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Comparative efficacy of short arc quadriceps exercise with and without EMG biofeedback in reducing pain and strengthening Vastus Medialis Obliques (VMO) in patients with patellofemoral dysfunction

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Abstract
The aim of the study was to compare the efficacy of Short Arc Quadriceps Exercise With and Without EMG Biofeedback in Patients with Patellofemoral Dysfunction.

Patellofemoral joint disorder and pain syndrome are one of the most common musculoskeletal pathologies treated by the orthopedic and sport medicine clinicians; yet the success rate of nonoperative therapy varies significantly. McConnell reports one in four of the general population have patellofemoral pain. Conservative treatment of patellofemoral pain syndrome is focused on restoring normal patellar tracking by improving dynamic stability of particular interest to the clinicians has been the vastus medial is oblique [VMO], it has been implicated as the primary medial stabilizer of the patella. [7].Short arc quadriceps exercises strengthen the VMO which helps in restoring normal patellar tracking. EMG biofeedback can be given to reinforce muscle contraction.

Biofeedback may be useful as an adjunct to conventional therapy. Biofeedback may be useful for re-education of muscle· So this study aims to compare the efficacy of short arc quadriceps exercises with and without EMG biofeedback in strengthening VMO and reducing pain in patient with patellofemoral dysfunction. Thirty patients with patellofemoral pain syndrome were randomly placed into 2 groups: Group A (*n* _ 15) and a Group B (*n* _ 15). Group A received short arc Quadriceps exercises along with Electromyographic biofeedback whereas the Group B received only short arc quadriceps exercise for a duration of 6 weeks. VMO strength were assessed by Electronic dynamometer and Pain by a visual analog scale(VAS) on first day and after 6 weeks of intervention. VMO strength improved significantly compared with the pre-treatment values in both groups. Mean VMO strength values in the experimental group, were significantly higher than those of the control group. Significant improvements in VAS score were seen in both groups, but Mean VAS score showed no differences between the groups. The study demonstrated that there was a significant increase of VMO strength with EMG biofeedback but the reduction of pain was similar in both groups. EMG biofeedback can be used as an adjunct in improving VMO strength in patients with patella-femoral dysfunction.

Keywords: patellofemoral pain syndrome; electromyographic (EMG) biofeedback; anterior knee pain; pain measurement

Introduction
Patellofemoral joint disorder and pain syndrome are one of the most common musculoskeletal pathologies treated by the orthopedic and sport medicine clinicians; yet the success rate of non-operative therapy varies significantly [1].

McConnell reports one in four of the general population have patellofemoral pain [2-]. The patient complains of the retropatellar or peripatellar pain [mainly medial side] precipitated by prolong sitting [movie-goer's sign] and the pain is proportional to the activity, particularly evident when squatting or descending stairs. Generally, onset is insidious and progression is slow. Patellar grind is positive and the patient complains of discomfort on palpation of the medial and lateral borders of the patella. Giving way and instability is also common [2].

Conservative treatment of patellofemoral pain syndrome is focused on restoring normal patellar tracking by improving dynamic stability of particular interest to the clinicians has been the vastus medialis oblique [VMO],

it has been implicated as the primary medial stabilizer of the patella [3]. The distal fibers of the VMO are angled at approximately 55^0 from longitudinal axis of the femur, making this portion of the muscle suited to prevent lateral subluxation of the patella [4]. Short arc quadriceps exercises strengthen the VMO which helps in restoring normal patellar tracking. The short arc quad (SAQ) exercises have a significant overall activation of the VMO and VL muscles than the straight leg raise (SLR) exercises [5].

Biofeedback is a specialized form of feedback that provides information directly to a patient about internal biological mechanisms via some sophisticated electronic devices[6]. John Basmajain quoted that biofeedback is "the technique of using equipment [usually electronic] to reveal to human being some of their internal physiological events, normal and abnormal, in the form of visual and auditory signals in order to teach them to manipulate these otherwise involuntary or unfelt events by manipulating the displaced signals [6].

Biofeedback is simply one –technique that therapist may employ to convey their message about motor programs and biomechanical schemata to the patient. Biofeedback can assist rehabilitation process by [6].

- Providing a clear treatment outcome or goal for the patient to accomplish
- Permitting the therapist and patient to experiment with various strategies [process] that generate motor pattern to achieve the desired outcome or goal.
- Reinforcing appropriate motor behavior.

EMG studies of the non-painful knee show that the ratio of VMO to vastus lateralis [VL] activity is 1:1 and that the VMO activity is tonic in nature [7, 8].In knees with patellofemoral pain VMO: VL activity becomes phasic in nature [9].

Fox stated that vastus medialis is phylogenetically the weakest of the quadriceps group; it appears to be the first muscle to lose strength and mass with inactivity and the last to rehabilitate [10].

