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Minimally invasive surgery for young female patients with mild-to -moderate juvenile hallux valgus deformity

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ABSTRACT

Background: We aimed to compare the clinical and radiographic outcomes of minimally invasive surgery (MIS) and distal chevron metatarsal osteotomy (DCMO) for young female patients with mild-to-moderate juvenile hallux valgus deformity.

Methods: We retrospectively reviewed the radiographs and clinical findings of young female patients with mild-to-moderate juvenile hallux valgus who underwent MIS (25 feet) or DCMO (30 feet). In 12 of 25 MIS feet, 2.0-mm bio-absorbable pins were used as an additional fixation device crossing the osteotomy site, and 1.4-mm Kirschner wires were used in the remaining 13 feet.

Results: Radiographic and clinical parameters preoperatively and at the final follow-up were not significantly different between the 2 groups. There were no significant differences in the increments of hallux valgus angle (HVA), distal metatarsal articular angle, medial sesamoid position, first metatarsal length, metatarsal length index, or relative second metatarsal length. Two MIS subgroups according to the additional fixation device showed no significant differences in HVA, the first to second intermetatarsal angle lateral translation ratio, or plantar offset at the final follow-up.

Conclusions: MIS for young female patients with mild-to-moderate juvenile hallux valgus deformity had similar radiographic and clinical outcomes compared to DCMO. Regarding additional fixation crossing the osteotomy site, both temporary Kirschner wires and absorbable pins showed no radiographic differences in terms of correction maintenance.

Level of evidence: 3.

1. Introduction

Minimally invasive surgery (MIS) for hallux valgus correction has had widespread popularity since Giannini et al. [1] introduced it as a simple, effective, rapid, and inexpensive way to correct hallux valgus deformity. However, it still remains very controversial whether MIS for hallux valgus correction is effective and whether the correction remains stable over time [2–4].

Olivia et al. [5] described that the most common complications following MIS are the recurrence of deformity, incorrect selection of the procedure, incorrect operative technique, and underestimation of osteotomy healing time. In contrast, the biggest advantages of MIS are that the correction can be done with a very small incision, less than 1 cm (cosmetics), and the procedure can be performed easily in a very short time (simplicity). The technique can be considered for young female patients who desire a less visible scar.

The purpose of the present study was to analyze the efficacy of MIS compared to open distal chevron metatarsal osteotomy (DCMO) for young female patients with mild-to-moderate juvenile hallux valgus deformity, focusing on the correctional power, postoperative correction maintenance, and cosmetics. To the best of our knowledge, there are no previous reports presenting the result of MIS for this sex- and age-specific group. We hypothesized that MIS would show similar correctional power and postoperative correction maintenance with better cosmetics compared to DCMO.

2. Materials and methods

2.1. Patient selection

Data from female patients aged from 16 to 30 years old who underwent MIS or DCMO for mild-to-moderate juvenile hallux valgus deformity correction from March 2008 to March 2016 with a minimum of 1 year of follow-up were reviewed retrospectively.

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Postoperative data were collected at the outpatient department via the patient recall method. Mild-to-moderate hallux valgus was defined as a deformity with the hallux valgus angle (HVA) less than 40°, and the first to second intermetatarsal angle (IMA) was less than 20°. The indication for surgery was when the symptom persisted despite conservative treatment including shoe modification, spacers, and pads. Thirty-two feet in the MIS group and 35 feet in the DCMO group were enrolled. Among them, patients with simultaneous forefoot surgeries (3 feet in the MIS group and 3 feet in the DCMO group) that could have affected the clinical outcome, such as a tailor's bunion correction osteotomy, a second Weil osteotomy, or resection arthroplasty for any type of toe deformity; systemic inflammatory conditions such as rheumatoid arthritis (2 feet in the MIS group); or a history of trauma that could have affected the forefoot alignment (2 feet in the MIS group and 2 feet in the DCMO group) were excluded. Finally, 25 feet in 21 patients in the MIS group and 30 feet in 24 patients in the DCMO group were enrolled. All MISs were performed by a single surgeon, while DCMOs were performed by multiple surgeons. Bilateral operations were performed sequentially.

