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Effects of kinesiotape on pain, range of motion, and functional status in patients with osteoarthritis: a randomized controlled trial

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This study aimed to determine the effects of kinesiotape (KT) on pain, range of motion, and functional status in patients with osteoarthritis of the knee. In this randomized controlled trial, patients with knee osteoarthritis, based on American College of Rheumatology criteria, and Kellgren-Lawrence grade 2 or 3 criteria were selected. Visual analogue scale and active range of motion were the primary outcome measures. Timed Up and Go test and 6-min walk test, were the secondary outcome measures. Evaluation was performed at baseline (T0), after 1 hr (T1), and after 72 hr (T2). We recruited 27 patients with osteoarthritis (age, 57.33±8.72 years; 63% female; body mass index, 29.7±4.3 kg/m^2) who were randomly assigned into KT or sham-KT groups. There was a significant group by time interaction for the visual analogue scale ($P<0.001$, $\eta^2=0.593$), active range of motion (flexion) ($P<0.001$, $\eta^2=0.492$), active range of motion (extension) ($P<0.001$, $\eta^2=0.351$), 6-min walk test ($P<0.001$, $\eta^2=0.568$), and Timed Up and Go test ($P=0.026$, $\eta^2=0.136$). Between-group comparisons revealed significant differences between KT and sham-KT in visual analogue scale and Timed Up and Go test in T1 and T2 assessments, with changes in knee flexion ($P<0.002$) and extension active range of motion ($P<0.010$) and 6-min walk test ($P<0.044$) at 72-hr posttreatment. This study showed that, 1 hr of KT is an effective treatment for decreasing pain and improving active range of motion and physical function at a 72-hr follow-up in patients with osteoarthritis.

Keywords: Osteoarthritis, Knee pain, Kinesiotape, Range of motion

INTRODUCTION

Osteoarthritis is one of the most common musculoskeletal disorders in adults (Johnson and Hunter, 2014). It is a degenerative joint disease affecting 15%–40% of people >40 years of age (White and Waterman, 2012). Moreover, the prevalence of osteoarthritis has increased because of increased average life expectancy (Lawrence et al., 2008; Vina and Kwoh, 2018). It is estimated that by 2020, the approximate number of individuals diagnosed with osteoarthritis will be ~57%, and those affected by movement limitations will be around ~66% (Lawrence et al., 2008). International data estimates that the condition affects >250 million people throughout the world (Lozano et al., 2012), however, the progression of treatment approaches for osteoarthritis of the knee appears to be slow. Many treatments offer limited efficacy (Kalunian, 2016), and are often focused on alleviating symptoms (Ouyang et al., 2018).

The current treatment of osteoarthritis (OA) is based on symptom management, primarily pain control, and relies on the combination of non-pharmacological and pharmacological approaches (Cutolo et al., 2015). Pharmacological approaches are generally limited to the use of acetaminophen or nonsteroidal anti-inflammatory agents (Filardo et al., 2016). In spite of these medications, many patients complain of persistent pain (Cutolo et al., 2015; Filardo et al., 2016; Kalunian, 2016), and may develop side effects. Physical therapy (Kalunian, 2016; McAlindon et al., 2014),

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exercise (Javadian et al., 2017), weight loss (Messier et al., 2005), acupuncture (Sánchez-Romero et al., 2018), and the use of canes and walkers (McAlindon et al., 2014) are frequently used as initial approaches, or as adjuncts to pharmacological therapy (Cutolo et al., 2015), but may be expensive or difficult to apply in practice.

Kinesiotape (KT), is an elastic woven-cotton strip with a heat-sensitive acrylic adhesive structure (Bravi et al., 2016). KT can increase muscle flexibility and strength (Mutlu et al., 2017). A number of studies have measured the effects of KT on pain intensity and knee joint range of motion in patients with osteoarthritis (Bravi et al., 2016; Cho et al., 2015; Lu et al., 2018; Ouyang et al., 2018; Sarallahi et al., 2016), but the results are contradictory and inconsistent, and further investigations are required to determine their effectiveness (Ouyang et al., 2018). Additionally, a lack of follow-up measurements to determine longer-term effectiveness are not available. Our aim was to assess the effect of KT on pain intensity during two different conditions (rest and during functional testing). Therefore, the aim of this study was to determine the effects of KT on level of pain, range of motion, and functional status in patients with OA of the knee.

