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Therapeutic Implications of a Tissue Homeostasis Approach to Patellofemoral Pain

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Summary: The underlying principle of treatment for patients with patellofemoral pain from a tissue homeostasis perspective is to maximize the range of painless loading for a given symptomatic joint (envelope of function) as safely and predictably as possible. Current therapeutic approaches aimed at surgical correction of chondromalacia and malalignment often are neither safe nor predictable. A tissue homeostasis approach involves addressing the pathokinematics—primarily through temporary but scrupulous load restriction, anti-inflammatory therapy, and a gentle painless rehabilitation program. Failing this, a careful and analytical surgical approach may be warranted to include a possible gentle peripatellar synovectomy. **Key Words:** Patellofemoral—Pain—Therapy—Homeostasis—Surgery.

The fundamental goal of a successful treatment program for patients with symptoms of patellofemoral pain is restoration of painless knee function. As previously described, the function of the knee and other joints can be characterized by a load/frequency distribution (the envelope of function) that defines a range of painless loading that is compatible with homeostasis of the joint tissues.[1–3] In the current author's view, the goal of orthopedic treatment generally should be to maximize the envelope of function for a given joint or musculoskeletal system as safely and predictably as possible. This therapeutic approach emphasizes restoration of tissue homeostasis, with the associated resolution of painful symptoms, over the achievement of certain measurable structural or biomechanical characteristics of the patellofemoral joint.

The tissue homeostasis perspective is inherently empiric, and thus fundamentally safer than many current therapies, which are based solely on correction of structural and biomechanical factors thought to be of causal significance. Such structurally and biomechanically oriented treatments can, and often do, result in the worsening of patellofemoral symptoms. An example would include an aggressive physical therapy program solely emphasizing vastus medialis obliquus strengthening to "correct maltracking" by extension of the knee against resistance, which results in increased anterior knee pain. Such a narrow emphasis on muscle strengthening at the expense of increased patellofemoral symptoms is inherently illogical and violates the medical principle of *primum non nocere*.

In addition, many currently accepted operative approaches to patients with patellofemoral pain, based solely on structural and biomechanical characteristics, can inadvertently result in worsening of symptoms. These include excessive use of the lateral release, aggressive chondroplasties for findings of chondromalacia, and major proximal and/or distal realignment surgery. (Fig. 1) The worst cases of patellofemoral pain and dysfunction that I have witnessed are those in patients who have had multiple surgical procedures for an initial problem of only modest patellofemoral discomfort.

Before the initiation of treatment, a diagnosis should be established. The assessment of patients with patellofemoral pain should concentrate on the history and physical examination, rather than imaging studies. A careful history often will elicit an underlying supraphysiologic loading event or series of events that preceded the development of symptoms. However, it is not unusual for patients to be unable to identify a specific occurrence of causal significance. They may simply report that certain activities of daily living associated with high patel-

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FIG. 1. Patient with multiple failed surgical procedures for patellofemoral pain. Each procedure was based on "correcting patellofemoral malalignment." All resulted in worsening of the patient's symptoms. (From Dye et al.[1] Reprinted with permission.)

lofemoral loading, such as stair climbing, squatting, kneeling, or sitting in and arising from chairs, have become symptomatic. One must exclude mechanical instability as a cause of symptoms, exemplified by a patellar dislocation. Such patients are treated differently and their cases are not within the scope of this article.

The clinical examination should be oriented to determine the anatomic site of pain and tenderness and to assess which loading activities are significant in the genesis of anterior knee pain. Specific sites of tenderness often lead to specific diagnoses, such as patellar tendinitis, synovitis, or retinacular strain. It also is important to have the patient reproduce, if possible, the activities that induce patellofemoral pain. For example, one should assess the knee under load by having the patient step on and down from a foot stool. It is important that the exact activities associated with the initiation and persistence of patellofemoral symptoms be identified so that they can be rigorously restricted. Such painful loading activities are, by definition, out of that individual patient's envelope of function. In addition, one should observe the muscle bulk and patellar tracking characteristics and the overall alignment of the limb. One also should assess if nonpatellofemoral sources may play a role in the genesis of symptoms, such as tight hamstrings or referred pain from an arthritic hip of saphenous nerve irritation.

