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Minimally invasive Dorsal cheilectomy and Hallux metatarsophalangeal joint arthroscopy for the treatment of Hallux Rigidus

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ABSTRACT

Background: Minimally invasive dorsal cheilectomy (MIDC) has become a popular alternative to an open approach for treating Hallux Rigidus (HR). To reduce some of the complications related to the MIDC approach, a first metatarsophalangeal (MTP) joint arthroscopy can be performed in addition to address the intra-articular pathology associated with Hallux Rigidus. This study aims to examine the effectiveness of MIDC with first MTP arthroscopy in patients with HR with a minimum 1-year follow-up.
Methods: This was a multicenter retrospective review for adult patients with Coughlin and Shurnass Grade 0–3 who were treated with MIDC and first MTP arthroscopy between 3/1/2020 and 8/1/2022, with at least one year of follow-up data. Demographic information, first MTP range of motion (ROM), visual analog scale (VAS), Manchester-Oxford Foot Questionnaire (MOXFQ), and EQ-5D-5 L scores were collected. Continuous data was expressed as a mean and standard deviation, categorical data was expressed as a percentage. Wilcoxon Rank Sum test was used to compare continuous variables. All $P < 0.05$ was considered significant.
Results: A total of 31 patients were included in the study. Average follow-up time was 16.5 months (range: 12 to 26.2). There was 1 (3.2%) undersurface EHL tendon tear, 2 (6.5%) conversions to an MTP fusion, and 1 (3.2%) revision cheilectomy and capsular release for MTP joint contracture. There was a significant improvement in patient's ROM in dorsiflexion (50 vs 89.6 degrees, $P = 0.002$), postoperative VAS pain scores (6.4 vs 2.1, $P < 0.001$), MOXFQ pain scores (58.1 vs 30.7, $P = 0.001$), MOXFQ Walking/Standing scores (56.6 vs 20.6, $P = 0.001$), MOXFQ Social Interaction scores (47.3 vs 19.36, $P = 0.002$), and MOXFQ Index scores (54.7 vs 22.4, $P < 0.001$).
Conclusion: We found that MIDC with first MTP arthroscopy was effective at improving patient-reported outcomes at one year with low complication and revision rates. These results suggest that MIDC with first MTP arthroscopy is an effective treatment for early-stage HR.
Level of Evidence: IV.

1. Introduction

Hallux Rigidus is a relatively common orthopedic pathology [2]. Conservative management of this condition consists of orthotics, anti-inflammatories, physical therapy, and first metatarsophalangeal joint (MTP) corticosteroid injections. These non-operative interventions are successful in alleviating patient's symptoms in 55% of cases. [9,17,21].

For patients who do not respond effectively to conservative management, surgery is often indicated. There have been multiple described surgical techniques for the treatment of Hallux Rigidus, with varying rates of success and complications [3–7,13–15,19]. Recently, there has been an increase in the use of minimally invasive dorsal cheilectomy (MIDC) for the treatment of early to moderate-stage Hallux Rigidus, with the potential for a faster rehabilitation time, lower overall morbidity, and clinical improvement for pain and MTP range of motion (ROM) with this technique compared to open dorsal cheilectomy [18,20,30]. However, several studies have found an

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increased rate of incomplete resections and retained bone fragments within the MTP joint in those undergoing MIDC compared to the open approach. [18,29] To counter these complications, a recent study by Glenn et al. combined the MIDC with a first MTP arthroscopy, allowing for direct MTP joint visualization and aiding in the removal of retained bone fragments, ensuring a complete resection, and identifying other intra-articular pathology [16]. This study of 20 patients demonstrated improvement in patient's pain and MTP range of motion with a low rate of complications and revision surgeries [16].

The recent study by Glenn et al. demonstrated the effectiveness of MIDC with first MTP arthroscopy in the treatment of Hallux Rigidus [16]. However, their study consisted of a small sample size with a limited minimum follow-up time of 3 months and limited outcome variables. The purpose of this study was to expand upon this previous work by investigating postoperative functional outcome measures and complication rates following MIDC with first MTP arthroscopy in the treatment of Hallux Rigidus in a larger cohort of patients with a minimum 1-year follow-up.

