Effectiveness of hallux valgus surgery on improving health-related quality of life: A follow up study

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ABSTRACT

Background: Hallux valgus (HV) negatively impacts health-related quality of life (HRQoL). Patient-reported outcome measures (PROMs) are increasingly used in clinical studies of the foot and ankle. We aimed to evaluate the effect of HV surgery on PROMs (i.e., pain scales, general HRQoL, and region-specific scales) and radiological angles. Additionally, we aimed to determine whether the effect on these outcomes depends on the type of surgery (including open and percutaneous techniques) and if it is influenced by potential confounding factors (i.e., age, HVA, 1–2 IMA, body mass index (BMI), and distal metatarsal articular angle (DMAA).
Methods: This was a longitudinal prospective study. We collected the clinical data of all patients who underwent surgery for symptomatic HV deformity in the orthopedic department of the Virgen de la Luz Hospital of Cuenca (Spain).The clinical outcomes were assessed using the American Orthopedic Foot and Ankle Society (AOFAS) Hallux metatarsophalangeal-interphalangeal (HMI) scale, visual analogue scale (VAS), Manchester Oxford foot questionnaire (MOXFQ), short form health survey (SF-12) and European Quality of Life-5 Dimensions (EQ-5D).
Results: A total of 72 patients (70 women, 97.2%) were included in the study 72 (72 feet).The AOFAS pre–post-surgery score changed from 42.16 (SD: 10.11) to 83.31 (SD: 6.23). Considering AOFAS domains, the pre–post change was from 14.17 (SD: 9.15) to 33.19 (SD: 4.69) for pain, from 27.22 (SD: 3.90) to 37.94 (SD: 2.78) for function, and from 0.78 (SD: 2.38) to 12.18 (SD: 3.45) for alignment. For other clinical outcomes was VAS score from 5.01(SD: 1.26) to 1.26 (SD: 0.96) and MOXFQ score from 61.44 (SD: 7.09) to 12.35 (SD: 4.85). SF-12 (physical) changed from 36.26 (SD: 5.32) to 47.06 (SD: 4.82), SF-12 (mental) from 38.23 (SD: 8.04) to 46.49 (SD: 4.16), and EQ5-D from 0.64 (SD: 0.008) to 0.90 (SD: 0.10).
Conclusions: Our data confirmed the improvements in the clinical and radiological outcomes after HV surgery, and provided some evidence of these improvements not depending on the type of surgery or on some potential confounding factors such as BMI, HVA, 1–2 IMA, and DMAA.

1. Introduction

Hallux valgus (HV) is a frequent pathological disorder of the forefoot [1] that commonly produces painful disability. HV is used to describe the structural deformity of the first metatarsophalangeal joint (MTPJ) [2,3], clinically determined when the HV angle is greater than 15° and the 1–2 intermetatarsal angle (IMA) is greater than 9° [4]. Although HV has a clear genetic component, being predominant amongst women [5], it is a progressive deformity, especially in those aged over 50 years. The prevalence of HV increases from 23% in adults aged 18–65 years to 35.7% in people aged over 65 years [6,7].

As a result of both pain and disability, HV deformity negatively impacts the health-related quality of life (HRQoL) [8,9]. The greater the HV angle and great toe pain, the worse the scores in the physical, psychological, and social aspects of HRQoL [10,11]. It has been determined [12] that HV deformity is coupled with

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significant foot-specific pain and disability, even when global physical functioning and participation in activities are not adversely affected. Over time, as severity of HV deformity increases, progressive muscle weakness occurs around the first MTPJ and both general and foot-specific HRQoL scoring progressively decrease [10,13].

Numerous surgical procedures have been developed for the treatment of HV [14]. However, no consensus exists on the optimal surgical technique to correct this deformity [15,16] Thus, the surgical choice should be taken after considering the range of causal factors [17–19]. Open procedures are the most commonly used surgical techniques, including chevron's distal osteotomy and scarf diaphyseal osteotomy in the first metatarsal [20–22]. In the last years, the interest in minimally invasive surgery (MIS) has been growing due to its theoretical advantages including lower morbidity and less time required for recovery and rehabilitation [23]. However, the evidence supporting percutaneous techniques is still inconclusive [24,25] per randomized control trials with designed treatment protocols and the use of validated tools for measurements.

