

## Current Concepts

# Diagnosis and Treatment of Patients with Patellofemoral Pain

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### ABSTRACT

The patient-athlete with patellofemoral pain requires precise physical examination based on a thorough history. The nature of injury and specific physical findings, including detailed examination of the retinacular structure around the patella, will most accurately pinpoint the specific source of anterior knee pain or instability. Radiographs should include a standard 30° to 45° axial view of the patellae and a precise lateral radiograph. Nonoperative treatment is effective in most patients. Prone quadriceps muscle stretches, balanced strengthening, proprioceptive training, hip external rotator strengthening, patellar taping, orthotic devices, and effective bracing will help most patients avoid surgery. When surgery becomes necessary, indications must be specific. Lateral release is appropriate for patella tilt (abnormal rotation). Painful scar or retinaculum, neuromas, and pathologic plicae may require resection. Proximal patellar realignment may be accomplished using arthroscopic or a combined arthroscopic/mini-open approach. Symptomatic articular lesions and more profound malalignments may require medial or anteromedial tibial tubercle transfer. Clinicians should be particularly alert for symptoms of medial subluxation in postoperative patients and should use the provocative medial subluxation test followed by lateral displacement patellar bracing to confirm a diagnosis of medial patellar subluxation. This problem may be corrected in most patients using a lateral patellar tenodesis. Current thinking emphasizes precise diagnosis, rehabilitation involving the entire kinetic chain, restoration of patella homeostasis, minimal surgical

intervention, and precise indications for more definitive corrective surgery.

Athletes and other patients with anterior knee pain are often persistent in pursuing treatment because participation in sports and daily activities may be substantially affected by the pain. In a retrospective study of 250 athletes, Blond and Hansen<sup>8</sup> found that many athletes continue to have problems even after a full nonoperative treatment program. Female patients are particularly affected by this type of pain.<sup>34</sup> Fortunately, many patients improve with appropriate nonoperative treatment.<sup>44,88</sup> Accurate diagnosis remains the cornerstone of designing an optimal rehabilitation program. When the problem is intractable, surgical intervention may be necessary.

### CAUSES OF PATELLOFEMORAL PAIN

There are six major anatomic structural sources of patellofemoral pain: subchondral bone, synovium, retinaculum, skin, muscle, and nerve. These structures may be affected by many factors, including systemic disease, but in orthopaedic sports medicine, the most common reasons for anterior knee pain are overuse, patellofemoral malalignment, and trauma. Several authors have espoused the theory that abnormal patellar alignment is often the root cause of pain.<sup>19,28,39</sup> Dye et al.<sup>21</sup> emphasized that increased subchondral bone activity is associated with anterior knee pain. They stressed the importance of spontaneous resolution of anterior knee pain with time. Whether pain occurs because of direct trauma, overuse, malalignment, or a combination of factors, rest often reduces symptoms. Alleviating stress on the subchondral bone and other irritated structures presumably allows remission of symptoms.

While opinions vary, there is little question that imbalance (malalignment) of the extensor mechanism can lead to overload of the retinaculum and subchondral bone. The

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result of patellofemoral imbalance or injury is activation of nociceptive (pain) fibers in the bone, synovium, or retinaculum, which results in pain. If there is a chronic imbalance, this activation may be self-perpetuating until the imbalance is corrected by rehabilitation or surgery. When the irritation or activation of nociceptors is from overuse or direct injury, rest and removal of the inciting factor(s) will often lead to relief.

Repetitive, high-frequency overload delivered to a malaligned extensor mechanism yields persistent, debilitating, unremitting pain in some athletes. Once the patellofemoral joint becomes overloaded and irritated, secondary subchondral bone degeneration,<sup>24</sup> chronic retinacular strain,<sup>33</sup> small-nerve injury,<sup>37,79</sup> or persistent aggravation of the peripatellar synovium<sup>10</sup> may occur.

Direct trauma, on the other hand, can cause a finite lesion in the peripatellar muscle or synovium, retinaculum, articular surface, or skin. Pain as the result of overtraining, as in repetitive overload, may respond to rest (so the affected structures can recover by normal processes).

When rest, time, and well-designed nonoperative measures fail to relieve pain and disability, surgical intervention may be justified to specifically eliminate lesions or patellofemoral imbalance (subluxation or tilt). Only surgery that is designed to alleviate specific, defined problems is justified. Before operating, the surgeon must understand the origin of the pain.

