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Comparing the Clinical Outcomes of Percutaneous Cheilectomy to Open Cheilectomy With Moberg Osteotomy for the Treatment of Hallux Rigidus

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Abstract

Background: Both an open cheilectomy with a Moberg osteotomy and percutaneous cheilectomy have been successfully used to treat hallux rigidus and preserve motion.
However, there have been no studies that have compared these 2 procedures using validated patient-reported outcomes such as the Patient Reported Outcome Measurement Information System.
Methods: A retrospective review of hallux rigidus patients between January 2016 and July 2021 collected 48 percutaneous cheilectomy (PC) patients and 71 open cheilectomy with Moberg (OCM) patients. Preoperative and minimum 1-year postoperative PROMIS scores were collected.
Results: The OCM and PC cohorts did not have significant differences in their postoperative PROMIS scores. Both cohorts had modest but significant improvements postoperatively in the physical function, pain interference, and pain intensity domains. The OCM group had a larger degree of improvement in physical function, pain interference, and pain intensity (P = .015, .011, .001, respectively). No significant difference was identified in the reoperation rate.
Conclusion: Patients undergoing an OCM had worse preoperative PROMIS scores and a modestly greater change in patient-reported outcomes than patients undergoing a PC.

Level of Evidence: Level III, retrospective review.

Keywords: hallux rigidus, MTP arthritis, cheilectomy, Moberg osteotomy, percutaneous

Introduction

Cheilectomy is a commonly employed surgical method for milder amounts of first metatarsophalangeal joint (MTP) arthritis to alleviate pain and maintain motion in the great toe.[11,26,35] Two of the most common variations to the traditional cheilectomy include adding a proximal phalangeal dorsiflexion osteotomy (Moberg) (OCM) or performing the cheilectomy percutaneously (PC).[11,17] Each of these procedures, which represent the most common approaches at the authors' institution, carry their own inherent benefits.

Because of the benefits of minimally invasive surgery, such as faster recovery and less pain and swelling, the PC has gained popularity, while also proving to have similar improvements to an open cheilectomy in patient-reported outcome measures and general satisfaction.[5,17,20,27,31,33] However, open cheilectomies are now commonly employed with Moberg osteotomies, which theoretically increase the

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functional range of motion at the MTP joint, shifting pressure away from the damaged cartilage.[14] The addition of a Moberg has shown to significantly improve patient's 1-year Patient Reported Outcome Measurement Information System (PROMIS) pain intensity scores and dorsiflexion.[13,24,32-34] Although the Moberg is a common addition, it is unknown whether the OCM becomes more effective at addressing HR pathology than a PC, as the PC may leave the joint susceptible to future arthritis.[3,4] To add, no studies have assessed the differences through validated patient-reported outcomes, such as PROMIS.[11,31] It is important to compare these procedures to allow for patients and surgeons to collectively make informed decisions when electing operative management.

The primary purpose of this study was to compare patient-reported outcomes of PC to OCM using PROMIS domains. A secondary purpose was to compare complications and reoperations between the PC and OCM cohorts. We hypothesized that the PC would deliver comparable improvement in PROMIS scores to the OCM. Additionally, we hypothesized that the PC would result in lower complication rates owing to its minimally invasive nature.

Methods

Patient Selection

Following institutional review board (IRB) approval, a retrospective review of prospectively collected data was performed. This single-center study investigated patients who underwent PC or underwent OCM by one of 7 fellowship-trained foot and ankle orthopaedic surgeons between January 1, 2016, and July 1, 2021. Patients were included if (1) they had a HR diagnosis, (2) underwent a PC or OCM, (3) had preoperative radiographs and preoperative and a minimum 1-year PROMIS follow-up, and (4) were ≥18 years old at the time of surgery. Patients were excluded if (1) they lacked preoperative or minimum 1-year PROMIS scores; (2) had concomitant midfoot/hindfoot/ankle procedures; (3) carried a diagnosis of rheumatoid arthritis or gout; or (4) had prior first ray procedures. The exclusion criteria were developed to standardize results and avoid confounding factors. Patients were divided into PC or OCM cohorts.

