Chapter 7

Knee and thigh

CHAPTER CONTENTS

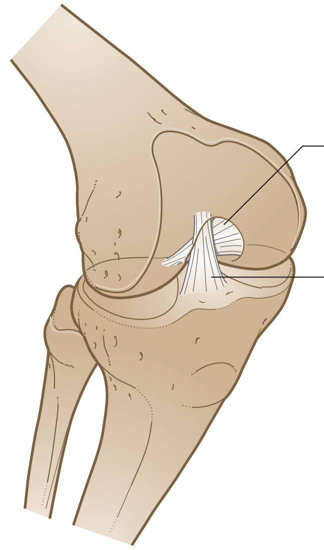

Figure 7.1 The knee joint showing where cruciate ligaments cross.

The knee is the largest joint in the body and is particularly susceptible to various types of injury or dysfunction due to its structural design. There are two articulations associated with the knee joint, the tibiofemoral and patellofemoral joints. The tibiofemoral is a true synovial joint where two long bones articulate with each other. It is the weight-bearing structure of the knee and as a result it plays an important role in shock absorption and locomotion. The patellofemoral articulation is neither a true synovial joint nor a weight-bearing articulation. The patellofemoral articulation is involved in numerous soft-tissue disorders at the knee because of the strong force loads associated with the quadriceps muscles during knee extension.

Knee injuries are rampant in sports activities, so the role of knee function in locomotion has been studied in great detail. Much attention has focused on joint trauma involving the internal knee structures, such as the cruciate ligaments, menisci, and articular surfaces. Yet soft-tissues acting on this joint are considerably important and massage plays an important role in management of numerous disorders in this area.

INJURY CONDITIONS

ANTERIOR CRUCIATE LIGAMENT SPRAIN

Description

The anterior cruciate ligament (ACL) is one of four primary stabilizing ligaments of the knee. The term *cruciate* means cross, and a lateral view of the knee shows how the anterior and posterior cruciate ligaments form a cross inside the knee joint (Fig. 7.1). The ACL attaches to the anterior aspect of the tibial plateau, and is designed to resist anterior translation of the tibia in relation to the femur. It also functions to limit hyperextension of the knee, and to resist medial rotation of the tibia in relation to the femur.

Sprains to the ACL are relatively common injuries. As more people become active in vigorous sports and recreational activities, these injuries are increasing even more. It has been estimated that ACL injuries occur at the rate of about 60 per 100,000 people per year.[1]

ACL sprains occur more often to women than to men. There are a number of different factors that may account for this statistic. The hormone estrogen can be a factor in causing relaxation in soft tissues, especially ligaments.[2,3] This greater degree of soft-tissue relaxation may account for an increase in ligamentous laxity and a greater number of ACL injuries. Women also have a larger Q angle than men. The *Q angle*, or Quadriceps angle, is determined by connecting a line between the tibial tuberosity and the midpoint of the patella. Another line is then drawn between the midpoint of the patella and the anterior superior

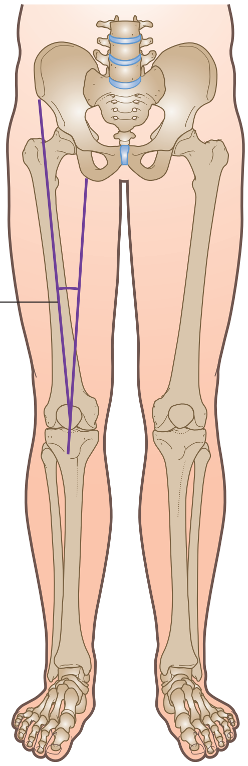

Figure 7.2 The Q angle.

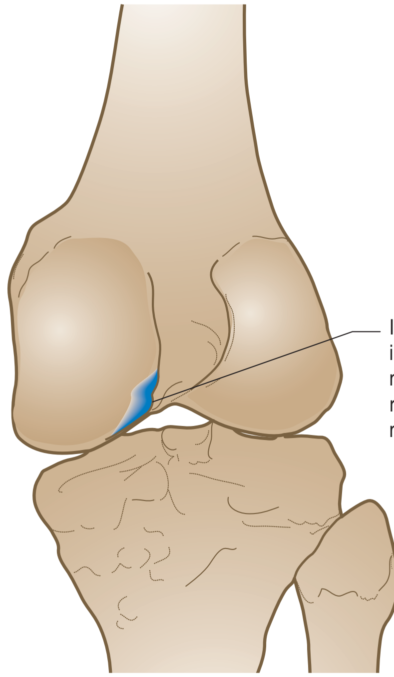

Figure 7.3 Posterior view of the right tibiofibular articulation showing the intercondylar notch.

iliac spine (ASIS). The angle formed between those two lines is the Q angle (Fig. 7.2).

Although sources vary on how much is too much for the Q angle, an angle of more than 15° in women and 10° in men is considered excessive.[4] Women have a larger Q angle because of the broader pelvis. There is some evidence that a larger Q angle may cause an increasing degree of pull by the quadriceps muscle group on the tibial tuberosity.[5]

The quadriceps group attaches to the tibial tuberosity. Due to its angle of pull, it pulls the tibia in an anterior direction. If there is a greater pull from the quadriceps on the tibial tuberosity, that increased quadriceps pull places a greater tensile load on the ACL and can contribute to ACL injury.

The quadriceps group pulls the tibia in an anterior direction. The ACL is designed to prevent excessive forward movement of the tibia. The hamstrings pull the tibia in a posterior direction. Consequently, they also prevent excessive forward tibial translation when contracting so their contraction aids the role of the ACL. Hamstring function and strengthening becomes an important aspect of ACL rehabilitation because these muscles can aid the role of an injured ACL.

Narrowness of the intercondylar notch can also play a part in the onset of ACL injury. If the intercondylar notch is narrow, the ACL may rub against the medial side of the lateral femoral condyle (Fig. 7.3). Friction of the ligament against the side of the femoral condyle is likely to increase the incidence of ACL injury.[6]

Valgus stress to the knee increases tension on the ACL against the femoral condyles as well. Therefore, when attempting to identify the possible cause of ACL injury, it is important to analyze the mechanical factors that played a role in the initial injury.

ACL sprains are acute injuries that happen as a result of excessive loads placed on the ligament. These excessive loads commonly happen under certain circumstances:

1. Sharp deceleration or deceleration before a change in direction. When there is a sharp deceleration, one leg is placed in front of

the other to stop or slow the momentum of the body. There is a very strong anterior translation force of the tibia on the femur as the knee acts to absorb the body's momentum. The quadriceps muscles contract strongly to offer muscular resistance to the momentum. This combination of momentum and strong quadriceps force produces the ACL injury.

2. Landing from a jump is another activity that produces a sudden ACL sprain. The mechanics of this activity are much the same as those in the deceleration from running. There is a very strong anterior translation force placed on the knee when landing from a jump. The quadriceps contract strongly to resist gravity and absorb the body's weight. The strong quadriceps activity and body momentum lead to excessive loads on the ACL.

Treatment

Traditional approaches

If the sprain is not severe, it is usually treated with activity modification and the use of protective knee bracing. However, if the injury is more severe, surgical intervention is often required. Surgical techniques for treatment of ACL sprains have advanced significantly in recent years, and now these surgeries are performed with very good results and much shorter rehabilitation periods.

In instances, a total reconstruction of the ligament is the favored procedure.[7] This procedure involves taking the middle portion of the patellar tendon and using it to replace the damaged ACL. Small chunks of bone on each end of the tendon are also removed with the section of tendon that is used. The bone chunks on the end of the tendon are fixed to the femur and tibia, and eventually grow back into the bone creating a stronger attachment. Length of rehabilitation until the person can get back to full levels of activity for a complete ACL reconstruction is usually about 6 months.[4]

After the surgery physical therapy is very important during the rehabilitative phase. For example, strengthening of the hamstring muscles is important, as they are synergists for the ACL against anterior translation of the tibia.

Soft-tissue manipulation

General guidelines Massage is not used for direct treatment of the ACL injury. Because the damaged ligament lies within the joint capsule deep inside the knee, it is inaccessible to palpation and massage treatment. However, massage still has a place in the rehabilitation of ACL sprains. Numerous secondary effects of the ACL sprain can benefit from massage treatment.

Spasm and/or tightness are/is common in the muscles surrounding the knee joint after an ACL sprain. Massage treatment to these muscles helps normalize biomechanical balance around the knee. Surgery is often performed for ACL injury and massage is advantageous for getting the individual back to optimum function following surgery. In the early stages after surgery, individuals may be prevented from moving their limbs through a full range of motion in order to protect the healing ligament. As a result, soft-tissue fibrosis may set in and cause longer delays in the healing process. Massage applications done during rehabilitation can enhance the healing process and prevent excessive fibrosis from developing. The various cross fiber and broadening techniques are most helpful in reducing the development of fibrosis.

The hamstrings are synergists with the ACL in stabilizing the knee against anterior tibial translation. As a result, they are prone to hypertonicity following ACL ligament injury. Massage applied to the hamstrings, helps them maintain proper neuromuscular tone. Reducing tension in the quadriceps with massage is also important because they pull the tibia in an anterior direction and place increased tensile stress on the ligament during healing.

Stretching of the quadriceps and hamstring muscles is advocated, but with some limitations. If the individual has had surgery for an ACL repair, it is crucial to consult with the client's physician and/or physical therapist to see what motions are being limited during the rehabilitation phase. During post-surgical rehabilitation certain motions are restricted to prevent excess stress on the ligament. Stretching must be performed within these motion limitations, and is usually not advised right after the surgical procedure. As the individual progresses through the post-surgical rehabilitation, more stretching is incorporated with the treatments, but should always be done within the functional limitations of the rehabilitation program.

Suggested techniques and methods

A. Sweeping cross fiber to quadriceps This technique applies superficial pressure to reduce tension in the quadriceps group. The stroke in the sweeping cross fiber technique travels diagonally across the fibers of the quadriceps muscle group with the sweeping motion of the hand and thumb (Fig. 7.4). Use successive sweeping strokes on the quadriceps until the entire muscle group has been covered.

B. Sweeping cross fiber to hamstrings A similar sweeping cross fiber technique is used to address superficial tension in the hamstrings, which might be hypertonic from the ligament sprain. Just as with the quadriceps technique, the stroke travels diagonally across the fibers of the muscle group (Fig. 7.5). Use successive sweeping strokes on the hamstrings until the entire muscle group has been covered.

C. Compression broadening to the quadriceps Increased pressure in this technique allows access to some of the deeper muscle fibers in this large muscle group. This broad cross fiber technique reduces hypertonicity. Use compression broadening strokes to work the entire length of the quadriceps muscle group. The application of each pressure stroke is directly transverse to the muscle fiber and primary circulatory flow (Fig. 7.6). Consequently, the muscle can be worked distal to proximal or proximal to distal.

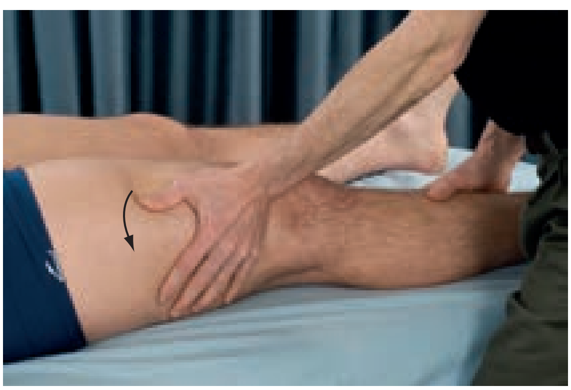

Figure 7.4 Sweeping cross fiber to quadriceps muscle group.

Figure 7.5 Sweeping cross fiber to hamstrings.

Figure 7.6 Compression broadening to quadriceps.

D. Compression broadening to the hamstrings Hypertonicity is further reduced with compression broadening. Apply the compression broadening techniques until the entire length of the muscle has been treated (Fig. 7.7). As with the quadriceps compression broadening technique, treatment can move distal to proximal or vice versa.

E. Deep longitudinal stripping to the quadriceps Elasticity and flexibility are enhanced with deep stripping applied to the quadriceps group. Deep stripping is used after broadening techniques and some of the more superficial applications are used to encourage adequate tissue fluid movement, warming, and superficial muscle pliability. Deep stripping can be performed first with a broad contact surface of pressure for more general muscle treatment and then with a small contact surface for deep specific muscle treatment (Fig. 7.8).

F. Deep longitudinal stripping to the hamstrings Stripping is used to treat the hamstrings for

Figure 7.7 Compression broadening to hamstrings.

Figure 7.8 Deep stripping on quadriceps.

excessive muscle tension. Use the deep stripping techniques on the hamstrings in the same fashion as they are used with the quadriceps. Start with broad contact surface of pressure and then gradually perform the stripping techniques with a small contact surface (Fig. 7.9).

Figure 7.9 Deep stripping on hamstrings.

Rehabilitation protocol considerations

- The ACL is deep within the knee joint so no direct treatment of the damaged ligament is possible. The treatment techniques listed here are directed at secondary muscle spasm that results from the ligament injury or compensating biomechanical patterns.
- Consult with the physician or other supervising rehabilitation specialist about treatment approaches that would be most appropriate. Modifications to the suggested techniques mentioned above may be necessary for each unique client situation.
- The hamstrings serve an important synergistic function with the ACL in certain positions of the knee. It is not always advantageous to attempt complete flexibility and pliability of the hamstring muscle group. In severe ligament sprains hypertonicity in the hamstring group provides additional stabilizing support for the damaged ligament. Muscle tension can then be gradually reduced as the client progresses through the stages of rehabilitation.

Cautions and contraindications Use caution with positioning if treatment is performed shortly after surgery. Protective braces are sometimes used to prevent the knee from going into full extension, which would stress the ACL. The practitioner must be careful not to put the knee in positions that compromise the ligament while it is healing. Range-of-motion activities need to be carried out in a very careful manner, so as not to further stress the ligament.

If surgery was performed for the ACL repair, use particular caution with treatment at the incision sites. It is wise to consult the orthopedic surgeon about the appropriateness of massage treatment in this region shortly after surgery. These sites can be susceptible to infection early in the healing process and all attempts should be made to keep them clean and free of massage lubricants that are being used during treatment. In some ACL repairs a section of the patellar tendon is harvested and used as ligament tissue. In this case use particular caution with massage treatment on or around the patellar tendon.

POSTERIOR CRUCIATE LIGAMENT SPRAIN

Description

The posterior cruciate ligament (PCL) connects the posterior aspect of the tibia to the anterior aspect of the femur. The primary function of the PCL is to prevent posterior movement of the tibia in relation to the femur (Fig. 7.1). PCL injuries are not as prevalent and cause far less functional instability than ACL injuries. However, PCL injuries may occur more often than they are actually reported.[8]

ACL injuries are most often the result of a non-contact injury where the momentum of the individual's body causes the injury. PCL injuries, however, occur more often from contact with an outside force. The mechanism of injury is usually a straight posterior force applied to the proximal tibia, driving it in a posterior direction. Common examples of PCL sprain include falling to the ground, where the proximal tibia hits the ground or another object first. This is especially likely to happen if the foot is dorsiflexed when the knee hits the ground, making the proximal tibia the initial point of impact.

Another example of PCL injury occurs to passengers in the front seat of a car in a head-on motor vehicle accident. If the force is sufficient, the passenger is thrown forward and the proximal end of the tibia hits the dashboard with a strong force. This force thrusts the proximal tibia posteriorly and causes a severe stretch or rupture to the PCL.

In addition to straight posterior stresses, the PCL may be injured from rotational stresses at the knee. Another role of the PCL is to prevent excessive rotation at the knee. Its orientation makes it a restraining ligament to lateral rotation of the knee.[9] Lateral rotation at the knee means the tibia is rotating laterally in relation to the femur. This motion occurs when an individual plants the foot and turns to the opposite side. This kind of sudden cutting motion happens a great deal in sporting activities, and is a common cause of ligamentous damage in the knee. Although its contribution to rotational stability is not great, there is still chance of ligament injury from excessive rotational stress. Biomechanical studies have also indicated that the PCL may play a stronger role in restraining rotational movements when the knee is in flexion compared to when it is in extension.

Isolated tears to the PCL can happen, but they are not very common. PCL injuries, especially those associated with rotational stresses at the knee, usually occur in conjunction with injuries to other soft tissues. The strong and powerful quadriceps, with their associated patellar tendon, lends additional resistance to direct posterior tibial translation. It is resisting rotational stress where the PCL and other soft tissues are under greater biomechanical demand.

Treatment

Traditional approaches

There are a number of different ways to treat PCL injuries. However, perhaps because isolated PCL injuries do not occur as often, treatment protocols for this problem remain undefined and controversial.[8]

Unlike ACL injuries, many PCL injuries are treated without surgery. If there is an isolated PCL injury and no other soft-tissue structure is significantly impaired, physical therapy is often sufficient to manage the condition.[10] Several authors have stated that non-operative procedures can be established for all grade 1 and 2 ligament injuries in the knee, as well as some grade 3 ligament tears that are isolated to the PCL only.[11]

Strengthening exercises are an important part of the rehabilitation process. Emphasis is placed on quadriceps strengthening because the quadriceps act as synergists to restrain posterior movement of the tibia on the femur.

Some PCL injuries are left untreated even if there is a significant tear to the ligament. If the client is not going to engage in activities that require a great deal of dynamic stability of the knee, the risks of surgery may outweigh the need for full knee stability. However, continued instability and excess movement in the knee are a potential risk factor leading to arthritic changes in the knee as the individual ages.

Soft-tissue manipulation

General guidelines Massage approaches primarily play a supportive role in treating PCL injuries. Because the PCL is deep inside the knee joint, it is inaccessible to the palpating hand and therefore massage does not directly affect the ligament healing. However, massage may be used as an indirect adjunct to other treatments. As with treatment of ACL injuries varying levels of muscle spasm or biomechanical imbalance can occur around the knee joint. Massage reduces muscular hypertonicity and assists in restoring proper biomechanical function. As mentioned earlier, the quadriceps is a synergist with the PCL in preventing posterior translation of the tibia. As such, they may become hypertonic following an injury to the PCL. Massage treatment to the quadriceps is beneficial to make sure they maintain optimum biomechanical balance as the client regains knee function.

If surgery is performed for this condition, prevention of post-surgical fibrosis is a valuable contribution of massage. Various cross fiber and broadening techniques are most helpful in this process. During the rehabilitative phase, stretching helps restore proper biomechanical balance around the knee joint. Stretching that is aimed at maintaining a good length and flexibility balance between the quadriceps and hamstrings is the goal. Stretching methods should not put excessive stress on the healing ligament structure.

Suggested techniques and methods Treatment strategies for PCL sprains are indirect. The PCL is not accessible to palpation so no direct massage treatment is administered to the injured ligament. Massage approaches are all aimed at maintaining optimum biomechanical balance around the knee as the damaged ligament heals. See the suggested techniques and methods described above in the section on anterior cruciate ligament sprains. The same techniques, methods, and rehabilitation protocol considerations are applicable for PCL sprains.

Cautions and contraindications Because the PCL is not directly accessible to palpation, it is not likely that massage will damage the healing ligament. The main potential for harm in a healing PCL is excessive motion during joint movements or stretching procedures. As long as care is taken when performing those procedures and the client's tolerance for pain is considered, these treatments should be appropriate. Knowing the severity of injury will allow the practitioner to determine when to treat the condition and how much work should be performed on the region. The more severe the injury, the greater must be the caution in applying soft-tissue interventions soon after the injury has occurred.

MEDIAL COLLATERAL LIGAMENT SPRAIN

Description

The medial (tibial) collateral ligament (MCL) is on the medial side of the knee and is the larger of the two collateral ligaments of the knee (Fig. 7.10). Its proximal attachment is on the medial condyle of the femur, and its distal attachment is on the medial side of the proximal tibia, just posterior to the pes anserine muscle group attachment. The pes anserine group includes the sartorius, semitendinosus, and gracilis. The angular direction of these muscles and their proximity to the MCL make them accessory stabilizers of the knee.[9] If there is a sprain injury to the MCL, these stabilizers can offer additional support.

The MCL is fibrously connected with the joint capsule of the knee. Injury to the MCL can also produce damage to the joint capsule. The medial meniscus also has a fibrous connection to the MCL. This fibrous connection is one of the main

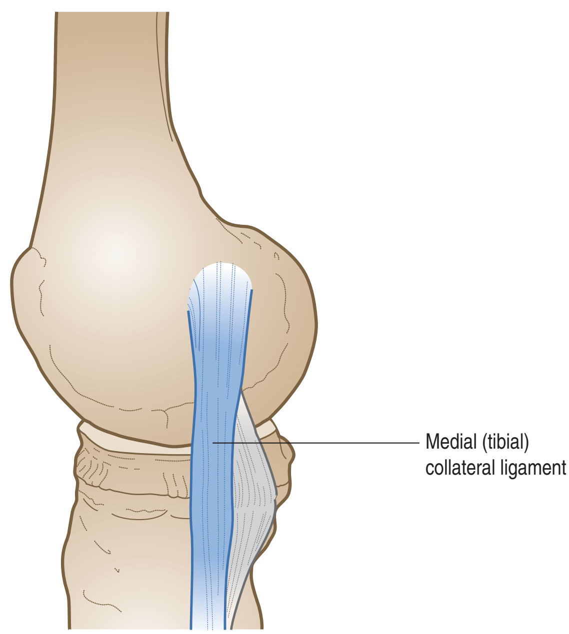

Figure 7.10 Medial view of the right knee showing the medial collateral ligament.

reasons that MCL sprains often occur in conjunction with meniscal damage. When the MCL is exposed to high tensile forces, it can pull on the medial meniscus causing a tear in the cartilage.

