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Original Article

A new isometric quadriceps-strengthening exercise using EMG-biofeedback

Cumhur C Kesemenli[1*], Hakan Sarman[2*], Tuncay Baran[1], Kaya Memisoglu[1], Ismail Binbir[3], Yilmaz Savas[4], Cengiz Isik[2], Ismail Boyraz[5], Bunyamin Koc[5]

[1]Department of Orthopedics and Traumatology, Kocaeli University School of Medicine, Kocaeli, Turkey; [2]Department of Orthopedics and Traumatology, Abant Izzet Baysal University School of Medicine, Bolu, Turkey; [3]Department of Physical Medicine and Rehabilitation, Golcuk Necati Celik State Hospital, Kocaeli, Turkey; [4]Department of Physical Medicine and Rehabilitation, Çanakkale Onsekiz Mart University School of Medicine, Çanakkale, Turkey; [5]Department of Physical Medicine and Rehabilitation, Abant Izzet Baysal University School of Medicine, Bolu, Turkey. [*]Equal contributors.

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Abstract: A new isometric contraction quadriceps-strengthening exercise was developed to restore the quadriceps strength lost after knee surgery more rapidly. This study evaluated the results of this new method. Patients were taught to perform the isometric quadriceps-strengthening exercise in the unaffected knee in the supine position, and then they performed it in the affected knee. First, patients were taught the classical isometric quadriceps-strengthening exercise, and then they were taught our new alternative method: "pull the patella superiorly tightly and hold the leg in the same position for 10 seconds". Afterward, the quadriceps contraction was evaluated using a non-invasive Myomed 932 EMG-biofeedback device (Enraf-Nonius, The Netherlands) with gel-containing 48 mm electrodes (Türklab, The Turkey) placed on both knees. The isometric quadriceps-strengthening exercise performed using our new method had stronger contraction than the classical method ($P < 0.01$). The new method involving pulling the patella superiorly appears to be a better choice, which can be applied easily, leading to better patient compliance and greater quadriceps force after arthroscopic and other knee surgeries.

Keywords: EMG biofeedback, quadriceps, strengthening, exercise

Introduction

Typically, physical therapy after knee surgery involves open and closed kinetic chain exercises, concentric, eccentric, and isometric contractions, and quadriceps-strengthening exercises [1-3]. However, no recent advances in these exercises have been reported [1-4]. The exercise method should be individualized based on the type of surgery, level of physical activity, and mentality [4-9]. It is recommended that quadriceps-strengthening exercises be started preoperatively and continued postoperatively to attain adequate quadriceps strength [2, 4]. The classical isometric contraction quadriceps-strengthening exercise involves "pressing the back of the knee downward through the bed, and holding the leg in the same position for 10 seconds" (**Figure 1**) [2, 4, 10-13]. However, it is difficult to understand how this method might be applied to isometric strengthening [4, 10-13]. Therefore, we proposed an alternative isometric quadriceps-strengthening exercise.

We hypothesized that greater isometric contraction strength in the quadriceps could be achieved by teaching patients to pull their patella superiorly first. This study evaluated the results of this new isometric contraction quadriceps-strengthening exercise.

Materials and methods

Patients

Thirteen patients (11 males, 2 females) who had knee surgery in University Hospital were included in the study. The mean patient age was 30 (range 15-57) years. All of the patients underwent arthroscopic anterior cruciate liga-

Figure 1. Classic method is showed isometric contraction quadriceps strengthening exercise. F: Femur, Cr: Cruris.

Figure 2. Electrodes were showed place on the parts of quadriceps muscle.

ment reconstruction with a hamstring autograft on their dominant leg, and had similar levels of physical activity and mental states.

Patients were excluded from this study if they had surgery performed on both knees, neuromuscular diseases, or could not perform the electromyography (EMG) biofeedback. The study began 1 week after the surgery to prevent any negative effects of postoperative pain on quadriceps muscle strength.

EMG biofeedback protocol

Patients reclined in a supine position on a standard examination table, and the quadriceps muscle activity during isometric exercises was evaluated using a non-invasive Myomed 932 EMG biofeedback device (Enraf-Nonius, The Netherlands) and gel-containing electrodes 48 mm in diameter (Türklab, The Turkey). The electrodes were placed on the vastus medialis, rectus femoris, and vastus lateralis (**Figure 2**). The patients were advised to exercise their unaffected knee first, followed by their affected knee. The patients were randomized to the exercise method applied first such that the first patient was treated with the classical method first, while the second patient was with the new method first. In the classical exercise method, the patients were told to "press the back of the knee downward through the bed and hold the leg in the same position for 10 seconds". In the new exercise method, the patients were told to "pull the patella superiorly tightly and hold the leg in the same position for 10 seconds" (**Figure 3**). The quadriceps muscle contraction strength was evaluated for each method using a Myomed 932 EMG-biofeedback device. The patients were allowed a 2 min rest between each method to prevent muscle fatigue.

The data gathered with the EMG biofeedback device were stored in a computer.

Before participating in the study, informed consent was obtained from all patients after the study was explained and their questions were answered.

Statistical analysis

Statistical analyses were done using SPSS 16.0 (SPSS, Chicago, IL, USA). We used the non-parametric Wilcoxon signed-rank test to examine the differences between the two methods. The greatest quadriceps muscle strengths with each method were compared.