## History

To make the right diagnosis, the wise clinician must listen carefully to the patient and determine the origin(s) of pain. Taking the history is extremely important for patients with patellofemoral pain.<sup>72</sup>

In situations with younger patients, patellofemoral problems are often of great concern to parents, and it should not be surprising if a parent intervenes, particularly on behalf of a relatively shy adolescent. Listen to the parent, but also be sure to ask probing questions of the patient.

The first questions should relate to onset of the pain. Did the pain occur spontaneously or was there a specific injury? Did the pain occur after previous surgery, suggesting scar pain, neuroma, or local irritation (perhaps causing release of pain-producing chemical substance P)?<sup>96</sup> Pain of an insidious and spontaneous onset is more likely related to an inherent problem such as malalignment. Spontaneous onset of pain can also occur in an athlete who creates overuse of retinacular structure around the front of the knee. Blunt trauma, of course, can crush articular cartilage, so whether the patient fell on a sidewalk, drove the knee into a dashboard, or struck the knee on artificial turf, the nature of the injury and subsequent problem will be similar. This information should direct and supplement the physical examination, as a blunt injury will typically cause damage to more proximal patellar cartilage, yielding pain and crepitation on compression of the patella with the knee in 70° to 120° of flexion.<sup>30</sup>

Spontaneous onset of pain may result from overuse, so establishing the patient's activity level and the association of pain to activity will help in establishing the source of

pain. Does the pain occur during running (knee toward extension) or with flexed-knee activities such as squatting beyond 90° of flexion? These functional questions are important as they may pinpoint a specific patellofemoral contact area causing the pain.<sup>30</sup>

Ask the patient to point, with one finger, to the location of pain. Surprisingly, most patients can do this quite accurately. Trying to narrow down the focus is extremely helpful in establishing the diagnosis and subsequent treatment. Pain diagrams, in which patients mark the site of pain origin on pictures of the knee, are also helpful.<sup>74</sup>

Listen as the patient describes the pain. Is the pain vague and diffuse or sharp and well localized? Is it intermittent or constant? To what extent is it activity-related? Is the pain deep and "behind the patella" or is it more superficial? Is the pain above or below the patella? Does it radiate up or down?

Be sure to find out about other problems and conditions. Lyme disease can manifest itself as a single swollen or painful knee. Ask about tick bites, unusual rashes, gout, other medical conditions, problems around the hip, and the patient's general health. Problems in the hip, in particular, can cause pain at the anterior knee level. When interviewing a young athlete, is the athlete expressing a desire to return to sport or is the parent more concerned about this?

As a general rule, anterior knee pain is substantially disabling to athletes and trusting that the pain is real is warranted, particularly if the description fits with known patterns of anterior knee pain.

Be sure to establish if there is a specific instability associated with the pain. Has there been a dislocation or have there been episodes of giving way? Have there been episodes of locking or a sense of a loose fragment in the joint? This is the time to determine whether the patient's primary disability is related to pain or is it instead related to instability. If the problem is primarily one of instability, when does the knee give out, how often, and at what degree of knee flexion?

## Physical Examination

Post<sup>72</sup> has contributed greatly to our knowledge of the physical examination of patients with patellofemoral pain. His recent review reflects a consensus developed by the International Patellofemoral Study Group through a series of meetings devoted specifically to appropriate examination of patients with anterior knee pain.

Observing the affected knee may reveal dystrophic changes, alteration of skin color, calluses related to kneeling or occupational abuse of the knee, scars, scratches, or rashes. The clinician should ask the patient to stand so lower extremity alignment may be observed. Watching the patient walk barefoot may demonstrate functional abnormalities such as excessive subtalar joint pronation.<sup>91</sup> The patient's reaction to lightly brushing the anterior aspect of each knee will demonstrate if there is any hypersensitivity. The retinaculum and patellar tendon are richly innervated with free nerve endings.<sup>7</sup> At this point, one can also determine whether there is numbness related to a previ-

ous procedure and palpate any scars or arthroscopy portals to find a neuroma or sensitive tissue.<sup>37,79</sup> The entire anterior knee, including the region of the distal quadriceps muscle and quadriceps tendon, should be gently palpated to look for sources of pain or hypersensitivity<sup>31,33</sup> (Fig. 1). The iliotibial band also must be palpated. Examine the knee flexed and extended. Move the patella around to see if displacing it one way or the other causes discomfort. Post<sup>72</sup> has reviewed the literature on Q angles, and this measurement appears to be of limited value.

