Arthroscopic Release for Symptomatic Scarring of the Anterior Interval of the Knee

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Background: Patients with a history of knee trauma or previous surgery may exhibit pain in the infrapatellar region that is refractory to conservative care. This may be due to subtle scarring of the anterior interval.

Hypothesis: Arthroscopic release of a scarred anterior interval will lead to improvement in anterior knee pain.

Study Design: Case series; Level of evidence, 4.

Methods: Twenty-five consecutive patients with isolated scarring of the anterior interval, confirmed with both magnetic resonance imaging (MRI) and arthroscopic examination, were included. All 25 patients had refractory anterior knee pain that was unimproved after a minimum of 6 months of physical therapy and nonsteroidal anti-inflammatory medications and pain during knee extension. All patients had a minimum of 2 previous surgical procedures, and 11 (44%) of the patients had a previous anterior cruciate ligament (ACL) reconstruction. All 25 (100%) patients had an apparent decrease in the cranial excursion of the patella and had a positive Hoffa test result. Fourteen (56%) patients had a preoperative flexion contracture of at least 5°. All patients underwent an isolated arthroscopic anterior interval release.

Results: All patients were evaluated by physical examination and standardized scoring instruments with an average follow-up of 4.0 years (range, 2.0-7.2). Twenty-one patients had full range of motion of the patella in all directions and a negative Hoffa test finding at final follow-up. All 14 (100%) patients with preoperative flexion contractures (>5°) experienced a full return of extension. The average Lysholm score improved from 59 preoperatively to 81 postoperatively ($P < .0001$). The average International Knee Documentation Committee (IKDC) score improved from 49 to 70 ($P < .001$). There were no complications. Four patients (16%) had failed results and required a second surgical release. Patients with failures had significantly lower preoperative Lysholm scores (score = 40) than those who did not (score = 58) ($P = .022$). Three of the failures were workers' compensation cases.

Conclusion: Scarring of the anterior interval changes the mechanics of the anterior structures of the knee and may lead to refractory anterior knee pain. Arthroscopic anterior interval release successfully provides pain relief in this patient population.

Keywords: anterior interval; scarring; anterior knee pain; infrapatellar fat pad

Anterior knee pain is common in athletes of any age.[3] Several anatomic structures in the anterior knee have been shown to be pain generators, including the medial and lateral retinaculum, infrapatellar fat pad, patellar tendon, patellar and tibial subchondral bone, as well as the anterior synovium and joint capsule. Occasionally, however, the origin is less clear, and the treatment success in these athletes with refractory knee pain is poor. Examination of the anterior interval may reveal subtle scarring, which may be responsible for pain in this patient population.

The senior author has defined the anterior interval of the knee as the space between the infrapatellar fat pad and patellar tendon anteriorly, and the anterior border of the tibia and the transverse meniscal ligament (anterior intermeniscal ligament) posteriorly.[13] No bridging scar tissue is normally present in this region.[13]

The structures of the anterior interval are mobile in the normal knee. The infrapatellar fat pad will displace posteriorly during flexion of the knee owing to pressure from the patellar tendon as the angle formed by the patellar tendon

