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Open Debridement and Soft Tissue Release as a Salvage Procedure for the Severely Arthrofibrotic Knee*

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ABSTRACT

Postoperative loss of knee motion is a well-recognized phenomenon. This paper reports our results with open debridement and soft tissue release as a salvage procedure in the treatment of patients with severe arthrofibrosis on whom arthroscopic surgical techniques had failed. Eight knees (eight patients) were identified retrospectively. There were four men and four women; mean age was 29 years. All had severely restricted motion with extensive intraarticular and periarticular fibrosis. Range of motion averaged 62.5° preoperatively (flexion 81°, loss of extension 18.8°). Patients underwent open debridement and soft tissue release to restore motion. There were no complications. Motion improved to an average of 124° after surgery. Average flexion improved from 81° to 125°. Loss of extension improved from 18.8° to 1.25°. Functional outcome was good, with Lysholm II scores averaging 79. Patient satisfaction was high. There was a high incidence of patellofemoral arthritis at follow-up. Furthermore, the patellar tendon shortened approximately 6 mm over time. While we do not advocate open debridement and soft tissue release as a first-line treatment for arthrofibrosis, we do conclude that it can be effective as a salvage procedure to restore motion in the profoundly arthrofibrotic knee.

Postoperative loss of knee motion is a well-recognized phenomenon with an incidence ranging from 4% to 35%.[5,10,20] Arthrofibrosis is the term that characterizes this process and represents a spectrum of pathologic abnormalities.[17] Loss of motion is seen after ACL reconstruction[3,5] but occurs even more frequently after multiligament knee injuries or knee dislocations.[1]

Excess scarring results in knee stiffness and restricted passive motion. This leads to abnormal joint kinematics, poor function, and early joint arthrosis.[15] Intraarticular, periarticular, or extraarticular processes can all be involved. The pathoanatomy covers a broad spectrum that includes adhesive bands,[12,19] cyclops lesions, patella infera syndrome,[11] and infrapatellar contracture syndrome.[14] Motion loss can also be the result of a technical error, such as a malpositioned graft that impinges in the notch or an insufficient notchplasty that blocks full extension. Occasionally, arthrofibrosis manifests as a more intense process of scarring about the knee. Such patients have joint ankylosis and patellar entrapment.[1] Their knees are swollen and stiff with "woody" fibrosis extending into the quadriceps muscle. The joint capsule has lost its compliance and restricts motion. Despite the cause or severity, however, most patients will respond to physical therapy, manipulation, or arthroscopic soft tissue release.[3,5,8,10,13,14,16–21]

A small subset of patients, however, will fail nonoperative and arthroscopic techniques to restore motion. In these patients, severe periarticular and intraarticular fibrosis may make arthroscopic techniques technically impossible, or obvious extraarticular contractures or malpositioning of grafts may destine other techniques to failure. An open procedure becomes the logical alternative. This paper reports our results with open debridement and soft tissue release, as a salvage procedure, for the treatment of patients with severe arthrofibrosis on whom arthroscopic treatment has been unsuccessful.

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TABLE 1
Data on the Eight Patients in this Study

Age (years)	Initial diagnosis[a]	Mechanism of injury	Surgery after injury[b]	Previous procedures[c]
43	MM tear	Fall	Subtotal meniscectomy for septic arthritis	Arthroscopic lysis × 2, open I&D, release, MUA
22	ACL tear	Basketball	Acute open ACL reconstruction (BPTB)	MUA/arthroscopic lysis × 2
25	ACL tear	Football	Acute ACL reconstruction (BPTB), MM repair	MUA, MUA/arthroscopic lysis
37	Tibial plateau fracture, ACL/PCL/MCL/LCL tears	Motor vehicle accident	ORIF/ICBG, MM repair, PCL, MCL, LCL reconstruction	MUA/arthroscopic lysis
29	ACL, MCL, PCL tears	Motor vehicle accident	Acute open PCL, MCL reconstruction	Arthroscopic lysis
26	ACL/PCL/MCL tears	Skiing	Acute open ACL/PCL reconstruction (hamstring tendon)	MUA/attempted arthroscopy
31	ACL/MM/LM tears	Skiing	Acute ACL reconstruction (hamstring tendon)	MUA
19	ACL/MM tears	Basketball	MM repair, acute open ACL reconstruction (BPTB)	Arthroscopy

[a] MM, medial meniscus; MCL, medial collateral ligament; LCL, lateral collateral ligament.
[b] BPTB, bone-patellar tendon-bone; ORIF, open reduction and internal fixation; ICBG, iliac crest bone graft.
[c] I&D, irrigation and debridement; MUA, manipulation under anesthesia.

MATERIALS AND METHODS

Patients

The study was retrospective. Informed consent was obtained. Eight patients, each with one injured knee, were included. All patients had been referred to the senior author (TLW) for treatment of extensive postoperative loss of knee motion. All had failed nonoperative and arthroscopic treatment and were treated with open debridement and soft tissue release as a salvage procedure for restoring motion.