2. Methods

2.1. Study design

A multicenter retrospective review was conducted for patients who had undergone MIDC with first MTP arthroscopy for the treatment of Hallux Rigidus between September 1st, 2020, and August 1st, 2022. This study was conducted in line with the STROBE guidelines for observational studies. [31].

2.2. Setting

This was a multi-center study and all operations were performed by 2 fellowship-trained foot and ankle surgeons.

2.3. Participants

Patients were included in the study population if they were at least 18 years old, and were treated with MIDC with first MTP arthroscopy (CPT: 28289) for the treatment of Hallux Rigidus (ICD-10: M20.20, M20.21, M20.22), and had at least one year of postoperative follow-up data. Only patients with Coughlin and Shurnass Classification Grade 0–3 were included in the study. Patients were excluded if they did not have at least one year of postoperative follow-up data or if the patient had a Coughlin and Shurnass Classification Grade 4. We excluded patients with revision surgery and additional procedures such as Moberg and akin osteotomies or lesser toe procedures. 8 patients were excluded over the study procedure as they had a biplanar Moberg/Akin varizing extension osteotomy generally for a degree of Hallux interphalangeus impinging on the second toe.

2.4. Outcomes

The primary outcome of this study was to determine if patients demonstrated a significant clinical improvement from their procedure on the Visual Analog scale for pain. Validated patient-reported outcome measures were used including the Visual Analog Scale for Pain (VAS) scores, Manchester-Oxford Foot Questionnaire (MOXFQ) scores, and EQ-5D-5 L scores. Secondary outcomes included the first MTP range of motion values, which were collected both preoperatively and at the most recent postoperative follow-up. Additional data collected included demographic information, procedure duration, time to most recent follow-up, complications, revision surgeries, and conversion to fusion surgeries.

Fig. 1. A) Pre-Operative and B) Post-Operative Radiographs Demonstrating the Minimally Invasive Dorsal Cheilectomy.

2.5. Bias

We attempted to remove bias by blinding the operating surgeons from the clinical outcome analysis, however, operating surgeons were not blinded from surgery type or during postoperative follow-up visits.

2.6. Statistical analysis and study size

There was no predetermined study size for this study and all patients who met the inclusion criteria were included. Continuous data was expressed as a mean and standard deviation, while categorical data was expressed as a percentage. Continuous data was compared using the Student's T-test or Wilcoxon Rank Sum test depending on the normality of the data, which was assessed using the Shapiro-Wilk test. Categorical data was compared using the Chi-Squared test. Post-hoc power analysis demonstrated a minimum of 24 patients in the study group were necessary to achieve a power of 80% to detect a 0.6-point difference in VAS scores. All $P < 0.05$ were considered significant..

2.7. Operative technique

Each patient underwent a percutaneous cheilectomy of the first MTP followed by first MTP arthroscopy. The technique is described in detail elsewhere [16,20,22]. First, the capsule is elevated off the dorsal aspect of the first MTP using a blunt periosteal elevator. A low-speed, high torque 3.0 wedge burr is introduced and a plane through the dorsal osteophyte is made (Fig. 3). This 'inside-out' technique protects the EHL tendon from iatrogenic injury (Fig. 3). The dorsal osteophyte is then removed, and the range of motion is checked (Fig. 3). A first MTP arthroscopy is performed through the dorsomedial and dorsolateral portals to identify any residual osteophytes and cartilage damage, remove loose bodies, debride synovitis, and reduce the risk of intra-articular irritation by washing

Fig. 2. A) Preoperative and B) Postoperative AP Radiographs Demonstrating the Minimally Invasive Dorsal Cheilectomy.

out any residual bone paste (Fig. 4). Post-operatively patients are allowed to mobilize fully weight-bearing in a surgical sandal for 1–2 weeks with the aim to return to normal footwear by 2 weeks and activities by week 4.