The primary function of the MCL is to enhance medial stability of the knee. Specifically, it is designed to resist a valgus force to the knee. A valgus angulation at a joint is one in which the distal portion of the bony segment deviates in a lateral direction. At the knee a valgus force refers to the angulation of the tibia. Therefore, it would be a force directed in a medial direction that would cause the distal end of the tibia to deviate in a lateral direction (Fig. 7.11).

The ACL also provides some stabilization against valgus stresses at the knee. This may be one reason why ACL injuries often occur with extreme valgus stress on the knee. The ACL appears to play a stronger role in resisting valgus stress when the knee is in an extended position. It is for this reason that assessment procedures often put the knee in partial flexion when testing the MCL, so the role of the ACL in medio-lateral stability is minimized.

The MCL is part of a group of tissues called the *unhappy triad*. The unhappy triad includes the ACL, MCL, and medial meniscus.[12] The triad gets its name from the frequency with which these structures are injured together from a single incident. The injury commonly involves a strong valgus or rotary force to the knee. Injuries that involve the ACL and MCL together are quite common, even if they do not include damage to the medial meniscus. Several studies have indicated that the unhappy triad may really be a misnomer, because the authors had found more frequent injury to the lateral meniscus than the medial meniscus with combined ACL/MCL injuries.[12] What is important to keep in mind is that the MCL is often injured along with other structures in the knee, and they could all be part of a complex knee injury.

Figure 7.11 The player on the left is experiencing a valgus force to his left knee.

Treatment

Traditional approaches

MCL sprains are frequently treated without surgery. A number of sources have indicated that surgical repair of MCL injuries, rest, and immobilization are being de-emphasized in favor of early controlled motion and functional rehabilitation.[13–16]

In multiple ligament injuries, such as one where the MCL and ACL are both severely sprained, the ACL is often treated surgically, while the MCL is treated with conservative measures.[17,18]

There are several reasons why MCL injuries may fare better with conservative treatment than ACL injuries. The ACL has about half the expansibility of the MCL, and therefore it may be less resistant to tensile stress injuries.[16] Blood supply, which is essential for healing, may also play an important role. Blood supply to the collateral ligaments appears to be better than that to the cruciate ligaments. This is likely to have a negative impact on healing in the cruciate ligaments.[19]

Non-operative treatment includes the use of splints or hinged knee braces. The knee braces are adjustable to the severity of the knee ligament injury. Other forms of conservative treatment include protected weight bearing, inflammation control, range-of-motion and resistance exercises. The goal is to help provide support through accessory soft tissues while the primary ligamentous damage is healing. Following a ligamentous injury, muscles that cross the joint may play a greater role in joint stability, so strengthening of those muscles may be in order to create stabilization around the joint. The use of exercise measures such as resistance bands and balance boards may also be helpful, especially if the individual is trying to rehabilitate in preparation for a return to sporting activity.[20]

Soft-tissue manipulation

General guidelines Unlike the cruciate ligaments, the MCL is easily accessible to treatment by soft-tissue manipulation. The client usually complains of a site of maximal tenderness in the ligament that corresponds to the primary site of tissue damage. Friction massage applied to the primary site of injury encourages fibroblast production and ligament healing.[21,22] In addition, the friction mobilizes the ligament against adjacent tissues and helps prevent fibrous adhesion with scar tissue during the healing process. Friction techniques used in treatment of a MCL sprain are most effective if they are performed perpendicular to the fiber direction of the ligament to prevent these adhesions.

In addition to the friction massage applications for the torn ligament fibers, massage can be applied to muscles that cross the joint to maintain their optimal tone and to decrease biomechanical imbalances that have been created in the process. It is likely that there is increased tension in the adductor muscles, as they will act as synergists for the medial collateral ligament. Following a sprain to this ligament, the adductor muscles can be hypertonic as they work to create stability around the knee. Stretching the adductor muscles is suggested if they have increased tightness following the injury. However, they may be contributing additional stability to the joint so over-zealous stretching can be counter productive.

Suggested techniques and methods

A. Sweeping cross fiber techniques to the medial knee Ligament, fascia, and muscle tissue is treated on the medial side of the knee with sweeping cross fiber techniques. There is an expanse of fascial connective tissue on the medial side of the knee. The sweeping cross fiber applications to the medial knee encourage mobility and pliability between the MCL and adjacent tissues. Start this technique with light pressure during the sweeping movements, then progress to gradually greater

Figure 7.12 Sweeping cross fiber to medial side of the knee.

pressure. Use a sweeping motion with the thumb or fingers on the medial knee tissues with a mild to moderate amount of force (Fig. 7.12).

B. Multi-directional short stripping Deeper pressure is used with stripping applied to the medial aspect of the quadriceps retinaculum, distal pes anserine group, MCL, and all adjacent tissues. Use the thumb, finger, or pressure tool to apply deep short stripping strokes to all the tissues adjacent to the MCL (Fig. 7.13). The primary purpose of these strokes is to reduce tension in the surrounding tissues and encourage mobility and pliability between the MCL and all surrounding soft tissues.

C. Deep friction to medial collateral ligament Ligament tissue healing is enhanced with friction applied to the primary site of tissue damage. Friction is applied perpendicular to the fiber direction

Figure 7.13 Multi-direction short stripping around medial collateral ligament and retinacular tissues.

of the MCL to encourage the greatest mobility between the healing ligament's scar tissue and adjacent soft tissues. Deep friction also encourages fibroblast proliferation that enhances the ligament healing. Perform the friction for several minutes and then follow with stretching and range-of-motion movements of the knee in multiple planes. Repeat the series of friction, movement, and stretching several times.

D. Sweeping cross fiber to the adductors Adductor tightness is likely to result from an MCL sprain. Sweeping cross fiber techniques are applied to the adductor muscle group to reduce excessive hypertonicity. The sweeping cross fiber movement has the thumb and hand moving with a diagonally curving motion across the adductor fibers (Fig. 7.14). It is also helpful to apply sweeping cross fiber techniques and effleurage to the thigh muscles to maintain optimum biomechanical balance.

Rehabilitation protocol considerations

- Direct treatment of an MCL sprain should only proceed if the injury is past the acute inflammatory stage.
- Properly assessing the degree of ligament damage guides the intensity and depth of deep stripping and deep friction techniques. The less severe is the injury, the earlier and more aggressive massage treatment can be. In a first-degree sprain, friction and deeper massage treatment can begin very soon, if not immediately. In a second- or third-degree sprain, superficial work in the area may begin right away, but direct work on the ligament injury should hold off at least several days after the acute inflammatory stage has ended. This waiting time gives the healing ligament a chance to have scar tissue spanning the torn and damaged fibers.
- Stretching and joint movement are an integral part of regaining optimum ligament function and should be immediately incorporated with the soft-tissue treatments administered in the clinic.
- Ice applications are sometimes used after more vigorous bouts of friction massage to reduce post-treatment inflammatory activity and decrease discomfort resulting from treatment.

Figure 7.14 Sweeping cross fiber to adductors.

Cautions and contraindications

The practitioner should accurately assess the condition to determine what level of friction massage is appropriate. Factors to consider include the severity of ligamentous injury (often determined with special orthopedic assessment tests), how recently the injury occurred, and visible signs of recent trauma in the area such as extreme redness, heat, or inflammation. If these signs or symptoms are present, it is better to delay massage treatment.

Stretching of the adductor muscles is advocated to reduce excess tension on surrounding thigh muscles that might be hypertonic after the injury. A number of the stretching positions for adductor muscles put increased valgus stress on the knee, so use caution in stretching the adductor muscle group.

Box 7.1 Clinical Tip

One of the key factors when treating an MCL sprain is to make sure the healing ligament does not adhere to underlying tissues. Treatment with deep transverse friction is a valuable approach to address that concern. However, there is still the possibility of adhesion with underlying tissues, especially because the MCL may be fibrously attached to the meniscus. One way to enhance the mobility of the healing ligament is to perform deep friction treatments to the MCL while moving the knee in flexion and extension. Performing friction while moving the knee through a range of motion provides the greatest opportunity to have a strong ligament repair that is not adversely bound to adjacent tissues.

LATERAL COLLATERAL LIGAMENT SPRAIN

Description

The lateral (fibular) collateral ligament (LCL) attaches to the lateral condyle of the femur superiorly and the head of the fibula inferiorly (Fig. 7.15). The LCL is significantly smaller than its counterpart on the opposite side of the knee, the MCL. The LCL is not connected to the joint capsule of the knee or to the meniscus like the MCL is, so injuries to this ligament are rarely as severe as injuries to the MCL.

Sprains to the LCL usually occur from a pure varus load to the knee. A varus load to the knee would be one in which the knee was forced into a position with the proximal end of the tibia more lateral and the distal end more medial. This would occur, for example, with a direct blow to the medial side of the knee by a force that is moving from medial to lateral.

However, when a laterally directed force hits the medial side of the knee, an ankle sprain is more likely to result than an LCL sprain. The lateral ankle ligaments are a weaker point in the kinematic chain when excessive varus force is applied to the lower extremity so ankle sprains are more common than LCL sprains. Another reason the LCL is not injured as often is that it is protected by the opposite lower extremity. Consider a potential varus force hitting the left knee and coming from the person's right side. If an individual is hit from the right side, the right knee takes a valgus impact and protects the left knee from excessive varus force. The right knee would likely sustain the ligament sprain and protect the left knee from the varus force.

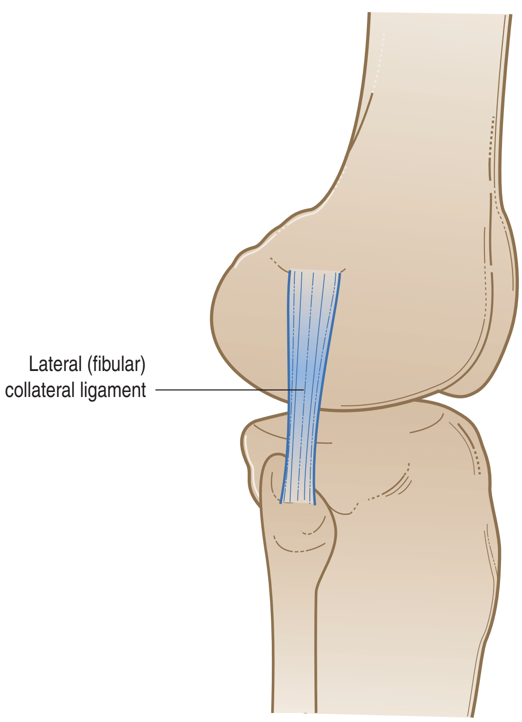

Figure 7.15 Lateral view of the right knee showing the lateral collateral ligament.

Treatment

Traditional approaches

Treatment for LCL sprains is similar to that for MCL sprains, and may include splints or hinged knee braces, protected weight bearing, inflammation control, range of motion and resistance exercises. The goal here is the same: to provide support through accessory soft tissues while the primary ligamentous damage is healing. However, since isolated tears of the LCL are not very common there is not a great deal of clinical evidence for effective treatments for this problem. The vast majority of these problems will be treated conservatively, with surgical treatment reserved for the most serious cases.

Soft-tissue manipulation

General guidelines Deep friction massage is used to encourage fibroblast proliferation and the proper mobility of the healing ligament tissue. Because the LCL is not fibrously connected to the joint capsule, concerns about transverse friction applications being used to prevent adhesion to the capsule are not an issue. However, the concept of maintaining mobility with transverse friction massage plays a part with fibers of the iliotibial band that are directly on top of the ligament.

With LCL sprains there is rarely the same amount of correlating muscle hypertonicity that is present in MCL sprains. For one thing, there are fewer muscles producing abduction of the thigh than adduction. It is the abductors that work synergistically with the LCL. Primarily these are the tensor fasciae latae and gluteal muscles acting through the iliotibial band. While excess tension is not generally found in these muscles with an LCL sprain, there is benefit in addressing them as a part of the kinetic chain in knee stability.

Stretching will not play as much of a role in the rehabilitation process with LCL sprains, because there are not many tissues that can be adequately stretched across this area. The LCL has some synergistic help from the tensor fasciae latae through tension developed in the iliotibial band. However, hypertonicity in these muscles is not likely to develop in the same way it does, for example, with the adductors in an MCL sprain. Therefore, stretching plays a less significant role in the rehabilitation of this injury than it does with MCL sprains.

Suggested techniques and methods

A. Sweeping cross fiber techniques to lateral knee Superficial tissues are addressed and ligament adhesion reduced with cross fiber techniques applied to the lateral side of the knee (Fig. 7.16). This technique addresses the expanse of fascial connective tissues on the lateral side of the knee, just as they are treated on the medial knee in an MCL sprain. Start this technique with light pressure during the sweeping movements, then progress to gradually greater pressure.

B. Multi-directional short stripping Deeper and more specific pressure is applied with these short stripping techniques. The primary purpose of these strokes is to reduce tension in the surrounding tissues and encourage mobility and pliability between the LCL and all surrounding soft tissues. Short stripping is applied to the lateral aspect of the quadriceps retinaculum, iliotibial band, LCL, and all adjacent tissues. Use the thumb, finger, or pressure tool to apply deep short stripping strokes to all the tissues adjacent to the LCL (Fig. 7.17).

Figure 7.16 Sweeping cross fiber to lateral side of the knee.

Figure 7.17 Multi-direction short stripping around lateral collateral ligament and retinacular tissues.

C. Deep friction to lateral collateral ligament Tissue healing is enhanced with deep friction applied to the site of fiber tearing in the LCL. The friction technique is applied perpendicular to the fiber direction of the LCL to encourage the greatest mobility between the healing ligament's scar tissue and adjacent soft tissues. Perform the friction for several minutes and then follow the friction treatment with stretching and range-of-motion movements of the knee in multiple planes. Repeat the series of friction, movement, and stretching several times.

D. Sweeping cross fiber to lateral thigh Iliotibial band and lateral thigh muscles are addressed with superficial sweeping cross fiber movements to reduce excessive hypertonicity (Fig. 7.18). Apply sweeping cross fiber techniques and effleurage to the thigh muscles to help maintain optimum biomechanical balance. Keep in mind when working on the lateral thigh region that the iliotibial band is a flat, sheet-like tendon and should never feel as pliable as the surrounding muscle tissue. Do not treat the iliotibial band aggressively in an effort to make it feel as soft and pliable as the surrounding muscle tissue.

Rehabilitation protocol considerations

- See the description of considerations under the MCL as they are virtually the same for this condition.

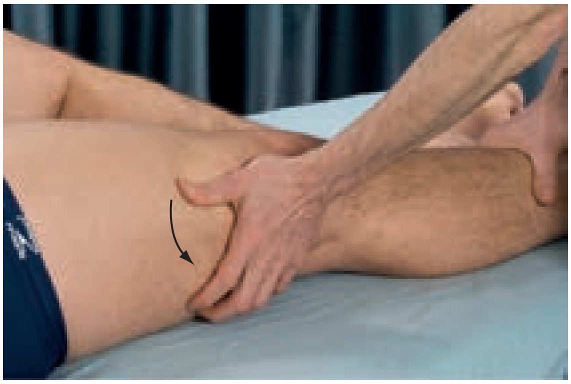

Figure 7.18 Sweeping cross fiber to iliotibial band and lateral thigh muscles.

- Surgery is performed far less often for LCL sprains, so there can be a greater reliance on soft-tissue treatment strategies to restore optimum function of the knee following an LCL sprain.

Cautions and contraindications The same cautions and contraindications exist as for treatment of MCL sprains except the cautions for stretching procedures are slightly different. Stretching procedures that focus on the thigh abductors are used most often to address tightness that may correspond with the ligament sprain. Use caution with thigh abductor stretches as some of the positions used to stretch this region put additional tensile stress on the LCL.

PATELLOFEMORAL PAIN SYNDROME

Description

Patellofemoral pain syndrome (PFPS) is not a specific condition with a clear cause or description. PFPS is a general term for anterior knee pain that may originate from a variety of causes. Some use the term incorrectly as a synonym for chondromalacia patellae. PFPS is characterized by anterior knee pain that is worse when using the extensors of the knee in activities such as ascending or descending stairs. The primary cause of the problem appears to be incorrect tracking of the patella during extension movements. Yet, it is not clear which tissues are the true source of pain in PFPS. Current literature indicates several possible sources of pain.

A basic comprehension of knee biomechanics is a prerequisite to understanding PFPS and patellar tracking disorders. To understand how a patellar tracking disorder occurs, it is important to understand some fundamental concepts of knee biomechanics. The patella is embedded in the quadriceps tendon, and its primary function is to improve the quadriceps' angle of pull on the proximal tibia. Because it is embedded in the quadriceps tendon, the patella is pulled superiorly along the quadriceps' line of pull. In most individuals, the quadriceps group does not pull in a straight superior direction, but along the line of the femur. The femur has a natural varus angulation (distal end of the femur deviating medially) so the quadriceps group pulls along this line. The degree to which this pull deviates from a straight vertical line can be visualized by evaluating the approximate Q angle for that individual and looking at the quadriceps line of pull (Fig. 7.19). See the description for how to determine the Q angle earlier in this chapter.

The distal portion of the vastus medialis muscle is called the VMO (vastus medialis obliquus), because its fibers run predominantly in an oblique (diagonal) direction. A primary function of the VMO is to offset the tendency of the other quadriceps muscles to pull the patella in a lateral direction. Strength imbalances between the VMO and the other quadriceps muscles are a main cause of tracking disorders and pain sensations associated with PFPS.[23]

Many anatomical structures around the knee joint, such as the quadriceps retinaculum and the fibrous joint capsule, are richly innervated. The medial and lateral sides of the patellar tendon have fibrous continuity with the joint capsule as well, and excessive stress on the tendinous fibers can pull on the capsule in turn. Consequently, it does not take a great deal of tensile force for the tissues to register pain.

Other tissues can also contribute to PFPS. The iliotibial band has fibrous connections with the lateral retinaculum of the quadriceps group. Excessive tightness in the iliotibial band could pull on the lateral retinaculum. Pain could result from the pull on the lateral side of the retinaculum, or from the tissues on the medial side of the knee that are also being pulled.

The client with PFPS complains of anterior knee pain that is aggravated by activities such as

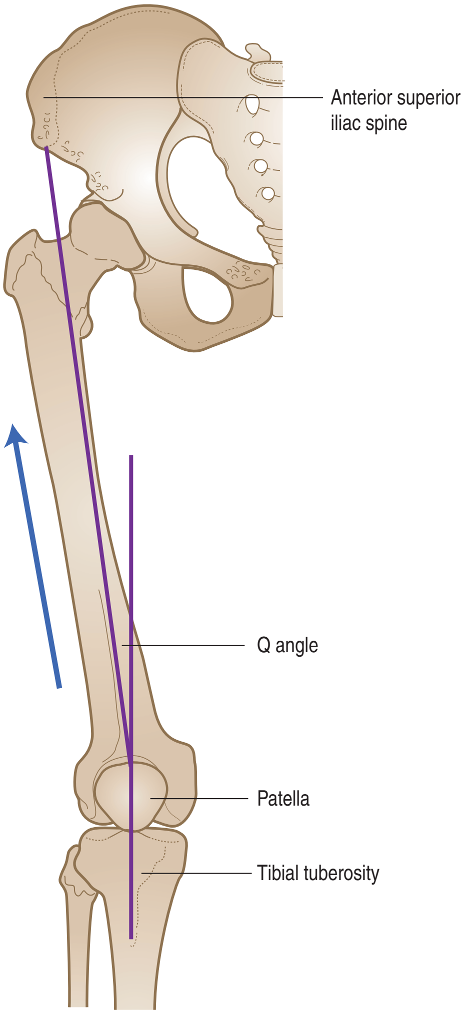

Figure 7.19 The quadriceps angle of pull depending on the Q angle (indicated by arrow).

ascending or descending stairs, squatting, or maintaining the knee in a flexed position for long periods. When the knee is maintained in a flexed position for long periods, many of the extensor tissues of the knee are pulled taut. The client may not feel anything until they change position. It is at this time that the pain sensations become most prominent. This experience is often called a *positive movie sign*, because it frequently happens in a theater when the individual stays seated in one position for about 2 hours. When they first get up and move around, there is a dramatic increase in pain sensations felt in the anterior knee region that gradually subsides after a few minutes.

Instability and feelings of giving way are also reported with PFPS. The instability is not necessarily from ligamentous damage or actual joint pathology. The cause of the sensation of instability and giving way comes primarily from reflex muscular inhibition. As there is a strong pain sensation in the knee extensors, the central nervous system essentially shuts off or decreases their contraction force. The individual experiences this sudden drop in quadriceps activity as the knee giving way and being unable to hold them up.

One of the clinical indicators that is often present in PFPS is atrophy of the quadriceps group. As a result of the knee pain, there is an inhibition of quadriceps activity. This can often lead to some degree of atrophy in the vastus medialis and lateralis muscles especially. This atrophy is evaluated by taking a circumferential measurement of the quadriceps group and comparing it to the unaffected side. A significant difference in circumferential measurement indicates some atrophy, and this can be a sign of extensor mechanism pathology. Atrophy is more apparent with quadriceps dysfunction than with some other muscle groups. That is because disuse atrophy affects anti-gravity muscles more than others. The quadriceps group is an anti-gravity muscle, and, therefore, more susceptible to this atrophy.[24]

Treatment

Traditional approaches

Conservative treatment is generally preferred for addressing PFPS. This is especially true if it is not clear which tissues are the source of pain. Conservative treatment comprises bracing, activity modification, and quadriceps strengthening exercises.[25]

There is some indication, although it is debated in the literature, that the VMO is most active in the last 20–30° of knee extension. Because one of its primary functions is to offset the tendency of lateral pull on the patella by the other quadriceps muscles, there is an emphasis on VMO strengthening.

