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Chevron osteotomy versus scarf osteotomy for hallux valgus correction: A meta-analysis

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ABSTRACT

Background: This study intended to investigate the optimal surgical strategy in hallux valgus (HV), and to provide a basis for clinical treatment of HV.
Methods: Studies related to chevron osteotomy and scarf osteotomy for HV were enrolled from online databases. Hallux valgus angle (HVA) was the main outcome variable. Enrolled studies included posttreatment data for intermetatarsal angle (IMA), American Orthopaedic Foot & Ankle Society (AOFAS) score, and complications. A random-effects model was applied for significant heterogeneity. Otherwise, a fixed-effects model was used. Heterogeneity was assessed with Q test and I^2 statistics. Publication bias was evaluated with Egger's test. Based on the influence of weighted mean difference values or odds ratios, a sensitivity analysis was performed.
Results: Four studies including 384 subjects were evaluated to determine the optimal surgical strategy for HV. There was no statistically significant difference between chevron and scarf groups for HVA, IMA, AOFAS score, and complication rates. Sensitivity analysis showed good stability. The likelihood of publication bias was small.
Conclusion: The effects of chevron osteotomy and scarf osteotomy for HV are comparable. Chevron osteotomy is less technically demanding.

1. Introduction

Hallux valgus (HV) is commonly seen in medical practice, which is often accompanied by significant functional disability and foot pain [1]. Factors associated with the development of HV are multifactorial but remain unclear [2]. Pooled prevalence estimates for HV were 23% in adults aged 18–65 years and 35.7% in elderly people aged over 65 years, with a huge social burden [3]. Despite of the high incidence, there are different opinions concerning follow-up and treatment [4].

Scarf osteotomy and chevron osteotomy are two main surgical treatments for HV [5]. Scarf osteotomy is a versatile and reproducible procedure for the correction of moderate to severe HV deformity [6]. A previous study has indicated that scarf osteotomy provides a predictable and effective correction for moderate to severe hallux valgus deformities [7]. After a mean follow-up of 33 months to assess clinical and functional outcomes in 32 HV patients, Lorei et al. showed that scarf osteotomy reduced pain, improved walking capacity, and led to improved contribution of the hallux in the roll-over process [8]. Chevron osteotomy is an accepted method for the correction of mild and moderate HV [9]. Chevron osteotomy for hallux valgus offers good results in the Foot And Ankle Outcome Score (FAOS) [10]. Trnka et al. have showed that chevron osteotomy is a reliable procedure for the correction of mild and moderate HV deformity [11]. Actually, appropriate surgical selection and proper technique will usually result in good to excellent outcomes [12]. A long-term follow-up study based on the American Orthopaedic Foot & Ankle Society (AOFAS) rating system to compare the treatment effect of scarf and chevron osteotomy in HV shows that both techniques present similar results (such as prevention of recurrence) at 14 years of follow-up [13]. However, Deenik et al. indicated that chevron osteotomy was superior to scarf osteotomy because it was less invasive, without sacrificing correction of hallux valgus angle (HVA) and intermetatarsal angle (IMA) [14]. Thus, it is vital to determine which osteotomy is the optimal surgical treatment for HV. Given the conflicting data, a meta-analysis was conducted to investigate the optimal surgical strategy, and to provide a basis for clinical treatment of HV.

Abbreviations: HV, Hallux valgus; HVA, hallux valgus angle; IMA, Intermetatarsal angle; AOFAS, American Orthopaedic Foot & Ankle Society; WMD, Weighted mean difference; FAOS, Foot And Ankle Outcome Score; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; CI, Confidence interval.

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2. Materials and methods

2.1. Data sources and keywords

This analysis was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [15]. A comprehensive search of electronic literature databases including PubMed (http://www.ncbi.nlm.nih.gov/pubmed), Embase (http://www.embase.com), and the Cochrane Library (http://www.cochranelibrary.com) was conducted to identify relevant studies. The keywords for the current study were: ("hallux valgus") and (scarf) and (chevron). The retrieval time for the present study was updated to October 10th; 2017.

