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FOOT & ANKLE

Recurrence rates with long-term follow-up after hallux valgus surgical treatment using shaft metatarsal osteotomies: a systematic review and meta-analysis

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- *Purpose:* Recurrence of hallux valgus (HV) following corrective surgery is a frequent concern. A recent systematic review estimated recurrence of HV in only 4.9%, which may be an underestimation, as most included studies had short- to mid-term follow-up. The purpose of this systematic review and meta-analysis was to synthesize and critically appraise the literature on the long-term outcomes of shaft osteotomies of the first metatarsal (M1) to treat HV without inflammatory disease or degenerative arthritis, and to assess the long-term HV recurrence rates of studies with a minimum follow-up of 5 years.
- *Methods:* This systematic review conforms to the PRISMA guidelines. The authors conducted a search using PubMed, Embase®, and Cochrane Central Register of Controlled Trials databases. Studies that report outcomes of shaft osteotomies of the M1 for non-inflammatory and non-degenerative HV having a minimum follow-up of 5 years were included. We found five eligible studies comprising six datasets, all assessed Scarf osteotomies with a mean follow-up that ranged from 8 to 14 years.
- *Results:* The HV recurrence rate was 40%, considering the threshold of >15° hallux valgus angle (HVA), 30% having >20°, and 2% having >25°.
- *Conclusion:* At a minimum follow-up of 8 years following shaft osteotomies of M1, the HVA was 15.9°, the intermetatarsal angle (IMA) was 7.7°, and the DMAA was 8.3°. Furthermore, the recurrence rates considering the various thresholds of HVA were: 40% having >15°, 20% having >20°, and 2% having >25°.
- *Level of Evidence*: Meta-analysis, Level IV

Keywords: AOFAS; hallux valgus; HVA; IMA; long-term; outcomes; recurrence

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Introduction

Hallux valgus (HV) is one of the most common forefoot pathologies and mostly causes pain, but less often can lead to impaired gait, poor balance, and an increased fall risk in older adults (1, 2). For symptomatic HV, operative correction is the standard, as it is more effective compared to conservative measures (3). Over the years, a multitude of surgical techniques have been described, including distal, shaft, and proximal osteotomies of the first metatarsal (M1), first metatarsophalangeal joint resections, soft tissue procedures, as well as first tarsometatarsal (TMT1) and metatarsophalangeal (MTP1) fusion (4).

The techniques have been modified by surgeons to attempt to avoid common complications such as residual pain or stiffness, under-/over-correction, necrosis of the metatarsal head, as well as fracture and nonunion. Recurrence is a frequent concern expressed by patients before surgery, which may occur in the long term from poor results of former surgical techniques (5). Recently, a systematic review by Barg *et al.* (6) revealed a recurrence rate of 5.6% following shaft osteotomies, but most of these studies were short- to mid-term follow-up outcomes and therefore could underestimate recurrence rates (7, 8, 9). Jeuken *et al.* (10) investigated long-term follow-up and found a recurrence rate of up to 78% at a mean of 14 years following surgery. Information on HV surgical outcomes and recurrence rates at long-term follow-up is of importance to set realistic expectations for both patients and surgeons.

The purpose of this systematic review and meta-analysis was to synthesize and critically appraise the literature on the long-term outcomes of shaft osteotomies of the M1 to treat HV without inflammatory disease or degenerative arthritis, and to assess the long-term HV recurrence rates of studies with a minimum follow-up of 5 years.

Materials and methods

The protocol for this systematic review was submitted to PROSPERO prior to commencement (registration no. CRD42022298199) and conforms to the principles outlined in the handbook of the Cochrane Collaboration (11), along with the guidelines established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (12).

Search strategy

The authors conducted a structured electronic literature search on 5 January 2023 using the PubMed, Embase®, and Cochrane Central Register of Controlled Trials databases, applying the keywords presented in Appendix I. The search was limited to articles published between 2000 and 2023. After the removal of duplicate records, each of the two researchers (ML and LN) screened the titles and abstracts to determine suitability for the review using the following predefined eligibility criteria:

Inclusion criteria

- Studies that report outcomes of shaft osteotomies of the M1 for non-inflammatory and non-degenerative HV have a minimum follow-up of 5 years.