Be sure to look for evidence of medial patellar subluxation in any patient who has had previous surgery.<sup>29</sup> With the knee extended, gently displace the patella slightly (about 1 cm) to the medial side (Fig. 2). Then flex the knee abruptly while letting go of the patella. Normally, this should not cause significant, if any, pain. If this maneuver causes reproduction of a disabling symptom, the patient may have a medial patellar subluxation, in which the patella is tracking from medial in extension laterally into the trochlea on knee flexion. This is a very important diagnostic test, particularly in patients who are symptomatic with feelings of instability after previous realignment surgery or lateral release. If this test is positive, apply a brace that securely holds the patella laterally. If the patient truly has medial subluxation, the properly applied brace should minimize or eliminate symptoms (Fig. 3).

Watch the tracking of the patella to see if it comes directly into the central trochlea on knee flexion. Observing and palpating the patella during knee flexion and extension can be helpful in determining if there is a smooth transition of the patella directly into the trochlea. At this point, flexion and extension of the knee with palpation of the patella will elicit any significant crepitation. The examiner should determine whether crepitus is painful and at what point in the flexion arc it occurs.<sup>30</sup> Crepitation near full extension of the knee suggests a more distally oriented articular lesion on the patella. Crepitation further into flexion suggests a more proximal lesion on the patella. Also, the examiner should look for evidence of a pathologic synovial plica.<sup>18</sup> A pathologic plica may



**Figure 1.** Palpating every part of the peripatellar retinaculum may reveal a nonarticular source of pain.



**Figure 2.** In patients with pain after previous patellofemoral surgery, check for an occult medial subluxation problem by using a medial subluxation test that reproduces the symptom of a patella going from “too far medial back into the sulcus” on knee flexion. Hold the patella medially (reproducing medial patellar subluxation) and then abruptly flex the knee while letting go of the patella. Reproduction of the symptom supports a diagnosis of medial subluxation.<sup>29</sup>

indicate a subtle malalignment.<sup>10</sup> Deficiency of the medial patellofemoral ligament is one of multiple factors that contribute to recurrent patellar instability. In general, the clinician should determine where restraints are deficient or overly tight while also analyzing abnormalities of alignment that affect patella tracking. Thus, it becomes possible to design an appropriate approach to stabilization of the patella, when necessary, based on restoring deficient restraints, releasing what is too tight, and improving alignment factors by nonoperative or operative means as necessary.

Every patient should be examined in the prone, as well as supine, position. With the patient in the prone position, the examiner can evaluate quadriceps muscle tightness



**Figure 3.** Application of the Trupull brace (DJ Orthopedics, Vista, California) will help control symptoms of medial subluxation.

and abnormal rotation around the hip (Fig. 4). Many patients with anterior knee pain benefit from mobilization of the extensor mechanism and hip rotator muscles. The patient should also be examined while lying on the side, such that the contralateral hip is flexed and iliotibial band tightness may be evaluated by adducting the hip.



**Figure 4.** Evaluation of a patient in the prone position will help reveal asymmetry of extensor mechanism tightness or hip rotation.

Weak hip external rotator muscles can cause problems at the patellofemoral joint, particularly in female athletes. While weakness of the hip external rotator muscles can make women more prone to ACL injury, they can also contribute to functional internal rotation of the hip, which results in an accentuation of lateral patellar tracking and instability. In this way, weak hip external rotator muscles can contribute to patellar instability and pain. The patient with patellofemoral pain should be examined standing, then asked to lift the contralateral foot off the ground while flexing the affected knee. If the hip goes into internal rotation as the patient does a single-legged squat, there may be hip external rotator muscle weakness such that strengthening of the hip rotator muscles may be indicated as part of the patellofemoral rehabilitation program.

