

Long-term Follow-up of Cheilectomy for Treatment of Hallux Rigidus

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Abstract

Background: Hallux rigidus is the most common arthritic condition in the foot. First metatarsophalangeal joint cheilectomy produces satisfactory results in retrospective studies with reported good to excellent results in up to 97% and pain relief and function in 92%. The results of cheilectomy for higher grades of hallux rigidus are less favorable. The purpose of this study was to evaluate the long-term functional results and survivorship of cheilectomy for treatment of hallux rigidus.

Methods: This was a retrospective, questionnaire-based study investigating the long-term results of cheilectomy for treatment of hallux rigidus. The preoperative arthritic grade was graded retrospectively according to the Hatstrup and Johnson (H&J) grading system. A questionnaire was administered via email or telephone that included questions regarding pain recurrence following surgery, current functional status, and satisfaction with the operation. Kaplan-Meier survival analysis was performed to estimate survival time between arthritic grades. We reviewed 165 patients (169 feet) with an average follow-up of 6.6 (5.0–10.9) years.

Results: The overall survival rate (painless at the time of last follow-up) was 70.4% (119 feet), with no significant difference between the 3 H&J arthritic grades. Most of the recurrences (28 feet, 75%) were at the first 2 years following the surgery. Nine feet (5.3%) had a second procedure at a mean postoperative time of 3.6 (range, 1.6–7.4) years. Of the 169 feet, 117 (69.3%) reported being satisfied or very satisfied and 127 (75.1%) indicated they would repeat the operation under the same circumstances.

Conclusion: Our study supports the use of cheilectomy for treatment of hallux rigidus (grade 1–3 Coughlin and Shurnas) as a reliable procedure with favorable results. At long-term follow-up, patients who underwent cheilectomy had a low revision rate and a moderately low rate of pain recurrence.

Level of Evidence: Level IV, retrospective case-series.

Keywords: osteoarthritis, osteoarthritis first metatarsophalangeal joint, patient-reported outcome measure, survival

Introduction

First metatarsophalangeal (MTP) joint osteoarthritis, or hallux rigidus, is the most common arthritic condition in the foot. Of all patients older than 50 years, 2.5% report degenerative arthritis of the first MTP joint.⁹ Progression of the arthritis involves loss of range of motion, osteophyte formation, and pain. The operative treatment for this condition involves motion-preserving surgeries, such as removal of the osteophytes and up to one-third of the arthritic portion of the joint (cheilectomy),^{4,6,15,21} periarticular osteotomy,^{16,22} interpositional arthroplasty,^{1,2,11} or implant arthroplasty or arthrodesis of the first MTP joint.^{5,8,12,17,18} Although osteotomies and arthroplasties showed inconsistent results, cheilectomy and first MTP joint arthrodesis showed good to excellent results in multiple studies and are the recommended operations for

treatment of lower stages of hallux rigidus with cheilectomy and advanced stages of hallux rigidus with arthrodesis.^{13–15}

Cheilectomy for treatment of hallux rigidus has satisfactory results in both short-term and long-term retrospective studies. In a retrospective study of 80 patients (93 feet) treated with cheilectomy with average 9.6-year follow-up, 97% of the feet had good-to-excellent results and 92% had

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success in pain relief and function. Six patients (7 feet) required conversion to arthrodesis.⁴ Other studies have shown similar or slightly less satisfactory results for a grade 1 or 2 hallux rigidus.^{19,21} The results of cheilectomy for higher stages of hallux rigidus are less favorable, with conversion rates to fusion of 25% to 56%.^{4,6,10} These studies report their results as pain or functional limitation at last follow-up and failure as severe pain or revision or conversion surgery.

