Physiotherapy with and without Superficial Dry Needling Affects Pain and Muscle Strength in Patients with Patellofemoral Pain Syndrome

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ABSTRACT

Objectives: To investigate the clinical efficacy of physiotherapy with and without superficial dry needling on patients with knee pain; patellofemoral pain syndrome.

Methods: A randomized clinical trial conducted in 2015, Tehran, Iran. Of patients with patellofemoral pain syndrome, thirty-four subjects were randomly divided into two groups (17 in each group). Group A was subjected to physiotherapy and group B to physiotherapy with superficial dry needling. Only for group B, superficial dry needling was applied during the ten-day sessions of physiotherapy, every other day. The needle remained for 6 minutes at three-points of the quadriceps muscle, accompanied with needle rotation. Both groups received 10 therapy sessions. For both groups, in the first and tenth sessions, knee pain and quadriceps muscle strength was evaluated.

Results: Statistical analysis showed the two variables in each group had significant improvements after the 10 sessions ($P<0.05$). Comparing the two groups, group B showed more pain reduction based on the visual analog scale ($P<0.05$). However, according to manual muscle testing method, the muscle strength between both the groups showed no significant difference ($P<0.156$).

Discussion: Physiotherapy with and without superficial dry needling were seen to reduce pain and increase muscle strength of patients with patellofemoral pain syndrome. However, performing physiotherapy with superficial dry needling had a more significant effect on reducing knee pain. Superficial needling can cause many physiological and neurophysiological effects. Through stimulation of pain control mechanisms, it can help in further reduction of pain.

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1. Introduction

Patellofemoral pain syndrome is one of the main causes of knee pain [1, 2]. This syndrome is fairly common, and its prevalence is about 25% of the population, with young adults being the most affected [3]. This syndrome is seen to affect

both the sexes, but its prevalence is higher in the case of women [4, 5]. Studies have shown the high prevalence of this syndrome in runners and athletes who perform jumping movements [3, 5]. Although there are no confirmed signs and symptoms to diagnose the syndrome, the patients typically suffer from pain in the anterior of the knee due to compression of the patellofemoral joint, which is felt around the patella while performing any sort of physical or sport activity [1, 6, 7].

Among the factors influencing the patellofemoral pain syndrome, quadriceps muscle insufficiency is one of the most studied factors. Numerous studies have proven that quadriceps muscle insufficiency (rectus femoris, vastus medialis, vastus lateralis, and vastus intermedialis) may occur due to pain, myofascial trigger point, and muscle strain. Generally, any factor that leads to disruption of the extensor mechanism of the knee can reduce muscle strength and change the movement pattern and finally, lead to patellofemoral pain syndrome [1, 3, 6, 8].

The treatment options for patellofemoral pain syndrome include surgical and non-surgical interventions. Non-surgical treatment includes medication and rest or rehabilitation strategies comprising of electrotherapy, laser, brace, tape, manual therapy, correcting the patient's daily activities, strengthening and stretching exercises, and dry needling (DN) [9-13]. If the rehabilitation treatment fails after the intervention duration of three to six months, then the surgical treatment approach can be followed [8]. However, according to the prior researches, surgery is not the preferred method [9, 10].

DN is a specific technique for the treatment of functional disorders of the skeletal muscles, fascia, and connective tissue. It can also be used to reduce pain, restore function, and reduce structural defects in muscles and joints. The DN treatment approaches are based on three models (including models of radiculopathy, spinal sensitization and myofascial trigger point model). The DN techniques can be divided into superficial and deep techniques [11, 12].

Hence, the present study aimed at investigating the treatment modules for patellofemoral pain syndrome involving physiotheraphical intervention with and without DN.

2. Methods

Study design and participants

The present study has a quasi-experimental design. The study was performed in the Rah-Ahan special clinics affiliated to the Tehran University of Medical Sciences between April 2014 to Jun 2015. Sampling was done among the patients with patellofemoral pain syndrome who were referred to this center for physiotherapy and who met the inclusion criteria for the study. Inclusion criteria were as follows: patients with unilateral patellofemoral pain syndrome with age ranging from 18 to 50 years and visual analog pain scale of about 3, positive Clark test, and pain and disability in at least three of the following activities involving pain around the patella, back pain during prolonged sitting and moving up and down the stairs and pain during squatting and kneeling [3, 12].