EMG biofeedback can be given to reinforce VMO contraction [11]. Biofeedback may be useful as an adjunct to conventional therapy. Biofeedback may be useful for re-education of muscle; using EMG monitoring, visual or auditory signals are provided to the patient when preset threshold of the muscle activity is achieved. Threshold can be modified as the patient progress. Through the use of positive "reward", biofeedback encourages muscle contraction, which is beneficial during strength training. It can provide improved timing of muscle activation, which in turn benefits dynamic stabilization of the knee [12].

So this study aims to compare the efficacy of short arc quadriceps exercises with and without EMG biofeedback in strengthening VMO and reducing pain in patient with patellofemoral dysfunction

Methodology

The total number of 30 Patellofemoral pain syndrome subjects [13 males and 17 females] aged between 18 to 45 years were selected for the study, according to the following criteria:

1. A diagnosis of unilateral patellofemoral pain syndrome based on the subject having at least 5 of the 7 following Symptoms. a) A positive apprehension test. b) Patella joint crepitus elicited on palpation of extended knee or when the knee is flexed. c) Retro patella aching pain after activities such as climbing and descending more than 10 stairs, or sitting or driving with knees flexed to 90° for more than 15 minutes. d) Quadriceps atrophy of.635cm or more when compared with the uninvolved thigh, as measured by a cloth tape measure placed 12.7cm from the medial tibial plateau. e) The knee gives way on stepping down twice within the last 12 months—not to be confused with sudden locking or giving away that occurs with meniscal injuries. f) Patella facet sensitivity. g) Retro patella pain for a minimum of 10 days but not longer than 48 months
2. no evidence of other intra- or extra-articular knee pathologies, determined by physical examination and radiographic evaluation; (3) normal range-of-motion values of the knee, as measured by a goniometer; (4) no history of knee trauma, intra-articular injection therapy, or surgery; and (5) no use of nonsteroid anti-inflammatory drugs within 15 days before treatment began.

Written informed consent was obtained from all patients after the study procedures were explained. Patients were randomized to Group A and Group B, each consisting of 15 patients. Group A received short arc quadriceps exercise with EMG biofeedback and Group B received short arc quadriceps Exercise without EMG biofeedback. Muscle strength was assessed by electronic dynamometer and pain was assessed by VAS scale [Visual analog scale]. Muscle strength and pain were assessed on 1^{st} day and at the end of 6^{th} week of treatment.

Procedure: Assessment of VMO Muscle strength using Electronic dynamometer:

VMO Strength was measured using electronic dynamometer. Electronic dynamometer is connected EMG biofeedback equipment [ECLI-Phenix USB 8] through captor ports.one hook of Electronic dynamometer is mounted to floor and other is tied to single sling. Subjects sat upright a test chair. A sling is placed over the lower leg. The quadriceps strength was measured using isometric "make" test. The subjects were asked to build force to maximum over a 2-second of period and maintain the maximum effort for approximately 5 seconds and value in kgs displayed on the computer was noted. Three trials are done and average value was taken.

EMG biofeedback

ECLI-Phenix USB 8 Biofeedback device was utilized for the study

Skin preparation:

Proper skin preparation will remove oils, dead skin cells and excess hair from the epidermis, thereby reducing potentially high impedance sources during recording session. If not removed; these elements will attenuate the EMG signals and may lead to increase noise levels [13].

Technique includes:

- Alcohol rub.
- Rub with slightly abrasive electrolytic paste.
- Dry skin shaving parallel to the direction of hair growth.

Electrode placement

A measurement is taken from anterior superior iliac spine [ASIS] to medial side of the knee joint. Then, $1/5^{th}$ of measurement is taken from medial joint line on the muscle bulk [VMO-vastus medialis obliques] and is marked by a marker and surface electrode is placed at an inclination degrees.

Exercises protocol

Group A – received short arc quadriceps exercises with EMG biofeedback.

Group B - received short arc quadriceps exercises without EMG biofeedback.

Short arc quadriceps exercises

Patient is positioned in long sitting with a towel under the knee to support it in flexion. Patient is instructed to extend the knee against the resistance of the rolled towel. Then hold for 6 second with 20 sec of rest period [14].

Treatment time: 30 minutes.

Number of repetition: 5 repetitions in 5 sets with 5 minutes of rest period.

Duration of the treatment: 6weeks.

Results

Statistical Analysis

Demographic results were descriptive and expressed as mean standard deviation (SD). Unpaired *t* test was used to compare the VMO Strength and the VAS between the groups. The significance level was set at *p* -.05.

Table 1: Sex distribution

Sex	Experimental group	Control group
Male	7 (46.7)	6 (40.0)
Female	8 (53.3)	9 (60.0)
Total	15 (100.0)	15(100.0)

Table 2: Age Distribution

Age group in years	Experimental group (n=15)	Control group (n=15)
≤ 20	3 (20.0)	3(20.0)
21-25	4 (26.7)	3 (20.0)
26-30	3 (20.0)	5 (33.3)
31-35	3 (20.0)	2 (13.3)
>35	2 (13.3)	2(13.3)
Mean age	27.67 ± 6.97	27.60 ± 6.35

Table 3: Comparison of VMO [vastus medialis obliques strength] between Group A and Group B.

