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MICA Procedure vs Open Chevron Osteotomy for Hallux Valgus Correction: A Prospective Cohort Study

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Abstract

Background: Currently, more than 150 surgical techniques have been described for the treatment of hallux valgus. The abundance of techniques indicates that there is no technique that has been designated as a gold standard. In recent years, a particular interest in the use of minimally invasive techniques has grown. The aim of this study was to prospectively compare clinical, radiologic, and postoperative outcomes between the MICA technique and open chevron technique over a 1-year follow-up period.

Methods: Between January 2016 and August 2020, data were prospectively collected from consecutive patients preoperatively and at 6 weeks, 3 months, and 12 months following minimally invasive chevron and Akin (MICA) or open chevron osteotomies. Radiographic outcomes were measured using weightbearing radiographs preoperatively and at 3 and 12 months postoperatively. Clinical outcomes were measured using the American Orthopaedic Foot & Ankle Society (AOFAS), Manchester-Oxford Foot Questionnaire (MOXFQ), VAS (visual analog scale), Foot Function Index (FFI), Foot and Ankle Outcome Score (FAOS), and Euro-QoL-5D (EQ5D) questionnaires.

Results: Of the 68 patients, 42 patients (62%) underwent a MICA surgery and 26 patients (38%) underwent open chevron osteotomy. Both groups showed significant improvement in HVA, IMA, and DMAA at the 1-year follow-up. Our findings show that both clinical and radiologic outcomes of the MICA technique are comparable to the conventional open technique. No significant differences were found in clinical outcomes (VAS, AOFAS, MOXFQ, FFI, and FAOS), complication rate, and operative times.

Conclusion: These results show that MICA is a safe alternative for chevron osteotomy. The clinical and radiologic outcomes of these 2 techniques by 12 months are comparable.

Level of Evidence: Level II, prospective cohort study.

Keywords: Hallux valgus, minimally invasive surgery, deformity correction

Introduction

Hallux valgus is a deformity condition including progressive anomaly of the first ray. Currently, more than 150 surgical techniques have been described for the treatment of hallux valgus. The abundance of techniques indicate that there is no technique that has been designated as gold standard.[4] In recent years, a number of new osteotomies have been described; in particular, there has been a growing interest in the use of

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minimally invasive techniques. Theoretically, it is said that minimally invasive techniques have potential advantages of decreasing recovery and rehabilitation times, thereby reducing the morbidity associated with both the disease process and the operative intervention.[4] Distal metatarsal chevron osteotomy (combined with distal soft tissue procedure or lateral release) is a good option in mild to moderate hallux valgus, providing good results in deformity correction and in symptom relief.[19] The minimally invasive version of the distal chevron osteotomy is the so-called minimally invasive chevron and Akin (MICA) procedure. The MICA technique is a technique that enables an open modified chevron and Akin to be done through a 3-mm incision.[9]

Prior studies have compared the outcomes between the minimally invasive technique and open technique of treating hallux valgus.[7,13,15,16] So far, these studies found comparable clinical and radiologic outcomes between both techniques. The extent of deformity seems to play a role in determining the best surgical technique, according to a study by Choi et al.[7] The limited amount of current evidence on minimally invasive techniques, together with the varying outcomes between previous studies and relatively small study sizes, highlights the need for prospective comparative studies on this matter. We believe that a reasonably sized prospective study, comparing 2 of the most commonly used techniques for hallux valgus correction, would have a significant contribution to the current literature. Therefore, the primary aim of this study was to compare radiologic outcomes between the MICA technique and open chevron (OC) technique over a 1-year follow-up period. Furthermore, clinical and postoperative outcomes were compared. We hypothesize that the MICA technique has comparable radiologic, clinical, and postoperative outcomes to the open chevron technique.

