Original Article

Arthroscopic Posterior Capsular Release Effectively Reduces Pain and Restores Terminal Knee Extension in Cases of Recalcitrant Flexion Contracture

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Purpose: To 1) evaluate the clinical efficacy of arthroscopic posterior capsular release for improving range of motion (ROM) in cases of recalcitrant flexion contracture and 2) determine patient-reported outcomes (PROs) postoperatively. **Methods:** Retrospective chart review was performed to identify patients who underwent arthroscopic posterior capsular release due to persistent extension deficit of the knee despite comprehensive nonoperative physical therapy between 2008 and 2021. Knee ROM and PROs (International Knee Documentation Committee [IKDC], Tegner, and visual analog scale [VAS]) were collected at final follow-up. **Results:** Overall, 22 patients were included with a median age of 37 years (interquartile range [IQR]: 20.5-44.3). Of these, 8 (36%) were male and 14 (64%) were female, and average follow-up was 3.7 ± 3.3 years. The most common etiology was knee flexion contracture after anterior cruciate ligament (ACL) reconstruction (59%). All patients failed a minimum of 3 months of nonoperative management. Prior to operative intervention, 100% of patients received physical therapy, 64% received extension knee bracing or casting, and 36% received corticosteroid injection. Median preoperative extension was 15° (IQR: 10-25) compared to 2° (IQR: 0-5) postoperatively ($P < .001$). At final follow-up, median extension was 0° (IQR: 0-3.5). Postoperative VAS pain scores at rest (2 vs 0; $P = .001$) and with use (5 vs 1.8; $P = .017$) improved at final contact, and most (94%) patients reported maintaining their extension ROM. Patients with ACL-related extension deficit reported better IKDC (81 vs 51.3; $P = .008$), Tegner (5.8 vs 3.6; $P = .007$), and VAS pain scores (rest: 0.2 vs 1.8; $P = .008$; use: 1.3 vs 5; $P = .004$) compared to other etiologies. **Conclusion:** Arthroscopic posterior capsular release for recalcitrant flexion contracture provides an effective means for reducing pain and restoring terminal extension. The improvement in extension postoperatively was maintained for most (94%) patients at final follow-up with a 14% reoperation rate.

Introduction

Flexion contracture or terminal extension deficit is a troubling clinical problem even among the most experienced surgeons. Etiologies of this condition include acute injury, repetitive microtrauma, or, commonly, as a complication of surgical intervention to the knee joint. Unfortunately, 0.5-11% of patients fail to achieve satisfactory return of range of motion (ROM)

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despite appropriate nonoperative treatments, including physical therapy for range of motion, quadriceps training, and extension orthosis bracing.[1-6] Modifiable risk factors include surgical technique, preoperative ROM, concomitant or multiple procedures, pain management, and BMI,[7] though even with a prevention-first approach, those who go on to experience a persistent extension deficit remain difficult to treat.

In many cases of persistent extension deficit, secondary to surgical insult or trauma, posterior capsular tissues become contracted, leading to subsequent limitations in range of motion and loss in terminal knee extension.[8,9] This is particularly disabling to knee function and results in poor patient outcomes, deterioration of knee function, and increased morbidity and disability by increasing stress on the quadriceps and patellofemoral articular cartilage.[10] Treatment of extension deficit requires early identification of motion limitation and potential causes, such as graft malposition following anterior cruciate ligament (ACL) reconstruction or capsular fibrosis and contracture. In most patients, motion can be successfully regained through physical therapy, splinting/bracing, and oral/intra-articular corticosteroids.[11] Manipulation under anesthesia (MUA) with or without arthroscopic debridement is another stepwise treatment option available for surgeons.[11] Despite exhausting these measures, extension deficit may persist in some patients; these recalcitrant cases pose a unique clinical challenge.

Variation in the surgical management of posterior capsule contracture is evident in the literature. Previous studies have demonstrated that an open posterior capsulotomy can be performed with satisfactory results.[12,13] Additionally, a mixed open and arthroscopic approach for severe flexion contractures was shown effective by Mariani,[14] though these techniques come with significant risk of complication near neurovascular structures.[15,16] An arthroscopic approach has been described, with posteromedial release typically sufficient to achieve ROM, although additional posterolateral release is acceptable.[16-18] To our knowledge, the only investigation of an all-arthroscopic posterior capsule release in a comprehensive cohort of patients with extension deficit was a 15 patient series by LaPrade et al. in 2008.[19] This study reported efficacy in regaining ROM for patients failing nonoperative and operative management, including physical therapy, manipulations, or anterior compartment arthroscopic debridement. Despite these results, there remains a paucity of data on the clinical and patient-reported outcomes following arthroscopic posterior capsular release for persistent extension deficit. Therefore, the purposes of this investigation were to 1) evaluate the clinical efficacy of arthroscopic posterior capsular release for improving ROM in cases of recalcitrant flexion contracture and 2) determine patient-reported outcomes (PROs) postoperatively. We hypothesized that arthroscopic posterior capsular release would result in improved knee motion postoperatively with satisfactory PRO scores.

