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Closed-Chain Quadriceps Strengthening and Hamstring Stretching in the Conservative Treatment of Medial Plica Syndrome: A Case Report

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The patient signed an informed consent allowing for the use of medical information and video footage for this report and received information on the institutions policies regarding the Health Insurance Portability and Accountability Act.

The author acknowledges Amy Litterini, PT, DPT for assistance with case report conception as well as Abigail Wood PT, DPT and Megan Jensen, PT, DPT for supervision of patient management.
ABSTRACT

Background and Purpose

Medial Plica Syndrome (MPS) is characterized by pain on the anteriomedial aspect of the knee. The pain results from irritation caused by repetitive use or direct impact. Closed-chain exercises and hamstring stretching have shown to decrease compressive forces on the anterior aspect of the knee. This case report will look at using these exercises in the conservative management of MPS.

Case Description

The patient is a 13-year-old female who sustained a direct blow to the anteriomedial aspect of her left knee. After a diagnosis of Chondromalacia Patella, she was treated with non-specific exercises. Pain continued and no progress was made. After persistent pain, an MRI revealed an inflamed medial plica (MP). The patient was referred to physical therapy with the hopes of using conservative treatment to avoid arthroscopic surgery to remove the MP.

Outcomes

After an episode of care that consisted of closed-chain exercises, hamstring stretching and functional rehabilitation, the patient showed improved strength and range of motion. Her impairment level, based on the Lower Extremity Functional Scale, showed a substantial improvement. She returned to playing with her friends and siblings, participating in soccer and was unrestricted in activities of daily living.

Discussion

The results of this case report suggest that closed-chain exercises and hamstring stretching may be beneficial in the management of MPS. The patient was able to avoid surgery and return to her prior level of function, even though she was discharged in the midst of another secondary medical issue.

Manuscript Word Count: 3,471
BACKGROUND and PURPOSE

Medial Plica Syndrome (MPS) is a source of anteriomedial knee pain that can severely limit one’s ability to use their knee for all activities. Griffith¹ and Bellary² recommend conservative treatment and Camanho³ found a majority MPS cases have been successfully managed with conservative treatment. Arthroscopic resections of the medial plica (MP) are reported to be 75-91% successful, however symptoms may persist¹.

As the synovial joint of the knee is developing in utero, three cavities are formed by mesenchyme tissue that later combine into one synovial cavity. Remaining folds on the synovial membrane are termed synovial plica. Four folds exist and they are named for their location. Irritation of the MP, located just medially to the patella, results in MPS.

Although MPS may be caused by overuse or repetitive use of the knee, direct injury to the knee may result in synovial hematoma also causing plica irritation⁴.

In a literature review, Bellary² found interventions aimed at decreasing compressive forces at the knee showed improved outcomes. According to Hartigan et al⁵, patellofemoral joint stress is minimal close to knee extension with weight bearing or closed-chain activities, while open-chain activities produce a large amount of compressive forces at the knee. Hamstrings may place stress on the anterior aspect of the knee during extension therefore, hamstring stretching could also be used to decrease the compressive forces at the knee¹. Griffith¹ stated that it is important for patients to avoid open-chain activities because they cause irritation to the MP.

This patient was selected for this case report because of her previous bout of unsuccessful physical therapy (PT). This approach used specific techniques aimed at decreasing anterior pressure on the medial aspect of the knee.
Therefore, the purpose of this case report is to demonstrate the use of close-chain quadriceps strengthening and hamstring stretching in a case of MPS in an adolescent to improve quadriceps strength and hamstring length, therefore decreasing pain and avoiding surgery.

CASE DESCRIPTION

Patient History

The patient’s mother signed an informed consent allowing the use of her medical information for this case report. The patient (TS) was a 13-year-old female who had just completed the seventh grade. She reported a fall down the stairs four months prior, and landed on her left (L) anteriomedial knee, which resulted in L anteriomedial knee pain. Previous conservative treatments, under a diagnosis of chondromalacia patella, which included open-chain activities and range of motion (ROM) exercises, were unsuccessful. (See Figure 1 for timeline of events) PT was terminated after little progress was made. She played soccer and ran track and field but was unable to participate in any sport or recreational activity. TS had three steps to get into her house, slept on the second floor, and lived at home with her parents and five siblings.

She presented with good health, no poor health habits or pertinent family medical history. She was a nonsmoker/drinker and her parents did not smoke either. She was taking no medications at the time of initial evaluation.

The patient sprained her right ankle 10 months prior to the initial onset of her current condition. Her current condition began four months ago after she fell down the stairs. Initial X-Rays of her L knee were negative for a fracture. An MRI, taken after
conservative treatment failed and pain did not subside with rest, revealed an inflamed MP.

TS and her mother reported a desire to avoid surgery and return to normal everyday activities. These included walking, ascending and descending stairs, bathing and playing with her siblings and friends and returning to full participation in soccer.

