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Effect of Electrical Stimulation to the Vastus Medialis Muscle in a Patient with Chronically Dislocating Patellae

A Case Report

RICHARD W. BOHANNON

Key Words: Dislocation, Electric stimulation, Muscle contraction, Patella.

Lateral subluxation and dislocation of the patella have been attributed to a number of different anatomical and functional abnormalities. These abnormalities include an increase in the “Q” angle above 15 degrees, a high-riding patella (patella alta), an external tibial torsion, a lateral insertion of the patellar tendon, a tilted patella, a low lateral femoral condyle, and a hypoplasia of the vastus medialis muscle. Regardless of the abnormality, however, conservative treatment is generally directed toward strengthening the quadriceps mechanism by resistive exercise. Although the quadriceps mechanisms of individuals with patellar problems have been found to generate less knee extension torque than healthy individuals, quadriceps femoris muscle strengthening may be accompanied by complications. Even when performed with EMG feedback, resistive exercise may lead to further augmentation of the lateral vector of the quadriceps femoris muscle force. Such an augmentation could conceivably increase the tendency of the patella to sublux or dislocate laterally. Investigators have reported that training with electrical stimulation results in increased isokinetic knee extension torque, and this technique, unlike resistance exercise, may allow truly selective training of the vastus medialis muscle.

This muscle, which has been shown to be mechanically capable of keeping the patella centered in the femoral groove in amputated lower limbs, may be able to prevent lateral subluxation and dislocation of the patella during voluntary or involuntary contractions. The purpose of this case report is to describe the effect of electrical stimulation on the vastus medialis muscle of a patient with a history of a bilaterally dislocating patella. The effect of electrical stimulation on patellar dislocation was assessed during and after its application.

PATIENT DATA

The patient was a 29-year-old man who reported that both his patellae had been dislocating since he was 8 years old. He reported that dislocation could happen at any time but usually occurred while he was walking, standing, or in the process of standing up. Before the initiation of the treatment, the patient had surgery on his right knee to prevent further subluxation and dislocation of that patella. The patient indicated that his left patella continued to dislocate 30 or more times a day, and that neither resistance exercise nor a patellar stabilization brace had proved successful in altering this tendency. His left patella would dislocate with every maximal contraction of the quadriceps mechanism when the knee was within 15 degrees of full extension and with only slight laterally directed pressure when the quadriceps femoris muscle was relaxed. The patient demonstrated the following factors associated with subluxing patellae: a low lateral femoral condyle, a “Q” angle of 20 degrees, and a tilted patella. His peak knee extension torque on the left (at 30°/sec) was 107 Nm. This torque is substantially less than but within 1.5 standard deviations of the normal value of 148.7 ± 32.2 Nm reported by Goslin and Charteris.

Unique Features of the Problem

Because the left patella dislocated during every maximal contraction of the quadriceps mechanism when the knee was at or near full extension, and because a specific assessment tool was available, a unique opportunity existed to determine the effect of electrical stimulation on the incidence of patellar dislocation during quadriceps femoris muscle contraction. Any consistent deviation from patellar dislocation during quadriceps femoris muscle setting

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demonstrated an effect of the electrical stimulation. A hand-held dynamometer* monitored the lateral displacement force of the quadriceps femoris muscle on the patella during maximal voluntary contractions.

PHYSICAL THERAPY PLAN

The patient received two to three hours of electrical stimulation to the left vastus medialis muscle four to five days a week for six weeks. A Respond®† neuromuscular stimulator was used. Stimulation was applied at a rate of 30–35 c/sec with an on-time of 10 seconds, an off-time of 20 seconds, and rise time of 2 seconds. The active electrode (3.0-cm diameter) was placed, and its position marked, over the vastus medialis muscle about 8.0-cm proximal to the superior aspect of the patella. The dispersive electrode (4.0 × 5.0 cm) was placed just proximal to the tibiofemoral joint line medial to the patella (Fig. 1). Both electrodes were carbon rubber. The stimulator was adjusted to the highest intensity the patient could tolerate. This intensity was adequate to make the vastus medialis muscle firm to palpation and to cause an obvious medial movement and counter-tilt of the patella when the patient relaxed his quadriceps femoris muscle. Electrical stimulation was the only treatment applied to the left lower extremity.