There are two basic categories of imaging of the patellofemoral joint: structural imaging (radiographs, computed tomography, and magnetic resonance imaging) and metabolic imaging (technetium scintigraphy and positron emission tomography). Standard screening radiographs, including a Merchant's or Lauren's view (axial patellofemoral radiographs), should be obtained to rule out overt structural causes of pain, such as fractures or osseous loose bodies. Minor degrees of tilting and subluxation of the patella relative to the femoral trochlea on axial radiographs do not, in this author's experience, reveal much regarding the genesis of anterior knee pain. In prior work, we noted that mild degrees of patellar tilting and subluxation did not correlate with the presence or absence of anterior knee pain.[4] In addition, magnetic resonance imaging is poor at identifying which of the patellofemoral tissues are producing pain.[5] As has been shown, even identified structural damage of articular cartilage may not necessarily play a role in the genesis of anterior knee symptoms.[6] A careful examination of magnetic resonance imaging of the patellofemoral joint often manifests low-grade effusions associated with symptomatic peripatellar synovitis. This finding frequently goes unreported by radiologists because of their focus on the structural characteristics of joints. Thus, it is important for the treating orthopedic surgeon to look at the images directly. I believe peripatellar synovitis to be one of the most common, underdiagnosed conditions of clinical significance about the knee. Technetium bone scans, which manifest loss of osseous homeostasis, often correlate well with patellar pain and its resolution.

The treatment of patients with patellofemoral pain, from a tissue homeostasis perspective, is a logical, empirically based program aimed at expanding the envelope of function for a given patient's knee to its maximum as safely and predictably as possible[1,2] (Fig. 2A—C). One must help create, in that patient's joint, the internal biologic environment most conducive to restoration of tissue homeostasis with the associated resolution of pain. Each patient's condition (mosaic of pathophysiologic processes) and healing potential are unique, so the treatment of each case must be individualized. It is the principles of treatment that are most important for healing to occur. In this author's experience, most patients with patellofemoral pain will have a response to the application of three basic principles: correcting the pathokinematics, principally by temporary but scrupulous adherence to load restriction within the patient's reduced envelope of function; an anti-inflammatory program; and rehabilitation. Loads across the symptomatic patellofemoral joint must be diminished to the point where no new tissue damage or irritation is being caused. Simply, the