Most studies [26–28] have reported improvements on the correction of the radiological angles (HVA and 1–2 IMA) as well as in HRQoL assessed by the American Orthopedic Foot and Ankle Society (AOFAS) scale. Although the AOFAS score cannot be considered a true patient-reported outcome measures (PROM) [29], it is usually the most used tool in clinical studies of the foot and ankle [30,31]. Systematic reviews [32] have shown that HV surgery is a more effective procedure than conservative or no treatment in reducing pain [33]. However, high-quality studies comparing similar types of HV treatments and rates of complications or unfavorable outcomes re lacking [34].

Thus, we aimed to evaluate the effect of HV surgery on PROMs (i.e., pain scales, general HRQoL, and region-specific scales) and radiological angles. Additionally, we aimed to determine whether the effect on these outcomes depends on the type of surgery (including open and percutaneous techniques) and if it is influenced by potential confounding factors (i.e., age, HVA, 1–2 IMA, body mass index (BMI), and distal metatarsal articular angle (DMAA).

2. Material and methods

2.1. Study design

This was a longitudinal prospective study conducted between March 2017 and May 2018. The study was designed and conducted in accordance with the Declaration of Helsinki and the Guidelines on Good Clinical Practice [35], and was approved by the Clinical Research Ethics Committee of the Cuenca Health Area. Written and oral informed consent was obtained from all participants.

We collected the clinical data of all patients who underwent surgery for symptomatic HV deformity in the orthopedic department of the Virgen de la Luz Hospital of Cuenca (Spain). All surgical techniques were performed by orthopedists and included open surgery (chevron osteotomy [36] and scarf osteotomy [37]) and percutaneous surgery with Reverdin–Isham osteotomy [38].

The inclusion criteria for patients were (1) older than 18 years with painful HV; (2) complete conservative treatment (including oral medication, shoe modification, and physical therapy for three months); (3) mild-to-moderate HV deformity [39], a pre-operative HVA < 40° and 1–2 IMA < 20°; (4) primary HV surgery, and (5) signed written informed consent. We excluded patients with severe hallux rigidus (radiological suggestion of severe degenerative arthritis) of MTPJ or stiffness, severe instability of the first tarsometatarsal joint, previous failed HV surgery, infection, peripheral vascular disease, peripheral neuropathy or other systemic diseases affecting the musculoskeletal system, and patients with a follow-up of <12 months.

A total of 81 eligible patients were initially included in our study, but 9 patients were lost to follow-up. The type of osteotomy was decided according to the HVA and 1–2 IMA. The surgeon's opinion also influenced the choice of surgical technique, based on his/her experience, as well as on the most dominant osteotomy used during his/her professional career".. Chevron osteotomy was conducted in 16 patients (16 feet), scarf osteotomy was performed in 24 patients (24 feet), and percutaneous surgery was completed in 32 patients (32 feet). Akin osteotomy [40] was performed in 22 patients (22 feet) (30%) of the total.

2.2. Clinical outcomes

The clinical outcomes were assessed using the AOFAS Hallux metatarsophalangeal-interphalangeal (HMI) scale [41], visual analogue scale (VAS) [42], Manchester–Oxford Foot Questionnaire (MOXFQ) [43], short form health survey (SF-12) [44], and European Quality of Life-5 Dimensions (EQ-5D) [45]. These outcomes were evaluated before surgery and at the end of the follow-up; additionally, the post-operative complications were recorded at end of follow-up.

The AOFAS-HMI scale (range, 0–100 best score) recording system combines subjective and objective data to assess the following clinical factors: pain (40 points), function (45 points), and alignment (15 points) [46]. The VAS consists of a straight line with the endpoints scoring 0 (no pain at all) to 10 (the worst pain imaginable). The MOXFQ is a patient-based questionnaire for assessing HRQoL in patients receiving foot and/or ankle surgery. It consists of a 16-item summative Likert scale scored from 0 to 4 (most severe) in three dimensions: pain, walking/standing, and social interaction. The total score ranges from 0 to 64. The MOXFQ index is calculated as the percentage of the maximum score dividing the total score by the maximum possible score (i.e., 64) and multiplied by 100 [47].

The SF-12 questionnaire is a 12-item survey including physical and mental health components (PCS-12 and MCS-12) [48]. EQ-5D [49], includes 5 questions about the patients' mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The total score ranges from 1 (without problems) to 0 (unable to perform/extreme problems).