Exclusion criteria included failure to regularly continue treatment sessions by the patients, NSAIA consumption during the study, patients with severe symptoms, patients' unwillingness to continue treatment, a history of knee surgery and severe trauma with meniscus or ligament tear, acupuncture treatment, pregnancy, cancer, secondary osteoarthritis and various rheumatologic diseases, and symptoms of abnormal neurological examination of sensation, movement, and reflexes [6, 7, 12].

Then, the selected patients were randomly divided into two groups. The control group (Group A) was treated with routine physiotherapy, and the target group (Group B) received routine physiotherapy plus superficial DN. Both the groups received 10 treatment sessions in two weeks.

Intervention

Physiotherapy program for both groups included: continuous ultrasound (US) (Novin biomedical engineering company, Iran), infrared light (IR), transcutaneous electrical nerve stimulation (Burst TENS, Novin biomedical engineering company, country) [13].

In group A, therapeutic exercises included leg rising, in which the knee was straightened, the heel was raised 20 cm above the floor and was put on hold for ten seconds. Then the leg was returned to the first position. The whole process was repeated 30 times. This practice was done with the patient from the third session onwards.

In Group B, the physiotherapy program was similar to the control group, with an additional treatment regime with superficial DN at three specific points. The first point was at about 8 cm above the lateral femoral condyle of the knee joint line in vastus lateralis muscle. The second point was about 8 cm above the medial femoral condyle of the knee joint line in vastus medialis muscle. The third point was about 8 cm above the base of the patella in the rectus femoris muscle. In general, the selection criterion was based on the fact that these points were the most common places of trigger points at quadriceps muscle and also these points overlapped with knee acupuncture points [3]. On the other hand, the consideration of the fixed points in all patients leads to the principle of uniformity of the treatment method.

Choosing superficial DN instead of deep DN method was based on the approach of Baldry (2002). Indeed, the main purpose of this study was not to inactivate

these points by needling. According to Baldry, superficial DN method is more effective in the case of patients with patellofemoral pain syndrome having a nociceptive pain [14-16]. One of the major treatment effects of superficial DN is the effect on A-delta fibers. Therefore, when superficial DN with a noxious stimulation leads to stimulation of A-delta fibers, the excitation remains almost 72 hours and gradually decreases [15].

On this basis, the interval time selected for the study was 48 hours in order to ensure greater stimulation of these fibers. Thus, the needling sessions were conducted every other day (sessions 1, 3, 5, 7 and 9). At these sessions, superficial DN was applied before doing routine physiotherapy. The needle with a length of 50 mm was used superficially up to a depth of 10 mm and maintained for 6 minutes at each point. To ensure that the needle is inserted to a depth of 1 cm in the body, the 50-mm needle was used with a 40-mm tube. To encourage the noxious stimulation and excite the A-delta fibers, when the needle was entered at the target point, it was spun ten times in the beginning and after the third and sixth minute, as suggested in a previous study [17].

Outcome measures

The outcome measures included visual analog pain scale (VAS) and manual muscle strength testing (MMT). Both groups were evaluated before and at the end of the treatment. VAS is a graph of a ruler (of length 10 cm) that is used to assess pain intensity. Number 10 in this ruler means the maximum amount of pain, and zero means no pain [18]. The manual MMT is a 6-grade manual scale to assess the strength of the muscles in which zero means no strength and 5 means normal. In the present study, to evaluate quadriceps' muscle strength, the patients sat at the edge of bed while the spine was upright and perpendicular to the bed. Then the patient extended her/his knee against the force by the examiner, then the grade of muscle strength was recorded [19].

Ethical considerations

The participants were informed of the goals and methods of the study, and their written consent was obtained to participate in the study. Any personal information of participants and their records will remain confidential.

Statistical analysis

SPSS software program version 19 was used for statistical analysis. The mean and standard deviation were used to represent descriptive statistics. To compare the distribution of numerical variables with normal theoretical distribution, the Kolmogorov-Smirnov (KS) test was used. In order to examine if the background variables including age, height, and weight matched in the two groups, independent t-test was used. Paired t-test was used to assess the significance of the pain scale and quadriceps muscle strength before and after the treatment in both the groups. Leven 's test was used to test the equality of variance. In addition, analysis of covariance was used to compare the changes in the parameters between the two groups after treatment.

