Botulinum Toxin Type A for Nonsurgical Lateral Release in Patellofemoral Pain Syndrome: A Case Study

David F. Drake, MD*; Peter E. Pidcoe, PT, DPT, PhD†; Jeff Ericksen, MD‡

ABSTRACT
Setting: Outpatient rehabilitation clinic. Patient: A 37-year-old physically active male. Case Description: The patient presented with anterior left knee pain, exacerbated when climbing stairs, sitting, and running. Exam showed lateral tracking patellae and palpable crepitus. One hundred fifty units of botulinum toxin A was injected into his left vastus lateralis. He underwent a 12-week home exercise program targeting the vastus medialis (VM). Assessment/Results: Visual analog scale decreased from 70 to 0 on a 150-mm scale, from initial until 8 weeks postinjection. Functional Index Questionnaire increased from 5 to 16 over the same period. Knee torque and surface electromyography findings showed increased activity of the VM during knee extension. Conclusion: Botulinum injection into the vastus lateralis in conjunction with VM strengthening may provide more effective treatment of patellofemoral pain syndrome. Further study is needed to explore this novel treatment of patellofemoral pain syndrome.

INTRODUCTION
Patellofemoral pain syndrome (PFPS) is the leading cause of knee pain in patients under the age of 45.1 PFPS can be defined as retropatellar or peripatellar pain that is often bilateral and aggravated by lower extremity activities, especially climbing stairs, squatting, and prolonged sitting.2 The causes of PFPS are multifactorial and have been hypothesized to include tightness of the iliotibial band, hamstring, hip muscles, or gastrocnemius, over pronation of the foot, and muscular imbalance of the vastus medialis obliquus (VMO) and the vastus lateralis (VL). These are thought to cause the patella to track laterally in the femoral groove, which, after years of symptoms may result in chondromalacia patella.3 Surface electromyographic (sEMG) studies show that patients with PFPS have delayed contraction of the VMO as compared to the VL and decreased sEMG activity of the VMO during concentric and eccentric knee extension.4–6 PFPS has been treated with a variety of rehabilitation strategies; however, there is limited evidence to support the use of patellofemoral orthoses, acupuncture, low-level laser, chiropractic patellar mobilization, or patellar taping in the treatment of PFPS.7–11 There is some evidence to support strengthening of the quadriceps and, in particular, VMO retraining, which specifically has been shown to reduce the symptoms of PFPS.12 Botulinum toxin has been used to decrease spasticity in patients with different neurologic disorders, but the injection of botulinum toxin into a muscle to allow that muscle’s agonist or antagonist to be focally strengthening, thus overcoming muscle imbalance, has not been studied. We hypothesized that the use of intramuscular botulinum toxin to correct the muscular imbalance seen in patellofemoral syndrome (lateral > medial forces on patella) would decrease knee pain.

THE PATIENT
A 37-year-old male who was very active having completed 2 marathons, numerous half marathons, and 150-mile bike rides reported a decrease in his activity because of knee pain. He presented with greater than a 3 month history of anterior knee pain, worse when climbing stairs, sitting with knee bent for a prolonged period, and running. His concern was that he was having pain when running and even walking and had to decrease his weekly mileage at a time when he wanted to start training for his first triathlon. Past medical history was significant for a sprained right ankle while in high school, but he had not had any prior knee trauma or any surgery in his lower extremities. Physical examination revealed a well developed, well conditioned male who had no focal deficits except for what appeared to be lateral tracking patella bilaterally with grade 2 crepitus in the left knee (Table I) and grade 1 crepitus in the right knee. He had no ligamentous laxity or joint line tenderness in either of his knees. Radiographs were normal (Fig. 1).

METHOD
Quantification of the level of pain at its worst during any activity was carried out using the visual analog scale (VAS) from 0 to 150 mm. The functional index questionnaire (FIQ) was used to measure the patient’s perceived functional level. The questionnaire consists of 8 activities that the patient rated from 0 to 2 from unable to perform to performing without difficulty. The FIQ (Table II) and VAS were shown in a previous study to be good discriminators of clinical change in PFPS.2 Three consecutive days of measurements were obtained and averaged to capture potential day-to-day variation. sEMG in conjunction with torque measures of concentric knee extension were used to evaluate VMO and VL activity as well as the force of active knee extension.13

After 4 weeks of treatment consisting of a 20% reduction in running and biking mileage, increased swimming activity, ice to the knees before and after activity, and nonsteroidal...
antiinflammatory drugs, there was no improvement in pain severity as measured by a 0 to 150 mm VAS or FIQ score.

The left VL was injected with 150 units of botulinum toxin A in divided doses along the length of the muscle using surface anatomy localization as the left knee was more symptomatic. He performed a 12-week home exercise program on both lower limbs, 3 times a week, consisting of short arc squats from 0 to 60 degrees, wall sits with the feet externally rotated, and stretching of the iliobibial band, quadriceps, adductors, hamstrings, and glutei. He was allowed to advance his running, biking, and swimming as tolerated. VAS and FIQ measurements were obtained at intervals before and after injection.

sEMG with maximal voluntary isometric contraction of knee extension at 45° with torque measured using a dynamometer was obtained at 0, 3, 7, and 15 weeks postinjection. Rate of fatigue was estimated using the median frequency of each power spectrum and linear regression to determine a slope as an index of fatigue. The fatigue protocol required that the subject produce a sustained isometric knee extension contraction at 45° of knee flexion with EMG data collected from the VL and VMO muscles. Fatigue estimates were computed using a 1024-point window that was progressed through the data using a half-overlap method. Each data window was convolved with a Hamming window to decrease edge effects and then transformed into frequency domain data via an FFT method. The median frequency of each power spectrum was determined by bisecting the area under the curve. These median frequencies were fit with a linear regression. The slope was recorded as an index of fatigue (higher negative slopes indicate increased fatigue rate). Torque data was collected from isometric maximal voluntary contraction knee extension at 45° for a period of 5 seconds.