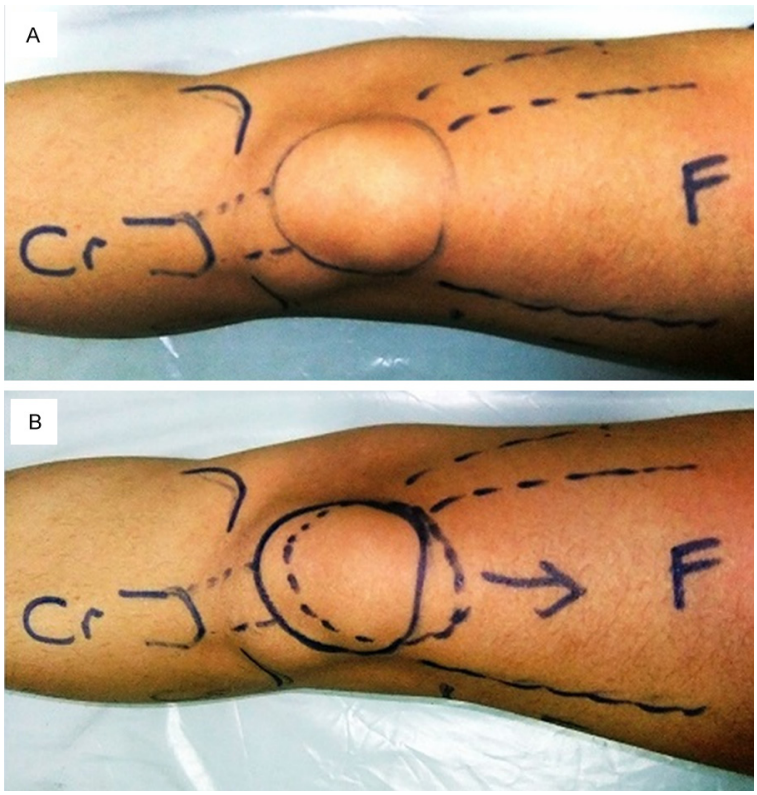


Figure 3. New method of isometric exercise of quadriceps strengthening. A: Resting on the patella. B: The patella is pulled superiorly. F: Femur, Cr: Cruris.

Table 1. Demographic features and measures of quadriceps muscle strengths for both knees

	M/F	Age	R/L	C 1	C 2	N 1	N 2
1.	M	52	R	280	280	300	300
2.	M	33	L	80	90	120	140
3.	M	25	L	220	300	300	310
4.	M	21	R	25	30	60	55
5.	M	15	L	80	80	100	130
6.	M	16	L	170	210	170	220
7.	M	57	R	90	100	150	160
8.	M	17	L	290	300	300	310
9.	M	21	R	300	300	300	320
10.	M	33	R	300	300	300	310
11.	M	35	R	125	120	150	150
12.	F	33	L	85	90	110	95
13.	F	34	R	300	295	315	285

M: Male, F: Female, R: Right, L: Left, C: Classical order, N: New order.

Results

The mean isometric contraction quadriceps muscle strength with the new method (pulling the patella superiorly) was 210 (range 55-320) mV versus 186 (range 25-300) mV for the classical method. The difference was significant ($P < 0.01$). The demographic features and four different measures of quadriceps muscle contraction strength are shown in **Tables 1** and **2**. In conclusion, the new method led to a greater increase in quadriceps muscle strength and stronger contraction when compared to the classical method.

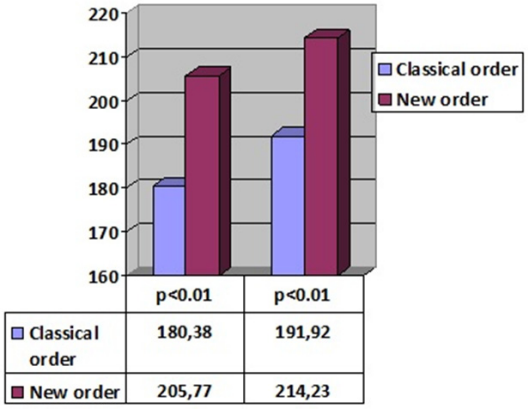
Discussion

Quadriceps muscle atrophy and adhesions that develop after knee surgery prolong the inactive and immobilization period. These two complications can prevent improvement in the knee range of motion [14-18]. For some isometric muscle-strengthening exercises, patients are simply instructed to "press the back of the knee downward through the bed and hold the leg in the same position for 10 seconds" [2, 4, 10-13, 16, 17]. The insufficient muscle contraction strength and long rehabilitation period with this classical isometric contraction exercise encouraged us to develop a different method. In addition, we sought a non-invasive method of evaluating the quadriceps muscle strength [15-17, 19].

The EMG Biofeedback device is a good device for controlling muscle activity, as it uses visual and auditory feedback to inform the patient. It is also used to increase muscle contraction power [2, 14, 15, 20-23]. In our study, we used EMG Biofeedback to evaluate muscle contraction strength.

The classical method of pressing the back of the knee downward through the bed and hold-

Table 2. Statistical analyses of results (Wilcoxon-signed rank test)



ing the leg in the same position for 10 s leads to insufficient quadriceps muscle contraction and increased muscle atrophy [2, 4, 11, 13, 16, 17]. Quadriceps weakness can result in reduced knee extension and a loss of joint range of motion [18-26]. Our new method of pulling the patella superiorly tightly and holding the leg in the same position for 10 s appears to increase quadriceps strength and joint range of motion when compared with the classical method.

Conclusion

Pulling the patella superiorly might be a better method of increasing isometric quadriceps muscle strength after arthroscopic and other knee surgery. The new method proposed here is also easy to understand and can be applied easily.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Hakan Sarman, Department of Orthopedics and Traumatology, Abant Izzet Baysal University School of Medicine, Golkoy 14280, Bolu, Turkey. Tel: +90 374 253 46 56/3301; +90 536 415 23 15; Fax: +90 374 253 46 15; E-mail: hakansarman@yahoo.com

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