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A comparative study of distal chevron osteotomy and minimally invasive surgery for surgical correction of hallux valgus deformity

Jihyun Hwang[1†], Sukjin Shin[2†], Seung Hun Baek[3] and Sung Jae Kim[3,4*]

Abstract

Background Hallux valgus is a common forefoot deformity that significantly impacts patients' functional status and quality of life. This study aims to compare the mid-term clinical and radiographic outcomes of DCMO and MIS in hallux valgus correction.

Methods A retrospective cohort study for 60 patients (34 DCMO, 26 MIS) was analyzed. Clinical outcomes were evaluated using the Manchester-Oxford Foot Questionnaire (MOXFQ) and Foot Function Index (FFI), while radiographic parameters such as hallux valgus angle (HVA), intermetatarsal angle (IMA), distal metatarsal articular angle (DMAA), and sesamoid position were assessed preoperatively and at the final follow-up. Statistical comparisons were performed using t-tests, Mann-Whitney U tests, and chi-square tests, with significance set at $p < 0.05$.

Results The DCMO group demonstrated superior clinical outcomes, with significantly better MOXFQ pain sub-scale ($p < 0.001$) and index scores ($p = 0.002$). However, although the between-group difference in pain-related outcomes was statistically significant, it did not reach the minimal clinically important difference (MCID), indicating that the clinical relevance of this advantage may be limited. The improvement in FFI scores was also significantly greater in the DCMO group ($p = 0.022$). In contrast, the MIS group exhibited superior radiographic correction, with significantly greater improvements in HVA ($p = 0.027$), IMA ($p = 0.001$), and sesamoid displacement ($p = 0.001$). First metatarsal shortening was more pronounced in the MIS group, showing a trend towards statistical significance ($p = 0.050$). Postoperative complications were comparable, with recurrence rates of 8.8% (DCMO) and 7.6% (MIS).

Conclusions DCMO showed statistically superior patient-reported outcomes, although its pain-related benefit did not exceed the MCID. MIS achieved greater radiographic correction. Procedure selection should be individualized according to patient-specific factors, radiographic goals, and surgeon expertise. In addition, surgeons transitioning

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to MIS should be aware of the potential risk of frictional heat-related soft tissue injury and should use meticulous fluoroscopic guidance, controlled instrumentation, and adequate irrigation to minimize this complication.

Keywords Hallux valgus, Distal chevron osteotomy, Minimally invasive surgery, Comparison analysis, Patient-reported outcomes

Introduction

Hallux valgus is one of the most common forefoot deformities, characterized by lateral deviation of the great toe and medial deviation of the first metatarsal [1, 2]. This condition often leads to pain, functional impairment, and difficulties in footwear fitting. Surgical correction is typically recommended for symptomatic cases that do not respond to conservative management. Recent literature has suggested that shoe modification and orthotic treatment may provide symptomatic relief in selected patients, but their efficacy remains limited in patients with persistent symptoms or progressive deformity [3]. Among the various surgical techniques available, two prominent approaches have gained attention: the traditional distal chevron metatarsal osteotomy (DCMO) and the more recent minimally invasive surgery (MIS) techniques.

DCMO has been widely used for hallux valgus correction due to its reliable outcomes and well-documented efficacy [4, 5]. This technique involves a V-shaped osteotomy at the distal metatarsal with lateral translation of the capital fragment, which allows for deformity correction while maintaining relative stability. Despite its effectiveness, this approach requires a relatively large incision and extensive soft tissue dissection, which can result in postoperative pain, prolonged recovery, and potential wound complications [6].

In contrast, MIS for hallux valgus correction has emerged as a promising alternative, leveraging smaller incisions, percutaneous techniques, and fluoroscopic guidance [7, 8]. This approach aims to minimize soft tissue trauma, reduce postoperative pain, and expedite recovery. Several studies have reported favorable outcomes with MIS, including improved cosmetic results and faster return to daily activities [9, 10]. However, concerns regarding the learning curve, accuracy of correction, and potential complications such as delayed union and fixation stability remain topics of ongoing discussion in the orthopedic community [11, 12].