Methods

Study design

After medical ethical committee approval (MEC-15-113), patients with hallux valgus deformity who were scheduled to undergo distal chevron osteotomy between January 2016 and August 2020 were considered eligible for study enrollment of this prospective cohort study. Inclusion criteria were (1) patients with mild to moderate (HVA up to 40 degrees and IMA up to 20 degrees) hallux valgus deformity, (2) male or nonpregnant female patients aging 18-90 years, and (3) approval of the Ethics Committee–approved informed consent. Exclusion criteria were (1) previous foot surgery; (2) earlier fracture to any bone of the foot, with exception of phalanx of digits 2 to 5; (3) cerebral palsy; (4) rheumatoid arthritis; (5) pregnant patients; and (6) diabetes mellitus with known vascular deficiency. After informed consent, patients received either MICA or open chevron osteotomy, based on which they visited one of the 2 surgeons in the outpatient clinic. Radiographs in weightbearing anterior-posterior and lateral position were taken preoperatively and postoperatively after 6 weeks, 3 months, and 1 year. For each radiograph, the hallux valgus angle (HVA), intermetatarsal angle (IMA), and distal metatarsal articular angle (DMAA) were measured twice, independently from one another, by 2 masked radiologic observers. Operative times were recorded and complication rates were measured until 1 year postoperatively.

Moreover, patients received questionnaires at similar follow-up moments preoperatively and postoperatively after 6 weeks, 3 months, and 1 year. These questionnaires included Foot Function Index (FFI),[5] Foot and Ankle Outcome Score (FAOS),[21] Manchester-Oxford Foot Questionnaire (MOXFQ),[18] Euro-QoL 5D (EQ5D),[24] and visual analog scale (VAS)[20] for pain, function, and satisfaction and were administered during each follow-up moment. Standard clinical follow-up at 2 weeks was performed for splint change and administration of the VAS. Lastly, patients received the American Orthopaedic Foot & Ankle Society (AOFAS)[22] questionnaire preoperatively and at 6 weeks, 3 months, and 1 year postoperatively (see Appendix A).

Surgical Technique: MICA

In the MICA group, the surgery was performed under direct fluoroscopic guidance.[23] The patients were in a supine position with a tourniquet around the upper leg. An extra-articular transverse osteotomy was performed through a 3- to 5-mm medial incision at the metatarsal neck with a Shannon burr of 2.0×20 mm. To prevent overheating, the reamer was frequently rinsed with sterile saline. Following displacement of the metatarsal head, the osteotomy site was fixed with 2 parallel fully threaded, cannulated, and headless 3.2-mm compression screws—1 bicortical prior to entering into the capital fragment and 1 unicortical. Subsequently, a 1- to 2-mm incision was created in the medial region of the proximal phalanx. Using a 3.1×13-mm wedge burr, a medially based closing wedge osteotomy (Akin) was created and fixed with 1 screw. A lateral soft tissue release was undertaken through a separate lateral incision of 3 to 5 mm (web space 1-2). The medial eminence was excised with a 3.1×13-mm wedge burr. All incisions were irrigated and closed. A local anesthetic block was provided for postoperative analgesia. Postoperative treatment consisted of full weightbearing, 2 weeks of bandage, and a rigid flat sandal. After 2 weeks, the bandage and sutures are removed. A removable hallux splint was applied for 3 more weeks, in order to exercise range of motion.

Surgical Technique: Open Chevron

The chevron procedure was performed with the patient in supine position with a tourniquet around the upper leg. The chevron osteotomy was performed by a medial incision centered over the first metatarsophalangeal (MTP) joint, while protecting the dorsomedial cutaneous nerve. The medial capsule was opened longitudinally and a strip of capsule was excised. The medial eminence of the first metatarsal head was removed. A transarticular lateral capsular release was performed until the hallux was in line with the first metatarsal. A 60-degree V-osteotomy centered in the first metatarsal head was performed; the capital fragment was displaced laterally. The osteotomy was secured with a titanium compression screw. A medial capsulorraphy was performed subsequently. Wounds were closed and a local anesthetic block is provided for postoperative analgesia. Postoperative care was similar to the MICA procedure.

Statistical Analysis

Categorical variables are presented as absolute values and percentages. Continuous variables are presented as median and interquartile range (IQR). Normality was tested by histograms per variable. To analyze statistical differences in outcomes between the MICA and open chevron group, univariate analyses were performed using a Fisher exact test for categorical variables, a Fisher exact test for parametric continuous outcomes, and a Mann-Whitney *U* test for nonparametric continuous outcomes. A linear regression analysis was performed to investigate improvement in radiologic outcome at 1-year follow-up. A *P* value of $<.05$ was considered statistically significant for all tests. All analyses were performed with Stata 14.0 (StataCorp, College Station, TX).