**Systems Review**

A systems review was then performed. (Results shown in Table 1) The musculoskeletal and integumentary systems were impaired. Gross active and passive ROM of the L knee was limited and resulted in pain. Decreased L knee flexion and extension were noted and the patient reported pain, particularly with knee extension. Muscular atrophy of the L quadriceps was also observed. Decreased gross L hip strength was noted with adduction, abduction and flexion. No pain was reported with hip strength testing. Swelling was also noted on the anteriomedial aspect of the L knee.

**CLINICAL IMPRESSION 1**

At initial evaluation of her second episode of care, the patient’s primary problem was extreme pain on the anteriomedial aspect of the L knee. An MRI performed one week prior to the second episode of care revealed an inflamed MP, therefore there were no other differential diagnoses at the time of this evaluation. However, if the patient continued to experience pain, did not gain L knee ROM or did not show improved strength, a reassessment would be performed to evaluate the need for a referral or a return to her orthopedic surgeon.

In the examination we looked at goniometry measurements of knee flexion and extension, edema/circumference measurements of the knees and palpation of the MP. All
procedures were performed bilaterally for comparison. The Lower Extremity Functional Scale (LEFS) was used to assess TS’s impairment level while the 0-10 pain scale was used to assess pain.

TS was an excellent candidate for a case report because of her previous episode of unsuccessful PT. Recognition and specific treatment of the patient’s pathology may have resulted in an earlier return to her normal activities. This case report will present closed-chain exercises and hamstring stretching that will allow the patient to improve quadriceps strength and hamstring length, thereby decreasing pain and avoiding surgery.

**EXAMINATION**

The results of the initial and final examination can be seen in Table 2. ROM measurements of the uninvolved right knee were taken first and will be used for comparison and to establish this patient’s normal ROM. Measurements were taken with a universal goniometer and were performed according to Norkin and White. Measurements of the L knee were limited by the patient’s reports of pain. She lacked four degrees of L knee extension and 41 degrees of L knee flexion, compared to the right knee. Brosseau et al found inter-, intra-test reliability and validity to be high for goniometry measurements using a universal goniometer.

Due to swelling on the anteriomedial aspect of the L knee, circumference/girth measurements were taken. Mild swelling, as noted by Bellary et al, may be present upon examination. Using a tape-measurer, leg circumference was taken in centimeters around the knee at the midpoint of the patella, five centimeters below the inferior pole of the patella and ten centimeters below the inferior pole of the patella. Compared to the right knee, mild swelling of .5 centimeters was noted at five and ten centimeters. Soderberg et
Muscular atrophy of the L quadriceps was visible and weakness of the L hip and L knee were discovered in the systems review. To evaluate this weakness and atrophy, manual muscle testing was performed bilaterally. Testing was performed as described by Kendall et al and a literature review by Cuthbert and Goodheart found there to be large amounts of evidence to support the reliability and validity of manual muscle testing. All testing of the right knee and right hip received a 5/5 grade meaning that she was able to hold against strong pressure in a gravity dependent position. Her L hip abductors, adductors, iliopsoas major and knee extensors all received a 4/5 meaning that she was able to hold in a gravity dependent position and against moderate pressure. Reports of pain were noted with testing of L knee extension.

Palpation of the L MP was then performed and pain was reproduced. According to Nigam and Shetty, palpation in full knee extension over the medial femoral condyle may produce pain and reveal a thickened medial patella plica. Pain was reproduced, but a thickened plica was not palpated.

A numeric pain rating scale was used to assess pain on a 0-10 scale. On the scale, 0 represents no pain and 10 represents worst possible pain. A literature review by Williamson and Hoggart found the numerical rating scale to be reliable and valid. On the day of initial examination, the patient reported 5/10 pain on the anteriomedial aspect of her L knee. Complaints of pain in patients with MPS may often be aggravated by activities that require repetitive knee flexion and extension. These activities may include jogging, cycling, and swimming. The patient reported 10/10 pain after periods of increased activity when she tried to play soccer and swim with her siblings.
Observational gait analysis was performed. TS was ambulating with a hinge knee brace and was limited in L knee flexion during the swing phase of gait. This resulted in L hip hike and L hip circumduction. Krebs et al\textsuperscript{12} found observation gait analysis to be moderately reliable.

Finally, the LEFS was used to assess the patient’s level of impairment. The test is a self-report questionnaire that consists of 20 questions that are based on everyday activities. Patients report their ability to perform tasks on a five-point scale ranging from 0, or extreme difficulty or unable to perform activity to 4, or no difficulty. A lower score indicates at greater disability. The test measures a patient’s initial function, is used to set functional goals, monitor progress, and show outcomes\textsuperscript{13}.