2.2. Study selection

The inclusion criteria for the present meta-analysis were as follows: 1) English language studies on the curative effect of scarf osteotomy and chevron osteotomy on patients with HV; 2) using chevron osteotomy and scarf osteotomy as the main treatment approach in chevron and scarf groups, respectively; and 3) posttreatment HVA and IMA data and AOFAS scores as the main outcome variables in each study.

If more than 1 study reported data for the same sample, then only the latest and most complete study was extracted. Non-treatise literature including reviews, letters, and comments were excluded.

2.3. Data extraction and quality assessment

Two investigators independently extracted the data from all selected studies in order to reduce bias. All investigators reached a consensus on all items through discussion and reexamination. The following data were extracted from each eligible study: surname of first author, year of publication, country, year of research, study type, follow-up time, characteristics of general demographic data in scarf and chevron groups (such as the number of cases and age composition), initial values of HVA, IMA, and AOFAS score in scarf and chevron groups, and clinical data after a period of treatment.

Methodological quality assessment of the included studies was based on the guidelines and tools for risk assessment of the Cochrane Collaboration recommendations [16].

2.4. Statistical analysis

The present meta-analysis was conducted using R 3.12 software (R Foundation for Statistical Computing, Beijing, China, "meta" package). The effect index for quantitative data was represented by the weighted mean difference (WMD), odds ratio (OR), and 95% confidence interval (CI). Heterogeneity assessment was based on the Q test [17] and I^2 statistics. The random-effects model was applied if significant heterogeneity was found ($P < 0.05$ or $I^2 > 50\%$). Otherwise, the fixed-effects model was used in the absence of statistical heterogeneity ($P > 0.05$ and $I^2 < 50\%$) [18]. Publication bias was evaluated using Egger's test [19]. Sensitivity analysis was performed to determine whether the overall outcomes (combined WMD value) would be affected by removing a single study in our meta-analysis.

3. Results

3.1. Included studies

As shown in Fig. 1, the present meta-analysis initially retrieved 51 studies from database searches, and 29 were excluded, including duplicates (n = 11) and studies unrelated to the research topics (n = 18). The full texts of the remaining 22 studies were reviewed, among which 17 additional studies including 4 reviews, 5 case series/reports, and 11 letters were excluded. Finally, a total of 4 publications with sufficient data were enrolled for the present meta-analysis [13,20–22].

