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Kinesio taping as a treatment method in the acute phase of ACL reconstruction: A double-blind, placebo-controlled study

Selvin Balki [a, *], Hanım Eda Göktaş [a], Zekeriya Öztemur [b]

[a] Cumhuriyet University, Faculty of Health Sciences, Sivas, Turkey
[b] Cumhuriyet University, Faculty of Medicine, Sivas, Turkey

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ABSTRACT

Objective: In this study, we aimed on investigating the effects of Kinesio taping (KT) in acute postoperative rehabilitation phase of anterior cruciate ligament (ACL) reconstruction.
Methods: Thirty male patients (mean age: 28.1 years) with ACL reconstruction were randomly assigned to two groups: (1) an experimental group to receive a KT treatment through the muscle and lymphatic correction techniques; or (2) a control group for sham KT. Both interventions were applied twice during a 10-day period from the fourth postoperative day. All patients received the same rehabilitation program for three months. The groups were compared according to range of motion (ROM), pain, swelling and muscle strength before treatment and on the fifth and tenth treatment days. Subjective evaluations were made with the Lysholm, modified Cincinnati and Tegner scores on the first and third postoperative months.
Results: Intragroup comparisons showed significant improvements in both groups on the fifth and tenth day and first and third month evaluations ($p < 0.05$). In comparison to the control group, the experimental group showed significant improvements in swelling around the patella, all pain measurements and hamstring muscle strength on the fifth KT day and knee flexion range of motion (ROM), night pain, all swelling measurements and hamstring muscle strength on the tenth KT day ($p < 0.05$).
Conclusion: Our results revealed that KT techniques applied in addition to the acute rehabilitation program of ACL reconstruction are beneficial in treatment of pain, swelling, knee flexion ROM, and hamstring muscle strength.
Level of evidence: Level I, Therapeutic study.

The anterior cruciate ligament (ACL) consists of the anteromedial band, which is responsible for the anterior stability of the knee, and the posterolateral band, which is responsible for the control of tibial rotation.[1] The ACL, which can be injured in daily life and during sports activities due to conditions such as movements causing extreme strain and rotation of the knee, outer impacts, immediate halting or change of direction, constitutes approximately half of sports knee injuries.[2] When complete tearing takes place, generally ACL reconstruction is needed[3]; however, pain, swelling, and motor disabilities such as decreased range of motion (ROM), proprioception, and muscular strength regularly occur after ACL reconstruction.[4] These factors should be minimized as soon as possible during a rehabilitation program to obtain successful results.[5,6]

In the phase of early rehabilitation in ACL reconstruction, in addition to drug therapies, different treatment methods such as cold application, leg elevation, knee brace, elastic bandage, compression socks, continuous passive motion (CPM) therapy, ankle pumping exercises, patellar mobilization, isometric exercises, and electrical stimulation are applied.[6–8] In this phase, it is endeavored to reduce inflammation, swelling and pain, increase proprioception, muscular strength, and ROM in lower extremities, ensure tissue healing, and ease fatigue.[6] The scope of potential effects reported for the Kinesio tape (KT) method exactly corresponds to the specified purposes.[9–14] However, the effects of KT practice after ACL reconstruction are under-recognized.[15–19]

* Corresponding author.
E-mail addresses: balkipt@hotmail.com, sbalki@cumhuriyet.edu.tr (S. Balki).
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Fig. 1. Kinesio tape lymphatic correction and rectus femoris muscle techniques.

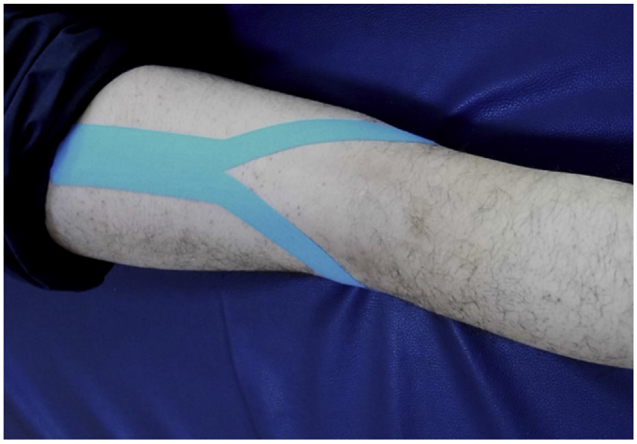


Fig. 2. Kinesio tape hamstring muscle technique.

