Effectiveness of kinesio taping on functional outcomes in patellofemoral pain syndrome patients with abnormal patellar tracking

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Abstract

This study aimed to compare quadriceps strength, muscle reaction time, and patient-reported outcomes in PFPS patients with abnormal patellar tracking with and without kinesio taping. Twenty patients with PFPS who applied kinesio taping and 19 who did not were included. Muscle strength and reaction time (acceleration time; AT) were evaluated using an isokinetic device. Patient-reported outcomes were measured using the visual analog scale (VAS) and Kujala anterior knee pain scale (AKPS). Conservative therapeutic exercises were performed in both groups. In each group, all parameters (quadriceps strength: $p < 0.001$, quadriceps AT: $p < 0.001$, patient-reported outcomes, including VAS: $p < 0.001$, AKPS: $p < 0.001$ for taping group; quadriceps strength: $p < 0.001$, quadriceps AT: $p < 0.001$, patient-reported outcomes, including VAS: $p < 0.001$, AKPS: $p < 0.001$ for non-taping group), improved after intervention in the symptomatic knees. However, there were no significant differences in quadriceps strength and AT, and patient-reported outcomes in the symptomatic knees between the groups with and without kinesio taping (all $p > 0.05$). In patients with PFPS with abnormal patellar tracking, the present study shows that kinesio taping seems to be ineffective for quadriceps strength and muscle reaction time, and patient-reported outcomes. Further studies are needed to clarify the effects of kinesio taping without conservative therapeutic exercise in PFPS patients with abnormal patellar tracking.

Introduction

Patellofemoral pain syndrome (PFPS) is commonly described as pain around the patella with abnormal patellar tracking.^{1,2} PFPS may be caused by various factors,^{3–5} such as patellar malalignment and maltracking, quadriceps weakness and imbalance, quadriceps angle, foot and ankle position, and loss of proprioception and neuromuscular control. Of these, patellar malalignment may affect the extensor mechanism,⁶ and weakened quadriceps induce patellar maltracking during knee flexion and extension,^{2,7} resulting in aggravated pain and dysfunction of the knee joint owing to elevated cartilage-bone stress in the patellofemoral joint.^{2,8} Therefore, many clinicians and physical therapists apply patellar taping to stabilize the patellar malalignment in such cases.^{9,10}

Previous studies have used various patellar taping techniques, such as kinesio taping and McConnell taping to stabilize the patella in patients with PFPS,^{10–20} which is debatable regarding the outcomes in terms of patellar alignment, patellar maltracking, and quadriceps muscle balance. However, to date, insufficient studies have investigated functional outcomes in terms of quadriceps muscle strength and reaction time, and patient-reported outcomes [including the visual analogue scale (VAS) and the Kujala anterior knee pain scale (AKPS)], in PFPS patients with patellar maltracking who applied taping. In particular, there are lack of studies which directly compared the functional outcomes in PFPS patients with abnormal patellar tracking with and without kinesio taping.

Therefore, the purpose of this study was to analyze the efficacy of patellar taping between the PFPS patients with abnormal patellar tracking with and without kinesio taping in terms of functional outcomes including quadriceps muscle strength and reaction time, and patient-reported outcomes. We hypothesized

that compared to patients with PFPS who did not apply kinesio taping, all parameters would improve in those who did.

Materials And Methods

Study design and patient enrollment

This study was performed in accordance with relevant guidelines and regulations, and approved by the Korea University Anam Hospital Institutional Review Board (No: 2017AN0178). Informed consent was obtained from all subjects and/or their legal guardians. This study retrospectively reviewed 109 patients diagnosed with PFPS by an orthopaedic surgeon between 2015 and 2017. In order to be diagnosed with PFPS, the patients should present anterior or retropatellar knee pain during at least two of the following daily functional activities: sitting for long hours, running, going up or down stairs, kneeling down, jumping or crouching.²¹ Plain radiographs were taken to confirm abnormal patellofemoral bony structures, such as the trochlear groove and patellar tilt.^{8,22} The patients were included in the PFPS group with abnormal patellar tracking if they had pain with a click, popping, or catching in the patella during flexion and extension of the knee joint. We excluded patients with a history of trauma or knee surgery, chondromalacia, knee osteoarthritis, have analgesics and anti-inflammatory drugs within 4 weeks, and difficulty in continuing kinesio taping because of skin problems during rehabilitation. Ultimately, 39 patients were enrolled in this study (Fig. 1). There were 20 patients in the taping group (with kinesio taping) and 19 patients in the non-taping group (without kinesio taping).

