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Original Article

Short-term effects of kinesio tape on joint position sense, isokinetic measurements, and clinical parameters in patellofemoral pain syndrome

Emine Eda Kurt, MD[1)*], Öznur Büyükturan, PT, PhD[2)], Hatice Rana Erdem, MD[1)], Figen Tuncay, MD[1)], Hicabi Sezgin, MD[3)]

[1)] *Department of Physical Medicine and Rehabilitation, Ahi Evran University Medical Faculty: Kırşehir, Turkey*
[2)] *Ahi Evran University School of Physical Therapy and Rehabilitation, Turkey*
[3)] *Department of Orthopedics and Traumatology, Ahi Evran University Medical Faculty, Turkey*

Abstract. [Purpose] To evaluate the short-term effects of kinesio tape on joint position sense, isokinetic measurements, kinesiophobia, symptoms, and functional limitations in patients with patellofemoral pain syndrome. [Subjects and Methods] A total of 90 patients (112 knees) with patellofemoral pain syndrome were randomized into a kinesio tape group (n=45) or placebo kinesio tape group (n=45). Baseline isokinetic quadriceps muscle tests and measurements of joint position sense were performed in both groups. Pain was measured with a Visual Analog Scale, kinesiophobia with the Tampa kinesiophobia scale, and symptoms and functional limitations with the Kujala pain scale. Measurements were repeated 2 days after kinesio tape application. [Results] No differences were found between baseline isokinetic muscle measurements and those taken 2 days after application. However, significant improvements were observed in the kinesio tape group, with regard to joint position sense, pain, kinesiophobia, symptoms, and functional limitations after treatment. Examination of the differences between pre- and post-treatment values in both groups revealed that the kinesio tape group demonstrated greater improvements compared to the placebo kinesio tape group. [Conclusion] Although short-term kinesio tape application did not increase hamstring muscle strength, it may have improved joint position sense, pain, kinesiophobia, symptoms, and daily limitations.

Key words: Patellofemoral pain syndrome, Kinesio tape, Joint position sense

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INTRODUCTION

Patellofemoral pain syndrome (PFPS) can be defined as retropatellar or peripatellar pain resulting from physical and biomechanical changes in the patellofemoral joint. Pain is most prominent when ascending or descending stairs, squatting, or sitting for prolonged periods with the knees flexed. PFPS is the most common diagnosis in patients complaining of knee pain[1, 2)] and tends to occur more frequently in young adults. The incidence of PFPS is reported to be between 15% and 25%[3, 4)].

Consensus is still lacking regarding the etiology, classification, diagnosis, and treatment of PFPS[5)]. The cause of patellofemoral pain has been reported to be multifactorial[4)]. Some modifiable risk factors have been theorized to play a role in the development and persistence of PFPS, including quadriceps weakness, specifically in the vastus medialis obliquus (VMO)[6)], patellar malalignment, and patellar hypermobility[7)].

Treatment protocols contain specific exercises thought to encourage VMO activity, such as general quadriceps strengthen-

*Corresponding author. Emine Eda Kurt (E-mail: eedakurt@gmail.com)

ing exercises and stretching tight lateral structures[8, 9]. Additionally, patient education, activity modification, electromyographic biofeedback, neuromuscular electric stimulation, physical agents for deep and superficial heating, bracing, shoe orthotics, knee sleeves, and nonsteroidal anti-inflammatory drugs are generally included in the nonoperative treatment of PFPS[10].

Beneficial effects of kinesio taping on the musculoskeletal system have been demonstrated by many studies[11–13]. Although there are reports of the beneficial effects of therapy for PFPS, there are also many conflicting opinions[14, 15]. The name of the technique is derived from the field of kinesiology because the application of the tape allows the body to move normally, while the fascia reacts to the tape via biomechanical or proprioceptive mechanisms. Fascia is a dense, irregular connective tissue that surrounds and connects every muscle both anatomically and functionally[16–18].

Kinesio tape was designed to mimic the qualities of human skin. It has roughly the same thickness as the epidermis and has elastic properties. Kase et al. have proposed several benefits, depending on the amount of stretch applied to the tape during application: 1) to provide a positional stimulus through the skin, 2) to align facial tissues, 3) to create more space by lifting fascia and soft tissue above the area of pain/inflammation, 4) to provide sensory stimulation to assist or limit motion, and 5) to assist in the removal of edema by directing exudate toward a lymph duct[19].

We aimed to detect the short-term effects of kinesio tape on pain, activities of daily living (ADLs), kinesiophobia, proprioception, and isokinetic measurements in patients with PFPS.