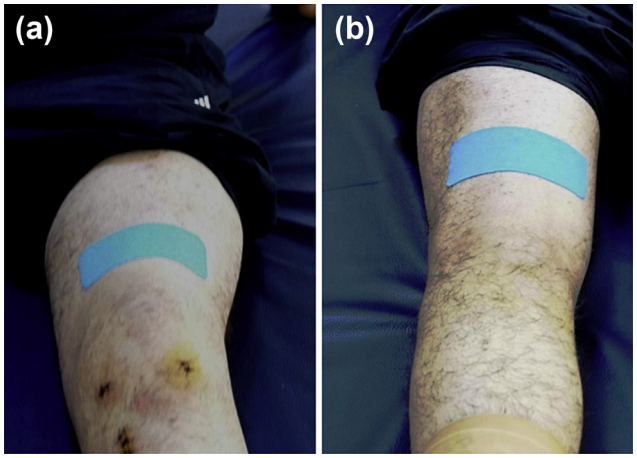


Fig. 3. Sham Kinesio tape application on the (a) front and (b) back side of the knee.

This study was designed to determine the effects of KT treatment on patients who underwent an ACL reconstruction with hamstring tendon autograft or allograft. For this purpose, sham KT treatment or a KT treatment through the muscle and lymphatic correction techniques were performed in addition to the postoperative acute phase ACL rehabilitation and their contributions to recovery in swelling, pain, muscle strength, ROM, and subjective functions were investigated.

Patients and methods

Thirty male patients (mean age: 28.1 years; range: 18–39 years) whose unilateral anatomical single-band ACL reconstruction was performed by the same surgeon using hamstring tendon autograft and tibialis posterior or peroneus longus allograft were included in this study. The patients were randomly assigned to two groups: (1) an experimental group to receive a KT treatment through the muscle and lymphatic correction techniques; or (2) a control group for sham KT Graft fixation was performed with ENDOBUTTON (Smith & Nephew PLC, London, UK) into the femoral channel and with BIORCI (Smith & Nephew PLC, London, UK) screws and staples into the tibial channel. Nine subjects underwent meniscus repair, ten subjects underwent partial meniscectomy, one subject underwent total meniscectomy, and four subjects underwent microfracture procedure.

The study's exclusion criteria were specified as previous surgeries undergone on lower extremities, multiligamentous knee injuries, history of KT treatment and systemic disease, and being outside of the age range of 18–45 years. Ethical approval was required for the study and the participants' written consents were received. The purchase of KTs was supported within the scope of the project.

Patients were divided into experimental and control groups through the randomization table for three months.[20] A rehabilitation program arranged for ACL + meniscus repair except for KT was applied on them. Small changes were made in the rehabilitation according to patients' personal development. Attention was paid to the continuation of full ROM and extension in the knee. The rehabilitation program was applied under the guidance of a physiotherapist five days a week for the first two postoperative weeks and twice a week for the following four weeks. The last six-week period was arranged as a home program. The patients were given knee-high varsity socks, angle-adjustable knee braces, and crutches for the first four to six weeks postoperatively. In the first four weeks of microfractures and meniscus repair, the patients were mobilized with partial weight on the operated side. Device-assisted CPM treatment was applied in the first postoperative week. In addition, cold application and passive patellar mobilization were started on the operated knee. Patients were given training regarding these practices.