When compared to the SF-36, the LEFS was reliable, had construct validity and the sensitivity to change was superior to that of the SF-36 in patients with a variety of lower extremity injuries. The LEFS was found to be sufficient for research purposes and making clinical decisions for individual patients\textsuperscript{13}. TS scored a 19/80 on the LEFS, indicating 76\% impairment.

TS would report to PT two times per week for two months. In one month TS would demonstrate full and pain free ROM of her L knee to assist with gait mechanics and ADL’s, as well as achieve a 5/5 MMT grade for all knee and hip motions to assist with recreational activities. In two months she would be unrestricted in gait, all ADL’s, and recreational activities with pain that is less than 2/10 on a 0-10 pain scale.

**CLINICAL IMRESSION 2**

Based on the data collected during the examination, the orthopedic surgeon’s diagnosis of MPS was confirmed. She had pain with palpation on the MP, mild effusion, L quadriceps
weakness and L hip weakness. Her gait abnormalities were consistent with protective

guarding against ROM that caused pain and the LEFS showed a large percentage of

impairment. These were all factors that were contributing to her impairments, activity

limitations and participation restrictions, which can be seen in Appendix 1. This patient

continued to be an excellent candidate for this case report because of her previous bout of

unsuccessful PT and her consistent findings with other reports of MPS\textsuperscript{1,2,3}.

The patient received the PT diagnosis: Pattern 4D: Impaired Joint Mobility, Motor

Function, Muscle Performance, and Range of Motion Associated With Connective Tissue

Dysfunction\textsuperscript{14}. After initial examination, there was no plan to refer this patient to other

healthcare professionals, however she had a follow-up appointment with the orthopedic

surgeon in one month.

Closed-chain quadriceps strengthening and hamstring stretching would be initiated as

part of the plan of care (POC) along with hip strengthening. The patient also received a

home exercise program to continue to build quadriceps strength, build hip strength and to

stretch her hamstrings.

With conservative treatment the patient is expected to show an improvement in ROM,

strength and a reduction in pain. Bellary et al\textsuperscript{2} found that with a conservative

rehabilitative approach there was chance that symptoms will improve over time. It is

important to note that younger patients may experience a stronger response to

conservative treatments, but only when they experience a short duration of symptoms\textsuperscript{2}.

Since her initial onset of injury was four months ago, this could have affected TS and was

monitored by continual reevaluation and observation.

\textbf{INTERVENTIONS}
Coordination, Communication, Documentation

After the initial examination and evaluation were completed, a plan of care (POC) was established. The findings of the initial examination and the POC were faxed to the referring orthopedic surgeon. TS and her mother were informed of the POC and the discharge (D/C) criteria. Prior to the patient’s next appointment with the referring orthopedic surgeon, one month into the episode of care, a progress note was written to elaborate on the patient’s progress, objective measures and short-term goals.

Patient/Client-Related Instruction

The patient and her mother were educated on MPS. After education, they understood the pathogenesis, the cause of the persistent pain and the conservative methods to be used to treat the condition. The patient and her mother were instructed on a home exercise program (HEP) that would be performed once a day and was to be followed with the application of ice for 15-20 minutes. They were also educated on the POC and D/C criteria.

Procedural Interventions

Bellary et al found the first and best course of action in the management of MPS is conservative treatment. A list of interventions used each week can be found in Table 3. A descriptive list of interventions can be found in Appendix 2 as well as a list of therapeutic exercises per session in Appendix 3. The patient was seen for a total of thirteen sessions, over eight weeks. She did not miss any appointments and reported that she completed her HEP each day. Her HEP can be found in Table 4. Not listed in Table 3, are five minutes of stationary bicycling that was performed at the start of each session. This was performed to improve ROM and to build strength. The
bike provides a repetitive ROM that TS would not guard against. Once she became comfortable with the bike, it allowed for strengthening of the quadriceps in a controlled manner. With each session the patient was able to bike faster and against more resistance with less reports of pain. A change in resistance can be found in Appendix 3. The use of a recumbent or stationary bicycle was found by Griffith\(^1\) to be a beneficial way of improving quadriceps strength. Another part of the interventions not included in Table 3, but was performed every day, was hamstring stretching. (Shown in Figure 2) Tight hamstrings increase the force needed to extend the knee, which can be a source of MP irritation\(^1\). Tight hamstrings cause stress to be placed on the anterior aspect of the knee at all times, especially during hip flexion and knee extension\(^1\). This stress can cause compression to the plica and further irritation. For this reason, the patient was stretching her hamstrings at least twice a day on her own and once at each session. The patient held the stretch twice for 30 seconds.