SUBJECTS AND METHODS

This single blind randomized controlled trial was conducted in the Physical Medicine and Rehabilitation Department Outpatient Clinic of the Ahi Evran University Medical Faculty. Declaration of Helsinki protocols were followed and local ethical committee approval was obtained for this study. The study design was approved by the Recep Tayyip Erdoğan University Ethical committee under process no:151/2014. The study was carried out from January 2015 through January 2016.

In total, 90 patients (36 males; 54 females) with a diagnosis of PFPS were included in this study. Participants had to be aged 20–40 years and have PFPS in order to be included. Exclusion criteria included diagnosis with tendinitis, Osgood-Schlatter syndrome, severe knee deformity (genu varum, valgum, and/or recurvatum), meniscus, ligament or cartilage damage, history of lower extremity trauma or operation, myopathy, polyneuropathy, pregnancy, or muscle weakness caused by systemic disease. Furthermore, patients who were obese (body mass index >30) or had history of physical therapy for PFPS in the last 6 months were excluded. The patients were randomized into 2 groups (Group 1, kinesio tape (KT) group; Group 2, placebo kinesio tape (PKT) group). Subjects were instructed to avoid taking analgesics or anti-inflammatory medication during the study (Fig. 1).

A certified KT practitioner applied all treatments. Before KT application, the skin was cleaned.

For the Kinesio tape group, KT application included VMO facilitation and patellar correction strips. With the knee flexed approximately 90°, Y strips were applied to the quadriceps. The anchor at mid-thigh was applied with zero tension. Then each piece of the Y strip was applied, bracketing and terminating below the patella. The middle section of the tape was applied under tension and the tails of the Y strip were applied without tension. A patellar tape strip (with the knee flexed approximately 90°) was applied with medium tension along the side of the knee cap (Fig. 2a)[19].

For the placebo kinesio tape group, 2 strips of KT were applied horizontally with the knee straight, one 7 cm above and one 7 cm below the superior and inferior patellar borders, with no tension on the tape. The approximate length of each strip was equal to the distance between the medial and lateral femoral condyles. This placement was chosen to avoid interaction of the tape with patellar positioning (Fig. 2b).

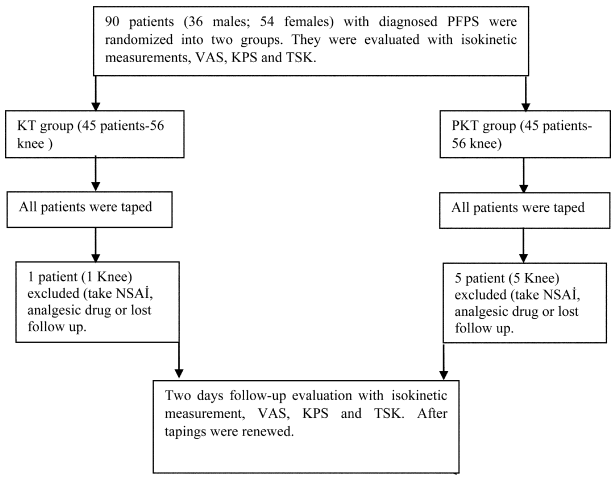

Fig. 1. Flowchart of study

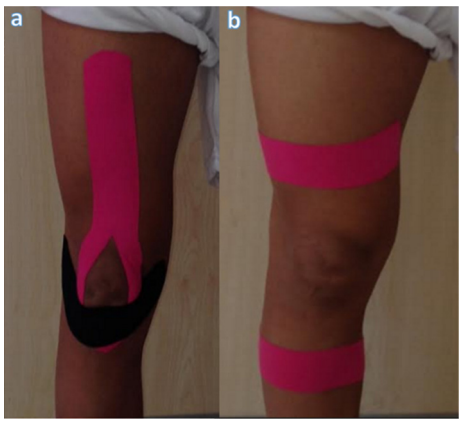

Fig. 2. Kinesio taping (a) and Placebo kinesio taping (b)

A visual analog scale (VAS) was used to determine pain intensity. The VAS is a 100-millimeter line without graduated marks, anchored with the words "no pain" on one end, and "the most severe pain" on the other. Subjects were instructed to place a mark along the line at a level representing the intensity of their present pain when walking and ascending and descending stairs. The VAS has been reported as a valid measure for the detection of a clinical change in pain in subjects with PFPS[20].

