THE EFFECT OF PATELLAR TAPING ON KNEE JOINT PROPRIOCEPTION IN PATIENTS WITH PATELLOFEMORAL PAIN SYNDROME

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Abstract- Proprioception has been found to have a relation to subjective knee function and patients with patellofemoral pain syndrome (PFPS) seem to have larger deficits than asymptomatic individuals little is known about whether taping can restore defects in proprioception or by which mechanisms it can improve anterior knee pain. To determine the effect of patellar taping on knee joint proprioception a pre and post intervention repeated measures design was conducted on 25 male with PFPS (23.6 ± 3.04 years) and 25 healthy male (23.5 ± 3.1 years). Active angle reproduction, passive angle reproduction, and threshold to detection of passive movement tests were measured. Each of the tests was done under taped and no-taped conditions in 20 and 60 degree of knee flexion. We found significant difference between taped and no-taped conditions in active angle reproduction test for both groups ($P < 0.05$). The other tests did not show any significant difference ($P > 0.05$). Obtained results suggest that patellar taping may improve knee proprioception during active angle reproduction. Two groups could benefit from taping but further researches are needed to determine whether the present results are applicable to other situations or not.

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INTRODUCTION

Patellofemoral pain syndrome (PFPS) is one of the most common musculoskeletal conditions (1, 2). One of four of the general population is likely to experience patellofemoral pain syndrome at some times during his/her lifetime (2). Treatment plan for PFPS includes muscle strengthening and stretching, flexibility exercises, electrical stimulation, bracing, foot orthotics and patellar taping (2, 3).

Among these, strengthening of vastus medialis to maintain proper patellar alignment during movement is emphasized. Therefore, various methods have been used in order to facilitate vastus medialis activity (2, 4). Patellar taping is used in treatment of patients with PFPS. Although it has been reported that patellar taping results in decreased pain (4, 5), increased quadriceps muscle activity (5, 6) and improved patellar alignment and position (7, 8), doubts still exist regarding the mechanism for its remedial effects.

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Proprioception and neuromuscular provide an important component for the maintenance of joint function and stability (9). Enhancement of proprioception and neuromuscular control is necessary in patients with PFPS. Proprioception and balance training should be begun immediately after injury or surgery in these patients (2).

We could improve knee joint proprioception with application of external supports such as an elastic bandage and a neoprene sleeve (10). The effects of these supports have been examined in healthy subjects (10, 11) and in patients with knee osteoarthritis (11, 12).

However, only two studies have investigated proprioception in individuals with PFPS with conflicting results (13, 14) but, we are unaware of any investigations comparing the effects of patellar taping on knee joint proprioception on subjects with PFPS. Only one study has been implemented to examine the effects of patellar taping on knee joint proprioception. This study was done in healthy subjects. Callaghan et al. (2002) found no significant difference between the tape and no-tape conditions in any of proprioceptive tests in healthy subjects, but with further analysis found that taping improved proprioception with those subjects who had 'poor' proprioception (15).

Therefore, the purpose of the present study was to determine the effects of patellar taping on the knee joint proprioception acuity in subjects with PFPS.

MATERIALS AND METHODS

The study was pre and post intervention repeated measures design. Twenty-five male with PFPS (Table 1) were selected from orthopedic clinics and hospitals in Tehran. The inclusion criteria were anterior or retro patellar pain elicited by at least two of the following activities: ascending / descending stairs, hopping, squatting, kneeling and prolonged sitting. Also compression of the patella against the femoral condyles with the knee in extension and resisted knee extension should elicited retro patellar pain. Participants were excluded if they had symptoms present for less than one month, clinical evidence of other knee pathologies, and knee surgery in the past three months, a history of patellar subluxation / dislocation, or musculoskeletal injury to either lower extremity.

Table 1. Description of subjects*

Variable	PFPS	Healthy
Age (year)	23.6 ± 3.04	23.5 ±3.11
Height (meter)	173.2 ± 4.94	175.6 ± 4.84
Weight (Kg)	65.4 ± 6.84	69.6 ± 8.32

Abreviation: PFPS,
*Data are given as mean ± SD.

Twenty-five control male subjects (Table 1) were recruited from students at Iran University of Medical Sciences, and acquaintances of the investigators. Control subjects were excluded if there was a history of current symptoms of PFPS, or any of the above-listed exclusion criteria.