Results

Study Population

A total of 68 patients were enrolled in this study, of which 42 patients (62%) of the patients were in the MICA group and 26 patients (38%) of the patients in the open chevron (OC group). Eighty-eight percent were female and the mean age was 46 years (SD: 12 years). Median body mass index (BMI) was 24, and 24% were smokers (see Table 1).

Table 1. Patient Demographics.

Demographics	MICA	Chevron	*P* Value
Age, y, mean (SD)	47 (12)	43 (12)	.32
Female gender, n (%)	39 (93)	21 (81)	.24
Body mass index, median (IQR)	25 (23-27)	24 (22-27)	.54
Smoking, n (%)	13 (31)	3 (12)	.06

Abbreviations: IQR, interquartile range; MICA, minimally invasive chevron and Akin.

Radiologic Outcomes

Both groups showed significant improvement in HVA, IMA, and DMAA at the 1-year follow-up (Table 2). In the MICA group, median HVA improved from preoperatively 28 degrees (IQR: 22-30) to 9 degrees (IQR: 7-13) at the 6-week follow-up, and to 11 degrees (IQR: 7-15) at the 1-year follow-up. In the OC group, median HVA improved from preoperatively 24 degrees (IQR: 19-25) to 10 degrees (IQR: 8-15) at the 6-week follow-up and to 15 degrees (IQR: 9-18) at the 1-year follow-up. Furthermore, median IMA improved from preoperatively 11 degrees (IQR: 10-14) to 5 degrees (IQR: 4-7) at the 6-week follow-up and to 6 degrees (IQR: 4-8) at the 1-year follow-up in the MICA group. In the OC group, median IMA improved from preoperatively 11 degrees (IQR: 8-12) to 6 degrees (4-8) at the 6-week follow-up and to 7 degrees (IQR: 5-9) at the 1-year follow-up. Lastly, DMAA improved from preoperatively 16 degrees (IQR: 13-18) to 8 degrees (IQR: 6-11) at the 6-week follow-up and to 7 degrees (IQR: 6-10) at the 1-year follow-up in the MICA group. In the OC group, DMAA improved from preoperatively 14 degrees (IQR: 12-16) to 9 degrees (IQR: 7-12) at the 6-week follow-up and remained 9 degrees (IQR: 8-13) at the 1-year follow-up. Univariate and linear regression analyses show comparable improvement in radiologic outcomes between both groups (Table 3).

Clinical Outcomes

Even though AOFAS scores were significantly different between the MICA group and OC group at all follow-up moments; however, improvement in AOFAS score over 1 year did not significantly differ between the groups ($P=.39$; Table 4). FFI scores were similar in both groups at all follow-up moments. However, improvement in FFI score at the 1-year follow-up was significantly better in the OC group compared to the MICA group ($P=.02$). All VAS, MOXFQ, and FAOS scores were similar in both groups at all follow-up moments, and no significant differences were found in the improvement of these scores (Table 4 and Supplemental Table 1).

Peri- and Postoperative Outcomes

Median operating time was 40 minutes (IQR: 34-42) in the MICA group and 34 minutes (IQR: 30-39) in the OC group ($P=.07$). Complication rates at 2 weeks, 6 weeks, 3 months, and 1 year did not differ between the 2 groups. After 1 year, there were 2 complications (5%) in the MICA group: 1 patient had a nonunion and 1 patient developed pseudogout. In the OC group, there were 3 complications (12%) at the 1-year follow-up: 1 patient developed a Morton neuroma and 2 patients experienced pain complaints of the osteosynthesis

Table 2. Radiologic Outcomes.