Hip Strengthening was also included into the episode of care because impairments at the hip may impact patellofemoral mechanics in multiple planes\(^\text{15}\). These altered mechanics would result in decreased patellofemoral contact, thereby increasing stress at the joint\(^\text{15}\). As seen in Table 3, TS performed low, moderate, and advanced levels of strengthening. These exercises were performed to strengthening her L quadriceps and L hip. When treating MPS, Griffith\(^1\) stated that patients should gradually increase strength over time to overcome any strength deficit in their quadriceps mechanism. As the patient demonstrated improved strength and dynamic stability, a gradual increase in resistance, sets or repetitions was applied.
All quadriceps-strengthening exercises chosen for this patient were closed-chain exercises. These exercises were aimed at decreasing compressive forces at the knee, thereby decreasing MP irritation. In the initial three weeks of therapy, low level strengthening was used to develop quadriceps strength. Strength was built during the first two weeks, but at the first session during week 3, the patient reported an increase in pain. The pain began after she swam in the pool for a long period of time and tried to play soccer with her cousins. These open-chain activities caused an increase in compressive forces on the anterior aspect of the knee and resulted in pain.

At the end of the third week, TS had been to her primary care physician (PCP) with reports of fatigue and thirst. A complete blood test was performed showing an iron deficiency. Iron is used to produce hemoglobin, which then brings oxygen to cells. The patient began taking an iron supplement. Moderate level strengthening exercises were used during weeks two through four. Due to reports of pain during the first session of week three, no moderate level strengthening was performed to reduce irritation of the MP.

As the patient showed improved strength, dynamic stability and an increased tolerance for exercise, advanced level strengthening was included during weeks four through six. Hip strengthening was not extensively covered during the PT sessions because it was included in the HEP. The HEP and sessions consisted of straight leg raises (hip flexion and abduction) and clamshells with level two TheraBand™. As hip strength improved, these exercises were removed from her HEP and substituted with side-stepping with level 3 TheraBand™.

During week five, a re-evaluation was performed prior to the patient’s follow-up with the

*The Hygenic Corporation 1245 Home Ave Akron, OH 04431
orthopedic surgeon. At this point the patient demonstrated full L quadriceps and L hip
strength, full L knee ROM, and pain was reported to be 1/10. At this point, a
recommendation was made to continue therapy for the remaining three weeks to perform
functional rehabilitation. A dynamic warm-up and low-level functional rehabilitation
began at the end of week 5. The patient tolerated an increase in activity without
complaints of pain. During week six, only advanced level strengthening was performed
due to a concussion suffered between weeks five and six. Prior to therapy, her primary
care physician cleared her for participation in PT as long as she remained symptom free.
The patient performed all exercises in both sessions without any complaint of knee pain
or concussion like symptoms. During week seven, moderate-level functional activities
were used to mimic sport specific activity. The patient was able to stop, pivot, accelerate,
decelerate and rapidly change direction without any complaints of pain or discomfort.
The patient also reported that she was participating in soccer games in her yard, running
with her siblings and playing with her friends.
Between weeks seven and eight, the patient began to experience severe nose bleeding and
fatigue. This resulted in a trip to the emergency room, to her primary care physician and
to a rheumatologist. She reported to PT on week eight without any reports of knee pain,
full strength and ROM. The rheumatologist had instructed the patient to not perform any
physical activity until they had discovered the cause of the chronic nosebleeds and
fatigue. Since the patient had reached her short and long-term goals, she was D/C from
PT until her secondary medical condition was resolved.

OUTCOME
Table 2 shows results of the initial evaluation compared to results at D/C. Significant improvements were made in gaining 47 degrees of L knee flexion and 5 degrees of extension. Swelling at the midline of the patella, and at 5 and 10 cm below the patella was reduced by .5 centimeters. The patient demonstrated full strength (5/5) of her hip abductors, hip adductors, iliopsoas major and knee extensors. A ballotable patella test revealed no pain.

Pain, 5/5 at initial evaluation and 10/10 at its worst, was now reported to be 0-1/10 and 2/10 at its worst. The LEFS was given to the patient again and she scored a 5% (4/80) impaired compared to 76% impaired at initial evaluation. She reported participating in soccer games, playing with friends and performing all ADL’s with little to no pain, before the nose bleeding and fatigue began.

The patient met all of her goals for PT. She demonstrated full and pain free ROM of her L knee, achieved a 5/5 MMT grade for all muscles of the knee and hip, was unrestricted in gait, all ADL’s, and recreational activities with pain that was less than 2/10.

**DISCUSSION**

This case report highlights the reduction of pain and avoidance of surgery after closed-chain exercises and hamstring stretching in the case of a female adolescent with MPS. This case report, coupled with the work of Griffith, Bellary and Nigam, suggests that these therapeutic exercises may be beneficial in the conservative rehabilitation in this patient population\(^1,2,3,4\).

In the case of MPS, using closed-chain exercises and hamstring stretching could decrease force on the anterior aspect of the knee. This would allow for the plica to become less irritated, heal and prevent further irritation. It is possible that by using these conservative
interventions, we can decrease the time a patient is experiencing symptoms, return them
to full activity, and possibly prevent any future irritation and pain.