In the taping procedures, general KT directions were followed.[10] A 5-cm-wide Kinesio Tex® Tape Gold™ (Kinesio USA, Albuquerque, NM, USA) was used in treatments. The patients' skin sensitivity was controlled with a KT test patch over a period of 24 h. Few hours after shaving the area of the skin to be taped, Y-shaped tapes were applied in origin-insertion direction to facilitate the muscles. While the patient was lying on lateral position, the tape was placed on the rectus femoris muscle with a tension of 25–30% bringing the hip to extension and the knee to 30-35° of flexion (Fig. 1) and the tape was placed on the hamstring muscle with a tension of 40–50% by bringing the hip to flexion and the knee to extension (Fig. 2). The base of the fan-tapes was placed towards the closest lymph nodes.[9] Their slices were applied with a tension of 15%, avoiding the stitches over the operated knee, and placed with the knee flexed approximately 10–15° from a different angle and direction to facilitate lymphatic flow (Fig. 1). In the sham KT practice, 10-cm-long, 'I' shaped tapes were placed on the anterior and posterior sides of the thigh and without applying tension in the transverse plan (Fig. 3). KT was applied twice during a 10-day period from the postoperative fourth day. Tapes were changed every five days. No

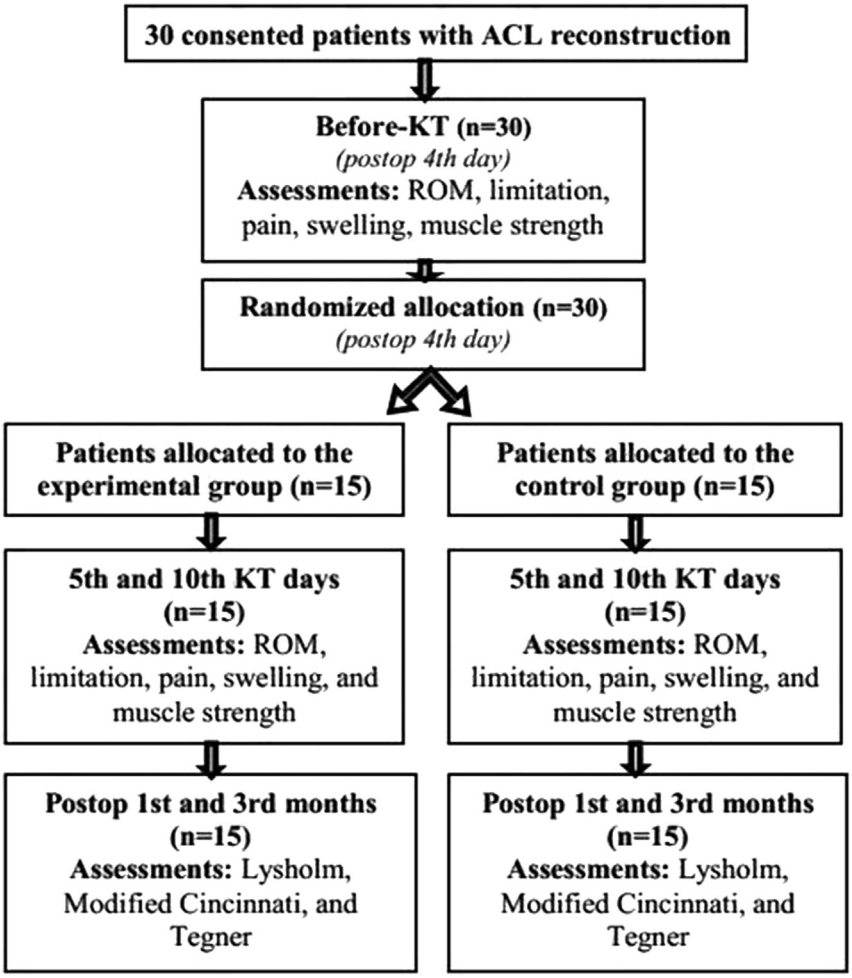


Fig. 4. Assessment flowchart in our study.

complication related to the KT treatment was experienced. Evaluations and KT application were performed by two researchers, with a double-blind approach.