There were four men and four women. Mean age was 29 years (range, 19 to 43). The most common initial injury was an ACL tear, with or without associated injuries, in seven of eight patients (Table 1). The most common original operations (in five of eight patients) were acute ACL reconstructions (within 1 month after injury). Risk factors for postoperative arthrofibrosis included multiligament injuries (in five of eight patients), acute (within 1 month of injury) reconstructions (in five of eight patients),[20,22] and septic arthritis (in one of eight patients). Each patient averaged 1.75 previous procedures (range, 1 to 5) for treatment of their motion loss.

When the patients were examined at our institution, we found that their mean arc of motion was 62.5° (range, 20° to 110°), mean flexion was 81° (range, 40° to 130°), and mean extension was 18.7° (range, 15° to 20°) (Table 2). The mean time from the original operation to open debridement and soft tissue release was 12.3 months (range, 6 to 19).

In all patients, the indication for surgery was functionally significant loss of motion. The severity and extent of periarticular and intraarticular fibrosis were marked. An open procedure was performed either because an arthroscopic release had failed to restore motion (in seven of eight patients), or because an arthroscopic procedure was technically impossible (in one of eight patients). In the patient in whom arthroscopy was aborted, extensive intraarticular adhesions and fibrosis coupled with myositis ossificans of the vastus lateralis muscle made the procedure technically impossible.

Anesthesia and Postoperative Analgesia

All patients received regional epidural anesthesia. After surgery, epidural catheters were left in place for patient-controlled analgesia. We believe, as do others,[22] that this type of anesthesia provides better postoperative pain control and therefore allows more intensive physical therapy in the immediate postoperative period. The standard pain-control protocol involved fentanyl citrate and mepivacaine hydrochloride with a low-dose continuous infusion and a patient-controlled rescue dose, up to a maximum of four doses per hour. Patients were assessed by a separate pain management team who titrated analgesics individually.

Surgical Technique

Each knee was approached systematically. Our goals were to restore motion and return the normal roll and glide

TABLE 2
Knee Motion (in Degrees) of the Eight Patients in this Study

Flexion		Extension	
Preoperative	Postoperative	Preoperative	Postoperative
40	120	−20	0
70	135	−15	0
80	120	−20	0
90	110	−20	−5
90	120	−20	0
40	110	−15	−5
130	145	−20	0
110	140	−20	0

kinematics to the knee. To restore flexion, we performed release of the capsular contractures, intraarticular fibrosis, and restricted patellofemoral mechanisms. To restore extension, we addressed anterior fibrosis, posterior capsular scarring, and graft-notch problems.

A tourniquet was placed around the upper thigh. After induction of regional anesthesia, passive range of motion in the affected limb was assessed and recorded. The lower extremity was then prepared and draped in the standard fashion. Previous incisions were identified. The limb was exsanguinated, and the tourniquet was inflated to approximately 350 mm Hg.

Surgical Approach and Medial Release

An anterior extensile approach to the knee was performed. When feasible, a standard midline incision was performed. Previous incisions were incorporated or modified as needed. The subcutaneous tissues were dissected and the extensor mechanism was visualized. To avoid compromising blood flow, undermining of soft tissue flaps was avoided. A medial parapatellar arthrotomy was performed through the medial aspect of the quadriceps tendon and the medial retinaculum, over the medial aspect of the patella, and down onto the anterior tibia.

An extensive medial release was then performed by careful subperiosteal dissection of the soft tissues over the medial tibial cortex. The periosteum was elevated to the level of the posterior tibial plateau, and the subperiosteal dissection included the deep medial collateral ligament and the semimembranosus tendon.[23] This release helps in mobilizing the tibia and regaining extension. Care was taken to maintain a medial soft tissue sleeve and to preserve the superficial medial collateral ligament.

The medial and lateral gutters were reestablished. A combination of blunt and sharp dissection was required to remove the dense adhesions and fibrosis that were encountered. Using sharp dissection, the anterior joint capsules and intraarticular adhesions/fibrosis were thoroughly debrided.

Extensor Mechanism Release and Patella Eversion

Scar tissue was universally encountered in the infrapatellar fat pad. This was carefully removed and the patellar tendon was mobilized from the anterosuperior border of the tibia. Particular care was taken to preserve the insertion of the patellar tendon into the tibial tubercle. Excessive tension on the patellar tendon was avoided. Lateral retinacular releases were performed to assist in eversion of the patella and to gain additional exposure. These were performed using the inside-out technique. Care was taken to identify the superior lateral geniculate vessels, which were preserved if possible. When eversion of the patella was not possible, the arthrotomy was extended proximally, and extensor mechanism scar tissue was removed until the patella could be everted. In particularly tight knees, moving the tibia anteriorly while rotating it externally was a maneuver that helped with exposure. To be able to mobilize the patients immediately after surgery and to avoid further disruption of the extensor mechanism, quadriceps-plasties, such as rectus snips, V-Y plasties and patellar turndowns, were not performed.