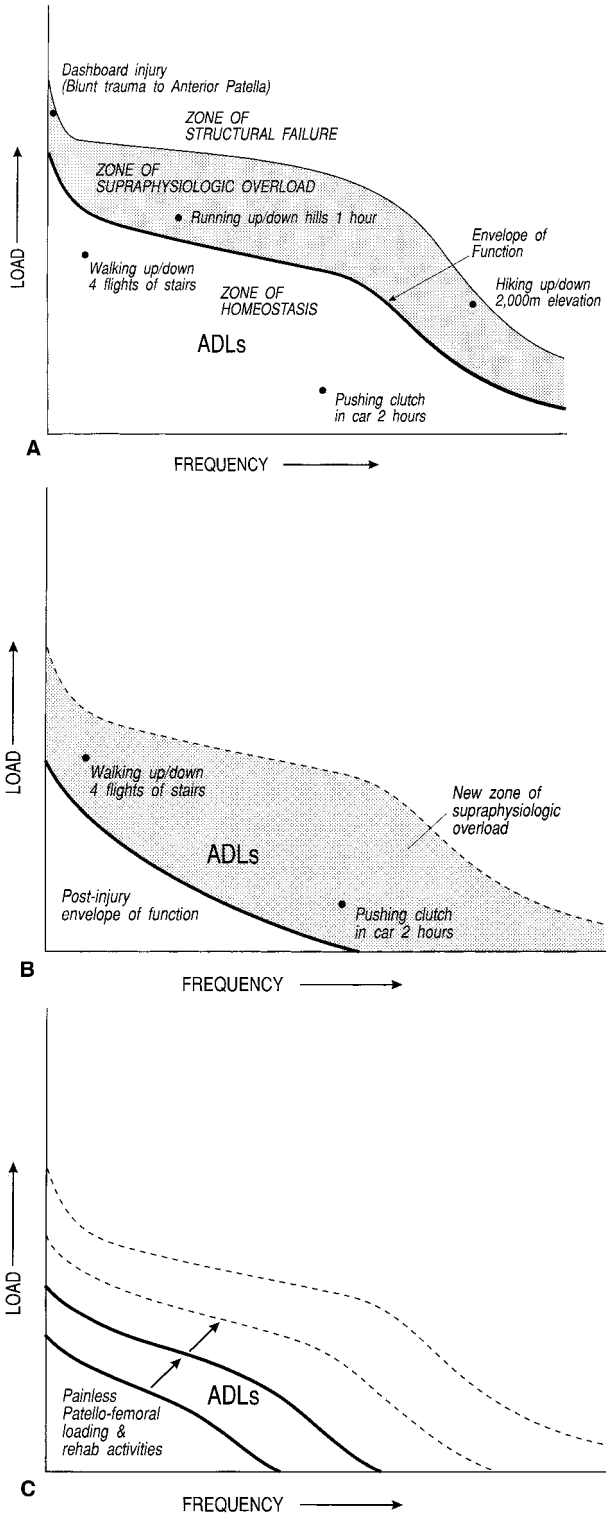

FIG. 2. The envelope of function. **A:** Supraphysiologic loads outside the envelope: a dashboard injury, running up hill 1 hour, and hiking downhill 2000 meters. **B:** Diminished envelope of function after supraphysiologic patellofemoral loading showing that activities of daily living and activities such as climbing four flights of stairs and pushing a clutch in a vehicle for 2 hours have become supraphysiologic loads, leading to recurrent loss of tissue homeostasis and continuance of peripatellar symptoms. **C:** Incremental expansion of the diminished envelope of function by restricting patellofemoral loading to within the envelope. (From Dye et al.[1] Reprinted with permission.)

patient must decrease the loading across the symptomatic joint to within its envelope of function, the range of loading that is clinically painless and most conducive to tissue healing (restoration of homeostasis). The patient must be made aware that continuing painful loading activities reflect a subversion of normal tissue healing processes. Analogies can be helpful in this effort. I believe an extremely common aspect of the mosaic of pathophysiologic events associated with anterior knee pain is patellofemoral synovitis. I liken this process to biting the inside of one's cheek. If one repetitively bites the inside of one's swollen cheek, the painful loss of homeostasis, represented by the irritated tissues, can persist indefinitely.[1]

Often the activities that are associated with the persistence of patellofemoral pain are readily identified and controllable, resulting in a rapid diminution of pain. Simple modifications of activities of daily living often can be sufficient to achieve such a range of painless patellofemoral loading. For example, such loading often can be accomplished by the limitation of excessive stair climbing, squatting, kneeling, and similar pain inducing activities that are out of that joint's envelope of function. Modifying the manner in which one sits in and arises from a chair is another activity of daily living that must be addressed. Sitting in a higher chair, to keep the knee in a more extended position, often is helpful. For women, in particular, the temporary use of an elevated toilet seat can be helpful. When resting, patients should be instructed to keep the knee in a more extended position, which can prevent the deep aching of the "movie sign." The movie sign may be caused by temporary restriction of venous outflow without obstruction of arterial inflow, resulting in transient, painful increased intraosseous pressure, which resolves rapidly with extension or ambulation.