MATERIALS AND METHODS

In this parallel randomized controlled trial, patients with knee pain following a recent diagnosis of OA based on American College of Rheumatology diagnostic criteria (Salehi-abari, 2016) and with Kellgren-Lawrence grade 2 or 3 criteria (Brandt et al., 1991) admitted to Imam Khomeini Hospital between October 2016 and October 2017 were screened for inclusion criteria. Ethical approval for the study was obtained from the Tehran University of Medical Sciences, in Iran. The patients were given a clear explanation of the objectives of the study, and written consent was provided by all patients.

The inclusion criteria were (a) diagnosed knee OA in a symptomatic knee joint that had been documented recently according to aforementioned criteria, (b) had a 10-cm visual analogue scale (VAS) score of 4–8 at rest, (c) no previous history of KT application, (d) >45 years of age, (e) able to walk independently, (f) body mass index of ≤35 kg/m^2. All eligible patients were examined carefully by an experienced sports medicine specialist.

The exclusion criteria included (a) previous diagnosis of rheumatoid arthritis, (b) previous knee joint replacement surgery of the affected joint, (c) any other surgical procedure on the lower limbs within the previous year, (d) a planned surgical procedure of the lower limbs within the next 6 months, (e) opioid analgesia, corticosteroid or analgesic injection intervention for knee pain within the previous 6 months, (f) allergic reaction to tape during treatment sessions, (g) any acute knee injuries to ligaments or bones, (h) any acute inflammatory reaction (redness and warmness), and (i) uncontrolled hypertension or a moderate to high risk of cardiac complications during exercise. The taping process and the measurements of all patients were performed at the Sports Medicine Research Center, under supervision of a sports medicine specialist with cooperation of a physiotherapist. Allocation to groups was achieved by a block randomization method (sham-KT tape vs. KT group). The allocation was concealed by using opaque, sealed envelopes that were consecutively numbered.

Outcome measurements

Primary outcome measures were the VAS and active range of motion (AROM). Secondary outcomes were Timed Up and Go (TUG) test, and 6-min walk test (6-MWT) test. Measurements were taken at baseline, 1 hr, and 72 hr later. To reduce bias, the assessor was not involved in the taping procedure.

Measurements

The intensity of pain was recorded via the VAS scale which is a scale composed of a 100-mm horizontal line in length (Stauffer et al., 2011). AROM was measured by standard goniometry (Watkins et al., 1991). Knee AROM was evaluated in the supine position with the hip in extension, patients were encouraged to bend their knees without losing heel contact from the table (Shariat et al., 2018). AROM was repeated 3 times and the best score recorded. The TUG test started with the patient seated in a chair (seat height, 46 cm; arm height, 67 cm), following a verbal command, the patient stood, walked 3 m forward, turned and returned to their seat. The test was repeated for 3 times and the quickest time in seconds reported. Test validity and reliability for this test have been reported previously (Podsiadlo and Richardson, 1991). The 6-MWT was performed to evaluate functional capacity in a 30-m-long indoor hallway free of obstacles. The length of the corridor was marked every 3 m. The participants were instructed to walk at a self-selected pace to cover as much distance as possible in 6 min (Maly et al., 2006). The test-retest reliability of the 6-MWT has been previously determined in patients with knee OA (Kennedy et al., 2005). During the test, all participants walked independently without the use of walking aids.