**RESULTS**

Within the first week after the injection the patient noticed a change in the way his quadriceps looked, noting defects in the muscle (Fig. 2). He also noted initially that his left VL was very sore. About 4 weeks later, this decreased and there was

**TABLE I.** Knee Crepitus Scale (Measured During Active Knee Extension)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Palpable Crepitus Through 1/3 of Knee ROM</td>
</tr>
<tr>
<td>2</td>
<td>Palpable Crepitus Through 2/3 of Knee ROM</td>
</tr>
<tr>
<td>3</td>
<td>Palpable Crepitus Through Greater Than 2/3 Knee ROM</td>
</tr>
<tr>
<td>4</td>
<td>Audible Crepitus</td>
</tr>
</tbody>
</table>

**FIGURE 1.** Radiographs of the knee.

**FIGURE 2.** Note small divot in left vastus medialis (VM) which the patient identified.

**TABLE II.** Functional Index Questionnaire (FIQ)

The following information is to be recorded at approximately the same time each day preferably at bedtime. Put a check mark in the column that best describes the way you feel. Please complete the following:

Today, did you have any problem or discomfort in your _____ knee at all with the following activities?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Unable to Do</th>
<th>Can do with Problem</th>
<th>No Problem</th>
<th>Unknown</th>
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</thead>
<tbody>
<tr>
<td>1. walking as far as a mile</td>
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<tr>
<td>2. climbing up 2 flights of stairs (16 steps)</td>
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<td>3. squatting</td>
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<tr>
<td>4. kneeling</td>
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</tr>
<tr>
<td>5. sitting for prolonged periods with your knees bent in one position</td>
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<td>(</td>
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<tr>
<td>6. climbing up 4 flights of stairs (32 steps)</td>
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<tr>
<td>7. running a short distance, say 100 meters (about the length of a football field)</td>
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<tr>
<td>8. walking a short distance (about a city block)</td>
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Each question is scored from 0-2 (unable to do – no problem). Questions in which participants answer "unknown" (i.e., not applicable) are not included in the data analysis. Adapted from: Harrison E, Quinney H, Magee D, Sheppard MS, McQuarrie A. Analysis of outcome measures used in the study of patellofemoral pain syndrome. Physiother Can 1995; 47(4): 264–72.
only soreness noted in the VM. The left knee VAS decreased from 70 to 0 on a 150-mm scale, although the right knee VAS did not change significantly, dropping from 48 to 32 on a 150-mm scale. Left knee FIQ reflects functional improvement with an increase from 5 to 16.

The fatigue estimates using surface EMG and sustained knee extension showed that in the left VMO there was increased rate of fatigue following injection of botulinum with recovery by week 7 and improvement beyond baseline by week 15. Fatigue data for the left VL showed increased fatigue rate through week 7 with some recovery by week 15. Torque production decreased following botulinum injection through week 7 and subsequently increased to greater than baseline levels by week 15.

DISCUSSION
Improper tracking of the patella in the femoral groove because of muscle imbalance between the opposing forces of the VM and VL has traditionally been thought to be one of the major causes of PFPS. Recent sEMG studies have shown both a low VMO to VL strength ratio and altered vastii recruitment in PFPS patients. As conservative treatment was not improving our patient’s symptoms, he was selected for this intervention.

By injecting the botulinum toxin into the VLO, we selectively weakened the VL, thus allowing a more focused strengthening of the VM. A stronger VM leads to greater medial forces on the patella, thus improving patellar mechanics with a subsequent decrease in retropatellar pain and other symptoms associated with PFPS.

With the increased load on the left VMO after weakening the VL, there is initially a greater fatigue rate. With focused strengthening, the rate of fatigue is already below the pre-injection or time 0 value by week 7 and continues to decline through week 15. The left knee sEMG and torque data support the assertion that the VMO was focally strengthened with torque at maximal voluntary isometric contraction, increasing beyond baseline at week 15 with VMO rate of fatigue decreasing below baseline and VL rate continuing to be elevated secondary to the continued effects of the botulinum. The increase in left VL fatigue rate through week 7 with some return by week 15 is consistent with the pharmacological duration of action of botulinum toxin A.

The FIQ and VAS improvement by week 8 possibly reflects the improved patella mechanics with a stronger VMO through strengthening exercises and a relatively weaker VL because of the continued effects of the botulinum. The torque data also supports the assertion that the VMO was focally strengthened with torque at maximum voluntary contraction increased beyond baseline at week 15 although at the same time point the VMO rate of fatigue is below baseline and VL rate continues to be above baseline.

In this patient, botulinum toxin was safe and effective for the treatment of patellofemoral pain. Side effects need to be considered before injection. The prominent side effects at this low dose (1.7u/kg) include allergy (rash, hives, itching, difficulty breathing), weakness, and pain.16 The lethal dose 50 has been reported at 39 unit/kg.17 This very active male had symptomatic relief of his PFPS with the use of botulinum toxin A injection. His symptoms improved and he completed his first triathlon and has since continued training for further triathlons. The active exercise alone may have improved his symptoms over time, but the botulinum toxin injections may have allowed a more rapid return to full activity.

Clearly, botulinum toxin type A is not the treatment for all cases of PFPS but consideration should be given to the use of neurotoxins in problems when a muscle imbalance is appreciated. Although further studies are needed to evaluate the use of botulinum toxin in the treatment of PFPS, this report proposes a practical guideline for the assessment and treatment of PFPS in patients with VM:VL weakness.

REFERENCES