Despite the increasing adoption of MIS techniques, there remains a need for robust comparative studies evaluating their clinical efficacy against traditional methods such as distal chevron osteotomy [13–15]. While previous research has provided some insight into the advantages and limitations of each approach, the relative superiority of one method over the other remains inconclusive. Furthermore, variations in surgical expertise, patient selection, and follow-up duration make it difficult to draw definitive conclusions.

This study compares the surgical outcomes of distal chevron osteotomy and MIS hallux valgus correction performed by a single surgeon [16]. By analyzing postoperative outcomes, radiographic parameters, and patient-reported satisfaction, it aims to provide valuable insights into the effectiveness and safety of these two techniques. The findings may help guide clinical decision-making and contribute to the ongoing evolution of surgical strategies for hallux valgus correction.

Methods

Participants

In this retrospective cohort study, we identified a total of 152 patients who underwent primary hallux valgus correction between October 2016 and December 2022 and were followed for a minimum of two years. Among all recruited patients, only those who underwent surgery using either the DCMO or MIS technique were selected. These patients were then divided into two groups according to the surgical method. All procedures were performed by one senior author at a single center. This study design was approved by our institute's institutional review board and ethics committee (HDT 2024-11-007).

The indications for surgery were the presence of discomfort in the bunion area in footwear and symptomatic lesser-toe deformities related to hallux valgus deformities, such as transfer metatarsalgia, unresponsive to other conservative treatments, such as medication or physical therapy. Exclusion criteria were less than a minimum follow-up of two years, previous hallux valgus correction surgery, or missed clinical evaluation surveys. Degenerative first metatarsophalangeal joints and surgery with other procedures, such as the Lapidus procedure or proximal metatarsal osteotomy, were also excluded. Patients with neurological disorders, such as diabetic peripheral neuropathy, were also excluded from the study.

Clinical outcome evaluation

The Manchester-Oxford Foot Questionnaire (MOXFQ) and the Foot Function Index (FFI) were used to clinically assess each patient preoperatively and at the final postoperative follow-up. The MOXFQ, designed and validated for assessing hallux valgus patients, has been widely used due to its reliability, high responsiveness, and correlation to SF-36 and AOFAS scores [17, 18]. The MOXFQ contains three domains: walking and standing, social

interaction, pain, and a representative summary index score derived from these domains [19]. All scores were converted to a metric scale from 0 to 100, where higher values indicate greater severity. Previously reported minimal clinically significant differences of the MOXFQ scores were followed, which were 16 for walking and standing, 12 for pain, and 24 for social interaction [13]. In addition to MOXFQ, the FFI was used to assess pain, disability, and activity limitations. The FFI provides a subjective assessment of foot function as a self-reporting questionnaire from patients, which has been adapted and validated across multiple cultures and languages, including Korean [20, 21].

Radiographic outcome evaluation

All radiographic measurements were taken preoperatively and at the final follow-up. Per the American Orthopedic Foot & Ankle Society standards, the hallux valgus angle (HVA), intermetatarsal angle (IMA), distal metatarsal articular angle (DMAA), sesamoid grade, and 1st metatarsal length were measured on an anteroposterior (AP) weight-bearing radiograph [22, 23]. Recurrent deformity was defined as a hallux valgus angle greater than 20° at the final follow-up [24]. All radiographic measures were repeated by another orthopedic surgeon at the institution, and inter-rater reliability was calculated for validation.

Operative technique

At the start of the surgery, the patient is positioned in a supine position. A surgical drape is folded and placed under the ipsilateral hip to maintain the foot in a neutral position and prevent external rotation. Anesthesia is administered via spinal anesthesia or a combination of popliteal and femoral nerve block.