Nevertheless, cheilectomy involves resection of only a portion of a diseased arthritic joint. Some studies found that in mid- to long-term follow-up, there was no or only minimal recurrence of osteophyte formation and deterioration of the arthritis.^{14,15} However, in another long-term follow-up of dorsal cheilectomy surgery, 30% of the patients had recurrence of the dorsal osteophyte⁶; less than half of those with recurrent osteophytes were symptomatic. A number of additional studies describe similar results with deterioration of the arthritis or osteophyte recurrence.^{4,16} The progression of the arthritic process is, however, expected and was also observed in follow-up of hallux rigidus with nonoperative treatment.²⁰

Our hypothesis was that our results were lower than 90% success rate previously reported. According to the expected progression of the arthritis, we wanted to analyze the timing of recurrence following cheilectomy. The purpose of this study was to evaluate the functional outcomes and survival of cheilectomy for treatment of hallux rigidus over sequential years for a minimum of 5 years following the surgery.

Methods

This is a retrospective study investigating the long-term results of cheilectomy for treatment of hallux rigidus in patients undergoing surgery with 3 fellowship-trained foot and ankle surgeons between August 2007 and December 2013. Inclusion criteria for the surgery were skeletally mature patients with Coughlin and Shurnas (C&S) grade 1 to 3 hallux rigidus.⁴ This is a 5-grade system (0-4) based on radiographic and clinical criteria. Grade 0 has stiffness in the joint but no radiographic findings or pain; grade 1 C&S has mild pain with extremes of range of motion, with mild dorsal osteophytes and minimal radiographic loss of joint space; grade 2 C&S has moderate pain with extreme range of motion, with moderate dorsal osteophytes and radiographic loss of less than 50% joint space; grade 3 C&S is characterized by marked stiffness, pain at extreme range of motion but no pain at midrange; with severe dorsal osteophytes and more than 50% joint space narrowing radiographically. Grade 4 C&S hallux rigidus is radiographically similar to grade 3 C&S, but clinically these patients have pain within the midrange of their first MTP joint motion, representing a more diffuse arthritic involvement that would not respond

well to a cheilectomy procedure. Exclusion criteria were patients who did not have preoperative radiographs on file, who had grade 0 or 4 C&S joint involvement, who had concomitant procedures performed other than cheilectomy, or it had been less than 5 years since the primary cheilectomy. Patient demographics, diagnoses, medical comorbidities, and physical examination notes were obtained from our electronic medical record system. This included analysis of the patients' self-reported preoperative pain level, scored on a 10-cm visual analog scale (VAS). These were collected and documented in the patients' charts at the time of their preoperative office visit.

Initial preoperative radiographic grading was classified using the Hattrup and Johnson grading system.¹⁰ This is a 3-grade purely radiographic classification system (grade 1 H&J: mild dorsal osteophyte formation with preservation of the joint space; grade 2 H&J: moderate dorsal osteophyte formation with moderate joint space narrowing and subchondral sclerosis or cyst formation; and grade 3 H&J: severe joint space narrowing with large dorsal osteophyte formation, loose bodies within the joint with subchondral sclerosis and cyst formation). Being a retrospective study, the physicians' assessment of pain during different phases of motion was not universally and uniformly documented, and as such the preoperative C&S grade could not be assessed for the purpose of this study. It is however the protocol of all the surgeons involved in the study to not perform cheilectomies on patients with pain at midrange of passive motion.

Follow-up evaluation was performed through a patient-reported outcome questionnaire (Table 1). The questionnaire included questions regarding the patients' function, current visual analog scale (VAS) for pain levels (0-100), satisfaction with the operative result, and likelihood to repeat the operative procedure using 5-point Likert scales, shoe-wear limitations, and details about need for further intervention in the operated foot, including MTP joint injections or revision procedures. Additionally, if the patient had an additional procedure or recurrence of the pain, we asked them to document the interval between the surgery and the recurrence. When patients had bilateral cheilectomies performed, we asked them to complete the questionnaire for each procedure.

One hundred sixty-five nonconsecutive patients (169 feet, 4 bilateral nonconcomitant procedures) were included in the study. The patient population included only patients who had a complete set of preoperative data sets and radiographs and who responded to the survey. There were 110 females (66.7%) and 55 (33.3%) males. Mean age was 54.2 (range, 18-76) years and mean body mass index (BMI) was 26.7 (range, 17.2-40.6). Results were obtained at an average follow-up of 6.6 (range, 5-11) years for the 169 feet. Patient demographics and hallux rigidus H&J grades are described in Table 2.