Operative Algorithm

The decision regarding whether to pursue a PC or OCM was made by each surgeon based on radiographs, preference, and the patient's symptoms and concerns. At our institution, surgeons typically offer either a OCM or PC for similar HR grades depending on surgeon preference for one procedure. This may result in selection bias. One highly trained surgeon in minimally invasive procedures performed all PCs. Although the surgeon who performs PCs may also offer a Moberg for their patients, the majority of patients opt solely for a PC to avoid the extended postoperative care of an additional Moberg osteotomy.[6] Patients were indicated with a joint-preserving procedure (ie, not arthrodesis) when no crepitus or pain were present during midrange of motion on physical examination.

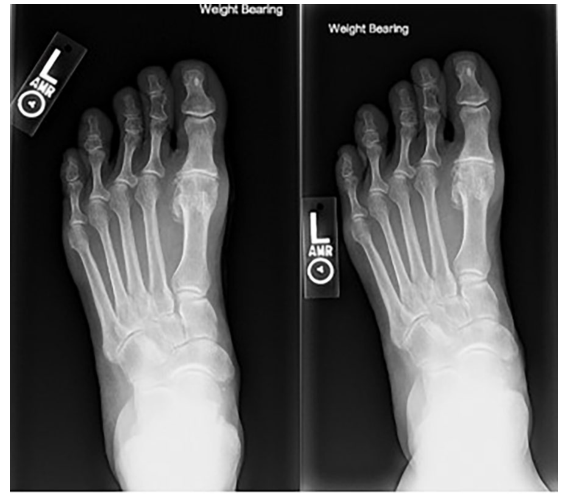

Figure 1. Preoperative (left) and PC postoperative (right) anteroposterior weightbearing radiograph. (PC, percutaneous cheilectomy.)

Operative Technique and Postoperative Treatment

Percutaneous cheilectomy. After local anesthesia at the first metatarsal phalangeal joint was placed, a small keyhole incision was made proximal and medial to the first MTP joint followed by dissection down to the capsule. The capsule was then released over the dorsal spur at the metatarsal head using a sharp elevator. A 3.1 × 13-mm burr was used to resect the dorsal and proximal osteophyte. If needed to access the lateral portion of the joint (10% of cases), a second incision was made laterally, adjacent to the joint, and the burr was then used to resect the lateral osteophytes. Debris was removed from the joint with a rasp and copious irrigation. Fluoroscopy was used to confirm adequate bone resection and full osteophyte excision. Preoperative and postoperative radiographs are shown in Figures 1 and 2.

Patients were allowed to bear weight immediately in a postoperative flat sandal. No narcotics were prescribed. Patients were transitioned into a regular shoe after 3 days and encouraged to resume normal activity.

Open cheilectomy with Moberg osteotomy. OCM was performed according to the technique described by Bonney

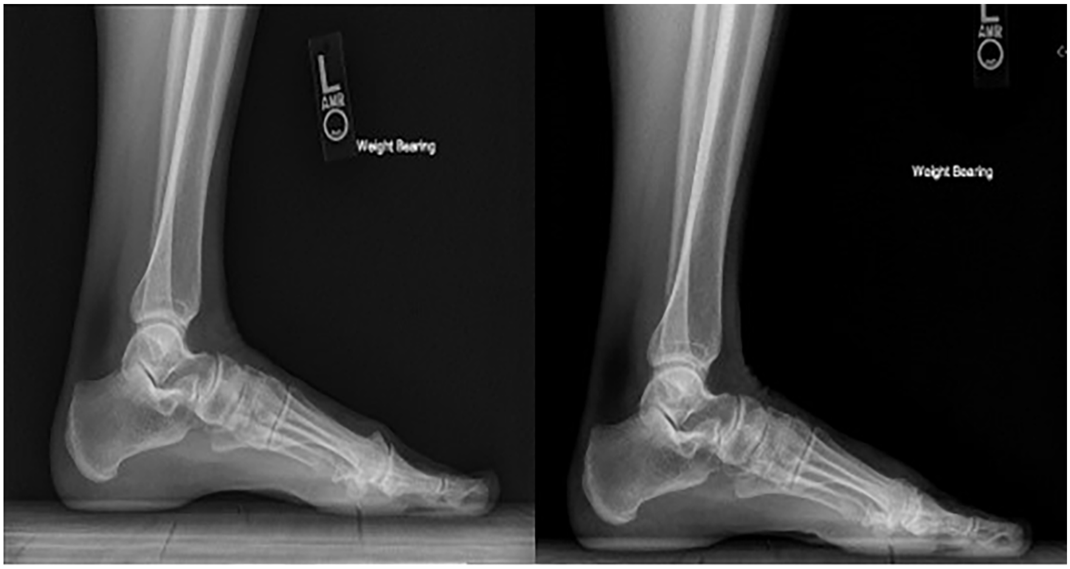

Figure 2. Preoperative (left) and PC postoperative (right) lateral weightbearing radiograph. (PC, percutaneous cheilectomy.)

