Diagnosis and Management of a Patient With Knee Pain Using the Movement System Impairment Classification System

Knee pain is one of the most common musculoskeletal complaints reported by individuals in physical therapy outpatient facilities. Based on various reports, the prevalence of knee pain is between 10% and 30%. Conservative care of knee pain is recommended over surgical intervention; however, there are numerous conservative treatment strategies. Conservative treatment techniques described in the literature include quadriceps strengthening,3,10,23,26 taping or bracing,2,10,11 hamstring stretching,3,11,12 hip strengthening,3,11,12 and use of foot orthotics.12 The dilemma for clinicians is that no specific treatment strategy has been shown to be most effective. One approach that may improve treatment effectiveness is to identify the movement impairment that contributes to the pain problem and then focus treatment strategies on the identified movement impairment.

Movement impairments of the lower extremity in the transverse and frontal planes have been proposed to contribute to knee pain.1,3,16,26 and knee injuries.1,3,10,12,23,26 Movement impairments may appear as abnormal alignment and impaired movement of the lower extremity during the performance of test items and functional activities. Abnormal alignment, such as knee valgus, knee varus, or rotation of the tibia relative to the femur, have been shown to be associated with anterior knee pain1,3,16 and the progression of osteoarthritis.1,3,16 Salsich and P ferm reported that tibiofemoral rotation was the largest predictor of patellofemoral contact area in individuals with patellofemoral pain. Two independent investigators compared the tibiofemoral joint alignment of subjects with anterior knee pain to controls and found that in the subjects with anterior knee pain, the tibia was in greater lateral rotation relative to the femur.1,3 In a study of cadavers, Lee et al.3,16 demonstrated that rotation between the tibia and femur resulted in a change in the contact pressures of the patellofemoral joint, which may contribute to patellofemoral pain problems.3,16 Recently, investigators have reported that increased hip muscular...
| TABLE 1 | MOVEMENT SYSTEM IMPAIRMENT (MSI) DIAGNOSES ASSOCIATED WITH KNEE PAIN |