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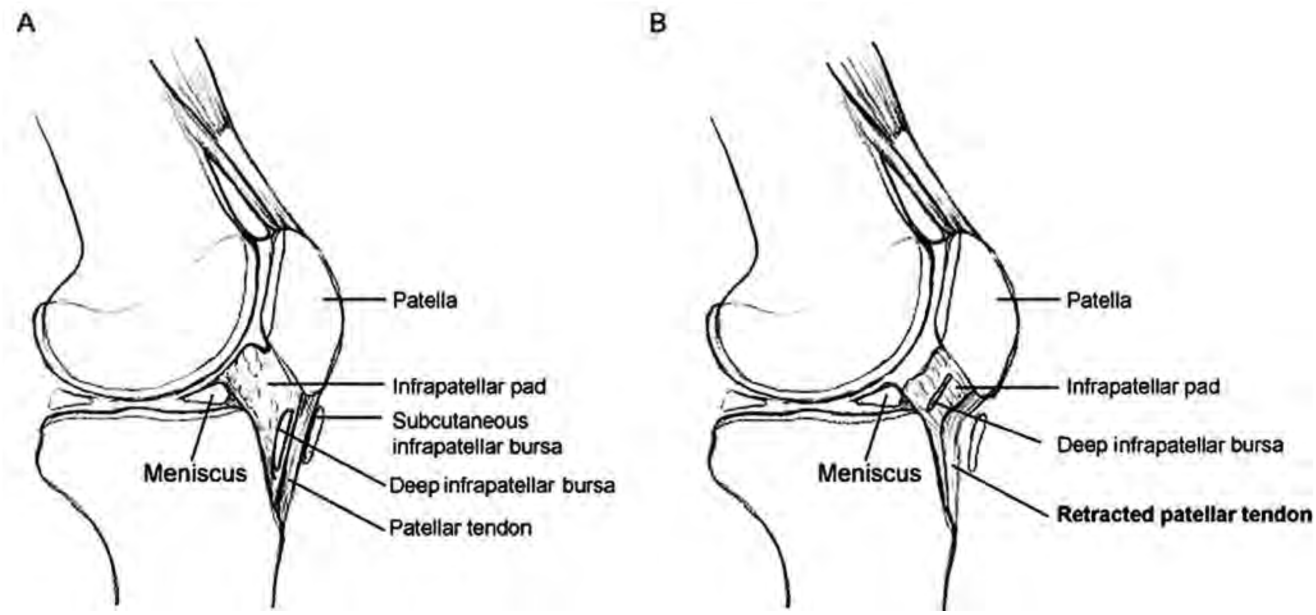

Figure 1. Normal anatomy of the anterior interval (A) and retraction of the patellar tendon with anterior interval scarring (B).

and anterior tibia decreases.[1] Conversely, extension moves the fat pad anteriorly away from the tibia. Previous studies have also shown similar movement of the transverse ligament.[7] Near full flexion, the transverse ligament moves in front of and above the ACL, while it moves anteriorly to the posterior margin of the fat pad near full extension.

If fibrosis courses from the fat pad to the transverse ligament and/or anterior surface of the tibia, it will lead to closure and dysfunction of the anterior interval. Closure of the anterior interval causes decreased excursion of the patellar tendon in relation to the anterior tibia (Figure 1).[1,14] The less elastic fibrotic tissue tethering the patellar tendon may cause stretching of the surrounding synovial tissue during knee extension, which is the position where the patellar tendon angle is the largest. Stretching of the synovium likely activates pain receptors and may lead to anterior knee pain and/or loss of full knee extension.[11]

The purpose of this study was to determine if release of the scarred anterior interval leads to less anterior knee pain and better patient function and activity level.

METHODS

Between 1998 and 2004, 25 patients were identified with isolated scarring of the anterior interval, which was confirmed with both MRI and arthroscopic examination. All 25 patients had refractory anterior knee pain. They were referred for surgical intervention after no improvement was seen following 6 months of physical therapy and nonsteroidal anti-inflammatory medications. All patients had pain during knee extension. The average age of the patients was 39 years (range, 18-66). There were 10 men and 15 women. Three patients were workers' compensation cases. All patients had a minimum of 2 previous surgical procedures, and 11 (44%) of the patients had a previous ACL reconstruction.

Imaging

All 25 patients had scarring of the anterior interval structures visualized on standard T1- and T2-weighted MRI images (Figure 2). All patients had at least mild chondromalacia of the patella and/or trochlea. None of the patients had evidence of meniscal tears, patellar tendinitis/tendinosis, or plica.