2.3. Radiological assessment

The radiological examination of HVA, 1–2 IMA and DMAA, was completed by the same independent observer and according to the same radiographic protocol. Weight-bearing dorsoplantar and lateral images were obtained preoperatively, immediately after the surgery, and at the end of the follow-up [50]. The HVA is measured using the anteroposterior view as the angle between the line connecting the center of the first metatarsal base and the metatarsal head with the line connecting the center of the proximal and distal articular surfaces of the proximal phalanx. The 1–2 IMA is measured as the angle between the former line and the line bisecting the diaphyseal portion of the second metatarsal. Finally, the DMAA is defined as the angle between the perpendicular line and the longitudinal axis of the first metatarsal [51,52].

2.4. Surgery procedures

The surgical procedures were completed using local or block anesthesia in the supine position and under tourniquet control. During surgery, the foot was kept externally rotated with its lateral edge on the operating table.

The distal metatarsal chevron osteotomy [36] was completed through a medial incision starting from the proximal phalanx medially, continuing proximally beside the medial margin of the

metatarsal; a longitudinal midline capsulotomy was performed in the identical plane as the incision. The apex of the osteotomy was positioned 1–2 mm superior to the center of the metatarsal head and the angle of the chevron was 60° to 90°. Fixation was achieved by two cannulated screws.

Scarf osteotomy [37] was performed with a skin lateral incision of 3–4 cm and a longitudinal capsular incision. The longitudinal osteotomy was oblique from the longitudinal axis of the first metatarsal and the transverse limbs ought to be parallel to each other, perpendicular to the second metatarsal, and approximately 60° to 80° positioned to the longitudinal osteotomy line. Fixation was achieved with a two headless compression screws.

The adductor hallucis tendon section and a lateral soft tissue release were completed in all cases for both techniques and an intraoperative observation for DMAA was performed. The hallux was then reduced to a neutral position and congruency of the MTPJ was confirmed under fluoroscopy.

Otherwise, percutaneous surgery was performed through a 3–5 mm skin incision on the medial and plantar side of the first metatarsal head. The exostosectomy was removed from this incision with a conical burr. Reverdin–Isham osteotomy [23,38] was performed using a Shannon straight burr. Finally, we completed a lateral soft tissue release of the MTFJ and a tenotomy of the adductor hallucis tendon through a 1–2 mm skin incision. All steps were verified under fluoroscopy. Osteosynthesis was not used in any case of percutaneous surgery. The Akin osteotomy [40] of the proximal phalanx was chosen for the existence of hallux interphalangeus. The Akin osteotomy was performed without osteosynthesis.

2.5. Statistical analysis

The sample size was estimated considering a pre–post-surgery difference of 2.5% (α error 0.05; statistical power of 0.80) in AOFAS scale mean score, obtaining a minimal estimated sample size of 43 patients. To have sufficient statistical power for examining other outcomes and estimating a 15% dropout rate, the minimum sample size was estimated on 72 patients.

Both statistical (Kolmogorov–Smirnov test) and graphical methods (normal probability plots) were used to assess the normal distribution for each continuous variable. In the descriptive statistics section, categorical variables are presented as sample (n) and percentage (%), and continuous variables are presented as mean and standard deviation (SD). Repeated measures ANCOVA models were used to test the mean differences of the pre–post-surgery clinical and radiological outcomes, adjusted by baseline values of clinical outcomes (i.e., VAS, MOXFQ, SF-12, and EQ-5D) in Model 1, and adjusted by baseline values, age, BMI, HVA, 1–2 intermetatarsal angle, and distal metatarsal articular in Model 2. We estimated the crude change and the effect size (ES) for each outcome using Cohen's d index [53]. The ES was categorized as 0.2 (weak effect), 0.5 (moderate effect), 0.8 (strong effect), and >1.0 (very strong effect). Additionally, Student's t-test and ANOVA were used to test mean differences in clinical outcomes at the end of follow-up in the categories of age, HVA (<30 and $\geq$30), 1–2 IMA (<13 and $\geq$13), BMI (normal weight, overweight, and obesity), and DMAA. Statistical analyses were performed using SPSS-IBM (V.24.0 SPSS Inc., Armonk, NY, USA), and statistical significance was set at $p \leq 0.05$.