Exclusion criteria

- Studies with a minimum follow-up <5 years.
- Studies on HV with inflammatory disease or degenerative arthritis (hallux rigidus).
- Narrative or systematic reviews, case reports, expert opinions, editorials, or letters to editors.
- Articles published in languages other than English, French, German, Italian, Spanish, or Dutch.
- Articles published before the year 2000.

Study selection

Studies that met the eligibility criteria during title and abstract screening underwent full-text screening by two researchers (ML and LN), and any disagreement was first discussed between the researchers. If required, a third researcher (FVR) resolved any disagreements. The reference lists of studies selected for full text review were searched, and a fellowship-trained foot and ankle surgeon (ML) was consulted to identify further relevant studies that may not have been captured by the database searches.

Data extraction and quality assessment

Data extraction was performed by two researchers (FVR and LN) independently, and their results were compared to ensure accuracy. Where there was disagreement in the documented value, the true value was ascertained by simultaneous review of the data in question by both researchers. The following data were extracted from the included studies: author(s), journal, year of publication, level of evidence, country where the study was performed, conflicts of interest, and funding declaration. Patient characteristics were retrieved, including the number of patients in each group, sex, and age. Indications for surgery and techniques, as well as pre- and post-operative angles and clinical scores, were extracted including HV angle (HVA), intermetatarsal angle (IMA), and American Orthopedic Foot and Ankle Society (AOFAS) score. Finally, all recurrences and complications were documented. The methodological quality of the eligible studies was assessed by two researchers (FVR and LN) according to the Joanna

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Table 1 Characteristics of the studies included.

	Hartenbach *et al.* (14)	**Hartenbach** *et al.* (14)	**Jeuken** *et al.* (10)	**Bock** *et al.* (7)	**De Vil** *et al.* (13)	**Kilmartin** *et al.* (15)
LoE	III		II	IV	II	IV
Study type	RS		PS	RS	PS	RS
Indication						
HVA	>20°				>20°	
IMA	>10°			<20°		
Cohort, feet *n*	36	41	36	93	23	
Mean FU	10	8	14	10	8	9
Surgical technique	Scarf*	Scarf†	Scarf	Scarf	Scarf	Scarf + akin osteotomies
Akin	28%	24%	N	19%	N	100%
Lateral release	Yes		Yes	Yes	Yes	Yes
COI	None		None	None	None	None
Funding	None		None	None	None	NR

*Interdigital approach; †transarticular approach.
LoE, level of evidence; PS, prospective study; RS, retrospective study.

Briggs Institute (JBI) checklist to appraise the reporting quality (10 items). Where there was disagreement between the researchers, consensus was achieved by discussion and review.

Statistical analysis

When available in the original articles, outcomes were tabulated: continuous outcomes were reported as means, standard deviations, and ranges, while categorical outcomes were reported as proportions. Heterogeneity was evaluated by visual inspection of forest plots, and using the I^2 statistic and its connected χ^2 test, to provide a measure of the degree of inconsistency across studies. Pooled estimates of raw means and their 95% CI were calculated using a random-effects model framework. Pooled estimates of proportions and their 95% CI were calculated via Freeman–Tukey double arcsine transformation using inverse-variance weighting within a random-effects model framework. *P*-values <0.05 were considered statistically significant. Statistical analyses were performed using R version 4.1.3 (R Foundation for Statistical Computing, Vienna, Austria) using the meta package.