The undersurface of the extensor mechanism and all peripatellar scar tissue were then excised until the patella was freely mobilized. Patellofemoral tracking was assessed at intervals throughout each procedure.

Ligament and Capsular Releases

After mobilization of the extensor mechanism, release of anterior structures, and excision of intraarticular adhesions, passive flexion and extension were assessed. The grafts could then be assessed for malposition and impingement. If present, the ACL was excised along with any associated hardware. The tibia was subluxated anteriorly, and the PCL and posterior aspect of the knee were then explored.

The knee was passively extended to check for PCL or capsular impingement. The capsule was inspected first. Because posterior capsular contractures were contributing to extension loss, generous posterior capsular releases were performed. We used the "femoral peel," as advocated by Windsor and Insall[23] to release flexion contractures in revision knee arthroplasty. Dense femoral scar tissues were "peeled" away from the posterior femur effectively skeletonizing the femur. Medial and lateral collateral ligaments were protected. The posterior capsule was also debrided of any thickened scar tissue. If the PCL was malpositioned or impinged, or if it blocked motion, it was excised. If a flexion contracture remained after these releases, the posterior capsule was further released from the proximal tibia using a periosteal elevator or a large currette. This subperiosteal dissection was carried distally until full extension could be achieved. Thus, in severe cases, both the posterior femur and tibia were skeletonized in a single posterior layer.

Closure

After deflating the tourniquet, meticulous hemostasis was performed with electrocautery. It has been our experience that postoperative hemarthrosis contributes significantly to pain and flexion contractures and may cause a more intense inflammatory response. Therefore, suction drains were also used routinely to prevent hemarthrosis and were left in place for 24 to 48 hours after surgery. Closure was also meticulous. Although the arthrotomy was not directly repaired, to leave the extensor mechanism free, the subcutaneous tissues and skin were closed tightly in layers.

Surgical Findings and Additional Procedures

At surgery, all eight patients had extensive periarticular and intraarticular fibrosis with complete obliteration of the suprapatellar pouch and peripatellar gutters. Sprague et al.[19] have described a classification based on pathoanatomy (Table 3). Extracapsular involvement, characterized by bands of tissue running from the proximal patella

TABLE 3
Sprague et al.[19] Pathoanatomic Classification of Arthrofibrosis

Group	Pathoanatomy
1	Discreet bands or a single sheet of adhesions traversing suprapatellar pouch
2	Complete obliteration of suprapatellar pouch and peripatellar gutters with masses of adhesions
3	Multiple bands of adhesions or complete obliteration of suprapatellar pouch with extracapsular involvement with bands of tissue from proximal patella to anterior femur

to the anterior femur (Sprague group 3), was found in all eight patients. The next most common finding at surgery was a malpositioned or tight graft (in six of eight patients). All eight patients were left with ACL-insufficient knees. Seven of our patients had their ACLs released; the other patient did not have an ACL. Two patients required complete PCL release for restoration of motion. Another required extensive debridement of his native PCL. To various degrees, posterior capsular releases were performed in all eight patients. Four patients required the more extensive capsular releases that included both the posterior femur and tibia.

Having removed all intraarticular adhesions and fibrosis, the menisci and chondral surfaces were inspected and additional procedures were performed as indicated. Retropatellar and trochlear articular lesions were treated with chondroplasty (in one of eight patients), myositis ossificans of the vastus lateralis muscle was excised (in one of the eight patients), and the anterior horn of the medial meniscus was repaired (in one of the eight patients).

Figure 1. The custom, drop-lock extension orthosis used postoperatively to maintain extension.

Postoperative Treatment

Patients were administered intravenous corticosteroids (100-mg hydrocortisone every 8 hours) beginning in the recovery room for 48 hours after surgery. Cryotherapy was also initiated immediately after surgery to decrease edema and pain. Compressive dressings were used to minimize edema. Continuous passive motion (0° to 60°, 6 hours per day) was begun on the day of surgery, and patients were encouraged to reach 90° of flexion. A custom, drop-lock extension brace was worn at night and in bed to maintain full extension (Fig. 1).

