RESEARCH ARTICLE

Minimally Invasive vs Open First Metatarsophalangeal Joint Cheilectomy: Radiographic Outcomes and Early Complications

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Abstract

Objectives: Current literature on surgical techniques has evaluated minimally invasive surgery (MIS) cheilectomy and its efficacy in comparison to the open technique. However, no study to date has evaluated MIS-Moberg in relation to open and MIS cheilectomy. This study assessed radiological outcomes and early healing and complications of patients who underwent open, MIS, and MIS-Moberg cheilectomies.

Methods: We conducted a retrospective cohort review of 134 patients who underwent first metatarsophalangeal (MTP) cheilectomy at an academic medical center between 2015 and 2024. Success of cheilectomy was determined radiographically. Postoperative complications were identified through medical record review.

Results: 73 open and 61 MIS cheilectomies were performed on 134 patients with a primary diagnosis of hallux rigidus. The pre-operative versus post-operative differences in dorsal cortical length (3.7±1.4) and sagittal articular P1 angle (7.3±4.8) were found to be statistically significant ($P<0.05$) for the MIS-Moberg group. Ten patients in the open cheilectomy were found to have dorsiflexion and plantarflexion stiffness compared to zero patients in the MIS and MIS-Moberg groups ($P<0.01$).

Conclusion: We showed a significantly greater rate of plantar- and dorsiflexion stiffness in open surgeries compared to MIS and MIS-Moberg. No other differences in healing rates or radiologic outcomes were observed. Based on preliminary results, the MIS-Moberg can successfully alter the radiographic alignment of the great toe and does not increase complications as compared to open or MIS cheilectomy alone.

Level of evidence: III

Keywords: Foot and ankle, Hallux rigidus, MIS, Moberg

Introduction

Hallux rigidus is a common orthopaedic condition that causes pain and stiffness at the first metatarsophalangeal (MTP) joint due to degenerative arthritis.[1] It is typically classified based on physical exam findings, including pain and range of dorsiflexion, as well as radiographic findings, such as presence of a dorsal osteophyte and loss of joint space, both of which comprise the Coughlin and Shurnas Classification system.[2] While conservative management of this condition involves physical therapy, corticosteroid injections to the joint, and orthotics, these interventions are successful in only 55% of cases.[3,4]

Surgery is often indicated for those who do not respond effectively to non-operative management. There are a variety of surgical techniques, ranging from cheilectomy and osteotomy to arthrodesis, depending on the severity of hallux rigidus, with varying success and complication rates.[2,5-7] Recently, there has been a surge of interest in minimally invasive surgical (MIS) cheilectomy for the management of early to moderate Hallux Rigidus, especially

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after the recent development of a specialized low-speed, high-torque burr.[8] MIS has several potential advantages including smaller incision size, reduced surgical time, decreased tissue damage, and potential faster recovery times compared to open cheilectomy.[9,10] Disadvantages include the need for specialized equipment, a learning curve for surgeons, and potentially inadequate bone removal.

While previous studies on MIS cheilectomy have reported improved patient outcomes and equivalent postoperative complication rates than open cheilectomy, these studies have small sample sizes and do not include the Moberg procedure.[11,12] Therefore, this study aims to compare early radiographical outcomes and complications between patients who underwent open and MIS first MTP cheilectomy, with or without Moberg osteotomy.

Materials and Methods

Study Design

This study conducted a retrospective cohort analysis of 134 patients who underwent first MTP cheilectomy at a single academic teaching hospital between July 2015 and January 2024, under institutional review board approval (IRB 2022P000829). Patients greater than 18 years of age who were skeletally mature and with a diagnosis of primary first MTP hallux rigidus were included in this study (n=159). Patients who had inadequate pre-operative imaging (n=18) and who did not undergo the first MTP cheilectomy (n=7) were excluded from this study. Procedures were performed by two foot and ankle fellowship-trained surgeons. Patients were assigned to open versus MIS or MIS-Moberg groups based on surgeon preference and experience with the technique.

Data Collection

Demographic information, medical and surgical history were obtained through online medical records. For each first MTP cheilectomy, patient's pre-operative measurements, type of surgery (open or MIS), laterality (left, right, or bilateral), fusion constructs used (screws, plate, staples, or hybrid), range of motion, grind test, hindfoot alignment, Coughlin classification, and concurrent procedures were recorded. Post-operative first MTP correction was assessed radiographically, and subsequent clinic visit notes were reviewed to assess for surgical complications and hardware-related issues. Radiological parameters that were assessed include differences between pre- and post-operative dorsal cortical length, hallux valgus interphalangeal angle (HVI), and sagittal articular P1 angle and screw trajectory for the Moberg osteotomy and screw fixation [Figure 1].