The control subjects were matched by age, height, and weight with PFPS group. Informed consent was obtained before participation in the study, and all rights of the subjects were protected.

Tests were performed on the Biodex Isokinetic Dynamometer (Biodex Corp, Shirley, NY). This Dynamometer is sensitive to 1-degree increments. A 10-cm wide strip of Hypafix (Smith & Nephew, Hull, UK) was used for taping. A sphygmomanometer cuff was supplied to provide equal sensory inputs to the lower limb of each patient from the Dynamometer's tibial pad. Visual cues were eliminated by blindfolds and hearing feedback was decreased by earmuffs.

Procedures

Before data collection, subjects were screened to determine if inclusion and exclusion criteria were met. The involved limb or the limb with more severe symptoms was tested in each patient. Healthy subjects were matched with patients, for example, if patient's right knee was tested; in the matched healthy subject the right knee was taped and tested. Each subject wore running shorts and was barefooted. During the actual testing sequence they were blindfolded. Subjects were seated comfortably on the testing seat with hips and knees at 90° flexion (Fig. 1).

Fig. 1. Biodex Isokinetic system.

The sphygmomanometer cuff was wrapped around the tibia. The tibial pad of the Isokinetic Dynamometer was secured above the malleoli. Sphygmomanometer was inflated to 40 mmHg and was checked during the test to be constant (15). The order of tests and target angles were randomly selected. After each test the subject walked around a 10 m perimeter at a comfortable pace to reduce the likelihood of any proprioceptive carry over in the next target angle.

Measurement of proprioception

Proprioceptive acuity was assessed by the subject's ability to reproduce active and passive positioning of the knee and threshold for detection of passive movement. In the reproduction tests, two target angles (20 and 60 degrees of knee flexion) were replicated and in TDPM test, a start position of 45-degree knee flexion was used.

Passive Angle Reproduction (PAR)

In the initial sitting position the machine's lever arm passively extended the test leg to the true preset angle (20 or 60 degrees of knee flexion) in a smooth, controlled manner at 5 deg/sec. The machine maintained this position for 3 seconds and the participant was asked to remember this knee position so that he or she could replicate it. The knee was then passively moved back to the starting position. After a 5-second rest period, the machine moved the knee through another cycle, stopping at the same preset angle. Two practice trials were completed for subject familiarization before main testing trials. Therefore, in this time the machine extended the knee passively and when the subject perceived the target angle, he pressed the hand held stop button. The procedure was performed three times. The average absolute difference between the target and reproduced angles during three repetitions was calculated for statistical analysis. During these tests the subjects were requested to relax all the muscles of the tested extremity as much as possible.

Active Angle Reproduction (AAR)

In this test, all of the conditions were the same as the previous test; only during the angle reproduction the subject moved the lower limb by active contraction of muscle at an angular velocity of approximately 5 deg/sec. The subject stopped moving the leg when he felt that the target angle was reproduced.

Threshold for Detection of Passive Movement (TDPM)

In this test, the position of the subject is similar to the other tests. Therefore, the knee was at the position of 45-degree of flexion; passive motion at angular velocity of 2 deg/sec toward flexion or extension was possible in this position. The onset and direction of movement was randomly selected. The subject was asked to press the handheld stop button as soon as motion was perceived. The absolute angular displacement values were recorded from the monitor of dynamometer computer. The average of three measured thresholds was used for statistical analysis.

Patellar taping

Subjects lay supine with the knees extended and the quadriceps relaxed. The base layer was applied from lateral femoral condyle to just posterior to the medial femoral condyle. The patella was completely covered by the base layer. Another layer was attached one thumb's breadth from the lateral patellar border, without pushing the patella, gathering the soft tissue over the medial condyle and

Fig. 2. Patellar taping method.

adhering to the medial condyle (Fig 2). For patients, taping was determined to be successful if a 50-percentage reduction in pain intensity (measured by VAS) was achieved during the single leg squat or stair ascending provocation tests. If not, the taping procedure was repeated until the desired decrease in pain intensity was achieved.

For healthy subjects the procedure was the same as above, and the subject was asked to indicate any uncomfortable feeling during provocation tests.