In the future, it would be beneficial to look at long-term results of adolescent females
with MPS that used closed-chain quadriceps strengthening and hamstring stretching. It
would be helpful to look to see if it is not only beneficial in relieving symptoms, but also
preventing further irritation.
REFERENCES


Table 1 Results of a systems review performed at initial evaluation.

<table>
<thead>
<tr>
<th>Systems</th>
<th>Impaired/Unimpaired</th>
<th>System Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Musculoskeletal</td>
<td>Impaired</td>
<td>Limited left knee ROM (Active) Decreased left knee strength Decreased left hip strength Left hip hike due to pain guarding</td>
</tr>
<tr>
<td>Neuromuscular</td>
<td>Unimpaired</td>
<td>N/A</td>
</tr>
<tr>
<td>Cardio Vascular Pulmonary</td>
<td>Unimpaired</td>
<td>Vital signs not taken</td>
</tr>
<tr>
<td>Integumentary</td>
<td>Impaired</td>
<td>Swelling anterior and medial to the left knee</td>
</tr>
<tr>
<td>Communication, Affect, Cognition</td>
<td>Unimpaired</td>
<td>The patient is alert and oriented x3 and learns best with pictures and demonstrations</td>
</tr>
</tbody>
</table>

ROM= range of motion, x3=person, place and time
**Figure 1 Timeline of patient’s episodes of care**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1 Month &amp; 2 Weeks</td>
<td>Initial Inj. 1st Episode of Care Begins due to lack of progress</td>
</tr>
<tr>
<td>-3 1/2 Months</td>
<td>M. Reveal. Inflammation Begins</td>
</tr>
<tr>
<td>-4 Months</td>
<td>Second Episode of Care Begins</td>
</tr>
<tr>
<td>-6 Months</td>
<td>Returned to Physical Activity, Continuing Functional Rehabilitation until Soccer Season</td>
</tr>
</tbody>
</table>

MP= Medial Plica, Time measured since onset of injury.
**Table 2 Examination Results**

<table>
<thead>
<tr>
<th>Testing</th>
<th>Results at Initial Evaluation</th>
<th>Results at D/C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goniometry</strong></td>
<td>L knee flexion= 90 degrees</td>
<td>L knee flexion= 137 degrees</td>
</tr>
<tr>
<td></td>
<td>L knee Extension= 0 degrees</td>
<td>L knee Extension= -5 degrees</td>
</tr>
<tr>
<td></td>
<td>R knee flexion= 131 degrees</td>
<td>R knee flexion= 131 degrees</td>
</tr>
<tr>
<td></td>
<td>R knee Extension= -4 degrees</td>
<td>R knee Extension= -4 degrees</td>
</tr>
<tr>
<td><strong>Edema/Circumference</strong></td>
<td>Midline of patella= 33cm</td>
<td>Midline of patella= 32.5 cm</td>
</tr>
<tr>
<td></td>
<td>5 cm below inferior pole of patella= 29.5cm</td>
<td>5 cm below inferior pole of patella= 29cm</td>
</tr>
<tr>
<td></td>
<td>10 cm below inferior pole of patella= 30.5cm</td>
<td>10 cm below inferior pole of patella= 30cm</td>
</tr>
<tr>
<td><strong>MMT</strong></td>
<td>L LE: 4/5 hip abductors, adductors, ilioptosas major, knee extensors, (rectus femoris, vastus medialis /lateralis)</td>
<td>L LE: 5/5 hip abductors, adductors, ilioptosas major, knee extensors (rectus femoris, vastus medialis /lateralis)</td>
</tr>
<tr>
<td><strong>Palpation</strong></td>
<td>Positive for the production of pain</td>
<td>Negative</td>
</tr>
<tr>
<td><strong>0-10 Pain Scale</strong></td>
<td>5/10 today</td>
<td>0-1/10 today</td>
</tr>
<tr>
<td></td>
<td>10/10 at the worst, this typically follows a period of increased activity</td>
<td>2/10 at the worst, this typically follows a period of increased activity</td>
</tr>
<tr>
<td><strong>Lower Extremity Functional Scale</strong></td>
<td>19/80, 76% impaired</td>
<td>4/80, 5% impaired</td>
</tr>
</tbody>
</table>