Intervention

Patients were instructed to not take analgesics or nonsteroidal

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anti-inflammatory drugs for 7 days prior to the intervention. After the baseline measurements, patients were randomly allocated to either the KT group or the sham-KT group. The KT (ARES, Siheung, Korea) had a width of 5 cm, and was applied by the same sports medicine specialist to ensure consistency. Taping was performed on the painful knee, and in patients with bilateral pain, taping was performed on the most painful side. Prior to tape application, the skin surface was removed of hair and cleansed. Patients were positioned lying on their side, hip extended, and knee joint at 60° of flexion. The knee was taped with an I-shaped KT starting at the origin of the rectus femoris, and a Y-shaped KT proximal to the superior patellar border. The taping had no tension at its base, whereas the portion between the anchor and the superior patella was stretched 15%–25%; Sham-KT was applied in the supine position with knee extension and KT was attached with no tension to the rectus femoris muscle in the same manner as in the KT group. After 72 hr, the KT was removed from the skin by the physician and the patients were carefully examined for any skin sensitivity.

Statistical analyses

The sample size for the study was calculated using G power software, and all the variables were subjected to the normality test. The result revealed that all variables were distributed normally to determine the mean values and standard deviation, and descriptive statistics were used in reporting the data. Differences over time between the experimental and control groups were assessed by a 2×3 (group by time) repeated measures analysis of variance. Bonferroni *post hoc* adjustments were carried out where necessary, and partial eta^2 (η_p^2). Effect sizes were also calculated, with 0.25, 0.40, and >0.40 representing small, medium, and large effect sizes, respectively (Fritz et al., 2012). Independent *t*-test was applied for between-group comparisons. We also performed an intention to treat analysis using an imputation method, "last observation carried forward" in order to deal with any missing data at follow-up (Fitzmaurice et al., 2001; Kargarfard et al., 2018). A priori significance level was set at $P<0.05$.

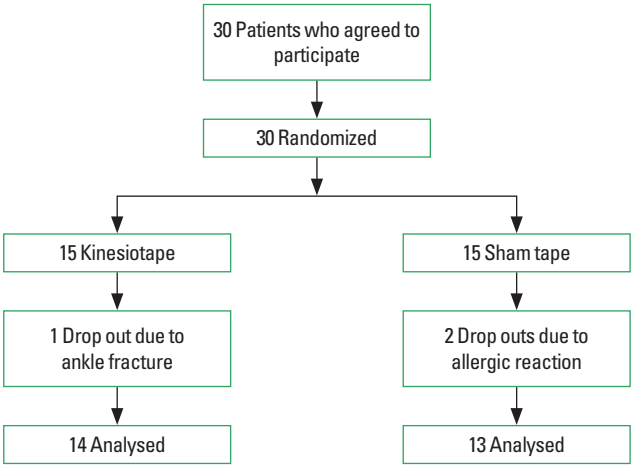

Fig. 1. Sampling frame of the study.

RESULTS

We recruited 30 patients with OA (age, 57.3±8.7 years; 63% female; BMI, 29.7±4.3 kg/m^2) (Fig. 1). During the study, three patients dropped out due to an ankle fracture and allergic reaction (not related to the trial), and two patients suffered from skin allergy related to the tape. Therefore, 27 participants completed the study (KT group: n=14; Sham-KT group: n=13). Physical characteristics of patients are reported in Table 1. There were no significant differences between the groups in any of the reported baseline parameters. The data of VAS, ROM, TUG, 6-MWT are Table 2.

Visual analogue scale

Pain intensity showed improvement between time points ($F[2, 50]=44.988$, $P<0.001$, $\eta^2=0.643$). *Post hoc* testing with Bonferroni correction revealed a mean improvement of 15.00 between T0 and T1 ($P<0.001$) in the intervention group, while these differences where 29.28 between T0 and T2 ($P<0.001$). No significant change was reported in sham-KT intervention between time points ($P>0.05$). A group by time interaction ($F[2, 50]=36.456$, $P<0.001$, $\eta^2=0.593$) was significant. Significant difference was detected between KT and sham-KT group after 1 hr ($P<0.001$) and 72 hr ($P<0.001$) of the intervention.