and Macnab.[2,24] A incision was made over the first MTP joint with blunt dissection to the level of the MTP joint. The EHL tendon was protected and the capsule was incised in line with its fibers for joint exposure. An Oscillating saw was used to remove the part of the dorsal head, up to 30%, and an oscillating rasp or rongeur to remove the osteophytes. A Moberg osteotomy was then performed, removing about a 3-mm wedge of the proximal phalanx. An oscillating rasp was used to contour the edges of the metatarsal head and proximal phalanx. Then a 7 × 9-mm staple or 2-mm screw were placed to fix the osteotomy. Copious irrigation was administered throughout the procedure. Range of motion was checked clinically and proper alignment of hardware was confirmed by fluoroscopy. Preoperative and postoperative radiographs are shown in Figures 3 and 4.

Recovery required elevation of the foot 80% of the time for 48 hours with gradual decrease in elevation. Patients were allowed immediate full weightbearing in a postoperative flat sandal. After 4-6 weeks, patients began to transition into normal footwear depending on the patient's age, comorbidities, activity levels, and level of bony bridging. However, radiographic union was not required for patients to begin progressive weightbearing.

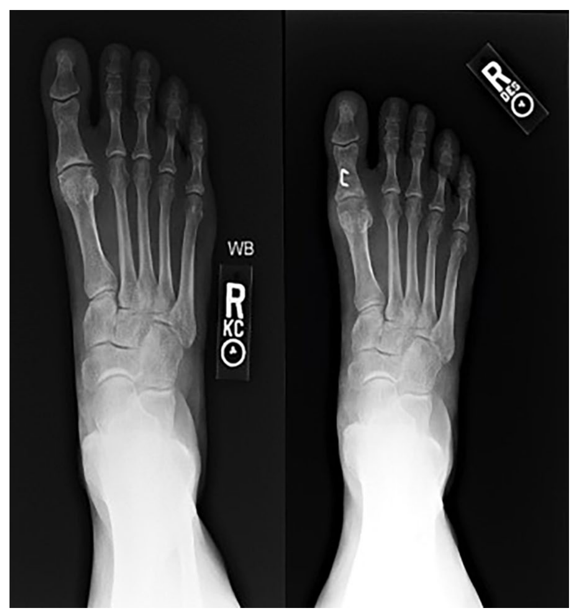

Figure 3. Preoperative (left) and OCM postoperative (right) anteroposterior weightbearing radiograph. (OCM, open cheilectomy with Moberg osteotomy.)

Clinical data. Patient charts were reviewed to obtain demographic data including patient age, body mass index, and to verify operative information. Postoperative clinical notes were reviewed to identify all minor complications such as infections, persistent pain, and major reoperation complications such as revisions and conversion to an MTP arthrodesis.

Radiographic data. The preoperative AP and lateral foot radiographs were viewed in Sectra IDS-7 PACS system (Sectra, Linköping, Sweden) to grade the stage of HR severity based on the classification system developed by Coughlin and Mann.[4,8] Surgeons used postoperative radiographs to note any osteophyte growth.