2.2. Operative technique

Patients were placed in the supine position under anesthesia. A pneumatic tourniquet was applied on the proximal thigh to prevent bleeding and obtain a better visual field. In the MIS group, an 8- to 10-mm medial incision was made just proximal to the bunion. A 1.2-mm Kirschner wire (K-wire) was inserted perpendicular to the first metatarsal longitudinal axis to guide the osteotomy direction. An osteotomy was performed along the guidewire with an oscillating saw. A longitudinally directed 2.0-mm K-wire was passed into the soft tissue from the osteotomy site to the great toe tip. Curved Kelly forceps were inserted into the medullary canal of the metatarsal shaft proximal to the osteotomy site, and lateral translation of the metatarsal head was obtained by pulling the metatarsal bone medially with the curved Kelly forceps. A slight plantar translation of the first metatarsal head was made simultaneously while correcting so as not to allow dorsal migration of the metatarsal head in the sagittal plane. A longitudinal K-wire was advanced into the medullary canal to meet the first metatarsocuneiform joint. Additional fixation was performed crossing the osteotomy site in proximal to distal and medial to lateral directions. In 12 of 25 feet, 2.0-mm Activa bioabsorbable pins (Bioretec Ltd., Finland) were used as an additional fixation device, while 1.4-mm K-wires were used in 13 feet (Fig. 1).

In the DCMO group, an adductor tenotomy was performed in 15 feet. In 7 of 15 feet, adductor tenotomy was performed through a 2-cm vertical incision made on the dorsum between the first and second metatarsal heads. The transverse intermetatarsal ligament and lateral capsule were also released. In 8 of 15 feet, isolated adductor tenotomy was performed through the first metatarsophalangeal articular space without the dorsal incision. After the medial eminence was excised through a medial longitudinal incision beyond the bunion, a guidewire was inserted in the center of the metatarsal head perpendicular to the first metatarsal shaft to mark the apex of the osteotomy, and a chevron osteotomy with 45°–60° was performed following the guidewire. With lateral translation and rotation of the distal fragment to correct the deformity, two or three 1.4-mm K-wires were fixed to secure the correction. An Akin procedure fixed with two 1.2-mm K-wires was added in 15 feet when the correction was not cosmetically satisfactory. The medial joint capsule was partially excised and repaired. Then, skin closure was performed.

2.3. Postoperative management

Only heel gait was permitted for 6 weeks using specially designed shoes with hard outer soles. In the MIS group, an elastic bandage was used to maintain the great toe in a reduced position during the heel gait phase, while the DCMO group used toe spacer placing into the first to second web space to maintain the correction. K-wires were removed when the postoperative