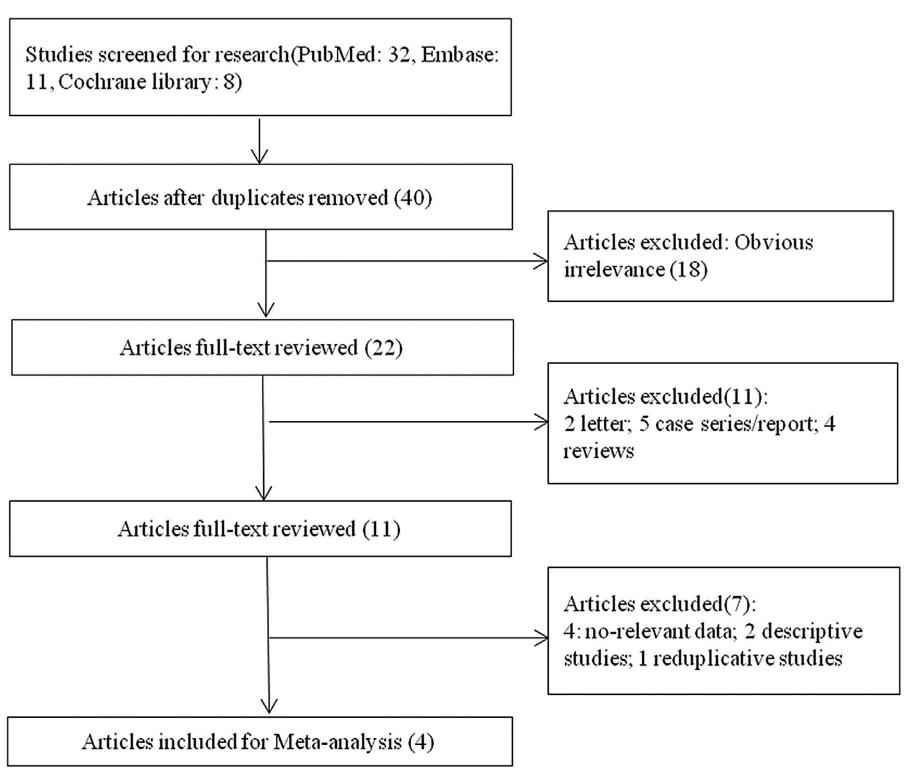

Fig. 1. Flow chart showing study selection procedure.

Table 1
Main characteristics of all eligible studies.

Author	Publication Year	Study location	Study year	Study type	Group	N	Age, y	Follow-up, mo	HVA, deg	IMA, deg	AOFAS
Choi JY	2016	South Korea	2005 .2-2015.1	Non-RCT	PCMO	54	49.7 ± 15.7	17.59 ± 11.6	36.2 ± 8.8	15.9 ± 3.3	64.7 ± 4.4
					Scarf	52	47.5 ± 13.2	19.85 ± 14.2	29.3 ± 5.5	14.4 ± 2.7	64.8 ± 5.0
Deenik AR	2007	Netherlands	1999.8-2001.6	RCT	Chevron	47[a]	Mean: 43	2-year	30.4 ± 7.7	13.4 ± 3.2	48.4 ± 13.6
					Scarf	49[a]	Mean: 45	2-year	28.9 ± 7.7	12.8 ± 3.2	47.4 ± 13.5
Jeuken RM	2016	Netherlands	NA	RCT	Chevron	37[*]	56.3 ± 13.9	13.8 ± 1.2 y	30.7 ± 3.4	13.5 ± 2.1	48.5 ± 11.4
					Scarf	36[a]	58.2 ± 14.1	13.8 ± 1.4 y	29.5 ± 2.9	12.6 ± 1.9	47.2 ± 10.9
Mahadevan D	2015	UK	2006.1- 2012.12	RCT	Chevron	60[a]	50.7 ± 14.1	1-year	32.3 ± 8.3	15.2 ± 3.1	NA
					Scarf	49[a]		1-year	29.5 ± 7.6	14.3 ± 2.9	NA

Notes: RCT: randomized controlled trial; y: year; mo: month; deg: degree; PCMO: proximal chevron metatarsal osteotomy; HVA: hallux valgus angle; IMA: intermetatarsal angle; AOFAS: AmericanOrthopaedic Foot & Ankle Society.
[a] Number of feet.

3.2. Characteristics of the included studies

The baseline characteristics of the 4 studies are presented in Table 1 and the postoperative data are shown in Table 2. The 4 studies included a total of 384 subjects (198 patients in the chevron group and 186 in the scarf group). The publication years of the literature were 2007–2016. The research populations were mainly located in Korea and the Netherlands. The mean follow-up period was more than 12 months. No age difference was observed in 2 groups (mainly middle and old age; mean age was greater than 40 years). The baseline HVA, IMA, and AOFAS scores in both groups before intervention were similar.

As shown in Fig. 2, no studies were at low risk of bias for all domains, which suggested that the quality of the included studies was generally acceptable.

3.3. Heterogeneity analyses

The posttreatment HVA, IMA, and AOFAS scores and complications in the chevron and scarf groups were investigated. The results showed that the heterogeneity test for HVA was statistically significant ($P < 0.01$, $I^2 = 78.0\%$). Therefore, the random effects model was adopted for the WMD values and 95% CI. The results of meta-analysis showed that there was no statistically significant difference between chevron and scarf groups (WMD = 0.4236, 95% CI: −2.3787-3.2259, Z = 0.30, P = 0.7670) (Fig. 3A).