Angle	MICA (n=42) Median	MICA (n=42) IQR	Chevron (n=26) Median	Chevron (n=26) IQR	*P* Value[a]
HVA					
Preoperative	28	22, 30	24	19, 25	**.01**
6 wk	9	7, 13	10	8, 15	.43
3 mo	10	7, 13	14	11, 19	**.01**
1 y	11	7, 15	15	9, 18	**.04**
Improvement, preoperative to 6 wk	16	13, 20	11	6, 15	**<.01**
Improvement, preoperative to 1 y	16	12, 20	9	5, 13	**<.001**
IMA					
Preoperative	11	10, 14	11	8, 12	.11
6 wk	5	4, 7	6	4, 8	.23
3 mo	5	4, 8	7	5, 9	.24
1 y	6	4, 8	7	5, 9	.15
Improvement, preoperative to 6 wk	6	5, 7	4	3, 5	**<.01**
Improvement, preoperative to 1 y	5	3, 7	3	2, 4	**<.01**
DMAA					
Preoperative	16	13, 18	14	12, 16	.14
6 wk	8	6, 11	9	7, 12	.23
3 mo	7	5, 9	10	7, 15	**.04**
1 y	7	6, 10	9	8, 13	**.01**
Improvement, preoperative to 6 wk	6	5, 7	4	3, 5	**<.001**
Improvement, preoperative to 1 y	5	3, 7	3	2, 4	**<.01**

Abbreviations: DMAA, distal metatarsal articular angle; HVA, hallux valgus angle; IMA, intermetatarsal angle; IQR, interquartile range; MICA, minimally invasive chevron and Akin.
[a]Boldface indicates statistical significance ($P < .05$).

Table 3. Linear Regression Analyses.

	Improvement in HVA, IMA, and DMAA Coefficient	95% Confidence Interval	*P* Value[a]
Preoperative HVA	0.58	0.26, 0.90	**.001**
Preoperative IMA	0.42	0.20, 0.65	**<.001**
Preoperative DMAA	0.53	0.28, 0.79	**<.001**

Abbreviations: DMAA, distal metatarsal articular angle; HVA, hallux valgus angle; IMA, intermetatarsal angle; IQR, interquartile range.
[a]Boldface indicates statistical significance ($P < .05$).

material, which were both removed at a time point later than 1-year follow-up (Supplemental Table 2).

Discussion

This prospective study demonstrated that the clinical and radiologic outcomes of MICA osteotomies and open Chevron osteotomies were comparable at the 1-year follow-up. Linear regression analysis showed that the improvements in HVA, IMA, and DMAA were comparable between both groups at the 6-week and 12-month follow-up. In total, 68 patients with hallux valgus were included and surgically treated with the MICA technique (68%) or open chevron technique (32%).

Hallux valgus is a common forefoot deformity that can cause both pain and decreased mobility. Its etiology is a multifactorial process including both intrinsic and extrinsic causes. Various conservative and surgical treatment options exist depending on the stage of the deformity. Regarding surgical treatment options, more than 150 surgical techniques have been described. One could argue that this indicates that no golden standard has been determined regarding surgical treatment. Recently, the percutaneous approach to surgically correct hallux valgus has gained popularity. Percutaneous hallux valgus surgery was initially carried out using techniques including Reverding-Isham,[18] Bösch,[3] and Simple, Effective, Rapid, and Inexpensive (SERI)[12] osteotomies. To minimize soft tissue disruption while achieving stable fixation of the osteotomy, even more minimally invasive techniques were developed. This led to the development of the MICA osteotomy in 2016.[23] Minimally invasive techniques may offer advantages of quicker recovery time and less pain. However, prolonged surgical times and a steep learning curve are possible disadvantages.[11]

Table 4. Clinical Outcomes.

	MICA (n=42)		Chevron (n=26)		
Questionnaire	Median	IQR	Median	IQR	*P* Value[a]
AOFAS					
Preoperative	52	30, 44	44	30, 44	**<.01**
6 wk	84	77, 95	74	74, 74	**<.01**
3 mo	87	82, 98	80	74, 89	**.01**
1 y	100	90, 100	90	80, 97	**<.01**
Improvement, preoperative to 6 wk	35	25, 46	30	28, 44	.98
Improvement, preoperative to 1 y	48	40, 51	51	35, 59	.39
MOXFQ					
Preoperative	42	28, 53	40	34, 61	.32
6 wk	47	30, 56	48	31, 61	.82
3 mo	32	17, 55	28	6, 47	.19
1 y	8	0, 23	14	0, 31	.71
Improvement, preoperative to 6 wk	–1	–19, 16	–6	–14, 16	.77
Improvement, preoperative to 1 y	32	11, 45	31	19, 36	.98
FFI					
Preoperative	33	28, 39	38	30, 51	**.07**
6 wk	38	26, 51	38	28, 45	.78
3 mo	32	24, 39	27	21, 39	.49
1 y	23	18, 35	23	20, 35	.85
Improvement, preoperative to 6 wk	–3	–13, 5	2	–4, 9	**.07**
Improvement, preoperative to 1 y	8	–1, 12	12	9, 22	**.02**
FAOS					
Preoperative	357	296, 419	360	234, 387	.13
6 wk	310	254, 372	297	230, 357	.58
3 mo	360	281, 419	389	290, 445	.40
1 y	458	350, 482	430	343, 478	.38
Improvement, preoperative to 6 wk	–49	–110, 20	–42	–80, 5	.50
Improvement, preoperative to 1 y	42	7, 88	90	17, 110	.29