L=Left, R=Right, cm=centimeters, LE= Lower Extremity
<table>
<thead>
<tr>
<th>Types of Therapeutic Exercise</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Moderate-Low Level</strong> Sport Specific Functional Training</td>
<td>Standing Short-Arc Quadriceps Sets with TheraBand™</td>
<td>Standing Short-Arc Quadriceps Sets with TheraBand™</td>
<td>Standing Short-Arc Quadriceps Sets with TheraBand™</td>
<td>Standing Short-Arc Quadriceps Sets with TheraBand™</td>
<td>Standing Short-Arc Quadriceps Sets with TheraBand™</td>
<td>Standing Short-Arc Quadriceps Sets with TheraBand™</td>
</tr>
<tr>
<td></td>
<td>6-8 Inch Step-Ups and Step-Downs</td>
<td>6 Inch Step-Ups and Step-Downs</td>
<td>Quadriceps Sets</td>
<td>Quadriceps Sets</td>
<td>Heel Slides in a pain free ROM</td>
<td>Pain during the first session limited progress</td>
</tr>
<tr>
<td><strong>Low-Level</strong> Sport Specific Functional Training</td>
<td>Standing Short-Arc Quadriceps Sets with TheraBand™</td>
<td>Standing Short-Arc Quadriceps Sets with TheraBand™</td>
<td>Standing Short-Arc Quadriceps Sets with TheraBand™</td>
<td>Standing Short-Arc Quadriceps Sets with TheraBand™</td>
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<td></td>
<td>8 Inch Step-Ups and Step-Downs</td>
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<td>8 Inch Step-Ups and Step-Downs</td>
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<tr>
<td><strong>High Level</strong> Strengthening</td>
<td>Leg Press 30 lbs.</td>
<td>Single Leg Mini-Squats</td>
<td>Standing Short-Arc Quadriceps Sets with TheraBand™</td>
<td>Standing Short-Arc Quadriceps Sets with TheraBand™</td>
<td>Leg Press 50 lbs.</td>
<td>Leg Press 50 lbs.</td>
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<tr>
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<td>Single Leg Mini-Squats With TheraBand™</td>
<td>Single Leg Mini-Squats With TheraBand™</td>
<td>Single Leg Mini-Squats With TheraBand™</td>
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<td><strong>Advanced Level</strong> Strengthening</td>
<td>Single Leg Stance While Kicking Soccer Ball</td>
<td>Single Leg Stance While Kicking Soccer Ball</td>
<td>Single Leg Stance While Kicking Soccer Ball</td>
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<tr>
<td></td>
<td>Zombie Walks</td>
<td>High Knees</td>
<td>Butt Kicks</td>
<td>Skipping for height and Distance</td>
<td>Grapevine</td>
<td>Jogging</td>
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<tr>
<td><strong>Low Level</strong> Strengthening</td>
<td>Single Leg Balance While Kicking Soccer Ball</td>
<td>Single Leg Balance While Kicking Soccer Ball</td>
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<td><strong>Dynamic Exercise</strong></td>
<td>Quadriceps Sets</td>
<td>SLR Flexion and Abduction</td>
<td>Heel Slides</td>
<td>Pain during the first session limited progress</td>
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<td>Goals met, progress to functional rehabilitation</td>
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**Legend:**
- **ROM:** Range of Motion
- **lbs:** pounds

**Table 3:** Therapeutic Exercise Per Week

- **Table:** Therapeutic Exercise perform per week, ROM = Range of Motion, lbs = pounds
<table>
<thead>
<tr>
<th>Exercise</th>
<th>Sets and Repetitions</th>
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<tbody>
<tr>
<td>Quadriceps Sets</td>
<td>2 sets of 20 of Repetitions</td>
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<tr>
<td>SLR- Flexion</td>
<td>2 sets of 20 of Repetitions</td>
</tr>
<tr>
<td>SLR- Abduction</td>
<td>2 sets of 20 of Repetitions</td>
</tr>
<tr>
<td>Mini-Wall Slides with Ball Squeeze</td>
<td>2 sets of 20 of Repetitions</td>
</tr>
<tr>
<td>Clamshells (Side Lying Hip ER with TheraBand™)</td>
<td>2 sets of 20 of Repetitions</td>
</tr>
<tr>
<td>Hamstring Stretching</td>
<td>2 repetitions of 30 seconds 2 times a day</td>
</tr>
</tbody>
</table>

SLR= Straight Leg Raise, ER= External Rotation
Figure 2 Supine Hamstring Stretching
Appendix 1 ICF Impairments, Activity Limitations and Participation Restrictions

- **Impairments**
  - Decreased L knee ROM,
  - Decreased L knee strength
  - Decreased L hip strength
  - L knee inflammation

- **Activity Limitations**
  - Difficulty ambulating
  - Difficulty walking up stairs, sitting, squatting and running

- **Participation Restrictions**
  - Dress
  - Bathe
  - Get into a car and onto the school bus
  - Play soccer
  - Run track and field
  - Play with siblings or friends.
Appendix 2 Interventions