Evaluation tests

Muscle strength and reaction time

Quadriceps muscle strength and reaction time were measured using an isokinetic device (Biodex multi-joint system 4, Biodex Medical Systems, Inc., Shirley NY).^{23,24} The rotational center of an isokinetic dynamometer was aligned with the lateral femoral condyle of the knee joint, and the patients were asked to perform five maximal repetitions of flexion and extension motions at 180°/s. Muscle strength was evaluated by peak torque normalized to body weight (peak torque/body weight, $\text{N}\cdot\text{m}\cdot\text{kg}^{-1}\times 100$).²⁵ A rapid coordination of muscle reaction is important in protecting joints.²⁶ The mechanism of muscle reaction is closely related to the arthrokinetic reflex, which is influenced by acceleration and velocity.^{24,27} Therefore, muscle reaction time was measured based on the acceleration time (AT, milliseconds) in the isokinetic strength test. The muscle reaction time was defined as the attaining time for pre-set angular velocity (180°/s in this study) during maximal contraction^{24,28} Therefore, slow acceleration time signified poor muscle reaction responses. Isokinetic muscle performance test was performed before and 1 month after patellar taping and therapeutic exercise

Patient-reported outcomes

The VAS and AKPS scores were used for patient-reported outcomes. For the VAS, 0 points indicated no pain and 10 points indicated the worst pain. The AKPS contains 13 items (for a total score range of 0 to 100), with greater scores indicating lower disability. Based on the results of a previous study,²⁹ changes in VAS by 1.5-2 points and AKPS by 8–10 points in patients with PFPS were defined as minimal clinically important difference (MCID).

Patellar taping intervention

For patellar taping, the kinesio taping with a width of 5 cm and a thickness of 0.5 mm (Nitto Denko Top®, Osaka, Japan) was used, which technique was applied based on a previous study by Logan et al.¹⁹ The taping was wrapped around the patella along the quadriceps muscle to stabilize the patella, as shown in Fig. 2. Kinesio taping was first applied during 30 minutes of conservative therapeutic exercise in our institution. Then, the patients were educated regarding the taping technique so that it could be applied during home exercise and daily activities. The taping was applied during whole treatment and follow-up period (a total duration of 1 month).

Conservative therapeutic exercise

The rehabilitation protocol was the same for all patients in both groups, as suggested in a previous study,²³ i.e., once per week for a total duration of 1 month.³⁰ The difference between the two groups was only whether kinesio taping is applied or not. The patients were instructed to perform open kinetic chain exercises, including multidirectional straight leg raises and knee extension with knee adduction in the pain-free range to improve the strength of the quadriceps and hip muscles. The patients were also asked to perform closed kinetic chain exercises, including wall squat exercise along with knee adduction and single leg squat in 50° below. Both single-leg balance exercises were performed to improve proprioception and neuromuscular control. The core and hip muscle strengthening program was added to all exercises. All patients were educated about home program exercises.

Statistical analysis

Based on a previous study on quadriceps strength in patients with PFPS,³¹ clinical significance was considered for a difference in quadriceps strength > at least 10%. In a pilot study of 5 knees in each group to detect a between-group difference in quadriceps strength of > 10%, 38 patients were required (*Cohen's d* effect size: 0.959). Therefore, in this study, we recruited 20 patients in the taping group and 19 patients in the non-taping group. To detect a significant difference in quadriceps strength of > 10% between the two groups, the power of the present study was 0.820.

Student's t-test was used to compare the quadriceps strength and AT, and patient-reported outcomes between the two groups. The paired t-test was used to compare the three related variables in each patient in both groups. The normality distribution of the continuous variables was determined using the Shapiro-Wilk test. Data were analyzed using SPSS version 21.0. (IBM, Armonk, NY, USA). The level of statistical significance was set at $P < 0.05$.

Results

Baseline characteristics

Table 1 shows the demographic data and there were no significant differences in sex, age, height, weight, and body mass index of the patients ($p > 0.05$).

Table 1
Demographic data of enrolled patients

	Taping group (n = 20)	Non-taping group (n = 19)	<i>p</i> -value
Sex (male/female)	5/15	3/16	0.305
Age (years) ^a	27.5 ± 5.4	27.3 ± 7.4	0.950
Height (cm) ^a	167.5 ± 6.3	166.5 ± 7.8	0.658
Weight (kg) ^a	62.6 ± 10.2	61.9 ± 6.9	0.804
Body mass index (kg/m ²) ^a	21.9 ± 2.3	22.2 ± 1.7	0.634
Injured side (right/left)	15/5	10/9	
Sports and activity, n (low:high) ^a	9/11	7/12	
^a Values expressed as mean ± standard deviation.			