<table>
<thead>
<tr>
<th>MSI Diagnosis and Description</th>
<th>Pain</th>
<th>Source of Pain Associated With MSI Diagnosis</th>
<th>Treatment Directed by MSI Diagnosis, Not Source of Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tibiofemoral rotation</td>
<td>• Pain along the joint line &lt;br&gt;• Pain associated with tibiofemoral rotation (WB or NWB)</td>
<td>• Patellofemoral joint&lt;sup&gt;30&lt;/sup&gt; &lt;br&gt;• Hamstrings &lt;br&gt;• Iliotibial band &lt;br&gt;• Popliteal &lt;br&gt;• Patellar tendons &lt;br&gt;• Quadriceps tendon &lt;br&gt;• Bursa &lt;br&gt;• Plica</td>
<td>• Education and modification of functional activities that contribute to impaired motion between the femur and tibia &lt;br&gt;• Address muscle imbalances contributing to MSI diagnosis &lt;br&gt;• Address contributions of hip musculature to limit excessive medial rotation or adduction of the femur</td>
</tr>
<tr>
<td>Tibiofemoral hypomobility</td>
<td>• Pain with WB that decreases with rest &lt;br&gt;• Pain is located deep in joint &lt;br&gt;• Stiffness</td>
<td>• Patellar ligaments&lt;sup&gt;4&lt;/sup&gt; &lt;br&gt;• Subchondral bone &lt;br&gt;• Patellofemoral joint &lt;br&gt;• Meniscus &lt;br&gt;• Joint capsule and ligaments</td>
<td>• Address contributions of the hip and foot &lt;br&gt;• Improve ROM, strength, and conditioning without increasing pain and swelling &lt;br&gt;• For patients with OA: caution against excessive strengthening of quadriceps and hamstrings in patients with knee malalignment or laxity&lt;sup&gt;44&lt;/sup&gt;</td>
</tr>
<tr>
<td>Knee extension</td>
<td>• Pain located at suprapatellar or infrapatellar tendon</td>
<td>• Patellofemoral joint &lt;br&gt;• Patellar tendon &lt;br&gt;• Quadriceps tendon &lt;br&gt;• Bursa &lt;br&gt;• Plica</td>
<td>• Education and modification of functional activities (ie, stairs and fitness activities) to improve the contribution of hip extensors and thus reduce requirement on quadriceps &lt;br&gt;• Address muscle imbalances contributing to MSI, such as improvement of hip extensor performance &lt;br&gt;• Gentle stretching of quadriceps &lt;br&gt;• Taping of patella may be indicated</td>
</tr>
<tr>
<td>Knee hyperextension</td>
<td>• Pain located along the anterior or posterior joint line of the tibiofemoral joint or peripatellar pain</td>
<td>• Patellofemoral joint &lt;br&gt;• Patellar tendon &lt;br&gt;• Bursa &lt;br&gt;• Plica &lt;br&gt;• Meniscus &lt;br&gt;• Joint capsule and ligaments &lt;br&gt;• Hamstrings &lt;br&gt;• Popliteus</td>
<td>• Education and modification of functional activities (ie, walking and standing) to decrease knee hyperextension &lt;br&gt;• Address muscle imbalances contributing to MSI, such as improvement of quadriceps and gluteal muscle performance</td>
</tr>
<tr>
<td>Patellar tracking</td>
<td>• Pain is peripatellar or retropatellar</td>
<td>• Patellofemoral joint &lt;br&gt;• Patellar tendon &lt;br&gt;• Fat pad &lt;br&gt;• Plica &lt;br&gt;• Subchondral bone &lt;br&gt;• Synovium &lt;br&gt;• Retinaculum &lt;br&gt;• Joint capsule and ligaments</td>
<td>Quadriceps performance may need to be addressed &lt;br&gt;• Lateral glide requires improvement of quadriceps performance &lt;br&gt;• Superior glide requires reduced quadriceps activity &lt;br&gt;• Stretches to short structures &lt;br&gt;• Lateral glide requires stretching of TFL &lt;br&gt;• Superior glide requires stretching of quadriceps &lt;br&gt;Taping of patella may be indicated&lt;sup&gt;42&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tibiofemoral accessory</td>
<td>• Instability or giving way &lt;br&gt;• May or may not have pain associated with instability</td>
<td>• Deficient ACL &lt;br&gt;• Deficient PCL &lt;br&gt;• Deficient posterolateral corner/complex</td>
<td>• Strengthening musculature surrounding the knee &lt;br&gt;• Neuromuscular retraining&lt;sup&gt;43&lt;/sup&gt;</td>
</tr>
<tr>
<td>Hypomobility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tissue Impairment</td>
<td>• Pain is associated with trauma or surgery</td>
<td>• Any structure of the knee associated with trauma or surgery</td>
<td>Improve ROM and strength according to the healing of the involved structure &lt;br&gt;Stage 1: tissue protection to reduce stress to injured structure &lt;br&gt;Stage 2: gradual progression of activities to gradually increase stress to structure without causing new injury &lt;br&gt;Stage 3: tissue stress progression to prepare tissue for return to normal activities</td>
</tr>
</tbody>
</table>

Abbreviations: ACL, anterior cruciate ligament; LR, lateral rotation; MR, medial rotation; MSI, movement system impairments; NWB, non-weight bearing; OA, osteoarthritis; PCL, posterior cruciate ligament; ROM, range of motion; TFL, tensor fascia latae; WB, weight bearing.

*If a movement impairment of the lower extremity is associated with knee pain and knee injuries, then treatment directed at correction of the movement impairment may be useful.*

*Directing treatment programs toward the correction of an identified move-
ment impairment has previously been described. In a prospective study, Hewett et al demonstrated that participation in an anterior cruciate ligament (ACL) injury prevention training program to correct knee valgus resulted in a reduced incidence of ACL injury in female soccer players. Pollard et al used a similar treatment program in female soccer players and demonstrated that, after training, the movement impairment of hip medial rotation during a landing task was reduced. In a case report, Mascal et al described successful treatment directed at correcting the identified lower extremity movement impairment of 2 individuals with patellofemoral pain. Identifying the movement impairment of the lower extremity associated with the individual's pain or injury and directed treatment to correct the movement impairment may result in improved outcomes.

**Purpose**

In this report, we report on the examination and treatment of an individual with knee pain that is consistent with a proposed movement system impairment (MSI) diagnosis of tibiofemoral rotation. Individuals with this proposed MSI diagnosis of tibiofemoral rotation would report knee pain associated with impaired motion and abnormal alignment of the tibiofemoral joint in the transverse or frontal plane. Most commonly, the impaired motion manifests as knee valgus, which is often the result of abnormal hip motion. The diagnosis is based on identifying a consistent pattern of movement that is associated with the patient's pain complaint and, when corrected, decreases or eliminates the pain. Emphasis of treatment is placed on educating the patient about the movement impairment and modifying the performance of functional activities to prevent the impaired pattern of lower extremity motion during functional activities. In addition, therapeutic exercise is prescribed to address impairments of muscle performance or flexibility presumed to be associated with the impaired movement. TABLE 1 provides the proposed MSI diagnoses associated with knee pain.