Methods

Primary Location where this investigation was performed: Mayo Clinic, Rochester, MN.

Ethical approval was obtained from the Mayo Clinic (Rochester, MN; Institutional Review Board [IRB]: 15-000601) and patients provided informed consent. After IRB approval, an institutional operative note database was queried for patients undergoing posterior capsular release procedures between January 2008 and March 2021. The terms "capsular release" and "capsule release" were used to identify the initial patient sample for screening. Operative notes and patient charts were screened for inclusion. Patients were included if they 1) underwent arthroscopic posterior capsular release for a symptomatic, relative extension deficit of at least 10°; 2) had an inadequate response to conservative management, including 3 months of physical therapy, bracing, or injection; and 3) had clinical follow-up with recorded range of motion.

Patient medical records were reviewed to obtain patient characteristics, including age, sex, body mass index (BMI), smoking status, and history of diabetes, surgical history, prior conservative therapies, preoperative VAS pain scores, surgical details, and clinical outcomes. In patients with native knees, patient-reported outcomes were collected at final follow-up, including VAS pain, IKDC, and Tegner scores.[20] Further analysis was performed to determine factors related to achieving threshold patient-acceptable symptom state for knee function (IKDC PASS).[21] Patients were asked whether their knee extension ROM had improved, maintained, or worsened since their last consultation. Patients were contacted by phone when necessary for final follow-up.

Surgical Technique

Posterior capsular release was only performed after a failed course of nonoperative treatment. A standard diagnostic arthroscopy was used to assess for and address concomitant knee pathologies. Posterior capsular release was performed at the discretion of the treating surgeon for persistent terminal knee extension intraoperatively. This arthroscopic technique has been cited previously.[16-18,22]

A transcondylar notch view was used to visualize the posteromedial compartment and establish a posteromedial portal. Next, a safe plane was created behind the capsule. Maintaining visualization throughout the entirety of this step was key. The transeptal approach allowed for posterior cruciate ligament (PCL) identification and manipulation anteriorly, effectively creating space anterior to the neurovascular structures. Both 30°

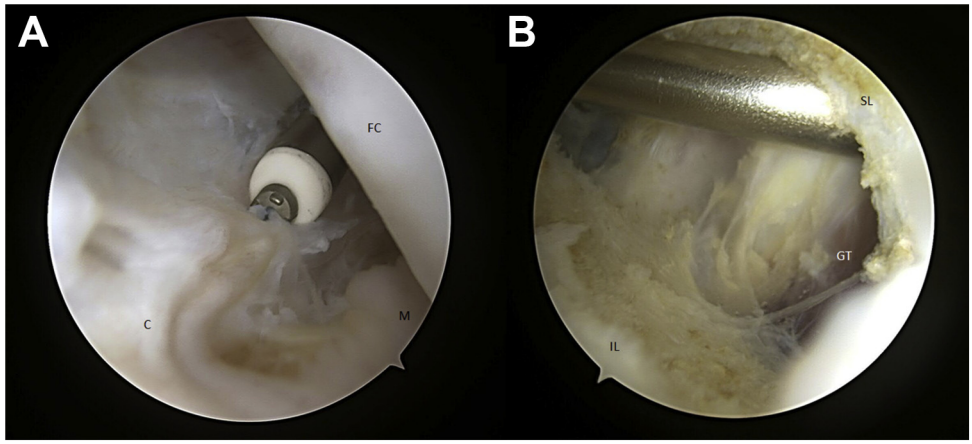

Fig 1. (A) Precapsular release and (B) postcapsular release (left knee). Viewing of the posterolateral knee from an anteromedial portal, through the intercondylar notch with a 30° arthroscope. (A) Femoral condyle (FC) shown to the right, with the posterolateral meniscocapsular junction inferiorly with the meniscus (M) to the right and capsule (C) to the left. An electrocautery device is used through the posterolateral portal. (B) Completed capsulotomy with capsulectomy, with the superior (SL) and inferior leaflets (IL) shown and the gastrocnemius tendon (GT) visible.

and 70° scopes were used, with care to avoid the meniscus as well.