The Kujala Pain Scale (KPS) was used to assess the severity of symptoms and physical limitations specifically. Kujala et al. developed a self-administered questionnaire, the "Kujala Score," for people with PFPS. The questionnaire consists of 13 questions, of which 3 refer to pain and physical alterations, 8 refer to possible limitations in functional capacity, and 2 describe the ability to participate in sports. Each question has several possible answers (3–5), and each response is rated from 0 to 10. This maximum score is 100, and the theoretical minimum is 0 points[21]. A version of the test validated for use in Turkey was employed by Kuru et al[22].

The Tampa Scale (TSK) was used to evaluate kinesiophobia. It was developed by Miller and colleagues in 1991 as a measure of fear of movement and re-injury, and was subsequently described by Vlaeyen et al[23]. Kinesiophobia is defined by the developers as "an irrational and debilitating fear of physical movement and activity resulting from a feeling of vulnerability to painful injury or (re)injury." The questionnaire consists of 17 statements about pain and patients were asked to signal the extent to which they agree with each statement by using a 4-point scale based on the model of fear avoidance, fear of work-related activities, and fear of movement/reinjury. Items are scored with possibilities ranging from 'strongly disagree' (score=1) to 'strongly agree' (score=4). The scores on items 4, 8, 12, and 16 are reversed. Total scores range from 17 to 68. A high value on the TSK indicates a high degree of kinesiophobia. A version of the test validated for use in Turkey was employed by Yılmaz et al[24].

An isokinetic dynamometer (Cybex 770 Norm, Lumex Inc., Ronkonkoma, NY, USA) was used to evaluate quadriceps strength. At the beginning of each evaluation, the dynamometer was calibrated. Subjects were seated with the hips and knees flexed at a 90° angle. The axis of the dynamometer was positioned parallel to the lateral femoral condyle. Tests were performed for all knees with PFPS. Before the test, trial repetitions were performed for orientation. The isokinetic strength of the quadriceps was tested at constant angular velocities of 60°/s and 180°/s with 3 repetitions at each velocity. A 30 s rest period was allowed between sets. During the test, subjects were verbally and visually encouraged.

The same dynamometer was used to evaluate knee joint proprioception. Subjects sat with the hips and knees flexed to 90°. The axis of the dynamometer was again positioned parallel to the lateral femoral condyle. A pneumatic boot and a blindfold were used to eliminate visual and cutaneous inputs. The continuous passive motion mode was used for testing at a constant velocity of 5°/s. Joint position sense evaluated between 0° of knee extension and 90° of knee flexion for a total range of 90° of knee movement. Knee movement from flexion to extension was stopped by pressing the abort button when subjects perceived that they had achieved the target position of the range (60°). Initially, 4 practice repetitions were performed in which subjects were alerted to the point coinciding with the criterion position (60°) by the practitioner. When subjects felt ready, the testing procedure started. The test subjects were asked to press the abort button when they felt they were at the midpoint of the range (60°). The outcome measure consisted of the deviation from 60° based on 3 repetitions[25].

Since the tape lost its adhesive properties in 22 patients for several reasons (take analgesic drug or lost follow up), it was renewed 24 hours later. All knees were re-taped 2 days later and were re-evaluated with isokinetic measurements, the VAS, KPS, and TSK.

SPSS software version 20 (IBM Corp., Armonk, NY, USA) was used for statistical analyses. Continuous data were described as the arithmetic mean ± standard deviation, whereas categorical data were described as percentages (%). The normal distribution of continuous data was examined by the Kolmogorov Smirnov test. If the data were normally distributed when comparing both groups, the Student's t-test was employed. If the data were not normally distributed, the Mann-Whitney U test was employed. Qualitative data comparisons of groups were performed using the χ^2 test. A statistical level of significance was accepted at $p<0.05$. For repeated measures, a paired t-test was used if the data were normally distributed, while a Wilcoxon test was employed if the data were not normally distributed.

RESULTS

There was no statistical difference between Group 1 and Group 2 with respect to demographic variables ($p>0.05$) (Table 1).

There were significant improvements in the KT group with respect to VAS ($p<0.001$), KPT ($p=0.002$), TSK ($p<0.001$), and joint position sense of the knee ($p<0.001$) after taping. However, no significant differences were found in the PKT group with respect to VAS ($p=0.547$), KPT ($p=0.396$), TSK ($p=0.779$), and joint position sense of the knee ($p=0.077$) after taping (Table 2). Significant differences were detected when comparing changes in the VAS ($p<0.001$), KPT ($p<0.001$), TSK ($p<0.001$), and joint position sense ($p<0.001$) between the KT group and PKT group (Table 3).