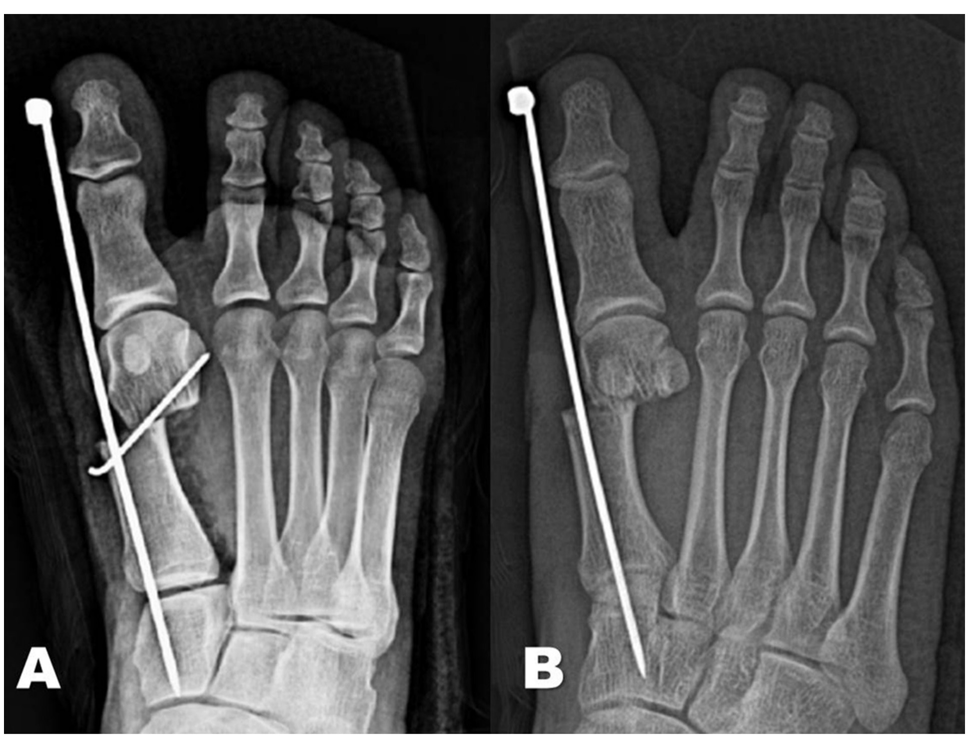

Fig. 1. Two types of additional fixation devices crossing the osteotomy site after longitudinal Kirschner wire fixation. Either a 1.4-mm Kirschner wire (A) or a 2.0-mm bio-absorbable pin (B) was used.

radiographs showed adequate bony union at 6 weeks postoperatively; weight-bearing on the whole foot was allowed after K-wire removal.

2.4. Assessment

Initially, the existence of general laxity (passive apposition of the thumbs to the flexor aspects of the forearms, hyperextension of the elbows beyond 10°, and hyperextension of the knees beyond 10°), operative time, and incision length were measured and compared. Radiographically, HVA, IMA, distal metatarsal articular angle (DMAA) and the medial sesamoid position as demonstrated by Hardy and Clapham [6] were measured using standing foot anteroposterior radiographs obtained preoperatively, on the first weight-bearing at 6 weeks postoperatively, and at the final follow-up. HVA was defined as the angle between the line from the center of the first metatarsocuneiform joint to the center of the first metatarsal head and the line from the center of the proximal phalangeal base to the center of the proximal phalangeal head longitudinal axes of the first metatarsal and proximal phalanx. IMA was defined as the angle between the two lines from the center of the metatarsocuneiform joints to the center of the first and second metatarsal heads. DMAA was defined as the angle between the line perpendicular to the distal metatarsal articular surface and the longitudinal axis of the first metatarsal.

Since the hallux valgus in young female individuals could be related to juvenile or adolescent hallux valgus, which is commonly combined with pes planus deformity, the talo-first metatarsal angle (Meary angle) and calcaneal pitch angle on the standing foot lateral radiographs were only measured preoperatively to determine the relation to the pes planus. To calculate the postoperative change of the first metatarsal length more precisely, the first metatarsal length, metatarsal length index (MLI) [7], and relative second metatarsal length [8] were measured. The first metatarsal length was defined as the longitudinal distance between the center of the first metatarsal base and the first metatarsal head MLI was defined as the perpendicular distance between the center of the second metatarsal head and the line drawn from the first to fifth metatarsal heads (Fig. 2A). The relative second metatarsal length was defined as the perpendicular distance from the apex of the second metatarsal head to the line drawn between the apex of the first and third metatarsal bones (Fig. 2B). To compare the degree of dorsal or plantar migration of the metatarsal head on the sagittal plane, plantar offset [9] was measured using lateral foot radiographs on the first weight-bearing at 6 weeks postoperatively and at the final follow-up. A negative value was assigned in cases of dorsal migration of the first metatarsal head.

In the MIS group, the lateral translation ratio [10] was measured on the first weight-bearing at 6 weeks postoperatively and at the final follow-up to determine the postoperative correction maintenance on the axial plane. The lateral translation ratio was defined as the ratio of the length of lateral translation to the whole metatarsal shaft diameter (Fig. 3).