Pain, swelling, limitation, ROM, and muscular strength were evaluated before treatment and on the fifth and tenth KT treatment days. The first measurements before KT were taken on the fourth day following the surgery. The fifth and tenth day assessments were carried out right after removing KT. Subjective functions were determined with the modified Cincinnati (30-point),[21] Lysholm and Tegner[22] tests in the postoperative first and third months (Fig. 4).

Knee extension limitation was designated in the supine position and flexion ROM was designated in the prone position using a universal goniometer. The patients were asked to push their knees downwards as much as they could while the goniometer's pivot tip was on the femur's lateral epicondyle to measure the extension limitation. The flexion ROM was measured when patients were asked to bend their knees.

The severity of pain at rest, sleep and during activity was determined based on a 11-point numerical pain scale in which 0 symbolizes 'no pain' and 10 symbolizes 'maximum pain'.[23] The swelling level was estimated as the difference between the operated and healthy sides' circumferential measurements. Measurements were taken on the mid-patella points of both legs, 10 cm below and above this point by using a measuring tape.

Isometric muscular strength measurements were performed by using a Baseline® hand dynamometer (Fabrication Enterprises Inc., White Plains, NY, USA) with the knee in 30° of flexion. While the hamstring strength measurement was conducted in the prone position, the quadriceps strength measurement was conducted on the side of the bed with the patient's back flat, arms crossed and the hip at 90° sitting position. After ensuring stabilization in these measurements, the dynamometer was placed on the proximal of malleolar in the vertical position and the patients were asked to push the dynamometer with their maximum strength for five seconds. The mean of three repetitions performed with two-minute intervals after the first attempt was recorded in kilogram-force.

The analysis conducted on activity pain data of the pilot study by using PASS 2008 showed that every group required 13 people for the study to have a statistical power of 80%. SPSS 14.0 was used for statistical analyses. Chi-square tests were applied for categorical data. In intergroup comparisons, the Mann–Whitney U test was used for the Tegner score, time between injury and repair, limitation, swelling, and pain parameters, and Student's t-test for the others. The Friedman test was applied for the limitation, swelling and pain measurements in intragroup evaluations on the change at three time points; whereas analysis of variance (ANOVA) was applied for other parameters. Statistical significance level was accepted as $p < 0.05$.

Table 1
Demographic and clinical characteristics of groups before Kinesio taping.

	Experimental group (n = 15)	Control group (n = 15)	p
Gender (male/female)	15/0	15/0	1
Average age (year)	28.60	27.66	0.681
Range (SD)	22-37 (4.50)	18-39 (7.45)	
Average height (cm)	176.33	179.33	0.224
Distribution (standard deviation)	167-185 (5.89)	170-190 (7.23)	
Average body weight (kg)	80.40	82.20	0.688
Range (SD)	66-97 (8.95)	64-115 (14.67)	
Educational level			0.479
Primary school/secondary school/high school/college	1/1/4/9	0/2/7/6	
Dominant side (n/%)			0.136
Right	11 (73.3%)	7 (46.7%)	
Left	4 (26.7%)	8 (53.3%)	
Side where ACL repair was conducted (n/%)			0.705
Right	9 (60%)	10 (66.7%)	
Left	6 (40%)	5 (33.3%)	
Reason of ACL injury (n/%)			1
Daily activities	5 (33.3%)	5 (33.3%)	
Sports	10 (66.6%)	10 (66.6%)	
Time between ACL injury and repair (month)	20.86	35.60	0.325
Range (SD)	2-84 (25.42)	1-132 (42.01)	
Graft type (n/%)			0.427
Hamstring autograft	9 (60.0%)	12 (80.0%)	
Allograft	6 (40.0%)	3 (20.0%)	
Simultaneous meniscus surgery (n/%)			0.413
No meniscus surgery	4 (26.7%)	6 (40%)	
Meniscus repair	4 (26.7%)	5 (33.3%)	
Partial meniscectomy	7 (46.7%)	3 (20.0%)	
Total meniscectomy	0 (0.0%)	1 (6.7%)	
Simultaneous microfracture procedure (n/%)			1
Yes	2 (13.3%)	2 (13.3%)	
No	13 (86.6%)	13 (86.6%)	

ACL: anterior cruciate ligament, SD: standard deviation.