➢ Low Level Strengthening
  o Quadriceps Sets
    ▪ The patient sits supine with their leg extended, then contracts quadriceps muscles to fully extend knee.
  o SLR Flexion and Abduction
    ▪ Flexion: The patient lies supine with contralateral foot flat on the mat. The patient lifts affected leg until parallel with contralateral thigh.
    ▪ Abduction: The patient side lies and lifts top leg to about 45 degrees.
  o Clamshells
    ▪ The patient side lies with a TheraBand™ just below the knee, and then externally rotates the top leg.
  o Mini-Wall slides with Ball
    ▪ The patient stands against a wall with their feet approximately 2 feet from the wall. The patient holds a ball between their legs and performs a mini-squat while sliding down the wall.
  o Heel-Slides in a pain free Range of Motion
    ▪ The patient is supine on a table. They then draws their heel up towards them within a pain free range of motion

➢ Moderate Level Strengthening
  o Standing Short-Arc Quadriceps Sets with Level 2 TheraBand™
    ▪ The patient stands 2/3 feet from a post and faces it. A TheraBand™ is secured to the post and around the patient’s knee. The patient then fully extends the knee by contracting their quadriceps.
  o 6-8 Inch Step-Ups and Step-Downs
    ▪ Step-Ups: The patient uses the affected limb to step up unto a step and comes back to the ground, without turning around, with the unaffected limb.
    ▪ Step-Downs: The patient begins elevated on a step. They then step down with the unaffected limb. They then step back up without turning around with the affected limb.
  o Single Leg Mini-Squats
    ▪ The patient stands with support for balance. The patient the slightly bends the knee to about 30 degrees, and returns to standing.
  o Lateral Stepping With Level 2 TheraBand™
    ▪ TheraBand™ is secured around the patient’s legs just below the knee. The patient steps laterally against resistance.

➢ High Level Strengthening
  o 8 Inch Step-Ups and Step-Downs
    ▪ Step-Ups: The patient uses the affected limb to step up unto a step and comes back to the ground, without turning around, with the unaffected limb.
Step-Downs: The patient begins elevated on a step. They then step down with the unaffected limb. They then step back up without turning around with the affected limb.

- Standing Short Arc Quadriceps Sets with Level 4 TheraBand™
  - The patient stands 2/3 feet from a post and faces it. A TheraBand™ is secured to the post and around the patient’s knee. The patient then fully extends the knee by contracting their quadriceps.

- Leg Press
  - The patient sits in a leg press machine with their legs shoulder width apart. They then extend their legs against resistance and returns to starting position.

- Single Leg Mini-Squats With Level 2 TheraBand™
  - The patient holds onto a TheraBand™ with both hands that is secured below the foot. The patient the slightly bends the knee to about 30 degrees, and returns to standing.

- **Dynamic Warm-up**
  - Zombie Walks
    - Walking with straight legs, the patient holds the opposite arm straight out and elevates the leg while attempting to touch their toes.
  - High Knees
    - The patient walks while bringing their knees to their chest and providing slight overpressure.
  - Butt Kicks
    - The patient jogs and brings heels up towards their buttocks.
  - Skipping for height and Distance
  - Grapevine
    - The patient moves laterally while crisscrossing legs alternating which leg steps in front.

- Jogging

- **Low-Level Sport Specific Functional Training**
  - Single Leg Balance
  - Single Leg Stance While Kicking Soccer Ball

- **Moderate-Level Sport Specific Functional Training**
  - Single Leg Stance on Foam Pad While Kicking Soccer Ball
  - Lateral Movement to Kick Soccer Ball
    - The patient stands in an athletic position and moves to the right or leg to stop the soccer ball and return it to the passer.
  - Light Jog While Dribbling and Passing Soccer Ball
  - T-Drill
    - The patient sprints forward ten yard, side shuffles right five yards, side shuffles 10 yards to the left, five yards back to the right and the back-peddles 10 yards to the start.
Appendix 3 Interventions by Session

Week 1

- Session 1
  - Exercise Bike
    - 5 minutes, Resistance= 0
  - Hamstring Stretching
    - 2x30 seconds
- Quadriceps Sets
  - 2x30 Repetitions
- Straight Leg Raise- Abduction and Flexion
  - 2x10 Repetitions
- Mini-Wall slides with Ball
  - 2x10 Repetitions

Week 2

- Session 1
  - Exercise Bike
    - 5 minutes, Resistance
  - Hamstring Stretching
    - 2x30 seconds
  - Mini-Wall slides with Ball
    - 2x10 Repetitions
  - Standing Short-Arc Quadriceps Sets with Level 2 TheraBand™
    - 2x10 Repetitions
  - 6 Inch Step-Ups and Step-Downs
    - x10 Repetitions
- Session 2
  - Exercise Bike
    - 5 minutes, Resistance= 3
  - Hamstring Stretching
    - 2x30 seconds
  - Lateral Stepping With Level 2 TheraBand™
    - 2x20' to the left
  - Single Leg Mini-Squats
    - 2x10 Repetitions
  - 8 Inch Step-Ups and Step-Downs
    - 2x10 Repetitions