There were no statistically significant differences between isokinetic muscle parameters before and after taping. The 60°/s angular velocity extension peak torque, 60°/s flexion peak torque, 60°/s agonist/antagonist ratio, 180°/s angular velocity extension peak torque, 180°/s flexion peak torque, and 180°/s agonist/antagonist ratio were calculated for both groups ($p>0.05$ for all measures) (Table 2). Additionally, no significant differences were found in isokinetic measurement gains, including 60°/s angular velocity extension peak torque, flexion peak torque, agonist/antagonist ratio, 180°/s angular velocity

Table 1. Demographic characteristics of patients

		KT group (N=44)	PKT group (N=40)
Age			
Mean ± SD		31.6 ± 6.9	30.9 ± 7.2
(min–max)		(21–40)	(20–40)
Gender (N)	Male	19 (43.2%)	16 (40%)
	Female	25 (56.8%)	24 (60%)
Height (cm)			
Mean ± SD		168.3 ± 10.7	167.9 ± 9.8
(min–max)		(155–191)	(156–189)
Weight (kg)			
Mean ± SD		69.6 ± 14.7	68.7 ± 15.3
(min–max)		(52.5–89.9)	(50.8–85.7)
BMI (kg/m^2)			
Mean ± SD		23.7 ± 2.4	23.2 ± 3.0
(min–max)		(21.6–24.7)	(19.5–25.8)
Effected side of patients	Right	23 (52.3%)	15 (37.5%)
	Left	10 (22.7%)	14 (35%)
	Bilateral	11 (25%)	11 (27.5%)
Duration of pain (month)		19.3 ± 5.5 (28–12)	21.1 ± 4.5 (27–12)

N: number of patient

Table 2. Measurements before and after KT application

	KT group (N=55)		PKT group (N=51)	
	BT Mean ± SD (min–max)	AT Mean ± SD (min–max)	BT Mean ± SD (min–max)	AT Mean ± SD (min–max)
Flexion peak torque (Nm)				
60°	44.4 ± 23.9	46.2 ± 24.5	49.9 ± 22.7	51.3 ± 22.0
180°	37.7 ± 18.9	38.7 ± 19.1	40.1 ± 18.7	41.4 ± 17.7
Extension peak torque (Nm)				
60°	72.8 ± 23.9	76.2 ± 28.1	82.9 ± 21.7	84.9 ± 18.4
180°	61.8 ± 20.1	64.2 ± 18.9	70.3 ± 18.3	71.4 ± 17.1
Agonist/antagonist ratio (%)				
60°	52.9 ± 13.1	53.3 ± 12.8	59.1 ± 12.1	57.8 ± 11.8
180°	63.8 ± 10.6	64.6 ± 10.1	69.5 ± 9.9	69.7 ± 8.8
Flexion ratio (J)	162.6 ± 98.6	165.9 ± 91.3	274.3 ± 101.9	269.6 ± 112.3
Ekstension ratio (J)	359.2 ± 195.6	363.2 ± 165.3	402.6 ± 216.4	399.3 ± 225.2
Proprioseption 60°	8.7 ± 6.6	6.7 ± 6.2*	6.7 ± 5.6	7.1 ± 6.1
VAS	4.7 ± 2.3	2.4 ± 1.6*	4.2 ± 1.8	4.1 ± 1.7
TSK	41.1 ± 10.5	32.9 ± 8.9*	33.9 ± 6.8	33.9 ± 6.9
KPS	67.9 ± 9.6	70.5 ± 9.8*	73.8 ± 7.8	73.6 ± 7.8

KT: kinesio tape; PKT: placebo kinesio tape; BT: before taping; AT: after taping; N: number of knees, *statistically significant different from AT $p<0.05$.

Table 3. Comparisons of changes between groups

	KT group Mean ± SD	PKT group Mean ± SD
Flexion peak torque (Nm)		
60°	1.87 ± 9.66	1.29 ± 4.83
180°	2.80 ± 23.42	1.61 ± 11.52
Extension peak torque (Nm)		
60°	3.32 ± 29.58	1.92 ± 20.61
180°	2.52 ± 14.71	1.11 ± 13.56
Agonist/antagonist ratio (%)		
60°	0.41 ± 2.72	−1.31 ± 3.46
180°	0.84 ± 2.54	0.36 ± 2.80
Flexion ratio (J)	21.13 ± 36.69	19.47 ± 38.69
Ekstension ratio (J)	17.58 ± 23.55	17.06 ± 31.85
Proprioseption 60°	−2.04 ± 4.36	0.38 ± 3.48*
VAS	−2.23 ± 1.95	0.98 ± 1.63*
TSK	−8.11 ± 7.45	0.98 ± 2.48*
KPS	0.80 ± 2.79	0.18 ± 1.13*

KT: kinesiotaping, PKT: placebo kinesiotaping. *p<0.05 is significant.

extension peak torque, flexion peak torque, and agonist/antagonist ratio between the KT group and PKT group (p>0.05 for all measures) (Table 3).