I believe there is an inflammatory component to most patellofemoral pain related to chronic synovial irritation and cytokine production in various innervated tissues that can respond well to simple anti-inflammatory treatment, no matter the specific tissue source. This would include intermittent tissue cooling and the use of oral nonsteroidal anti-inflammatory medications of the surgeon's choice. Patients often report improvement of patellofemoral pain with a repetitive tissue cooling program of icing 15 to 20 minutes, two to three times per day. This is especially helpful after aggravating patellofemoral activities. I believe the symptomatic benefit of tissue cooling reflects both a temporary decrease in swelling of inflamed peripatellar tissues, not unlike the use of an ice pack in a patient with a symptomatic swollen cheek, and a decrease in metabolic activity resulting in a temporarily decreased cytokine production within inflamed innervated tissues. One must caution the patient against overcooling the knee so that a new iatrogenic hypothermal injury is not created.

Rehabilitation, to include *painless* muscle strengthening, stretching, and patellofemoral taping, often are beneficial in combination to help create the biomechanical environment to encourage maximal tissue healing. Some degree of muscle atrophy is common in patients with patellofemoral pain. This sign often is interpreted as a primary factor in the genesis of symptoms, when it may in fact represent a secondary phenomenon of disuse. Nonetheless, muscle strengthening, including the vastus medialis obliquus, is considered beneficial. However, such strengthening exercises must be performed in a painless manner: in other words, within the envelope of function for that individual patient. It does little good to force patients to strengthen the quadriceps musculature in such a way (e.g., painful extension of the knee against resistance) as to aggravate already sensitive and inflamed peripatellar tissues. What may be good for the molecular engines (muscles) may be bad for the biologic transmission (knee). Stretching of tight structures, such as the hamstrings and retinacula, often is beneficial and also should be performed in a slow measured fashion so as not to create new tissue damage. The absence of pain is the best indicator that the involved structures are not being damaged.

Patellar taping, often referred to as "McConnell taping" after the Australian physical therapist who developed it,[7] can be of great benefit if it results in noticeable pain reduction (Fig. 3). I believe the often dramatic improvement of patellofemoral discomfort with this technique reflects a decrease in mechanical irritation of peripatellar tissue (not unlike using a finger to pull the swollen cheek tissue away from the teeth), rather than representing a correction of patellofemoral malalignment. Taping also may increase the beneficial proprioceptive characteristics of the joint. This often successful technique is best used temporarily to protect the symptomatic joint while tissue homeostasis/healing occurs. It is not designed for long-term use. Prolonged taping can lead to other problems, such as skin irritation.

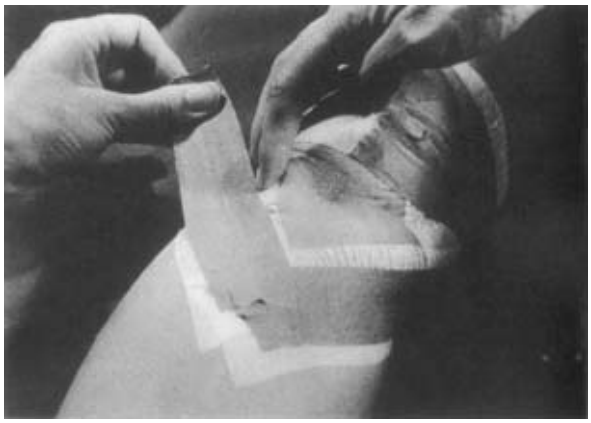

FIG. 3. Example of McConnell taping. (From Grelsamer and McConnell.[7] Reprinted with permission.)

The mosaic of loss of tissue homeostasis leading to patellofemoral pain is often one of crisis and resolution. I am unaware of any physical therapy technique that has resulted in documented permanent correction of indicators of malalignment (e.g., Q angle, shallow femoral trochlear sulcus) after successful nonoperative treatment. I have found that the knowledge of the concepts of safe patellofemoral loading, as exemplified by the envelope of function, can be a powerful tool in the resolution of symptoms, in and of itself, in that patients have a much better understanding of the biomechanical environment that induces symptoms and if diminished can protect the knee. Regarding bracing, an elastic knee sleeve with a patellar relief zone can be helpful in many patients. Some patients report improvement with braces designed to correct maltracking. The use of bracing is a logical choice, if the symptoms are controlled. Nonrigid orthotics also can be of benefit in some patients.