Physical therapy, including both active and passive motion, was initiated in the recovery room, with daily sessions in the morning and afternoon thereafter. Patients were also taught self-assisted motion exercises. Patients were prescribed toe-touch weightbearing and were advanced to full weightbearing by 2 weeks. Early quadriceps muscle activity was advocated. Discharge criteria included full extension, flexion to 60°, pain control, and independence in ambulation, transfers, exercise, and brace routine. After discharge, supervised physical therapy sessions in an outpatient facility were combined with a home exercise program. Patients continued to use continuous passivemotion and wore the drop-lock brace at night. Weeks 1 to 6 were characterized by progressive weightbearing; active and passive motion (0° to 120°); hip, hamstring, and calf progressive resistive exercises; isometric exercises; patellar mobilization; short-crank bicycle ergometry; and cryotherapy. Thereafter, the program was individualized according to each patient's progress. Weeks 6 to 12 emphasized restoration of a normal gait, and patients began closed chain quadriceps muscle-strengthening in a 90° to 40° arc (leg press, partial squats, wall slides). A proprioception program was begun and endurance exercises were initiated. After week 12, a functional exercise program was initiated and running was allowed. Throughout the rehabilitation, emphasis was placed on maintaining and improving flexibility.

Because the mechanical blocks to motion were removed, patients had full motion restored at surgery. Most patients, however, lost some motion in the immediate postoperative phase, but they showed improvements by the first postoperative visit (10 to 14 days). Slow but steady progress in motion continued until 9 months to 1 year after surgery.

TABLE 4
Del Pizzo et al.[4] Grouping for Arthrofibrosis

Group	Extension	Flexion	Severity
1	<5°	>110°	Mild
2	5°–10°	90°–110°	Moderate
3	>10°	<90°	Severe

TABLE 5
Modified Blauth and Jaeger[2] Grading for Arthrofibrosis

Grade	Range of motion	Severity
I	>120°	Mild
II	80°–120°	Moderate
III	40°–80°	Severe
IV	<40°	Extreme

TABLE 6
Shelbourne et al.[17] Classification of Arthrofibrosis

Type	Flexion	Extension
1	Normal	<10°
2	Normal	>10°
3	>25°	>10°
4	>30°	>10° with patella infera

Complications and Subsequent Procedures

There were no complications. Four subsequent procedures were performed in three patients. No patients required further open debridement and soft tissue release. One patient underwent manipulation under anesthesia in the immediate postoperative period for failure to maintain adequate motion; another underwent arthroscopic debridement and manipulation under anesthesia after 3 months for recurrent scar formation and loss of extension, with a further arthroscopic debridement for patellofemoral arthrosis at 7 months. At 7 months, one patient had complaints of instability. Initially, she had suffered a posterior knee dislocation and had had her PCL repaired. At examination, she had lacked 20° of extension. At surgery, she had undergone an extensive posterior capsular release (femoral and tibial) and had her PCL excised because it was fibrotic and tight. Her ACL was also noted to be absent. By 3 months, she had regained most of her motion and at 7 months had symptoms of instability. At 9 months, she underwent an ACL/PCL reconstruction with allografts.

Outcomes

All patients were available for follow-up at a mean of 57 months (range, 9 to 113). Preoperative and postoperative ranges of motion were documented. In an attempt to understand the cause or causes of arthrofibrosis and to determine its treatment and predict its outcome, classification schemes have been developed for patients with the

TABLE 7
Modified Lysholm II Knee Score for the Eight Patients in this Study

Function	Score
Limp	
None	5
Slight or periodic	3
Severe and constant	0
Support	
None	5
Stick or crutch needed	2
Weightbearing impossible	0
Locking	
None	15
Catching sensation, but no locking	10
Locking occasionally	6
Locking frequently	2
Locked joint at examination	0
Instability	
Never	25
Rarely during athletic activities	20
Occasionally during daily activities	10
Often during daily activities	5
Every step	0
Pain	
None	25
Inconstant and slight during strenuous activities	20
Marked during or after walking more than 2 km	10
Marked during or after walking less than 2 km	5
Constant	0
Swelling	
None	10
After strenuous activities	6
After ordinary activities	3
Constant	0
Stairs	
No problem	10
Slight problem	6
One step at a time	3
Impossible	0
Squatting	
No problem	5
Slight problem	4
Not beyond 90° of flexion of the knee	2
Impossible	0

disease. Del Pizzo et al.,[4] Blauth and Jaeger,[2] and Shelbourne et al.[17] have outlined classifications based on motion loss (Tables 4 through 6). We retrospectively classified all patients according to these three rating schemes and reclassified them at the most recent follow-up. To quantify functional outcome, a modified Lysholm II score (Table 7) was determined.[9] Subjective patient assessments were also made. Preoperative and postoperative radiographs of the involved knees were compared. The lengths of the patellar tendon and patella on the lateral radiograph were recorded. The Insall-Salvati index[7] was calculated by dividing the length of the patellar tendon by the longest diameter of the patella. The normal range is from 0.80 to 1.20, with patella infera defined as an Insall-Salvati index less than 0.80. Statistical analysis was performed, and results were compared using the paired Student's *t*-test. The threshold for statistical significance (alpha) was set at $P \leq 0.05$.