Short arc quadriceps extension exercises against resistance are commonly used to strengthen the VMO. A short arc extension movement is performed in the last 20–30° of knee extension and repeated over and over. It is thought that strengthening the VMO in this range of the extension movement reduces the biomechanical imbalance around the joint.

Another intervention that has met with clinical success is patellar taping.[26–28] The client has restrictive tape placed on them similar to the way athletes do during sporting activities. The tape is thought to both encourage proper patellar tracking and influence proprioception in a way that leads to corrections in faulty biomechanical patterns.[29] Very often it is not one single treatment that is most effective, but a combination of various methods performed together.[30]

If conservative measures are not successful in alleviating the problem, surgical intervention may be used. One of the common surgical procedures for this problem is the lateral retinacular release. In this procedure the lateral retinaculum is cut in order to decrease the amount of lateral pull on the extensor mechanism. The effectiveness of lateral release surgery has been questioned recently.[31–33] One reason may be that the optimal biomechanical balance around the joint has been disturbed.

The problems from this procedure can also stem from the role of the lateral retinaculum. One study found that the lateral retinaculum helps stop the patella from moving laterally.[34] If this is actually true, surgically cutting the retinaculum can aggravate the problem.

Soft-tissue manipulation

General guidelines Because a primary component of PFPS appears to be pain originating from the soft tissues around the knee, massage is valuable in treating this problem. Changes may not be immediate because the treatment is attempting to alter biomechanical patterns that have been established for some time. However, the client should feel some improvement in symptoms within three or four treatments. Massage treatment focuses on all of the quadriceps muscles as well as the patellar tendon and fascial retinacular tissues around the knee.

PFPS treatment addresses the soft-issue distress resulting from the patellar tracking disorder. In some cases there are other biomechanical issues, such as genu valgum or overpronation, which are exacerbating the tracking disorder. Some of these other biomechanical disorders may need correction in addition to the treatments that are focusing on the soft tissues around the patellofemoral articulation.

Stretching the quadriceps group is helpful both in the treatment room and for the client to do at home. It is a good idea to demonstrate proper quadriceps stretching methods for the client to make sure they are not overexerting or targeting the wrong muscles during the stretching procedure. An effective quadriceps stretch that is easy to perform at home is demonstrated in Figure 7.20.

Suggested techniques and methods

A. Sweeping cross fiber to quadriceps Initial tension reduction in the quadriceps is achieved with sweeping cross fiber techniques. This technique also reduces excess pull on the retinacular tissues. The stroke travels diagonally across the fibers of the quadriceps muscle group with the sweeping motion of the hand and thumb. (See this picture in Fig. 7.4.) Use successive sweeping strokes on the quadriceps until the entire muscle group has been covered.

Figure 7.20 Common quadriceps stretch.

B. Compression broadening to the quadriceps Deeper pressure enhances muscle fiber spreading with compression broadening techniques. Use compression broadening strokes to work the entire length of the quadriceps muscle group. The application of each pressure stroke is directly transverse to the muscle fiber and primary circulatory flow. The muscle can be treated distal to proximal or proximal to distal. This technique is pictured in Figure 7.6.

C. Deep longitudinal stripping to the quadriceps Deep stripping is used after broadening techniques and some of the more superficial applications are used to encourage adequate tissue fluid movement, warming, and superficial muscle pliability. Deep stripping is performed first with a broad contact surface of pressure for more general muscle treatment and then followed with a small contact surface for deep specific muscle treatment. This technique is pictured in Figure 7.8.

D. Multi-directional short stripping on the retinaculum Short stripping strokes are applied to the medial and lateral aspects of the quadriceps retinaculum to reduce excess tension on the retinacular tissues. Use the thumb, finger, or pressure tool to apply deep short stripping strokes to the retinacular tissues around the patellofemoral joint. These techniques are illustrated in Figures 7.13 and 7.17. The primary purpose of these strokes is to encourage pliability and mobility in the fascial retinacular tissues.

E. Friction for patellar mobility Patellar mobility is enhanced with friction techniques applied around all sides of the patella. Grasp the patella between the thumb and fingers of both hands. Pull or push the patella as far to each side as possible and hold it in that position. When pushed medially, use short back and forth friction techniques along the medial side of the patella. When pushed laterally, use short back and forth friction techniques along the lateral border of the patella (Fig. 7.21).

F. Active engagement lengthening movements Increased pliability and flexibility are enhanced in the quadriceps with active engagement lengthening techniques. This technique also pulls on the retinacular tissues to encourage their pliability. The client can be positioned so the lower leg drops off the end or side of the table and is able to move through a full range of flexion and extension. Instruct the client to move the lower leg in full flexion and extension at a slow and steady pace.

Figure 7.21 Patellar mobility friction treatment.

During the knee extension, perform a deep stripping technique to the quadriceps. Begin with a broad contact surface such as the fist or heel of the hand. Then gradually move to a more specific contact surface such as fingertips, thumbs, or a pressure tool (Fig. 7.22).

Rehabilitation protocol considerations

- While working on the soft tissues around the patellofemoral joint, pay particular attention to the tissues that reproduce the client's primary pain complaint when they are treated.
- After progress has been made with the techniques mentioned above and when the client is in the later stages of rehabilitation, additional resistance can be added to the active engagement methods with weights, resistance bands, or manual resistance offered by the therapist.

Figure 7.22 Active engagement lengthening for quadriceps.

- Pin and stretch techniques are also effective and can be used when active engagement methods are begun.
- In some cases fibrous adhesion has developed in the retinacular tissues. In these cases there can be significant pain when performing some of the deep friction or stripping techniques on the retinacular tissues, especially due to the rich innervation of these tissues. Work within the client's pain tolerance when addressing these fibrous restrictions. If the client is able to withstand a greater degree of discomfort, more progress can usually be made in tissue mobility enhancement.
- If the client is performing quadriceps strengthening as part of the treatment for patellar stability, achieving biomechanical balance of soft tissues around the knee with massage is an important adjunctive treatment.
- One of the common challenges in a problem like PFPS is overdoing activity once the condition begins to resolve. It is important to coach the client on a progressive and gradual return to activity that is not too fast. If the return to previous activity levels is too fast, the client is likely to stress the tissues that are attempting to return to normal function. This is likely to cause an aggravation of symptoms.

Cautions and contraindications The practitioner should be careful pressure and intensity of certain treatments, especially the various deep stripping and friction treatments. The retinacular tissues are likely to be sore following treatment if the treatment is too aggressive. Because it may not be clear what the client's pain tolerance is and how his/her tissues react to the treatment, work a little less intensely in the first few treatments until the client's response can be evaluated.

CHONDROMALACIA PATELLAE

Description

Like PFPS, chondromalacia often starts with a patellar tracking problem. In fact, PFPS is a likely precursor to chondromalacia. However, there is a distinct difference between the two in that unlike PFPS, chondromalacia is a distinct clinical entity that can be verified through specific evaluation procedures. Chondromalacia literally means softening of the cartilage. The cartilage in this condition is not the meniscal fibrocartilage of the knee, but the hyaline cartilage on the underside of the patella.

If the patella is not tracking properly in the groove created by the two femoral condyles, there is an increased amount of friction on the underside of the patella. This increased friction eventually causes a softening and degeneration of the articular cartilage. The surface of the cartilage can become uneven and the client is likely to report crepitus (grating or grinding sensations) during flexion and extension of the knee.

For years it was assumed that the pain of chondromalacia was a result of the softening of the articular cartilage. Because the pain was happening in the same individuals who had crepitus and showed cartilage degeneration with arthroscopic examination, this only made sense. Yet, recent discoveries have indicated that the articular cartilage underneath the patella does not contain nerve endings so the cartilage degeneration is not causing the pain. However, the sub-chondral bone just below the surface of the cartilage is richly innervated and is the source of pain when the cartilage overlying it has degenerated.[35,36] Some clinicians state that chondromalacia should be used only as a descriptive term and not as a diagnosis of the pain since there is so little innervation of the articular cartilage.

Treatment

Traditional approaches

Because chondromalacia appears to develop from dysfunctions in patellar mechanics that are similar to PFPS, the treatment approaches are similar. This condition is initially managed conservatively with activity modification, bracing, stretching, and strengthening exercises. Strengthening exercises performed are generally the same as those for PFPS.

If the problem is not resolved through conservative treatment, surgical approaches can be used. Surgery for chondromalacia emphasizes smoothing the underside of the patella to prevent additional grinding of the articular surface resulting from the damaged and degenerated cartilage. This procedure is effective in alleviating symptoms for the majority of people who have it. Decreasing activities that place additional biomechanical stress on the knee is also important. Clients can also decrease biomechanical stress on the knee with compressive knee braces that encourage proper patellar tracking.

Soft-tissue manipulation

General guidelines Massage treatment and rehabilitation protocol considerations for chondromalacia are the same as for PFPS. Because a large part of the problem is dysfunction in the extensor mechanism of the knee, treatment approaches focus attention in that area. The cartilage under the knee is inaccessible to massage and, therefore, no attempt is made to directly alter the course of the primary site of injury. In addition, because this problem involves roughening of the contact surface between two bones, massage would not have significant impact on changing the course of that problem.

Cautions and contraindications One of the distinguishing characteristics that separate chondromalacia patellae from PFPS is the pain that is felt directly underneath the patella in chondromalacia. This pain is from friction and pressure on the subchondral bone. When performing massage or range-of-motion activities around the knee for chondromalacia, use caution not to exert undue pressure directly on the patella. It is likely to be painful and aggravate the existing condition.

Box 7.2 Clinical Tip

Chondromalacia and PFPS are two conditions that are closely related and the soft-tissue treatment for them is very similar. Stretching the fascial connective tissues of the quadriceps retinaculum is a valuable aspect of correcting patellar tracking problems that are creating these conditions. To stretch and fully mobilize the retinacular tissues, perform stripping techniques on the retinaculum itself while simultaneously moving the knee into flexion. These stripping techniques combined with lengthening the fascial retinacular fibers are very effective but can be uncomfortable for the client. Adjust the pressure and movement accordingly.

ILIOTIBIAL BAND FRICTION SYNDROME

Description

Iliotibial band (ITB) friction syndrome is an overuse condition that causes lateral knee pain. It occurs often in people who perform repetitive flexion and extension actions of the knee, such as runners and cyclists. Several predisposing factors make an individual more likely to develop this condition.

When the knee is in extension the iliotibial band lies anterior to the lateral epicondyle of the femur. As the knee moves into flexion the band moves in a posterior direction over the lateral epicondyle (Fig. 7.23). The posterior aspect of the band contacts the epicondyle first. Once the posterior fibers have made contact with the epicondyle the band drags across the epicondyle. Friction starts to occur between the band and the epicondyle at slightly less than 30° of flexion. This means the posterior edge of the band impinges against the lateral epicondyle just after foot strike in the gait cycle. Recurrent rubbing can produce irritation and subsequent inflammation, especially beneath the posterior fibers of the ITB. The posterior fibers can be tighter against the lateral femoral epicondyle than the anterior fibers.[37]

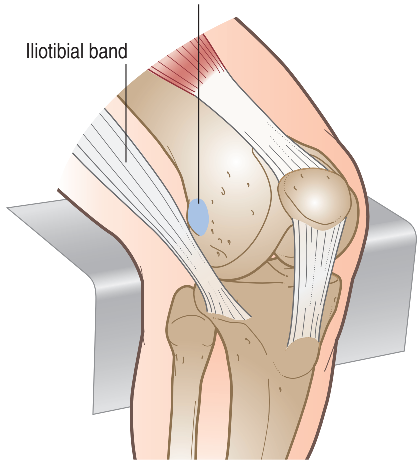

Figure 7.23 Movement of the iliotibial band in relation to the lateral epicondyle of the femur.

One of the primary functions of the iliotibial band is to enhance knee stability. There is a great deal of tension on the band to aid in this stability. However, excess tension can pull the band too tightly against the femoral epicondyle and this leads to the tissue irritation and inflammation of ITB friction syndrome.

In addition to tension on the band, anatomical variations in the knee, lower extremity, or ITB itself can contribute to this problem. A prominent lateral epicondyle can stick out further and cause excess friction. The postural distortion of genu varum (commonly referred to as 'bow legged') may cause increased tension on the band and subsequent pressure against the lateral knee. Activity that puts increasing varus stress on the lateral knee can also aggravate this problem. Running on the side of crowned roads can exacerbate this problem. The leg on the 'downhill' side of the slope is exposed to greater varus stress and therefore increased tension on the ITB.

One study found that individuals with ITB friction syndrome had a significantly thicker iliotibial band over the femoral epicondyle than a non-symptomatic control group.[38] Because it appears that the posterior fibers are primarily at fault, the thicker band makes it more difficult for the posterior fibers to roll over the lateral femoral epicondyle. It is not clear, however, if the thickened band is the cause of the condition or a result of continued friction.

Various sources have also described the pain of ITB friction as originating from a bursa that lies between the ITB and the femoral epicondyle. However, there is disagreement about the role played by this bursa, or even if it is an individual bursa. Nemeth and Sanders state the tissue under the ITB consists of a synovium that is a lateral extension and invagination of the actual knee joint capsule and not a separate bursa as often described in the literature.[39] In either event, there is a richly innervated cushioning tissue between the ITB and the femoral epicondyle that can also be the source of pain sensations in this condition.

While the literature on this condition has focused on the role of the iliotibial band and the synovial tissue underneath the band as the source of pain, there can be other possible causes for similar pain sensations. Restrictions in the local fascial tissue, and the development of myofascial trigger points in the vastus lateralis muscle can produce pain in a similar region and should be thoroughly investigated.[40]

Treatment

Traditional approaches

ITB friction syndrome is usually attributed to some repetitive activity that the client is performing. Therefore, activity modification is one of the primary methods of addressing the problem. If an individual is running, for example, the change can come through decreased distance or changing the location so they are not running on a sloped surface. Some authors advocate the use of orthotics to address lower-extremity biomechanical patterns that aggravate the ITB friction.[41,42]

Other methods of conservative treatment are employed as well. Anti-inflammatory medication can be used to decrease the inflammatory reaction of the ITB or the synovial tissue underneath it. Corticosteroid injection is one form of anti-inflammatory treatment that can be used in the region of the ITB friction. However, concerns over detrimental effects of corticosteroid injection have made this treatment method less desirable.[43]

Surgery is performed on ITB friction syndrome if conservative treatment is unsuccessful. However, surgery should generally only be recommended if attempts at conservative treatment have failed.[44] In the surgical procedure for this problem a small section of the posterior aspect of the ITB is cut away, so the band may more easily glide over the lateral epicondyle of the femur.

Soft-tissue manipulation

General guidelines Massage can be an important part of the treatment arsenal for ITB friction syndrome. However, there are some important considerations in how and where massage techniques should be applied. As mentioned earlier, it is likely that myofascial trigger points, especially in the vastus lateralis muscle, may be contributing to pain sensations in the area. Investigate the possibility of these trigger points being the source of lateral knee pain. If the tissues are tight and sensitive but produce no characteristic referral sensations, myofascial treatments can still be effective.[45]

Bear in mind that, when working on the vastus lateralis muscle, pressure is being applied directly through the ITB. It is tempting to think that the ITB is loosening or 'releasing' through this type of work. However, the ITB is tendinous tissue and is not shortened or contracted itself. The tightness in the ITB, if it is excessive, is originating with the muscles that insert into the band up near the hip – the tensor fasciae latae and the gluteus maximus. Because these muscles are likely contributing to ITB friction, they should be a primary focus of treatment.

Suggested techniques and methods

A. Sweeping cross fiber to lateral and anterior thigh region This technique is moderately superficial in its pressure level and is designed primarily to enhance flexibility and tissue pliability in the soft tissues of the lateral thigh. Use the sweeping cross fiber motion that glides diagonally across the anterior and lateral thigh muscles (Fig. 7.24). There is initially a light to moderate pressure in this technique which can be increased as further treatment progresses.

B. Deep stripping techniques to lateral thigh muscles Stripping techniques should start with a broad contact surface such as the palm or back side of the hand first, and then gradually move into a small contact surface, such as the finger, thumb, or pressure tool (Fig. 7.25). Use caution with pressure when performing stripping techniques on the lateral thigh, especially directly over the iliotibial band. This region is likely to be very tender.

Figure 7.25 Stripping with broad contact surface on the lateral thigh.

C. Static compression Trigger points in the vastus lateralis, gluteus maximus, or tensor fasciae latae can contribute to ITB tension. Use the stripping techniques mentioned in B above to identify myofascial trigger points and encourage tissue elongation. Once trigger points or particular areas of heightened neuromuscular tension have been identified, static compression is applied to decrease neuromuscular activity (Fig. 7.26).

D. Pin and stretch to tensor fasciae latae Tension on the ITB is reduced by treating the tensor fasciae latae. The client is in a side-lying position on the table. The lower extremity is brought into a position of extension and abduction to shorten the tensor fasciae latae. Once in that position, apply pressure to the tensor fasciae latae muscle. It is a good idea to use a broader contact surface first and then gradually incorporate a small contact

Figure 7.24 Sweeping cross fiber to lateral thigh muscles.

Figure 7.26 Static compression to lateral thigh region to treat trigger points.

Figure 7.27 Pin and stretch on tensor fasciae latae. The muscle's shortened position is pictured (prior to moving the lower extremity into the muscle's stretch position).

surface as the technique is repeated several times. While maintaining pressure on the muscle, gradually lower the client's leg off the back side of the table until the tensor fasciae latae is fully stretched (Fig. 7.27). In later stages of treatment or to get an even greater effect of the pressure applied, have the client slowly drop their own leg, so the tensor fasciae latae is working eccentrically during the pin and stretch.

E. Deep friction to the iliotibial band Apply deep friction to the fibers of the iliotibial band (ITB) to stimulate fibroblast proliferation and encourage a positive healing response for the damaged tissue (Fig. 7.28). Depending on where the primary site of irritation is in the ITB, friction can aggravate the inflamed synovial tissue underneath the band. To avoid working directly over the epicondyle and irritating the synovial tissue, place the knee in different positions as the friction treatment is applied. To work the anterior edge of the band, keep the knee in extension. To work the posterior edge of the band, keep the client's knee in full flexion. Try several different knee positions to see which produce the least discomfort to work the middle fibers of the band.

Figure 7.28 Friction to the iliotibial band.

Rehabilitation protocol considerations

- If the condition is in an advanced stage, it may be too tender for friction or direct pressure techniques directly over the lateral epicondyle. Evaluate the severity of the condition to determine if these techniques should be used initially or held for later stages of rehabilitation.
- Presence of a tight ITB does not necessarily mean ITB friction syndrome will result. Consequently, a client can have an ITB that feels tight due to the tension on the tendinous fibers. It should not be a treatment goal to make the ITB as pliable and flexible as surrounding tissue.
- Biomechanical compensations in the lower extremity can play a role in the onset of ITB friction syndrome. Address soft-tissue tension in muscles throughout the lower extremity, especially the quadriceps group as they can contribute to ITB tension.
- Heat applications applied to the lateral thigh tissues may enhance stretching and massage treatment approaches through increased connective tissue pliability.

Cautions and contraindications When performing friction techniques over the distal end of the ITB, use caution if the client reports a pain sensation with this treatment that mimics the pain they were experiencing during activity. This could indicate pressure from the technique is aggravating the ITB, and further compressing the inflamed synovial tissue underneath the band.

MENISCAL INJURY

Description

Inside the knee are two fibrocartilage structures that separate the tibia and femur – the lateral and medial meniscus (Fig. 7.29). Their primary function is to absorb shock and provide a greater degree of contact surface between the femur and the tibia. The shock absorbency of the meniscus

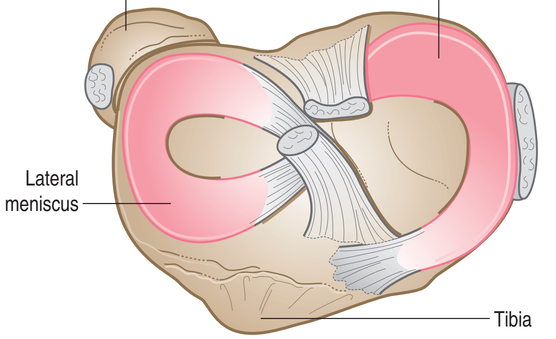

Figure 7.29 Superior view of the right knee showing the medial and lateral meniscus.

is crucial for long-term knee joint health. Each meniscus also provides a protective function to prevent the femur from rolling off the top of the tibial plateau. If the meniscus is severely damaged or removed from the knee, joint degeneration with arthritis is likely to follow.

The meniscus can be damaged from either compressive or tensile forces. Compressive forces can cause the meniscus to break, chip or tear. It is easy to see the amount of compressive force focused on the articulation between the femur and the tibia due to body weight. Tensile forces can also cause meniscal injury because the medial collateral ligament is connected to the medial meniscus. If there is an acute valgus force to the knee that pulls the MCL, it may be enough to pull or tear a portion of the meniscus as well.

Pieces of the meniscus can become separated from the intact meniscus and float around in the knee joint cavity. These loose bodies of cartilage can interfere with proper knee mechanics and often cause a locking or disruption of smooth knee movement.[46] Commonly, the knee will lock during one motion, but not lock when that motion is immediately repeated. This periodic locking occurs because the loose body of cartilage has moved slightly and is not in the same position to cause a joint restriction. Because this loose body of cartilage is often moving around in the joint and can so easily appear and then disappear it is sometimes referred to as a *joint mouse*.