**CASE DESCRIPTION**

**Patient History**

The patient was a 50-year-old woman (height, 1.73 m; body mass, 105.6 kg) referred to a University-based outpatient physical therapy facility. Informed consent was obtained and the rights of the patient were protected. The patient reported having had bilateral knee pain for 3 months. Her pain began following activities related to moving into a new home, such as packing and carrying household items. She reported a gradual onset of pain and did not recall a specific injurious event. One month prior to her initial visit to our facility, she saw an orthopedic physician who diagnosed the underlying condition as patellofemoral chondrosis. The physician prescribed Vioxx (25 mg daily) and advised her to use ice packs. According to the radiologist's report, radiographs did not reveal any ossicle, joint space, or soft tissue abnormalities in the tibiofemoral or patellofemoral joints of either knee.

The first author performed the initial evaluation and provided treatment for both lower extremities. To be concise, only the findings related to the knee that was most painful will be reported. The patient reported intermittent aching pain located in the medial and anterior aspects of the left knee. An 11-point numerical rating scale was used to grade the pain severity experienced during the previous week. She reported her average pain intensity as 5/10 and worst pain intensity as 6/10. The pain was reported to increase when she sat with her knees flexed for more than 10 minutes and when she stood for more than 30 minutes. She also reported that her pain increased when she descended stairs and participated in water aerobics.

The patient was asked to complete the activities of daily living scale of the Knee Outcome Survey (ADLS-KOS). The ADLS-KOS is a reliable and valid measure of knee pain and function. Scores range from 0 to 100, with 0 representing a complete loss of function and 100 representing no loss of function and no pain. The patient's score was 73% and she stated that her goals were to (1) have less knee pain, (2) be able to participate in water aerobics, and (3) be able to descend stairs without pain.

The patient reported that she had no prior episodes of knee pain. Her past medical history included high blood pressure and a diagnosis of degenerative disk disease with 2 bulging disks in the lumbosacral spine. Previous pain related to the lumbar spine included low back pain, with radiating pain into her left posterior thigh and foot. She reported that the lower back pain and radiating pain had resolved after receiving treatment prior to the initial visit at our facility. Daily doses of medications included 100 mg of Atenolol for hypertension and 25 mg of Vioxx for knee pain.

For 17 years, the patient was employed full time as a secretary in a hospital setting. Her primary duties included transcribing communications and other computer-related activities. The device she used for transcription required use of a right foot pedal. Fitness activities in which she participated included water aerobics, swimming, and walking. Recreational hobbies included sewing, using a machine that also required use of a right foot pedal.

**Physical Examination**

**Tests of Movement and Alignment**

The examiner assessed a number of tests of movement and alignment. Femoral alignment was assessed by observing the posterior vertical excess that is associated with the insertion of the hamstrings. The patient stood with the femur in medial rotation; the medial hamstring insertion was more prominent than the insertion of the lateral hamstring. In single-limb stance, the patient demonstrated excess-
sive femoral medial rotation, this was determined by observing rotation of the vertical creases in a clockwise direction. With bilateral hip and knee flexion (partial squat), she demonstrated increased hip adduction and knee valgus, and reported that her pain increased compared to standing. The patient was instructed to perform the partial squat while limiting hip adduction and knee valgus. She was able to perform the movement correctly and without pain. Tibial lateral rotation was observed and pain was reproduced when the patient performed active knee flexion in prone. When the lateral rotation was limited by physical assistance from the examiner, the patient was able to flex her knee painlessly.

Functional activities including sitting, stair climbing, walking, and rising from a seated position to standing were also assessed. Because the patient reported an increase in pain when she sat for more than 10 minutes, she was asked to simulate the position in which she sat while working (Figure 1A). The patient demonstrated sitting with her right lower extremity extended to reach the pedal for her transcription machine. The left knee was positioned in tibial lateral rotation; this was determined by visual observation of the tibial tubercle appearing to be located lateral to the tricompartmental groove of the femur and her foot pointing in the lateral direction. She stated that she sat in a similar position while she used her sewing machine. She reported no increase in her pain when she assumed the position during the examination. She reported that her pain increased after prolonged sitting. The patient was instructed how to modify her sitting position while at work and while using her sewing machine by positioning her knee over her foot and pointing her foot directly forward.