Table 1. Cheilectomy Patient-Reported Outcomes Survey.


How satisfied are you with the result of the surgery in your great toe?	<input type="checkbox"/> Very dissatisfied <input type="checkbox"/> Dissatisfied <input type="checkbox"/> Neither satisfied nor dissatisfied <input type="checkbox"/> Satisfied <input type="checkbox"/> Very satisfied
Would you repeat the surgery under the same circumstances?	<input type="checkbox"/> Definitely not <input type="checkbox"/> Probably not <input type="checkbox"/> Can't decide <input type="checkbox"/> Probably yes <input type="checkbox"/> Definitely yes
Would you recommend the surgery to a friend?	<input type="checkbox"/> Definitely not <input type="checkbox"/> Probably not <input type="checkbox"/> Can't decide <input type="checkbox"/> Probably yes <input type="checkbox"/> Definitely yes
Did you experience pain relief within the first 6 months following surgery?	<input type="checkbox"/> The pain became much worse/unbearable after the surgery <input type="checkbox"/> The pain worsened somewhat after the surgery <input type="checkbox"/> I felt no change in the amount of pain after the surgery <input type="checkbox"/> I had some pain relief after the surgery <input type="checkbox"/> All/most of the pain improved after the surgery
If you initially felt better after the surgery, did the pain in your big toe return?	<input type="checkbox"/> Yes, and the pain was much worse <input type="checkbox"/> Yes, and the pain was somewhat worse <input type="checkbox"/> Yes, and the pain was about the same as before surgery <input type="checkbox"/> No, the pain did not return
If you answered "yes" to the previous question, approximately when did the pain return after surgery?	<input type="checkbox"/> 1 year <input type="checkbox"/> 2 years <input type="checkbox"/> 3 years <input type="checkbox"/> 4 years <input type="checkbox"/> 5 years <input type="checkbox"/> 6 years <input type="checkbox"/> 7 years <input type="checkbox"/> 8 years <input type="checkbox"/> 9 years <input type="checkbox"/> 10 years <input type="checkbox"/> > 10 years
At present, how much pain do you have in the great toe on a daily basis?	<input type="checkbox"/> No pain worst pain possible 
Following the original surgery, have you had additional treatment for the great toe?	<input type="checkbox"/> Yes <input type="checkbox"/> No
If you answered "yes" to the previous question, please select the additional treatment(s):	<input type="checkbox"/> Another cheilectomy/bone spur removal <input type="checkbox"/> Great toe fusion/arthrodesis <input type="checkbox"/> Great toe joint replacement/arthroplasty <input type="checkbox"/> Steroid injection <input type="checkbox"/> Other procedure
Does the foot you had operated on limit your walking?	<input type="checkbox"/> If other, please list: _____ <input type="checkbox"/> No difficulty <input type="checkbox"/> Some difficulty <input type="checkbox"/> Severe difficulty
For females: Because of your great toe, do you currently have any limitations in the shoes you wish to wear? Please indicate the shoes you are able to wear.	<input type="checkbox"/> Greater than 1-inch heels <input type="checkbox"/> 1-inch heels <input type="checkbox"/> Dress shoes without a heel <input type="checkbox"/> Comfortable shoes only <input type="checkbox"/> Custom-made shoes only
For males: Because of your great toe, do you currently have any limitations in the shoes you wish to wear? Please indicate the shoes you are able to wear.	<input type="checkbox"/> Dress/fashionable shoes <input type="checkbox"/> Comfortable shoes only <input type="checkbox"/> Custom-made shoes only
Do you currently have any activity restriction because of the great toe joint?	<input type="checkbox"/> No limitation of daily activities <input type="checkbox"/> Some limitation of daily activities <input type="checkbox"/> Major limitation of daily activities

Table 2. Patient Demographics and Hallux Rigidus Arthritic Grades (165 Patients; 169 Feet).