ROM (flexion)

AROM of knee flexion significantly improved between time

Table 1. Baseline characteristics of patients with osteoarthritis randomized to kinesiotape (KT) and sham-KT groups (n=27)

Characteristic	All (n=27)	KT group (n=14)	Sham-KT group (n=13)	Between-group comparison
Age (yr)	57.33±8.72	57.50±6.67	57.15±8.79	0.24
Height (cm)	165.03±9.08	163.07±5.83	167.15±7.50	0.76
Weight (kg)	77.51±6.84	74.14±6.50	81.15±5.30	0.14
BMI (kg/m^2)	29.74±4.32	28.41±5.30	27.60±4.80	0.18
Sex, female:male	17:10	9:5	7:6	0.15

Values are presented as mean±standard deviation or number.
BMI, body mass index.

Table 2. Changes in VAS, ROM (flexion), ROM (extension), TUG, and 6-MWT in KT and sham-KT groups (n = 27)

Variable	KT group (n = 14)			Sham-KT group (n = 13)			*P*-value		Partial eta squared
	Pretest	Posttest	Follow-up	Pretest	Posttest	Follow-up	Time effect	Group by time interaction	
VAS	55.71 ± 13.42	40.71 ± 8.28	26.42 ± 11.50	56.92 ± 11.09	56.15 ± 11.92	55.38 ± 11.26	< 0.001	< 0.001	0.593
ROM (flexion) (°)	102.64 ± 15.30	117.50 ± 13.30	125.92 ± 8.75	110.15 ± 13.30	110.30 ± 13.28	110.84 ± 13.50	< 0.001	< 0.001	0.492
ROM (ext) (°)	-7.85 ± 3.39	-6.07 ± 3.77	-3.78 ± 3.44	-7.84 ± 3.55	-7.92 ± 3.66	-7.61 ± 3.68	< 0.001	< 0.001	0.351
TUG (sec)	8.17 ± 1.25	8.17 ± 1.25	7.35 ± .94	10.62 ± 1.94	10.41 ± 2.21	9.52 ± 1.50	< 0.001	0.026	0.136
6-MWT (m)	360.42 ± 64.43	391.00 ± 49.20	456.57 ± 76.59	403.53 ± 56.72	403.53 ± 57.17	400.53 ± 59.01	< 0.001	< 0.001	0.568

Values are presented as mean ± standard deviation.
VAS, visual analogue scale; ROM, range of motion; TUG, Time Up and Go; 6-MWT, 6-min walking test; KT, kinesiotape.

points ($F[1.921, 48.025] = 32.184$, $P < 0.001$, $\eta_p^2 = 0.563$). *Post hoc* testing with Bonferroni correction revealed a mean improvement of 14.143° between T0 and T1 ($P < 0.001$) in the intervention group, while these changes where 23.286° between T0 and T2 ($P < 0.001$). There were no significant changes in the sham intervention between time points ($P > 0.05$). A group by time interaction ($F[1.921, 48.025] = 24.252$, $P < 0.001$, $\eta^2 = 0.492$) was found. Between-group comparison showed not significant after 1 hr ($P = 0.173$), although significant differences were evident after 72 hr between KT and sham-KT group ($P = 0.002$).

ROM (extension)

AROM of the knee extension significantly improved between time points ($F[1.794, 44.861] = 17.182$, $P < 0.001$, $\eta_p^2 = 0.407$). *Post hoc* testing with Bonferroni correction detected a mean improvement of 1.786° between T0 and T1 ($P = 0.025$) in the intervention group, while these changes improved from T0 and T2 with 4.071 ($P < 0.001$). There were no significant changes in the sham intervention between time points ($P > 0.05$). A group by time interaction ($F[1.794, 44.861] = 27.713$, $P < 0.001$, $\eta^2 = 0.351$) was evident. Between-group comparison showed no significant difference after 1 hr ($P = 0.208$), although significant differences were evident after 72 hr between the KT and sham-KT groups ($P = 0.010$).

TUG

Time effect ($F[1.926, 48.150] = 23.691$, $P < 0.001$, $\eta^2 = 0.487$) was evident between baseline 1 hr, and baseline and 72 hr. *Post hoc* testing with Bonferroni correction detected a mean improvement of 1.425 sec between T0 and T1 ($P < 0.001$) in the KT group, these changes reached 2.249 sec between the T0 and T2 assessment. No significant changes were reported in the sham treatment ($P > 0.05$). A group by time interaction ($F[1.926, 48.150] = 3.948$, $P = 0.026$, $\eta^2 = 0.136$) was significant; there are significant differences between two groups after 1 hr ($P = 0.003$) and 72 hr ($P < 0.001$) of tape application.