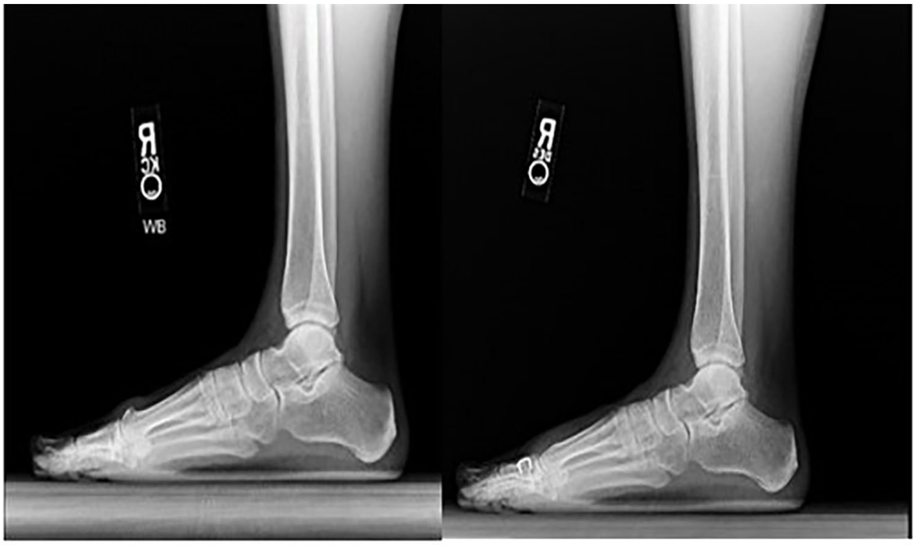

Figure 4. Preoperative (left) and OCM postoperative (right) lateral weightbearing radiograph. (OCM, open cheilectomy with Moberg osteotomy.)

Patient-reported outcome measures. This study evaluated patient-reported outcomes via PROMIS, a computerized adaptive test (CAT) that is endorsed by the American Orthopaedic Foot & Ankle Society.[16] The CAT uses item response theory, decreasing response burden and improving efficiency. PROMIS has been validated for use in HR pathology and cheilectomies.[1] Preoperative and minimum 1-year postoperative PROMIS physical function, pain interference, and pain intensity scores were collected. Preoperative scores, most recent postoperative scores, and change from preoperative to most recent postoperative scores were compared within and between the PC and OCM groups. The PROMIS domains were physical function, pain interference, and pain intensity. PROMIS scores are reported as t scores with a US population mean of 50 and SD of 10. Higher scores in each domain connotate a higher degree of that dimension (ie, higher pain intensity indicates worse pain).

Statistical analysis. Descriptive statistics was presented as median, interquartile range for continuous variables, and frequency and percentage for categorical variables. Differences in patient, surgical, and PROMIS outcomes between cohorts were compared using the t test and Pearson χ^2 or Fisher exact test. Paired t test was used to determine differences in preoperative and postoperative scores. Statistics were performed controlling for age, body mass index, gender, and preoperative PROMIS scores.

For continuous variables, estimates of the difference in medians of the cohorts were reported along with 95% bootstrapped CIs with 3000 replicates, using the Bca method, or percentile and normal method.[19,23] For categorical variables, 95% CIs were calculated for the difference in binomials using the Newcombe Score method.[22] Finally, changes in PROMIS scores by cohort were described using the median estimate with 95% distribution free CIs based on the binomial distribution. Statistical significance was established at alpha 0.05 and CIs that do not cross zero.[1] Analysis was conducted on R: A Language and Environment for Statistical Computing (R Core Team 2022, Vienna, Austria) and confintr package.

Results

Demographics and Preoperative Data

Patient demographic information can be found in Supplemental Table S1. There were 48 PC patients and 71 OCM patients identified. There were no significant differences in body mass index, the distribution of sex, or preoperative HR grades between the 2 cohorts with this sample size. In the PC cohort, 23% had grade II and 77% and grade III, and in the OCM cohort, 24% had grade II and 76% had grade III ($P=.86$). Although there was a difference in age with a mean age of 60 years in the PC group and a mean age of 54.3 years in the OCM group, the 95% CI crossed zero (−3.1, 9.7), and this is not likely clinically significant. Additionally, there was a significant difference in the time to most recent PROMIS score follow-up (20.3 months for PC vs 13.8 months for OCM; $P<.001$). The average follow-up time for last in clinic visit with radiographs was

Table 1. Preoperative and Postoperative PROMIS Scores in Percutaneous and Open Cheilectomy Patients.[a]

	Percutaneous Cheilectomy	Open Cheilectomy	*P* Value	95% CI
Preoperative				
Physical function	48.8 ± 8	45 ± 6.4	**.006**	**4.1, 9.6**
Pain interference	54.6 ± 6.8	58.1 ± 5.8	**.004**	**−8.3, −3.3**
Pain intensity	47 ± 7	50 ± 6.8	**.03**	**−8.9, −2.2**
Postoperative				
Physical function	51.9 ± 8.5	51.8 ± 8.8	.97	−5.2, 3.0
Pain interference	50.2 ± 8.3	49.5 ± 9.7	.66	−5.6, 1.8
Pain intensity	42 ± 7.6	39.9 ± 8.3	.17	−4.3, 1.9

[a]Data presented as mean ± SD. The 95% CI values are bounded by the median, denoted as lower, upper. Boldface indicates significance.