Abbreviations: AOFAS, American Orthopaedic Foot & Ankle Society; DMAA, distal metatarsal articular angle; FAOS, Foot and Ankle Outcome Score; FFI, Foot Function Index; HVA, hallux valgus angle; IMA, intermetatarsal angle; IQR, interquartile range; MICA, minimally invasive chevron and Akin; MOXFQ, Manchester-Oxford Foot Questionnaire.
[a]Boldface indicates statistical significance ($P < .05$).

It is well known that clinical scores show significant improvements after hallux valgus surgery,[14] and our results are in line with this finding. The AOFAS scale score is the most commonly used outcome measure for scoring clinical outcomes.[1] In this study, AOFAS scores improved from 52 preoperatively to 100 at the 12-month follow-up for the MICA group. In the open group, AOFAS scores improved from 44 preoperatively to 92 at the 12-month follow-up. Similar significant improvements in MOXFQ scales were found in both groups. The MOXFQ scale is a questionnaire gaining popularity within hallux valgus research, because of its recent validation[18] and reportedly better responsiveness.[10] Strikingly, the open technique group scored significantly better in FFI scores at 6 weeks. However, preoperative FFI scores were near to significantly better in this group already, therefore the scores should be considered as comparable. Even though there were more smokers in the MICA group ($P = .06$; Table 1), this did not result in higher rates of pseudoarthrosis or other postoperative complications.

Radiologic outcomes were comparable between the MICA group and open technique group in our study. This finding is in line with multiple studies that have compared the outcomes of a percutaneous technique and the open technique.[6,8,16] A randomized controlled trial performed by Kaufman et al[15] compared clinical and radiologic outcomes between minimally invasive vs open chevron osteotomies for hallux valgus surgery. They found no significant differences in any of the determined outcome measurements; however, their study size was relatively small. Furthermore, our results concerning radiologic outcomes suggest that a distinction in the extent of hallux valgus should be made. Preoperatively, patients in the MICA group had relatively comparable angle scores for HVA, IMA, and DMAA. The MICA group showed a 7-degree better correction than open chevron. This can be explained because the additional Akin in MICA accounts for a 7-degree extra correction, the Akin has not been performed in the open chevron group. A study by Biz et al[2] coheres with this, reporting that a percutaneous technique is a good option for mild hallux valgus.

Even though MICA surgery has shown to be effective and safe, the technique is not without complications[1,17] and comes with a steep learning curve. A systematic review by Bia et al[1] showed that the most common complications include stiffness of the first metatarsophalangeal joint in 9.8%; infection, ranging from 1.9% to 14.3%; and deformity recurrence in 7.8%. Complication rates did not differ between percutaneous techniques and open techniques. This is consistent with the findings of our study, where no differences in complication rates were found between the 2 groups. In the MICA group, 2 patients (5%) had a complication at the 12-month follow-up, including a nonunion and a pseudogout. In the open group, 3 patients (12%) had complications, including 1 Morton neuroma and 2 patients who experienced complaints of their osteosynthesis material that required hardware removal.

This study should be interpreted in terms of its strengths and limitations. First, this was a single-center study in which 2 orthopaedic surgeons performed all surgeries. Second, 4 patients were lost to follow-up at 12 months, resulting in missing radiologic and clinical outcomes for these patients. Third, our follow-up of 12 months is regarded as a preliminary result. Both cohorts will be continued to be followed.