Scarring in the fat pad was differentiated from acute edema and hemorrhage by low signal changes on both T1- and T2-weighted images in the former and increased signal intensity on T2-weighted images in the latter. Because bone also has low signal intensity on MR images, plain radiographs were used to differentiate scar from ossification. An enlarged area of hypointensity or blooming effect on gradient echo images allowed differentiation of hemosiderin from fibrosis.[6]

Scarring was identified as an extensive fibrotic reaction coursing from the posterior portion of the fat pad to the anterior surface on the tibia and/or transverse meniscal ligament. Scarring was prominent at previous arthroscopic portal or incision sites and in the area of fat pad resection.

Physical Examination

Twenty-five (100%) patients had a subjective decrease in the cranial excursion of the patella. A Hoffa test was performed on all patients (Figure 3).[5] All 25 patients had a positive Hoffa test result. Range of motion was measured

Figure 2. An MRI of scarred anterior interval. The arrow indicates a low T1-weighted signal on the posterior border of fat pad, which is consistent with scar tissue.

in the supine position. Fourteen (56%) patients had a preoperative flexion contracture compared with the other knee (range, 5°-10°). A flexion contracture was defined as a 5° or more difference in flexion between the 2 knees. Two patients had an extension contracture of 5°. Six (24%) had peripatellar tenderness. None of the patients had an effusion. All patients had limitation of patellar mobility. This was measured by comparing the medial-lateral and superior-inferior glide with the opposite extremity.

Arthroscopic Technique

All patients underwent an isolated arthroscopic anterior interval release. The cornerstone of arthroscopic examination of the anterior interval began with the establishment of a modified anterolateral viewing portal (Figure 4). The viewing portal was established more lateral and proximal than the standard placement to allow visualization of the anatomical structures of interest and to avoid filling the fat pad with saline.

Viewing the anterior interval with the 30° arthroscope, the surgeon should visualize the infrapatellar fat pad at the anterior border of the interval. Extending the knee during direct visualization should show opening of the interval, including anterior translation of the fat pad and the transverse meniscal ligament. Normal anterior excursion of the anterior horns of the medial meniscus should also be seen. Flexion of the knee should close the interval, which correlates to posterior translation of the fat pad and transverse meniscal ligament.

The infrapatellar fat pad can be seen extending from the inferior pole of the patella to the anterior horns of the

Figure 3. Demonstration of the Hoffa test. For the Hoffa test, the thumb was placed at the margin of the infrapatellar fat pad and the patellar tendon with the knee bent 30°. Pressure was applied with the thumb, and the knee was fully extended. Increased pain in the fat pad indicated a positive test result.

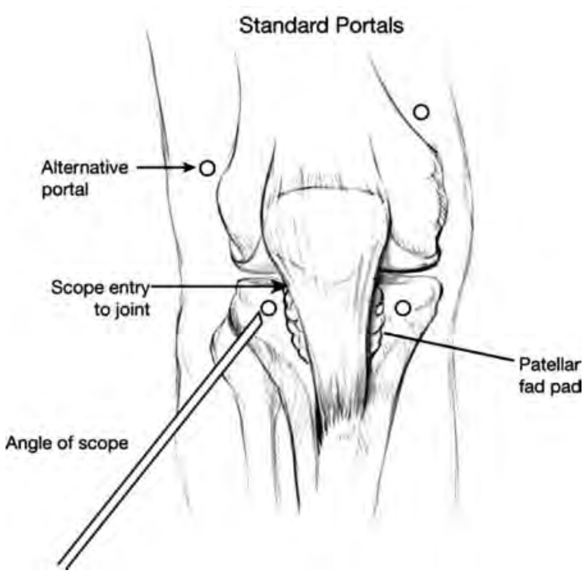

Figure 4. Three arthroscopic portals made in the superomedial, inferomedial, and high inferolateral positions. The portal placement was adjusted to allow for visualization of fat pad and anterior interval release. Reprinted with permission from Feagin JA, Steadman JR. *The Crucial Principles in Care of the Knee*. Lippincott Williams & Wilkins: Philadelphia; 2008.