Treatment

Traditional approaches

If the meniscal damage is not severe, physical therapy is usually successful in the gradual management and healing of the meniscal damage. Tears that occur in the outer edge of the meniscus, which has a greater vascular supply, have a good potential for healing. Tears on the inner portion of the meniscus where there is less blood supply do not have a good prognosis for healing on their own and may need to be treated surgically.[47]

While there have been a number of innovative surgical procedures for addressing meniscal damage, it does not appear imperative that meniscal tears always be treated surgically. Clinical evidence shows that people often get along fine with non-surgical treatment of meniscal problems. In fact, the risks of removing a meniscus can far outweigh those of leaving a tear in a portion of it.[48] Yet there are some concerns with non-operative treatment as well. Loose fragments can detach and a potentially repairable tear can pulverize and become too damaged for repair.

Soft-tissue manipulation

General guidelines In this condition, the structures of concern are deep within the knee joint and out of reach for treatment with massage. There is little, if anything, that massage can do to address torn cartilage itself. As with ACL and PCL injuries, massage treatment and rehabilitation protocol considerations for meniscal damage focus on restoring proper biomechanical balance around the joint. Various muscles in the lower extremity can be hypertonic in an effort to compensate for altered knee mechanics resulting from the meniscal injury. Soft-tissue manipulation is a helpful adjunct to other measures used to treat the meniscal injury. To address meniscal damage with massage use the techniques and recommendations listed under ACL sprain at the beginning of the chapter.

Cautions and contraindications When performing soft-tissue treatments around the knee, use caution with techniques that put pressure on the lateral or medial side of the knee near the joint line. If there is a meniscal injury that is near the periphery of the meniscus, pressure in this area could cause additional discomfort for the client. The pressure is unlikely to aggravate the injury, but could cause additional discomfort for the client.

PATELLAR TENDINOSIS

Description

This condition is frequently referred to as patellar tendinitis. The suffix -itis indicates an inflammatory condition. However, many are moving away from this term because a majority of overuse tendon disorders result from collagen degeneration in the tendon and not inflammatory activity.[49] Patellar tendinosis is also called jumper's knee because of the frequency with which it occurs in people who perform jumping activities like basketball or volleyball. However, the problem is by no means limited to people who do jumping activities. Pain is felt at the onset of activity and it is common for pain to subside during activity, only to return later when activity ceases.

The patellar tendon is the distal attachment tendon for the quadriceps muscle group. The patella is imbedded within the patellar tendon dividing the tendon into an upper and lower section (Fig. 7.30). The upper section is called the suprapatellar tendon and the lower section, the infrapatellar tendon. The lower section is sometimes erroneously identified as the patellar ligament because the fibers pass from the patella to the tibia, connecting bone to bone. However, the patella is imbedded within the tendon, making it structurally, functionally, and physiologically tendon tissue. The proper name for this structure is the infrapatellar tendon.[50]

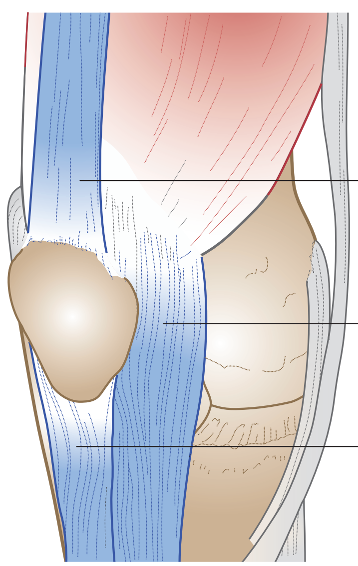

Figure 7.30 Suprapatellar and infrapatellar portions of the patellar tendon.

Tendinosis occurs in either the suprapatellar or infrapatellar tendons. The condition appears in order of frequency at the infrapatellar tendon's insertion into the patella (65% of cases), the attachment of the suprapatellar tendon into the patella (25% of cases), and the patellar tendon insertion into the tibial tuberosity (10% of cases).[51,52] Dysfunction with the infrapatellar portion of the tendon accounts for 75% of all cases. If the tendinosis is not properly managed a complete rupture of the tendon can result.[53]

If left untreated, it can progress to a chronic state of degeneration and necrosis in the tendon.[54] Healing of collagen degeneration in tendinosis can take months instead of weeks because of the slow metabolic rate in tendon tissue.[55] As with a number of other conditions affecting the extensor mechanism of the knee, pathology with the patellar tendon can cause quadriceps atrophy. This may be detectable on visual comparison of the affected and unaffected sides, but can be confirmed by comparing circumferential measurements of the distal quadriceps on each side.

Treatment

Traditional approaches

Various anti-inflammatory medications have been used for treatment, but since this is not truly an inflammatory problem their benefit is highly questionable and generally ineffective.[49,56] When the problem is viewed as one that is not an inflammatory reaction in the tendon, the entire treatment paradigm shifts. While cryotherapy is traditionally considered as a modality aimed at reducing the inflammatory process, it may still be a beneficial part of tendinosis treatment. Cryotherapy is a vasoconstrictor and one of the keystones of this problem is abnormal development of vascularity in the injury site.[57] Cryotherapy is also beneficial for pain management during treatment.

Strength training has been used effectively in the treatment of tendinosis. It is employed early in the development of the condition as a means of conditioning the tendon for increased demands. However, if the tendinosis has progressed too far, strength training can be detrimental and aggravate the problem. In a measured amount it appears beneficial. One reason it may be effective is the stimulation of collagen production during tensile load on the tendon. As long as tendon load during strength training is not excessive and repetitive, it can assist the healing process.

Soft-tissue manipulation

General guidelines Because a primary part of the problem in tendinosis results from excess tensile load on the quadriceps group, soft-tissue manipulation should focus attention on reducing tension in these muscles. Numerous techniques used on the quadriceps group are effective for that purpose. Friction treatments are aimed at the site of primary discomfort in the tendon (usually infrapatellar tendon) in order to encourage fibroblast proliferation and tendon healing. Friction massage applied to tendinosis can be uncomfortable so cryotherapy is sometimes used prior to or immediately after friction treatment to reduce the discomfort.

Activity modification is an important part of addressing tendinosis conditions. The collagen degeneration in tendinosis takes a long time to heal, so reducing offending activities decreases the load on the tendon and gives the body time to mend the damaged collagen fibers. Along with activity modification, regular stretching of the quadriceps group is an important component of treatment.

Suggested techniques and methods All of the treatment techniques A–F that are described in the section on PFPS are valuable in the treatment of patellar tendinosis. In addition, deep friction applied directly to the site of primary tendon dysfunction is important.

A. Deep friction Friction treatment can be performed transversely or longitudinally (along the tendon's fiber direction). Deep friction treatment is generally more effective if the tendon being treated is on a slight stretch, so keep the knee in partial flexion during the treatment (Fig. 7.31). Stretching and range-of-motion movements should be incorporated along with the friction treatments.

Rehabilitation protocol considerations

- Treatment of tendinosis is likely to have limited benefit if the client is not able to decrease or eliminate certain offending activities, especially during the course of treatment. The tendency for those recovering from tendinosis is to return to activities once the pain recedes in the affected tendon. However, tendon healing is much slower than other tissues and an early return to activity can easily re-aggravate the condition, making for a prolonged and chronic condition. It is better to be conservative in returning to activities that are likely to irritate the condition.
- The primary treatment goals of addressing any tendinosis condition involve decreasing tension on the offending muscle group and stimulating fibroblast proliferation. These objectives should be addressed simultaneously.
- If the condition is not severe, massage treatment can employ more intense forms of treatment such as pin and stretch or active engagement methods relatively soon. If the tendinosis is more advanced, it is best to gradually build up to the use of those treatment techniques. Use sweeping cross fiber, compression broadening, and passive stripping techniques first.
- The length of time necessary for positive outcomes with tendinosis varies significantly. If the tendinosis is of recent onset, the likelihood for a quicker resolution is greater. If the condition has been around a long time, there is likely damage to the collagen matrix of the tendon and healing time will be greater.
- Strength training is routinely used to condition tendons for the increased loads that are placed on them. However, if strength training begins

Figure 7.31 Deep transverse friction to the infrapatellar tendon with the knee flexed and the tendon on stretch.

too soon, it could further stress the damaged tendon fibers. It is best to wait until the rehabilitation process is well underway before engaging in significant strength training. Pain can be a guide. There should not be tendon pain associated with strengthening activities. If there is pain, long-term tendon damage could result.

Cautions and contraindications In some cases tendon damage is not the result of excessive activity. Certain systemic disorders or medications, such as fluoroquinolone antibiotics, could cause collagen degeneration in the tendon.[58–60] Massage that is too aggressive in these cases could potentially produce further tendon damage. If there is no overuse activity or recent change in activity levels that would indicate the onset of tendinosis, consider a systemic, metabolic, or medication-induced tendon injury as a possibility. Treatments should be tempered to a decreased intensity level in those conditions. Tendon pathologies caused by a systemic disorder could be continually aggravated, even despite the complete cessation of activity.

HAMSTRING STRAINS

Description

Hamstring strains involve a tear in the muscle-tendon unit of the hamstring muscles; biceps femoris, semitendinosus, or semimembranosus. These strains, as with all other muscle strains, are graded as first degree (mild), second degree (moderate), or third degree (severe). Strains can occur anywhere along the muscle, but frequently occur at or near the musculotendinous junction. This is a common location for tears to occur, because it is a place where the contraction force is transmitted from a yielding tissue type (muscle) to a non-yielding tissue type (tendon). This tissue interface becomes a focal point of stress and, consequently, a common site for muscle tearing. Third-degree muscle strains in the hamstrings also commonly occur at the interface where the tendon meets the bone at the ischial tuberosity.[61]

Muscle strains can happen to any muscle in the body, but are more common in the hamstrings than in other muscles. There are several reasons for this injury frequency. Strength imbalances between the hamstrings and quadriceps are a primary cause of hamstring strains. The structure and biomechanical demands placed on the hamstrings can be another reason. The hamstrings are multi-articulate muscles because with the exception of the short head of the biceps femoris they all cross more than one joint.

Multi-articulate muscles are more susceptible to muscle strain because they are acting across more than one joint at a time. The relationship of muscle length to the amount of tension generated in the muscle, referred to as the length/tension relationship, is such that great demands are placed on the hamstring muscles when they are not in a position to handle the mechanical load of their length/tension relationship. These high loads overwhelm the contractile unit and connective tissues within the muscle and cause a strain or tear in the fibers. It is interesting, however, that despite the short head of the biceps femoris only crossing the knee joint, the greatest number of hamstring strains occur in the biceps femoris.[62]

Various factors including lack of flexibility, muscle fatigue, insufficient warm-up, and strength imbalances play a role in the onset of hamstring strains.[63] Hamstring strains are usually an acute injury, but small levels of stress can accumulate and cause chronic low-grade tearing as well. Along with acute strains it is common to have a large amount of bruising. Bruising can extend down the posterior lower extremity over the days following the injury, making the problem look much more widespread than it really is.

Hamstring strains are characterized by sharp pain that occurs at the initial time of injury. The client frequently describes hearing a loud pop or snap when the injury occurred. Pain is strong locally, and the three hallmarks of musculotendinous injury are present – pain with palpation, pain with manual resistance, and pain with stretching. Symptoms may persist for long periods and re-injury is common.

Adverse neural tension can also play a part in the onset of hamstring strains.[64] The increase in neural tension causes an elevated level of tonus in the muscle, which in turn makes the muscle more susceptible to mechanical strain. This can become a vicious cycle because adverse neural tension can occur as a result of hamstring strain as well.[65] Fibrous adhesions or scar tissue in the hamstring muscles from a strain can restrict mobility of the sciatic nerve. Then a situation of adverse neural tension develops leading to the likelihood of frequent recurrence of the strain.

Treatment

Traditional approaches

The principle mode of treatment starts with PRICE (Protection, Rest, Ice, Compression, Elevation). A physician may prescribe anti-inflammatory medication, although long-term use of anti-inflammatory medication is generally not advised for this condition.[66]

Functional treatment involving stretching and strength training to build the muscle back to its original level of strength is a mainstay of this conservative approach. Treatment that includes movement and strength training can become more active after the sub-acute phase when the initial swelling has subsided.[67] Conservative treatment emphasizing a reduction in offending activities is usually enough to let the body's healing processes take care of the strain if it is not severe.

If there is a grade three strain, or one that includes a tendon avulsion (tearing away of the tendon from its attachment to the bone), surgery may be indicated, although not all avulsions need surgery. If there is suspicion of a severe muscle strain, it should be properly evaluated to determine if there is a tendon avulsion or avulsion fracture. An avulsion fracture occurs when the tendon pulls a small chunk of bone with it as it pulls away from the attachment site.

Soft-tissue manipulation

General guidelines The primary function of massage treatment for hamstring strains is to reduce reactive muscle tightness and address the primary site of the fiber tearing. Reduction of muscle tightness is accomplished with effleurage, compression broadening techniques, sweeping cross fiber, and longitudinal stripping techniques performed on the hamstrings.

In addition to these passive techniques, various forms of massage with active engagement are effective as well. These methods enhance functional restoration to the hamstring group by emphasizing soft-tissue manipulation during movement. Both shortening and lengthening movements are used for this purpose. Additional muscular effort can be recruited to enhance the effectiveness of elongating deeper fascial tissues. Use a piece of resistance band or the hand to produce additional eccentric load for the hamstrings during the elongation.

It is also important to address the primary site of tissue damage. Massage is an effective way to stimulate collagen production at the site of tissue damage. Deep transverse friction (DTF) helps create a healthy and mobile scar. Identification of the actual strain is accomplished by finding a site of maximum tenderness that reproduces the primary complaint the client initially had. If the strain is of sufficient intensity, a palpable defect is likely to be felt in the muscle.

Apply friction to the site of the strain for several minutes. The friction massage should be alternated with other forms of tissue mobilization including effleurage, sweeping cross fiber, and stretching. That series of techniques should then be repeated several more times.

As the injury site is beginning to heal, stretching is an important aspect of treatment. Stretching has benefits not only in elongating the myofascial tissues in the leg, but also in reducing adverse neural tension that can contribute to perpetuation of the problem.[64]

Suggested techniques and methods Numerous techniques and methods will be valuable in addressing hamstring strains. The following techniques that have been described in prior sections of this chapter are used to address hamstring strains.

A. Sweeping cross fiber to hamstrings This stroke reduces initial muscle tension throughout the muscle group. The stroke travels diagonally across the fibers of the muscle group (Fig. 7.5). Use successive sweeping strokes on the hamstrings until the entire muscle group has been covered.

B. Compression broadening to the hamstrings Further fiber broadening and muscle pliability is enhanced with compression broadening techniques. Apply the compression broadening techniques until the entire length of the muscle has been treated. Compression broadening techniques can move distal to proximal or vice versa (Fig. 7.7).

C. Deep longitudinal stripping Tissue elasticity is enhanced with deep stripping techniques. Start with a broad contact surface of pressure and then eventually perform the stripping techniques with a small contact surface (Fig. 7.9). Use caution in stripping techniques near the site of muscle strain, especially if the strain is more severe.

D. Deep transverse friction Friction is applied to the primary site of tissue damage. In most cases this

Figure 7.32 Deep transverse friction to proximal musculotendinous junction of hamstring muscles.

will be at the musculotendinous junction, but use proper assessment to identify the injury site specifically. Friction is applied transverse to the fiber direction of the hamstrings to help proper alignment of scar tissue as the damaged tendon fibers are healing (Fig. 7.32).

Rehabilitation protocol considerations

- The degree or intensity of work is directly related to the severity of the strain. For example, vigorous stripping is not used early in the rehabilitation process, especially in the case of a second- or third-degree strain. In the case of a more severe strain, use lighter work such as effleurage and sweeping cross fiber until a greater degree of tissue repair has occurred at the primary injury site. Accurate assessment is crucial for identifying the severity of injury and appropriate treatment at different stages of the injury management.
- When working with athletes or others in active lifestyles, deeper and more penetrating methods such as active engagement shortening or lengthening techniques can also be incorporated. These techniques are used in the latter stages of rehabilitation when a significant degree of tissue remodeling has already been accomplished. There should be sufficient strength and resiliency rebuilt in the hamstring muscle before attempting these procedures.
- Stretching should be a fundamental component of the treatment from the outset. Stretching enhances tissue mobility and will aid in developing an optimally functioning tissue repair site.

Cautions and contraindications The primary cautions and contraindications with massage treatment of hamstring strains are related to working aggressively on the injury too soon after its occurrence. If the strain is severe and affects the attachment site instead of the musculotendinous junction, there could be a tendon avulsion. If an avulsion is suspected refer the client for orthopedic evaluation in case surgical reattachment of the tendon is deemed necessary.

ADDUCTOR STRAINS

Description

Strains to the adductor muscle group are relatively common, especially for people engaged in various sporting and recreational activities. They are also called, *groin strain* or *groin pull*. Regardless of the name, the pathology is a strain to one of the adductor muscles of the thigh. The adductor group is composed of five different muscles: adductor longus, adductor brevis, adductor magnus, pectineus, and gracilis (Fig. 7.33). Of these five, the adductor longus is the muscle most often strained.[68] However, the fibers of these different muscles often blend together near their attachment

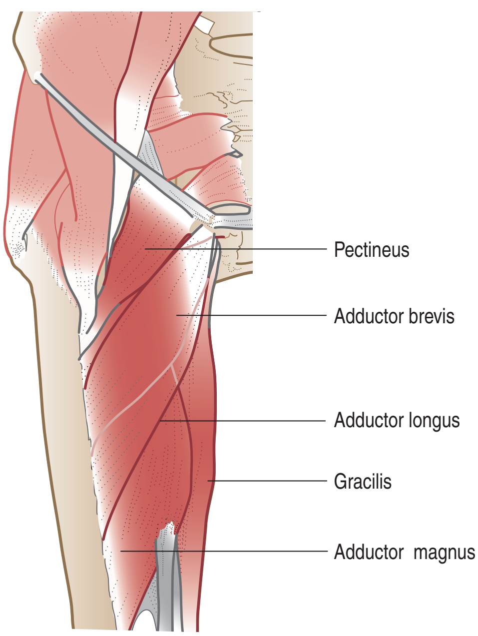

Figure 7.33 Adductors of the thigh.

sites, so it is difficult to distinguish among them at the musculotendinous junction.

As with other muscles, an adductor strain is graded as either mild (first degree), moderate (second degree), or severe (third degree). A third-degree strain usually indicates a complete rupture of the muscle tendon unit or an avulsion of the tendon from its attachment site on the bone. The classification for grading strains is somewhat subjective, so there can be slight variations in determining the category of this injury.

There are several common causes of adductor strain. A forced abduction of the thigh that goes beyond the individual's flexibility limit is a common cause. An example of this is when a person slips on the ice and one leg suddenly goes out to the side. Another example is during a blocked kick in soccer. A sudden eccentric load is put on the adductors when the individual is kicking the ball with the instep of the foot and they are blocked in mid stride of the kick. The sudden stopping of the kick can be enough to produce a strain on one of the adductor muscles. The same type of sudden loading to the adductors can occur when an individual suddenly changes direction while running, turning to the side opposite that of the planted foot.

Strength deficits are a factor in the development of adductor strains. For example, ice-skating is an activity that uses a tremendous amount of adductor muscle activity, both to maintain balance and create forward propulsion on the skates. One study with hockey players found that the players were 17 times more likely to sustain an adductor muscle strain if the adductor muscle strength was less than 80% of the abductor muscle strength.[69]

Clients who have sustained an adductor strain generally complain of pain localized near the attachment of the adductor muscles on the pubic bone. The majority of adductor strains occur near the proximal attachment of the muscles. Swelling or ecchymosis may be present, but their absence does not rule out an adductor strain. Look for the classic musculotendinous injury triad, which includes pain with palpation, pain with stretching, and pain with manual resistance.

Treatment

Traditional approaches

The usual treatment of PRICE (Protection, Rest, Ice, Compression, Elevation) is the first line of treatment for an individual who has sustained an adductor strain. A physician may prescribe anti-inflammatory medication, although long-term use of anti-inflammatory medication is generally not advised for this condition.[66]

Functional treatment involving stretching and strength training later in the course of rehabilitation is used to build the muscle back to its original level of strength. Treatment that includes movement and strength training can become more active after the sub-acute phase when the initial swelling has subsided.[67] Conservative treatment emphasizing a reduction in offending activity is usually enough to let the body's healing processes take care of the strain if it is not severe.

Strength training is used as a preventive strategy for individuals who are at risk of developing adductor strains. The strength increase allows the muscles to develop greater resistance to the forces that produce muscle strain.[70] Strength training can be used following a strain, but should not be performed aggressively because the increased demands on the tissue could produce further damage.

Soft-tissue manipulation

General guidelines As with other muscle strains, the primary function of treating them with massage will be to reduce reactive muscle hypertonicity and address the site of tissue tearing. Reduction of muscle hypertonicity can be accomplished primarily with effleurage, compression broadening techniques, sweeping cross fiber, and longitudinal stripping techniques.

Deep friction massage is applied to the site of the strain in the muscle. Identify the primary site of tissue injury in the strain by finding a site of maximum tenderness that reproduces the client's complaint. If the strain is of sufficient intensity, a palpable defect may also be felt in the muscle. The triad of signs for musculotendinous injury should be present: pain with palpation, pain with manual resistance, and pain with stretching. In each of these three situations, it is likely that the primary site of pain is going to be the location of tissue tearing.

Deep transverse friction is applied to the site of the strain to help develop a functional, flexible, and pliable injury repair site. The friction massage should be alternated with other forms of tissue mobilization including effleurage, sweeping cross fiber, and stretching. That series of techniques should then be repeated several more times.