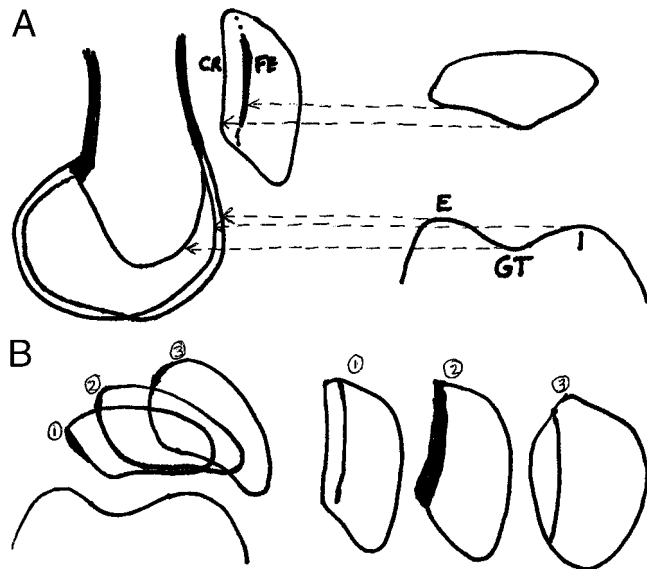
### IMAGING

An axial radiograph at 30° or 45° of knee flexion is most appropriate for radiographic evaluation of patellar alignment.<sup>61</sup> The most common mistake made when obtaining radiographs to determine knee alignment is for the axial radiograph of the patellofemoral joint to be in too much flexion, thereby missing more subtle instabilities that may be present. Criteria for normal alignment are well established.<sup>3,56,61</sup>

Grelsamer et al.<sup>41</sup> have suggested that tilt (rotation) of the patella may be best evaluated radiographically by taking a precise axial radiograph and then drawing a line from the medial to lateral edge of the patella to determine the relationship of this line to a horizontal plane. Patellofemoral incongruence may be evaluated by determining the relationship of the central ridge of the patella to the center of the trochlea.<sup>3,61</sup>

Dejour et al.<sup>16,17</sup> have emphasized the importance of the precise lateral radiograph in evaluating patients with patellofemoral pain. Malghem and Maldague<sup>58</sup> also pointed out that rotational malalignment of the patella may be readily identified on the lateral radiograph. Close evaluation of a precise lateral radiograph (posterior condyles overlapped) will demonstrate trochlear dysplasia very well.<sup>16</sup> The ability to evaluate these precise radiographs requires much practice, but is very helpful in understanding patellofemoral alignment and structure as they relate to patellofemoral pain and instability (Fig. 5). The careful examiner will be able to establish the depth of the trochlea throughout its extent by evaluating the precise lateral radiograph. Murray et al.<sup>65</sup> compared the precise lateral radiograph to axial radiographs and documented sensitivity of the lateral radiograph in evaluating patients with patellar instability.

Computerized tomography for evaluation of patellofemoral alignment should be done at 0°, 15°, 30°, and 45° of knee flexion.<sup>81</sup> Precise midpatellar transverse images must be obtained.<sup>82</sup> A major advantage of CT is that transverse images may be obtained at any degree of knee flexion.<sup>81,82</sup> The relationship of the patella to the tibial tubercle may also be established.<sup>49</sup> Biedert and Gruhl<sup>6</sup> have suggested that CT without quadriceps muscle contraction is most practical.



**Figure 5.** The precise lateral radiograph provides abundant information about the morphologic characteristics and rotational alignment of the patella. A, patella central ridge (CR), edge of the lateral facet (FE), as well as the external (E), internal (I), and central (GT) aspects of the trochlea. B, the degree of patella rotation can be discerned by the lateral patella profile. When the patella is tilted, the central ridge and lateral facet overlap on the lateral radiograph. (Adapted from Maldague and Malghem<sup>58</sup>)

Magnetic resonance imaging seems to be less helpful in evaluation of most patients with patellofemoral pain, but it may be helpful as a kinematic or MR arthrotomogram<sup>86</sup> study in difficult or unique situations.<sup>84,95</sup> Magnetic resonance imaging may be most helpful in uncovering specific cartilage impact or muscle lesions (vastus medialis obliquus muscle) in patients with patellofemoral pain who are difficult to evaluate.<sup>55,90</sup>

Accurate axial and lateral radiographs remain the standard for evaluation of patients with patellofemoral pain. A knee flexion weightbearing posteroanterior radiograph is the standard evaluation in our office.<sup>76</sup> An axial view in less flexion (20°) may be more sensitive in some cases that are difficult to diagnose.<sup>56</sup>

A radionuclide scan may be helpful in the evaluation of selected patients. Dye and colleagues<sup>20,21</sup> have emphasized the functional importance of nuclear imaging as activity of bone remodeling in the patella or trochlea, or both, may be followed to demonstrate evidence of healing with time after a painful episode or injury. Radionuclide scans may be particularly helpful in patients who have injuries related to workers' compensation cases when there is a need for objective documentation of a subchondral bony response to injury or patellar imbalance.

Neyret and others have used CT at the hip, patella, and tibial tubercle levels to establish a tomographic Q angle (Neyret technique).<sup>39</sup> By obtaining transverse images at these levels, the clinician can establish incongruities and excessive lateral alignment factors radiographically. This

type of evaluation is most appropriate when standard radiographs and clinical examination fail to provide enough information to design treatment appropriately.