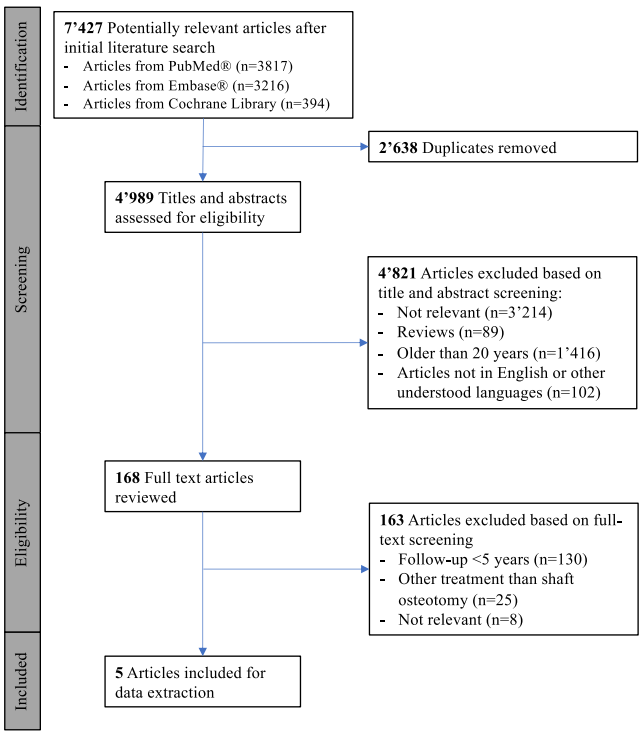

Figure 1
PRISMA Flowchart (7, 10, 13, 14, 15).

Results

The systematic search returned 7427 records, of which 2638 were duplicates, leaving 4989 for screening. A total of 4821 studies were excluded by examining their titles and/or abstracts, and a further 163 studies were excluded after full-text review, as 130 had a follow-up <5 years, 25 were on treatments other than shaft osteotomy, and eight were not relevant. This left five eligible studies (7, 10, 13, 14, 15), with a total of 229 feet (Table 1, Fig. 1). The five studies comprised six datasets, and all assessing Scarf osteotomies, with a mean follow-up (Mean FU) that ranged from 8 to 14 years.

Quality assessment

Of the five eligible studies, one was a randomized controlled trial and four were case series. Statistical analyses were insufficient in two of the five studies, as one insufficiently described its statistical methods, while the other did not describe them at all (Table 2). Of the five studies, the one randomized controlled trial scored

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Table 2 JBI checklist for case series and randomized controlled trials.

		Bock *et al.* (7)	De Vil *et al.* (13)	Kilmartin *et al.* (15)	Hartenbach *et al.* (14)	Jeuken *et al.* (10)
Case series						
1	Were there clear criteria for inclusion in the case series?	Y	Y	N	Y	
2	Was the condition measured in a standard, reliable way for all participants included in the case series?	Y	Y	Y	Y	
3	Were valid methods used for identification of the condition for all participants included in the case series?	Y	Y	Y	Y	
4	Did the case series have consecutive inclusion of participants?	Y	Y	U	Y	
5	Did the case series have complete inclusion of participants?	Y	Y	Y	Y	
6	Was there clear reporting of the demographics of the participants in the study?	Y	Y	Y	Y	
7	Was there clear reporting of clinical information of the participants?	Y	Y	Y	Y	
8	Were the outcomes or follow-up results of cases clearly reported?	Y	U	Y	Y	
9	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	Y	Y	Y	Y	
10	Was statistical analysis appropriate?	Y	U	N	Y	
Randomized controlled trials						
1	Was true randomization used for assignment of participants to treatment groups?					U
2	Was allocation to treatment groups concealed?					U
3	Were treatment groups similar at the baseline?					Y
4	Were participants blind to treatment assignment?					U
5	Were those delivering treatment blind to treatment assignment?					NA
6	Were outcomes assessors blind to treatment assignment?					U
7	Were treatment groups treated identically other than the intervention of interest?					Y
8	Was FU complete and if not, were differences between groups in terms of their FU adequately described and analyzed?					Y
9	Were participants analyzed in the groups to which they were randomized?					Y
10	Were outcomes measured in the same way for treatment groups?					Y
11	Were outcomes measured in a reliable way?					Y
12	Was appropriate statistical analysis used?					Y
13	Was the trial design appropriate, and were any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?					Y

high for risk of bias (10), while one case series also scored high for risk of bias (50%) (15).

Hallux valgus angle

Of the six included datasets, all reported pre- and post-operative HVA (Table 3). At a minimum follow-up of 5 years, the pooled HVA following shaft osteotomies was 15.9 (CI: 12.0–19.8; 6 datasets; I^2 = 93%) (Fig. 2).

Intermetatarsal angle

Of the six included datasets, five reported pre- and post-operative IMA (Table 3). At a minimum follow-up of 5 years, the pooled IMA following shaft osteotomies was 7.7 (CI: 6.7–8.7; 5 datasets; I^2 = 81%) (Fig. 3).

Distal metaphyseal articular angle

Of the six included datasets, three reported pre- and post-operative DMAA (Table 3). At a minimum follow-up of 5 years, the pooled DMAA following shaft osteotomies was 8.3 (CI: 7.0–9.5; 3 datasets; I^2 = 36%) (Fig. 4).