To conclude, these results show that MICA may offer equivalent clinical and radiologic outcomes to the conventional open chevron osteotomy. No significant differences were found in the clinical outcomes (VAS, AOFAS, MOXFQ, FFI, and FAOS), complication rate, and operative times during our assessment period. The results of this prospective study comparing 2 of the most commonly used techniques for hallux valgus correction show that MICA and chevron osteotomy appear essentially equivalent.

Ethical Approval

Ethical approval for this study was obtained from the Medical Ethical Committee (MEC-15-113).

Declaration of Conflicting Interests

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Appendix 1. Follow-up Moments.

	Preoperation	2 wk	6 wk	3 mo	1 y
Informed consent	X				
Radiograph (AP/LAT WB)	X		X	X[a]	X[a]
Clinical evaluation (AOFAS)	X		X	X	X[a]
Questionnaires (FFI, FAOS, MOXFQ, EQ5D, VAS, PASIPD)	X[a]	X (only VAS)[a]	X[a]	X[a]	X[a]

Abbreviations: AOFAS, American Orthopaedic Foot & Ankle Society; AP, anteroposterior; EQ5D, Euro-QoL-5D; FAOS, Foot and Ankle Outcome Score; FFI, Foot Function Index; LAT, lateral; MOXFQ, Manchester-Oxford Foot Questionnaire; PASIPD, Physical Activity Scale for Individuals with Physical Disabilities; VAS, visual analog scale; WB, weightbearing.
[a]Not standard, additional for this study.

Supplemental Table 1. VAS Outcomes.

	MICA (n=42)		Chevron (n=26)		
Questionnaire	Median	IQR	Median	IQR	*P* Value[a]
VAS pain					
Preoperative	30	12, 50	45	27, 56	**.09**
2 wk	15	8, 40	30	15, 49	.22
6 wk	25	8, 41	24	10, 41	.89
3 mo	19	4, 45	15	1, 36	.50
1 y	8	0, 30	6	0, 46	.50
Improvement, preoperative to 6 wk	8	−16, 27	13	−14, 30	.19
Improvement, preoperative to 1 y	21	0, 35	21	10, 36	.51
VAS function					
Preoperative	14	6, 31	30	17, 54	**.07**
2 wk	51	40, 74	50	40, 75	.66
6 wk	33	17, 59	56	20, 66	.26
3 mo	15	2, 43	11	1, 50	.89
1 y	1	0, 10	5	0, 25	.24
Improvement, preoperative to 6 wk	−15	−41, 8	−19	−32, 10	.67
Improvement, preoperative to 1 y	7	0, 29	19	9, 26	.13

(continued)

Supplemental Table 1. (continued)

	MICA (n=42)		Chevron (n=26)		
Questionnaire	Median	IQR	Median	IQR	*P* Value[a]
VAS satisfaction					
Preoperative	53	25, 70	51	31, 73	.94
2 wk	30	10, 50	50	30, 60	**.06**
6 wk	34	10, 60	44	20, 52	.62
3 mo	20	10, 65	45	1, 60	.85
1 y	8	0, 35	10	1, 57	.49
Improvement, preoperative to 6 wk	21	−17, 50	17	−15, 35	.63
Improvement, preoperative to 1 y	33	5, 60	25	0, 40	.38

Abbreviations: IQR, interquartile range; MICA, minimally invasive chevron and Akin; VAS, visual analog scale.
[a]Boldface indicates statistical significance ($P < .1$).

Supplemental Table 2. Peri- and Postoperative Outcomes.

	MICA (n=42)	Chevron (n=26)	*P* Value
Surgery time, min, median (IQR)	40 (34-42)	34 (30-39)	.07
Complication, n (%)			
2 wk	2 (5)	1 (4)	>.99
Wound infection	2	0	
Venous thrombosis	0	1	
6 wk	2 (5)	0 (0)	.52
Wound infection	1	0	
Screw break	1	0	
3 mo	5 (12)	0 (0)	.15
Delayed union	5	0	
Nonunion	0	0	
1 y	2 (5)	3 (12)	.36
Nonunion	1	0	
Morton neuroma	0	1	
Pseudogout	1	0	
Complaints related to osteosynthesis material	0	2	

Abbreviations: IQR, interquartile range; MICA, minimally invasive chevron and Akin.