Clinically, the American Orthopaedic Foot and Ankle Society (AOFAS) hallux metatarsophalangeal-interphalangeal scale [11] was calculated to evaluate the functional outcome. It contains pain (40 points), function (45 points), and alignment (15 points). The standardized mean was calculated as a score from 0 to 100, with 100 representing the best possible outcome. The AOFAS scale was not validated. We also compared the preoperative range of motion of the first metatarsophalangeal joint (total, plantar flexion, dorsiflexion) to those at the final follow-up.

The cosmetic satisfaction rate was determined by the number of positive answers when the individuals were asked, “Regarding the postoperative scar, are you cosmetically satisfied with the surgery?” Finally, complications related to surgery during the follow-up period were evaluated.

All patients provided written informed consent before the study. This study was approved by our institutional ethical review committee. The means and standard deviations for all of the dependent parameters were calculated using SPSS 19 (IBM Corp., Armonk, NY). The Mann–Whitney U test was used to assess the

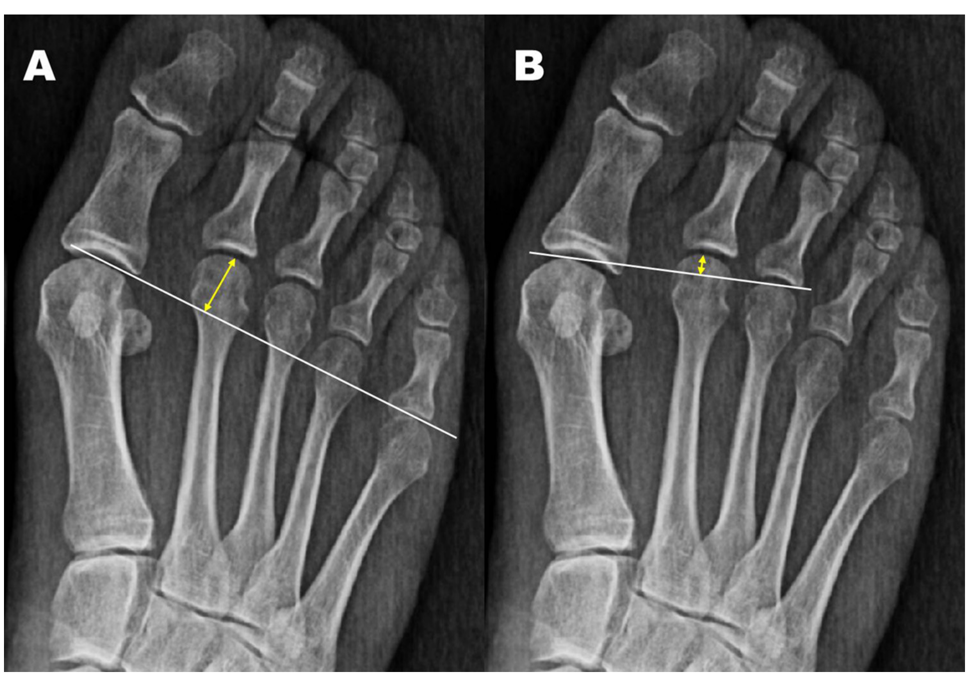

Fig. 2. The metatarsal length index was defined as the perpendicular distance between the center of the second metatarsal head and the line drawn from the first to fifth metatarsal heads (A). The relative second metatarsal length was defined as the perpendicular distance from the distal end of the second metatarsal head to the line drawn between the distal ends of the first and third metatarsal bones (B).

Fig. 3. The lateral translation ratio, defined as the length of lateral translation (B) divided by the whole metatarsal shaft diameter (A), was calculated.

differences for nonparametric parameters. Fisher's exact test was used to analyze differences in the ratio of general laxity, pes planus, and cosmetic satisfaction. Statistical significance was determined at a *P*-value of less than 0.05 for all analyses.

3. Results

Patient demographics, surgery-related factors, and preoperative radiographic parameters are summarized in Table 1; no significant differences in age, follow-up duration, or the ratio of general laxity were noted. The operative time (23.0 vs. 45.2 min) and length of incision (9.3 vs. 45.4 mm) were significantly shorter in the MIS group ($P < 0.001$ for both). In preoperative radiographic parameters, there were no significant differences between the 2 groups. With regard to preoperative pes planus deformity, mild pes planus was defined as a Meary angle between -4° and -15°, while moderate-to-severe pes planus was defined as a Meary angle of less than -15°. The number of moderate-to-severe pes planus deformities was not significantly different between the 2 groups.