Comparison of functional outcomes between the two groups

There was no significant difference in quadriceps strength and AT of the symptomatic knees between the taping and non-taping groups. ($p > 0.05$, Table 2). There was no significant difference in patient-reported outcomes, including VAS and AKPS, of the symptomatic knees between the taping and non-taping groups. ($p > 0.05$, Table 3).

Table 2
Comparison of quadriceps strength and AT between the taping and non-taping groups

Pre-intervention				Post-intervention		
	Taping group	Non-taping group	<i>p</i> -value	Taping group	Non-taping group	<i>p</i> -value
Quadriceps strength	87.3 ± 31.3	88.9 ± 37.8	0.884	137.8 ± 52.2	162.9 ± 28.5	0.072
<i>MD (95% CI)</i>	-1.6 (-23.4 to 20.2)			-25.1 (-52.6 to 2.4)		
<i>Cohen's d</i>	-0.04			-0.59		
Quadriceps AT	60.4 ± 16.1	70.5 ± 18.9	0.081	48.7 ± 14.8	54.2 ± 13.0	0.227
<i>MD (95% CI)</i>	-10.1 (-21.6 to 1.3)			-5.5 (-14.6 to 3.6)		
<i>Cohen's d</i>	-0.57			-0.39		
<i>MD, mean difference; CI, confidence interval; AT, acceleration time</i>						
The measurement unit of quadriceps strength was N·m·kg ⁻¹ × 100						
The measurement unit of quadriceps AT was milliseconds.						
Values are expressed as mean ± standard deviation.						

Table 3
Comparison of VAS and AKPS between the taping and non-taping groups

Pre-intervention				Post-intervention		
	Taping group	Non-taping group	<i>p</i> -value	Taping group	Non-taping group	<i>p</i> -value
VAS	5 ± 1.1	5 ± 1.0	0.469	3 ± 1.0	3 ± 1.1	1.0
<i>MD (95% CI)</i>	0 (-0.4 to 0.9)			0 (-0.7 to 0.7)		
<i>Cohen's d</i>	0			0		
AKPS	52.5 ± 7.9	49.7 ± 6.6	0.244	68.3 ± 9.3	69.9 ± 7.4	0.986
<i>MD (95% CI)</i>	2.7 (-1.9 to 7.5)			-1.6 (-5.5 to 5.4)		
<i>Cohen's d</i>	0.38			-0.19		
<i>MD, mean difference; CI, confidence interval; VAS, visual analog pain scale; AKPS, anterior knee pain scale.</i>						
Values are expressed as mean ± standard deviation.						

Comparison of functional outcomes in each group

In the taping group (Fig. 3A), quadriceps strength (87.3 ± 31.3 vs. 137.8 ± 52.2 , $p < 0.001$, effect size [*Cohen's d*] = -1.17), AT of the quadriceps (60.4 ± 16.1 vs. 48.7 ± 14.8 , $p < 0.001$, effect size [*Cohen's d*] = 0.75), and patient-reported outcomes, including VAS (5 ± 1.1 vs. 3 ± 1.0 , $p < 0.001$, effect size [*Cohen's d*] = 1.90) and AKPS (52.5 ± 7.9 vs. 68.3 ± 9.3 , $p < 0.001$, effect size [*Cohen's d*] = -1.83), improved in the symptomatic knees after kinesio taping.

In the non-taping group (Fig. 3B), quadriceps strength (88.9 ± 37.8 vs. 162.9 ± 28.5 , $p < 0.001$, effect size [*Cohen's d*] = -2.21), AT of the quadriceps (70.5 ± 18.9 vs. 54.2 ± 13.0 , $p < 0.001$, effect size [*Cohen's d*] = 1.00), and patient-reported outcomes, including VAS (5 ± 1.0 vs. 3 ± 1.1 , $p < 0.001$, effect size [*Cohen's d*] = 1.90) and AKPS (49.7 ± 6.6 vs. 69.9 ± 7.4 , $p < 0.001$, effect size [*Cohen's d*] = -2.88), improved in the symptomatic knees after conservative therapeutic exercises.

Discussion

The most important result of the present study was that among the PFPS patients with patellar maltracking, quadriceps strength, quadriceps AT, and patient-reported outcomes did not significantly differ between the taping and non-taping groups.