Stair ambulation was assessed using a simulated step up and step down. The patient's knee was in valgus as she stepped both up and down. She reported an increase in her knee pain during the step up and down, compared to standing. The patient was instructed to perform the step up and step down while keeping her knee over her second toe. The patient was unable to perform the activities correctly, so the examiner provided manual assistance. With manual assistance, the patient was able to step up and step down with less pain than when she performed the activities without assistance.

Rising from a seated position and walking were also assessed. The patient demonstrated knee valgus when rising from sitting to standing; however, she reported no increase in her pain. When she was walking, she demonstrated excessive femoral medial rotation during early midstance.

**Palpation** The patient reported tenderness when the examiner palpated along both the medial joint line of the left tibiofemoral joint and the articular surface of the adductor tubercle of the patella. Tenderness along the medial and lateral tibiofemoral joint line is consistent with the proposed PTE diagnosis of tibiofemoral rotation. Joint line tenderness may also indicate a possible meniscal tear; however, the patient reported no complaints of locking or buckling and tests for meniscal integrity were negative. 

**Joint Flexibility and Muscle Performance** Hip flexor extensibility was assessed using methods described by Kendall et al. The patient demonstrated limitation in the length of the iliopsoas and tensor fascia lata (TFL) of the left lower extremity. For the measurement, the patient was positioned in supine with her lumbar spine in neutral. The patient was asked to hold her right lower extremity to her chest to maintain the neutral spine position during the performance of the test. The examiner then lowered the patient's left lower extremity into extension while stabilizing the pelvis by applying pressure on the left anterior superior iliac spine (ASIS).

To test the length of the TFL, the knee was flexed 90° and the lower extremity was lowered into hip extension while maintaining the hip in neutral internal rotation/external rotation and neutral hip adduction/abduction. As the examiner lowered the limb into hip extension, the tibia rotated laterally and the patient reported that her pain was produced.
The test was modified and manual assistance was provided to prevent lateral rotation of the tibia. The patient reported that her pain was abolished with the manual assistance. The examiner noted that the final hip position was approximately 20° of hip flexion and concluded that the TFL length was limited. The test was then modified to test the iliopsoas. The examiner lowered the patient's left lower extremity into hip extension with the hip abducted to accommodate the limited length of the TFL. The examiner noted that the final hip position was approximately 10° of hip flexion. The knee then was extended to accommodate the length of the rectus femoris; however, no additional hip extension was noted. The examiner concluded that the iliopsoas was limiting hip extension. Measurements were not made with a goniometer.

Ankle dorsiflexion range of motion (ROM) was 0° with the knee extended and 15° with the knee flexed; the findings are indicative of a short gastrocnemius. Hip lateral rotation ROM appeared to be limited, however, an accurate measurement was not possible because of motion at the tibiotalar joint. As has been shown previously, when hip rotation ROM is measured with the patient prone, the ROM measurement may be exaggerated if the tibiotalar joint is not stabilized. The patient had full knee extension but knee flexion was limited slightly by soft tissue approximation.

Muscle performance was assessed using manual muscle testing as described by Kendall. The patient demonstrated decreased muscle performance of the hip lateral rotators (3/5) and the iliopsoas (4/5). The manual muscle test for the posterior fibers of the gluteus medius could not be performed due to the limitation in the length of the hip flexors, iliopsoas, and TFL. Length of the hamstring and quadriceps was considered normal (5/5). The examination findings consistent with the proposed MSI diagnosis of tibiotalar rotation are summarized in TABLE 2.