menisci. The medial patellomeniscal ligament (Kaplan ligament) can be seen as a fibrous thickening coursing from the inferior pole of the patella, along the medial border of the fat pad, and attaching to the medial anterior horn. The lateral patellomeniscal ligament is often difficult to visualize with a hypertrophic fat pad and may have to be viewed from the anteromedial portal. If scarring is present, these structures are rarely visualized. The transverse ligament

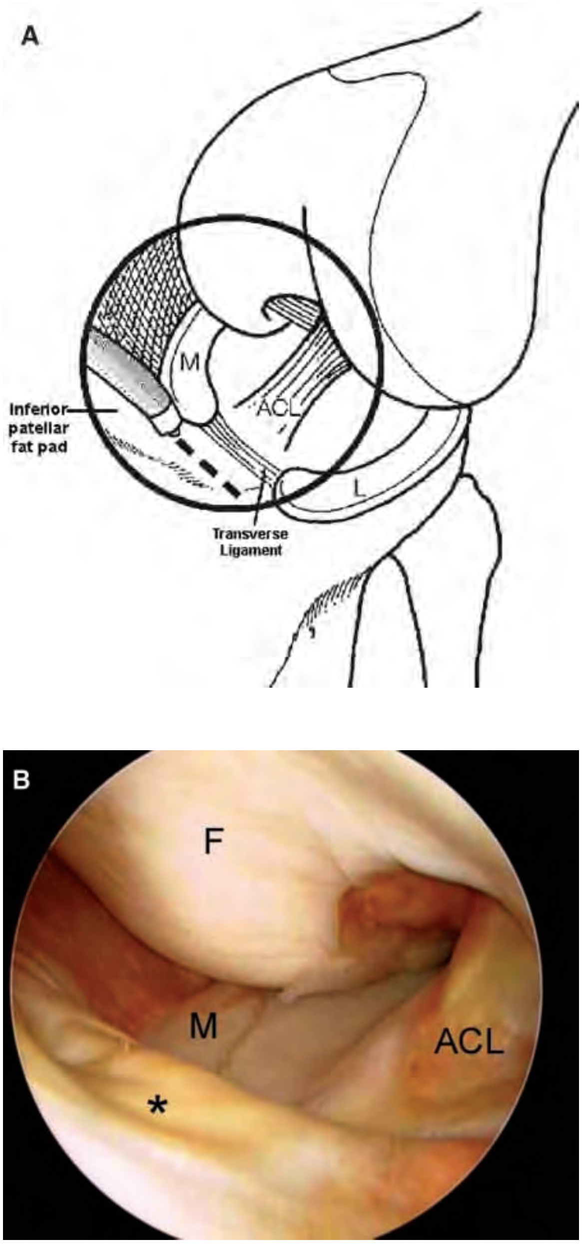

Figure 5. A, The interval release extends from the lateral border of the medial meniscus (M) to the medial border of the lateral meniscus (L), just anterior to the intermeniscal ligament. Care was taken to avoid injury to the anterior meniscal attachment during release. Reprinted with permission from Feagin JA, Steadman JR. *The Crucial Principles in Care of the Knee*. Lippincott Williams & Wilkins: Philadelphia; 2008. B, Arthroscopic view of anterior interval scarring. F, femur; *, anterior interval.