Recurrence rate

Two datasets reported the recurrence of HV considering a threshold of HVA >15° (Table 4, and Fig. 5). The overall

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Table 3 Radiographic and clinical outcomes.

			HVA		IMA		AOFAS	
Study	**Cohort***	**Mean FU**	**Preop**	**Postop (>5y)**	**Preop**	**Postop (>5y)**	**Preop**	**Postop (>5y)**
Hartenbach *et al.* (14)	36	10	36 ± 7	13 ± 13	17.2 ± 3	7.3 ± 4	59	
Hartenbach *et al.* (14)	41	8	36 ± 7	16 ± 8	16.5 ± 3	6.5 ± 3	60	
Jueken *et al.* (10)	36	14	30	22	12.6	8.9	47	80
Bock *et al.* (7)	93	10	31 ± 8	15 ± 11	13.9 ± 3	7.0 ± 3	57	95
De Vil *et al.* (13)	23	8	39	20	15.0	9.0	47	88
Kilmartin *et al.* (15)	73	9	37 ± 7	10 ± 6	16.0 ± 3			

*refers to number of feet.

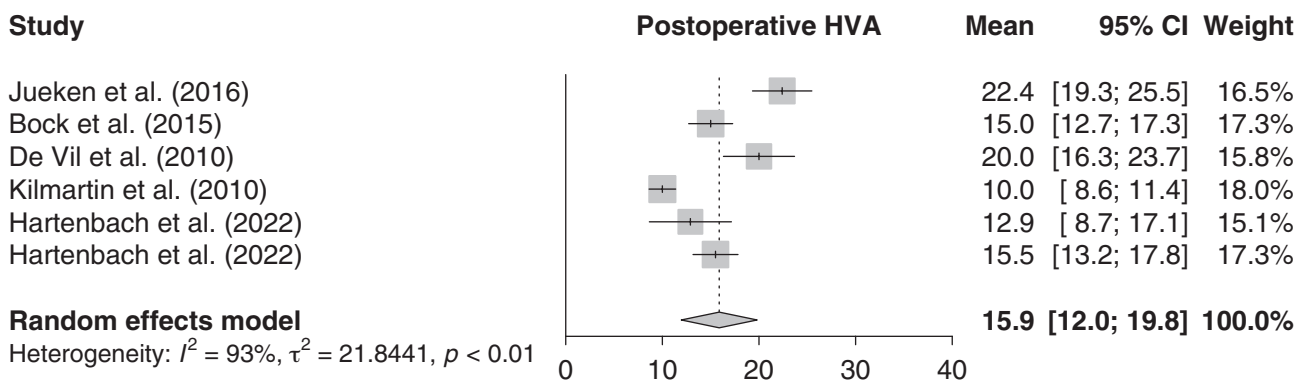

Figure 2

Forest plot on postoperative HVA (7, 10, 13, 14, 15).

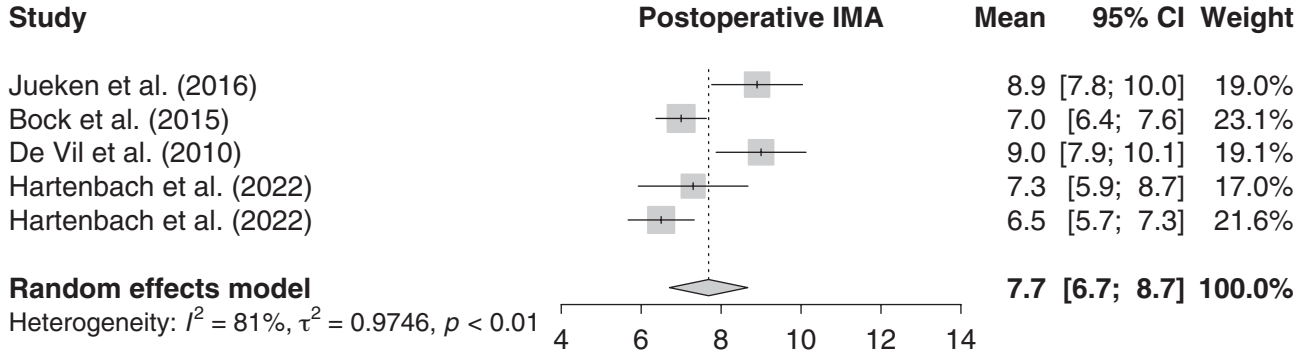

Figure 3

Forest plot on postoperative IMA (7, 10, 13, 14, 15).