In addition to the soft-tissue treatment methods advocated, stretching is an important part of the rehabilitation process. Stretching methods can be performed in the clinic at the same time that other soft-tissue treatments are being administered. The client can also be instructed in stretching procedures which can be performed at home.

Suggested techniques and methods

A. Sweeping cross fiber to adductors Superficial relaxation and fiber broadening occurs with sweeping cross fiber methods. The stroke travels diagonally across the fibers of the muscle group (Fig. 7.34). Use successive sweeping strokes on the adductor group until the entire region has been covered.

B. Compression broadening to the adductors Deeper compression broadening techniques reduce hypertonicity as well as encourage muscle fiber repair and development of a functional scar. Apply the compression broadening techniques until the entire length of the muscle has been treated. Compression broadening techniques can move distal to proximal or vice versa (Fig. 7.35).

C. Deep longitudinal stripping Stripping techniques emphasize muscle elasticity and pliability. Start with a broad contact surface of pressure and then gradually perform the stripping techniques with a small contact surface (Fig. 7.36). Use caution in stripping techniques near the site of muscle strain, especially if the strain is more severe.

Figure 7.35 Compression broadening to adductors.

D. Deep transverse friction Friction is applied to the primary site of tissue damage, which is usually at the musculotendinous junction. Use proper assessment to identify the injury site specifically. See the discussion of deep friction treatments in Chapter 4 for guidelines about length of friction treatments and incorporating friction with movement and stretching of the affected tissues. Friction is applied transverse to the fiber direction of the hamstrings to encourage proper alignment of scar tissue as the damaged tendon fibers are healing (Fig. 7.37).

A common site of strain to the hamstrings is at the proximal musculotendinous junction. This poses challenges in treatment because of the proximity to the groin. Soft-tissue work in the groin area can be uncomfortable both physically and psychologically for the client. Consequently, a great sense of presence and care is needed when performing treatments. Special attention to draping and hand position assures

Figure 7.34 Sweeping cross fiber to adductors.

Figure 7.36 Deep stripping on the adductors.

Figure 7.37 Deep friction to the adductors.

the client will feel a greater sense of comfort and confidence with the treatment. One way to address this issue is to have the client place a hand over the top of the drape to hold it in place over the groin while working this region. This reduces the possibility of unintentional contact with the genital region. Pay close attention to hand and finger position when performing friction or stripping techniques in this region. Keeping the fingers curled into the palm when treating this region also decreases the chance of unintentional contact by the practitioner's finger tips.

Rehabilitation protocol considerations See the description of rehabilitation protocol considerations for hamstring strains in the previous section. These considerations will be the same for treating adductor strains.

Cautions and contraindications Bear in mind that there are vascular structures traveling through the femoral triangle in the region of the adductor muscles. The femoral artery and vein, as well as the femoral nerve, can be compressed during manual treatment of the adductors. Keep in close communication with the client in order to recognize signs or symptoms of compressing these structures.

POSTURAL DISORDERS

The next section includes a number of structural and postural disorders of the knee and thigh. These disorders are not considered injury conditions, as are the prior conditions in this chapter. However, they can produce considerable stress on other tissues or structures and contribute to their dysfunction. Massage is generally not used to correct these postural deviations, but can be a therapeutic approach to restoring appropriate biomechanical balance around the joint.

GENU VALGUM

Description

This is the condition that is known in layman's terms as *knock-knees*. It is a structural deviation of the lower extremity that is defined by a varus angulation of the femur and a valgus angulation of the tibia (Fig. 7.38). It is unclear exactly what causes this problem. In some cases it seems to be a congenital postural distortion, while in others it seems to be more of an acquired condition. Children often have genu valgum during the growth years, and eventually grow out of the problem as their skeletal and muscular structures mature.

There are a number of problems that can result from genu valgum, which often involve biomechanical dysfunction of the lower extremity, especially around the knee. The femur already has a natural varus angulation so it does not drop straight down onto the tibial plateau. Yet, weight

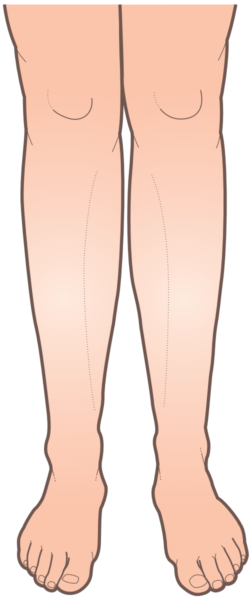

Figure 7.38 Genu valgum.

is transmitted from the femur to the lower leg. It would be best if this weight could be transmitted as evenly as possible. When the angulation is increased as it is in genu valgum, there is an increasing amount of compressive force on the lateral meniscus and the lateral aspect of the tibial plateau. There is also, consequently, a greater degree of tensile stress on some of the soft-tissue structures on the medal side of the knee that are spanning the joint, such as the joint capsule or the medial collateral ligament. The increased tensile stress causes these structures to be more vulnerable to injury.

A more significant concern with genu valgum is the effect it has on patellar tracking. The patella must glide in a superior and inferior direction in relation to the femoral condyles during flexion and extension of the knee. With an individual that has genu valgum, there is a tendency for the patella to track in a more lateral direction as it moves superiorly during knee extension. This alteration in patellar tracking can lead to a number of soft-tissue pain complaints in and around the knee, such as patellofemoral pain syndrome or chondromalacia patellae.

Treatment

Traditional approaches

Changing genu valgum is not easy. If there appears to be a severe genu valgum it may be addressed surgically, especially in children. However, changing lower-extremity misalignment in adults with non-surgical approaches has proved difficult.[71] Orthotics are used to address lower-extremity alignment problems, but they do not appear very effective with genu valgum. The client can be advised to avoid activities that could make the problem worse. For example, an individual with significant genu valgum may not be cut out for recreational running because the likelihood of developing knee pain is high.

Soft-tissue manipulation

General guidelines It is unclear if there is any soft-tissue intervention that is successful in correcting genu valgum. Suggestions have been made that adductor muscle tightness can play a role in genu valgum, but how much of a role it plays is unclear. There are other factors of bony alignment that do not appear to be significantly affected by soft-tissue tightness. However, massage treatment of all the thigh musculature can aid in developing optimal biomechanical balance and postural correction.

Cautions and contraindications Other than general precautions there are no major contraindications for working on a client with genu valgum.

GENU VARUM

Description

This postural distortion is just the opposite of genu valgum. It is the condition commonly referred to as *bow-legged*. In this problem there is a valgus angulation of the femur and a varus angulation of the tibia (Fig. 7.39). Both genu valgum and genu varum take their name from the angulation of the tibia, and not of the femur. Genu varum can occur frequently in children as their bones are growing. It is quite common for children to have genu varum in the first years of life and then grow out of it and have genu valgum for several years after that before finally achieving a more normal degree of knee alignment.

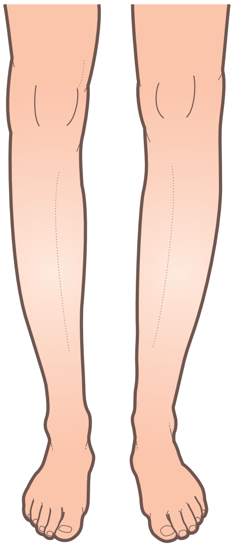

Figure 7.39 Genu varum.

Like genu valgum, this postural distortion can aggravate other lower-extremity problems. In genu varum there is greater compressive stress on the medial meniscus, and greater tensile stress on the lateral knee structures such as the lateral collateral ligament or the iliotibial band. Greater tensile stress on the iliotibial band from genu varum is a common contributing factor to iliotibial band friction syndrome.

In most cases, genu varum is associated with structural changes that cause the misalignment, and not soft-tissue changes that can be improved with massage. Genu varum has a reputation of occurring in certain activities like riding horses for long periods. It is unlikely that soft-tissue treatment can actually reverse this process without significant postural retraining. However, soft-tissue treatment of conditions like iliotibial band friction syndrome that result from genu varum may be addressed with massage treatment.

Treatment

Traditional approaches

Genu varum is addressed in the same way as genu varum. Orthotics are sometimes used to address the ramifications of this postural disorder. If genu varum appears that it is going to be a problem in children, corrective braces or surgery are sometimes used to address the postural distortion.

Soft-tissue manipulation

General guidelines Massage treatment for genu varum is only an adjunctive procedure that focuses on restoring optimal biomechanical balance in the muscles and fascia of the thigh region.

Cautions and contraindications Other than general precautions there are no major contraindications for working on a client with genu varum.

Box 7.3 Case Study

Background

Marie is a 46-year-old advertising executive who travels a great deal. In order to reduce stress and stay in shape she has recently begun a recreational running program. She really likes running and does not want to give it up. Unfortunately, she has been experiencing anterior knee pain on her left knee and she believes it is associated with her running as she first noticed it about a month after starting her running program. The pain comes on while she is running and does not seem to bother her as much on the days when she does not run. She also notices the pain when she squats down to pick something up off the floor. She has tried to increase stretching prior to and after her activities, but said she also feels the knee pain somewhat when she attempts quadriceps stretching.

Observation of Marie's posture from an anterior position indicates a slight genu valgum posture in her lower extremity. Viewed from the lateral direction there is also a slight degree of anterior pelvic tilt apparent. When palpating the soft tissues around her knee there is tenderness in the fascial, retinacular, and tendinous tissues around the medial and inferior side of her patella.

Questions to consider

- What are three different tissues around the knee that could be responsible for Marie's pain?
- While we don't have enough information from a thorough evaluation, does Marie's knee pain initially sound like something that would be treatable with massage? Why or why not?
- Marie travels a great deal and long trips on an airplane sometimes cause an increase in her symptoms. Why might sitting for long periods cause an increase in pain?
- Do you think that she might have an internal joint disorder, such as a meniscal injury or ligament sprain? Why or why not?
- How might other postural conditions, such as overpronation or pelvic tilt, contribute to Marie's knee pain?
- Is there anything Marie might be able to do at home that will help this condition?

References

1. Arnold T, Shelbourne KD. A perioperative rehabilitation program for anterior cruciate ligament surgery. Physician Sportsmed. 2000;28(1):283–293.
2. Arendt E, Dick R. Knee injury patterns among men and women in collegiate basketball and soccer. NCAA data and review of literature. Am J Sports Med. 1995;23(6):694–701.
3. Boden BP, Griffin LY, Garrett WE, Jr. Etiology and prevention of noncontact ACL injury. Physician Sportsmed. 2000;28(4):53–60.
4. Torg J, Shephard R. Current Therapy In Sports Medicine. 3rd ed. St. Louis: Mosby; 1995.
5. Nisell R. Mechanics of the knee. A study of joint and muscle load with clinical applications. Acta Orthop Scand Suppl. 1985;216:1–42.
6. Harner CD, Paulos LE, Greenwald AE, Rosenberg TD, Cooley VC. Detailed analysis of patients with bilateral anterior cruciate ligament injuries. Am J Sports Med. 1994;22(1):37–43.
7. Delay BS, Smolinski RJ, Wind WM, Bowman DS. Current practices and opinions in ACL reconstruction and rehabilitation: results of a survey of the American Orthopaedic Society for Sports Medicine. Am J Knee Surg. 2001;14(2):85–91.
8. Morgan EA, Wroble RR. Diagnosing posterior cruciate ligament injuries. Physician Sportsmed. 1997;25 (11):224–232.
9. Kapandji IA. The Physiology of the Joints: Volume 2 – Lower Limb. Vol 2. 5th ed. Edinburgh: Churchill Livingstone; 1987.
10. Parolie JM, Bergfeld JA. Long-term results of nonoperative treatment of isolated posterior cruciate ligament injuries in the athlete. Am J Sports Med. 1986;14(1):35–38.
11. Kannus P, Jarvinen M. Nonoperative treatment of acute knee ligament injuries. A review with special reference to indications and methods. Sports Med. 1990;9(4): 244–260.
12. Shelbourne KD, Nitz PA. The O'Donoghue triad revisited. Combined knee injuries involving anterior cruciate and medial collateral ligament tears. Am J Sports Med. 1991; 19(5):474–477.
13. Azar FM. Evaluation and treatment of chronic medial collateral ligament injuries of the knee. Sports Med Arthrosc. 2006;14(2):84–90.
14. Edson CJ. Conservative and postoperative rehabilitation of isolated and combined injuries of the medial collateral ligament. Sports Med Arthrosc. 2006;14(2):105–110.
15. Deckey JE, Gibbons JM, Hershon SJ. Rehabilitation of collateral ligament injury. Sport Med Arthroscopy. 1996; 4(1):59–68.
16. Meislin RJ. Managing collateral ligament tears of the knee [Electronic Version]. Physician Sportsmed. 24. Retreived 3-24-08.
17. Reider B. Medial collateral ligament injuries in athletes. Sports Med. 1996;21(2):147–156.
18. Shelbourne KD, Porter DA. Anterior cruciate ligament-medial collateral ligament injury: nonoperative management of medial collateral ligament tears with anterior cruciate ligament reconstruction. A preliminary report. Am J Sports Med. 1992;20(3):283–286.
19. Fu F, Stone D. Sports Injuries: Mechanisms, Prevention, Treatment. Baltimore: Williams & Wilkins; 1994.
20. Morris PJ, Hoffman DF. Injuries in cross-country skiing. Trail markers for diagnosis and treatment. Postgrad Med. 1999;105(1):89–91, 95–88, 101.
21. Davidson CJ, Ganion LR, Gehlsen GM, Verhoestra B, Roepke JE, Sevier TL. Rat tendon morphologic and functional changes resulting from soft-tissue mobilization. Med Sci Sport Exercise. 1997;29(3):313–319.
22. Hammer WI. Functional Soft-Tissue Examination and Treatment by Manual Methods. 3rd ed. Boston: Jones and Bartlett; 2007.
23. Thomee R, Augustsson J, Karlsson J. Patellofemoral pain syndrome: a review of current issues. Sports Med. 1999; 28(4):245–262.
24. McComas A. Skeletal Muscle: Form and Function. Champaign: Human Kinetics; 1996.
25. Tria AJ, Jr., Palumbo RC, Alicea JA. Conservative care for patellofemoral pain. Orthop Clin North Am. 1992;23 (4):545–554.
26. Callaghan MJ, Selfe J, McHenry A, Oldham JA. Effects of patellar taping on knee joint proprioception in patients with patellofemoral pain syndrome. Man Ther. 2007:19–24.
27. Herrington L. The effect of corrective taping of the patella on patella position as defined by MRI. Res Sports Med. 2006;14(3):215–223.
28. Aminaka N, Gribble PA. A systematic review of the effects of therapeutic taping on patellofemoral pain syndrome. J Athl Train. 2005;40(4):341–351.
29. Crossley K, Cowan SM, Bennell KL, McConnell J. Patellar taping: is clinical success supported by scientific evidence? Man Ther. 2000;5(3):142–150.
30. Crossley K, Bennell K, Green S, McConnell J. A systematic review of physical interventions for patellofemoral pain syndrome. Clin J Sport Med. 2001;11(2):103–110.
31. Kolowich PA, Paulos LE, Rosenberg TD, Farnsworth S. Lateral release of the patella: indications and contraindications. Am J Sports Med. 1990;18(4):359–365.
32. Christoforakis J, Bull AM, Strachan RK, Shymkiw R, Senavongse W, Amis AA. Effects of lateral retinacular release on the lateral stability of the patella. Knee Surg Sports Traumatol Arthrosc. 2006;14(3):273–277.
33. Panni AS, Tartarone M, Patricola A, Paxton EW, Fithian DC. Long-term results of lateral retinacular release. Arthroscopy. 2005;21(5):526–531.
34. Desio SM, Burks RT, Bachus KN. Soft tissue restraints to lateral patellar translation in the human knee. Am J Sports Med. 1998;26(1):59–65.
35. Niskanen RO, Paavilainen PJ, Jaakkola M, Korkala OL. Poor correlation of clinical signs with patellar cartilaginous changes. Arthroscopy. 2001;17(3):307–310.
36. Radin EL. A rational approach to the treatment of patellofemoral pain. Clin Orthop. 1979(144):107–109.

37. Nishimura G, Yamato M, Tamai K, Takahashi J, Uetani M. MR findings in iliotibial band syndrome. Skeletal Radiol. 1997;26(9):533–537.
38. Ekman EF, Pope T, Martin DF, Curl WW. Magnetic resonance imaging of iliotibial band syndrome. Am J Sports Med. 1994;22(6):851–854.
39. Nemeth WC, Sanders BL. The lateral synovial recess of the knee: anatomy and role in chronic iliotibial band friction syndrome. Arthroscopy. 1996;12(5):574–580.
40. Travell J, Simons, D. Myofascial Pain and Dysfunction: The Trigger Point Manual. Vol 2. Baltimore: Williams & Wilkins; 1992.
41. Barber FA, Sutker AN. Iliotibial band syndrome. Sports Med. 1992;14(2):144–148.
42. McNicol K, Taunton JE, Clement DB. Iliotibial tract friction syndrome in athletes. Can J Appl Sport Sci. 1981; 6(2):76–80.
43. Fadale PD, Wiggins ME. Corticosteroid injections: their use and abuse. J Am Acad Orthop Surg. 1994;2(3):133–140.
44. Martens M. Iliotibial band friction syndrome. In: Torg JS, Shephard RJ, eds. Current Therapy in Sports Medicine. St. Louis: Mosby; 1995:322–324.
45. Fredericson M, Guillet M, DeBenedictis L. Quick solutions for iliotibial band syndrome. Physician Sportsmed. 2000;28(2).
46. Bernstein J. Meniscal tears of the knee. Physician Sportsmed. 2000;28(3):83–90.
47. Weiss CB, Lundberg M, Hamberg P, DeHaven KE, Gillquist J. Non-operative treatment of meniscal tears. J Bone Joint Surg Am. 1989;71(6):811–822.
48. Noble J, Erat K. In defence of the meniscus. A prospective study of 200 meniscectomy patients. J Bone Joint Surg Br. 1980;62–B(1):7–11.
49. Torstensen ET, Bray RC, Wiley JP. Patellar tendinitis: a review of current concepts and treatment. Clin J Sport Med. 1994;4(2):77–82.
50. Lowe W. Orthopedic Assessment in Massage Therapy. Sisters, OR: Daviau-Scott; 2006.
51. Fredberg U, Bolvig L. Jumper's knee. Review of the literature. Scand J Med Sci Sports. 1999;9(2):66–73.
52. Ferretti A. Epidemiology of jumper's knee. Sports Med. 1986;3(4):289–295.
53. Depalma MJ, Perkins RH. Patellar tendinosis. Physician Sportsmed. 2004;32(5):41–45.
54. Pellecchia GL, Hamel H, Behnke P. Treatment of infrapatellar tendinitis – a combination of modalities and transverse friction massage versus iontophoresis. J Sport Rehabil. 1994;3(2):135–145.
55. Khan KM, Cook JL, Bonar F, Harcourt P, Astrom M. Histopathology of common tendinopathies – update and implications for clinical management. Sport Med. 1999; 27(6):393–408.
56. Almekinders LC, Temple JD. Etiology, diagnosis, and treatment of tendinitis – an analysis of the literature. Med Sci Sport Exercise. 1998;30(8):1183–1190.
57. Khan KM, Cook JL, Maffulli N, Kannus P. Where is the pain coming from in tendinopathy? It may be biochemical, not only structural, in origin. Br J Sports Med. 2000; 34(2):81–83.
58. Williams RJ, III, Attia E, Wickiewicz TL, Hannafin JA. The effect of ciprofloxacin on tendon, paratenon, and capsular fibroblast metabolism. Am J Sports Med. 2000;28(3): 364–369.
59. Casparian JM, Luchi M, Moffat RE, Hinthorn D. Quinolones and tendon ruptures. South Med J. 2000; 93(5):488–491.
60. Khaliq Y, Zhanel GG. Musculoskeletal injury associated with fluoroquinolone antibiotics. Clin Plast Surg. 2005; 32(4):495–502, vi.
61. Kujala UM, Orava S, Jarvinen M. Hamstring injuries. Current trends in treatment and prevention. Sports Med. 1997;23(6):397–404.
62. Garrett WE, Jr., Rich FR, Nikolaou PK, Vogler JB, 3rd. Computed tomography of hamstring muscle strains. Med Sci Sports Exerc. 1989;21(5):506–514.
63. Worrell TW. Factors associated with hamstring injuries. An approach to treatment and preventative measures. Sports Med. 1994;17(5):338–345.
64. Kornberg CaL, P. The effect of stretching neural structures on grade one hamstring injuries. Journal of Orthopaedic and Sports Physical Therapy. 1989;10(12):481–487.
65. Turl SE, George KP. Adverse neural tension – a factor in repetitive hamstring strain. J Orthop Sport Phys Therapy. 1998;27(1):16–21.
66. Mishra DK, Friden J, Schmitz MC, Lieber RL. Anti-inflammatory medication after muscle injury. A treatment resulting in short-term improvement but subsequent loss of muscle function. J Bone Joint Surg Am. 1995; 77(10):1510–1519.
67. Kisner C, Colby LA. Therapeutic Exercise: Foundations and Techniques. 2nd ed. Philadelphia: F.A. Davis; 1985.
68. Renstrom PA. Tendon and muscle injuries in the groin area. Clin Sports Med. 1992;11(4):815–831.
69. Tyler TF, Nicholas SJ, Campbell RJ, McHugh MP. The association of hip strength and flexibility with the incidence of adductor muscle strains in professional ice hockey players. Am J Sports Med. 2001;29(2):124–128.
70. Garrett WE, Jr., Safran MR, Seaber AV, Glisson RR, Ribbeck BM. Biomechanical comparison of stimulated and nonstimulated skeletal muscle pulled to failure. Am J Sports Med. 1987;15(5):448–454.
71. Krivickas LS. Anatomical factors associated with overuse sports injuries. Sports Med. 1997;24(2):132–146.