The posteromedial capsule was then transected, starting medially, and moving laterally to the posterior cruciate ligament and using an arthroscopic shaver to clean up the free edges, as necessary, until the medial head of the gastrocnemius muscle was well visualized. If the extension deficit persisted after posteromedial release, then the transcondylar notch was used once again to visualize the placement of a posterolateral portal, and a safe plane was created behind the posterolateral capsule. The capsule was transected from lateral to medial, and free edges were cleaned until the lateral head of the gastrocnemius muscle was well visualized (Fig 1).

Rehabilitation

All patients received intensive, in-person physical therapy starting immediately after surgery with additional at home exercises to be performed daily. Standard rehabilitation included turnbuckle extension orthosis bracing, active and passive range of motion exercises, and quad activation postoperatively. Continuous passive motion machines and dynamic extension braces were used at the discretion of the operating surgeon.

Table 1. Baseline Characteristics

Age, years	37 (20.5-44.3)
Sex	
Male	8 (36%)
Female	14 (64%)
BMI, kg/m^2	26.2 (24.5-27.7)
Smoking status	
Never	15 (68%)
Former	4 (18%)
Current	3 (14%)

NOTE. Data presented as *n* (%) or median interquartile range (IQR).

Statistical Analysis

Data are presented as *n* (%) or median interquartile range (IQR). Wilcoxon signed rank tests were used to compare changes in preoperative and postoperative VAS pain, knee extension, ROM, and flexion ROM. Fisher's exact test or χ^2 (Chi-square) analysis for categorical variables were utilized when appropriate. All tests were 2-sided, and *P* values <.05 were considered significant. Analysis was performed using SAS JMP version 14.1.0 (SAS, Inc., Cary, NC).

Results

The initial search returned 32 patients undergoing posterior capsular release. One patient underwent concomitant unicompartmental knee arthroplasty, and 9 patients had less than 3-month follow-up and were subsequently excluded. After application of exclusion criteria, 22 patients were included. Baseline patient characteristics are reported in Table 1. All patients failed nonoperative management, as 100% of patients received physical therapy, 64% received knee bracing or casting, and 36% received corticosteroid injection prior to requiring surgical intervention. The most common etiology of extension deficit was anterior cruciate ligament (ACL) reconstruction following ACL injury (59%). Previous manipulation under anesthesia (MUA) was performed in 9 (41%) patients and arthroscopic debridement in 11 (50%) patients. The median time from injury or most recent operation to capsular release was 8.0 months (IQR: 3.1-11.9). Two patients had no prior knee surgeries.

The median preoperative extension was 15° (IQR: 10-25), which improved to 2° (IQR: 0-5) immediately postoperatively ($P < .001$). At final follow-up, median extension was 0° (IQR: 0-3.5). Median preoperative flexion was 107.5° (IQR: 90-126.3) compared to 135° (IQR: 110-140) postoperatively ($P < .001$). Etiology,