Table 2. Change from Preoperative to Postoperative PROMIS Scores in Percutaneous and Open Cheilectomy with Moberg Patients.[a]

	Preoperative	Most Recent Postoperative	Mean Difference	*P* Value	95% CI
PC					
Physical function	48.8 ± 8	51.9 ± 8.5	2.8	**.0346**	−1.5, 3.6
Pain interference	54.6 ± 6.8	50.2 ± 8.3	−4.35*	**.001**	**−7.9, −0.8**
Pain intensity	47 ± 7	42 ± 7.6	−4.65*	**.001**	**−9.4, 0**
OCM					
Physical function	45 ± 6.4	51.8 ± 8.8	6.77*	**.001**	**3, 8.7**
Pain interference	58.1 ± 5.8	49.5 ± 9.7	−8.62*	**.001**	**−11.4, −4.7**
Pain intensity	50 ± 6.8	39.9 ± 8.3	−9.99*	**.001**	**−12.8, −5.8**

Abbreviations: OCM, open cheilectomy with Moberg osteotomy; PC, percutaneous cheilectomy.
[a]The 95% CI values are bounded by the median, denoted as lower, upper. Boldface indicates significance.
*Clinical significance based on previously cited minimal clinically important differences.[25]

7.1 months for the PC cohort and 6.3 months for the OCM cohort ($P = .61$).

Patient-Reported Outcomes

Preoperative and most recent postoperative PROMIS score data are shown in Table 1. There were notable differences in preoperative PROMIS scores between the cohorts. Specifically, the OCM group demonstrated lower physical function ($P = .006$), higher pain interference ($P = .004$), and higher pain intensity ($P = .027$) compared with the PC group, preoperatively. However, postoperatively, there were no significant differences detected between the cohorts in any PROMIS domain at the most recent follow-up in this sample size (Table 1).

Changes in preoperative to postoperative PROMIS scores are demonstrated in Table 2. For the PC group, there were significant improvements in the physical function ($P = .0346$), pain interference ($P \leq .001$) and pain intensity domains ($P \leq .001$). However, the 95% CI (−1.5, 3.6) for physical function indicates this may not be significant. Similarly, for the OCM group, there were significant improvements in the physical function, pain interference, and pain intensity domains ($P \leq .001$ for all).

Although both groups experienced significant preoperative to postoperative improvement in physical function, pain interference, and pain intensity, the degree of improvement for the OCM cohort was significantly greater than in the PC cohort ($P = .015$, .011, .001, respectively). However, the 95% CI crossed zero for the difference in pain intensity improvement (−0.4, 10.1) (Table 3).

Complications and Subsequent Surgeries

Complications data is presented in Table 4. It was noteworthy that there was a 6.2% revision rate in the PC group, with 1 being a conversion to arthrodesis (after 15 months) and 2 revision PC (after 7 and 35 months), compared with a 1.45% revision rate in the OCM group, with only 1 interpositional arthroplasty after 21 months ($P = .302$). With these numbers, there were no significant differences detected in complications between groups for persistent pain, regrowth of bone spurs, and conversions to arthrodesis, and there were no infections in either group.

Table 3. Difference in Preoperative to Postoperative Changes in PROMIS Scores in Percutaneous Cheilectomy and Open With Moberg Patients.[a]

	Percutaneous Cheilectomy	Open With Moberg	*P* Value	95% CI
Physical function	2.8 ± 8.7	6.8 ± 8.3*	**.015**	**−3.6, −1.8**
Pain interference	−4.4 ± 8.3*	−8.6 ± 8.9*	**.011**	**0.3, 9.0**
Pain intensity	−4.7 ± 7.4*	−10 ± 8.5*	**.001**	−0.4, 10.1

[a]Data are presented as mean ± SD. The 95% CI values are bounded by the median, denoted as lower, upper. Boldface indicates significance based on $P < .05$.
*Clinical significance based on previously cited minimal clinically important differences.[25]

Table 4. Complications and Revisions of Patients Who Underwent Percutaneous Cheilectomy or Open Cheilectomy With Moberg Osteotomy.