3. Results

3.1. Characteristics of the case series

The final number of patients included in the study was 72 (72 feet), mean age 59.67 years (SD: 11.39) and including 70 women (97.2%). Each patient was followed for at least 12 months with a total mean follow-up period of 17.68 months (SD: 3.11 months). Demographic baseline characteristics are summarized in Table 1.

Clinical and radiological outcomes

For the total sample, AOFAS pre–post-surgery score changed from 42.16 (SD: 10.11) to 83.31 (SD: 6.23). Considering AOFAS domains, the pre–post change was from 14.17 (SD: 9.15) to 33.19 (SD: 4.69) for pain, from 27.22 (SD: 3.90) to 37.94 (SD: 2.78) for function, and from 0.78 (SD: 2.38) to 12.18 (SD: 3.45) for alignment. The pre–post-surgery change for other clinical outcomes was: VAS score from 5.01 (SD: 1.26) to 1.26 (SD: 0.96) and MOXFQ score from 61.44 (SD: 7.09) to 12.35 (SD: 4.85). In relation to general QoL PROMs, SF-12 (PCS) changed from 36.26 (SD: 5.32) to 47.06 (SD: 4.82), SF-12 (MCS) from 38.23 (SD: 8.04) to 46.49 (SD: 4.16), and EQ5-D from 0.64 (SD: 0.008) to 0.90 (SD: 0.10) (Table 2).

The pre–post-surgery change in the radiographic measurements included: HVA from 30.8° (SD: 3.56°) to 10.22° (SD: 1.01°), 1–2 IMA from 12.31° (SD: 1.60°) to 7.71° (SD: 0.86°), and DMAA from 13.44° (SD: 0.88°) to 7.55° (SD: 0.99°) (Table 2).

Non-significant differences were found in clinical outcomes at the end of the follow-up by type of surgery except for the PCS-12 between scarf osteotomy and percutaneous surgery ($p = 0.006$). Regarding the angles, greater improvements in the 1–2 IMA were found for chevron osteotomy versus scarf osteotomy, chevron osteotomy versus percutaneous surgery, and scarf osteotomy and percutaneous ($p = 0.001$). In addition, better improvements in DMAA were found for chevron versus scarf osteotomy, chevron osteotomy versus percutaneous surgery, and scarf osteotomy versus percutaneous ($p = 0.001$; Supplementary Material Table S1). Finally, after controlling for baseline clinical outcomes (model 1), as well as for baseline clinical outcomes, age, BMI, HVA, 1–2 IMA, and DMAA, the differences in clinical and radiological outcomes were not substantially modified (Tables 3 and 4).

Table 1
Characteristics of the case series (n = 72 cases in 72 patients).

Variable	Mean
Age (years)	59.67 ± 11.39
Female n, (%)	70 (97.2)
Weight (Kg)	68.53 ± 9.01
Height (cm)	158.48 ± 6.79
BMI (Kg/m^2)	27.35 ± 3.86
Normal weight n, (%)	21 (29.2)
Overweight n, (%)	32 (44.4)
Obesity n, (%)	19 (26.4)
Side	
Right n, (%)	38 (52.8)
Left n, (%)	34 (47.2)
Indication for surgery	
Pain, n (%)	15 (20.8)
Shoe fit problems, n (%)	2 (2.8)
Pain and shoe fit problems, n (%)	55 (76.4)
Family history, n (%)	62 (86.1)
Maternal inheritance, n (%)	42 (58.3)
Paternal inheritance, n (%)	20 (27.8)
Metatarsalgia, n (%)	23 (31.9)
Lesser toe deformities, n (%)	13 (18.1)
Metatarsal formula	
Index minus, n (%)	56 (77.8)
Index plus, n (%)	1 (1.4)
Index minus plus, n (%)	15 (20.8)
Egyptian foot, n (%)	57 (79.2)
Hallux rigidus	
Grade 1, n (%)	9 (12.5)
Grade 2, n (%)	4 (5.6)
Follow-up (months)	17.68 ± 3.11

Results are shown as mean and (±) Standard deviation. For categorical variables the values are expressed in percentages.
Abbreviation: BMI, body mass index.

Table 2
Mean differences of the preoperative and end of follow-up clinical and radiological outcomes.