3. Results

A total of 34 patients with patellofemoral pain syndrome were selected on the basis of their clinical symptoms and radiography. The subjects were randomly divided into two groups with 17 patients in each group. All of them received the full course of therapy.

The results presented in Table 1 shows all the P-values are greater than 0.05. Hence, both the groups were found to match in terms of background variables before starting the interventions. In Group A, the pain score before treatment was 6±2.39 and was 4.05±1.91 after the treatment, and this reduction was found to be statistically significant (P=0.001). MMT is a qualitative rating variation, so the changes were evaluated through Wilcoxon test, and P=0.003 was obtained. According to the statistical results obtained, it can be expressed that routine physiotherapy can lead to significant improvement in both pain and muscle strength after 10 treatment sessions.

Table 1. Comparison of the similarity of distribution of the study variables between the two groups before treatment.

Variables	Routine physiotherapy plus superficial dry needling group		Routine physiotherapy group		P-value
	Mean	Standard deviation	Mean	Standard deviation	
Age	37.88	9.53	33.58	8	0.16
Weight (kg)	79.29	13.61	73.76	16.22	0.29
Height (cm)	170.35	9.55	165.17	8.15	0.09
BMI (kg/m^2)	26.87	4.79	26.97	5.36	0.95
Disease duration year/month	1.88	1.16	2.11	1.16	0.56
VAS	7.05	1.14	6	2.39	0.11

P-value: The probability of the independent sample t-test; BMI: Body Mass Index;

VAS: Visual Analog pain Scale.

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In Group B, the pain score before treatment was 7.0±1.14 and after the treatment was 2.94±0.96. This reduction was found to be significant (P<0.001).

Applying Wilcoxon test for MMT, P=0.002 was obtained. According to the statistical results obtained, it can be expressed that routine physiotherapy and superficial DN can lead to significant improvement in both pain and quadriceps muscle strength after treatment for 10 sessions.

On comparison of both the groups, covariance analysis showed that routine physiotherapy plus superficial DN caused more pain reduction (P=0.001). The probability of significant changes of MMT was determined by Mann-Whitney test (P=0.156). The overall statistical results showed that in comparing the two groups, there was a significant difference in VAS, but no significant differences were observed for MMT.

4. Discussion

Assessment of pain

In each treatment group, the pain intensity reduced in the tenth session as compared to the first session. On comparing the two groups, physiotherapy plus superficial DN caused more pain reduction. The mechanisms of pain reduction in both the groups can be explained by the following factors. In both groups, the most common therapy used were TENS, US, IR, and exercise, and each of these modalities alone was found to activate pain control mechanisms. BURST TENS was used in the present research, it relieves pain by activating both mechanisms of pain control: gate control of pain and secretion of endorphins [1, 10, 12].

IR and the US also accelerated its positive effects on pain relief with reduced muscle spasms and muscle repair [13]. So, the pain relief is logical in physiotherapy group at the tenth session. The combination group showed a better trend. The superficial needling alone can lead to pain relief with different mechanisms. One of the most important effects of superficial needling is mild stimulation of the related structures which are responsible to reduce pain responses [16]. Superficial needling stimulates mechanoreceptors, especially A-beta fibers, which leads to a reduction in pain through the spinal gate control. Stimulation of these thick nerve fibers leads to the stimulation of the inhibitory cells in a gelatinous substance of spine (SG). The gelatinous substance cells with pre-synaptic inhibition of primary afferent cells (A delta and C) and post-synaptic inhibition of spino-talamic transitional cells (T cell) prevents the transmission of pain to the higher centers. It results in pain relief. This declines the effect of A-delta and C-fibers on spino-talamic transitional cells. Hence, it can be concluded that superficial needling leads to the close of the pain gate and prevents transmission of pain signals [20].

On the other hand, superficial needling stimulates A-delta fibers and sends signals to the spinal cord, midbrain, and pituitary axis. These stimulations lead to pain relief in the distant areas to the affected site by releasing substances such as encephalin, serotonin, norepinephrine, beta- endorphin, and other similar substances in the blood and cerebrospinal fluid. In fact, these stimulations lead to the activation of encephalin, serotonin, and noradrenaline pain-inhibitory system. The increase in the control of pain and the strengthening of the gelatinous substance of the Lamina 2 of the spinal cord (SG) lead to an analgesic effect, and subsequently create the opportunity for tissue repair [15].

