction of malalignment as well as first toe pronation associated to HV.
- It indicated in patients with osteoporosis. Although not contraindicated, the use of osteosynthesis hardware could lead to fixation problems arising from the weakness of the bone substrate.

The Regnauld technique is not intended to alter the time honored criteria established for treatment of HV. The

technique is just an economical way of supplementing the procedures used to address alterations of the MTP and DASA angles, which uses a traditional approach and which has a low percentage of complications and highly satisfactory clinico-functional, radiographic and subjective medium-term results.

The Keller-Brandes-Lelièvre technique will remain a treatment option for elderly patients, with low functional demands and significant disabling deformities. Since its indication is limited to that age group a wide spectrum is left for application of the Regnauld technique.

Initial expectations are satisfactory but only long-term follow-up will demonstrate whether the AOFAS scores, results of the subjective evaluation tests and the radiographic measurements of the different angles are preserved. New 5 and 10-year post-op follow-up reviews will determine whether the recurrent cases and those showing incipient progression to HR continue to reflect the low percentages obtained in the present study.

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