Of note, this procedure differs from the one described by Alvarez et al., which utilized a first MTP arthroscopy before the percutaneous cheilectomy. [1] The senior authors of this study felt performing the first MTP arthroscopy procedure before the MIDC posed an unnecessary challenge and did not allow for adequate clearing of debris from the first MTP joint following the cheilectomy procedure, which in turn may result in worse overall outcomes. Additionally, the procedure utilized in this study does not require the use of traction, in contrast to the procedure described by Alvarez et al., which may further reduce the risk of damage to the soft tissue surrounding the first MTP joint and may limit complications. [1] Overall, despite no comparative studies between the two techniques, the senior authors of this manuscript felt percutaneous cheilectomy followed by first MTP arthroscopy provided less risk and potentially greater benefits for patients compared to the technique described by Alvarez et al. [1].

3. Results

3.1. Participants

A total of 31 patients were included in the study, with an average follow-up time of 16.5 months (range: 12 to 26.2 months). Demographic information for the patients is displayed in Table 1. The average procedure duration was 37.1 min (range: 27 to 52 min).

3.2. Outcomes

There was a significant improvement in patient's VAS pain scores (6.4 vs 2.1), P < 0.001), MOXFQ pain scores (58.1 vs 30.7, P = 0.001), MOXFQ Walking/Standing scores (56.6 vs 20.6, P = 0.001), MOXFQ Social Interaction scores (47.3 vs 19.36, P = 0.002), and MOXFQ Index scores (54.7 vs 22.4, P < 0.001) compared to their preoperative scores. Additionally, there was a significant improvement in patient's ROM in dorsiflexion (50 vs 89.6 degrees, P = 0.002), but not in plantarflexion (11.3 vs 18.6 degrees, P = 0.07). There was an improvement in general health-related quality of life in both the EQ-5D Index and EQ-VAS scores (Table 2) however this improvement was not statistically significant (p = 0.07, 0.33).

3.3. Complications

Overall complication rate was of 6.25% (2/31). There was one (3.2%) complication of a symptomatic undersurface EHL tendon tear that had to be repaired using 2–0 Fiber Wire 18 months after the index procedure and one (3.2%) patient underwent revision open cheilectomy and capsular release for MTP joint contracture. 2 (6.25%) patients were converted to an MTP fusion after 1 year from the index procedure for progressive arthritis. There were no nerve injuries or wound infections.

3.4. Discussion

MIDC for the treatment of Hallux Rigidus has been demonstrated to be effective in treating patients' pain and improving functional outcomes [18,20,30]. However, the procedure has been cited to carry a risk of complications such as incomplete resection, EHL tendon injury, and retained bone fragments in the first MTP when compared to the traditional open approach [20,21,25,29,30]. The combination of the MIDC procedure with a first MTP arthroscopy, has demonstrated significant improvements in postoperative outcomes with a small complication rate, although the minimum follow-up time was relatively short at only 3 months postoperatively. [16] The current study looked to expand upon these results by examining patient-reported outcomes such as VAS, MOXFQ, and EQ-5D-5 L scores, complications, and revision surgeries following MIDC with first MTP arthroscopy with a minimum of 1-year follow-up data using validated outcome measures. The results of this study have