We used this patellar taping technique because, 1) there is not a reliable method for accurate assessment of patellar orientation (16-19), 2) it is suggested that a *change in symptoms and functional outcome in response to taping is a guideline* for selection of the taping technique (3, 16), 3) it is reported that the taping could not correct patellar alignment (4, 20) and the lateralization of the patella is the most common misalignment. Patellar taping was applied by one of 3 principal investigators (H.M).

Statistical analysis

For detection of normal distribution the Kolmogarov-Smirnov test was used. This test showed that the AAR, PAR test had normal distribution ($P < 0.05$) but the TDPM test was not normally distributed ($P > 0.05$). Therefore we used paired t-test for AAR, PAR tests and Wilcoxon signed rank test for TDPM test. Absolute difference between the target angle and the average of three times repetitions were calculated for AAR and PAR tests. In TDPM the average of three measurements of absolute angular displacement values were used for statistical analysis. All analysis were performed using SPSS software (Version 11) with the significance level set at $P < 0.05$.

RESULTS

The average absolute difference scores for all test and conditions are presented in Table 2 and Table 3. The paired *t* test indicated that for both groups the taping could significantly improve AAR in 20-degree flexion ($P < 0.05$).

Table 2. Average Absolute Difference (AAD) Scores between target and reproductive angles in healthy subjects*

	Condition				
Test	**No-tape**		**Tape**		***P* value**
Active angle reproduction					
60 degree angle	2.74	1.22	3.06	1.37	0.1
20 degree angle	3.89	2.28	2.79	1.51	0.03†
Passive angle reproduction					
60 degree angle	3.11	1.52	2.45	1.02	0.06
20 degree angle	4.13	1.9	3.48	1.14	0.14
Threshold to detection of passive movement	0.97	0.3	0.94	0.32	0.5

*Data are given as mean ± SD.

† Statistically significant.

Table 3. Average Absolute Difference (AAD) Scores between target and reproductive angles in patellofemoral patients*

Test	Condition				*P* value
	No-tape		Tape		
Active angle reproduction					
60 degree angle	5.84	1.35	5.25	1.57	0.07
20 degree angle	5.37	2.3	4.28	2.27	0.006†
Passive angle reproduction					
60 degree angle	4.83	2.18	4.46	2.29	0.3
20 degree angle	5.14	2.15	4.21	2.65	0.12
Threshold to detection of passive movement	1.1	0.35	1.06	0.35	0.65

*Data are given as mean SD.
† Statistically significant

The paired *t* test showed that the tape and no-tape conditions for PAR in 20 and 60 degree had no significant difference. Also taping did not affect significantly AAR (60 degrees) in both groups ($P > 0.05$).

The Wilcoxon signed rank test for TDPM revealed no significant difference in both groups before and after tape ($P > 0.05$).

DISCUSSION

Results showed that patellar taping could influence active reproduction in 20-degree angle. It was the only statistically significant result that was achieved in this study (Fig. 3, 4).

As far as we know, this was the first study to examine the effect of patellar taping on knee joint proprioception in PFPS patients. Although benefits were reported in healthy subjects in one previous study (15) further studies are needed to confirm those finding. The observed improvement in proprioception in our patients is in contrast with the findings in normal, pain-free subjects reported by Callaghan *et al*. They showed that the effects of patellar taping on knee joint proprioception neither in active test nor in passive reproduction tests were significant (15). There is evidence that afferent receptors are present in the skin, muscle, ligaments and joint capsule and that these contribute to the proprioception input of knee complex (21). The primary position sense or movement receptors in the

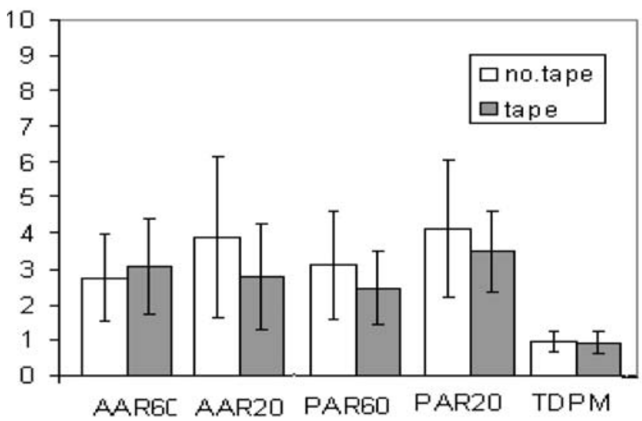

Fig. 3. Results of knee joint proprioception in healthy subjects in tape and no-tape conditions: mean value and standard deviation. AAR=Active angle reproduction; PAR=passive angle reproduction; TDPM=Threshold to detection of passive movement; 20=20 degree of knee flexion; 60=60 degree of knee flexion.