Results

In assessments made before the KT treatment, the groups were homogeneous in terms of demographic and clinical characteristics ($p > 0.05$) (Tables 1–3, Figs. 5 and 6). Intragroup comparisons showed significant improvements in both groups on the fifth and tenth KT treatment days and in the postoperative first and third month evaluations ($p < 0.05$) (Tables 2 and 3, Figs. 5 and 6). In comparison to the control group, the experimental group showed significant improvements in swelling around the patella, all pain measurements and hamstring muscle strength on the fifth KT treatment day and knee flexion ROM, night pain, all swelling measurements and hamstring muscle strength on the tenth KT treatment day ($p < 0.05$) (Table 2, Figs. 5 and 6). There was no significant improvement in subjective functions, knee extension limitation and extensor muscle strength ($p > 0.05$) (Table 3).

Table 2
Intragroup and intergroup comparisons for the goniometric and dynamometric measurements at three time points.

Time	Experimental group (n = 15) mean ± SD	Control group (n = 15) mean ± SD	Intergroup statistics (p)
Knee extension limitation (°)			
Before KT	3.66 ± 3.51	1.66 ± 3.08	0.082
5th KT day	2 ± 2.53†	1.33 ± 2.96‡	0.312
10th KT day	0.66 ± 1.75†	0.33 ± 1.29‡	0.550
Knee flexion ROM (°)			
Before KT	28.80 ± 8	30.93 ± 6.07	0.418
5th KT day	50.93 ± 11.71*	43.66 ± 7.42*	0.052
10th KT day	76.80 ± 14.85*	60.13 ± 8.79*	**0.001**
Quadriceps muscle strength (kg-force)			
Before KT	2.46 ± 0.99	2.66 ± 1.54	0.676
5th KT day	6.40 ± 2.29*	5.46 ± 2.79*	0.327
10th KT day	9.73 ± 3.08*	8.26 ± 2.93*	0.193
Hamstring muscle strength (kg-force)			
Before KT	2.60 ± 1.35	2.53 ± 0.91	0.876
5th KT day	6.33 ± 1.54*	5.13 ± 1.40*	**0.034**
10th KT day	9.86 ± 2.32*	7.53 ± 2.16*	**0.008**

ROM: range of motion.
ANOVA and Friedman (in limitation assessment) test results compared to before Kinesio taping (KT) results.
*$p < 0.001$, †$p < 0.01$, ‡$p < 0.05$. P values below 0.05 are written in bold.

Discussion

Treatment of postoperative pain and swelling is important during the rehabilitation of ACL reconstruction. This is because the swelling causes a decrease in the quadriceps strength through arthrogenic muscle inhibition[24] and the pain complicates exercising.[25] KT may pull the skin upwards and increase the lymphatic drainage through blood circulation, and therefore reduce edema and relieve the pain by removing the pressure on the subcutaneous pain receptors.[11,12,14] KT is commonly used in pain treatment.[14] Various neurological and non-neurological mechanisms have been defined for the pain effect of KT.[14] A previous study has shown that postoperative edema and pain were reduced with a 28-day KT treatment in patients with ACL reconstruction.[19] In addition, postoperative KT treatments performed by using the lymphatic correction technique have been reported to be effective in controlling pain and edema.[11,12]

Table 3
Mean scores of the modified Cincinnati, Tegner and Lysholm scales.