### TABLE 2 Results of the Physical Examination

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Findings Indicating MSI Diagnosis of Tibial Rotation</th>
<th>Patient’s Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alignment</td>
<td>LR of tibia</td>
<td>Positive sign, no pain increase</td>
</tr>
<tr>
<td></td>
<td>MR of femur</td>
<td>Positive sign, no pain increase</td>
</tr>
<tr>
<td>Single-limb stance</td>
<td>MR of femur (stance limp)</td>
<td>Positive sign, no pain increase</td>
</tr>
<tr>
<td>Hip flexion of uninvolved limb and stand with weight on involved limb</td>
<td>LR of tibia (flexed limb)</td>
<td>Positive sign</td>
</tr>
<tr>
<td>Single-limb stance</td>
<td>MR of femur</td>
<td>Positive sign, pain increase*</td>
</tr>
<tr>
<td>Knee flexion of involved limb and stand with weight on uninvolved limb</td>
<td>MR of femur (stance limp)</td>
<td>Positive sign, pain increase*</td>
</tr>
<tr>
<td>Bilateral hip and knee flexion (partial squat)</td>
<td>Shortened length of TFL</td>
<td>Positive sign, pain increase*</td>
</tr>
<tr>
<td>Hip flexor length test</td>
<td>LR of tibia as hip is extended in neutral hip abduction/adduction and hip (LB/VR)</td>
<td>Positive sign, pain increase*</td>
</tr>
<tr>
<td>Manual muscle test</td>
<td>Weak posterior gluteus medius</td>
<td>Not tested</td>
</tr>
<tr>
<td>Knee flexion in prone</td>
<td>Weak hip lateral rotators</td>
<td>Positive sign, pain increase*</td>
</tr>
<tr>
<td>Knee extension in sitting</td>
<td>LR of tibia</td>
<td>Positive sign, pain increase*</td>
</tr>
<tr>
<td>Functional activity</td>
<td>Shortened length of gastrocnemius</td>
<td>Positive sign, pain increase*</td>
</tr>
<tr>
<td>Sitting (specific to work)</td>
<td>MR of femur or LR of tibia</td>
<td>Positive sign, pain increase*</td>
</tr>
<tr>
<td>Stairs</td>
<td>MR of femur or LR of tibia</td>
<td>Positive sign, pain increase*</td>
</tr>
<tr>
<td>Gait</td>
<td>MR of femur or LR of tibia</td>
<td>Positive sign, pain increase*</td>
</tr>
<tr>
<td>Rise from sitting to standing</td>
<td>MR of femur or LR of tibia</td>
<td>Positive sign, pain increase*</td>
</tr>
</tbody>
</table>

*With correction, the patient reported a decrease in pain.

Abbreviations: LR, lateral rotation; MR, medial rotation; MSI, movement system impairment; TFL, tensor fascia lata.

Intervention

Treatment was provided 4 times over a 2-month period. The treatment program included a combination of instruction in (a) correct performance of functional activities, (b) home exercises, and (c) tapping. Emphasis of treatment was placed on training the patient to restrict tibiotalar rotation during functional activities for 2 reasons. First, we believe that repeated use of the patient's preferred movement and alignment strategies during functional activities contributed to...
the cumulative stress on the tissues, leading to tissue injury and pain. Second, the patient reported problems with functional activities. Therefore, addressing functional activities first may have facilitated the patient's adherence with the rest of the rehabilitation program.

The exercises that were prescribed emphasized correcting the specific alignment and movement impairments identified in the examination. The lower extremity muscle length and strength impairments contributing to the tibiofemoral rotation also were addressed with the prescribed exercises.

Visit 1
During her initial visit, the patient was given information about the diagnosis of tibiofemoral rotation. The patient must understand what factors might be contributing to her pain so she could recognize and correct faulty movement and alignment strategies during her daily activities. Specific instructions also were provided regarding performance of functional activities (TABLE 3). The activities addressed included those that the patient had reported as being painful, such as prolonged sitting and descending stairs. Walking and rising from a chair did not evoke pain, but the patient did demonstrate signs of tibiofemoral rotation when she performed the activities; therefore, these activities also were addressed. The patient was instructed in the proper positioning of the lower extremity; specifically, she was told to keep her knees over her foot and not allow the knee to roll in. She also was instructed to squeeze her seat muscles during walking, in an attempt to activate the hip lateral rotators and adductors, thereby to reduce the amount of hip medial rotation and hip adduction. After instruction, the patient practiced each of the activities with specific modifications (TABLE 3).

During the initial visit, the patient was given instructions for 6 exercises to perform at home: (1) knee extension with ankle dorsiflexion in sitting, (2) hip lateral rotation with abduction in side lying, (3) knee flexion in prone, (4) hip lateral rotation in prone, (5) hip lateral rotation isometrics with the knees flexed in prone, and (6) weight shifting in standing (APPENDIX A).