Surgical procedures for the DCMO technique

For the DCMO procedure, a longitudinal skin incision of approximately 4 cm is made along the medial aspect of the first metatarsophalangeal (MTP) joint. A longitudinal capsular incision parallel to the metatarsal bone is made over the MTP joint capsule, followed by an additional vertical incision at the joint exposure site, forming a cross-shaped (cruciate) capsulotomy. The MT head is exposed, and a bunionectomy is performed using a microsaw, preserving the sulcus of the MT head while executing the osteotomy just medial to it. With distal traction applied to the proximal phalanx, a #15 blade is inserted into the joint space to release the lateral soft tissues. Care is taken to avoid plantar-directed movements with the blade to prevent flexor tendon injury. A varus force is applied to the MTP joint to confirm adequate release of lateral soft tissue tension. Subsequently, a chevron osteotomy is performed at the distal MT head, with the apex positioned approximately 1 cm proximally. The plantar aspect of the osteotomy plane is extended beyond the MT head to ensure a stable articulation between the sesamoid bones and the MT head. The proximal fragment is secured with a towel clip, and the distal fragment is laterally translated. A guide pin for screw fixation is inserted from the dorsoproximal to the plantar-distal direction for temporary fixation. The correction is verified using C-arm fluoroscopy, and once the alignment is deemed appropriate, a screw is inserted for final fixation. The prominent medial bone at the osteotomy site is further resected using a microsaw to achieve a smooth medial contour. If the MTP joint remains congruent but residual hallux valgus deformity is observed externally, an Akin osteotomy is performed as an additional correction. The medial joint capsule is sutured, with partial resection of redundant capsule tissue to adjust for the corrected alignment. The vertical limb of the cruciate capsulotomy allows for additional correction of the hallux valgus angle (HVA), while the horizontal limb assists in medializing the sesamoid bones, further enhancing correction. The subcutaneous tissue and skin are closed, and any excess skin is excised to improve the initial cosmetic outcome. A 2-inch elastic bandage (EB) is applied to maintain the MTP joint in slight varus overcorrection, completing the procedure. No additional splinting is applied.

Surgical procedures for the MIS technique

Details of the MIS technique have been previously described in the literature [22]. Details of the MIS technique have been previously described in the literature [22]. Briefly, all MIS procedures were performed without a tourniquet. The patient was placed supine, and the operative foot was positioned to permit anteroposterior and lateral fluoroscopic assessment throughout the procedure. Before osteotomy, 2.0-mm K-wires were inserted percutaneously to plan the direction of subsequent screw fixation. A percutaneous medial incision was made around the first metatarsal neck, and a distal first metatarsal osteotomy was performed using a Shannon burr under fluoroscopic guidance. The metatarsal head was then shifted laterally to correct the deformity, with attention to avoiding excessive shortening, sagittal malalignment, or malposition of the distal fragment. Temporary fixation was achieved using the pre-positioned K-wire. After fluoroscopic confirmation of metatarsal alignment, sesamoid reduction, and correction of the hallux valgus deformity, the temporary wires were exchanged for guide pins, and two screws were inserted for definitive fixation. Residual bony prominence at the proximal osteotomy site was removed with a burr when necessary. If residual hallux valgus deformity or metatarsophalangeal joint incongruency remained, an Akin osteotomy and percutaneous lateral soft-tissue release were performed as required.

Final fluoroscopic images were obtained to confirm correction, screw position, osteotomy stability, and sesamoid alignment. The procedure was completed with elastic bandaging to maintain the hallux in slight varus overcorrection, without additional splinting. For rehabilitation, weight-bearing with a hard-sole post-operative shoe begins 1–2 days after surgery, as tolerated by pain. Range of motion exercises for the MTP joint start 1 week postoperatively. The corrected MTP position is maintained using an EB for six weeks. At week six, the post-operative shoe is replaced with a regular shoe. For the MIS procedure, additional taping for approximately two months is applied to maintain the corrected MTP joint angle.

Statistical analysis

All measured variables from both groups were summarized using descriptive statistics. The normality of the data distribution was assessed using the Kolmogorov-Smirnov test and the Shapiro-Wilk test. Results were presented as mean ± standard deviation (SD) for normally distributed data, whereas non-normally distributed variables were reported as median and interquartile range (IQR). Comparisons between the two groups were conducted using appropriate statistical tests. For normally distributed continuous variables, an independent t-test was applied, while non-normally distributed continuous variables were analyzed using the Mann-Whitney U test. Categorical variables were compared using the Chi-square test or Fisher's exact test, depending on the expected frequency distribution. A p-value of < 0.05 was considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 24.0 (IBM Corp., Armonk, NY, USA).