VMO Strength	Group A		Group B	
	Mean	SD	Mean	SD
Pre	11.47	1.19	11.40	1.35
Post	15.33	1.15	12.40	1.38
Significance	Student t=72.744 P<0.001		Student t=16.846 P<0.001	
Effect of treatment by Cohen's Effect size	3.24 Very Large Effect		0.73 Moderate effect	

Table 4: Comparison of pain value measured by VAS between Group A and Group B

VAS	Group A		Group B	
	Pre	Post	Pre	Post
Minimum	4	1	4	1
Maximum	7	3	7	3
Mean	5.73	1.67	5.67	1.40
SD	0.79	0.61	0.82	0.63
Significance	P=0.001		P=0.001	
Inference	Significantly improved		Significantly Improved	

Discussion

Biofeedback is a therapeutic procedure that uses electronic or electromechanical instruments to measure, process, and feed back to patients, in the form of auditive and/or visual feedback signals, information about their normal and/or abnormal neuromuscular and autonomic activity. Biofeedback treatment is used to help patients develop greater awareness of, and an increase in, voluntary control over their physiologic processes that are otherwise involuntary and unfelt.

EMG biofeedback on VMO Muscle strength:

In this study, the VMO [vastus medialis obliques] strength in biofeedback group showed significant increase than control group

The improvement can be attributed for the following reason:

- Boucher [15]. *et al.* suggested that patellofemoral pain syndrome is associated with a depressed vastus medialis obliques/vastus lateralis ratio of integrated electromyography. This means that a neuromuscular component is added to the syndrome, as revealed relatively to the vastus medialis oblique relative to vastus lateralis. The imbalance between the between the vastus medialis and vastus lateralis can lead to further maltracking and subluxation. If this happens, an important goal of conservative treatment in patellofemoral pain syndrome must be to increase the medial force acting on the patella by selectively training of the vastus medialis obliques. The rehabilitation strategy should include a neuromuscular management, such as electromyographic [EMG] biofeedback, which may help in the learning process of muscular control and help to provide better patellofemoral stability.
- Biofeedback may have contributed to the increased force by motor unit recruitment or by increasing firing rates in the active motor units pools. Basmajain noted that, by the help of visual signals, patients could control the recruitment as well as the frequency of discharge of motor units, which could produce a greater amount of tension [16].
- Using EMG monitoring, visual signals are provided to the patient when preset threshold of the muscle activity is achieved. Threshold can be modified as the patient progress. Through the use of positive "reward", biofeedback encourages muscle contraction, which is beneficial during strength training. It can provide improved timing of muscle activation, which in turn benefits dynamic stabilization of the knee
- While exercises with EMG biofeedback helps to strengthen VMO. Strengthening of VMO helps in realigning the patella medially there by preventing lateral tracking of patella.
- EMG biofeedback helps in the learning process of

muscular control and helps to provide better patellofemoral stability. Thus, the critical balance between the vastus medialis obliques and vastus lateralis may be better restored. The peak torque produced by the quadriceps femoris muscle could be significantly increased when electromyographic biofeedback is added to isometric contraction.

- Reinforcing appropriate motor behavior
- Provides a clear treatment outcome or goal for the patient to accomplish.

Therefore, EMG biofeedback can be used for strengthening vastus medialis oblique [VMO], which helps medially stabilizing the patella thereby preventing lateral tracki patella.

EMG biofeedback on pain

There was a significant decrease in mean visual analog scale [VAS] score in both groups, but the reduction of pain were similar in both group.

EMG biofeedback is used as an adjunct device and not as treatment in its own right. Dursun N **[17].** *et al.* in his study found the scores of VAS in the patients receiving electromyographic biofeedback were similar to the VAS scores of patients who received conventional therapy.

Short arc exercises without EMG biofeedback on muscle strength and pain

In this study Group B were treated with short arc quadriceps exercise without EMG biofeedback. There was no significant increase in the VMO strength. This is because there was no feedback about exercises performances to the patient, where as in EMG biofeedback there was a feedback which helped the patient to learn the process of motor control to provided better patellofemoral stability.

Conclusion

The implications of EMG biofeedback along with physical therapy have brought about a picture of giving a significant increase in VMO [vastus medialis obliques] strengthening in patients with patellofemoral pain syndrome. Short arc quadriceps with EMG biofeedback realign patella by improving strength of VMO [vastus medialis obliques], which is one of causative factors of patellofemoral pain syndrome [PFPS]. EMG biofeedback is used in the treatment of patellofemoral dysfunction to strengthen vastus medialis oblique [VMO] with an intent to shift the patella in to more optimal position of biomechanical alignment. Although the vastus medialis of the biofeedback group showed extra strengthening, it appeared to have no effect on the pain.

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