Chapter 8

Hip and pelvis

CHAPTER CONTENTS

The hip and pelvis region make up the structural core of the body and contain its center of gravity. The functional relationships between the pelvis, hip, lumbar spine, and lower extremity are crucial for proper gait, movement, and function. The interaction between this region and other areas of the body are also crucially important. Muscular, fascial, and neurological connections between the pelvic region, upper extremity, and cranium create a symbiotic relationship necessary for human movement in the vertical gravity plane.

The hip and pelvis region have two major articulations on each side of the body: the sacroiliac (SI) joint and the iliofemoral (hip) joint. Iliofemoral and sacroiliac joint mechanics are closely related and understanding the numerous pathologies in this region requires familiarity with both. The SI joint is an articulation designed for stability and is often viewed as a *keystone* in the architecture of the pelvis. Body weight is transmitted from the upper body across the SI joint to the lower extremities. The joint is held tightly in place by a complex webbing of ligaments on the anterior and posterior sides to manage the high force loads of the region.

The hip is a far more mobile joint. It is the body's largest ball and socket joint, and permits movement in several planes. Although muscles acting across the hip joint can generate large force loads, hip joint pathologies generally result from chronic compressive stress. This region also houses the largest diameter nerves in the body. As a result of being so large, these nerves are susceptible to compression by adjacent bone and soft tissues in a number of locations. This is such a biomechanically complex region that entire textbooks have been written on lumbo-pelvic mechanics. Yet, soft-tissue pathology plays an important role in numerous disorders in this region and the orthopedic massage practitioner can make valuable contributions to relieving pain and injury complaints.

INJURY CONDITIONS

PIRIFORMIS SYNDROME

Description

Piriformis syndrome is frequently described as an entrapment of the sciatic nerve by the piriformis muscle. However, there are other nerves in the region that the piriformis can compress; these nerve compression pathologies may be called piriformis syndrome as well. By far the most common problem involves compression of one or both divisions of the sciatic nerve by the piriformis muscle in the gluteal region.

The normal path of the sciatic nerve courses from the anterior region of the sacrum through the greater sciatic notch in the ilium. The nerve then passes inferior to the piriformis and over the top of the other five deep hip rotator muscles (Fig. 8.1). The sacrospinous ligament is just inferior to the piriformis muscle. The sciatic nerve courses between the inferior border of the piriformis muscle and the superior border of the sacrospinous ligament. Because the sacrospinous ligament is a dense and taut structure, nerve damage can occur from compression against the sacrospinous ligament. The sciatic nerve is susceptible to damage even from light levels of pressure.[1]

The superior gluteal nerve also exits through the greater sciatic notch, but travels superior to the piriformis muscle on its way to innervate the gluteal muscles (Fig. 8.1). Tightness or tendinous fibers in the superior portion of the piriformis can trap the superior gluteal nerve against the greater sciatic notch. If this occurs, the client describes aching

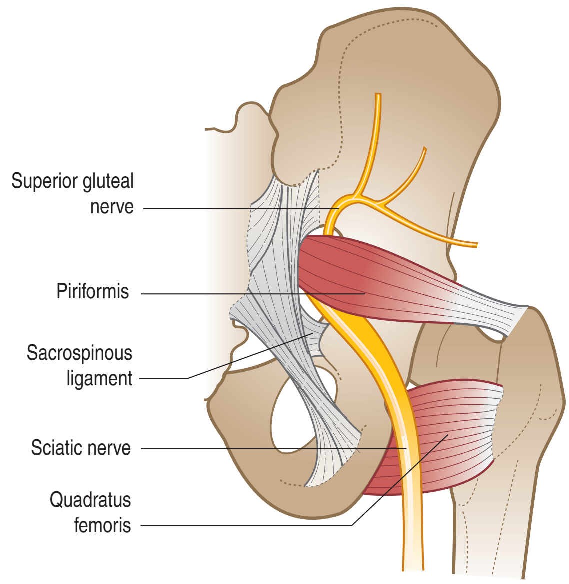

Figure 8.1 Posterior view of the right pelvis showing sciatic nerve and superior gluteal nerve in relation to the piriformis muscle.

buttock pain and usually demonstrates weakness in the hip abductors.

Pain sensations similar to those in piriformis syndrome can also come from myofascial trigger points in the piriformis muscle. Sacroiliac joint dysfunction can also produce pain in the hip and pelvis region, although it is not as likely to cause radiating pain down the posterior lower extremity.[2] Myofascial trigger points in this region should be treated even if it appears that nerve compression is the primary problem. Trigger points are often the root of the problem by causing greater tightness in the piriformis and deep hip rotator muscles.

Anatomical variations in the gluteal region create a number of different ways that nerve compression can occur. The sciatic nerve often separates into the tibial and peroneal divisions as it passes through the greater sciatic notch and passes the piriformis muscle. Cadaver dissections have indicated that about 10% of the population has one division of the nerve going through the muscle and the other division going below it. Another 2–3% has one division of the nerve above and one division below. A remaining 1% of the population has both divisions going right through the middle of the muscle.[2] Figure 8.2 shows these different variations.

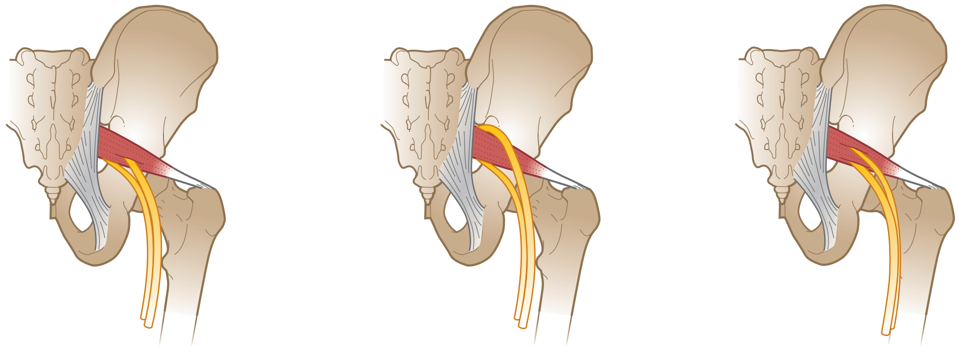

Figure 8.2 Variations on sciatic nerve and piriformis arrangement.

When looking at these different anatomical variations, it seems likely that an individual with the sciatic nerve perforating the piriformis muscle would be in serious discomfort all the time. However, this does not always occur. There are numerous locations where a nerve goes through a muscle without adverse symptoms. For example, the musculocutaneous nerve perforates the coracobrachialis muscle in the arm, and few people ever have a problem.

In the common arrangement of the sciatic nerve, it lies just inferior to the piriformis muscle and superior to the sacrospinous ligament. The ligament is a very dense and unyielding structure, and therefore when the nerve is pressed against it, symptoms are likely. On the other hand, muscle tissue is relatively soft and pliable. Therefore, it provides a greater cushion around the nerve even if the nerve travels directly through the middle of the muscle.

A client with piriformis syndrome usually reports pain and/or paresthesia in the gluteal region that is also felt down the posterior lower extremity, sometimes all the way to the foot. Low back pain is common with this problem as well. The concurrent presence of low back pain makes identification of this problem even more crucial. The symptoms of piriformis syndrome are similar to those arising from problems with the lumbar nerve roots. Making the assumption that the client's pain comes from nerve roots rather than the piriformis, unless this is the case, could delay healing or prevent it entirely as the cause of the pain may not be addressed.

Symptoms of piriformis syndrome are aggravated from sitting for long periods, as this places compression on the nerve and causes local tissue ischemia as well. Sitting with a wallet in the back pocket is another common aggravator of nerve compression. While piriformis syndrome is most common as a chronic compression injury, it is also possible to occur as an acute injury resulting from a direct blow or fall on the buttock region.[3]

Treatment

Traditional approaches

One of the more important factors in addressing piriformis syndrome is to establish the primary cause of compression. If there are any activities that exacerbate the problem, such as sitting on a large wallet, they need to be modified or terminated first. In many cases, changing this pattern is all that is needed to resolve the condition.

Stretching and range-of-motion activities are used to address tightness in the piriformis muscle that leads to nerve compression. Stretching can be performed in the clinic as well and the client can be instructed to do these stretches at home. Anti-inflammatory medications have been used to treat this problem, but their use for this problem is questionable.[4]

Surgery may be performed for piriformis syndrome if conservative treatment is ineffective. Physicians use diagnostic tests such as MRI and CT scans to determine anatomical variations of the piriformis muscle and sciatic nerve.[5] If the nerve is perforating the piriformis muscle, the nerve can be surgically repositioned. However, surgery for this condition is controversial, because it is believed that surgery is not warranted in many cases. For example, if the person has not been symptomatic with the nerve in this position and it suddenly becomes a problem, there is a question as whether the muscle needs to be cut and the nerve repositioned, or if conservative treatments are a better option.

Because myofascial trigger points in the piriformis muscle can be a contributing factor, treatment focuses on neutralizing them. Myofascial treatments, such as spray and stretch or dry needling, are sometimes used to address trigger point dysfunction in this region. Ice is also used as a treatment to decrease neurological activity in the piriformis muscle prior to stretching. However, since the depth of penetration of cold applications is only around 1 cm, it is questionable how much ice can really do to affect the piriformis muscle.[6] Injection of the trigger points is sometimes performed to reduce their activity and treat the muscular components of the problem.

Soft-tissue manipulation

General guidelines There are a number of massage and soft-tissue treatment approaches for piriformis syndrome. Myofascial trigger points in the piriformis muscle can be treated with static compression techniques. This may be done with either a broad contact surface or a small contact surface like the thumb, elbow, or pressure tool.

The piriformis may be difficult to palpate, due to the thickness of the overlying gluteus maximus. However, anatomical landmarks can help identify its location. Find the upper and lower borders of the sacrum and then locate a point about half way between those two landmarks. Connect a line from that point to the greater trochanter of the femur. This will be the approximate path and location of the piriformis muscle (Fig. 8.3).

It is important to know the location of the piriformis muscle, because this condition involves nerve compression by the piriformis muscle. Treatment involves pressure to the piriformis, so it is important that the practitioner does not exacerbate the problem. If the client reports a reproduction of the primary symptoms, then it is apparent that the area where pressure is being applied is aggravating the nerve compression, and pressure should be removed from that area.

One way to avoid complicating the nerve compression is to apply treatments to the ends of the piriformis muscle and avoid putting further direct compression on the site of nerve entrapment. The muscle will still get a strong soft-tissue treatment intervention, and a reduction of muscle tension will result.

Another way to effectively treat hypertonicity in the piriformis muscle without putting direct pressure on the compression site is through active-assisted stretching procedures. Passive or active stretching techniques effectively address the piriformis but do not put additional compression on the sciatic nerve.[7] However, similar to massage, stretching the hypertonic muscle can increase compression on the nerve by tightening the tissues around the nerve. Practitioners should pay close attention to any symptom changes reported by the client during therapy.

Suggested techniques and methods

A. Sweeping cross fiber Superficial sweeping cross fiber techniques are applied to the gluteal muscles to reduce hypertonicity and make it easier to treat the piriformis. Use a sweeping motion of the hand and thumb to deliver broad cross fiber sweeping techniques to the gluteal muscles (Fig. 8.4).

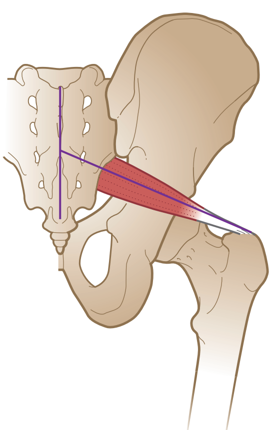

Figure 8.3 Locating the piriformis muscle for treatment.

Figure 8.4 Sweeping cross fiber to gluteal muscles.

Figure 8.5 Stripping on the piriformis.

B. Longitudinal stripping on piriformis Use the thumb, finger tips, pressure tool, or other small contact surface to perform a stripping technique on the piriformis muscle (Fig. 8.5). The stripping technique can be performed from either the proximal to distal attachment of the piriformis or vice versa. There is no clear physiological preference of one direction over the other.

C. Pin and stretch for piriformis The client is in a prone position with the knee flexed. Grasp the ankle with one hand and move the client's thigh into full lateral rotation; this places the piriformis in its shortest position. Apply pressure to the piriformis with the other hand using a thumb, finger, pressure tool, or other small contact surface. With pressure maintained on the muscle, pull the client's leg laterally (notice that the thigh moves in medial rotation), fully stretching the piriformis (Fig. 8.6). Repeat this technique several times for the maximal benefit.

D. Active engagement lengthening to piriformis More specific treatment of the piriformis is accomplished with active engagement methods. This technique can feel intense for the client, but it is highly effective for reducing tension in the muscle. The client is in a prone position with the knee flexed. Instruct the client to engage an initial (non-maximal) isometric contraction by holding the leg in the starting position while the practitioner attempts to pull the leg in a lateral direction, which rotates the thigh medially. The client is instructed to slowly release the contraction while the practitioner continues to pull the leg. Simultaneously, the practitioner performs a longitudinal stripping technique on the piriformis (Fig. 8.7). The piriformis is engaged eccentrically during this treatment.

E. MET (active-assisted stretching) to piriformis This technique is effective if there is concern about putting additional compression on the region of nerve entrapment near the piriformis. The client is in a prone position with the knee flexed. Instruct the client to hold the leg stationary as the practitioner attempts to pull the leg laterally (moving the thigh in medial rotation). This resisted movement engages an isometric contraction. The client holds the contraction for about 5–8 seconds and then releases the contraction. Upon release, the practitioner pulls the leg laterally (thigh moving in medial rotation) thereby stretching the piriformis.

Rehabilitation protocol considerations

- The gluteal musculature is thick in this region and soft-tissue applications must go through this tissue to reach the piriformis. Appropriate time should be spent working to relax these

Figure 8.6 Pin and stretch on piriformis.

Figure 8.7 Active engagement lengthening to piriformis.

more superficial tissues prior to commencing deep work on the piriformis. If appropriate attention is not paid to treating the muscles first, the treatment can feel invasive to the client.

- After treating all of the muscles in this region, stretching is valuable to enhance muscle pliability and reduce compression on the affected nerve(s).
- Relevant activity modifications should be included with treatment strategies to decrease aggravating factors.

Cautions and contraindications A number of other conditions can produce symptoms similar to entrapment of the sciatic nerve by the piriformis muscle. Use comprehensive assessment procedures to identify the particular nerve and compression location as accurately as possible. If any treatment aggravates the neurological sensations it should be terminated. An increase in sensory irritation by further compressing the nerve is likely to make the muscle even tighter.

Box 8.1 Clinical Tip

Piriformis syndrome is routinely misdiagnosed as a problem resulting from lumbar disc pathology. However, even though it is a nerve compression in the gluteal region, there can be muscular tightness in the low back region and other regions of the lower extremity that should be addressed. Treat the tissues adjacent to the entire length of the sciatic nerve and its branches from the lumbar nerve roots to the distal fibers of the plantar nerves in the foot. This can encourage full neural mobility in any of the nerve disorders affecting extremity nerves.

SACROILIAC JOINT DYSFUNCTION

Description

Pain that is felt in the sacroiliac region, low back, pelvis, or thigh, may be the result of sacroiliac dysfunction. There are a number of problems that can occur at this joint, all of which may have similar symptoms, and can be classified as sacroiliac joint dysfunction. The primary problems occurring at the sacroiliac joint include ligament sprains, friction between the articular surfaces, and joint misalignment.

The sacrum acts as a wedge between the two halves of the pelvis, holding the weight of the upper body. As such, there are large compressive forces on the joint that force the sacrum in an inferior direction. The sacrum is held firmly into this joint by a tight webbing of ligamentous structures (Fig. 8.8).

Because of the need for stability, there is very little motion possible at the SI joint. There is a slight degree of motion in the sagittal plane. The forward tipping of the superior surface of the sacrum is called *nutation* and the backward tipping is called *counternutation*; the range for both is only 7–8°. This motion is essential for proper mechanics during walking, bending over, and other motions because each innominate (half of the pelvis) must rotate independently. Motion at a joint is usually controlled by muscles that span directly between the two bones of the joint. At the SI joint no muscles span directly from the sacrum to the ilium. Instead joint motion is controlled by a collection of muscles, ligaments, and fascia in the lumbosacral region.[8,9]

Movement must be equal at the sacroiliac joints on both sides of the body. If movement is not equal, joint dysfunction occurs and pain

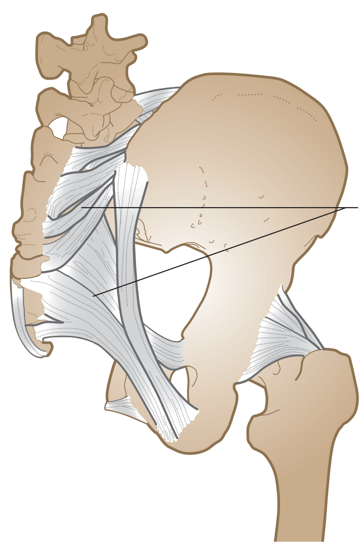

Figure 8.8 Webbing of ligamentous structures that hold the sacroiliac joint.

production from that dysfunction is likely. Despite the fact that the sacroiliac joints on each side of the body are symmetrical in design and close to each other, they operate somewhat independently in relation to the pelvis. Many sacroiliac dysfunctions are unilateral.[10]

Even though there is slight motion at the joint, it is held close to stationary by a complex structure of ligaments. Ligaments that contribute to stability in the region include the anterior sacroiliac, posterior sacroiliac, iliolumbar, sacrotuberous, and sacrospinous ligaments. Because there are no muscles that go directly from the sacrum to the ilium, the importance of these ligaments in maintaining stability at the joint is increased.

With ligaments as the primary joint stabilizers, the likelihood of joint dysfunction and sprain is heightened during pregnancy, when relaxin is released in the body. The effect of the hormone relaxin is to increase the pliability of ligament tissue, especially in the ligaments around the pelvis. Therefore, during pregnancy, more motion may be permitted at the sacroiliac articulation with less resultant stability.

Ligaments stabilizing this joint are influenced by muscle activity that is distant from the joint. After examining fascial connections in numerous cadaver studies, Vleeming and his colleagues made some interesting discoveries about lumbopelvic biomechanics.[11] They found that (1) gluteus maximus tissue is connected to the sacrotuberous ligament, (2) there is fascial continuity between part of the biceps femoris long head and the sacrotuberous ligament, and (3) there is fascial continuity from the posterior aspect of the piriformis to the posterior sacroiliac ligament. As a result, contractions from these muscles can affect tension levels on the ligament structures, which in turn affect the biomechanics of the sacroiliac joint. Similar concepts have been described by Tom Myers, with his discussion of *Anatomy Trains*.[12]

Other regions of muscular activity can also be influential. There is evidence that the thoracolumbar fascia transmits tensile force through the connective tissue to the contralateral gluteus maximus. Because the gluteus maximus has fascial connections with the sacrotuberous ligament, muscular activity in the latissimus could conceivably affect mechanics at the sacroiliac joint. Muscle tightness that affects bony alignment through tension on the related ligaments is what researchers refer to as a *force closure* of the joint, as opposed to a *form closure* that results from bony displacement.[13]

Unlike other joints in the body, the articulation between the bony surfaces of the sacrum and ilium are not smooth. The two joint surfaces are moderately rough and irregular because the joints are not designed for free gliding motion. The rough surface between the two bones helps produce stability in the joint. However, the irregular surface can become problematic if the joint surfaces become misaligned. It has been suggested due to the misalignment of the ridges and depressions that the joint can become 'locked' this is one explanation for the sensation of joint locking that client's report. This would be an example of *form closure* mentioned above. It may also be an explanation for the effectiveness of some high velocity joint manipulations that are used to treat sacroiliac joint problems. The sudden movement allows the irregular contact surfaces of the joint to be realigned once again.

Dysfunction of the sacroiliac joint can result from either acute injury, such as an automobile accident, or from chronic dysfunctional biomechanics, such as gait alterations. A good example of dysfunctional biomechanics affecting the SI joint is a structural leg-length discrepancy. If one leg is longer than the other, an unequal amount of force is placed on the two sacroiliac joints. The unequal force causes altered biomechanical function and pain. The patient with sacroiliac joint dysfunction often complains of diffuse pain in the lumbar or sacral region, which can be mistaken for lumbar disc pathology.[14] Pain can also refer into other areas such as the groin or posterior leg.

Treatment

Traditional approaches

There are a number of approaches for treating sacroiliac dysfunction, but no ideal treatment protocol has been established. Joint mobilization and manipulation are used with success in many cases. The exact mechanism by which these approaches work is not clear. Manipulation could be altering joint position, but there is not full agreement on this theory. Some suggest manipulation does not alter the position of the sacroiliac joint, yet manipulation does reduce pain in many cases.[15] Various physical therapy modalities such as ultrasound with or without phonophoresis (cortisone or other medications driven through the skin with ultrasound) are sometimes used.[16]

Strength training and exercise programs function to gain stability in the sacroiliac joint. Bracing or lumbar corsets may be worn to decrease dysfunctional biomechanics. Another method that has been used with some success involves proliferant injections. In this procedure, a substance is injected into the joint region that aids in the proliferation of fibrous tissue, subsequently making the joint more stable.