## CURRENT CONCEPTS IN NONOPERATIVE TREATMENT

Standard physical therapy for patients with patellofemoral pain usually consists of vastus medialis obliquus muscle strengthening, kinetic chain balancing, orthotic devices, stretching the lateral retinaculum, prone quadriceps muscle stretching, aerobic conditioning, taping, bracing, and reassurance. Recent studies have reemphasized that quadriceps muscle deficiency is a fundamental problem in patients with this condition.<sup>67,93</sup>

Most important in accurate nonoperative treatment is proper classification.<sup>30,94</sup> Treatment today should be individualized: every tight structure should be mobilized and the kinetic chain balanced appropriately for the individual patient. A specific bracing or taping program and an aerobic low-impact conditioning program suited to the patient should be designed. Nonoperative treatment is effective for most patients.<sup>50,89</sup> Witvrouw et al.<sup>98</sup> pointed out that altered vastus medialis obliquus muscle response time, a shortened quadriceps muscle, diminished explosive strength, and hypermobile patella are risk factors. These must be treated specifically, when appropriate. Hip rotator muscle strengthening helps balance and align the entire lower extremity. Particularly in women, hip external rotator muscle strength can help balance patellar tracking and also help reduce the risk of ACL injury.

There has been increased interest in taping<sup>22,38,59,60</sup> and bracing<sup>63</sup> in the treatment of patients with patellofemoral pain and instability. Taping techniques recommended by McConnell<sup>60</sup> have become standard in the offices of most physical therapists who are knowledgeable about patellofemoral pain. These techniques involve manipulation of the patella and using tape to modify tilt or subluxation. Patients seem to benefit from the use of these taping techniques. Ernst et al.<sup>22</sup> have shown that patellar taping may improve knee extensor function during weightbearing activities.

Current rehabilitation programs make use of a brace that places a customized medially directed pull on the patella and by straps that attach to separate fixation points above and below the knee (see the Trupull Brace [DJ Orthopedics] shown in Fig. 3). This brace has been helpful in treating athletes with patellar instability and it improves extensor mechanism function better than knee sleeves and patellar cut-out braces. Other braces use a variety of attachment straps to the knee sleeve from which they originate and produce an effect similar to that of a patellar cut-out brace. All of these braces are helpful in providing less specific patellar support. The on-track brace is a combined tape/brace concept. A variable resistance hinge brace (Protonics, Inverse Technology Corp., Lincoln, Nebraska) provides resistance to knee flexion and therefore may protect the quadriceps muscle to some extent. Exercise programs with this brace have been helpful

in the rehabilitation of some patients with patellofemoral arthrosis.

Closed chain exercise may offer some advantage in patients with patellofemoral pain.<sup>97</sup> Pedaling forward is preferable to pedaling backward.<sup>68</sup>

## SURGICAL TREATMENT OF PATIENTS WITH PATELLOFEMORAL PAIN

### Lateral Release or Proximal Realignment

During the 1980s, lateral retinacular release was well accepted as a primary surgical procedure for patients with resistant patellofemoral pain.<sup>15,54</sup> Indications at that time were often ill-defined, and the main topic of discussion was whether or not to shave loose fragments of cartilage from the patella or trochlea. Since then, indications have been refined considerably, and we now recognize that lateral release is most appropriate for patients with a tight lateral retinaculum associated with rotational (tilt) malalignment of the patella.<sup>27,30,36</sup> This mechanical configuration is often associated with an excessive lateral pressure syndrome, originally described by Ficat et al.<sup>24</sup> In patients for whom nonoperative treatment fails to relieve patellofemoral pain, pain relief may be obtained after lateral retinacular release as long as there is a good mechanical reason for doing the procedure. Proper preoperative evaluation followed by careful arthroscopy will determine whether lateral release is appropriate.<sup>70</sup>

The procedure may be done open or arthroscopically, but as techniques for arthroscopic release have improved and the concept of meticulous hemostasis arthroscopically after tourniquet release has evolved, more of these procedures are being done arthroscopically. Hemarthrosis is the most common postoperative complication, but it is likely that the incidence of hemarthrosis has diminished with improved arthroscopic hemostasis techniques.

Lateral release does nothing mechanically for a patella that is normally aligned. Post, in unpublished research in 1991, has shown that lateral retinacular restraints are important in blocking excessive lateral displacement of the patella, as well as in limiting medial displacement. The lateral retinaculum is oriented in the anteroposterior plane, such that release of it is unlikely to allow medial transfer of the patella.