RESULTS

Motion

Range of motion increased significantly in all patients. Patients gained, on average, 62° of motion. Flexion improved from a mean of 81° (range, 40° to 130°) to a mean of 125° (range, 110° to 145°). Extension loss improved from a mean of 18.8° (range, 15° to 20°) to a mean of 1.25° (range, 0° to 5°). Table 2 lists the data for individual patients. All improvements in range of motion were highly statistically significant ($P < 0.01$). Patients' classifications also correspondingly improved as they regained motion (Table 8).

Functional Outcome and Patient Satisfaction

Mean improvement in Lysholm II scores was 35.5 points per patient (Table 9) ($P < 0.05$). Only one patient noted a slight or periodic limp. No patient used an assistive device for ambulation. While all patients were able to return to sports, only one patient, a collegiate basketball player, was able to achieve her preinjury level. Another patient, who had come to our hospital with severe joint stiffness (25° total range of motion), was able to return to rock climbing, although he did note some difficulty at the extremes of flexion. Subjectively, all eight patients reported that they were very satisfied with their results.

Radiographs

Knee joint arthrosis was common on follow-up radiographs (in five of the eight patients). The patellofemoral joint was the most commonly involved compartment (Figs. 2 and 3). Before surgery, patients tended to have patella infera, although none had an Insall-Salvati index of less than 0.08. It is very interesting to note that the patellar tendon continued to shorten with time. While the mean length of the patella remained fairly constant, at 46 mm before surgery and 47 mm at the most recent follow-up (no significant difference, $P = 0.5$), the mean patellar tendon length decreased from 45 mm before surgery to 39 mm at the most recent follow-up ($P = 0.01$), clearly indicative of ongoing extensor mechanism problems. The calculated Insall-Salvati index correspondingly decreased from a mean of 0.98 preoperatively to 0.84 at most recent follow-up ($P = 0.04$).

TABLE 9
Lysholm II Scores for the Eight Patients in this Study

Lysholm II scores	
Preoperative	Postoperative
25	83
83	69
45	80
15	73
23	82
29	83
48	94
80	68

DISCUSSION

While postoperative knee stiffness is relatively common, most stiff knees respond well to conservative therapy, manipulation, or arthroscopic release. Those that do not respond to these therapies present a significant challenge. To our knowledge, there is no report clearly documenting the clinical and radiographic course in this subset of patients. While the incidence of arthrofibrosis that is refractory to arthroscopic treatment remains unknown, we believe it is relatively low. Only eight patients, of several thousand seen by the senior author, fell into this category. It is important to recognize that seven of eight patients in this study were specifically referred by other surgeons for profound motion loss and that all eight patients had failed results with less invasive techniques to restore motion.

We do not advocate open debridement and soft tissue release as a first-line treatment approach. The literature and our own experience clearly support that most patients, even those with severe motion loss, can be treated by more conservative means.[3–6,8,10–13,16–19,21,23] This technique should be considered a salvage procedure reserved for the severely arthrofibrotic knee that has failed less invasive techniques.

Noyes et al.[10] reported on 207 knees that had motion loss after ACL reconstruction. After aggressive physical therapy, manipulations, and arthroscopic procedures, profound motion loss was found only in two knees. Cosgarea

TABLE 8
Motion Classification for the Eight Patients in this Study

Del Pizzo et al.[4] group		Blauth and Jaeger[2] grade		Shelbourne et al.[17] type	
Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative
3	1	4	1	4	0
3	1	3	1	4	0
3	1	3	1	4	0
3	1	3	2	4	1
3	1	3	1	4	1
3	2	4	2	4	1
3	1	2	1	3	0
3	1	2	1	4	1