Outcomes	Preoperative n (72)	End of follow-up n (72)	Δ Crude change	95% CI	ES*
Clinical					
VAS [b]					
Total	5.01 ± 1.26	1.26 ± 0.96	−3.75	(-4.01 to -3.49)	**3.347**
AOFAS [a]					
Total	42.16 ± 10.11	83.31 ± 6.23	41.15	(38.72 to 43.58)	**4.900**
Pain	14.17 ± 9.15	33.19 ± 4.69	19.02	(17.01 to 21.04)	**2.616**
Function	27.22 ± 3.90	37.94 ± 2.78	10.72	(9.55 to 11.89)	**3.165**
Alignment	0.78 ± 2.38	12.18 ± 3.45	11.40	(10.54 to 12.25)	**3.846**
MOXFQ [b]					
Total	61.44 ± 7.09	12.35 ± 4.85	−49.08	(-50.73 to -47.43)	**8.081**
Pain	69.31 ± 12.31	10.76 ± 6.80	−58.54	(-61.16 to -55.91)	**5.887**
Walking	62.24 ± 7.85	15.04 ± 7.42	−47.21	(-49.81 to -44.60)	**6.179**
Social	50.61 ± 12.46	10.07 ± 5.40	−40.53	(-43.21 to -37.86)	**4.221**
SF-12 [a]					
PCS	36.26 ± 5.32	47.06 ± 4.82	10.79	(9.55 to 12.03)	**2.127**
MCS	38.23 ± 8.04	46.49 ± 4.16	8.25	(6.49 to 10.01)	**1.290**
EQ-5D [a]					
Total	0.64 ± 0.08	0.90 ± 0.10	0.26	(0.23 to 0.28)	**2.871**
Radiological [c]					
HVA	30.80°±3.56	10.22°±1.01	−20.58	(-21.32 to -19.83)	**7.865**
1−2 IMA	12.31°±1.60	7.71°±0.86	−4.59	(-5.08 to -4.11)	**3.581**
DMAA	13.44°±0.88	7.55°±0.99	−5.88	(-6.18 to -5.59)	**6.288**

Results are shown as mean and (±) Standard deviation. Bold values indicate statistical significance p ≤ 0.05.
Abbreviations: VAS,visual analogue scale; AOFAS,American Orthopaedic Foot and Ankle Society; MOXFQ, Manchester-Oxford Foot Questionnaire; SF-12,Short Form-12 Health Survey; PCS, Physical Component Score; MCS, Mental Component, Score; EQ-5D, EuroQol-5D; HVA, hallux valgus angle; 1−2 IMA, 1−2 intermetatarsal angle; DMAA, distal metatarsal articular angle; ES, effect size.
P values for all comparisons between preoperative and end of follow-up were statistical significance p ≤ 0.001.
[a] Higher scores indicate a better health-related quality of life.
[b] Lower scores indicate a better health-related quality of life.
[c] Lower scores indicate a better radiological outcome.
* The size of the effect was categorized as 0.2 (considered a weak effect), 0.5 (considered a moderate effect), 0.8 (considered a strong effect), and >1.0 (considered a very strong effect) by Cohen.

Overall, no differences were found when we analyzed the mean of the clinical outcomes at the end of follow-up by categories of HVA, 1−2 IMA, age and BMI. (Supplementary material table S2).

3.2. Complications

At the end of follow-up, a total of seven complications occurred in six patients (six feet) (8.4%). There were two patients suffering transfer metatarsalgia, three patients with recurrent asymptomatic HV, one patient had first MTFJ stiffness, and another patient had complex regional pain syndrome type 1. One patient suffered metatarsalgia and recurrent asymptomatic HV simultaneously. No patient suffered head necrosis or troughing [54], failure of fixation, delayed wound healing, or Varus deformity.

4. Discussion

This follow up study was aimed to examine the effect of HV surgery on PROMs (i.e., pain scales, general HRQoL, and region-specific scales) and radiological angles, and to determine whether the observed effects could be modified by the type of surgery (including open and percutaneous techniques) and by confounding factors. Our data indicated that HV surgery improves patients' PROMs and radiological angles regardless the type of surgery. These effects persist after controlling for potential confounders (i.e., age, HVA, 1−2 IMA, BMI, and DMAA).