Soft-tissue manipulation

General guidelines No muscles span directly from the sacrum to the ilium and govern SI joint mechanics. However, myofascial connections span the SI joint indirectly and aid in controlling movement at the joint. Muscles with a strong influence on SI joint mechanics include the gluteus maximus, biceps femoris, and latissimus dorsi. It is important to address these muscles along with others in the region, as they all have effects on SI joint mechanics.

While strength training is used to regain stability in the joint, an argument could be made that reducing hypertonicity in the muscles that have produced the force closure of the sacroiliac joint may be more helpful. The problem around the joint, after all, is usually not a strength deficiency, but an imbalance in the forces acting on the joint. Massage can function to bring the body back to homeostasis by reducing tension in the hypertonic muscles rather than increasing strength (tension) in other muscles. The end result of reducing muscle tension is a more biomechanically balanced joint.

Other muscles that are important for sacroiliac mechanics should be addressed with massage as well. In particular, treatment should focus on the lumbar, gluteal, and hamstring muscles. Stretching of the muscles in this region after soft-tissue treatment is an important adjunct. Stretching procedures should be performed with care so as not to put excess tensile load on tissues contributing to the biomechanical imbalance.

Suggested techniques and methods

A. Sweeping cross fiber Superficial hypertonicity in the gluteal muscles is reduced with sweeping cross fiber techniques. Use a sweeping motion of the hand and thumb to deliver broad cross fiber sweeping techniques to the gluteal muscles (Fig. 8.4).

B. Deep stripping to gluteus maximus Gluteus maximus crosses the SI joint and has facial connections with ligaments in the region, so excess tension in this muscle can adversely affect SI joint mechanics. Apply stripping techniques to the gluteus maximus along the direction of the fibers. Use a broad contact surface, such as the backside of the fist initially, then follow with stripping techniques using a small contact surface, such as finger tips, thumbs, or pressure tool (Fig. 8.9).

C. Static compression to gluteal muscles Myofascial trigger points play an important role in altering SI joint mechanics. Static compression techniques are an effective way to neutralize trigger points' adverse effects. Begin the static compression with a broad contact surface first and follow with small contact surface compression such as the elbow, thumb, finger, or pressure tool (Fig. 8.10).

D. Sweeping cross fiber to lumbar muscles The superficial lumbar muscles are treated to reduce tension on the myofascial tissues spanning the SI joint. Use the thumb, backside of the fingers, base of the hand, or other broad contact surface to perform longitudinal and sweeping cross fiber applications (Fig. 8.11). Pay particular attention to the lumbodorsal fascia, quadratus lumborum,

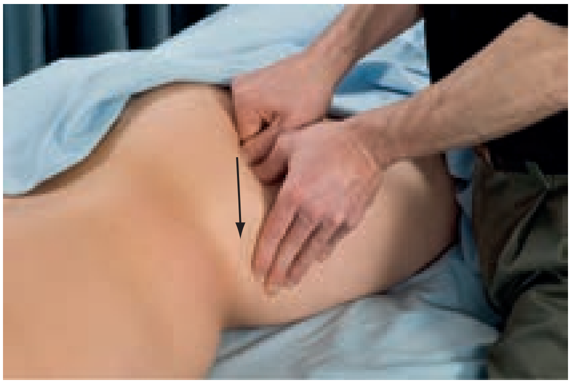

Figure 8.9 Deep stripping on gluteus maximus.

Figure 8.10 Static compression to gluteal muscles.

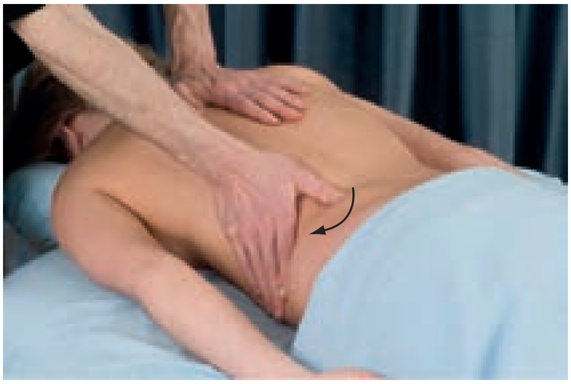

Figure 8.11 Sweeping cross fiber to lumbar muscles.

Figure 8.12 Deep longitudinal stripping on lumbar muscles.

Figure 8.13 Friction to posterior sacroiliac ligaments.

and erector spinae due to the fascial continuities from these muscles that act on the SI joint.

E. Deep longitudinal stripping on the lumbar muscles Deep stripping techniques are applied to the same muscles addressed in D above. Encourage elongation in the specific myofascial fibers with small contact surface pressure such as the finger tips, thumb, or pressure tool (Fig. 8.12).

F. Friction to posterior sacroiliac ligaments In some cases there is fiber stretching or tearing to the posterior sacroiliac ligaments. Perform short back and forth friction directly on the sacroiliac ligaments, paying particular attention to any actions that reproduce the client's discomfort (Fig. 8.13).

G. Deep longitudinal stripping on hamstrings Hamstring tension can play a prominent role in SI joint dysfunction. Deep stripping is used to treat the hamstrings for excessive muscle tension that may contribute to dysfunctional SI joint mechanics. Start with a broad contact surface of pressure and then eventually perform the stripping techniques with a small contact surface (Fig. 8.14).

Rehabilitation protocol considerations

- The techniques presented above may not be necessary for each client or for every session. Accurate assessment is crucial to determine the primary factors that will guide the clinical decision of which techniques to employ.
- Strength training is sometimes used for SI joint dysfunction, but it is best reserved for the later stages of rehabilitation. It can be used when the symptoms have significantly decreased, joint mechanics appear more normalized, and soft-tissue hypertonicity has been resolved. Strengthening activities performed too early in the rehabilitative process may adversely alter joint mechanics.

Figure 8.14 Deep longitudinal stripping on hamstrings.

Cautions and contraindications Patients with sacroiliac joint dysfunction may have difficulty lying in certain positions on the treatment table. It is a good idea to have several options for positioning when determining which treatment methods to perform. Use caution when applying pressure around the SI joint region, especially with techniques such as that of F described above. Pressure applied directly on the sacrum during friction treatment can be painful if they aggravate misaligned joints or overstretch ligament tissue.

Encourage clients to move slowly when getting up from the treatment table or changing positions after soft-tissue treatment for SI joint pathology. Proprioception and joint position can change substantially when in a non-weight-bearing position after treatment. When the client gets up and weight is once again transmitted through the SI joint, the relaxed tissues of the joint may allow greater joint movement, which could be painful.

TROCHANTERIC BURSITIS

Description

The trochanteric bursa lies directly over (superficial to) the greater trochanter of the femur. Its primary purpose is to reduce friction between the greater trochanter of the femur and the iliotibial band, which is superficial to it. This bursa can become irritated and inflamed from an acute blow to the lateral hip region, such as falling directly on the hip.

Chronic compression or repetitive friction from the iliotibial band (ITB) can also cause inflammation of the bursa. Trochanteric bursitis is more common in the middle age to older population.[17, 18] Chronic trochanteric bursitis from iliotibial band friction is more common than the acute type.

Symptoms from trochanteric bursitis include aching pain over the lateral hip region. Pain is usually aggravated by additional pressure directly over the greater trochanter. Clients complain that it hurts to lie on the affected side. Repeated activities of hip flexion such as stair climbing or running are also likely to aggravate the symptoms.

Although the most common symptom is lateral hip pain, pain can also radiate into the groin or into the lateral thigh region.[19] Because friction from the iliotibial band is a causative factor, tension in the gluteus maximus and tensor fasciae latae that attach to the iliotibial band play a role in the onset of the problem as well.

The other gluteal muscles, especially gluteus medius and minimus should not be ignored in this problem. Tendon pathology in these muscles, especially near their distal attachment sites, can masquerade as trochanteric bursitis.[20] A detailed physical examination should help clarify the location of the pain.

Treatment

Traditional approaches

The primary goal of any bursitis treatment is to reduce inflammation in the affected bursa. This can be done with a number of different conservative methods such as rest, ice, stretching of the muscles attached to the ITB, and non-steroidal anti-inflammatory drugs (NSAIDs).[17] Strength training of hip musculature is also used, although it should be avoided if it aggravates the problem.

If conservative treatment is not successful, corticosteroid injections are used to reduce inflammation in the bursa. Steroid injections are usually effective and yield prolonged results.[19] In the event that steroid injections are not successful, surgery might be performed for trochanteric bursitis. This is not a common procedure, but excision (removal) of the irritated bursa can be performed if all other treatment options have been unsuccessful.[21]

Soft-tissue manipulation

General guidelines Soft-tissue manipulation for treatment of trochanteric bursitis takes an indirect approach. There is no benefit from applying direct massage to an inflamed bursa and, in fact, this approach is contraindicated because of further compression and irritation to the bursa. However, if the bursa is being irritated by tightness in structures, such as the tensor fasciae latae acting through the iliotibial band, then soft-tissue manipulation can reduce tension in those structures.

Hypertonicity in the gluteal muscles can be effectively reduced with deep longitudinal stripping techniques. Stripping methods should also focus on the gluteus medius and minimus because tension in these muscles can further aggravate bursa compression. Myofascial trigger point pain referral patterns in these muscles can also mimic trochanteric bursitis.

Treatment should also focus on the tensor fasciae latae muscle, as it is one of the primary causes of excess tension on the iliotibial band. Static compression and deep longitudinal stripping are some of the best techniques for addressing tension in this muscle. These procedures are more effectively performed with the client in a side-lying position.

Suggested techniques and methods

A. Sweeping cross fiber to gluteal muscles Sweeping cross fiber techniques are applied to the gluteal muscles to reduce superficial hypertonicity. Use a sweeping motion of the hand and thumb to deliver broad cross fiber sweeping techniques to the gluteal muscles (Fig. 8.4). Similar techniques should be applied to the tensor fasciae latae prior to deeper techniques such as stripping or pin and stretch.

B. Deep stripping to gluteus maximus The gluteus maximus pulls on the iliotibial band and when tight can contribute to the band rubbing over the trochanteric bursa. Apply stripping techniques to the gluteus maximus along the direction of the fibers. Use a broad contact surface, such as the back-side of the fist first and eventually follow with stripping techniques using a small contact surface, such as finger tips, thumbs, or pressure tool (Fig. 8.9).

C. Static compression to the tensor fasciae latae The client is in a side-lying position. Use a small contact surface such as the thumb, finger, elbow, or pressure tool to apply compression to the areas of tightness in the TFL muscle (Fig. 8.15). In particular, search for active myofascial trigger points that reproduce lateral hip or high pain.

Figure 8.15 Static compression on tensor fasciae latae.

D. Deep stripping to the tensor fasciae latae The client is in a side lying position. Perform a series of effleurage and sweeping cross fiber techniques on the TFL first to begin reducing tension in the muscle prior to deep stripping. Use a small contact surface such as a finger, thumb, or pressure tool to apply longitudinally stripping techniques to the TFL from the proximal attachment all the way through its insertion into fibers of the ITB (Fig. 8.16).

E. Pin and stretch for the tensor fasciae latae This technique uses the pin and stretch concept along with eccentric activity in the TFL to encourage lengthening of the muscle and lessen tension on the ITB. The client is in a side-lying position.

Figure 8.16 Deep stripping on the tensor fasciae latae.

Figure 8.17 Pin and stretch on tensor fasciae latae. Photo shows the final position at the end of the stretch.

Bring the client's thigh into a position of abduction to shorten the TFL muscle. Ask the client to hold their leg in that position. Apply static compression to the muscle while the client holds the leg in the abducted position. Then instruct the client to slowly drop the leg off the back-side of the table (Fig. 8.17). This can feel intense for the client so gauge the pressure carefully with this technique. A variation on this technique can be used by applying a stripping technique during the client's eccentric adduction of the thigh instead of static compression; this is even more effective in reducing tension in the TFL muscle.

Rehabilitation protocol considerations

- Greater caution should be observed if the bursitis is in a more aggravated condition. Use caution with techniques that increase pressure on the bursa.
- As the bursitis recedes greater levels of pressure can be used and rehabilitative exercise can be combined with the soft-tissue treatment

Cautions and contraindications Because the aggravated and inflamed bursa is close to where treatment is being performed on the lateral hip muscles, it is important to make sure that additional pressure is not applied to the irritated bursa. The area over the inflamed bursa will be tender, so the client will describe local tenderness in the region. Trochanteric bursitis may be managed with anti-inflammatory medications. These medications can alter the client's pain sensations so use caution with pressure levels if the client is using these medications.

POSTURAL DISORDERS

The next section includes a number of structural and postural disorders of the hip and pelvis. These disorders are not considered injury conditions, as are the prior conditions in this chapter. However, they can produce considerable stress on other tissues or structures and contribute to their dysfunction. Massage is not always used to correct these postural deviations, but it may be a helpful approach to restoring appropriate biomechanical balance in the region.

ANTERIOR PELVIC TILT

Description

In an anterior pelvic tilt, both innominates (halves of the pelvis) are rotated in an anterior direction (Fig. 8.18). The increased anterior pelvic tilt also causes an exaggeration of the lumbar lordosis. It is valuable to measure the innominates separately as sometimes one may rotate more than the other.[22] Several factors may contribute to an anterior pelvic tilt, but typically it is from an imbalance of muscles pulling on the pelvis and/or lumbar region.

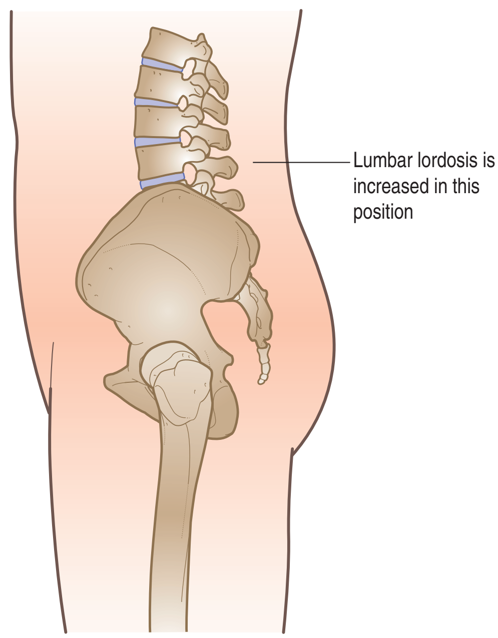

Figure 8.18 Anterior pelvic tilt.

An anterior pelvic tilt is part of a postural distortion pattern affecting the low back and pelvic muscles called the lower crossed syndrome.[23,24] The lower crossed syndrome got its name from the pattern of tension in the muscles when the body is viewed from the side (Fig. 8.19). There are two types of muscles in the body that play a central role in the lower crossed syndrome. The postural muscles are important for maintaining erect posture during locomotion. When fatigued, the postural muscles have a tendency to become hypertonic.

The phasic muscles play a greater role in creating movement. Containing a higher concentration of fast-twitch muscle fibers, the phasic muscles have a tendency to fatigue more easily and become weakened when overstressed.[25] The tendency for the phasic muscles to weaken is exaggerated by the law of reciprocal inhibition. The law of reciprocal inhibition that when one muscle gets a stimulus to contract, its opposite – or antagonist – muscle is neurologically inhibited to contract. If the postural muscles are hypertonic, they naturally inhibit the phasic muscles. A look at these two groups of muscles illustrates this point.

Primary postural muscles that tend toward hypertonicity in the low back and pelvic region include the iliopsoas, erector spinae, rectus femoris,

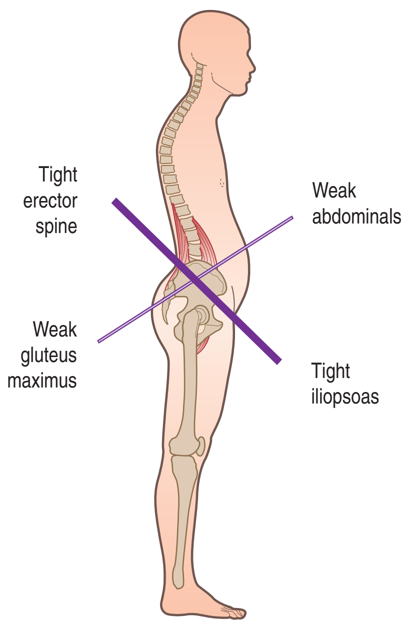

Figure 8.19 Lower crossed syndrome (from Chaitow L, DeLany J. Clinical Application of Neuromuscular Techniques. Vol 1. Edinburgh: Churchill Livingstone; 2000).

and quadratus lumborum. When hypertonic, these muscles exaggerate the lumbar lordosis and create an anterior pelvic tilt. In addition, the postural muscles are susceptible to the development of myofascial trigger points as they become hypertonic.[26] In the graphic above (Fig. 8.19) the line connecting the regions where these muscles are located demonstrates one side of the cross.

Opposing this group are the phasic muscles of the abdomen and pelvis. The phasic muscles in this region include the gluteus maximus, gluteus medius, and rectus abdominis. The line connecting between the phasic muscles establishes the other side of the cross. Our current sedentary lifestyle encourages overuse of the postural muscles at the expense of the phasic muscles. The phasic muscles can become weak from disuse.

Treatment

Traditional approaches

The treatment protocol suggested is usually for the individual to strengthen the abdominal muscles, often through sit-ups or crunches. However, these exercises can recruit the iliopsoas as a flexor of the trunk if the legs or feet are held on the floor in the sit-up. This is counter-productive if the desire is to reduce hypertonicity in the iliopsoas.

While strengthening of the abdominal musculature can be beneficial, these muscles are often weak primarily because they are phasic muscles and the hypertonic postural muscles are inhibiting them. Clinical experience has shown that an effective resolution is to reduce hypertonicity in the postural muscles, and not necessarily attempt to increase strength in the inhibited phasic ones.[27] It is also important for the client to engage in postural re-education to deal with established biomechanical patterns.

Soft-tissue manipulation

General guidelines Soft-tissue treatment for anterior pelvic tilt focuses on the hypertonic muscles creating the distortion. Emphasis is on reducing tightness in spinal extensor muscles, quadratus lumborum, iliopsoas, and rectus femoris. A variety of techniques including sweeping cross fiber, deep longitudinal stripping, pin and stretch, and active-assisted stretching are used to treat these muscles.

Direct massage is used to address the muscles responsible for creating the anterior pelvic tilt. Treatment of the iliopsoas is more challenging. Soft-tissue practitioners often treat this muscle with techniques that apply pressure through the abdomen to get to the muscle. Because the iliopsoas attaches to the anterior aspect of the lumbar vertebral bodies, it is very deep in the abdomen. It is contacted with finger pressure by pressing on the lateral side of the abdomen in a posterior and medial direction.

However, there are potentially dangerous contraindications to performing palpatory treatment of the iliopsoas in this region. This muscle lies directly adjacent to the external iliac artery (Fig. 8.20). Pressure on the external iliac artery can cause a back flow of pressure in the vascular structures, and could eventually cause the rupture of an aortic aneurysm. For that reason, performing the deep abdominal approach described above is not advised and it is beneficial to have alternative methods for treating the iliopsoas muscle. The MET procedure described in D below is effective in reducing muscle tightness, but does not put pressure directly on the iliopsoas and so concerns of vascular pressure are eliminated.

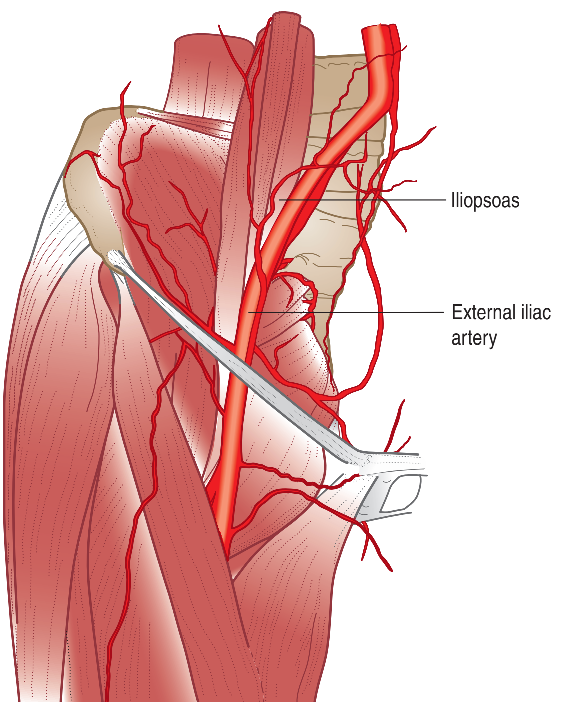

Figure 8.20 Relationship of the iliopsoas to the external iliac artery.

Suggested techniques and methods

A. Effleurage and sweeping cross fiber to lumbar muscles Superficial muscle tension is reduced in the lumbar muscles with long gliding effleurage and sweeping cross fiber techniques are applied to the lumbar muscles. These techniques are performed prior to deep stripping applications. Use the thumb, back-side of the fingers, base of the hand, or other broad contact surface (Fig. 8.11).

B. Deep longitudinal stripping on the spinal extensors Deep stripping techniques are applied to the erector spinae and other lumbar extensor muscles close to the spine. Encourage elongation in the specific myofascial fibers with small contact surface pressure such as the finger tips, thumb, or pressure tool (Fig. 8.12).

C. Deep stripping for quadratus lumborum The client is in a prone position. Use the thumb or fingertips to perform a longitudinal stripping technique on the quadratus lumborum (Fig. 8.21). Use stripping motions from the iliac crest to the transverse processes, iliac crest to twelfth rib, and transverse processes to twelfth rib as the quadratus lumborum has fibers running in all these directions. When working from lateral to medial on the fibers running from the iliac crest to the transverse processes, apply pressure deep enough to treat up under the lateral edge of the erector spinae muscle group. However, use caution not to apply too much pressure directly against the tips of the transverse processes.