Visual analog scale (VAS) pain ratings and Patient-Reported Outcomes Measurement Information System (PROMIS) scores were not reported in this study, due to lack of patient data in the medical record.

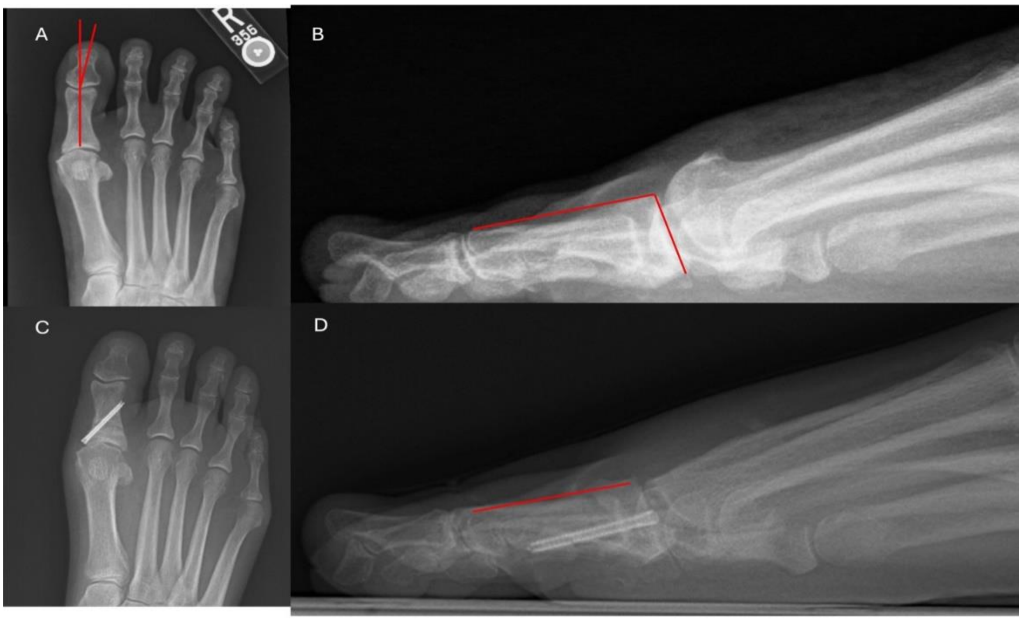

Figure 1. Pre- and post-operative radiographs following MIS cheilectomy/Moberg osteotomy showing the arthritic change on the AP view (A) and dorsal spurring (B). Image (A) also demonstrating the measurement for HVI. (B) Demonstrates sagittal articular P1 angle measurement. (D) Shows the post-op dorsal cortical length measurements. Images C and D also show the alignment of the screw fixation

Statistical Analysis

Descriptive statistics were calculated using Microsoft Excel (Microsoft, Redmond, WA). Statistical analyses were performed using IBM SPSS 2021 software (IBM, Armonk, NY). Shapiro tests were used to assess normality. Fisher's exact tests and Mann-Whitney U-tests were used based on the non-normal data distribution. Statistical significance was defined as $P<0.05$.

Results

Patient Demographics

First MTP cheilectomies were performed in 134 patients (37% male, 63% female), 13 of whom had bilateral procedures. The average patient age was 52.73 ± 10.14 years old. Of the 134 procedures, 73 were open (54%), 49 were MIS (37%), and 12 were MIS with Moberg (9%). 13 patients in the cohort (10%) had a history of smoking but reported no smoking at the time of surgery and during post-operative recovery. 79 procedures were right sided (59%) and 55 procedures were left sided (41%, P=0.04). There were no other significant group differences in demographic factors or medical comorbidities [Table 1].

Early Healing and Follow-up

All cheilectomies demonstrated successful debridement of the dorsal spur in both open and MIS groups. All Moberg osteotomies healed radiographically. There were no reported delayed unions or non-unions in any patient. The median length of follow-up was 3 months (range 0 – 65 months).

Table 1. Patient Demographics and Medical Comorbidities

	Total (n=134)	Open (n=73)	MIS (n=49)	MIS-Moberg (n=12)	Significance (α = 0.05)
Age	53.71 ± 15.52	52.4 ± 9.3	53.4 ± 11.2	52 ± 11.3	0.85
Gender					
Male	50 (37%)	25 (34%)	22 (45%)	3 (25%)	0.32
Female	84 (63%)	48 (66%)	27 (55%)	9 (75%)	
Laterality					
Left	55 (41%)	27 (37%)	26 (53%)	2 (17%)	0.04*
Right	79 (59%)	46 (63%)	23 (47%)	10 (83%)	
Smoking Status					
Never	112	60	42	10	
Current	1	1	0	0	0.88
Former	21	12	7	2	
Alcohol Use	70	41	21	8	0.29
Diabetes	3	3	0	0	0.28
Vascular Disease	0	0	0	0	-
Hypertension	21	11	8	2	0.98
Cardiac Disease	11	10	1	0	0.39
Pulmonary History	0	0	0	0	-
Other Comorbidities	56	50	5	1	0.63

Radiological parameters

Comparison of radiographic outcomes between pre-operative and post-operative films in the MIS Moberg group are shown in [Table 2]. All radiographical variables were found to be statistically significant from preoperative measures, indicating a technically successful Moberg osteotomy across all patients in the MIS-Moberg group (n=12).