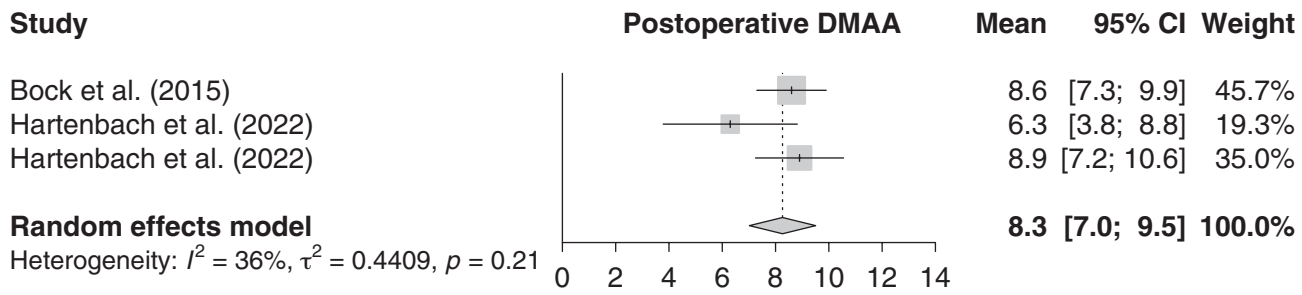

Figure 4

Forest plot on postoperative DMAA (7, 14).

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Table 4 Recurence and complications.

Study	Cohort	Age	Mean FU	Recurrence thresholds				Reoperation	Revision for recurrence or hallux valgus
				>15°	≥20°	>25°	Other		
Hartenbach *et al.* (14)	36	59	10		17%	11%		6%	0%
Hartenbach *et al.* (14)	41	54	8		29%	2%		12%	0%
Jueken *et al.* (10)	36	44	14	78%			73%		3%
Bock *et al.* (7)	93	50	10		30%	8%		14%	1%
De Vil *et al.* (13)	23	45	8						0%
Kilmartin *et al.* (15)	73	57	9	8%	8%	0%		25%	0%

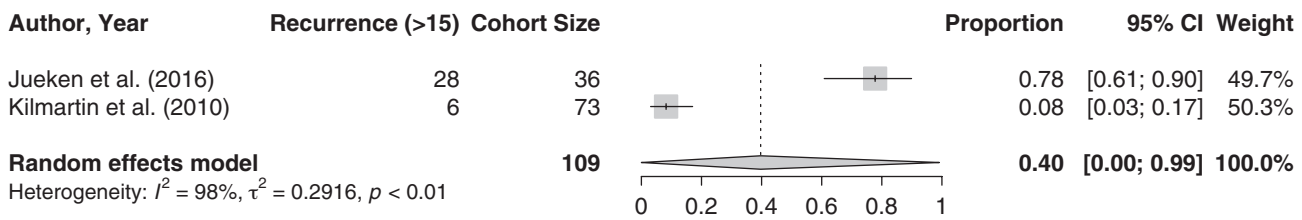

Figure 5

Forest plot on recurrence rate considering HVA > 15° (10, 15).

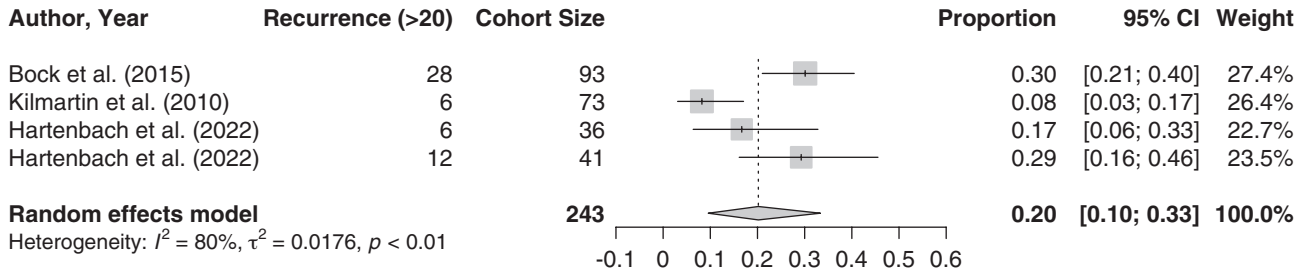

Figure 6

Forest plot on recurrence rate considering HVA > 20° (7, 14, 15).

recurrence rate using a threshold of HVA >15° reported in the two datasets was 0.40 (CI: 0.00–0.99) with considerable heterogeneity (I^2 = 98%).