Measurements	Postop month	Experimental group n = 15	P value intragroup (experimental)	Control group n = 15	P value intragroup (control)	P value intergroup
Modified	1st	7.00 ± 0.84	0.001*	7.60 ± 1.05	0.001*	0.097
Cincinnati	3rd	23.93 ± 2.25		23.00 ± 1.96		0.236
Tegner	1st	0.66 ± 0.48	0.001*	0.60 ± 0.50	0.001*	0.710
	3rd	2.73 ± 0.79		2.86 ± 0.74		0.593
Lysholm	1st	72.33 ± 5.61	0.001*	74.26 ± 5.16	0.001*	0.335
	3rd	85.13 ± 6.27		86.93 ± 5.86		0.424

Paired-samples t-test results.
*$p < 0.001$.

In this study, significant decreases were observed in pain severity after the first five days of KT treatment. Comparisons conducted at the final follow-up showed that the swelling on the operated knee was reduced significantly in the experimental group. Despite this decrease in swelling, no significant increase occurred in the quadriceps strength of the operated leg. Various reasons may have played a role in this result: (1) the duration of KT treatment was short and full recovery was not obtained in swelling around the knee, (2) it failed to apply sufficient tension during the KT application on the rectus femoris due to acute conditions,[10] (3) graft types protecting the quadriceps muscles were used in surgery and the KT method was not effective in increasing the quadriceps strength under healthy conditions,[26,27] and (4) in order to protect the graft, measurements of isometric muscle strength were conducted at 30° of knee flexion.[28] However, the maximum isometric strength of the quadriceps muscle is determined through measurements performed at 60° of knee flexion for the optimal correlation between force and height.[29] (5) In addition, atrophy developing after ACL injury and surgery leads to a loss in the quadriceps strength.[30] It was found that atrophy could not be prevented through KT treatment applied in the early rehabilitation period of ACL repair.[19]

The reason to loss in muscular strength after ACL reconstruction is unknown. The source of this insufficiency is thought to be mechanical and neuronal factors, condition loss and activity changes in the motor unit.[31,32] In the acute and subacute periods of ACL reconstruction, KT's acute effects on the muscle activity and strength have been analyzed in the literature, after KT was applied on the quadriceps muscle on its own or with the mechanical/proprioceptive support provided for the knee.[15–18] Patients who underwent hamstring autograft ACL reconstruction with no findings of pain and inflammation were included in a randomized and controlled study.[17] After the quadriceps KT practice, no significant change was reported in balance and the quadriceps muscle's electromyographic activities and isokinetic strength. In other studies, as a result of the KT practice, significant increases were reported in dynamic balance, isokinetic quadriceps and hamstring muscular strength, quadriceps electromyographic activities, and jumping performance.[15,16,18]

Kinesio tape's effects and mechanisms on the muscle strength following ACL reconstruction are not clear.[15–18] KT may send continuous mechanical/elastic stimuli to skin receptors.[10] The support and stimuli provided through the KT applied on the joints and muscles may increase the activation of big motor units by increasing the muscular strength.[33] Hamstring autografts were used on 70% of the subjects who were included in this study for ACL reconstruction. Hamstring tendon autograft in ACL surgery may lead to a reduction in the knee flexion strength in the long-term.[31,32] Therefore, both anterior and posterior muscles of the thigh were facilitated and lymphatic correction was performed on the knees in the KT treatment in the experimental group. Thus, the operated area that was exposed to neuronal inhibition and various mechanical changes during the ACL reconstruction was supported with KT. In the experimental group, measurements with hand dynamometer showed a significant increase in the isometric hamstring strength. Isometric methods are recommended[29] and the use of hand dynamometers is preferred in muscular strength measurements under acute conditions in joint surgeries.[34]