Radiographic parameters on the first weight-bearing at 6 weeks postoperatively and at the final follow-up and correctional power for the radiographic parameters are described in Table 2. Of the radiographic parameters on the first weight-bearing at 6 weeks postoperatively, no significant differences were noted, except the plantar offset was significantly greater in the MIS group. At the final follow-up, no significant differences were found between the groups. Regarding the lateral translation ratio of the MIS group, the lateral translation ratio was decreased by 11.3% from 53.8 ± 5.3% on the first weight-bearing at 6 weeks postoperatively to 42.5 ± 6.5% at the final follow-up.

Correctional power was defined as the difference in each radiographic parameter between preoperative and final follow-up measurements. There were no significant differences in the correctional power of HVA, DMAA, medial sesamoid position, first metatarsal length, MLI, or relative second metatarsal length.

Additionally, the MIS group was divided into 2 subgroups according to the additional fixation device (Table 3). HVA, IMA lateral translation ratio, and plantar offset at the final follow-up were not significantly different between the 2 subgroups.

Clinically, the AOFAS hallux metatarsophalangeal-interphalangeal scale preoperatively and at the final follow-up was not significantly different between the groups. In both groups, the AOFAS hallux metatarsophalangeal-interphalangeal scales were significantly increased after the surgery. Range of motion was slightly decreased throughout the surgery with a slight decrease in plantar flexion (Table 4). Twenty-two out of 25 patients (88%) in the MIS group and 20 out of 30 patients (66.67%) in the DCMO group gave a positive answer when questioned if they were cosmetically satisfied with the surgeries ($P = 0.03$).

Table 1
Patient demographics, surgery related factors and preoperative radiographic parameters of each group.

		MIS (25 cases in 21 patients)	DCMO (30 cases in 24 patients)	P-value
Patient demographics	Age	21.3 ± 5.1	22.4 ± 3.8	0.244
	Follow up duration (months)	19.9 ± 1.1	20.5 ± 3.9	0.464
	Direction (right:left)	16:09	18:12	
	Existence of general laxity	8 (32%)	9 (30%)	0.587
Surgery related factors	Operative time (min)	23.0 ± 2.4	45.2 ± 7.8	<0.001
	Incision (mm)	9.3 ± 1.2	45.4 ± 2.8	<0.001
Preoperative radiographic parameters	HVA (°)	25.3 ± 3.4	25.9 ± 3.0	0.49
	IMA (°)	14.4 ± 0.8	14.1 ± 0.7	0.22
	DMAA (°)	4.0 ± 5.9	4.8 ± 6.1	0.61
	Meary angle (°)	−3.8 ± 10.4	1.4 ± 14.9	0.138
	CPA (°)	20.2 ± 3.7	19.9 ± 4.0	0.42
	Number of mild pes planus cases	1 (4%)	0 (0%)	0.01
	Number of moderate to severe pes planus cases	8 (32%)	9 (30%)	0.587
	Medial sesamoid position	4.1 ± 1.0	4.0 ± 0.7	0.837
	First metatarsal length (mm)	60.8 ± 2.6	62.5 ± 4.4	0.09
	MLI (mm)	10.0 ± 1.5	10.8 ± 1.7	0.077
	Relative second metatarsal length (mm)	3.2 ± 1.1	3.5 ± 1.5	0.312

MIS, minimally invasive surgery; DCMO, distal chevron metatarsal osteotomy; HVA, hallux valgus angle; IMA, first to second inter-metatarsal angle; DMAA, distal metatarsal articular angle; CPA, calcaneal pitch angle; MLI, metatarsal length index; MIS, minimally invasive surgery; DCMO, distal chevron metatarsal osteotomy.

Table 2
Radiographic parameters on the first weight-bearing at 6 weeks postoperatively and at the final follow-up and correctional power for the radiographic parameters of both groups.