Knee extension with ankle dorsiflexion was prescribed to improve the extensibility of the gastrocnemius muscle and to decrease the amount of time the knee was kept in a flexed position during periods of prolonged sitting; this exercise was to be performed with 5 repetitions, 3 to 4 times a day. Active hip lateral rotation with abduction performed in side lying is prone was used to improve muscle performance of the hip lateral rotators; this exercise was to be performed with 10 repetitions, once or twice a day. The patient was encouraged to increase the number of repetitions as long as she was able to perform the exercise properly. Active knee flexion and hip lateral rotation in prone were prescribed to improve the extensibility of the TFL and to increase the recruitment of the tibial medial rotators. The patient was instructed to restrict tibial lateral rotation by pointing her toes toward the opposite side during the performance of these 2 exercises and to perform 10 repetitions of each exercise once or twice a day.

In an effort to reduce hip medial rotation during the stance phase of walking, she was instructed to perform the weight-shifting activity frequently throughout the day. She was instructed to shift her weight onto the left foot and contract the hip lateral rotators on the left side when standing. The patient was told that she should not experience an increase in pain either during or after performance of her exercises. She was told to discontinue any exercise that produced an increase in pain until she consulted her therapist. The patient was given written instructions for proper performance of the exercises and a phone number to call if she had any questions or concerns.

Visit 2
During the patient's second visit 1 week after the first visit, she reported a marked decrease in pain with an average pain intensity of 2/10 and worst pain intensity of 3/10 during the course of the week. She reported that she had stopped taking Vioxx and that the functional activity instructor was helpful in reducing her pain. Proper performance of functional activities, such as walking, was practiced during the treatment session and the patient's performance of the home exercise program also was observed. Further instruction was provided to ensure proper ankle dorsiflexion during the seated knee extension exercise. Further instruction
also was provided to increase the recruitment of (a) the hip lateral rotators during the performance of hip lateral rotation side-lying and (b) the gluteals during the weight shift exercise. Additional cues were provided to improve the performance of the knee flexion in prone and hip lateral rotation in prone exercises. The patient was encouraged to continue with her program as instructed.

**Visit 3**
The third visit took place approximately 5 weeks after the initial evaluation. The patient reported that she had 1 episode of increased knee pain (7/10) since the last visit. The episode began the morning after swimming for approximately 20 minutes and the pain persisted for 2 days. She used ice packs and ibuprofen to control her pain during this episode. At the time of her third visit, her pain had returned to the level she had reported on her second visit and she was no longer using the ice or ibuprofen.

She reported that her pain increased after descending 4 flights of stairs. The examiner decided to tape the patient's knee in an attempt to increase the control of bilateral rotation during stair ambulation (Figure 2). The taping technique was developed by one of our clinicians but has not been described in the literature. The tape was applied while the patient was standing. Cover-Roll was applied first to protect the skin. Three strips of the Leukosport tape were applied diagonally along the limb from the mid portion of the anterolateral thigh posteriorly behind the popliteal crease to the mid portion of the anteromedial tibia. Three strips of tape also were applied diagonally along the limb from the mid portion of the anteromedial thigh posteriorly to the mid portion of the anterolateral tibia. Finally, small strips of tape were applied from the patella to the posteromedial aspect of the knee. Prior to application of the tape, the patient was asked to perform a step-down from a 20.3-cm-high step. When she stepped down, she reported pain of 4/10.

![Figure 2](image)

**Figure 2.** (A) Anterior view of taping method to reduce tibiofemoral rotation. (B) Posterior view of taping method to reduce tibiofemoral rotation.

The patient repeated the step-down task after the tape had been applied. Her pain was 0/10. The patient was instructed to wear the tape as long as it was comfortable, but to remove the tape after 3 days to prevent problems with her skin. The patient also was given written information regarding precautions of tape and its removal.

**Visit 4**
Ten weeks after her initial visit, the patient reported that she had not experienced any pain during the previous 2 weeks. She had worn the tape for 3 days before removing it. The relief of pain experienced when the tape was on persisted after the tape was removed, so that she was now able to descend 4 flights of stairs and sit through an entire movie without pain.

During this visit, the patient demonstrated improved lower extremity alignment and movement, and no pain during performance of single-limb stance, partial squat, stair ambulation, and rising from a sitting position. She also demonstrated proper sitting position for work and sewing. She did not demonstrate improvement with walking; she still demonstrated excessive femoral medial rotation during stance. Muscle performance and flexibility also were reassessed. The patient demonstrated a 4+/5 manual muscle grade for the hip lateral rotators. There was no pain during the test for TFL flexibility. Flexibility of the TFL appeared to have improved, as compared to the initial visit; however, goniometric measurements were not taken.