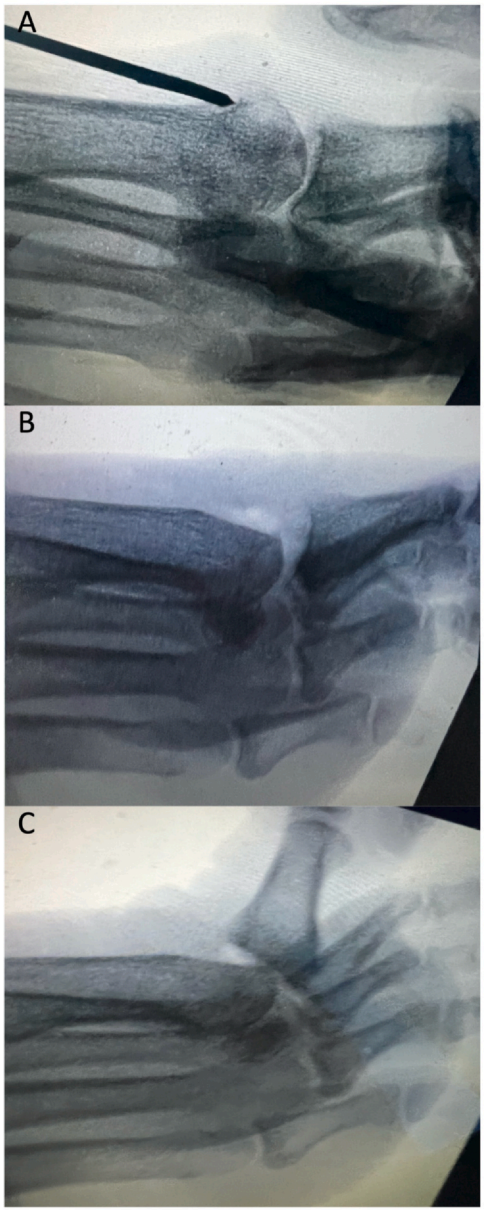

Fig. 3. Intraoperative Fluoroscopy Demonstrating A) Burr Placement for Minimally Invasive Dorsal Cheilectomy with B) Subsequent Resection and C) Range of Motion Analysis.

Table 1
Categorical and Continuous Demographic Information of MIDC with First MTP Arthroscopy Patients.

	Mean ± SD	Minimum	Maximum
Age (years)	54.2 ± 11.6	26.2	80.8
Procedure Duration (minutes)	37 ± 7.6	27	52
Postoperative Follow-Up (months)	16.5 ± 4.5	12.0	26.2
	Count	Percentage	
Gender			
Male	10	32.3%	
Female	21	67.7%	
Laterality			
Right	17	54.8%	
Left	14	45.2%	
Complication	1	3.2%	
Revision Cheilectomy	1	3.2%	
Fusion Conversion	2	6.5%	

demonstrated significant improvement in clinical foot function using a validated foot-specific outcome measure and also found non-significant improvement in general health-related quality of life.

The increased utilization of MIDC in foot and ankle surgery has led to increased literature regarding patient-reported outcomes associated with this procedure. Teoh et al. found that MIDC was successful in improving both patient's VAS scores and MOXFQ scores in all domains and Razik et al. reported open cheilectomy was also demonstrated to improve patient's MOXFQ scores in all domains, with both studies citing a similar rate of improvement in patient's MOXFQ scores [25,30]. In contrast, Morgan et al. found that patients who underwent MIDC had more improvement in their foot pain and functional status compared to those who underwent open cheilectomy, although this result was not significant [24]. Additionally, Glenn et al. and Hickey et al. found significant improvement in patients' pain scores and first MTP ROM following MIDC with first MTP arthroscopy [16,20]. The results of this current study support the findings of Glenn et al. and Hickey et al., demonstrating that patients who underwent MIDC with first MTP arthroscopy had a significant improvement in their VAS pain scores, in multiple MOXFQ domains, and first MTP dorsiflexion.

The potential for complications and revisions are important considerations when evaluating the effectiveness of MIDC with MTP arthroscopy in the treatment of Hallux Rigidus compared to the traditional open approach. For open cheilectomy, previous systematic reviews and retrospective studies have demonstrated a complication rate ranging from 3% to 6%, with a revision surgery rate ranging from 2% to 8.8% [18,23,26,28]. These numbers are similar to our results in this study.