	Percutaneous Cheilectomy (n = 48)	Open With Moberg (n = 71)	*P* Value	95% CI[a]
Revision, n (%)	3.0 (6.2)	1 (1.4)	.302	−2.5, 15.5
Persistent pain, n (%)	2 (4.2)	1 (1.4)		
Osteophyte regrowth, n (%)	1 (2.1)	0 (0)		
Arthrodesis conversion, n (%)	1 (2.1)	0 (0)	.403	−3.3, 10.9

[a]Data are presented as mean ± SD. The 95% CI values are bounded by the median, denoted as lower, upper.
Indications for revisions were grouped as persistent pain, or osteophyte regrowth. The OCM revision was a conversion to a Cartiva implant. The PC revisions included 1 conversion to arthrodesis and 2 revision PCs.

Discussion

To our knowledge, this is the first study to compare PC to OCM by using validated patient-reported outcome scores and provide a direct comparison between these two surgeries. This study provides insight into the two most common choices for HR patients at our institution. At a minimum of 1-year postoperative follow-up, there were no significant differences in patient-reported outcomes between the OCM and PC groups with these cohort sizes, highlighting that neither procedure could be deemed superior. However, patients who underwent an OCM had greater improvements in the PROMIS physical function and pain interference domains compared with patients who underwent a PC.

As hypothesized, both cohorts exhibited significant improvements in patient-reported outcomes, with no differences in postoperative PROMIS scores between the two groups. Interestingly, though, the OCM cohort demonstrated clinical improvements of a more substantial magnitude. One explanation for this may be the difference in mean follow-up time between the PC and OCM with the PC having, on average, almost 7 months of additional follow-up. Although the PC cohort has a longer follow-up, Kim et al[13] found that OCM patients' PROMIS scores are stable between 1 and 2 years postoperatively, which suggests that PROMIS scores are unlikely to substantially change over this 7-month difference. Despite statistical differences in preoperative physical function, pain interference, and pain intensity, these differences fell within the minimal clinically important differences (MCIDs) for cheilectomies suggesting that this statistical difference may not matter clinically.[25] A previous study demonstrated that the MCIDs for the PROMIS physical function, pain interference, and pain intensity domains in HR were 4.2, 4.2, and 3.9, respectively.[25] Another explanation for the preoperative differences between the cohorts may be that the pain and disability threshold for a given surgeon to perform a PC are lower than for an OCM owing to its less invasive nature. Although patients and surgeons may choose to delay open surgery until they have more severe symptoms given the longer recovery with an OCM, our findings suggest that these patients may obtain similar outcomes to patients who underwent a PC earlier.

When assessing whether the changes in PROMIS scores met the previously established MCIDs, the PC cohort met the MCID threshold in the domains of pain interference and pain intensity (−4.35 and −4.65, respectively), whereas the OCM cohort met the threshold in the domains of physical function, pain interference, and pain intensity (+6.7, −8.62, and −9.99, respectively). The changes observed in the pain intensity and interference domains of the OCM group surpassed magnitudes that were more than twice their respective MCIDs, even exceeding double the values achieved by PC.[25] Given that the MCID threshold was achieved in more domains for the OCM patients and by a significant magnitude, the procedure may better address the comprehensive aspects of physical function, allowing patients to delay surgery longer than if they had a PC.

The potential rationale behind the OCM procedure's broader improvement and similar postoperative scores lies in the mechanics of the Moberg, which alters the configuration of the loaded first MTP, redirecting joint contact plantarly.[14] Although previous gait analysis studies suggest that cheilectomy alone does little to alter the pathologic biomechanics of hallux rigidus, our data imply that the addition of a Moberg may improve physical function by addressing underlying pain and pathology. These results align with other studies in the literature. Kim et al[13,14] were able to highlight the efficacy of OCM by demonstrating significant improvements in the PROMIS domains of physical function, pain interference, and pain intensity scores from preoperatively to both 1 and 2 years postoperatively. Additionally, at 2 years postoperatively, the patients had clinical improvements in PROMIS scores in physical function (+7.85), pain interference (−9.14), and pain intensity (−10.47). Similar to our study, these outcomes of pain relief reached figures more than double the cited MCID for cheilectomies.[25]