The patient reported performing some of her activities on a daily basis, because those were easy to perform throughout her workday. Activities that she performed daily included knee extension with ankle dorsiflexion in sitting, weight-shifting activity in stance, and modifications of her functional activities. She reported that she performed the other exercises approximately 30% of the time. The performance of her home program was observed. She could perform each exercise independently, except for hip lateral rotation in the side-lying position. Because she still had difficulty recruiting the hip lateral rotators, the
exercise was modified. The patient was instructed to perform hip abduction in prone and to position her femur in slight lateral rotation. The patient was encouraged to continue with her home program and to contact her therapist if she had any questions. The patient required no further visits.

**Phone Follow-up**

One year after discharge, the patient was contacted by telephone and a questionnaire designed to assess long-term outcomes was mailed to her.

**OUTCOMES**

The patient was seen 4 times over the span of 2 months. Overall, the patient reported a cessation of pain and an improvement in her functional activities (Table 4). Her average pain intensity rating was 5/10 at initial visit, 2/10 at week 2, 1/10 at week 5, and 0/10 at 1 month. At 10 weeks and at 1 year the patient reported no difficulty with sitting, standing, ascending/descending stairs, or participating in water aerobics. The patient also demonstrated an increase in the scores of the ADL-S-KOS, compared to scores at the initial visit.20,21 She had a score of 73% at the time of her initial visit, 86% at the time of her final visit, and 95% at 1 year after her initial visit.

**DISCUSSION**

We have reported on the examination, diagnosis, and treatment of an individual with anterior knee pain. A standardized examination, including tests of alignment and movement, was performed and a MSI diagnosis was assigned. The signs and the subject's report of pain were consistent with the proposed MSI diagnosis of tibiofemoral rotation. Emphasis of treatment was placed on having the patient correct the identified movement and alignment impairments while performing her daily activities. Exercises also were prescribed to address muscle performance and flexibility impairments that are presumed to contribute to tibiofemoral rotation. Movement impairment-specific treatment resulted in improvements on a number of outcome variables, including a decrease in pain and improvement in functional activities.

Although the patient improved with the treatment prescribed, we acknowledge that another approach may have achieved similar outcomes. Strong evidence to support the existence of a causal relationship cannot be established from a case report. Other treatments that have been shown to decrease symptoms in patients with knee pain include quadriceps strengthening,26,27 hamstring stretching,2,4 and use of foot orthotics.2 The use of quadriceps strengthening is based on the theory that the pain is a result of either patellar malalignment or poor patellar tracking. Upon examination, the patient did not demonstrate any signs of patellar malalignment or poor patellar tracking. Therefore, quadriceps strengthening was not prescribed. In addition, the patient did not have short hamstrings; therefore, hamstring stretching was not prescribed. The patient did not demonstrate excessive pronation during stance or gait assessment, therefore, foot orthotics were not prescribed.

Other factors may have contributed to the patient's outcomes. The effect of time on symptoms resolution must be considered. Based on the time needed to achieve tissue healing, resolution of pain would be expected to occur within 4 to 8 weeks. The patient reported no noticeable decrease in her pain during the 3 months prior to her initial visit. She reported a decrease in the average intensity of her pain from 5/10 to 2/10 within the first week of physical therapy. So, it is unlikely that her symptom relief was due to time alone. The concurrent use of medications and ice may have provided the patient with relief of pain. She reported having used both Vicodin and ice during the month prior to her first visit and having experienced minimal relief. She discontinued the use of Vicodin before her second visit to physical therapy when she noticed a significant decrease in her pain. Therefore, it is unlikely that the resolution of pain was due to the anti-inflammatory effects of either the medication or the ice.

Because the patient had not experienced complete resolution of her pain with 5 weeks of treatment, the examiner decided to use a taping technique that has been developed in her clinic. The tape was applied in an attempt to limit the amount of rotation occurring at the tibiofemoral joint. The patient reported that she experienced no pain when descending stairs while the tape was in place. Anderson
et al performed a study on the knees of cadavers in which a similar taping technique was used. They demonstrated that taping can significantly reduce rotation of the tibiobromal joint. Although the intent of the taping was to minimize rotation at the tibiobromal joint, it is possible that other mechanisms resulted in the decrease in pain. The technique used by the author included strips of tape applied to the patella in the medial direction as described by McConnell; these strips of tape were provided to prevent excessive pull of the iliotibial band on the patella. It is possible that the patellar taping may have provided the relief without the strips of tape applied diagonally. We plan to study the effectiveness of this taping method in future trials.