The treatment program must be individualized and empiric, meaning that the patient must be helped to find his/her envelope of function, anti-inflammatory therapy, and exercise program that results most reliably in pain reduction. It is not unlike trying to find the numbers to a combination lock. The solution is unique, and the patient must be helped to find it from inherently safe treatment choices. The patient must persist with the treatment principles long enough for healing to occur. Once the painful symptoms have resolved, the patient may gradually and incrementally increase patellofemoral loading. Our experience with technetium scintigraphy with documented resolution of patellofemoral pain along with restoration of osseous homeostasis revealed that a period of 6 to 9 months of conservative therapy often is required for a successful nonoperative program.[8] However, many patients can experience resolution of their patellofemoral symptoms much sooner. One often must be diligent and persevere with the principles of this program to be successful. The first pain-free day does not mean that the envelope of function has been fully restored but that healing is occurring. The tissue homeostasis approach is inherently safe, in that any treatment factor that results in increased symptoms of patellofemoral pain is halted immediately. When in doubt, go to the safe region of the envelope of function by decreasing loading. No one program will work for all patients because the underlying mosaic of pathophysiology and tissue healing responses are unique.

SURGERY

Surgery can be beneficial as part of a tissue homeostasis approach to patellofemoral pain but must be ap-

proached rationally and cautiously.[9] As noted, the worst cases of patellofemoral pain and dysfunction often are in patients who have had multiple operative procedures in an attempt to correct a supposed chondromalacia or malalignment etiology.

Often the initial surgery was a lateral release, with or without an aggressive chondroplasty, followed by additional attempts at improving the alignment characteristics of the symptomatic joint. Reversing the high rate of failure after surgery for patellofemoral pain is one of our greatest orthopedic challenges. In this author's opinion, the high rate of failure results almost entirely from the belief that patellofemoral malalignment or chondral injury is the primary cause for patellofemoral pain.

Surgery performed from a tissue homeostasis perspective must be logically aimed at those aspects of the mosaic of pathophysiology responsible for the genesis of anterior knee pain most amenable to operative intervention. Not all tiles of the mosaic can be addressed with surgery, so improvement, rather than complete restoration of painless function after surgery, is most common. Operative procedures must be done in a manner that respects the patellofemoral tissues by being as gentle as possible, so as not to create an additional permanent injury to the joint.

In my experience, most patients with chronic peripatellar pain that does not resolve with the conservative treatment principles outlined have peripatellar synovitis as a substantial aspect of their problem. Careful arthroscopic removal of swollen and inflamed peripatellar synovium can be helpful (Fig. 4A—B). However, through the years I have learned that one must follow certain basic principles to help achieve improvement with the use of such surgery. The inflamed synovium must be cleared so that one can visualize the inferior articular cartilage surface of the patella. There are few occurrences more metabolically irritating to a living knee than a substantial hemarthrosis. Thus, the avoidance of a postoperative hemarthrosis is *crucial.* This is achieved most often by a meticulous intraoperative hemostasis following the arthroscopic debridement of impinged synovium. I always drain the knee with a 1/8-inch diameter Hemovac (at least for a few hours following surgery and occasionally overnight, depending on the output). Approximately 40 mL 1% lidocaine with 1:100,000 epinephrine is injected in the synovium and fat pad tissues deep to the region of the synovectomy. In addition, 50 mL 0.25% Marcaine with 1:200,000 epinephrine and 10 mg morphine is injected into the knee through the Hemovac tube, which is clamped for at least a period of 15 minutes to 1 hour. This is followed by application of a compressive dressing.