To our knowledge, no studies have evaluated PC outcomes using PROMIS scores. Teoh et al reported patient-reported outcomes using the Manchester-Oxford Foot Questionnaire and demonstrated improvements in all domains. However, they compared their results to an outside study for open cheilectomy and concluded that their postoperative Manchester-Oxford Foot Questionnaire outcomes were worse and had higher reoperation rates than those of their open cheilectomy counterparts.[10] Our study was able to directly compare patient-reported outcomes and complication rates between the two cohorts rather than rely on the literature alone.

With regard to reoperations, no significant differences could be detected between the groups, contrary to our hypothesis. The revision rate of 6.2% for the PC group was lower than the reports of 12% by Teoh et al. and Stevens et al., but similar to the 6.5% conversion to arthrodesis in Gauthier et al., which may be accounted for by small sample sizes in other studies or by improved technique.[7,29,31] The 1.45% reoperation for the OCM group is similar to other studies that report 0% to 4.8% screw removal rates.[12,18,21,30,32] The OCM may allow for a greater amount of resection, which may play a role in decreasing the progression of arthritis.[9] However, the higher, although not significant, complication rate in the PC group could also be attributed to longer follow-up time.

With similar postoperative patient-reported outcomes, the benefits of the PC technique, such as postoperative care, and near immediate return to work and physical activity, cannot be overlooked. However, surgeons can guide patients that the OCM may yield larger improvements in physical function and alleviate pain to a greater extent, even in the setting of more severe preoperative symptoms. Future work investigating the results of a PC with a percutaneous Moberg vs OCM will likely offer more insight as to whether a minimally invasive approach with the addition of a dorsiflexion proximal phalanx osteotomy provides added benefit.

The limitations of the investigational approach should be considered when reviewing our results. The addition of a Moberg osteotomy to the open group compared with a percutaneous cheilectomy may have influenced the results. However, at our institution, open cheilectomies are typically performed with a Moberg osteotomy whereas percutaneous cheilectomies rarely include a Moberg osteotomy; thus, this comparison provides the most robust comparison between the most common procedures to treat HR at the institution. Another limitation is selection bias, as patients who had less symptoms may have opted for a less invasive procedure, PC, whereas those with more symptoms opted for an OCM; however, all patients were given the option of both procedures and had similar grades of arthritis. Similarly, there is response bias as patients who were very dissatisfied or happy with their surgery are more likely to fill out PROMIS questionnaires, as well as performance bias as patients with PC may think their surgery was less effective since it was less invasive. Additionally, we were not able to control for radiographic arch height parameters or first ray hypermobility.[15,28,35] Although this study used patients from multiple surgeons, future studies could improve on this study's generalizability by using a larger patient population, multiple institutions, and a longer average follow-up time. Further research should analyze preoperative factors between these cohorts that may have led surgeons to choose OCM over PC, as well as investigate the outcomes of an OCM compared to a PC with Moberg.

Conclusion

In our limited cohort, postoperative scores between the OCM and PC group were not significantly different. However, patients undergoing an OCM had worse preoperative PROMIS scores and a greater change in patient-reported outcomes than patients undergoing a PC.

Ethical Approval

Ethical approval for this study was obtained from the Institutional Review Board (IRB 2020-2132).

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. Disclosure forms for all authors are available online.

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Table S1. Demographics of Patients who underwent Percutaneous Cheilectomy or Open Cheilectomy with Moberg Osteotomy.

	Percutaneous Cheilectomy (n = 48)	Open With Moberg (n = 71)	*P* Value[a]
Age, y, mean ± SD	60.0 ± 11.0	54.3 ± 10.4	**.005**
Sex, n (%)			
Male	13 (27)	20 (28)	.92
Female	35 (73)	51 (72)	
Radiographic grade (n, %)			
Coughlin and Shurnas II	11 (23)	17 (24)	.89
Coughlin and Shurnas III	37 (77)	54 (76)	
Average follow-up, mo, mean ± SD			
PROMIS	20.3 ± 7.7	13.8 ± 3.8	**.001**
Radiographs	7.1 ± 9.1	6.3 ± 5.6	.61

[a]Boldface indicates significance.