Overzealous or inappropriate lateral release can cause medial patellar subluxation, a particularly debilitating problem.<sup>29,45</sup> Thus, lateral release should be used only for specific mechanical indications, and the extent of release should be limited to accomplish only the desired mechanical goal. In most patients, release to the level of the proximal patellar pole is all that is necessary. Maintaining some vastus lateralis obliquus muscle support on the lateral side<sup>42</sup> is generally advisable and will help to reduce the complication of medial patellar subluxation.

Balance of support structures around the front of the knee is important, as is proper tracking.<sup>26</sup> Some patients require a proximal imbrication or reconstruction of the medial patellofemoral ligament to control lateral subluxation.<sup>2,11,25,43,46,53,66,78</sup> Fithian and Meier<sup>25</sup> recently

emphasized the importance of restoring the medial patellofemoral ligament. Sallay et al.,<sup>78</sup> however, pointed out that patients may experience pain after medial patellofemoral ligament reconstruction.

To decide whether proximal realignment is appropriate, the surgeon should ask if the primary problem relates to deficiency of medial support structure for the patella (the medial patellofemoral ligament), or whether the primary problem is one of an underlying abnormality of the alignment vector. The other question that the surgeon should ask is whether any surgical procedure is likely to increase loading of a painful or potentially painful articular lesion. Unfortunately, many patients with patellar instability, particularly those who have sustained a dislocation, may have a medial patellar articular lesion to which adding load may be detrimental. This may account for the finding of Sallay et al.<sup>78</sup> of pain in some patients after medial patellofemoral ligament reconstruction.

Current indications, therefore, for performing a proximal realignment procedure are 1) deficient medial patellar support structure, specifically the medial patellofemoral ligament, and 2) the ability to perform a proximal medial patellofemoral reconstruction without increasing the load to an articular lesion. Because of the high incidence of medial articular lesions after dislocation, there is good reason to be cautious about proximal realignment procedures in patients with patellofemoral pain, considering the location of articular lesions in the design of the procedure. Myers et al.<sup>66</sup> have pointed out that proximal realignment does not work well in patients with patellofemoral pain and should be reserved for patients who have sustained a dislocation and require stabilization.

When proximal realignment is selected as treatment, the surgeon should assess the medial support structure and decide if medial imbrication/vastus medialis obliquus muscle advancement is sufficient or whether a specific reconstruction of the medial patellofemoral ligament should be undertaken. Attention must be given to restoring the patellotibial and patellomeniscal ligaments as well as the medial patellofemoral ligament.<sup>9,25</sup> In either case, it is important not to "overdo" any medial repair procedure. Most often, these procedures are accompanied by a lateral release. While Insall et al.<sup>46</sup> recommended an extensive medial imbrication procedure, we have found that a proximal medial imbrication can be achieved successfully through a short medial incision placed over the vastus medialis obliquus muscle and proximal medial retinaculum, which is where the medial patellofemoral ligament inserts into the patella. This may also be accomplished arthroscopically. Imbrication or reconstruction on the medial side is strictly limited to restoration of normal balance without tightening in a way that will increase medial pressure. The goal is restoration and maintenance of balance of the patella within the trochlea. Radiofrequency thermal shrinkage of the medial retinaculum is not yet proven.

Because early motion is so important in patients with patellofemoral disorders, any medial reconstruction should be secure enough to allow daily motion of the knee

postoperatively. A modified program in which the patient removes the knee immobilizer once a day for 5 minutes to simply flex the knee 90° a single cycle daily during the first 5 to 6 weeks after surgery has been very helpful and has virtually eliminated postoperative stiffness problems after routine patellofemoral surgery. Of course, the repair must be secure enough to allow this.

### Distal Realignment

When lateral patellar malalignment leads to chronic pain with or without instability, there is frequently articular damage. This usually occurs on the lateral facet (excessive lateral pressure syndrome described by Ficat et al.<sup>24</sup>) and distal central patella.<sup>30</sup> Stabilization of the extensor mechanism must therefore combine restoration of normal patellar tracking with unloading of damaged articular surfaces. In some patients, this is possible with a straight medial tibial tubercle transfer (Elmslie-Trillat procedure).<sup>14,53,74</sup> Patients generally do well with this approach to restoring patellar stability when it is accurately performed for the right indications and secured with stable fixation allowing early range of motion.<sup>66</sup> Muneta et al.<sup>64</sup> confirmed the efficacy of tibial tubercle transfer for correcting abnormal patellar tracking.