Demographic	n (%)
Sex ^a	
Male	55 (33)
Female	110 (67)
Laterality ^b	
Left	70 (41)
Right	99 (59)
Current tobacco use ^a	
Yes	9 (5)
No	156 (95)
DM ^a	
Yes	6 (4)
No	159 (96)
RA ^a	
Yes	2 (1)
No	163 (99)
Gout ^a	
Yes	3 (2)
No	162 (98)
Age, y, mean (range)	54 (18-76)
BMI	27 (17-41)
Hattrup and Johnson grade, n (%) ^b	
1	30 (18)
2	118 (70)
3	21 (12)

Abbreviations: BMI, body mass index; DM, diabetes mellitus; RA, rheumatoid arthritis.

^aData reported as number (%) of patients (n = 165).

^bData reported as number (%) of feet (n = 169).

Operative Indication and Technique

Operative indications were clinical and radiographic evidence of symptomatic hallux rigidus that had failed non-operative treatment, including shoe-wear modification or inserts to limit first MTP joint motion, cortisone injections, and activity modification. The surgeons used the Coughlin and Shurnas grading system for decision making, with midrange pain and a positive axial grind test as a contraindication for cheilectomy and indication for fusion of the joint. Some patients with midrange pain elected to undergo a cheilectomy procedure despite being educated about expected less favorable results and thus were included in the study.

Surgery was performed via a direct dorsal approach to the first MTP joint just medial to the extensor hallucis longus tendon. The dorsal osteophyte was resected using an osteotome or a sagittal saw (surgeon preference), resecting 25% to 33% of the dorsal metatarsal head as required by arthritic involvement. The remaining metatarsal head and base of the proximal phalanx was debrided of rim osteophytes and loose degenerative cartilage using a rongeur.

Radiographic Evaluation

All patients underwent preoperative anteroposterior (AP), lateral, and oblique weightbearing views of the affected foot, which were used for severity grading via our digital radiographic picture archiving and communication system (PACS; SECTRA, Shelton, CT). These were graded according to the Hattrup and Johnson grading system by a single orthopedic foot and ankle fellowship-trained surgeon not involved in the care of any of the patients and blinded to all preoperative and final outcome results. We also documented the presence of loose bodies or calcification within the joint capsule.

Statistical Analysis

Descriptive statistics were generated for all survey responses and patient variables. Paired sample *t* tests were used to compare pre- and postoperative pain levels. One-way analysis of variance, chi-square, and Kruskal-Wallis tests were used to compare patient demographics and results to survey responses between preoperative arthritic grades, and presence of loose bodies within the joint; and between groups of those experiencing no pain relief from surgery, those experiencing pain relief with eventual pain recurrence, and those experiencing no pain at final follow-up. Bivariate logistic regressions were performed to determine which patient background variables were related to the return of pain. Any variable that was related to the return of pain at $P < .25$ and not causing any multicollinearity was entered into a Cox regression analysis to examine time to return of pain, with time to follow-up used for patients reporting no recurrence of pain. Kaplan-Meier survival analysis was performed to estimate survival time between H&J arthritic grades, using censored survival time to last follow-up of patients reporting no recurrence of pain. Statistical significance was set at $P \leq .05$.

Results

The patient satisfaction survey showed that 69% to 75% were satisfied or very satisfied with the result of the surgery or would repeat the surgery under the same circumstances (Table 3). The patient reported outcome and function are detailed in Table 3.

Preoperative pain was significantly improved from a mean of 64 ± 25 of 100 to 11 ± 23 postoperatively ($P < .0001$). In 119 (70.4%) of the 169 feet, the pain the patients had never returned following their cheilectomy procedure. In 22 feet (13%), it was reported pain never being relieved following primary cheilectomy. In 28 feet (16%), the pain was initially relieved but eventually returned after the surgery. Of these 50 patients reporting

Table 3. Patient-Reported Outcomes and Abilities With Shoe-Wear and Activities.