The results of the heterogeneity test for IMA were statistically significant ($P < 0.01$, $I^2 = 73.6\%$). Therefore, the random effects model was used to calculate the WMD values and 95% CI. The results of meta-analysis showed that there was no statistically significant difference between chevron and scarf groups (WMD = 0.0170, 95% CI: −1.0140-1.0479, Z = 0.03, P = 0.9743) (Fig. 3B).

Table 2
Postoperative data.

Author	Publication Year	Group	N	HVA, deg	IMA, deg	AOFAS
Choi JY	2016	PCMO	54	17.2 ± 9.4	8.7 ± 4.2	88.6 ± 4.8
		Scarf	52	12.9 ± 5.9	7.2 ± 2.7	88.5 ± 3.5
Deenik AR	2007	Chevron	47[a]	17.2 ± 5.8	10.3 ± 1.9	89.0 ± 12.2
		Scarf	49[a]	18.1 ± 5.7	9.9 ± 2.0	91.2 ± 12.1
Jeuken RM	2016	Chevron	37[a]	19.8 ± 5.6	8.3 ± 2.7	80.1 ± 15.9
		Scarf	36[a]	22.4 ± 5.2	8.9 ± 2.6	79.5 ± 14.1
Mahadevan D	2015	Chevron	60[a]	14.3 ± 7.4	5.8 ± 2.5	NA
		Scarf	49[a]	13.0 ± 7.6	6.9 ± 2.8	NA

[a] Number of feet.

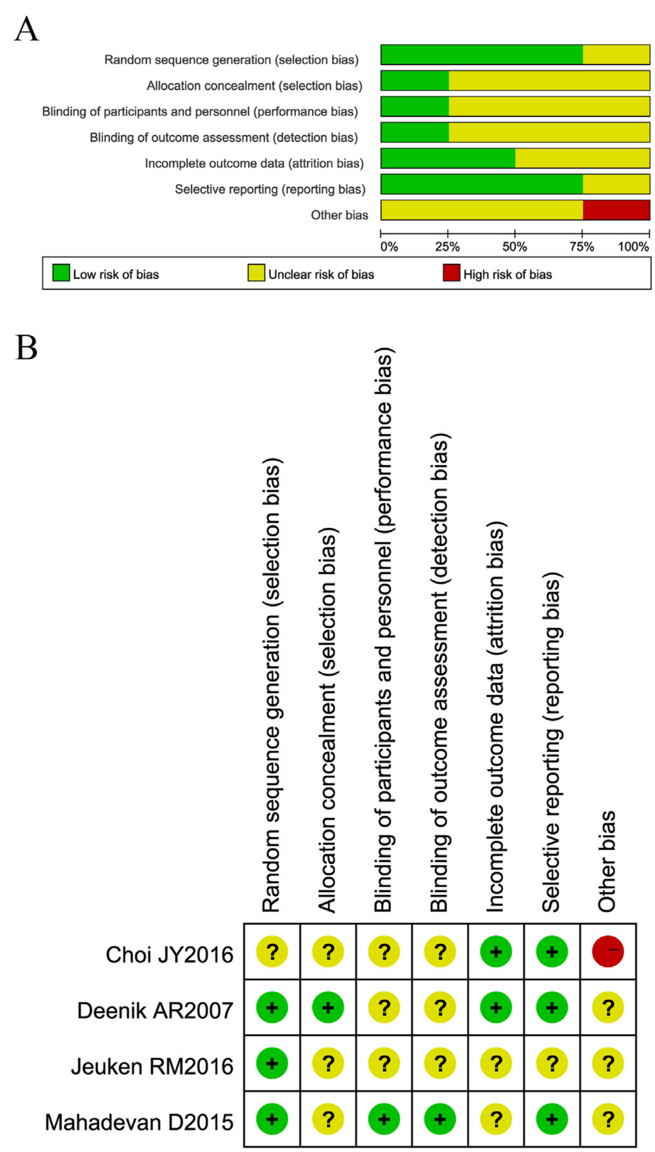

Fig. 2. Quality assessment and bivariate boxplot for enrolled studies in the current study. A, quality assessment of included studies using tools in the Cochrane Collaboration recommendations; B, bivariate boxplot for the risk of bias in the current study.