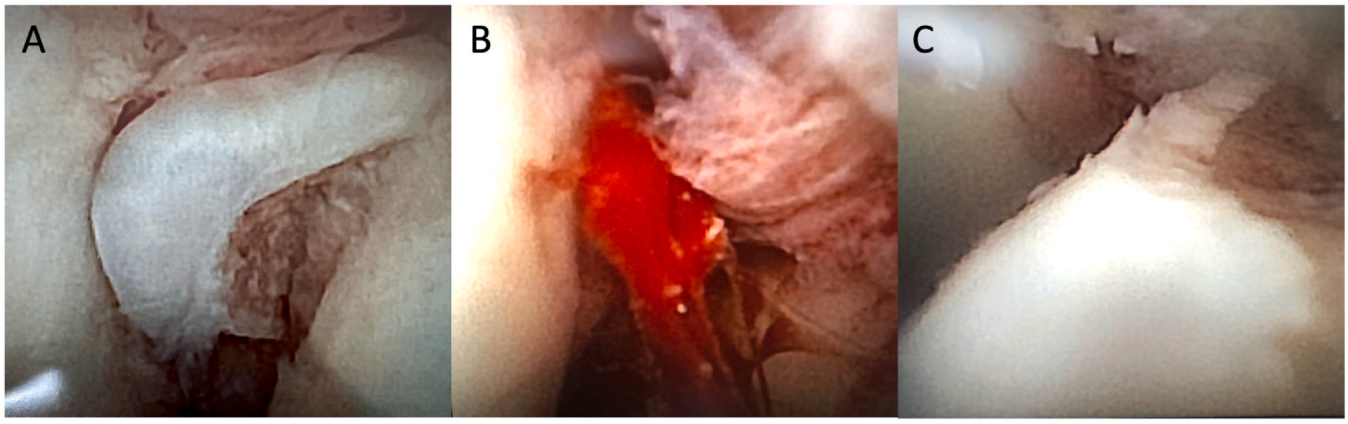

Fig. 4. First Metatarsophalangeal (MTP) Arthroscopy following Minimally Invasive Dorsal Cheilectomy Demonstrating A) Loose Body within the MTP Joint, B) First MTP Synovitis, and C) Resection of Head of the First Metatarsal Status Post Minimally Invasive Dorsal Cheilectomy.

Table 2
Pre- and Postoperative Patient Reported Outcomes and First MTP Range of Motion.

	Preoperative Mean ± SD	Postoperative Mean ± SD	P-Value
ED5D Index	0.64 ± 0.2	0.76 ± 0.21	0.069
EQ-VAS	70 ± 19	76 ± 17	0.334
VAS Pain	6.5 ± 2.7	2.1 ± 1.9	< 0.001
MOXFQ Pain	58.1 ± 17.9	30.7 ± 26.2	0.001
MOXFQ Walking/Standing	56.6 ± 21.9	20.6 ± 26.1	0.001
MOXFQ Social Interaction	47.3 ± 22.5	19.4 ± 22.9	0.002
MOXFQ Index	54.7 ± 18.9	22.4 ± 23.5	< 0.001
First MTP Dorsiflexion (Degrees)	50 ± 20.8	89.6 ± 1.3	0.002
First MTP Plantarflexion (Degrees)	11.3 ± 9.6	18.6 ± 7.8	0.07

The most common complications seen in those undergoing open cheilectomy were superficial skin infections and transient paresthesia due to injury to the dorsomedial cutaneous branch of the superficial peroneal nerve. [18] For MIDC, previous studies have demonstrated a complication rate ranging from 0% to 11.3% and a revision surgery rate ranging from 0% to 12.8% [16,29,30,32]. The most common complications in those undergoing MIDC were residual pain, residual stiffness, superficial skin infection, and dorsal medial cutaneous nerve injury [27,29].

In directly comparing MIDC to open cheilectomy, Stevens et al. found those who underwent MIDC had a higher rate of complications and revision surgeries compared to those who underwent open cheilectomy, while Teoh et al. and Dawe et al. found MIDC had a similar complication and revision surgery rate when compared to open cheilectomy. [10,27,29,30].

Glenn et al. demonstrated no nerve injuries, wound healing issues, infections, or revision surgeries for incomplete resection in 20 patients undergoing MIDC with first MTP arthroscopy, whereas Hickey et al. demonstrated one delayed EHL rupture, three instances of postoperative stiffness requiring manipulation, one revision arthroscopic cheilectomy, and no conversions to first MTP fusion in 36 patients undergoing MIDC with first MTP arthroscopy [16,20]. It is worth noting, however, that neither of these studies directly compared the results of MIDC with first MTP arthroscopy to the traditional open approach. The authors of these studies attribute the low complication rate to the addition of the first MTP arthroscopy. The MTP arthroscopy not only allows surgeons to adjust the cheilectomy to minimize the risk of incomplete resection but also to clean out the joint and associated intraarticular pathology.