Table 2. Surgical History and Range of Motion for All Patients

Patient	Original Pathology	Last Operation	Age	Time From Last Surgery to PCR (months)	Extension			Flexion			Final Follow-Up (months)
					Pre-Op	Post-Op	Δ	Pre-Op	Post-Op	Δ	
1	ACL injury	Arthroscopic debridement, MUA	35	17.5	15	0	15	135	135	0	46.4
2	ACL injury	ACLR	47	8.5	10	0	10	120	135	15	13.8
3	ACL injury	Arthroscopic debridement	17	15.4	10	0	10	120	145	25	9.0
4	ACL injury	Hardware removal	42	51.7	15	0	15	100	100	0	53.4
5	ACL injury	ACLR	47	7.4	15	-4	19	135	150	15	15.5
6	ACL injury	Arthroscopic debridement, MUA	38	2.4	20	0	20	75	125	50	79.7
7	ACL injury	ACLR	12	1.4	10	0	10	100	135	35	74.5
8	ACL injury	ACLR	37	6.8	35	15	20	90	70	-20	7.8
9	ACL injury	ACLR	64	8.9	10	0	10	105	160	55	69.3
10	ACL injury, lateral and medial meniscus tear	ACLR, lateral and medial meniscus repairs	19	5.6	20	2	18	120	135	15	15.1
11	ACL injury and lateral meniscus tear	ACLR, partial lateral meniscectomy	18	12.0	10	0	10	130	140	10	4.3
12	ACL injury	None (ACL injury treated non-op)	45	N/A	35	0	35	85	130	45	42.3
13	Osteochondral lesion of lateral femoral condyle	Arthroscopic debridement	21	12.4	25	10	15	93	95	2	54.5
14	MPFL instability	TTO	14	2.7	7	2	5	110	140	30	41.0
15	PVNS	Arthroscopic debridement	32	4.3	30	2	28	90	110	20	50.9
16	PVNS	None (PVNS)	25	N/A	25	5	20	90	129	39	71.8
17	Tibial fracture	Arthroscopic debridement	37	2.7	15	0	15	120	140	20	38.6
18	ACL injury	Arthroscopic debridement	44	11.3	10	5	5	125	135	10	123.1
19	Osteochondritis dissecans	Arthroscopic debridement, MUA	39	10.0	20	3	17	100	111	11	147.2
20	Post-arthroscopic infection	I&D	40	1.4	25	-5	30	55	96	41	6.8
21	Tibial/Fibular fracture	ORIF tibial plateau fracture	53	11.6	15	6	9	135	140	5	3.0
22	ACL injury, medial and lateral meniscus tear	MUA	22	4.8	5	-2	7	145	145	0	5.4
Means			34.0	9.9	17.4	1.8	15.6	108.1	127.3	19.2	44.2

ACLR, anterior cruciate ligament reconstruction; I&D, irrigation and debridement; MCLR, medial collateral ligament reconstruction; MPFL, medial patellofemoral ligament; MUA, manipulation under anesthesia; ORIF, open reduction and internal fixation; PVNS, pigmented villonodular synovitis; TTO, tibial tubercle osteotomy.

previous surgical procedures, and ROM findings may be found in Table 2. Concomitant procedures at the time of posterior capsule release included arthroscopic debridement in 18 patients, cyclops lesions excision in 5 patients, synovectomy in 3 patients, chondroplasty in 4 patients, ACL graft resection in 3 patients, and hardware removal in 1 patient. Most (94%) patients reported maintaining their extension ROM at a median 3.7 years after intervention (Table 3).

Overall, 3 (14%) patients required additional intervention for recalcitrant loss of extension: one underwent MUA, one underwent revision arthroscopic debridement with medial and lateral retinacular releases, and one underwent revision posterior capsular release and progressed to total knee arthroplasty at the time of final follow-up. One patient had persistent pain, decreased ROM, and functional deficits, and elected to undergo a through-knee amputation.

PROs were obtained for 18 (86%) of the 21 patients with native knees (one patient with a total knee arthroplasty was removed from analysis) at an average of 3.7 ± 3.3 years (range: 0.3-12.3). Three patients were unable to be contacted for PROs. VAS pain scores at rest and with use were both significantly improved at final contact (Table 4).

Patients who experienced extension deficit due to ACL-related pathology reported significantly higher IKDC (81 vs 51.3; P =.008) and Tegner (5.8 vs 3.6;

Table 3. Patient-Reported Outcomes*

Follow-Up in Years, Median (IQR)	3.7 (1.0-5.8)
IKDC score	70.2 (50.6-90)
VAS pain, at rest	0 (0-2)
VAS pain, with use	1.8 (0-5.3)
Tegner	4 (3.8-6.3)
Extension	
Maintained	17 (94%)
Worsened	1 (6%)

*Presented as median interquartile range (IQR), *n* (%) unless otherwise stated.

Table 4. Preoperative and Postoperative VAS Pain*

	Preoperative	Postoperative	ΔMedian	*P* Value
VAS pain, at rest	2 (0.5-4.5)	0 (0-2)	−2	.001
VAS pain, with use	5 (3-7)	1.8 (0-5.3)	−3.2	.017

VAS, visual analog scale.
*Presented as median interquartile range (IQR).

$P = .007$) scores with lower VAS pain scores (rest: 0.2 vs 1.8; $P = .008$; use: 1.3 vs 5; $P = .004$) compared to patients with other etiologies of extension deficit. Additionally, patients with ACL-related pathology (8/11) reached the PASS threshold for IKDC score more often compared to patients with other etiologies of extension deficit (0/7) (72.7% vs 0%; $P = .003$).