We found pre–post improvements in the VAS, AOFAS (total score and specific domains), MOXFQ (total score and specific domains), PCS and MCS of SF-12, and EQ-5D scores, similar to findings reported in previous studies [55–57]. Although most studies only reported data from the AOFAS and VAS scales, the use

of PROMs [58] is encouraged to assess HV surgery outcomes [59]. Their inclusion could provide valuable information for the evaluation of patients' outcomes [33], and could play an important role in determining the impact of HV surgery on HRQoL.

The correction of radiological angles is related to improvement in PROMs [29], although we observed a correction in the angles and poor scores in the PROMs, especially in the pain scoring. From this perspective, our data showed improvements after surgery in the three radiological angles (i.e., HVA, 1−2 IMA, and DMAA) similar to those previously reported in other studies [60,61].

When we analyzed whether the observed effects on clinical outcomes could be modified by the type of surgery and confounding factors, we did not find substantial differences in the results after adjusting for different sets of confounders [62]. The differences found in the 1−2 IMA and DMAA angles between types of surgery may be due to the surgeon's decision based on the initial angles. Additionally, the role of BMI in HV surgery outcomes has been previously studied [63,64] and BMI did not act as a predictor for functional outcomes; thus, patients with obesity should not be excluded from HV surgery [65].

The overall complication rate in our study was 8.4%. Although these figures are slightly higher than those reported by other studies [66–68], our complication rate is acceptable, considering the surgical variability and the lack of appearance of serious complications. Additionally, recurrence is a feared complication after HV surgery, with rates ranging from 3% to 73% [61,64,69,70], being 4.2% in our study. A recent systematic review presents a recurrence of 5.1% [71] HV recurrence has been correlated with preoperative HVA, 1−2 IMA, and DMAA [72–74]. Preoperative HVA has been considered the most important predictor of outcomes after HV surgery, with 1−2 IMA and DMAA playing secondary roles

Table 3

Pre-post mean differences on the clinical outcomes by types of surgery, controlling for baseline outcome (model 1) and baseline outcome, age, body mass index, hallux valgus angle, 1-2 intermetatarsal angle and distal metatarsal articular angle(model 2).