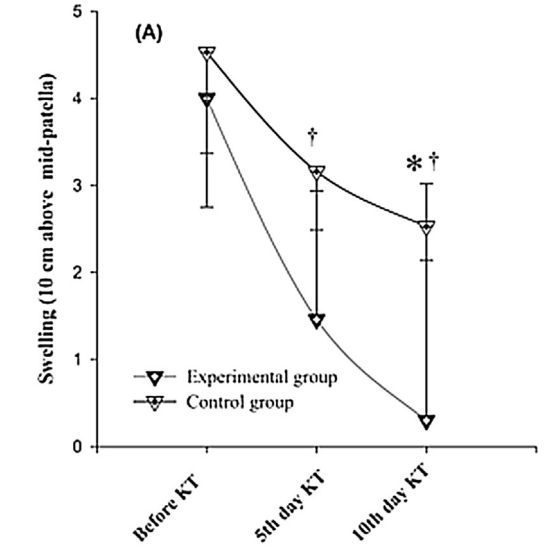
The quadriceps and hamstring muscles control the knee's dynamic stability.[35] The hamstring muscle forms an agonist effect on the ACL function and mechanically protects the ACL against the antagonist effect of quadriceps activities.[34,35] Strength increases observed to be related to the hamstring muscle in this study may have positive effects on protection of the recovering graft. This is especially important for patients with hamstring autograft reconstruction as they often experience impaired knee flexion strength on the operated side.[31]

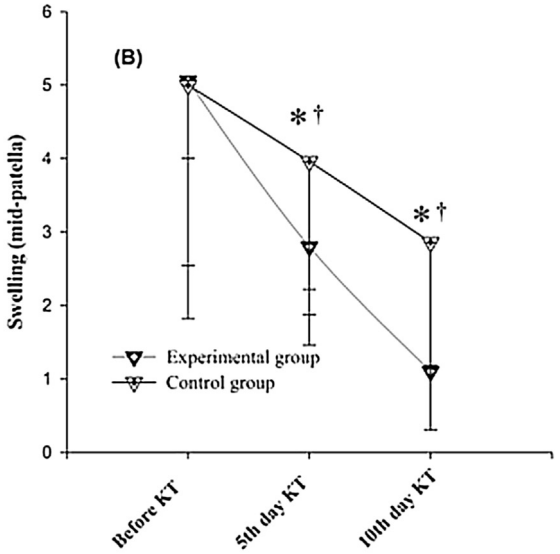
Quadriceps strength is a significant factor that determines the functional level after ACL reconstruction.[36] Quadriceps strength insufficiency may develop after ACL surgery even if the exercises have been performed.[30] The KT treatment given to the experimental group in this study did not lead to a significant increase in the quadriceps strength. In parallel, no significant difference was found between the groups in terms of function and activity levels measured at the postoperative first and third months. When the results were examined together, a KT practice supported by physical agents such as electrical stimulation[8] and vibration treatments[37] may be useful in the follow-up of ACL reconstruction if applied for 10 days or longer; this is because the quadriceps muscle that gains strength may increase the rehabilitation effect and ensure protection of the knee against degenerative changes.[36,38]

It was reported in previous KT studies that the knee ROM increases after surgery were observed only in the direction of extension.[12,15,19] In our experimental group, no significant improvement was confirmed in extension limitation, however, a significant increase was observed in flexion ROM. Since ROM measurements were active-assistive, this increase was thought to be related to the significant effect caused by the KT treatment on knee flexion strength.

Limitations for this study may include the absence of no tape group, the use of different graft types in surgery, simultaneous performance of surgeries for cartilage/meniscus injuries and unexamined medication needs of the patients.

Conclusively, the KT lymphatic correction and rectus femoris-hamstring muscle techniques added to the early rehabilitation of anatomical single-band ACL reconstruction may be effective in controlling edema and pain, and increase the flexion strength and ROM in the operated knee. KT treatment may be recommended for the rehabilitation of hamstring autograft after ACL reconstruction.