Week 3

- Session 1
  - Exercise Bike
    - 5 minutes, Resistance= 0
  - Hamstring Stretching
    - 2x30 seconds
  - Quadriceps Sets
    - x30 Repetitions
  - Straight Leg Raise- Abduction and Flexion
• x15 Repetitions

Heel-Slides in a pain free ROM

• X15 Repetitions

Session 2

Exercise Bike

• 5 minutes, Resistance= 3

Hamstring Stretching

• 2x30 seconds

Standing Short-Arc Quadriceps Sets with Level 2 TheraBand™

• 2x10 Repetitions

6 Inch Step-Ups and Step-Downs

• x10 Repetitions

Straight Leg Raise- Abduction and Flexion

• 2x10 Repetitions

Week 4

Session 1

Exercise Bike

• 5 minutes, Resistance= 4

Hamstring Stretching

• 2x30 seconds

Standing Short-Arc Quadriceps Sets with TheraBand™

• 2x20 Repetitions

8 Inch Step-Ups and Step-Downs

• 2x10 Repetitions

Single Leg Mini-Squats against level 3 TheraBand™

• 2x15 Repetitions

Leg Press

• 30 lbs. x10 Repetitions

Week 5

Session 1

Exercise Bike

• 5 minutes, Resistance= 5.5

Hamstring Stretching

• 2x30 seconds

Standing Short Arc Quadriceps Sets with TheraBand™

• 3x15 Repetitions

8 Inch Step-Ups and Step-Downs

• 2x15 Repetitions

Leg Press

• 50 lbs. 2x10 Repetitions

Single Leg Mini-Squats With Level 3 TheraBand™

• 2x15 Repetitions
Session 2

- Exercise Bike
  - 5 minutes, Resistance= 5.5
- Hamstring Stretching
  - 2x30 seconds
- Dynamic Warm-Up
  - Each Exercise 2x40’
    - Zombie Walks
    - High Knees
    - Butt Kicks
    - Skipping for height and Distance
    - Grapevine
    - Jogging
- Low-Level Sport Specific Functional Training
  - Single Leg Balance
    - 2x1 minute
  - Single Leg Stance while Kicking Soccer Ball
    - 2x30 seconds

Week 6

Session 1

- Exercise Bike
  - 5 minutes, Resistance= 5.5
- Hamstring Stretching
  - 2x30 seconds
- Standing Short Arc Quadriceps Sets with TheraBand™
  - 3x15 Repetitions
- 8 Inch Step-Ups and Step-Downs
  - 2x15 Repetitions
- Leg Press
  - 50 lbs. 2x10 Repetitions
- Single Leg Mini-Squats With Level 3 TheraBand™
  - 2x15 Repetitions

Session 2

- Exercise Bike
  - 5 minutes, Resistance= 5.5
- Hamstring Stretching
  - 2x30 seconds
- Standing Short Arc Quadriceps Sets with TheraBand™
  - 3x15 Repetitions
- 8 Inch Step-Ups and Step-Downs
  - 3x15 Repetitions
- Leg Press
  - 50 lbs. 2x10 Repetitions
- Single Leg Mini-Squats With Level 3 TheraBand™
  - 2x15 Repetitions
Week 7

Session 1
- Exercise Bike
  - 5 minutes, Resistance= 6.5
- Hamstring Stretching
  - 2x30 seconds
- Dynamic Warm-Up
  - Each Exercise 2x40’
    - Zombie Walks
    - High Knees
    - Butt Kicks
    - Skipping for height and Distance
    - Grapevine
    - Jogging
- Moderate-Level Sport Specific Functional Training
  - Single Leg Stance on Foam Pad while Kicking Soccer Ball
    - 3x1 minute
  - Lateral Movement to Kick Soccer Ball
    - 2x 3 minutes
  - Light Jog While Dribbling and Passing Soccer Ball
    - 5 minutes

Session 2
- Exercise Bike
  - 5 minutes, Resistance= 6.5
- Hamstring Stretching
  - 2x30 seconds
- Moderate-Level Sport Specific Functional Training
  - Single Leg Stance on Foam Pad while Kicking Soccer Ball
    - 3x1 minute
  - Lateral Movement to Kick Soccer Ball
    - 2x 3 minutes
  - Light Jog While Dribbling and Passing Soccer Ball
    - 5 minutes
  - T-Drill
    - x3 Repetitions
- Dynamic Warm-Up
  - Each Exercise 2x40’
    - Zombie Walks
    - High Knees
    - Butt Kicks
    - Skipping for height and Distance
    - Grapevine
    - Jogging
Week 8

Session 1

- Hamstring Stretching
  - 2x30 seconds

- Quadriceps Sets
  - x30 Repetitions

- Straight Leg Raise- Abduction and Flexion
  - x15 Repetitions

- Heel-Slides in a pain free ROM
  - X15 Repetitions