In the present study, quadriceps strength did not differ between the two groups. A possible reason for no difference in quadriceps strength may be insufficient patellar stabilization from kinesio taping. Patellar

position has a significant impact on quadriceps force.³² However, a systematic review, regarding the effect of kinesio taping for patellar stabilization in patients with PFPS, reported that it had no effect.¹⁷ Another possible explanation may be the effect of conservative therapeutic exercises. In a recent study by Mutlu et al.,³³ no difference was observed in the quadriceps strength of patients with knee osteoarthritis after patellar taping for 1 month. In addition, in a previous study by Mason et al.,³⁴ quadriceps strength was evaluated after conservative therapeutic exercise and patellar taping, each for 2 weeks in patients with PFPS; it was observed that quadriceps strength did not differ after taping, but improved after conservative therapeutic exercise. Furthermore, Bloomer et al. reported that conservative therapeutic exercises can be effective in improving quadriceps strength in patients with PFPS.³⁵ Taken together, these findings indicate that the improvement in quadriceps strength in patients with PFPS might be attributed to conservative therapeutic exercises,³⁶ and not taping.⁵ Our results are in the same vein with these findings. In the present study, there was no difference in quadriceps strength of the symptomatic knees between the two groups. Therefore, these findings imply that the improvement in quadriceps strength might be better with conservative therapeutic exercises than with kinesio taping.

Several previous studies have reported improved quadriceps muscle reaction after patellar taping in patients with PFPS.^{10,18,37} In the present study, however, there was no significant difference in quadriceps muscle reaction time between the two groups. A possible explanation for this may be differences in muscle evaluation methods. In the present study, quadriceps AT was measured using an isokinetic device to assess the time to reach the pre-set angular velocity during maximal muscle contraction. However, in previous studies,^{10,18,37} electromyography (EMG) was used to assess the vastus medialis oblique (VMO) and vastus lateralis (VL), which are components of the quadriceps muscles. Authors reported that the VMO was activated earlier than the VL after patellar taping. Another possible explanation may be the same therapeutic exercises for both groups. Chang et al.³⁸ and Irish et al.³⁹ reported that VMO muscle reaction can be improved by therapeutic exercises in patients with PFPS. In the present study, the same therapeutic exercises were performed for both groups; thus, improved quadriceps muscle reaction time might be affected by therapeutic exercises rather than patellar taping. Therefore, the authors propose further prospective studies to elucidate the results of the present study more clearly.

Previous studies have reported various results on the effects of patellar taping in terms of pain and function in patients with knee pain, including PFPS and knee osteoarthritis.^{12,14,19,33} A previous study by Mutlu et al.³³ and a systematic review by Logan et al.¹⁹ reported that patellar taping was effective in improving pain and knee joint function. In contrast, a previous study by Günay et al.¹² and a systematic review and meta-analysis by Ramírez-Vélez et al.¹⁴ reported that patellar taping was ineffective for pain and knee joint function. In the present study, there was no difference for patient-reported outcomes (including VAS and AKPS) between the two groups. This may be due to the improved quadriceps strength and muscle reaction time in both groups. Previous studies have reported that patient-reported outcomes may be influenced by improved muscle strength and muscle reaction time.^{23,40-42} In particular, in previous studies by Mutlu et al.³³ and Logan et al.¹⁹, patellar taping was applied along with conservative

therapeutic exercises. Therefore, the authors suggest that the effect of taping in terms of pain and function in PFPS patients with abnormal patellar tracking should be carefully interpreted.

The present study has several limitations. First, this was a retrospective study without a normal control group, thus a prospective study comparing with normal controls is needed. Second, we did not confirm abnormal patellar tracking from applied kinesio taping while evaluating muscle performance using an isokinetic device. Finally, there is a short-term follow-up period of 1 month. However, according to the clinical practice guidelines for the management of PFPS,³⁰ taping was not recommended because it was no benefit in the longer term (> 1 month).

Conclusions

This study has demonstrated that the kinesio taping seems to be ineffective for quadriceps strength and muscle reaction time, and patient-reported outcomes, in patients with PFPS with abnormal patellar tracking. However, further studies are needed to clarify the effects of kinesio taping without conservative therapeutic exercise in patients with PFPS with abnormal patellar tracking.

Declarations

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Conflict of Interest: The authors declare that they have no competing interests regarding this article.

Institutional Review Board Approval: Approval for this study was obtained from the Korea University Anam Hospital (No: 2017AN0178).

Author contributions

JHL and KHS collected and analyzed the patient clinical data. JHL and KHS and KMJ interpreted data and were major contributors to writing the manuscript. All authors read and approved the final manuscript.

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Data availability

All data generated or analyzed during the current study will not be disclosed due to the policy of the Korea University Anam Hospital Research Ethics Board.

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Figures

Figure 1

Study flow diagram.

Figure 2

Kinesio taping technique

Figure 3

Quadriceps strength ($\text{N} \cdot \text{m} \cdot \text{kg}^{-1} \times 100$), quadriceps muscle reaction time (ms), and patient-reported outcomes (points) of the symptomatic knees in the kinesio taping (A) and non-kinesio taping (B) groups. AT, acceleration time; VAS, visual analog pain scale; AKPS, anterior knee pain scale.