6-MWT

Time effect showed significant improvement in 6-MWT ($F[2, 50] = 29.022$, $P < 0.001$, $\eta^2 = 0.537$). *Post hoc* testing with Bonferroni correction detected a mean improvement of 30.57 sec between T0 and T1 ($P = 0.005$) in the KT group, these changes reached 96.147 sec between the T0 and T2 assessments ($P < 0.001$). A group by time interaction ($F[2, 50] = 32.881$, $P < 0.001$, $\eta^2 = 0.568$) revealed significant changes. There was no significant difference between the KT and sham-KT groups after 1 hr ($P = 0.054$) while significant differences were detected after 72 hr ($P = 0.044$).

DISCUSSION

This study examined the effects of KT on pain, range of motion, and functional status in patients with knee OA. The main findings of this study were that there was a significant group by time interaction related to VAS, ROM (flexion), ROM (extension), and TUG. The current research design allows us to conclude that KT is a cost effective and useful treatment for reducing pain and improving function in patients with OA of the knee. Our findings indicate the positive impact of KT after 1 hr and also after 72 hr.

KT is hypothesized to activate an increase in circulation to the taped area, a physiological change that may help increase AROM within the relevant muscle groups. An additional theory is that fear and limitation of movement is associated with pain intensity in patients with knee OA; the application of KT may provide enhanced sensory feedback. Cho et al. (2015) reported significant improvements in VAS during walking following KT application. Another recent study showed that pain was decreased after a single KT application and this effect could be maintained 3 weeks later (Aydoğdu et al., 2017). Minimal detectable changes (MDC) re-

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ported 25.4 for VAS while minimal clinically important difference (MCID) defined by baseline VAS scores-based on Stauffer et al. (2011) in our study this value is 19–27 units. We found 29.28 improvements after 72 hr of kinseiotaping application with a large effect size, although we only found a 15-unit improvement after 1 hr since beginning the intervention, this suggests that to maximize the taping effects on pain the intervention may need to be applied for a longer duration. Previous reports showed that KT improves flexion range of motion of the knee joint (Aydoğdu et al., 2017; Cho et al., 2015; Lemos et al., 2018; Mutlu et al., 2017; Wageck et al., 2016), which is inconsistent with our findings. Our results demonstrated 23.286° increase in knee flexion active ROM after 72 hr of the intervention with a large effect size; therefore these improvements can be considered clinically important since the MDC for knee flexion consider is 7.9° (Mehta et al., 2017). We found a change of 4.071° in knee extension AROM (moderate effect size) which exceeded the 3.8° MDC (Mehta et al., 2017). This suggests that KT could improve AROM in patients with knee OA.

We found that functional improvements in the TUG could be related to a decreased level of pain and improvement in ROM. A previous study has shown that KT may have a positive effect on the TUG (Castrogiovanni et al., 2016) which is in concordance with our findings; 6MWT is used to assess the submaximal level of functional performance and it was reported to be the most responsive physical performance measure in patients with knee OA following physiotherapy intervention (Bennell et al., 2011). An MCIDs of 50 m for 6MWD (Perera et al., 2006) have been reported and we found more than 96-m differences after 3 days of KT application showing that KT may be a useful treatment for improving functional performance in patients with OA.

There are several limitations in our study, which should be considered; there was a lack of blinding of investigators who applied the KT. We did not include an extended follow-up (>3 days) to determine the long-term effectiveness of KT on OA of the knee. Additionally, this study was only performed in patients with OA grades 2 and 3, and further studies would need to be conducted in patients with more or less severe OA of the knee.

This study provides preliminary evidence for the use of KT for improving pain and function in patients with OA of the knee. It is recommended that clinicians and therapists introduce KT as a practical method for decreasing level of pain and improving function. Future studies should examine the effectiveness of KT over the longer-term, and directly compare the treatment with other therapeutic options in patients with OA.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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