		Chevron osteotomy n (16)		Scarf osteotomy n (24)		Percutaneous surgery n (32)	
VAS [b]		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Total	Preoperative	5.18 ± 1.37	5.19 ± 1.37	5.00 ± 1.18	5.00 ± 1.18	4.94 ± 1.29	4.93 ± 1.29
	End-of follow up	1.37 ± 0.95	1.37 ± 0.95	1.50 ± 0.83	1.50 ± 0.83	1.03 ± 1.03	1.03 ± 1.04
	ES	3.23	3.24	3.43	3.43	3.35	3.34
AOFAS[a]							
Total	Preoperative	41.68 ± 10.90	41.69 ± 10.99	41.45 ± 10.44	41.56 ± 10.44	42.93 ± 9.71	42.94 ± 9.70
	End-of follow up	84.31 ± 5.53	84.31 ± 5.54	82.00 ± 5.90	82.03 ± 5.90	83.81 ± 6.80	83.81 ± 6.81
	ES	4.93	4.93	4.60	4.59	4.87	4.87
Pain	Preoperative	12.50 ± 10.00	12.50 ± 10.03	15.00 ± 8.84	15.01 ± 8.84	14.37 ± 9.13	14.38 ± 9.13
	End-of follow up	33.12 ± 4.78	33.12 ± 4.79	31.66 ± 3.80	31.67 ± 3.80	34.37 ± 5.04	34.37 ± 5.04
	ES	2.63	2.63	2.44	2.44	2.71	2.71
Function	Preoperative	28.68 ± 3.77	28.69 ± 3.77	26.12 ± 3.98	26.12 ± 3.99	27.31 ± 3.78	27.32 ± 3.78
	End-of follow up	37.50 ± 2.44	37.50 ± 2.44	38.54 ± 2.82	38.54 ± 2.83	37.71 ± 2.91	37.72 ± 2.90
	ES	2.77	2.77	3.60	3.60	3.1	3.1
Alignment	Preoperative	0.50 ± 2.00	0.50 ± 2.01	0.33 ± 1.63	0.32 ± 1.62	1.25 ± 2.95	1.25 ± 2.95
	End-of follow up	13.68 ± 2.82	13.69 ± 2.80	11.79 ± 3.56	11.80 ± 3.56	11.71 ± 3.54	11.72 ± 3.54
	ES	5.40	5.38	4.14	4.15	3.21	3.21
MOXFQ [b]							
Total	Preoperative	60.71 ± 7.95	60.71 ± 7.95	62.40 ± 7.72	62.40 ± 7.71	61.08 ± 6.27	61.10 ± 6.27
	End-of follow up	12.30 ± 4.63	12.30 ± 4.62	12.88 ± 5.17	12.89 ± 5.17	11.99 ± 4.84	12.00 ± 4.84
	ES	7.44	7.44	7.53	7.53	8.76	8.76
Pain	Preoperative	69.68 ± 12.97	69.69 ± 12.98	69.79 ± 12.46	69.80 ± 12.45	68.75 ± 12.24	68.75 ± 12.24
	End-of follow up	11.25 ± 5.62	11.25 ± 5.62	12.08 ± 5.69	12.09 ± 5.70	9.53 ± 7.96	9.54 ± 7.97
	ES	5.84	5.84	5.96	5.96	5.73	5.73
Walking	Preoperative	60.22 ± 8.84	60.21 ± 8.84	64.40 ± 8.12	64.40 ± 8.09	61.64 ± 6.95	61.65 ± 6.93
	End-of follow up	15.80 ± 6.78	15.80 ± 6.78	14.84 ± 7.71	14.85 ± 7.70	14.80 ± 7.71	14.80 ± 7.72
	ES	5.63	5.63	6.25	6.27	6.38	6.38
Social	Preoperative	50.78 ± 11.60	50.79 ± 11.60	50.00 ± 11.36	50.00 ± 11.35	50.97 ± 13.94	50.97 ± 13.94
	End-of follow up	7.81 ± 2.79	7.82 ± 2.80	10.67 ± 5.67	10.68 ± 5.67	10.74 ± 5.98	10.74 ± 5.98
	ES	5.10	5.10	4.38	4.38	3.75	3.75
SF-12 [a]							
PCS	Preoperative	36.33 ± 5.29	36.33 ± 5.30	35.27 ± 4.69	35.28 ± 4.71	36.98 ± 5.81	36.98 ± 5.80
	End-of follow up	47.37 ± 4.84	47.38 ± 4.83	44.63 ± 4.26	44.63 ± 4.26	48.70 ± 4.60	48.70 ± 4.60
	ES	2.18	2.18	2.10	2.10	2.23	2.23
MSC	Preoperative	38.37 ± 9.43	38.37 ± 9.43	38.83 ± 6.54	38.84 ± 6.54	37.71 ± 8.53	37.71 ± 8.52
	End-of follow up	45.56 ± 2.94	45.56 ± 2.93	47.51 ± 3.83	47.52 ± 3.82	46.18 ± 4.81	46.18 ± 4.80
	ES	1.02	1.02	1.61	1.61	1.22	1.22
EQ-5 [a]							
Total	Preoperative	0.66 ± 0.09	0.66 ± 0.09	0.62 ± 0.06	0.62 ± 0.06	0.65 ± 0.07	0.65 ± 0.07
	End-of follow up	0.91 ± 0.09	0.90 ± 0.09	0.88 ± 0.09	0.89 ± 0.09	0.90 ± 0.11	0.90 ± 0.10
	ES	2.77	2.77	3.40	3.40	2.90	2.90

Results are shown as mean and (±) Standard deviation. Bold values indicate statistical significance $p \leq 0.05$.

Abbreviations: VAS,visual analogue scale; AOFAS,American Orthopaedic Foot and Ankle Society; MOXFQ, Manchester-Oxford Foot Questionnaire; SF-12,Short Form-12 Health Survey; PCS, Physical Component Score; MCS, Mental Component, Score; EQ-5D, EuroQol-5D; ES, effect size.

P values for all comparisons between preoperative and end of follow-up were statistical significance $p \leq 0.001$. * The size of the effect was categorized as 0.2 (considered a weak effect), 0.5 (considered a moderate effect), 0.8 (considered a strong effect), and >1.0 (considered a very strong effect) by Cohen. Model 1: adjusted by baseline outcome; Model 2: adjusted by baseline outcome, age, body mass index, hallux valgus angle, 1−2 intermetatarsal angle and distal metatarsal articular angle.