		MIS (25)	DCMO (30)	*P*-value
On the first weight-bearing at 6 weeks postoperatively	HVA (°)	5.9 ± 2.0	5.7 ± 4.4	0.792
	IMA (°)	4.0 ± 1.6	3.9 ± 2.3	0.959
	DMAA (°)	3.3 ± 3.0	2.4 ± 2.2	0.193
	Medial sesamoid position	2.3 ± 0.7	2.4 ± 0.9	0.479
	1st metatarsal length (mm)	58.8 ± 3.7	59.1 ± 4.2	0.800
	MLI (mm)	10.9 ± 2.0	11.3 ± 1.5	0.317
	Relative second metatarsal length (mm)	3.8 ± 1.5	4.4 ± 1.4	0.175
	Plantar offset (mm)	1.8 ± 2.2	0.4 ± 1.1	0.003
At final follow-up	HVA (°)	12.4 ± 4.6	11.5 ± 5.7	0.487
	IMA (°)	4.9 ± 2.2	5.9 ± 3.0	0.152
	DMAA (°)	2.5 ± 1.6	3.3 ± 4.6	0.407
	Medial sesamoid position	2.8 ± 1.2	2.7 ± 1.1	0.662
	First metatarsal length (mm)	58.8 ± 3.7	59.1 ± 5.3	0.77
	MLI (mm)	10.8 ± 1.8	11.6 ± 2.2	0.181
	Relative 2nd metatarsal length (mm)	4.2 ± 1.1	4.6 ± 1.6	0.231
	Plantar offset (mm)	0.5 ± 1.7	0.1 ± 1.0	0.213
Correctional power for the radiographic parameters	Δ HVA (°)	−12.8 ± 7.1	−14.4 ± 6.5	0.093
	Δ IMA (°)	−9.5 ± 2.4	−8.2 ± 3.3	0.101
	Δ DMAA (°)	−1.5 ± 5.6	−1.5 ± 6.6	0.988
	Δ Medial sesamoid position	−1.3 ± 0.8	−1.4 ± 1.0	0.087
	Δ First metatarsal length (mm)	−2.0 ± 4.0	−3.4 ± 3.8	0.194
	Δ MLI (mm)	0.9 ± 1.4	0.8 ± 1.2	0.861
	Δ Relative second metatarsal length (mm)	1.0 ± 1.0	1.1 ± 1.4	0.086

MIS, minimally invasive surgery; DCMO, distal chevron metatarsal osteotomy; HVA, hallux valgus angle; IMA, First to second intermetatarsal angle; DMAA, distal metatarsal articular angle; MLI, metatarsal length index; Δ, delta, an increment of a variable.

Table 3
Radiographic parameters of MIS subgroups according to the additional fixation device.

	MIS-nonabsorbable (13)	MIS-bioabsorbable (12)	*P*-value
Preoperative HVA (°)	24.9 ± 3.4	25.7 ± 3.5	0.541
HVA at final follow-up (°)	12.9 ± 5.5	12.0 ± 3.6	0.625
Preoperative IMA (°)	14.3 ± 0.7	14.4 ± 0.9	0.678
IMA at final follow-up (°)	5.0 ± 2.2	4.8 ± 2.3	0.825
Lateral translation ratio on the first weight-bearing at 6 weeks postoperatively (%)	55.0 ± 4.6	52.5 ± 5.9	0.239
Lateral translation ratio at final follow-up (%)	42.4 ± 2.0	42.7 ± 1.9	0.682
Plantar offset on the first weight-bearing at 6 weeks postoperatively (mm)	2.1 ± 1.6	1.5 ± 2.7	0.505
Plantar offset at final follow-up (mm)	0.6 ± 1.7	0.4 ± 1.8	0.738

MIS, minimally invasive surgery; HVA, hallux valgus angle; IMA, first to second inter-metatarsal angle.

Table 4
Clinical outcomes of both groups.