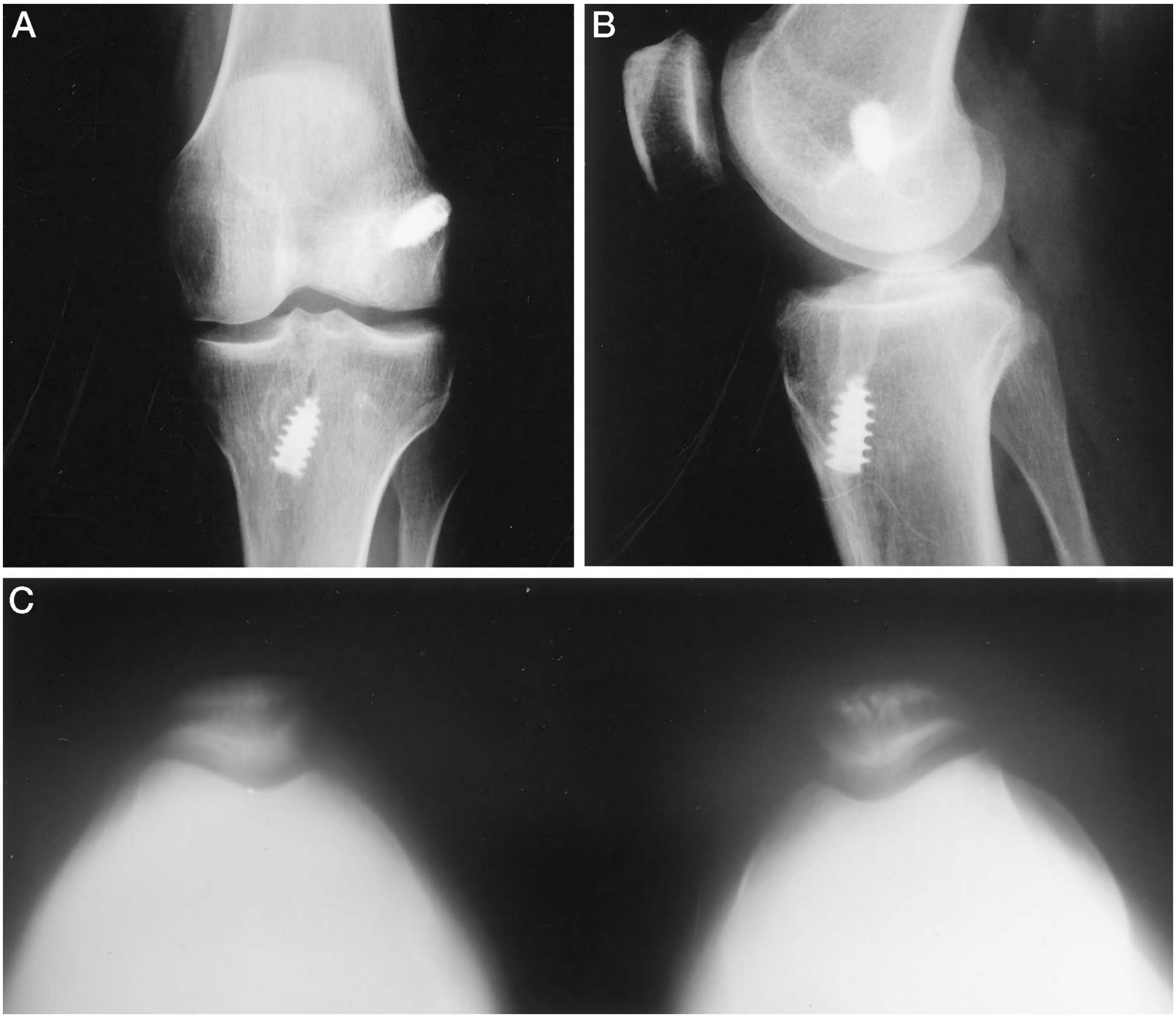

Figure 2. Radiographs of the knee of a 27-year-old, former women's collegiate basketball player who had undergone an ACL reconstruction. She subsequently developed severe motion loss due to arthrofibrosis and underwent open debridement and release. At 6 years after surgery AP (A), lateral (B), and Merchant view (C) radiographs demonstrate an excellent result with only mild medial and patellofemoral joint arthrosis. Note the early osteophyte formation at the medial joint line and the inferior pole of the patella.

et al.[3] had 1 patient, of 61 patients with arthrofibrosis, who had failed results after less invasive measures. This patient underwent posteromedial capsulotomy, excision of intraarticular adhesions, and posterior capsular release for persistent motion loss. Harner et al.[6] reported that, of 255 patients who underwent ACL reconstructions, 27 suffered loss of motion. Of these, six required an open procedure to reestablish motion, and the authors report that all improved. None of these reports detail the surgical technique or outcome in this patient population. Benum[1] performed the only other study that specifically examined patients who required open procedures to restore motion after surgical treatment of knee injuries and posttraumatic conditions. In that series, seven patients underwent extensive capsulotomy. Range of flexion improved from 70° to 134°. No patients complained of postoperative instability, and patient satisfaction was also high.

Sprague et al.[19] described a classification scheme for arthrofibrosis based on the pathoanatomy of the knee. The most severely involved patients, classified as group 3, had complete obliteration of the suprapatellar pouch and peripatellar gutters and did not regain flexion after arthroscopic debridement. These patients also had extracapsular involvement with bands of tissue extending from the proximal patella to the anterior femur. All eight patients in our series had severe arthrofibrosis with pathoanatomy that could be similarly classified. Many of our patients, however, also had other causes of motion loss, the most common of which was graft malposition. While associated causes of arthrofibrosis were identified in many of our