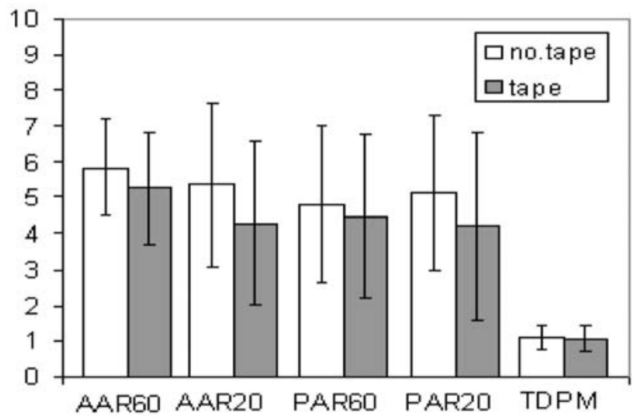

Fig. 4. Results of knee joint proprioception in PFPS subjects in tape and no-tape conditions: mean value and standard deviation. AAR=Active angle reproduction; PAR=passive angle reproduction; TDPM=Threshold to detection of passive movement; 20=20 degree of knee flexion; 60=60 degree of knee flexion.

joint capsule and ligaments are located deep within the soft tissues and therefore may not be affected by an external knee supports even if the support is an elastic bandage or tape with full skin contact. External support allows for massive stimulation of the skin and subcutaneous structures and increased pressure on the underlying musculature. Plausible receptors to be involved include free nerve endings and hair end organs that react strongly to new stimuli and adapt quickly (21).

The afferent signal from the cutaneous receptors may themselves provide proprioceptive information or they may facilitate proprioceptive and neuromuscular control by increasing relevant sensitive or motor neuron excitability (21).

It appears that the facilitating role of taping is dominant because we tested proprioception in two situations (AAR, PAR) but improvement was seen in active angle reproduction test. Another mechanism involved in the improvement of proprioception may be the effects on VMO onset activity (4) and alteration in the recruitment threshold and order of motor unit activity in patients with PFPS. Any alteration in the above parameters could result in more appropriate afferent signals from muscle receptors (4, 22). Pain could inhibit quadriceps muscle activity. The reduction in knee pain after patellar taping could be resulted in greater knee extensor moment and power than the no- tape condition (6). So facilitation of motor performance could improve proprioception through correction of afferent input from muscle receptors (12). Ernst suggested that one explanation for the increase in knee extensor function is that the patellar taping procedure may provide proprioception input (3).

In passive angle reproduction tests we found no significant difference between tape and no-tape conditions. The improvement in the ability to passively replicate target angles with the use of the tape is consistent with previous reports. Callaghan *et al.* showed that the taping may be useful in improving proprioception in healthy subjects with poor proprioception (15). Because the taping was more effective in the patients, our results seem to enforce this theory in healthy subjects with poor proprioception and also in patients with PFPS.

Another aspect of proprioception that was tested in our study was joint motion sense during the threshold to detecting passive motion test (Fig. 3, 4).

In this test, the taping was less effective in improving joint motion sense. The average absolute error has been increased (negative effect) and in the healthy subjects, no significant change was seen. The usual range of angular velocity for the threshold to detecting passive motion is 2˚/S to 5˚/S. Although we used a testing angular velocity of 2˚/S which was within the usual range, but it seems that the lower velocity is sensitive for this test.

Implications for practice and research

Several implications for rehabilitation are evident from the results of this study. We could improve proprioceptive status in healthy and PFPS subjects using patellar taping. Applying an external support such as tape may reduce the risk of injury by enhancing proprioception input. In injured athletes, taping could improve neuromuscular control and resulted in much sooner returning to sport competition.

The effect of patellar taping on knee joint proprioception has not been studied, and further studies are necessary in this regard. We suggested that in the other work, the evaluation of patellar taping should be done in both sexes and in functional tasks to determine this patellar effects.

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Conflict of interests

The authors declare that they have no competing interests.

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