Discussion

The primary finding of this study is that arthroscopic posterior capsular release is an effective means to restore knee function, reduce pain, and improve range of motion in cases of persistent extension deficit of the knee. All patients except one (94%) reported maintaining the improvement in knee extension at final follow-up. In the present study, ACL reconstruction following injury was the most common etiology (59%), and patients who experienced posterior capsular contracture following ACL injury reported better subjective outcomes regarding pain and function at final follow-up compared to those with other etiologies of capsular contracture.

Regaining terminal knee extension is critical for achieving patient satisfaction and normal knee function. Sachs et al. reported that a loss of 5° of terminal extension could result in gait abnormality and contribute to patellofemoral pain with mild walking, and losses of 10° of extension is poorly tolerated.[23] Loss of knee flexion is better tolerated compared to loss in extension, particularly because of compensatory chronic quadriceps activation to maintain stance and increase contact forces in the patellofemoral joint.[10] Unfortunately, the opportunity for successful nonoperative management of flexion contractures decreases after 1 year from time of insult, with the ideal timeframe for surgical intervention within 9 months.[24] In the present study, nonoperative management was exhausted in all patients with mean time to capsular release of 8.0 months. Additionally, some patients in this cohort had prior intra-articular surgical intervention, such as debridement without success. LaPrade et al. described a similar cohort of patients who had failed multiple modes of conventional treatment, reporting efficacy with release as a technique for persistent cases.[19] The present investigation mirrors this result, with improvement of median extension to 0° at final follow-up, which was maintained at an average of 3.7 years in most patients. Recalcitrant cases, though uncommon when viewed in the context of flexion contractures entirely, can be the most troubling for clinicians. These results support posterior capsular release as a viable technique for treating persistent loss of terminal knee extension.

Another consideration regarding surgical intervention for posterior capsular contracture is open capsulotomy versus arthroscopic release, or a combination of the two. Tardy et al. investigated 12 patients with chronic flexion contracture after ACL reconstruction treated with both arthroscopic and open posterior release and reported an improvement of terminal extension.[25] Similarly, Wierer et al. and LaPrade et al. both reported improvements in terminal extension using arthroscopic intervention alone.[19,26] The present study adds to this body of work as an all-arthroscopic technique was used with satisfactory results. Although more technically challenging, arthroscopic procedures, when compared to open procedures, generally have decreased operative times, less postoperative pain, faster recovery, and reduced risk of complication.[27] Arthroscopic posterior capsule release provides a less invasive means to treat capsular contracture than arthrotomy and open debridement.

Two previous studies have reported PROs to determine subjective patient knee function after posterior capsular release for extension deficits. In a cohort of post-ACL reconstruction patients treated with open posterior capsular release by Tardy et al., the average IKDC score was 86.4 at final follow-up of 38 months, and all patients except one (92%) reached the minimum PASS-IKDC threshold.[25] Additionally, Wierer et al. investigated post-ACL reconstruction patients treated arthroscopically for extension deficit and reported improvement in median Lysholm score from 52 to 92 at final follow-up of 25 months.[26] Of note, the literature suggests that surgery for loss of motion after ACL reconstruction does not significantly influence knee function at 2 years postoperatively.[28] Similarly, the present study found that most patients with ACL-related etiology reached the IKDC-PASS threshold at final follow-up. It is possible that ACL-related pathology results in a lesser "hit" to the knee when compared

to those who experienced osteocartilaginous injury, as studies have demonstrated increased rates of arthrofibrosis development with concomitant procedures or complex injuries.[6,29] Accordingly, patients with an ACL-related etiology of extension deficit may be appropriately counseled regarding a postoperative return to satisfactory knee function after arthroscopic intervention. Overall, arthroscopic posterior capsular release in conjunction with detailed rehabilitation is an effective option for cases of continued extension deficit after failed nonoperative management.

Limitations

This study is not without limitations. First, the retrospective nature of the current investigation introduces the possibility for surgeon and selection bias. Second, the relatively small sample size and diverse etiology makes it difficult to perform subgroup analyses that are sufficiently powered. This includes the analyses to determine factors associated with poor outcomes within our cohort. Lastly, while the heterogeneity of our patient cohort may be more generalizable, these differences must be taken into consideration when interpreting the presented results.

Conclusion

Arthroscopic posterior capsular release for recalcitrant flexion contracture provides an effective means for reducing pain and restoring terminal extension. The improvement in extension postoperatively was maintained for most (94%) patients at final follow-up with a 14% reoperation rate.

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