Table 1 Baseline demographic data

	DCMO group	MIS group	*p*
No.	34	26	-
Age (years)	55.21 ± 12.26	54.04 ± 10.95	0.699
Sex (male : female)	5 : 29	1 : 25	0.165
Follow-up duration (months)	46.5 (37.0–53.25)	38.5 (33.5–44.0)	0.332
Preoperative clinical score			
MOXFQ score			
Walking and standing	64.3 (57.1–71.4)	64.3 (53.5–64.3)	0.107
Pain	50.0 (37.5–80.0)	42.5 (38.8–60.0)	0.157
Social interaction	50.0 (37.5–62.5)	56.3 (50.0–68.8)	0.115
Index total	56.74 ± 9.02	54.55 ± 7.87	0.329
Foot function index			
Pain	40.5 (33.0–49.5)	40.0 (31.0 to 42.0)	0.129
Disability	43.47 ± 6.56	41.08 ± 6.76	0.172
Total	84.26 ± 10.10	78.62 ± 13.41	0.068
Visual analogue scale for pain	4 (3–5.3)	4 (4–5)	0.641
Radiological measurements			
Hallux valgus angle (°)	28.54 ± 8.27	26.50 ± 9.17	0.368
Intermetatarsal angle (°)	12.58 ± 2.65	12.99 ± 2.77	0.560
Distal metatarsal angle (°)	5.14 ± 13.52	8.34 ± 4.44	0.204
Sesamoid grade (1–7)	4 (4–5)	5 (4–6)	**0.026**

Data are given with mean ± SD, or median (IQR) according to normality. Statistically significant values are shown in bold

DCMO, distal chevron metatarsal osteotomy; MIS, minimal invasive; MOXFQ, The Manchester–Oxford Foot Questionnaire; SD, standard deviation; IQR, interquartile range

Results

There were no significant differences in demographics or the preoperative clinical severity between the two groups Table 1.

No significant differences in the preoperative radiologic severity were found except for the median sesamoid grade assessed on the tibial sesamoid seven positions (TSP) scale [25]. Although the median TSP scale was 1 grade higher in the MIS group, it is reported not to be an important factor for hallux valgus incongruency [26].

The results of the clinical outcome comparisons are summarized in Table 2.

The DCMO group demonstrated statistically significant superior outcomes in both the MOXFQ and FFI scores compared to the MIS group.

Specifically, in the MOXFQ score, the pain subscale and index score were significantly better in the DCMO group ($p < 0.001$, $p = 0.002$, respectively). However, the median difference between the two groups in the pain subscale was 10, which is smaller than the minimum clinically important difference (MCID) of 12 for the MOXFQ pain subscale. This suggests that the observed difference may not be clinically meaningful, despite the statistical significance. Regarding preoperative-to-postoperative improvement, no significant differences were observed between the two groups.

For FFI scores, the final postoperative scores did not show a significant difference between groups. However, the extent of improvement from preoperative to postoperative values was significantly greater in the DCMO group across all subscales and total scores.

The VAS score for pain showed comparable results between the two groups, with no significant difference observed.

The comparison of postoperative patient satisfaction is depicted in Fig. 1.

Summarizes the comparative analysis of radiographic outcomes in Table 3.

Sesamoid grade: 1–7 All the measurements were acceptable measurement reliability (intraclass correlation coefficients = 0.821–0.925). In contrast to the functional assessment results, the MIS group demonstrated

Table 2 Comparison of clinical outcome

	Final measurements		*p*	Δ change		*p*
	DCMO Group	MIS Group		DCMO Group	MIS group	
MOXFQ score						
Walk	0 (0–3.6)	1.8 (0–7.1)	0.295	64.3 (57.1–70.4)	64.3 (53.6–64.3)	0.419
Pain	0 (0–5.0)	10 (0–10.0)	**< 0.001**	50.0 (35.3–78.5)	42.5 (38.8–60.0)	0.233
Social	0 (0–12.5)	6.3 (3.2–25.0)	0.152	50.0 (25.0–62.5)	50.0 (29.7–62.5)	0.857
Index	2.1 (0–6.7)	6.0 (3.2–14.0)	**0.002**	50.6 (43.0–59.9)	50.4 (24.5–57.0)	0.168
Foot function index						
Pain	9 (2–12)	10 (2–18)	0.239	32.5 ± 9.89	26.19 ± 11.56	**0.027**
Disability	7.6 ± 11.08	11.1 ± 10.52	0.129	35.6 ± 8.42	30.0 ± 11.31	**0.031**
Total	17 (8.8–21.3)	23 (2.8–32.0)	0.135	68.12 ± 14.32	56.19 ± 22.32	**0.022**
VAS	1 (1–2)	1 (1–1.3)	0.458	3 (1–4)	3 (2–4)	0.784