Four datasets reported the recurrence of HV considering a threshold of HVA > 20° (Table 4 and Fig. 6). The overall recurrence rate using a threshold of HVA > 20° reported in the four datasets was 0.20 (CI: 0.10–0.33) with considerable heterogeneity (I^2 = 80%).

Two datasets reported the recurrence of HV considering a threshold of HVA > 25° (Fig. 7). The overall recurrence

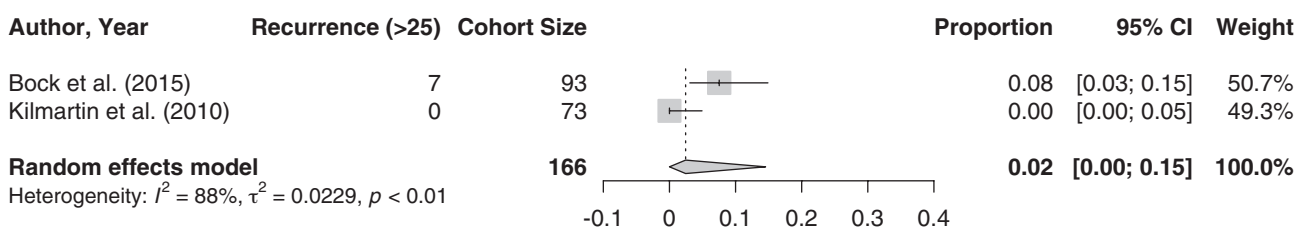

Figure 7

Forest plot on recurrence rate considering HVA > 25° (7, 15).

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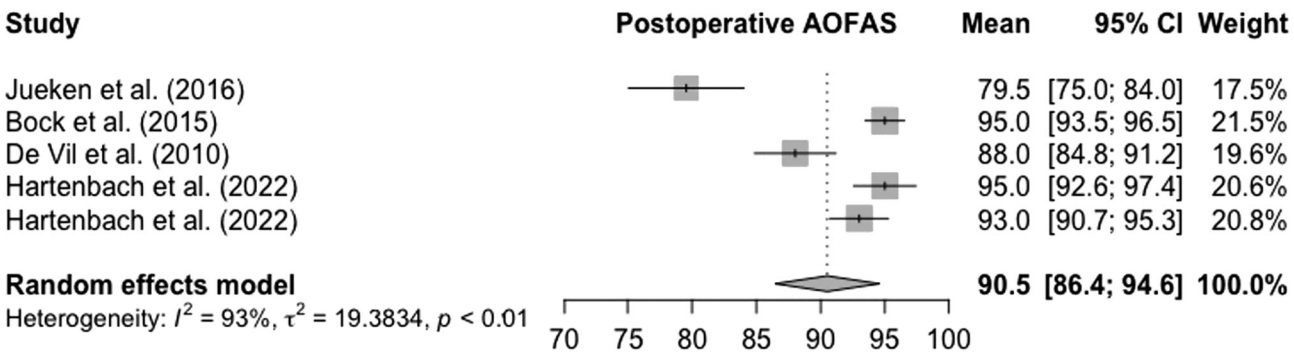

Figure 8

Forest plot on postoperative AOFAS (7, 10, 13, 14, 15).

rate using a threshold of HVA > 25° reported in the two datasets was 0.02 (CI: 0.00–0.15) with considerable heterogeneity (I^2 = 88%).

AOFAS

Of the six included datasets, five reported pre- and post-operative AOFAS (Fig. 8 and Table 3). At a minimum follow-up of 5 years, the pooled AOFAS following shaft osteotomies was 90.5 (CI: 86.4–94.6; 5 datasets; I^2 = 93%)

Revision rates

The revision rate was 0–3% following shaft osteotomies.