Table 2. Comparison of Radiographic Parameters for MIS-Moberg, Preoperatively versus Postoperatively

Radiographic Parameter	MIS-Moberg (n=12)			
	Preoperative	*Postoperative*	*Difference*	*P*
Dorsal Cortical Length (mm)	32.3 ± 4.1	28.7 ± 4.0	3.7 ± 1.4	<0.05*
Sagittal Articular P1 Angle	84 ± 7.2	76.9 ± 8.2	7.3 ± 4.8	<0.05*

*Statistical significance of $P < 0.05$ ($\alpha = 0.05$)

Complication Rates

Complication rates are reported in [Table 3]. Ten patients (13.6%) in the open cheilectomy were found to have dorsiflexion and plantarflexion stiffness compared to zero patients in the MIS and MIS-Moberg groups (p<0.01). There were no other significant differences in complications between open, MIS, and MIS-Moberg groups.

Discussion

In this study, we report radiographic findings and early complication rates comparing open versus MIS versus MIS-Moberg techniques for cheilectomies. Our results demonstrate that all cheilectomies and Moberg osteotomies healed successfully with no significant difference in wound healing rates. Additionally, this study found comparable efficacies of open versus MIS versus MIS-Moberg in terms of complication rate, apart from MIS and MIS-Moberg patients reporting a decreased rate of dorsiflexion and plantarflexion stiffness, compared to those in the open group. Thus, based on preliminary results, the MIS-Moberg can successfully alter the radiographic alignment of the great toe and does not increase complications as compared to open or MIS cheilectomy alone. None of the patients in this study required additional surgery for dorsal impingement pain.

Our findings support the limited literature on this topic, due to the novel MIS nature of this procedure in addressing hallux rigidus. Teoh et al. described a similar complication rate between open and MIS cheilectomy in their retrospective cohort analysis, with two patients experiencing post-operative wound infections and another two patients encountering delayed wound healing after a mean follow-up of 50 months.[13] While our study did not record VAS and PROMIS scores due to insufficient data, Teoh et al.'s study reported improved PROMIS scores with the MIS group, further supporting the MIS technique for dorsal cheilectomies. Furthermore, 30% of the open patient cohort and 13% of MIS or MIS-Moberg cohort reported post-operative stiffness with either dorsiflexion, plantarflexion, or both. This could stem from bone debris irritating the joint due to insufficient irrigation.[14]

Table 3. Complication rates of Open vs MIS vs MIS-Moberg groups

Complication	Open	MIS	MIS-Moberg	P
DF and PF stiffness	10	0	0	0.01*
DF stiffness	8	7	1	0.79
PF stiffness	4	0	0	0.18
Sesamoid pain	1	4	1	0.16
Total	23	11	2	0.41

*DF = dorsiflexion; PF = plantarflexion

However, other studies have highlighted the increased risk of re-operation after MIS cheilectomies. Stevens *et al.* reported 12.8% of their MIS cohort required further surgery compared to the 2.6% of the open group at 3-years of follow up after 1st metatarsophalangeal joint (MTPJ) arthrodesis.[15] Their MIS cohort required arthrodesis due to 1st MTPJ pain and stiffness. This was also found in our study across all groups, with our open cohort having the most cases of stiffness.

One drawback of this study is the absence of either pre- or post-operative patient-reported outcomes measures, which would have provided useful insight into a symptomatic comparison between open, MIS, and MIS-Moberg cheilectomies. Additional limitations pertain to the retrospective approach of the data collection, which did not elucidate how each surgeon selected one operative technique over the other, and whether any bias was introduced. This could also shed light on the differences in the group sizes of the three operative techniques. Additionally, a greater follow-up period is warranted to assess long-term outcomes of the MIS-Moberg procedure.

Conclusion

Our study suggests MIS-Moberg is a viable addition to MIS cheilectomy, and potential alternative to open cheilectomy, given its comparable results in terms of radiographical outcomes, early healing and no greater complication rate. Open cheilectomy was also found to have a significantly higher rate of dorsiflexion and plantarflexion stiffness compared to MIS procedures.

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