Reported Outcome and Function	Very Satisfied	Satisfied	Neither Satisfied Nor Dissatisfied	Satisfied	Very Dissatisfied
Operative result satisfaction ^a	63 (37)	54 (32)	15 (9)	22 (13)	15 (9)
Likelihood to repeat ^a	Definitely yes	Probably yes	Can't decide	Probably not	Definitely not
Likelihood to recommend to friend ^a	81 (48)	46 (27)	6 (4)	17 (10)	19 (11)
	78 (46)	47 (28)	10 (6)	19 (11)	15 (9)
	Greater than 1-inch heels	1-inch heels	Dress shoes without a heel	Comfortable shoes only	Custom-made shoes only
Female shoe-wear ^b	21 (19)	32 (29)	27 (25)	30 (27)	0
	Dress/fashionable shoes			Comfortable shoes only	Custom-made shoes only
Male shoe-wear ^b		46 (84)		7 (13)	2 (4)
	No limitation		Some limitation	Major limitation	
Daily activity restriction due to great toe ^a	136 (81)		29 (17)	4 (2)	

^aResults are displayed as n (%) and refer to total number of feet (N = 169).

^bResults are displayed as n (%) and refer to total number of patients (N-female = 110, N-male = 55).

Table 4. Additional Procedures Following Cheilectomy.^a

Procedure	n (%)
Corticosteroid injection	14 (8)
Revision cheilectomy	1 (0.6)
Revision arthrodesis	6 (4)
Revision arthroplasty	2 (1)

^aResults refer to the number (%) of feet (total N = 169).

pain after surgery, the mean VAS pain level was 46 ± 25 , which was still significantly lower than the preoperative level ($P = .008$). For 9 feet, patients reported that the pain was worse following surgery, whereas 41 of 50 feet with recurrence reported the pain as being the same as, or mildly improved compared with that before surgery.

Cox regression analysis revealed those with older age ($P = .062$) and male sex ($P = .058$) to be marginally but not significantly related to having less likelihood of pain returning following initial pain relief from primary cheilectomy (longer survival time). No other patient factors, including BMI, smoking, presence of gout, diabetes mellitus (DM), rheumatoid arthritis (RA), and H&J arthritic grade, affected pain recurrence following surgery. Additionally, the presence of loose bodies within the joint was not found to be a predictor of operative outcome.

Nine feet (5%) underwent subsequent additional surgery (Table 4) at a mean postoperative time of 3.6 (range, 1-7) years. The 1 foot that had a second cheilectomy procedure initially had H&J grade 1 hallux rigidus arthritis, whereas 5 feet with initial H&J grade 2 and 1 foot with initial H&J grade 3 subsequently underwent conversion to MTP joint fusion. The 2 conversions to MTP joint arthroplasties were performed on feet with initial H&J grade 1 and H&J grade 2 hallux rigidus, respectively.

Fourteen received a corticosteroid injection following primary cheilectomy for postoperative pain or stiffness. Of these 14 feet receiving injections, 2 eventually required a revision procedure.

Effect of Arthritic Grade

Most of the feet (118 feet) had H&J grade 2 arthritic changes (Table 2). One-way analysis of variance revealed that patients with H&J grade 1 arthritis were significantly younger than the patients with H&J grade 2, who, in turn, were significantly younger than H&J grade 3 arthritis patients (47 vs 55 vs 60 years, respectively, $P < .0001$). There was no significant difference between H&J arthritic grades in the prevalence of comorbidities such as preoperative pain VAS, smoking, DM, RA, and gout. The overall satisfaction rate ($P = .427$) and pain VAS score ($P = .544$) at the final follow-up also did not differ significantly among the 3 groups of H&J arthritis grades. Although this was a large cohort study, the number of patients with H&J grade 3 hallux rigidus may have been too small for statistical comparative analysis.