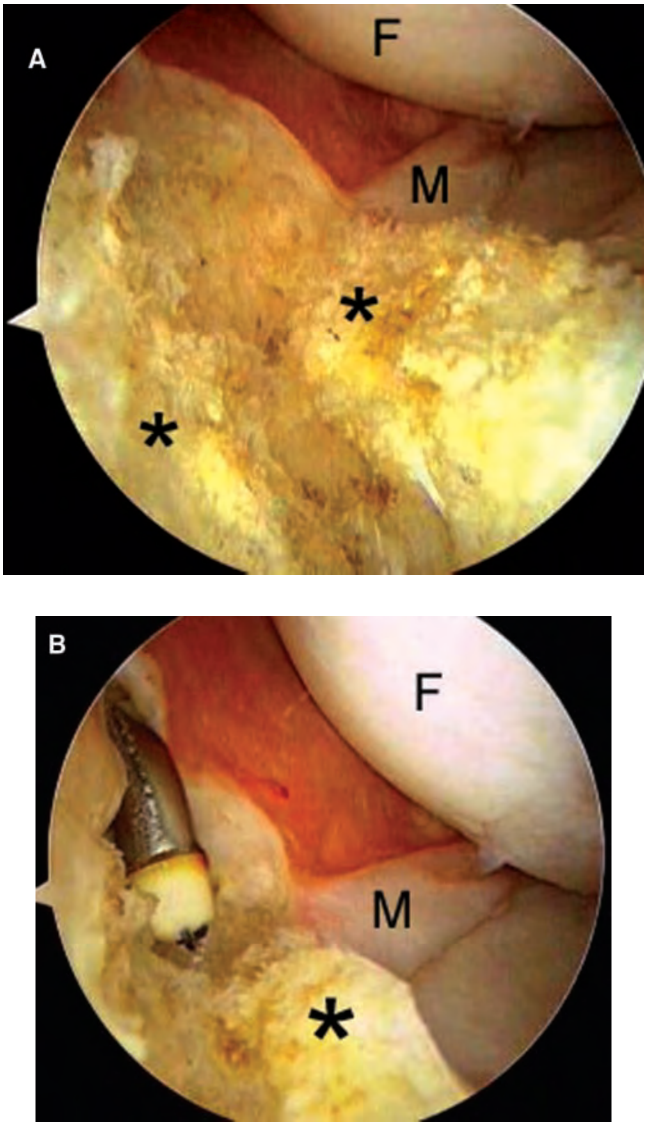

Figure 6. The anterior interval should widen with full extension (A) and close with flexion (B) after successful release. M, medial meniscus. F, femur; *, anterior interval.

of the knee can be visualized coursing between the anterior horns if it is present.

Scar tissue was attached to the anterior tibia, superior or inferior to the transverse ligament, or directly to the ligament (Figure 5). A probe was used to instrument the anterior interval both anterior and posterior to the transverse ligament to identify scarring of the anterior tibia. Closure of the interval was confirmed by visualization of the interval with flexion and extension of the knee. A normal interval will be confirmed with normal-appearing fat approximating the anterior surface of the tibia, and the fat will withdraw from the surface of the tibia on extension. There was little to no movement of the fat pad with interval closure. Meniscal excursion was also visualized during flexion and extension. Deficient excursion was seen with interval closure; however, some excursion was seen if the anterior meniscal horns did not attach to the tibial plateau.

Scar tissue tethering the anterior interval was released using an electrothermal probe. This maneuver relieved tension on the surrounding synovial tissue. A 70° angled probe was well suited to reach the interval from the anteromedial portal. A systematic release of the scar tissue anterior to the transverse ligament was performed starting just anterior to the medial meniscal anterior horn and proceeding laterally to the lateral meniscal anterior horn (Figure 6A). Care was taken to cauterize any bleeding during ablation. The release was continued from proximal (at the level of the meniscus) to approximately 1 cm distal along the anterior tibial cortex or until normal fat pad tissue was seen. Care was taken to avoid cauterizing or causing thermal necrosis to the bone of the anterior tibia or the patellar tendon. Hemostasis was obtained in the anterior interval to prevent postoperative bleeding or recurrent scarring. Adequate release was confirmed by visualizing the interval widening by 1 to 1.5 cm with extension of the knee and closing with flexion (Figure 6B).

Postoperative Care

The principal goals of the postoperative program include the maintenance of anterior interval space and the prevention of scar reformation while preserving joint mobility. Regaining strength was secondary to the above goals. Exercises that caused pain were avoided, and postoperative regimens were specifically tailored to each patient.