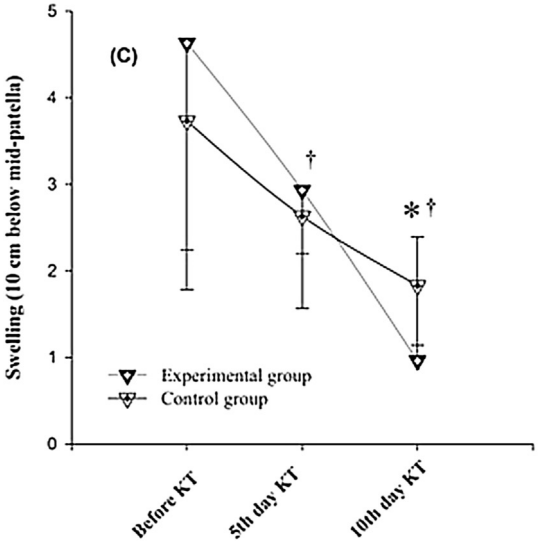
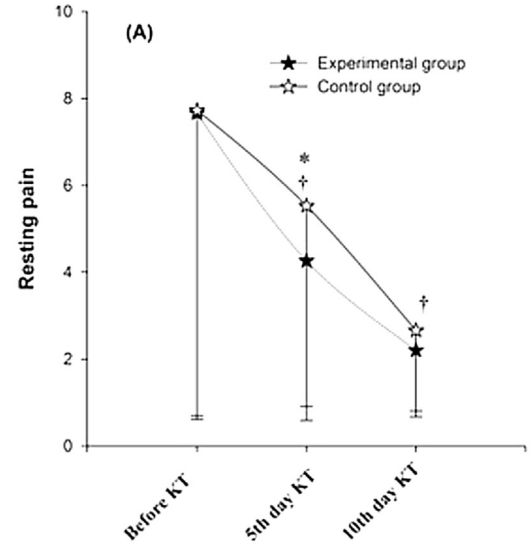
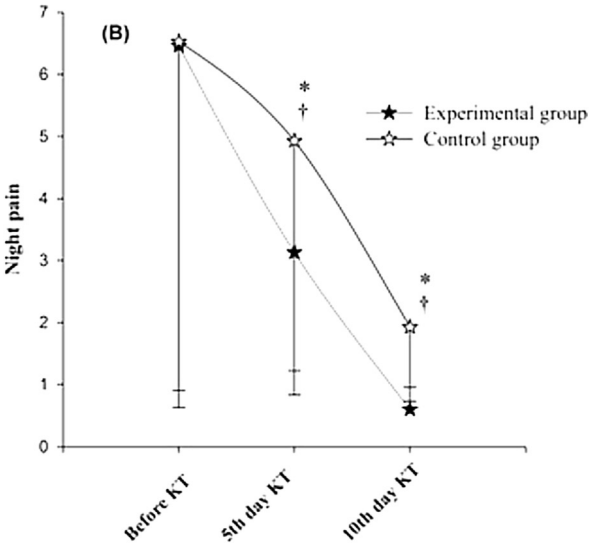


Fig. 5. Swelling scores at three time points: (A) above mid-patella, (B) mid-patella, (C) below mid-patella. *Intergroup comparison ($p < 0.05$). †Intragroup comparison ($p < 0.05$).





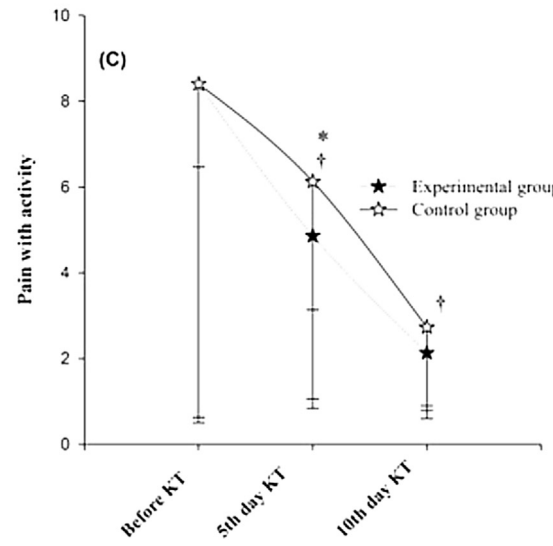


Fig. 6. Pain scores at three time points: (A) resting pain, (B) night pain, (C) pain with activity. *Intergroup comparison ($p < 0.05$). †Intragroup comparison ($p < 0.05$).

Conflicts of interest

No conflicts declared.

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