The patient demonstrated improvement in the strength of the hip lateral rotators and slight improvement in the extensibility of the TFL. A greater increase in muscle extensibility might be expected given the length of time the patient was seen; however, the patient had a low level of adherence to her home exercise program. Upon each return visit, the patient required additional instruction for proper performance of each of the exercises assigned the previous session. Low exercise adherence may have limited the amount of improvement with strength of the hip lateral rotators.

The patient did report that she consistently modified her functional activities, particularly sitting alignment. She also demonstrated improved performance during the reassessment at her follow-up visits. The fact that her pain decreased within the first week, despite poor performance of the exercises, suggests that addressing the performance of the patient's functional activities may have been helpful in reducing the patient's pain complaints. By simply changing her sitting position at work and modifying other functional activities, she was able to reduce her pain from an average intensity of 2/10 to 2/10. We believe that addressing functional activities is important for all patients; however, it may be particularly helpful for patients that have difficulty performing an exercise program. Regarding the patient in this case, we hypothesize that improved performance of exercises may have resulted in a faster resolution of pain.

A limitation of this case report is the lack of specific criteria to indicate the patient's poor performance on the movement and alignment tests used in the examination. Clinical measures to determine rotation between the tibia and femur are challenging. Quantification of tibiobromal joint motion is difficult, particularly when the patient is performing a motion such as walking. Despite these limitations, observational movement analysis is a key component of the physical therapy examination. We have established methods to standardize the test items; however, the reliability and validity of the methods have not been tested. We hope to develop future studies to address this deficiency.

We believe the association of the patient's pain behavior with the identified movement impairment is important to making the diagnosis. If the patient has an increase in pain and appears to demonstrate increased tibiobromal motion, the examiner performs a secondary test. The secondary test involves performing the same test item with correction of the observed tibiobromal motion impairment and then reassessing the patient's pain behavior. If the pain improves with the corrected movement compared to the impaired movement, the examiner is more confident the impaired movement may be contributing to the pain problem. The method of performing secondary tests has been reported previously.

CONCLUSION

In this report, we describe the evaluation and treatment of a patient with anteromedial knee pain. The patient's examination findings and report of pain were consistent with those proposed to constitute the MSI diagnosis of tibiobromal rotation. Treatment was described which emphasized the modification of alignment and movements of the knee to limit tibiobromal rotation during performance of functional activities. The patient also was instructed in an exercise program to address muscle and motor control impairments that were proposed to contribute to the MSI diagnosis of tibiobromal rotation. The patient had reduced pain from 5/10 to 2/10 in 10 weeks with no return of pain at 1 year. She also had improvement of function represented by an improved ADL-S-KOS from 73% at the initial visit, 86% at 10 weeks, and to 96% at 1 year after end of therapy. Further research to assess the effectiveness of treatment programs proposed to improve specific movement impairments of the knee is indicated.

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REFERENCES


EXERCISES FOR THE INITIAL HOME PROGRAM AND PROGRESSION:
(ITALICS DENOTE PATIENT-SPECIFIC CUES GIVEN AT TIME OF TREATMENT.)

**VISIT 1**
1. Knee extension with ankle dorsiflexion in sitting
   *Do not allow the thigh to roll in*

2. Hip lateral rotation with abduction in side lying
   *Squeeze seat muscles and gently roll knee towards the ceiling*

3. Knee flexion in prone
   *Point toes to the inside (toward opposite leg)*

4. Hip lateral rotation in prone
   *Point toes to the inside (toward opposite leg)*

5. Hip lateral rotation isometrics with knees flexed in prone
   *Squeeze seat muscles as you gently push your feet together.*

6. Weight shifting in standing
   *(no picture available)*
   *In standing shift your weight to the left foot and squeeze the left seat muscle*  
   *Do not let your knee roll in*

**VISIT 2 AND 3**
- Previous exercises reviewed
- No new exercises added

**VISIT 4**
- Previous exercises reviewed
- Exercise 2: hip lateral rotation and abduction in side lying change to hip abduction in prone

- Hip abduction in prone
  *Roll the left thigh out slightly*

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