The initial phase of rehabilitation focused on range of motion exercises and patellar mobility. Patients were limited to touch-down weightbearing for the initial 1 to 2 weeks after surgery. Patellar and patellar tendon mobilization were central to the rehabilitation protocol.

The stationary bicycle was begun at 1 to 2 weeks with no resistance at a slow speed. After approximately 6 weeks, the goal was achieving functional strength. Treadmill walking at a slow speed and 7% elevation was begun at 6 weeks. Elastic resistance exercises and one-third knee bends, avoiding deeper bends over 30°, were also begun at 6 weeks. After approximately 3 months, the patient proceeded to advanced strengthening and return to sport.

Statistics

Descriptive statistics were calculated using standard formulae. The effect of patient age on Lysholm score was assessed using Pearson correlation with post hoc independent sample t tests. For comparison of Lysholm scores between groups, an independent t test was used. We analyzed changes in Lysholm and Tegner scores (preoperative vs final follow-up) using a paired t test. Statistical analysis was performed with the SPSS version 9.0 software package (SPSS Inc, Chicago, IL).

RESULTS

All patients were evaluated by physical examination and standardized scoring instruments with an average follow-up of 4.0 years (range, 2.0-7.2). Twenty-one patients had full range of motion of the patella in all directions and a negative Hoffa test finding at final follow-up. All 14 (100%) patients with preoperative flexion contractures (>5°) experienced a full return of extension, and patients with flexion deficits had a return to full flexion. The average Lysholm score was improved from 59 preoperatively to 81 postoperatively ($P < .0001$). The average IKDC score improved from 49 to 70 ($P < .001$). There were no complications. The average Tegner score at follow-up was 4.5. The average patient satisfaction with outcome was 8 (range, 1-10), on a 1-to-10 scale, with 10 being extremely satisfied.

Degeneration of the articular surfaces of the patella and/or trochlea was observed in all patients of this study. Four patients (16%) had results that were considered failures, which was defined as having signs and symptoms consistent with rescarring of the interval at 1-year follow-up and therefore required a second surgical release. Patients with failures had a significantly lower preoperative Lysholm score (score = 40) than those who did not (score = 58) ($P = .022$). There were no differences in age, gender, or preoperative IKDC scores between the 2 groups ($P > .05$). One patient developed patellar tendinosis and underwent open debridement of the patella and repeat anterior interval release. Three failures were workers' compensation cases. One workers' compensation patient graded himself at 95% improvement at the initial 2 follow-ups but then began having symptoms when he returned to work. One patient had essentially no postoperative rehabilitation due to insurance reasons. The other failed patient began weightbearing as tolerated on postoperative day 2 and kept the knee immobilized for 2 months despite efforts to redirect the postoperative protocol. However, all patients with failed results had improvements in their Lysholm and IKDC scores compared with their preoperative evaluation.

DISCUSSION

Anterior interval scarring produces tension on the fat pad, synovium, transverse ligament, and periosteum.[14] Altered tension on the synovium, which contains type IVa free nerve endings and Substance P, likely causes pain.[3,8] It is, therefore, no surprise that pain is often eliminated or markedly reduced after arthroscopic anterior interval release. Fisher and Shelbourne[4] previously reported marked improvement in anterior knee pain and stiffness after release of anterior scar tissue.

The group of patients in the present study represents a special population. These patients all experienced recalcitrant anterior knee pain that was clearly refractory to conservative treatment. Patients demonstrated pathologic restriction of patellar and patellar tendon mobility, but most patients maintained a preoperative range of motion that did not qualify for a diagnosis of infrapatellar contracture syndrome based on the criteria published by Paulos et al.[11] In our opinion, this group of patients represents an earlier (perhaps less aggressive) stage of anterior interval scarring, which may eventually lead to full-blown infrapatellar contracture syndrome. However, all patients experienced significant functional morbidity due to this anterior interval scarring. The diagnosis and prompt treatment of these patients were the focus of this study. If patients are identified at this early stage, an open release of scar tissue may be unnecessary.