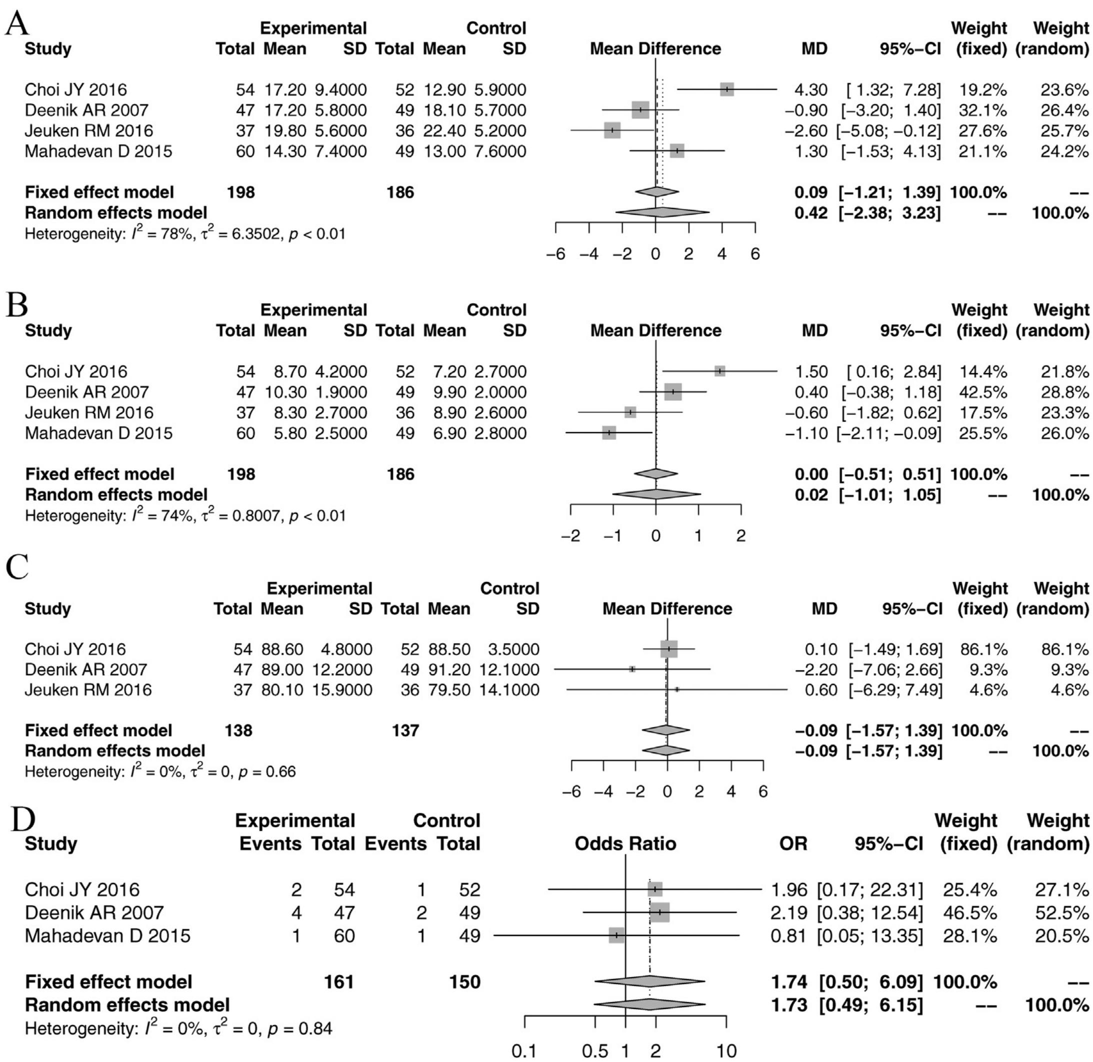

Fig. 3. Forest plot analyses for chevron group and scarf groups. A, forest plot of hallux valgus angle curative effect comparing chevron and scarf groups; B, forest plot of intermetatarsal angle curative effect comparing chevron and scarf groups; C, forest plot of American Orthopaedic Foot & Ankle Society curative effect comparing chevron and scarf groups; D, forest plot of complication rates comparing chevron and scarf groups.

The results of the heterogeneity test for AOFAS scores were statistically significant ($P = 0.66$, $I^2 = 0\%$)). Therefore, the random effects model was used for the calculation of WMD values and 95% CI. The results of meta-analysis showed that there was no statistically significant difference between chevron and scarf groups (WMD-0.0900, 95% CI: −1.5702-1.3901, Z = 0.12, P = 0.9051) (Fig. 3C).

There was no significant heterogeneity for the data on complications ($P = 0.8359$, $I^2 = 0\%$). Thus, the fixed-effects model was applied for the calculation of OR and 95% CI. Meta-analysis showed that there was no significant difference in the complication rates between chevron and scarf groups (OR = 1.7435, 95% CI: 0.4995-6.0862, Z = 0.87, P = 0.3938) (Fig. 3-D).

3.4. Sensitivity analysis and publication bias

Sensitivity analysis was applied in the present study, and the removal of any single study had a minimal impact on the value of WMD/OR, which indicated the stability of the analysis (Fig. 4).

Publication bias for HVA, IMA, AOFAS scores, and complications were determined using Egger's test. The results showed that the P value of Egger's test for HVA (t = 2.1661, P = 0.1627), IMA (t = 0.0860, P = 0.9393), AOFAS score (t = 0.5610, P = 0.6745), and complications (t = 1.751, P = 0.3303) was >0.05, indicating that there was no publication bias.

4. Discussion

HV is a relatively common, yet challenging condition for both the patient and the surgeon [23]. Although scarf and chevron osteotomies are the main surgical treatments for HV, the clinical difference is unclear [13,14]. In the present study, a total of 4 studies including 384 subjects were enrolled for meta-analysis to investigate the optimal surgical strategy for HV. The results showed that the posttreatment values for HVA, IMA, and AOFAS scores in the chevron and scarf groups were all improved and the differences were not statistically significant (all P > 0.05). The complication rate was comparable between chevron and scarf groups. All results indicated that the clinical effects of the two procedures were equal for patients with HV.

Since first described in 1976, chevron osteotomy has been proved to be a successful surgical strategy for HV [24]. However, a recent study showed that in some HV patients, chevron osteotomy could result in involuntary medial translation of proximal intermetatarsal divergence (the proximal first metatarsal