In our study, we had an overall complication rate of 6.25% which is similar to open procedures reported in the literature but a very low revision rate [10,27,29,30]. We had 1 (3.2%) undersurface EHL tendon tear that had to be repaired 1.5 years after the index procedure, and 1 (3.2%) patient who underwent revision cheilectomy and capsular release for MTP joint contracture. Like open procedures, some patients progress to worse arthritis and in our series, we did have 2 (6.5%) cases of progressive arthritis that required an MTP fusion 1 year from the index procedure.

An interesting finding of our study concerns the lack of statistical significance regarding EQ-5D-5 L scores. Given the fact there was a significant difference in the postoperative values of other patient-reported outcomes such as MOXFQ and VAS Pain compared to their preoperative state, it may be presumed that EQ-5D-5 L would follow a similar trend, although this proved not to be the case. A potential explanation for our findings is that EQ-5D-5 L has been cited to have low test-retest relatability in patients with orthopedic concerns, particularly for pain and mobility domains [8]. On the contrary, MOXFQ has previously been validated in assessing patient-reported outcomes and complaints in orthopedic patients [11,12]. Based upon these findings, it may be reasonable to assume that MOXFQ demonstrated significant findings while EQ-5D-5 L did not because MOXFQ has more reliability within the orthopedic population and therefore is more likely to accurately convey a patient's orthopedic condition compared to EQ-5D-5 L. Further study may be necessary to directly compare EQ-5D-5 L to MOXFQ in orthopedic populations, particularly in Hallux Rigidus patients.

3.5. Strengths

Strengths of this study include the multicenter, international setting using validated patient-reported outcome measures. This study is one of two studies to investigate patient-reported outcomes and postoperative outcomes following MIDC with first MTP arthroscopy and the first study to do so with at least 12 months of postoperative data and with both EQ-5D-5 L and validated MOXFQ scores, as the previous study by Glenn et al. contained patients with a minimum follow-up time of 3 months.

3.6. Limitations

There are several limitations to this study. First, our study was comprised of a small cohort of 31 patients and a short minimum follow-up time of 12 months, which limits our ability to generalize our results. However, this sample size is larger with a longer minimum follow-up time than the previous study evaluating MIDC with MTP arthroscopy, comprising a larger power. Additionally, there was no control group in our current study, so we were unable to determine whether the improvements in patient-reported outcomes or the low rate of complications and revision surgeries are superior to either MIDC alone or open cheilectomy.

3.7. Conclusion

Our study found that MIDC with first MTP arthroscopy was effective at significantly improving patient-reported outcomes, specifically patient's pain scores, at one year with low complication and revision rates. MIDC and first MTP arthroscopy is an effective and safe treatment for hallux rigidus and may be considered as an alternative to an open approach.

Ethical approval

Ethical approval for this study was obtained from the Prisma Health Institutional Review Board [2069376–1].

Funding

No funding was obtained for the current study.

Conflict of Interest

The following authors declare the following conflicts:

- Dr. J. Benjamin Jackson III
  - Leadership Role in South Carolina Orthopedic Association
- Dr. Jonathan Kaplan

  - IP Royalties from Enovis / Novastep, Surgical Fusion Inc, and Treace
  - Paid Consultant for Artelon, Edge Surgical, Enovis / Novastep, Exactech, Surgical Fusion Inc, and Treace
  - Board or Committee Member for American Orthopaedic Foot and Ankle Society
  - Editorial or Governing Board Member for Foot and Ankle International
  - Stock Options in GLW Medical Innovation
- Dr. Robbie Ray
  - Teacher at Marquardt UK MIS
  - Research and Development Consultant for Medartis
- Dr. Tyler Gonzalez
  - Stryker- consultant
  - Treace Medical Concepts Inc- consultant , royalties, stock or stock options
  - Exactech- consultant
  - Enovis- consultant, royalties
  - SFI- consultant, royalties
  - Vilex- consultant, royalties
  - Surgebright- consultant
  - REVIEWER-Foot and Ankle International ,Foot and Ankle Orthopedics, Foot and Ankle Specialist, JAAOS
  - SOCIETY MEMBER-AOFAS Post Graduate Education Committee, AOFAS on Demand Committee

No other authors have any conflicts of interest to declare.

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