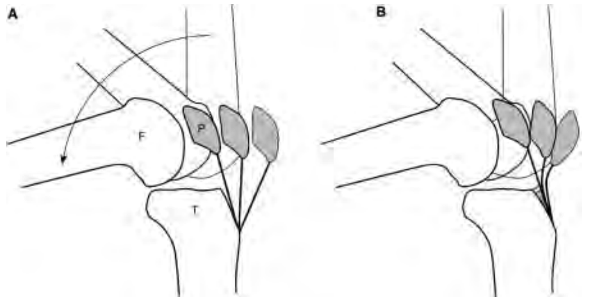

Figure 7. Improvement in patellar tendon excursion after anterior interval release. (A) Reestablished tendon excursion after release of (B) tethered patellar tendon with scarring. F, femur; P, patella; T, tibia.

The process of scarring is initiated in the acute phase by hemorrhage and inflammation, which is followed by a fibroblastic cell response in the chronic phase. Fibrosis of the anterior interval can be caused by trauma to the infrapatellar fat pad via direct injury to the ACL or patellar tendon or from impingement of the apex of the fat pad against the lateral condyle, or by iatrogenic injury during routine arthroscopy or ACL reconstruction.[2,8,10] Rosenberg et al[12] have identified scarring of the infrapatellar fat pad in 9 of 10 knees after patellar tendon graft harvest. Other studies have depicted scarring in the anterior structures of the knee with direct blows to the knee, twisting injuries, repetitive minor trauma, as well as immobilization, especially in the presence of hemarthrosis.[8,10]

Previous studies have shown that the infrapatellar fat pad contains vascular endothelial growth factor (VEGF).[15] The release of this factor after breeching the synovial lining of the fat pad during trauma or surgery may lead to vascular ingrowth and eventual scarring. Although the exact mechanism of intra-articular fibrosis is not known, several plausible theories exist. Inflamed synovium produces inflammatory cytokines platelet-derived growth factor (PDGF) and transforming growth factor beta-1 (TGF-β1), all of which promote the proliferation of fibroblasts and the production of collagen in synovial tissue and lead to eventual fibrosis. Previous studies have shown that PDGF and TGF-β1 are present in intra-articular scar tissue and in synovial fluid in patients with joint trauma.[9,15]

Degeneration of the articular surfaces of the patella and/or trochlea was observed in all patients of this study. This may be due to the increased patellofemoral forces produced by the tethering of the patellar tendon (Figure 7). Ahmad et al[1] demonstrated increased patellar flexion, medial and distal translation, and a distal shift of the contact area of the patella by creating severe anterior interval closure in a cadaveric model. This biomechanical change is most severe during extension, which matches the clinical findings of this patient population. Flexion allows the femur to roll posteriorly along with the patella, which is in contact with its anterior surface. The patellar tendon is compressed against the anterior tibia as a result of the posterior roll back of the femur, reducing the tissue strain created by the adhesion.[1]

The most common complication of this procedure is rescarring of the interval. This is likely due to the predilection for scar tissue formation in this patient population. Dynamic MRI data of normal knees show a 22% decrease in patellar tendon excursion with full weightbearing.[14] Therefore, patients should be kept nonweightbearing postoperatively for 1 to 2 weeks. Diligent hemostasis and trimming of remaining overhanging scar tissue after interval release may further aid in decreasing the rate of rescarring. Another important component of the postoperative care to avoid rescarring is patella and patellar tendon mobilization. This may also be critical in the prevention of anterior interval scarring after arthroscopy.

In summary, subtle scarring of the anterior interval changes the biomechanics of the anterior structures of the knee and may lead to refractory anterior knee pain. Arthroscopic anterior interval release successfully provides pain relief in this patient population.

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