The patient then is told to remain at a low level of activity for several days after surgery. I liken this temporary restriction of loading after surgery as similar to letting a soufflé set without banging the oven door. After the surgery, the patient must help create the internal conditions to allow healing to occur most rapidly. In my experience, this is done by icing five to six times per day for 15 to 20 minutes, straight leg raising, and the initiation of an appropriate careful, reasoned, and painless postoperative rehabilitation program the week after the surgery. In addition, a gentle, conservative chondroplasty may be beneficial to stabilize the region of chondral damage. I disagree that aggressive drillings, picking procedures, mosaicplasties, or cartilage transplantation techniques in the patellofemoral joint region are indicated in most cases. The biomechanical environment in this region often is just too severe for long-term success of most cartilage replacement techniques. The removal of loose bodies also can be of benefit.

A lateral release should be performed only in the set-

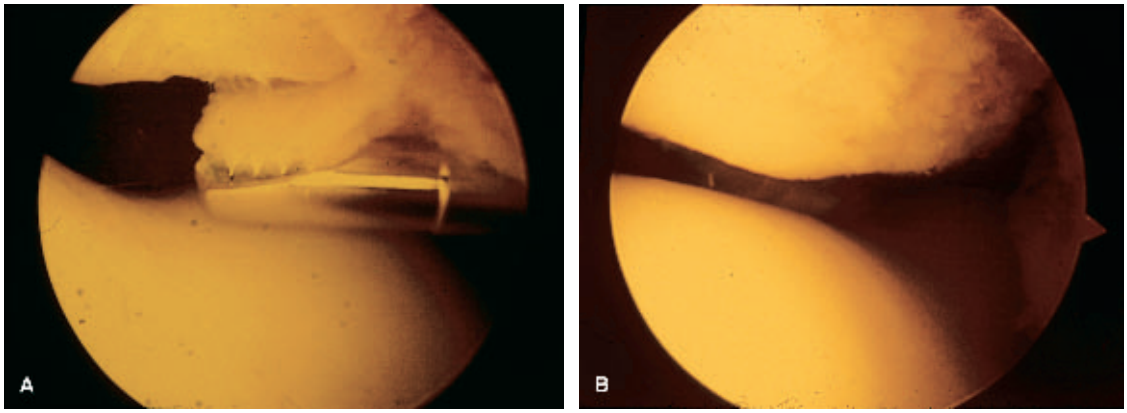

FIG. 4. Peripatellar synovectomy in a patient with patellofemoral pain. **A:** Before synovectomy. **B:** After synovectomy. (From Dye et al.[1] Reprinted with permission.)

ting of a documented tight lateral retinaculum, as described by Fulkerson and Hungerford.[10] I rarely perform this procedure, despite seeing a large number of symptomatic patellofemoral pain cases. The rate of performance of the lateral release within The International Patellofemoral Study Group has dramatically decreased during the past decade, as it has been recognized that this operation is not a panacea and has inherent dangerous characteristics. Major proximal and distal realignments for patellofemoral pain are more dangerous because they often involve extensive tissue dissection and osteotomy of bone. The long-term results of such procedures are inherently unpredictable, no matter how well the patellofemoral joint tracking may appear to have been improved at surgery. The unpredictability is attributable to factors beyond the surgeon's control, including the development of differential postoperative muscular atrophy and possible alteration of cerebellar sequencing of motor unit firing. In most cases, such major surgery should be contemplated only for demonstrated recurrent symptomatic patellofemoral instability or for established patellofemoral arthrosis. Herrenbruck, Mullen, and Parker discuss the treatment of established arthrosis in a related article in this current symposium.

Restoration of tissue homeostasis (healing) of perturbed highly loaded tissues involved in the genesis of patellofemoral pain is a result of billions of years of molecular and cellular evolutionary refinements. Respecting the special nature of the patellofemoral joint through a careful empiric treatment program designed to maximize healing as predictably and safely as possible is best in most cases. Failing this, a careful analytical surgical approach may be warranted.

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