Discussion

This systematic review and meta-analysis aimed to synthesize and critically appraise the literature on the long-term outcomes of shaft osteotomies of the M1 to treat non-inflammatory and non-degenerative HV. We found five eligible studies, with a mean follow-up that ranged from 8 to 14 years. At a minimum follow-up of 8 years following shaft osteotomies of M1, the HVA was 15.9°, the IMA was 7.7°, and the DMAA was 8.3°. Furthermore, the recurrence rates considering the various thresholds of HVA were: 40% having >15°, 20% having >20°, and 2% having >25°. Finally, there was considerable heterogeneity in all reported outcomes.

In a recent meta-analysis, Barg *et al.* (6) investigated outcomes of various surgical treatments for correction of HV with a mean follow-up of 4 years and found an average rate of recurrent deformity of 4.9% from a total of 16 273 feet; the authors, however, did not specify what HVA thresholds were used to define HV recurrence, making comparisons with the present meta-analysis difficult. In a recent systematic review on Scarf osteotomies, Clarke *et al.* (9) found a recurrence rate of 3.6–11.3% in studies with short- to mid-term follow-up (1 to 4 years), which increased to 30–78% in studies with long-term follow-up (10 to 14 years). The high recurrence rates in the long term for all categories of surgical procedures suggest that a better understanding of the pathogenesis and prognosis of HV is required to prescribe the ideal treatment before modifying or introducing new surgical techniques (16, 17).

In a randomized controlled trial by Jeuken *et al.* (10), the authors compared distal (Chevron) to shaft (Scarf) procedures 14 years following surgery and found, using an HVA threshold of >15°, rates of recurrence of 73% vs 78%, respectively. These rates were higher than the present meta-analysis, in which we found a recurrence rate of 40% following shaft osteotomies using the same threshold as Jeuken *et al.* (10). Furthermore, the recurrence rates following shaft osteotomies are seemingly higher than those in the literature following distal osteotomies. Faber *et al.* (18) performed a randomized controlled trial (RCT), comparing TMT1 fusion vs distal osteotomies, and the authors found low recurrence rates (9% and 9%) for both treatments. It should be noted that they clinically defined their recurrences without using a threshold. Finally, a recent meta-analysis on distal osteotomies revealed a recurrence rate of 64% using HVA > 15° (19).

In the present meta-analysis on shaft osteotomies, we found a mean postoperative HVA of 15.9°. This angle was greater than expected and exceeds the threshold of 15° to be considered recurrent HV. This could indicate that, in a normally distributed population, following HV surgical correction, more than 50% of patients are considered to have a recurrence of HV. However, it is also interesting that the revision rate is relatively low, ranging from 0–3%, indicating that patients could be asymptomatic, oligosymptomatic, or are disappointed with the initial surgery and do not want a revision. Several hypotheses can be raised concerning these results: firstly, patients may have only have a moderate recurrence with few symptoms and no revision required; secondly, patients may be disappointed with the first procedure and not consider a revision because of the bad experience already underwent; or thirdly, revisions were performed at another center. It is impossible to provide retrospective clarification of this situation with the present study, and it is likely that a mix of these

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different hypotheses may have occurred for patients with recurrences.

Limitations

The results of the present review should be interpreted with the following limitations in mind. First, there was high heterogeneity among outcomes of shaft procedures and measurements, making it difficult to compare outcomes. This heterogeneity was, however, consistent with those previously reported in similar studies (6, 9), and might be due to the lack of consensus in defining a recurrence in HV; some authors use HVA thresholds (15°, 20°, or 25°), while others only consider symptomatic recurrence or those requiring revision. As the most common threshold to define HV is an HVA greater than 20°, we would recommend using this same threshold to define recurrence in future studies in order to minimize heterogeneity. Finally, due to the limited number of studies on the long-term outcomes of shaft osteotomies, the confidence intervals are often large, which could make it difficult to draw firm conclusions.

Conclusion

At a minimum follow-up of 8 years following shaft osteotomies of M1, the HVA was 15.9°, the IMA was 7.7°, and the DMAA was 8.3°. Furthermore, the recurrence rates considering the various thresholds of HVA were: 40% having >15°, 20% having >20°, and 2% having >25°.

ICMJE Conflict of Interest Statement
The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the study reported.

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