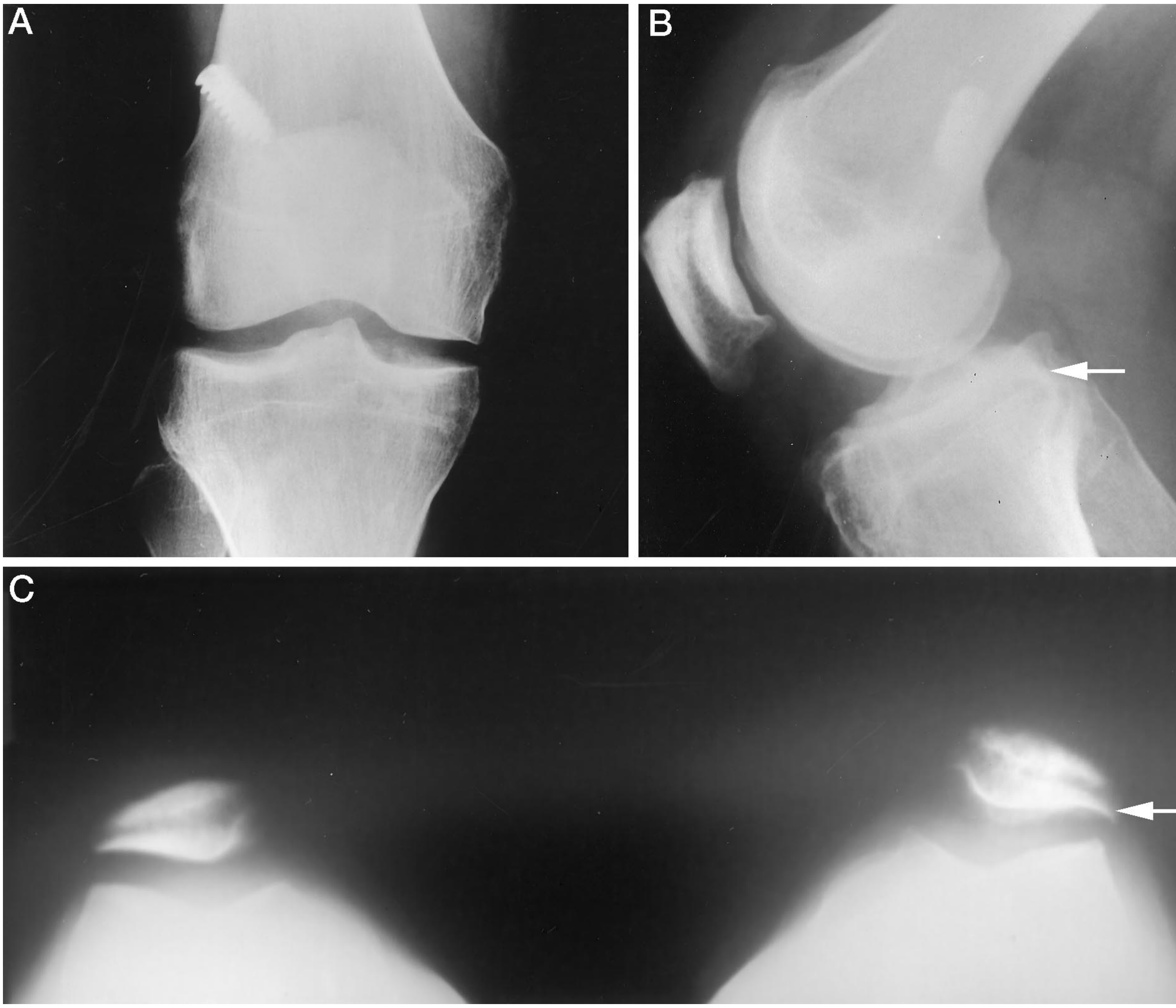

Figure 3. Radiographs of the knee of a 25-year-old male recreational basketball player who suffered an ACL tear. He underwent open debridement and release as a salvage procedure for his severely arthrofibrotic knee. A, the AP radiograph at 7 years after surgery shows medial joint space narrowing, osteophyte formation, and some subchondral sclerosis. B, the lateral radiograph demonstrates patellofemoral arthrosis with osteophytes inferiorly and superiorly on the patella. Posterior tibial osteophytes can also be seen on this view (arrow). C, the Merchant view shows sclerosis and early patellofermoral degenerative changes (arrow).

patients, we can only speculate as to the overall mechanism. It is likely that many factors, including genetics, mechanism and pattern of injury, timing of surgery, surgical technique, and postoperative rehabilitation, contributed to the pathogenesis of motion loss.[6,10,20,23]

The four-part classification scheme that Shelbourne et al.[17] described for arthrofibrosis occurring after ACL reconstruction is useful in that it provides both a descriptive and prognostic guide. All patients in that series were treated arthroscopically with intensive postoperative rehabilitation. Sixteen patients had lost at least 30° of flexion and greater than 10° of extension and had patella infera (type 4). This group, which is most similar to our patients, had less predictable results than other groups, with an average gain of 18° of extension and 42° of flexion. Moreover, 5 of the 16 patients in that study failed to regain full extension, and 1 patient had an unsuccessful result. When comparing this study with ours, one should remember that they differ on several counts. Our population was not restricted to patients with ACL reconstructions, and many of our patients had suffered more severe initial injuries that required more extensive surgery. Moreover, all of our patients had already had failed results with arthroscopic attempts at restoring motion. Nevertheless, the average extension gain and flexion gain were very similar in the two studies.