[a] Higher scores indicate a better health-related quality of life.

[b] Lower scores indicate a better health-related quality of life.

in postoperative outcomes [62,74]. Other factors that can influence HV recurrence are non-compliance with postoperative recommendations, including early forefoot weight bearing and removal corrective bandage, and wear stiletto heels [71]. We found an acceptable recurrence rate for the three surgical techniques and found no differences between them [62,75].

There are some limitations to this study that should be acknowledged. First, the follow-up period was relatively short for evaluating long-term HV recurrence. Second, the variability in the surgical techniques and the involvement of different surgeons might have affected the results, although it provides some advantages such as it might better reflect actual practice than when reporting data from a single surgeon or technique. Third, although AOFAS is the most used instrument, this tool has some limitations in assessing the impact of HV surgery on HRQoL in

terms of validity, reliability, and responsiveness, which may impact the statistical power of our effect estimates. Finally, numerous factors may have influenced clinician- and patient-related outcomes, such as type of surgery, surgeon skill, other associated forefoot diseases (lesser toe deformities, metatarsalgia), and comorbidities.

In conclusion, our data confirmed the improvements in the clinical and radiological outcomes after HV surgery, and provided some evidence of these improvements not depending on the type of surgery or on some potential confounding factors such as BMI, HVA, 1−2 IMA, and DMAA. In addition, our outcomes indicated the suitability of including PROMs (pain scales, general QoL, and region-specific scales) as important outcomes in the assessment of HV surgery, since they are probably more important for the patient than the purely radiological findings.

Table 4

Pre-post mean differences on the radiological outcomes by types of surgery, controlling for baseline outcome (model 1) and baseline outcome, age, body mass index, hallux valgus angle, 1-2 intermetatarsal angle and distal metatarsal articular angle (model 2).

		Chevron osteotomy		Scarf osteotomy		Percutaneous surgery	
		n (16)		n (24)		n (32)	
HVA[a]		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Preoperative	31.44 ± 3.34	31.43 ± 3.34	32.21 ± 3.55	32.21 ± 3.55	29.44 ± 3.26	29.43 ± 3.27
	End-of follow up	10.32 ± 1.08	10.31 ± 1.07	9.91 ± 0.92	9.91 ± 0.92	10.41 ± 1.01	10.40 ± 1.01
	ES	8.50	8.50	8.60	8.60	7.88	7.86
1−2 IMA[a]							
	Preoperative	12.00 ± 0.96	12.00 ± 0.96	14.00 ± 1.35	14.00 ± 1.32	11.18 ± 0.78	11.19 ± 0.78
	End-of follow up	7.68 ± 0.78	7.69 ± 0.78	7.04 ± 0.62	7.04 ± 0.62	8.21 ± 0.71	8.22 ± 0.71
	ES	4.93	4.92	6.62	6.74	3.98	3.98
DMAA[a]							
	Preoperative	13.68 ± 0.96	13.69 ± 0.96	13.62 ± 0.96	13.63 ± 0.97	13.19 ± 0.73	13.18 ± 0.73
	End-of follow up	6.50 ± 0.63	6.50 ± 0.63	8.58 ± 0.50	8.53 ± 0.51	7.31 ± 0.64	7.31 ± 0.64
	ES	8.84	8.85	6.58	6.58	8.56	8.55

Results are shown as mean and (±) Standard deviation. Bold values indicate statistical significance p ≤ 0.05.
Abbreviations: HVA, hallux valgus angle; 1−2 IMA, 1−2 intermetatarsal angle; DMAA, distal metatarsal articular angle; ES, effect size.
P values for all comparisons between preoperative and end of follow-up were statistical significance p ≤ 0.001. * The size of the effect was categorized as 0.2 (considered a weak effect), 0.5 (considered a moderate effect), 0.8 (considered a strong effect), and >1.0 (considered a very strong effect) by Cohen. Model 1: adjusted by baseline outcome; Model 2: adjusted by baseline outcome, age, body mass index, hallux valgus angle, 1−2 intermetatarsal angle and distal metatarsal articular angle.
  [a] Lower scores indicate a better radiological outcome.

Conflicts of interest

None of authors declare a conflict of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.fas.2021.08.002.

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