Figure 8.21 Deep stripping to quadratus lumborum.

D. MET for iliopsoas The client is in a supine position with one thigh hanging off the side of the table. The client holds the opposite thigh in a fully flexed and bent knee position. The client attempts hip flexion of the hanging thigh, while the practitioner offers resistance. The client holds the contraction for about 5–8 seconds, and then releases the contraction. As the client releases the contraction, the practitioner pushes the thigh into extension to stretch the iliopsoas muscle (Fig. 8.22). If the client experiences discomfort, instruct the client to further flex the opposite hip, which will increase rotation of the pelvis, straighten the spine, and reduce facet joint compression.

Rehabilitation protocol considerations

- Perform soft-tissue treatment methods several times before engaging in strength training for muscles in this region. The body needs to re-adjust to different proprioceptive and neuro-muscular patterns.
- Strength training methods are routinely used to address the postural distortion of anterior pelvic tilt. Studies on the use of strength training have indicated that if hypertonic muscles are not properly addressed, dysfunctional compensation and recruitment patterns develop. That is why strength training should not be the first intervention, but should come at a point after soft-tissue treatment interventions.
- Many postural disorders such as anterior pelvic tilt persist because neuromuscular patterns of tension are continually reinforced. Despite soft-tissue treatment or strengthening activities, correction of many anterior pelvic tilts will not have a lasting change unless the client engages in some form of postural re-training which reinforces corrected biomechanical patterns.

Figure 8.22 MET for iliopsoas from Thomas test position with the leg off the side of the table.

Cautions and contraindications

Use great caution with any iliopsoas treatment technique that uses direct pressure through the abdomen. As mentioned above, there is a risk of adverse vascular responses. When performing MET for the iliopsoas above, be aware that some clients experience back discomfort with this technique due to compression of the lumbar facet joints.

POSTERIOR PELVIC TILT

Description

A posterior rotation of the two innominates that make up the pelvis is a posterior pelvic tilt. This postural distortion gives the individual an appearance of a very flat back and buttocks that appear tucked under (Fig. 8.23). The posterior

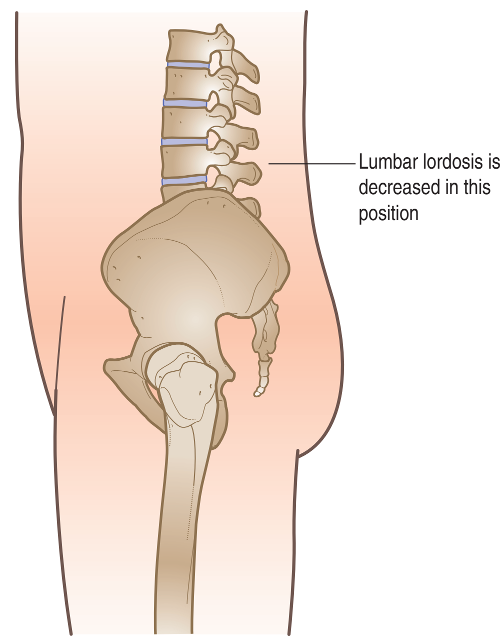

Figure 8.23 Posterior pelvic tilt.

tilt is less common than the anterior tilt. There are detrimental ramifications to the posterior tilt.

There is only slight movement at the sacroiliac joints, so when the pelvis moves it also brings the sacrum and lumbar spine along with it. A posterior rotation decreases the lumbar lordosis and causes the vertebrae to be stacked vertically on top of one another. A primary function of the lumbar lordosis is to decrease compressive forces in the spine and to allow for proper shock absorption. The more vertical arrangement of the vertebral bodies on top of each other increases the compressive forces on the intervertebral discs and can play a role in lumbar disc pathology.[28]

Several factors contribute to posterior pelvic rotations; many of these stem from chronic postural misuse such as sitting in a slouched position. Because the posterior pelvic rotation may be exacerbated by a continual reinforcement of poor biomechanics, like slouching, short-term interventions may not be effective unless accompanied by repeated postural re-education and a reconditioning of proper body mechanics.

The muscular and soft-tissue factors that contribute to posterior pelvic rotation are opposite those that create the anterior pelvic rotation. Tightness in the abdominal muscles and/or tightness in the hamstrings can pull the pelvis into a posterior rotation. However, because both the abdominals and hamstrings are phasic muscles, they tend toward weakness, not hypertonicity when fatigued. Therefore, it takes a significant amount of tightness in the hamstrings or abdominals combined to produce this postural distortion alone. More often, posterior rotation is an adapted pattern that is reinforced by poor mechanics in sitting and standing.

Treatment

Traditional approaches

Traditional treatment of a posterior pelvic tilt focuses on strength training and postural reeducation. In many cases a posterior tilt that appears evident in a sitting position is not evident in a standing position due to changes in hip mechanics. Treatment of the posterior pelvic tilt is consequently not emphasized as greatly.

Soft-tissue manipulation

General guidelines Treatment of posterior pelvic rotations should address hypertonicity evident in the abdominal and hamstring muscle groups. Investigate these muscles for presence of myofascial trigger points as well. Unlike the anterior pelvic tilt, muscular hypertonicity is not as much of a factor in creating a posterior pelvic tilt. The postural distortion is more related to chronic postural positions in either standing or sitting. Consequently, postural re-education is an essential component of treating the posterior pelvic tilt. Soft-tissue manipulation alone, without some form of postural retraining is unlikely to achieve a lasting effect.

Suggested techniques and methods

A. Sweeping cross fiber for rectus abdominis The rectus abdominis pulls its attachments on the pubis in a superior direction. Sweeping cross fiber techniques reduce muscle tightness that contributes to the postural distortion. Sweep diagonally across the fibers of the rectus abdominis with the thumb (Fig. 8.24). Treat the whole length of the rectus abdominis from the rib cage to the inferior attachments near the pubis.

B. Sweeping cross fiber to hamstrings The hamstrings can pull inferiorly on the pelvis causing the posterior rotation. Reducing tension in this muscle group helps decrease their downward pull on the pelvis. The stroke travels diagonally across the fibers of the muscle group (Fig. 8.25). Use successive sweeping strokes on the hamstrings until the entire muscle group has been covered.

Figure 8.24 Sweeping cross fiber to rectus abdominis.

Figure 8.25 Sweeping cross fiber to hamstrings.

C. Deep longitudinal stripping Hamstring tension is further reduced with deep stripping techniques. Use the deep stripping techniques on the hamstrings after some of the more superficial techniques such as the sweeping cross fiber. Start with broad contact surface of pressure and then gradually perform the stripping techniques with a small contact surface (Fig. 8.26).

Rehabilitation protocol considerations

- Massage treatment can help reduce hypertonicity that may be contributing to the problem. However, postural change should be encouraged early on in the treatment process and reinforced on a regular basis.
- Stretching methods are valuable after soft-tissue treatment to encourage flexibility of the involved tissues. It is helpful if stretching is performed prior to regular postural retraining exercises.

Figure 8.26 Deep longitudinal stripping to hamstrings.

Cautions and contraindications Other than general precautions and working within the client's pain and comfort tolerance, there are no major contraindications or cautions for addressing a posterior pelvic tilt with massage.

LATERAL PELVIC TILT

Description

When one side of the pelvis is higher than the other side, the individual has a lateral pelvic tilt (Fig. 8.27). The tilt is named for the side toward which the pelvis tilts. If the right side is higher, it is considered a left lateral tilt because the pelvis is tilting to the left. Think of the pelvis as a bowl and the side to which the water would spill is the side the tilt is named for.

The lateral pelvic tilt can result from muscular dysfunction, in which case it is considered a functional disorder. When it is caused by irregular bone size or alignment issues in the lumbar spine or lower extremity, it is considered a structural disorder. Failure to discriminate between structural and

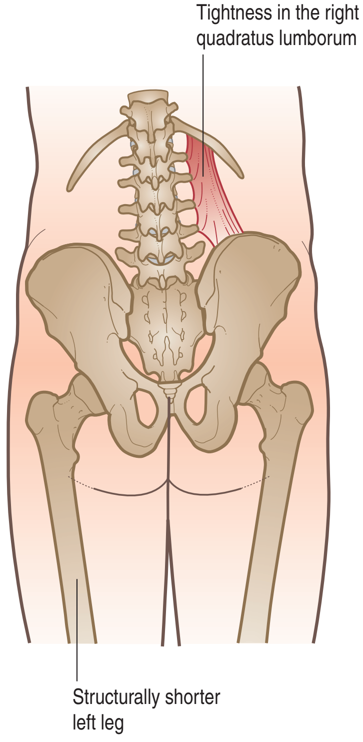

Figure 8.27 Lateral pelvic tilt.

functional causes of a lateral pelvic tilt can cause clinical confusion and inappropriate treatment. Two of the most common causes of lateral pelvic tilt are functional changes from lumbar muscle tightness, and structural problems resulting from a true leg-length discrepancy.

The pelvis can tilt in a lateral direction if there is hypertonicity or spasm in the low back muscles, especially if the tightness is exaggerated on one side. This is particularly apparent with hypertonicity of the quadratus lumborum (QL), because it is a primary lateral flexor of the lumbar spine. The QL muscle is particularly susceptible to hypertonicity because it is a postural muscle of the trunk. If tightness in the QL is markedly greater on one side than the other, it can pull the pelvis higher on the side that is tighter. The tightness may be the result of an acute episode of back pain, or it may occur from improper habitual postural patterns that have been adopted over time.

If the client has a true, structural leg-length discrepancy, it causes a lateral pelvic tilt. A true, structural leg-length discrepancy is accurately evaluated with a full lower-extremity X-ray. However, that is not practical in many cases and a comparable test can be achieved by using a tape measure to measure the distance between the ASIS on one side to the medial malleolus on the same side.[29] Regardless of the functional contribution to pelvic tilting by the QL, the length of these bones never changes. Therefore, one can discriminate between a functional shortening that is caused by QL tightness and one that is caused by a true difference in the length of the bones of the lower extremity. In addition to the leg-length discrepancy, other structural causes of lateral pelvic tilt include a smaller innominate on one side and structural scoliosis.

Treatment

Traditional approaches

If the lateral pelvic tilt is caused by a true leg-length discrepancy, an orthotic or heel lift under the short side is usually prescribed. Lateral pelvic tilts caused by major structural disorders, such as structural scoliosis, are much more difficult to treat. They may involve wearing braces, corsets, or, in more extreme cases, surgical treatment to correct the spinal deformity. Traditional treatment of lateral pelvic tilts that are functional disorders and caused by muscular tightness usually involves physical therapy, stretching, and in some cases muscle relaxants.

Soft-tissue manipulation

General guidelines It is suggested that the hamstrings contribute to lateral pelvic tilt by pulling down on the low side of the pelvis.[30] This would certainly make sense in a non-weight bearing position. However, with the weight of the upper body resting on the femoral heads, it is unclear how the pelvis could be pulled any further inferiorly. Hypertonicity in the hamstrings would more likely pull the pelvis into a posterior rotation, as their angle of pull has a greater tendency to act on the pelvis in the sagittal plane.

If the apparent leg-length difference is primarily functional and caused by hypertonicity in the QL, then treatment of the hypertonic QL is the most effective approach. There are a variety of techniques to address tightness in the quadratus lumborum including static compression, deep longitudinal stripping, pin and stretch, and active-assisted stretching.

If the cause of the lateral pelvic tilt is a structural disorder, massage has limited effectiveness in making a postural correction. However, various detrimental ramifications can result from the structural dysfunction and these can be addressed by massage. For example, if a structural scoliosis has caused the lateral pelvic tilt, muscles on the concave side of the scoliotic curve are likely to be hypertonic. They benefit from the same muscular treatments that are applied in a functional lateral pelvic tilt.

Suggested techniques and methods It is valuable to treat the lumbar muscles bilaterally in a lateral pelvic tilt. However, place greater emphasis on the high side of the lateral tilt because these muscles need the most therapy to reduce hypertonicity.

A. Effleurage and sweeping cross fiber to lumbar muscles Use the thumb, back-side of the fingers, base of the hand, or other broad contact surface to perform longitudinal and sweeping cross fiber applications to the lumbar muscles (Fig. 8.11). If the lateral pelvic tilt is resulting from an acute spasm, use caution with the amount of pressure in this technique because deep pressure moving rapidly across the muscle fibers can cause reactive muscle splinting.

B. Static compression to hypertonic lumbar muscles Apply static compression to the lumbar muscles with a broad contact surface such as the fist or palm. After achieving some initial relaxation in the lumbar tissues, use a more specific contact surface, such as the fingertip, thumb, or pressure tool (Fig. 8.28). Be cautious about the depth of pressure with these more specific pressure applications, especially if the QL is in spasm.

C. Deep stripping to quadratus lumborum After achieving some relaxation in the superficial back muscles and initial tension reduction in the QL, apply deep longitudinal stripping to the QL muscle. Use the thumb or fingertips to perform a longitudinal stripping technique on the quadratus lumborum (Fig. 8.21). Use stripping motions from the iliac crest to the transverse processes, iliac crest to twelfth rib, and transverse processes to twelfth rib as the quadratus lumborum has fibers running in all these directions. When working from lateral to medial on the fibers running from the iliac crest to the transverse processes, apply pressure deep enough to treat under the lateral edge of the erector spinae muscle group. However, use caution not to apply too much pressure directly against the tips of the transverse processes.

D. Pin and stretch for quadratus lumborum This technique uses the pin and stretch concept along with eccentric activity in the QL to encourage reduction of hypertonicity. The client is in a side-lying position. Bring the client's thigh into a position of abduction to shorten the QL muscle. Abducting the thigh shortens the QL because when the thigh is abducted the pelvis lifts a little higher on the same side. Ask the client to hold their leg in that position (as long as this does not produce further muscle pain in a client with muscle spasm). Apply static compression to the QL with the thumb while the client holds the leg in an abducted position. Instruct the client to slowly drop the leg down off the back-side of the table; continue to hold the static compression position as the client lowers the leg (Fig. 8.29). This treatment can feel intense for the client so gauge the pressure carefully. A variation on this technique can be used by applying a stripping technique during the client's eccentric adduction of the thigh instead of static compression. This variation is even more effective in reducing tension in the quadratus lumborum.

Rehabilitation protocol considerations

- Unlike the posterior and anterior pelvic tilts, which appear to be postural aberrations reinforced from chronic misuse over time, muscular (functional) lateral pelvic tilts are often caused by recent dysfunctional muscular activity. Consequently, massage and soft-tissue treatment interventions are more effective in this condition.

Figure 8.28 Static compression to lumbar muscles.

Figure 8.29 Pin and stretch to quadratus lumborum. Photo shows the final position at the end of the stretch.

- Massage and soft-tissue treatments should be engaged immediately. Stretching procedures are most effective when performed after massage treatment has made the lumbar muscles more pliable.
- Self-massage or stretching procedures that the client can perform at home will assist in maintaining optimum tissue flexibility and restoring proper balance to the pelvic musculature.

Cautions and contraindications Other than general precautions and working within the client's pain and comfort tolerance, there are no major contraindications or cautions for addressing a lateral pelvic tilt with massage.

Box 8.2 Case Study

Background

Daniel is a 42-year-old insurance specialist who spends a great deal of time traveling in his car. He is also moderately active at home, as he likes to keep in shape. He has not been able to do as much physical activity recently due to an accident he had several weeks ago. While getting out of his car he slipped on the ice in the parking lot and fell against the curb, landing on his right gluteal region. It was painful at the time, and has continued to give him problems ever since. The pain he reports is mostly a dull aching pain felt in his gluteal region and right lower extremity. He went to the doctor after the accident and had X-rays performed. The doctor mentioned that he did not have any broken bones or serious injuries. The doctor suggested he rest for a while and come back if the condition did not get better or got worse.

His pain is aggravated from long hours in his car, which unfortunately he must keep doing for his work. He says it usually feels better when he can stop and move around some, so he tries to make more frequent stops when he is driving to decrease the discomfort. Sometimes the pain wakes him up at night, and he will take aspirin so he can go back to sleep. He thinks massage might be able to help him reduce his pain and get back to his active regimen.

Questions to consider

- The doctors have ruled out any fractures with an X-ray, but based on the information we have, what might be the cause of Daniel's injury?
- A sudden fall like his could have caused an injury to ligaments such as the iliolumbar, posterior sacroiliac, or sacrotuberous ligaments. Would you choose to treat these problems with massage? If so, how would you go about it?
- Daniel is reporting pain down his lower extremity so it is possible that he has a nerve injury. If he suffered a compression injury to one or more of the nerves in the gluteal region, would you choose to treat him with massage?
- Do you think thermal modalities would be advantageous for Daniel to use at home? If so, which ones would you recommend and why?
- A multi-disciplinary approach is often valuable in treatment. Based on what we know from Daniel's condition, do you think he might benefit from seeing another health professional besides you? If so, who else would you send him to?
- What are some of the major cautions and possible contraindications you want to be aware of in addressing Daniel's condition.

References

1. Rask MR. Superior gluteal nerve entrapment syndrome. Muscle Nerve. 1980;3(4):304–307.
2. Travell J, Simons, D. Myofascial Pain and Dysfunction: The Trigger Point Manual. Vol 2. Baltimore: Williams & Wilkins; 1992.
3. Benson ER, Schutzer SF. Posttraumatic piriformis syndrome: Diagnosis and results of operative treatment. J Bone Joint Surg Am 1999;81A(7):941–949.
4. Almekinders LC. Anti-inflammatory treatment of muscular injuries in sport – An update of recent studies. Sport Med. 1999;28(6):383–388.
5. Jankiewicz JJ, Hennrikus WL, Houkom JA. The appearance of the piriformis muscle syndrome in computed tomography and magnetic resonance imaging. A case report and review of the literature. Clin Orthop. 1991;262:205–209.

6. Prentice W. Rehabilitation Techniques in Sports Medicine. St. Louis: Mosby; 1990.
7. Chaitow L. Modern Neuromuscular Techniques. New York: Churchill Livingstone; 1996.
8. Lowe W. Orthopedic Assessment in Massage Therapy. Sisters, OR: Daviau-Scott; 2006.
9. Voorn R. Case report: can sacroiliac joint dysfunction cause chronic Achilles tendinitis? J Orthop Sports Phys Ther. 1998;27(6):436–443.
10. Basmajian J, Nyberg R. Rational Manual Therapies. Baltimore: Williams & Wilkins; 1993.
11. Vleeming A, J.P. VW, Snijders CJ, et al. Load application of the sacrotuberous ligament: influences on sacroiliac joint mechanics. Clinical Biomechanics. 1989;4:203–205.
12. Myers TW. Anatomy Trains. Edinburgh: Churchill Livingstone; 2001.
13. Snijders C, Vleeming A, Stoeckart R, Mens J, Kleinrensink G. Biomechanics of the interface between spine and pelvis in different postures. In: Vleeming A, Mooney V, Dorman T, Snijders C, Stoeckart R, eds. Movement, Stability, & Low Back Pain. New York: Churchill Livingstone; 1999.
14. Weksler N, Velan GJ, Semionov M, et al. The role of sacroiliac joint dysfunction in the genesis of low back pain: the obvious is not always right. Arch Orthop Trauma Surg. Dec 2007;127(10):885–888.
15. Tullberg T, Blomberg S, Branth B, Johnsson R. Manipulation does not alter the position of the sacroiliac joint. A roentgen stereophotogrammetric analysis. Spine. 1998;23(10):1124–1128; discussion 1129.
16. Gotlin R. Sacroiliac joint injury. e-Medicine; 2006.
17. Browning KH. Hip and pelvis injuries in runners. Physician Sportsmed. 2001;29(1):23–26.
18. Mehta A. Common Musculoskeletal Problems. Philadelphia: Hanley & Belfus; 1997.
19. Shbeeb MI, Matteson EL. Trochanteric bursitis (greater trochanter pain syndrome). Mayo Clin Proc. 1996;71(6):565–569.
20. Kingzett–Taylor A, Tirman PF, Feller J, et al. Tendinosis and tears of gluteus medius and minimus muscles as a cause of hip pain: MR imaging findings. AJR Am J Roentgenol. 1999;173(4):1123–1126.
21. Slawski DP, Howard RF. Surgical management of refractory trochanteric bursitis. Am J Sports Med. 1997; 25(1):86–89.
22. Vleeming A, Mooney V, Dorman T, Snijders C, Stoeckart R. Movement, Stability, & Low Back Pain. New York: Churchill Livingstone; 1999.
23. Chaitow L. Muscle Energy Techniques. New York: Churchill Livingstone; 1996.
24. Janda V. Muscles as a pathogenic factor in back pain. Paper presented at: IFOMT, 1980; New Zealand.
25. Liebenson Ce. Rehabilitation of the Spine. Baltimore: Williams & Wilkins; 1996.
26. Chaitow L, DeLany J. Clinical Application of Neuromuscular Techniques. Vol 1. Edinburgh: Churchill Livingstone; 2000.
27. Janda V. Rational therapeutic approach of chronic back pain syndromes. Paper presented at: Chronic back pain, rehabilitation, and self-help, 1985; Turku, Finland.
28. Soderberg G. Kinesiology: Application to Pathological Motion. Baltimore: Williams & Wilkins; 1986.
29. Magee D. Orthopedic Physical Assessment. 3rd ed. Philadelphia: W.B. Saunders; 1997.
30. Phaigh R. The Treatment of Pain. Eugene: Onsen Techniques; 1991.