Data are given with mean ± SD, or median (IQR) according to normality. Statistically significant values are shown in bold

DCMO, distal chevron metatarsal osteotomy; MIS, minimal invasive; MOXFQ, The Manchester–Oxford Foot Questionnaire; VAS, visual analogue scale; SD, standard deviation; IQR, interquartile range



Fig. 1 Comparison of patient's satisfaction. Four cases of dissatisfaction were observed in the MIS group; however, no statistically significant difference was found ($p = 0.062$)

Table 3 Comparison of radiological outcome

	Final measurements		*p*	Δ change		*p*
	DCMO group	MIS group		DCMO group	MIS group	
HVA (°)	11.1 ± 6.62	7.2 ± 6.53	**0.027**	17.5 ± 6.78	19.3 ± 10.24	0.403
IMA (°)	8.3 ± 2.81	5.7 ± 2.99	**0.001**	4.3 ± 2.79	7.3 ± 3.81	**0.002**
DMAA (°)	7.9 (– 5.8–11.7)	4.3 (0.4–5.5)	0.586	5.5 ± 6.89	4.6 ± 5.86	0.612
Sesamoid grade	3 (3–4)	2 (2.0–4.0)	0.064	1 (0.8–2.0)	2 (1.0–3.0)	**0.001**

HVA, hallux valgus angle; IMA, intermetatarsal angle; DMAA, distal metatarsal articular angle; DCMO, distal chevron metatarsal osteotomy; MIS, minimal invasive. Statistically significant values are shown in bold

Table 4 Comparison of 1st metatarsal shortening after surgery

	DCMO group	MIS group	*p*
Preoperative 1st MT length (mm)	64.5 ± 4.68	64.2 ± 4.73	0.797
Final 1st MT length (mm)	60.5 ± 5.36	58.5 ± 6.24	0.185
Δ change (mm)	4.0 ± 3.19	5.7 ± 3.33	0.050

DCMO, distal chevron metatarsal osteotomy; MIS, minimal invasive; MT, metatarsal

Table 5 Postoperative complications between two groups

	DCMO Group	MIS Group
Screw pull-out	0	1/26 (3.8%)
Delayed wound healing	0	1/26 (3.8%)
Recurrence*	3/34 (8.8%)	2/26 (7.6%)
Superficial nerve injury	0	0
Tendon injury	0	0
Non-union	0	0
Hallux varus deformity	0	0

DCMO, distal chevron metatarsal osteotomy; MIS, minimal invasive

*Recurrence was defined as final hallux valgus angle > 20°

statistically significantly superior radiographic outcomes compared to the DCMO group. HVA and IMA significantly improved correction in the MIS group ($p = 0.027$, $p = 0.001$, respectively). Notably, for IMA, the final follow-up values as well as the extent of preoperative-to-postoperative improvement demonstrated highly significant statistical superiority in the MIS group.

Regarding sesamoid grade, the final follow-up values did not show a statistically significant difference between the groups. However, the degree of correction from preoperative to postoperative status was significantly greater in the MIS group. Considering that the preoperative sesamoid grade (as shown in Table 1) was more severe in the MIS group, this suggests that the corrective capacity for sesamoid displacement was also superior in the MIS group compared to the DCMO group.

Comparison of first metatarsal shortening between the two groups is summarized in Table 4.

Although greater shortening was observed in the MIS group compared to the DCMO group (4.0 ± 3.19 mm vs. 5.7 ± 3.33 mm, $p = 0.05$), the difference did not reach statistical significance. However, with a p-value of 0.05, there was a strong trend suggesting greater first metatarsal shortening in the MIS group.

The postoperative complications of the two groups are summarized in Table 5.

No severe complications requiring additional surgical intervention were observed in either group. Recurrence after surgery was noted in three cases (8.8%) in the DCMO group and two cases (7.6%) in the MIS group.)

Radiographic examples of each surgical technique are presented in Figs. 2 and 3, respectively.