DISCUSSION

We determined that the improvements in the KT group were statistically significant compared to the measurements in the PKT group. In this study, we observed that 2-day KT application did not increase quadriceps muscle strength in patients with PFPS and there were no significant differences in the isokinetic assessment tests as compared to the PKT group. However, statistically significant improvements were found in the KT group post-taping with regard to pain, physical limitations, symptoms, kinesiophobia, and joint position sense. Furthermore, when comparisons were made between groups before and after the application of tape, significant improvements were found in the KT group with regards to pain, physical limitations, symptoms, kinesiophobia, and joint position sense as compared to the PKT group.

Aktaş et al. found that the patellar correction and quadriceps facilitation technique of KT application brought about a significant increase in hop distance and isokinetic knee extension peak torque in healthy subjects[26]. Similarly, another study performed with 20 healthy females found that applying KT on the anterior surface of the thigh, in the direction of the vastus medialis, lateralis, and rectus femoris fascia, could increase eccentric muscle strength (isokinetic eccentric peak torque), in healthy adults[16]. Additionally, Freedman et al.[12] reported that the application of patellar KT produced statistically significant improvements in short-term pain and single leg triple jump test function in patients with PFPS. There was also a study reporting that taping may reduce pain and increase maximum voluntary isometric contraction in knee flexion in patients with PFPS[27]. In contrast to Janwantanakul[14] and Fu et al.[15], KT application did not affect muscle activity measured by electromyography in healthy subjects; additionally, there was no significant increase in quadriceps muscle strength even after 12 weeks. Similarly, in a study of healthy males, the application of KT to the skin overlying the quadriceps muscle did not enhance the strength or power of knee extensors[28]. There is no consensus about the effects of kinesio taping in patients with PFPS. Different results may be due to differences in measurement technique, kinesio taping techniques, and the demographic characteristics of the evaluated population. Multiple articles have mentioned this lack of agreement[10, 29, 30].

There are a few studies that have evaluated the effect of taping on joint position sense of the knee in patients with PFPS. Aytar et al.[30] reported that no significant differences were found between the KT group and PKT group regarding the intensity of pain, quadriceps strength at 60°/s and 180°/s, and joint position sense, and additionally, that no significant difference was found between pre-taping measures and those taken 45 minutes after taping regarding joint position sense at 45°. However, our study results indicate significant differences between the KT group and PKT group with respect to joint position sense. Similarly, Muray and Hulsk reported that KT application enhanced proprioception in the ankle[31]. Cho et al. found that KT application led to reduced pain, improved proprioception, and improved active range of motion in patients with knee osteoarthritis. In the same study, it was documented that placebo taping did not affect pain, proprioception, or active range of motion[32]. The mechanism of improvements in proprioception may be explained by increased feedback from the muscle spindles, soft tissue, and skin following the application of the tape[31, 32]. Kuru et al. reported that KT has a positive

effect on pain and functional condition in patients with PFPS[33]. This study results supports our outcomes. Additionally, we detected that pain and functional condition may improve even after 2 days.

Several mechanisms may help explain the pain-relieving effect of KT. Adhesive tape can improve patellar alignment in healthy controls and those with PFPS and therefore, therapeutic tape may reduce pain by improving patellar alignment[30]. A cross-sectional study of patients with anterior knee pain showed an excessively negative orientation towards pain, that is, the belief that pain will get worse and that one is helpless to deal with pain (kinesiophobia). This belief is associated with pain intensity and disability in patients with anterior knee pain, just as it is in other patients with chronic pain. In the same study, 97 patients with chronic anterior knee pain showed improvement in kinesiophobia after treatment[34]. It has been suggested that an excessively negative orientation towards pain and fear of movement (kinesiophobia) are related to increased pain chronicity and disability in patients[35]. In our study, a reduction in kinesiophobia was detected after 2 days in the KT group.

There were a few limitations to this study. First, there were no comparisons between different kinesio taping techniques. Second, the researcher who performed the measurements was not blinded. Only patients were blinded. Lastly, we analyzed only short-term effects. Long-term effects could be different or better than our results.

KT may have an effect on pain, joint position sense, and functional impairments in patients with PFPS in the short-term, although we did not detect differences in quadriceps strength before and after taping. Kinesio taping is time and cost effective, and easily applied. Additionally, there are currently no known adverse effects. Therefore, adding it to exercise therapy and/or physical treatment protocols can help improve symptoms in a clinical setting by increasing patient compliance.

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