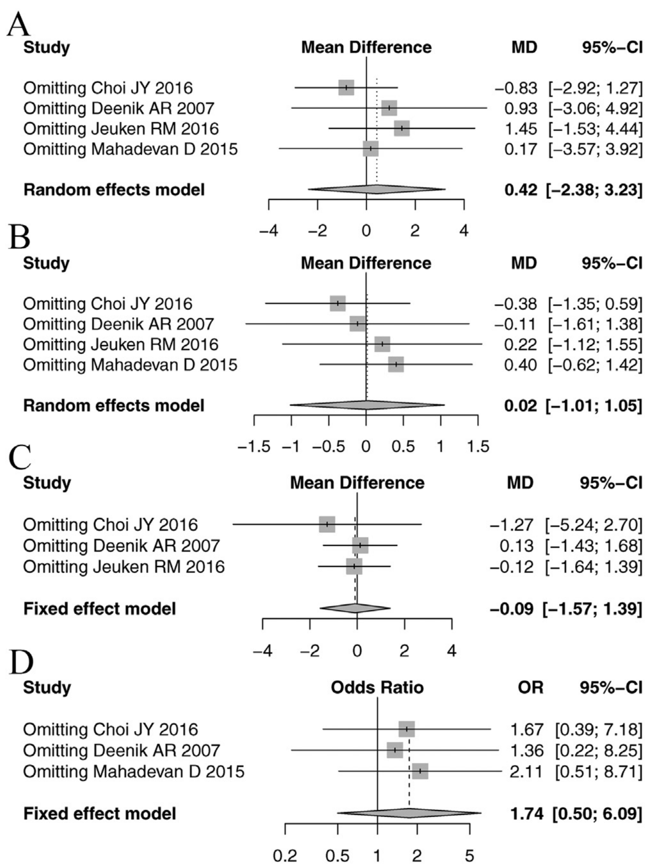

Fig. 4. Sensitivity analysis for the current study. Sensitivity analysis for HVA (A), IMA (B), AOFAS (C), and Complications (D).

fragment) [25]. To evaluate the clinical effect of chevron osteotomy for HV, a follow-up study was performed on 438 patients by van Groningen et al. [10]. The AOFAS scores in that study appeared to vary with physician-dependent outcomes, and improved outcome may therefore be possible with increased attention to surgical details. Scarf osteotomy for HV has been widely used in recent years, mainly because of its versatility for the correction of deformity [26]. The evaluation of radiographic and clinical results shows that short scarf osteotomy is an effective surgical procedure for moderate HV, with the benefits of minimized soft tissue dissection and stable fixation [27]. However, Milczarek et al. showed some limitations of scarf osteotomy outcomes for certain HV patients, such as overweight individuals [28]. In some circumstances, combined surgery (such as scarf osteotomy and Akin closing-wedge osteotomy) has been proved safe and effective for HV [29]. A 6-year follow-up study on 64 recurrent HV cases showed that no one type of treatment for HV could be applied in all cases [25]. The present meta-analysis showed that posttreatment values for HVA, IMA, and AOFAS score in the chevron group and the scarf group were all improved. There was no significant difference in the complication rate between chevron and scarf groups. In a previous study, Deenik et al. also found no significant difference between the two groups with respect to HVA, IMA, and AOFAS score [21]. Thus, based on the results in the current study, we speculated that the clinical effects of these two osteotomy procedures were equivalent. However, a further investigation based on different types of osteotomy procedures is needed to confirm this speculation. The results of heterogeneity testing for all indexes in the current study were significant. Thus, the random-effects model was adopted. There might be several explanations for these results. The data included in the present study were collected from different countries (or areas), with different research backgrounds and intervening conditions, and heterogeneity among different studies was apparent. Furthermore, some other factors such as sex, age, and other demographic data might be affected. Thus, a further investigation based on a random control study is needed.

There were some limitations in the present study. First, the sample sizes in the enrolled studies were relatively small. Thus, there was no subgroup analysis and regression study. Second, compared with AOFAS scores, the Manchester-Oxford foot questionnaire (MOFQ) was more suitable and validated for measuring outcomes after hallux valgus correction. The MOFQ was performed in 2 of the included studies and the data in one of the studies were expressed as median with interquartile range, which was not suitable for meta-analysis. Thus, we only analyzed the AOFAS score in this study. Therefore, further studies with larger sample sizes are needed to confirm our findings and to provide a more accurate statistical analysis.

5. Conclusion

Both chevron and scarf osteotomy showed improved outcomes in patients with HV. No significant difference was observed between chevron and scarf osteotomy for the treatment of HV patients with respect to HVA, IMA, AOFAS score, and complication rate. The clinical effects of chevron and scarf osteotomy were comparable for HV patients. However, Chevron osteotomy with less technical demanding may be favored.

Fund

None.

Competing interests

None of the authors have any potential conflicts of interest associated with this research.

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