As a prerequisite to consistently achieving successful results, we believe that adequate visualization is required so that all pathologic structures can be debrided or excised. Occasionally, this cannot be accomplished with arthroscopic techniques. While open debridement and soft tissue release is clearly associated with a greater shortterm operative morbidity, there are advantages to the open procedure. These include the ease of debridement and the ability to excise periarticular and extraarticular lesions. Graft position, function, and impingement can also be evaluated. The extensor mechanism can be mobilized more thoroughly. The posterior capsule is more easily assessed and can be more thoroughly released through an open procedure. The femoral or tibial capsule or both can be released to gain additional extension. When extensive debridement is required, an open technique permits more thorough hemostasis, which prevents postoperative flexion contractures and possibly diminishes the inflammatory response. The use of suction drains may further prevent hemarthrosis after surgery. A similar degree of hemostasis may be difficult to achieve with arthroscopy. Shelbourne et al.[17] reported that, after arthroscopic treatment of patients with type 4 arthrofibrosis, extensive hematoma was common because of resection of the medial and lateral structures of the patella.

We believe that, at the time of surgery, it is essential to reestablish the normal roll and glide of the knee. The joint kinematics are significantly altered not only by the extensive fibrosis but also by the loss of dynamic and static stabilizers of the knee. Any structure, be it pathologic or not, that alters the normal roll and glide motion must be excised. Structures that can block extension include a malpositioned graft (anterior tibial tunnel), a fibrotic cruciate ligament, a cyclops lesion, excessive anterior scar, an insufficient notchplasty, a fibrotic posterior capsule, or any combination of these. Each must be addressed systematically. The literature has demonstrated that extension loss consistently results in greater morbidity and difficulty with ambulation than does flexion loss.[14] Therefore, it is critical to regain full extension at the time of surgery. In this patient population, postoperative methods for restoring extension were simply inadequate. The degree of immediate postoperative flexion was less of a concern. In our experience, additional flexion can usually be achieved with rehabilitation. The custom drop-lock knee orthosis that we used to maintain extension, although not as rigid as casting, was well-tolerated and could be removed for range of motion exercises and bathing. Alternative techniques of splinting have been described and may be equally efficacious.[17]

In addition to the surgical release, a rigorous postoperative regimen was also followed. Intravenous systemic corticosteroids were administered to decrease inflammation in the immediate postoperative period. They have been used in a variety of inflammatory disorders, and we found them effective and without any adverse effects. Postoperative pain control is imperative for the maintenance of motion gained after manipulation or arthroscopic debridement of arthrofibrosis. We believe that regional anesthesia is superior when postoperative analgesia is continued through an indwelling epidural catheter. Excellent analgesia allows for early motion. Although we did not study this issue specifically, our patients were consistently pleased with their pain control. Accordingly, there was a decrease in the use of systemic narcotics and an increase in early knee motion. Our postoperative rehabilitation program was modified from our standard ACL protocol. We believe that aggressive rehabilitation is paramount for success.

Good knee function requires nearly normal active and passive range of motion with sufficient strength to perform activities of daily living, work, and sports. Despite the difficulties of this patient population, we obtained improvements in motion and function that were consistently good and statistically significant. Furthermore, functional outcomes and patient satisfaction were high. While others have expressed concerns about renewed scar formation and subsequent stiffness,[8] this was not borne out in our series. Consistent with other reports in the literature,[1,17] we found symptomatic instability in the ACL-deficient knee to be uncommon. Our study does suggest, however, that when both cruciate ligaments and the posterior capsule are released, instability may result. Therefore, patients who require PCL release to restore motion should to be informed about the potential for recurrent instability.

While results from this study were encouraging, only one patient was able to return to her preinjury level of competition. Furthermore, we have concerns about progressive joint degeneration and continued patellofemoral arthrosis. It is not surprising that, given the traumatic and surgical insults to the knees in this study, radiographs demonstrated degenerative changes. Forceful manipulations and aggressive therapy may have contributed to chondral damage. Undoubtedly, the changes noticeable in the patellofemoral joint are linked with the progressive patellar tendon shortening. Patients who require open debridement and soft tissue release to salvage knee motion are at significant risk for the development of degenerative joint disease. The development of patella infera seems to accompany joint degeneration and may foreshadow further joint degeneration. Continued careful follow-up is obviously warranted.

We concluded that for select patients, in whom arthroscopic techniques have failed, open debridement and soft tissue release can be an effective salvage procedure to return mobility and function to the knee. The technique effectively restores motion and allows satisfactory functional recovery.

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