		MIS (25)	DCMO (30)	*P*-value
Preoperative	AOFAS scale	58.6 ± 8.6	59.1 ± 7.8	0.834
	Range of motion (overall, 115°)	108.6 ± 5.5	108.5 ± 5.1	0.945
	Range of motion (plantar flexion, 45°)	43.4 ± 2.4	43.2 ± 2.5	0.723
	Range of motion (dorsiflexion, 70°)	65.2 ± 4.4	65.3 ± 4.3	0.911
At final follow-up	AOFAS scale (overall, 100)	88.9 ± 6.4	88.9 ± 6.2	0.991
	Range of motion (overall, 115°)	104.2 ± 5.3	103.0 ± 6.6	0.470
	Range of motion (plantar flexion, 45°)	39.8 ± 4.4	38.8 ± 5.4	0.476
	Range of motion (dorsiflexion, 70°)	64.4 ± 4.4	64.2 ± 4.4	0.845

AOFAS, American orthopaedic foot and ankle society; MIS, minimally invasive surgery; DCMO, distal chevron metatarsal osteotomy.

In the MIS group, the complications observed during follow-up included revision operation because of osteotomy site irritation in 2 of 25 feet (8%). This osteotomy site irritation occurred by 3 months postoperatively in all patients but disappeared by 6 months postoperatively with an osteotomy remodeling (Fig. 4). In the DCMO group, a revision proximal chevron metatarsal osteotomy was performed in 1 of 30 feet (3.3%) because of recurrence at 2 years postoperatively, and 1 of 30 feet (3.3%) had the first metatarsophalangeal joint stiffness observed during the follow-up period. No postoperative deep or pin site infection, malunion or nonunion of the osteotomy site, hallux varus, or avascular necrosis of the first metatarsal head were reported. Additionally, no adverse effects with the pin crossing the first metatarsocuneiform joint were noted.

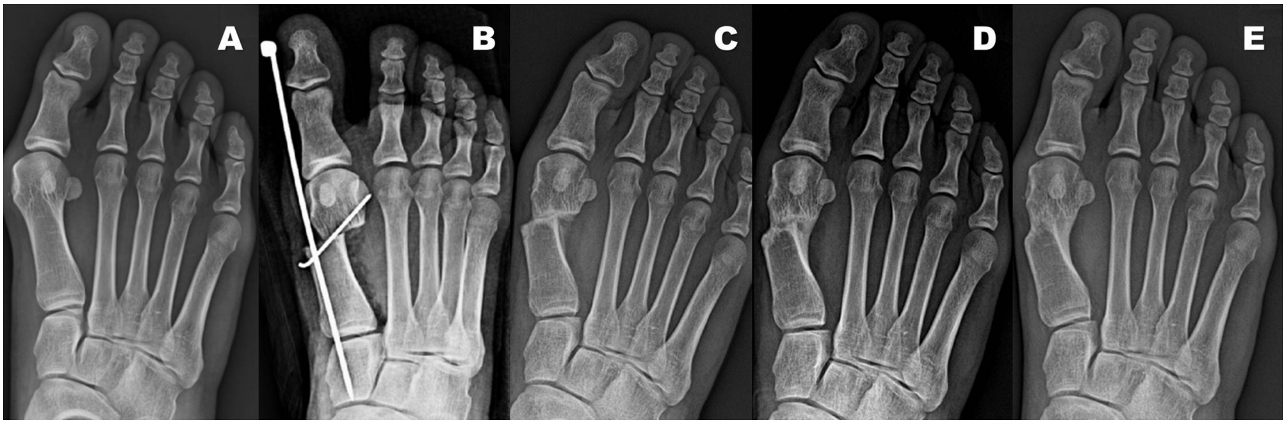

Fig. 4. Radiographs preoperatively (A), immediately postoperatively (B), and at 3 (C), 6 (D) and 18 (E) months postoperatively show the remodeling process of the osteotomy site. Osteotomy site irritation disappeared by 6 months postoperatively as it became smooth.