Because many patients benefit from some unloading of the patella at the time of realignment, anteromedial tibial tubercle transfer is often preferable, particularly when there is distal articular softening (Fig. 6). Anteromedial tibial tubercle transfer permits a shift of contact area in early flexion proximally and off of a softened distal patellar articular surface. Anteromedial tibial tubercle transfer also permits rigid fixation with cortical screws such that postoperative stiffness is uncommon. Results from anteromedial tibial tubercle transfer have been very good.<sup>5,23,32,35,36,77</sup> Oblique osteotomy of the tibia does weaken this area,<sup>13</sup> so full weightbearing should be avoided for 6 weeks postoperatively.<sup>87</sup> Results after anteromedial tibial tubercle



**Figure 6.** Anteromedial tibial tubercle transfer osteotomy. This image demonstrates placement of a Tracker guide (Mitek, Norwood, Massachusetts) used to define the desired oblique osteotomy plane.

transfer are best when there are distal or lateral, or both, facet patellar articular lesions; it is less good when there are proximal (direct impact, blunt injury) and medial facet lesions.<sup>71</sup> Arthroscopy of the patellofemoral joint before performing the osteotomy will help determine the most appropriate approach to realignment,<sup>71</sup> such that normal tracking may be restored<sup>69</sup> without adding load to a lesion.<sup>30,71</sup> Straight anteriorization of the tibial tubercle as provided by the Maquet procedure has yielded less favorable results,<sup>48,57,80</sup> with numerous problems reported.<sup>75</sup> This procedure, accordingly, is not frequently chosen today.

The versatility, stable fixation, early motion, and lower morbidity of an oblique osteotomy and anteromedial tibial tubercle transfer approach to patellar decompression and realignment make this appealing, particularly when there are distal and lateral articular lesions.<sup>30,71</sup> In a long-term follow-up study, Buuck and Fulkerson<sup>12</sup> found that increased activity and return to sports was possible in most patients after anteromedial tibial tubercle transfer.

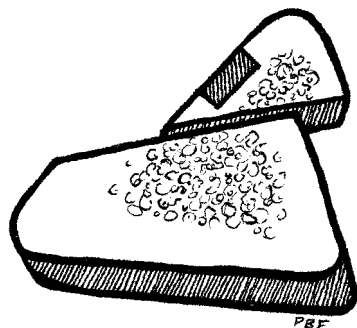
### RETINACULAR AND SYNOVIAL PROBLEMS

Some patients have an isolated source of pain in the synovium, peripatellar retinaculum, patellar tendon, or soft tissue around the front of the knee.<sup>31,33,37</sup> A superficial neuroma related to previous surgery can cause intractable pain that can be treated simply by excision of the neuroma, once it is identified. Kasim and Fulkerson<sup>52</sup> have pointed out the importance of identifying retinacular lesions by careful clinical examination and have reported the high success rate possible with this simple surgical approach in carefully selected patients. Many operations, such as lateral retinacular release, involve incisions that may release an entrapped nerve or denervate a neuroma inadvertently. The careful surgeon, however, will identify retinacular or synovial sources of pain preoperatively and release or resect these specifically. In some patients, this will eliminate the need for other surgery.<sup>52</sup>

### ACL RECONSTRUCTION AND PATELLOFEMORAL PAIN

A recent study from Finland reiterates the occurrence of anterior knee pain after reconstruction of the ACL in many patients.<sup>47</sup> Kartus et al.<sup>51</sup> have recently emphasized the high incidence of anterior knee pain after ACL reconstruction. Shino et al.<sup>85</sup> reported that patellofemoral articular degeneration from subtle changes in patellofemoral tightness may occur after ACL reconstruction. The harvest site of a bone-patellar tendon-bone graft may be another source of anterior knee pain. Muellner et al.<sup>62</sup> suggested that ACL reconstruction may alter patellar alignment. Aglietti et al.<sup>1</sup> and Shelbourne and Trumper<sup>83</sup> have noted the importance of knee motion after ACL reconstruction to avoid pain.

Early motion, proper graft placement, precise graft harvesting, and lack of preoperative anterior knee symptoms are factors in the control of patellofemoral pain after ACL reconstruction. When patellofemoral pain occurs after



**Figure 7.** Anterolateral tibial tubercle transfer for salvage of previous excessive distal realignment. Note that the location of previous Hauser transfer posteromedially (diagonally striped rectangle) has been shifted anterolaterally.