On each treatment day, the electrodes were properly positioned and the intensity of the stimulator was adjusted to the maximum tolerable level. To assess the capacity of electrical stimulation to prevent patellar dislocation, the patient performed several maximum voluntary contractions of the left quadriceps femoris muscle with the knee fully extended.

The Chatillon push-pull gauge was used at initial testing and at two, four, and six weeks to take five measurements of the lateral displacement force on the patella during maximum voluntary quadriceps femoris muscle setting with the knee in full extension; electrical stimulation was not applied during this test. Figure 2 shows a measurement with the Chatillon push-pull gauge. These measurements indicated whether changes were occurring in the lateral displacement force on the patella—a change that would be consistent with selective strengthening of the vastus medialis muscle. The mean of the five force measurements was recorded.

RESULTS

On every treatment day, maximal voluntary contractions of the left quadriceps mechanism did not result in patellar dislocation. Therefore, the patient demonstrated on more than 75 occasions that electrical stimulation of the vastus medialis muscle can prevent patellar dislocation during its application.

The residual effects of electrical stimulation were not so positive. The patella vigorously pulled laterally during quadriceps femoris muscle setting. Before treatment, the push-pull gauge measured the lateral displacement force during the muscle setting as 53 N. This force was 51, 47, and 53 N after two, four, and six weeks of treatment, respectively. The left patella continued to dislocate regularly during functional activities when the electrical stimulator was not in use.

DISCUSSION

The consistency with which electrical stimulation of the vastus medialis muscle prevented patellar dislocation during quadriceps femoris muscle setting demonstrated the positive effect of the stimulation during treatment. Lateral displacement force on the patella during maximal voluntary quadriceps femoris muscle contraction was more than 46 N. The electrical

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stimulation may have prevented patellar subluxation by creating an equal and opposite medial force in the vastus medialis muscle or by reducing the lateral force in the other quadriceps femoris muscle components or both. Although knee extension force was not measured during muscle setting in full knee extension, the patient gave no indication of limiting his effort during stimulation. The capacity of neuromuscular stimulation to prevent patellar dislocation during its application raises the possibility of using such stimulation as an electrophysiological orthosis. Such orthoses, which have been used successfully in hemiplegic patients, may have a place in treating patients with chronically subluxing or dislocating patellae. By incorporating a foot-switch trigger, the stimulator might be adjusted to fire at heel strike—the time during gait when quadriceps femoris muscle activity is greatest. The unavailability of such a switch during the period of this patient’s treatment prevented testing the stimulator as an orthosis during gait.

The initial reduction in the lateral patellar dislocating forces (second and fourth weeks) during contraction of the quadriceps femoris mechanism was not present the sixth week. Had the reduction continued, a case could possibly have been made for the presence of selective strengthening of the vastus medialis muscle. Although measurement of the lateral displacement force of the patella is a practical method for documenting treatment effect, these measurements did not demonstrate such an effect. Because increases in muscle strength resulting from electrical stimulation are probably the result of hypertrophy rather than learning, and because increases in strength resulting from hypertrophy probably occur after three to five weeks of training, changes in patellar lateral displacement force (secondary to vastus medialis muscle strengthening) might be more likely after a longer training program than is reported in this article. The treatment described might therefore merit testing over a longer period of time on a larger sample of patients with hypermobile patellae. The approach described in this article for measuring the lateral displacement force on the patella could be an integral part of such testing.

SUMMARY

Electrical stimulation to the vastus medialis muscle of a patient with chronically subluxing patellae prevented dislocation of the left patella during its application. No effect could be demonstrated while the stimulator was off. Other clinicians may, nonetheless, wish to adopt the method described in this article for assessing the efficacy of electrical stimulation on patellar dislocation, both while stimulation is applied and while it is not applied.

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