4. Discussion

There have been several reports about MIS for hallux valgus correction. Magnan et al. [12] stated that the clinical results of percutaneous distal metatarsal osteotomy for correction of hallux valgus appeared to be comparable to those obtained with traditional open techniques. Comparing DCMO [13] and scarf osteotomy [14], MIS was reported to result in similar clinical and radiographic improvement. Giannini et al. [15] performed bilateral surgery with a scarf osteotomy on one side and MIS on the other, at random. They found no clinical or radiographic differences between the groups. On the contrary, Kadakia et al. [16] insisted that the intraoperative correction with MIS was routinely lost after removal of the intramedullary K-wire, leading to a high rate of recurrence of hallux valgus deformity as well as dorsal elevation of the first metatarsal head fragment. Huang et al. [17] also found that MIS had a higher recurrence rate of up to 6.7% (6 of 89 feet) compared to other traditional distal metatarsal osteotomies. In our study, MIS showed similar radiographic parameters on the first weight-bearing at 6 weeks postoperatively compared to DCMO.

In terms of midterm results and complications of MIS, Ianno et al. [18] reported satisfactory clinical and radiographic results after 73 months of postoperative follow-up. Deformity recurred in 16 of 85 feet (18.8%), 9 of which were observed in patients with preoperative HVA more than 40°. They also concluded that preoperative congruence of the first metatarsophalangeal joint and the medial sesamoid position was related to a high postoperative recurrence rate.

Recently, Brogan et al. [9] introduced the third generation MIS, which created a 3D correction of the deformity. They used a 2×20 mm Shannon burr (WG Healthcare, UK) to make a chevron-shaped first metatarsal neck osteotomy. They also compared this technique to DCMO, concluding that the midterm result was comparable to traditional DCMO for mild-to-moderate deformity. However, they did not mention the operative time in their articles. We anticipate that creating the osteotomy with a Shannon burr would take much longer than traditional MIS or even an open technique.

The biggest concern about MIS was the loss of correction after the longitudinally fixated K-wire removal. At the final follow-up, the HVA, IMA, and the medial sesamoid position remained acceptable in both the MIS and DCMO groups with no significant differences. We also measured the lateral translation ratio. Enan et al. [10] mentioned that the extent of lateral translation of the first metatarsal head was decreased by 20.1% (from $56.2 \pm 1.84\%$ to $36.1 \pm 15.9\%$) at 21 months of follow-up. In our study, loss of initial lateral translation was less (11.3%, from $53.8 \pm 5.3\%$ to $42.5 \pm 6.5\%$) than their study with a similar follow-up duration (19.9 ± 1.1 months). We suggest that lateral translation loss can be reduced with the additional fixation crossing the osteotomy site. Regarding the additional fixation crossing the osteotomy site, we tried to fix either a temporary K-wire for 6 weeks or a permanent bio-absorbable pin. Interestingly, neither additional fixation devices showed significant differences in terms of osteotomy maintenance (lateral translation ratio or plantar offset). We concluded that bio-absorbable pin fixation could be also suggested as another safe and cosmetically acceptable method to secure the osteotomy site.

Regarding the shortening of the first metatarsal bone, we measured 3 indices to obtain reliable results: first metatarsal length, MLI, and relative second metatarsal length. There were no significant differences although 1–2 mm shortening of the first metatarsal bone was detected in both groups. Plantar offset after the operation is another important issue for MIS although many authors have insisted that the dorsal migration of the first metatarsal head should be avoided. We also tried to create a slight plantar migration during the operation, but it tended to return to neutral with weight-bearing on the forefoot.

The main limitation of the current study was a relatively short mean follow-up duration of less than 2 years. Since the patients were young, it was impossible to predict the long-term effect on correction maintenance. Mid- or long-term follow-up studies should be conducted in the future. There was the variability in the fixation method and Akin osteotomy in one group only. A small sample size in each group and the retrospective study design were other limitations.

5. Conclusions

In conclusion, MIS for young female patients with mild-to-moderate juvenile hallux valgus deformity resulted in similar radiographic and clinical outcomes compared to DCMO. Regarding additional fixation crossing the osteotomy site, both temporary K-wires and absorbable pins showed no radiographic differences in terms of correction maintenance.

Conflict of interest

The authors have no conflicts of interest.

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