Post-hoc power analysis

Because this was a retrospective cohort study, priori sample size calculation was not performed. Instead, all eligible patients who met the inclusion and exclusion



Fig. 2 Examples of surgical cases using the DCMO technique, **A** 57 years female patient, preoperative radiograph, **B** radiograph at 6 weeks postoperatively, **C** final follow-up radiograph)



Fig. 3 Examples of surgical cases using the MIS technique. **A** 34 years female patient, Preoper-ative radiograph, **B** Radiograph at 6 weeks postoperatively, **C** Final follow-up radiograph

criteria during the study period were included. A post-hoc power analysis was performed using the actual group sizes of 34 patients in the DCMO group and 26 patients in the MIS group, with a two-sided significance level of 0.05. For continuous variables, the observed effect size was calculated using Cohen's d, defined as the absolute between-group difference divided by the pooled standard deviation. This analysis showed that the current sample size provided adequate power to detect large radiographic differences. In particular, IMA correction showed a large effect size (Cohen's d = 0.92), corresponding to an estimated post-hoc power of 93.4%. The final IMA also showed a large effect size (Cohen's d = 0.90), with an estimated power of 92.5%. In contrast, the power was more limited for outcomes with smaller effect sizes, including clinical scores, first metatarsal shortening, recurrence, and postoperative complications. Because recurrence and other complications occurred infrequently, the present sample size was not sufficient to reliably detect small differences in these outcomes. Therefore, although recurrence and complication rates were comparable between the two groups, these findings should be interpreted with caution.

Discussion

In this study, we comprehensively compared distal chevron metatarsal osteotomy (DCMO) and minimally invasive surgery (MIS) to correct hallux valgus deformity, focusing on mid-term clinical and radiographic outcomes. Our findings revealed that while DCMO demonstrated superior clinical results, MIS exhibited enhanced radiographic correction capabilities.

In the current study, groups with DCMO technique reported statistically significant improvements in the pain subscale and total index scores of the MOXFQ score. Although the final follow-up scores of the FFI did not show a significant difference between the two groups, the DCMO group exhibited a more pronounced improvement from preoperative assessments to final follow-up compared to the MIS group. This disparity may be attributed to the senior surgeon's extensive experience with DCMO and the relatively early phase of adopting MIS techniques, which could have influenced the outcomes.

Meanwhile, the MIS group radiographically achieved significantly better results in the HVA and the IMA at the final follow-up. Notably, the correction magnitude of the IMA was substantially greater in the MIS group. Additionally, the degree of sesamoid reduction was significantly more pronounced in the MIS group, indicating a more effective realignment of the sesamoid apparatus.

These findings are consistent with previous studies that have compared DCMO and MIS techniques. Kaufmann et al. re-ported that minimally invasive distal chevron osteotomy demonstrated comparable long-term outcomes to the open technique, with no significant differences in clinical or radiographic results [27]. Similarly, Kim et al. found that both open and minimally invasive distal chevron osteotomies effectively corrected hallux valgus deformities, with MIS showing advantages in correcting the distal metatarsal articular angle (DMAA) [28].

Regarding the shortening of the first metatarsal, although the difference was not statistically significant, the MIS group tended to experience more shortening than the DCMO group. This observation aligns with the findings of Choi et al., who noted that minimally invasive distal chevron Akin osteotomies resulted in a greater decrease in the DMAA and an increase in the relative length of the second metatarsal at the final follow-up [29]. The risk of the first metatarsal shortening in MIS procedures may be due to the use of burrs, which can remove more bone compared to traditional osteotomy techniques using saw blades. This aspect warrants careful consideration, as excessive shortening of the first metatarsal can lead to transfer metatarsalgia and other complications [30–32].

Regarding complications, one case (3.8%) of delayed wound healing was observed in the MIS group. Although MIS techniques are generally associated with smaller incisions and reduced soft tissue disruption, this case was attributed to a mild thermal injury caused by frictional heat during repeated screw guide pin positioning. The wound healed completely after approximately four weeks of dressing care. This case underscores an important technical precaution for surgeons transitioning to MIS hallux valgus correction: repeated guide pin manipulation, prolonged burr use, and inadequate irrigation may generate thermal injury around the percutaneous incision. Therefore, careful fluoroscopic planning, controlled instrumentation, and adequate irrigation are essential to minimize frictional heat-related soft tissue complications.