Survival Analysis

Lack of pain recurrence following primary cheilectomy was treated as "survival" because of the low number of revision surgeries. Kaplan-Meier survival analysis (Figure 1) of the survival rate of cheilectomy shows that most of the recurrence of pain happened in the first few years following the surgery. Log-rank testing revealed that there was no significant difference in survival curves among the H&J arthritic grades ($P = .512$), with 76.2% survival (16 feet) in H&J grade 3 patients, 63.3% (19 feet) in H&J grade 1, and 71.2% (84 feet) in H&J grade 2 at the final follow-up. Twenty-one

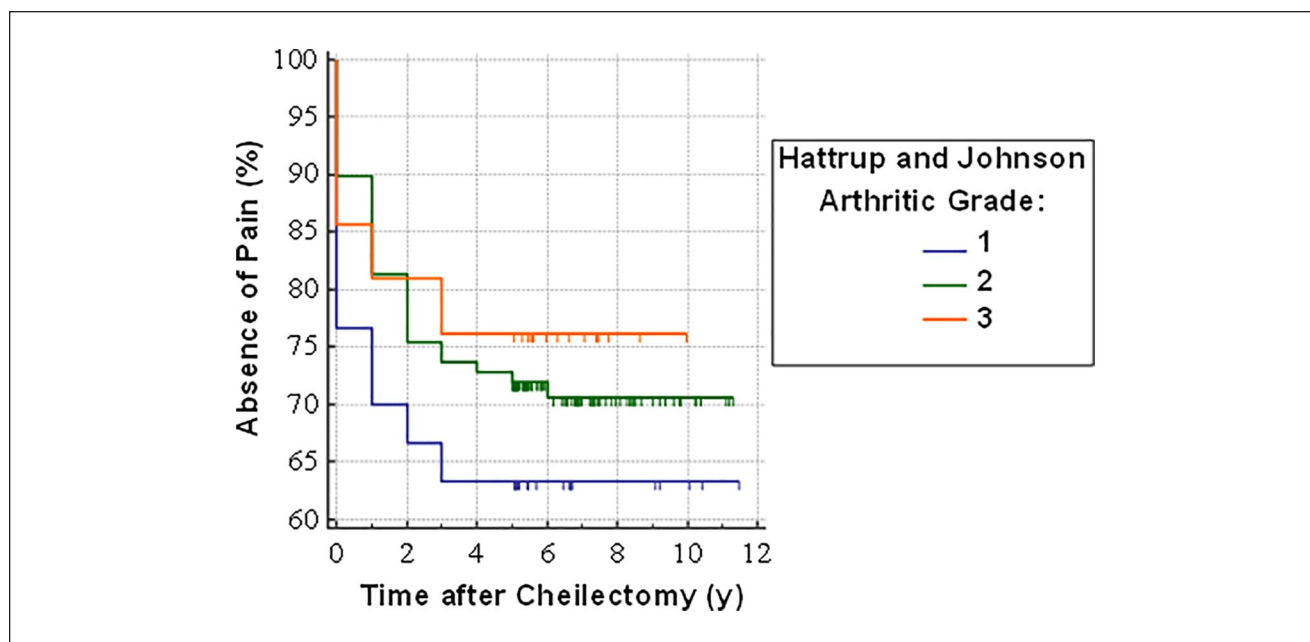


Figure 1. Kaplan-Meier survival analysis after primary cheilectomy. Survival was measured as absence of pain, compared between Hattrup and Johnson grades 1, 2, and 3 hallux rigidus.¹⁰ Patients never experiencing pain relief following surgery have been indicated as having pain return at Time=0. Tick-marks indicate latest follow-up times of patients who are still pain-free.

of the total 28 feet (75%) that had recurrence of pain had an early recurrence (within the first 2 years after the surgery).

Discussion

Patient satisfaction after cheilectomy was 69%, with a failure rate of 29% regardless of the initial H&J arthritic grade. Failure was considered as recurrence of the pain following the surgery. This definition is not consistent in the literature. In a long-term study, there was an 8% failure rate for cheilectomy surgery as those requiring conversion to MTP joint arthrodesis.⁴ The authors also describe 97% patient good to excellent subjective results; however, up to 58% of their cheilectomy group still reported having some pain in the first MTP joint.⁴ Similar results were found with 90% subjective satisfaction with cheilectomy at a mean follow-up of 63 months and 13% of symptomatic feet at the final follow-up.⁶ Only 6 of the feet had a second procedure for arthrodesis. Another study reported that 91% of their patients, at an average of 65 months of follow-up, felt that they are better than prior to the surgery, and 78% were reportedly satisfied, including 4 feet (6%) that had a secondary fusion surgery.⁷ A quantitative literature review analyzed 69 articles discussing operative treatment for hallux rigidus and found an average success rate of 74% (range, 40% through 100%) after cheilectomy surgery.¹³