ACL reconstruction, however, it can be difficult to treat, particularly when there is infrapatellar contracture.

The history and physical examination are very important in evaluating patients who have pain after ACL reconstruction. Note whether return of motion was delayed. Scarring behind the patellar tendon, which can tether the patella and increase load to the distal articular surfaces of the patella, is a cause of patellofemoral arthrosis after ACL reconstruction.<sup>92</sup> Improper graft placement or delay in obtaining full extension can also lead to patellofemoral deterioration and pain.

When anterior knee pain occurs after ACL reconstruction, physical examination should help determine whether the pain is articular (most often related to deficient or delayed range of motion) or related to soft tissue (infrapatellar contracture, harvest site pain, or tendinitis). Physical therapy should emphasize restoration of motion, mobilization of the patella, and pain control. These patients can be difficult to treat, however, and continue to have chronic anterior knee pain that requires surgical intervention. Surgery in these patients should be specific for the clinical findings and may include infrapatellar contracture release, tibial tubercle anteriorization, patellar tendon or harvest site debridement, lateral release, steep anteromedial tibial tubercle transfer, notchplasty, cyclops debridement, neuroma resection, or a combination of these procedures.

## PATELLOFEMORAL SALVAGE SURGERY IN ATHLETES

Unfortunately, there are some athletes and vigorous persons who become severely disabled by anterior knee pain and fail to improve or are made worse by surgery. Such patients require very careful attention. Often the treatment goal may be a return to pain-free or even less painful daily activity instead of sports. Nonetheless, there are situations in which vigorous activity or return to full athletic activity may be possible after the correction of previous patellofemoral surgery failure.

Selection of the proper salvage surgical procedure is not really much different from planning primary surgery except that the surgeon should look carefully for evidence of

retinacular scar related to previous surgery,<sup>52</sup> infrapatellar contracture,<sup>92</sup> extensive cartilage damage, medial patella instability,<sup>29</sup> or a previously overlooked source of pain, sometimes in an area other than the patellofemoral joint. One must also recognize reflex sympathetic dystrophy, complicating psychiatric issues, and secondary gain from legal or compensation issues. Most patients, however, including those with workers' compensation issues, have real pain and need help.

Medial patellar instability is a fairly common reason for a poor result from patellofemoral surgery, but this diagnosis has been elusive. Patients with sudden episodes of painful instability after previous patellofemoral surgery should always be tested for evidence of medial patellar subluxation.<sup>29</sup> For patients with medial patellar subluxation, surgery is usually warranted. The procedure advocated by Hughston and Deese,<sup>45</sup> using a narrow strip of patellar tendon left attached to the patella and then woven into the iliotibial band, has worked very well for controlling this problem. This procedure can provide enormous relief and, in some cases, can result in return to vigorous activities.

If there is medial patellofemoral arthrosis related to a previous dislocation and excessive medial tibial tubercle transfer, anterolateral tibial tubercle transfer might be necessary to realign and unload the patellofemoral joint<sup>28</sup> (Fig. 7). A limited medial release is also usually indicated in these patients. Immediate range of motion exercise is importance in the postoperative period.

Infrapatellar contracture may cause recalcitrant anterior knee pain and requires release, either in combination with other surgery or as an isolated procedure.<sup>92</sup> Some patellofemoral pain patients have a "mini patellar contracture," in which there is no patella infera, but there are painful tight bands of scar tissue in the retroapatellar fat pad region. Release of a painful infrapatellar contracture may be accomplished through a short lateral peripatellar tendon incision, after which hemostasis and early range of motion should be emphasized.

Residual lateral instability of the patella after previous surgery can cause persistent disability and may require an Elmslie-Trillat procedure<sup>4,14</sup> or reconstruction of the medial patellofemoral ligament.<sup>11</sup> In a salvage situation in which there is residual lateral patellar instability together with a distal or lateral patellar articular lesion, an anteromedial tibial tubercle transfer is frequently successful for relieving both pain and instability.<sup>5,23,32,35</sup> Kelly and Griffin<sup>53</sup> have stated that patients with more advanced patellofemoral degeneration are not candidates for proximal realignment.

Patellectomy<sup>99</sup> and patellofemoral replacement<sup>40</sup> are rarely indicated in young, active patients, but may be necessary when there is severe patellofemoral pain related to end stage articular degeneration. Whenever possible in younger patients, however, procedures that unload painful lesions, release painful retinaculum synovium or scar, and balance the extensor mechanism are preferable, accompanied by early range of motion.

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