The recurrence rates observed in our study were 8.8% in the DCMO group and 7.6% in the MIS group. These rates are within the range reported in the literature, where recurrence rates after hallux valgus surgery vary between 2.7% and 16% [33, 34]. The comparable recurrence rates between the two groups suggest that both DCMO and MIS are relatively effective in maintaining correction over the mid-term follow-up period. Furthermore, studies comparing open and MIS procedures have reported similar recurrence rates, indicating that technique selection should be based on individual patient characteristics and surgeon experience [28, 35].

Regarding first metatarsal shortening, the MIS group showed a tendency toward greater shortening than the DCMO group, although this difference did not reach statistical significance. Because excessive shortening of the first ray may alter forefoot load distribution and contribute to transfer metatarsalgia, we additionally reviewed whether the degree of shortening was associated with transfer metatarsalgia in our cohort. Although this finding was occasionally suspected in clinical practice, no statistically significant association between first metatarsal shortening and transfer metatarsalgia was identified in the present study. Nevertheless, given the limited sample size and the relatively small number of symptomatic cases, this finding should be interpreted with caution. Further studies with larger cohorts are needed to clarify the clinical relevance of first metatarsal shortening after MIS hallux valgus correction.

This study has several limitations that should be acknowledged. Firstly, as a retrospective chart review, it is subject to inherent biases, and the lack of randomization may affect the generalizability of the findings. Secondly, the follow-up period was limited to the mid-term, and longer-term outcomes were not assessed. Third, the outcomes of the MIS group may have been influenced by the surgeon's learning curve. The surgeon had performed approximately 20 MIS cases before the procedures included in this study, but this was still relatively early in the learning process. Therefore, the results should be interpreted with caution. Fourth, post-hoc power analysis indicated that the current sample size provided sufficient power to detect relatively large differences in radiographic outcomes, such as IMA correction, but limited power to detect moderate differences in clinical outcomes, first metatarsal shortening, and small differences in recurrence or complication rates. Therefore, the comparable recurrence and complication rates observed in this study should be interpreted with caution, and larger prospective studies are needed to confirm these findings. Fifth, the lack of randomization may have introduced selection bias, as the choice of procedure could have been influenced by patient characteristics, deformity severity, or surgeon preference. Although baseline characteristics were generally comparable between groups, unmeasured confounding factors cannot be excluded. Therefore, future prospective randomized studies are needed to validate these findings.

Future studies with longer follow-up periods, larger sample sizes, and randomized controlled designs are necessary to validate these findings and provide more definitive conclusions.

Conclusion

In conclusion, our study indicates that DCMO offers superior clinical outcomes, while MIS provides better radiographic correction in surgically treating hallux valgus deformity. These findings suggest that both techniques have distinct advantages, and the choice of procedure should be tailored to the individual patient's needs and the surgeon's expertise. As MIS techniques continue to evolve and surgeons gain more experience, it is anticipated that the clinical outcomes associated with MIS will further improve. Ongoing research and long-term studies are essential to fully elucidate each surgical approach's benefits and potential drawbacks, guiding optimal treatment strategies for patients with hallux valgus. In addition, surgeons transitioning to MIS should be aware of the potential risk of frictional heat-related soft tissue injury and should use meticulous fluoroscopic guidance, controlled instrumentation, and adequate irrigation to minimize this complication.

Author contributions

Conceptualization, J.H.H. and S.J.K.; methodology, S.J.S. and S.J.K.; validation, J.H.H. and S.J.S.; formal analysis, S.H.B. and S.J.K.; investigation, J.H.H., S.H.B., S.J.S. and S.J.K.; writing—original draft preparation, J.H.H. and S.J.K.; writing—review and editing, J.H.H., S.H.B. and S.J.S.; visualization, S.H.B.; supervision, S.J.S. and S.J.K.; project administration, S.J.K.; funding acquisition, S.J.K. All authors have read and agreed to the published version of the manuscript.

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Data availability

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Institutional Review Board Statement: This study was conducted in accordance with the Decla-ration of Helsinki and approved by the IRB/EC of Dongtan Sacred Heart Hospital (HDT 2024-11-007 and approved on 2 December 2024). And Informed consent was obtained from all subjects involved in the study.

Consent for publication

All the author approved the manuscript.

Competing interests

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