Our results of 5% of patients requiring a second procedure were similar to the published results we reviewed here of 4.4% through 8%.^{4,6,7} One literature review reported a

2.4% revision rate,¹³ whereas another systematic review published in 2010 reviewing 23 mid- to long-term follow-up studies with 706 isolated cheilectomies found an 8.8% revision rate.¹⁹

The patient satisfaction rate in our study was 69%, which is slightly lower than the average satisfaction rate of 74% in a literature review.¹³ However, 75% of our patients declared that they would repeat the surgery under the same circumstances. Furthermore, we found that women had a nonsignificant marginally higher probability for recurrence of the pain and shorter survival time without pain ($P = .058$), which is an outcome that was not noted in previous studies. Lower scores and satisfaction rates were found, however, in females following arthrodesis of the first MTP joint.²³ This difference could be attributed to more stress on the joint from higher-heeled shoe-wear or as female sex being a risk factor for hallux rigidus.^{3,14} This pain recurrence outcome could also have been affected by a selection bias, as women anecdotally seem to prefer doing a cheilectomy over a fusion and not losing motion at the first MTP joint even with higher degrees of arthritis.

We also found that older age was marginally but not significantly related to less chance for recurrence of pain ($P = .062$). A similar finding was reported before with significantly higher scores and satisfaction rate in patients older than 60 years.⁷ We found no influence of the H&J grade of the arthritis in the joint on patient satisfaction, pain following the surgery, or the need for revision. This finding was brought up in several previous reports.^{6,7,19} However, this

finding is heavily biased by the fact that the patient with midrange pain and a positive grind test were offered other procedures like arthrodesis or interpositional arthroplasties, despite similar radiographic findings, and that this clinical description was not available for our study. In rare cases, a patient was offered cheilectomy in the presence of a positive grind test. This was after educating patients about the less-favorable results and higher chances for a revision procedure to arthrodesis.

In this study, we present the timing of the recurrence of pain. From our knowledge, this is the first study to discuss the timing for recurrence of pain. We found only a few studies that describe the timing of the revision surgery. One of these studies, which described the long-term results of minimally invasive dorsal cheilectomy,²¹ similarly found that most of the failures were within the first 2 years postsurgery. Another study reported a 4.9% failure rate, documented as revisions in mid- to long-term follow-up.¹⁶ Three patients from these 4 cases (75%) had revision procedures within the first 3 years following the cheilectomy.

This study does have several limitations. First, this is a retrospective study, which may present recall bias occurring with our patients and precluded an accurate clinical description of pain with range of motion preoperatively. Second, it is a questionnaire-based study. At final follow-up, we did not examine or radiograph the patients and we based our results on their description. However, the main goal of this study was to evaluate the patient's perspective on the results of the surgery, and grade the success rate as a lack of pain recurrence and not only as a revision rate. We believe that because the decision to perform a revision surgery for cheilectomy is based not only on the failure of the previous surgery to relieve the pain but also on patient desires, and because some patients would prefer their pain over fusion of the joint, there is a discrepancy between the revision rate and the satisfaction or return of pain rate.

Conclusions

Our study supports that cheilectomy for treatment of hallux rigidus (grade 1-3 C&S) is a reliable procedure with favorable results. These results can be summarized as a low revision rate of 5%, a moderately high satisfaction rate of 69%, and a moderately low rate of pain recurrence of 30%. These results were not influenced by the preoperative H&J arthritic grade, as long as it was performed on patients with no midrange pain. We observed that older age and male sex had higher satisfaction rates that can be potentially influenced by less demand on the first MTP joint. Although there are data to support further deterioration of the joint following cheilectomy, most of our failures, or recurrence of pain, occurred within the first 2 years. We believe that the data presented here in this study can help with future

decision making of both surgeons and their patients with hallux rigidus.


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