Another reason for reducing pain is the increase in local blood circulation in both the groups. Routine physiotherapy plus superficial DN can lead to an increase in local blood

circulation. It happens partly due to the use of modalities and partly due to needling. This is confirmed according to the studies by Shah and other researches by using Doppler ultrasonography [21, 22]. Therefore, an increase of local blood circulation is emphasized in the combination treatment that can be more effective in reducing pain.

Other physiological effects of needling might be due to the stimulation of fibroblasts leading to pain relief. Superficial needling leads to mechanical changes in the fibroblasts and brings changes in their appearance from circular to oblong face. The mechanical changes in fibroblasts can lead to a lot of events in the cellular and extracellular phenomenon. For example, it can lead to mechanoreceptors and nociceptors irritation mechanism. Changes in the structure of actin, cell contraction, changes in the composition of the extracellular matrix genes, and ultimately reduce pain and introduce neurological changes [23-28].

The result of the present study was consistent with the results derived from the research by Orlando Mayoral and colleagues in 2013 on patients with knee arthroplasty [29]. In 2007, Sierre Adam and colleagues did their research on two treatment groups (Chiropractic-Chiropractic and DN) in patients with patellofemoral pain syndrome. In both the groups, there was a reduction in pain after the treatment, and the reduction was even faster in the case of DN group. However, no significant difference was observed between the groups [12]. Another study was undertaken in 2001 by Henderson on patients with patellofemoral pain syndrome. DN and US on vastus lateralis muscle trigger points were performed and examined for both the groups (DN and US groups). However, there was no difference in pain reduction between the two groups [3].

Assessment of quadriceps muscle strength

The results of this study show that in each treatment group, there was an increase in quadriceps muscle strength at the tenth session compared to the first session. However, while comparing the two treatment groups at the end of the treatment, there was no difference found between the two groups. There were activation mechanisms of pain reduction in both groups, and moreover, processes were implemented to increase the local blood circulation due to the use of electrical modalities and physiological effects of needling. These factors provided appropriate conditions for optimal muscle nutrition and led to more muscle tissue repair and balance that ultimately, increased the strength of the quadriceps.

In Group B, the condition for improving muscle strength seemed better, because needling was seen to activate the satellite cells that allowed muscle repair. In addition, needling led to the stimulation of fibroblasts and collagen production. The stimulation of these cells caused muscle repair that ultimately, increased its the power.

Our results regarding muscle strength are in line with the research results conducted in recent years. Orlando Mayoral and colleagues in 2013 applied the DN technique in patients with knee arthroplasty. They found that the maximum of isometric muscle strength in the intervention group was similar to placebo group after treatment [29]. In 2009, Adam Sayers investigated the effect of DN on the vastus medialis muscle in patients with patella femoral pain syndrome. He used a dynamometer to evaluate muscle strength. Both groups showed an increase in muscle strength, but at the end of the sessions, there was no difference between the two groups [12]. Another study by Henderson (2005) performed on patients with patellofemoral pain syndrome using DN and US on the trigger points of vastus lateralis muscle showed no difference between the amounts of quadriceps muscle strength by Cybex isokinetic device [3].

Limitations

To cover ethical considerations, the present study compared two treatment groups but did not investigate the pure effect of superficial DN in comparison to the placebo method. The use of more accurate methods such as EMG muscle activity to assess the muscle strength and muscle status could have resulted in more precise assessment, and even the smaller changes could be compared.

5. Conclusion

Physiotherapy with and without superficial DN can reduce pain and increase the muscle strength of patients with patellofemoral pain syndrome. However, adding DN to physiotherapy showed caused more knee pain reduction. Although adding superficial DN to physiotherapy could lead to further increase in muscle strength, these changes were not significantly different.

Clinical application

Based on the results of this study, applying physiotherapy plus superficial DN can be recommended as an appropriate and more effective treatment strategy to improve the symptoms of patients with patellofemoral pain syndrome.

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Conflict of Interests

The authors declared no conflict of interests.

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