Original Investigation / Özgün Araştırma

The Effectiveness of Various Physical Therapy and Rehabilitation Modalities in Patients Developing Knee Contracture Due to Immobilization

İmmobilizasyona Bağlı Diz Kontraktürü Gelişen Hastalarda Farklı Fizik Tedavi ve Rehabilitasyon Yöntemlerinin Etkinliği

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ABSTRACT

Objective: The purpose of this study was to assess the effects of different physiotherapy and rehabilitation programs on knee range of motion (ROM), pain, depression, health status among patients who developed knee contracture due to immobilization.

Methods: Thirty-six patients were included. The patients were divided into four groups: Group 1, stretching exercises (SE); group 2, SE and whirlpool (WP); group 3, SE and ultrasound (US); group 4, SE, WP and US. Each patient's knee ROM was assessed by using goniometry. Pain was assessed by using the visual analog scale (VAS), depression was assessed by using the Beck Depression Scale (BDS), health status was determined using Short Form-36 (SF-36) before and after the treatment, at the first and at the third months of the treatment.

Results: In all of the treatment groups, a significant increase in knee flexion was observed in the study periods compared to the pretreatment period; no statistically significant difference was detected between the groups. Assessing the VAS results, all the treatment groups except group 4 experienced a significant improvement in pain severity in the longterm compared to pretreatment; no significant difference between groups was detected. Significant improvement in health status, measured using SF-36 subgroup scores for physical function, pain, was observed within all treatment groups in the longterm compared to pretreatment. All of the treatment groups showed significant improvement in their BDS scores in the long-term compared to pretreatment.

Conclusion: SE application increased flexion mobility and as a result, both depression level and health status improved.

Keywords: Knee contracture, range of motion, health status, rehabilitation

ÖZET

Amaç: Bu çalışmanın amacı immobilizasyona bağlı diz kontraktürü gelişen hastalarda farklı fizik tedavi ve rehabilitasyon programlarının eklem hareket açıklığı (EHA), ağrı, depresyon düzeyi ve sağlık durumu üzerine etkinliğini değerlendirmekti.

Yöntemler: Bu çalışmaya 36 hasta alındı. Hastalar dört gruba ayrıldı: Grup 1'e germe egzersizi (GE), grup 2'ye GE ve whirlpool (WP), grup 3'e GE ve ultrason (US), grup 4'e GE, WP ve US tedavisi uygulandı. Hastaların diz EHA gonyometre ile değerlendirildi. Ağrı derecesi visual analog skala (VAS) ile, depresyon düzeyi Beck depresyon skalası (BDS) ile ve sağlık durumu Short-Form-36 (SF-36) ile tedavi öncesinde, tedavi sonrasında, tedaviden sonra 1. ay ve 3. ayda değerlendirildi.

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Bulgular: Tedavi gruplarının hepsinde tedavi öncesine göre tüm kontrol dönemlerinde diz fleksiyon hareketinde anlamlı artış saptandı, ancak gruplar arasında istatistiksel olarak anlamlı bir üstünlük tespit edilmedi. VAS sonuçları değerlendirildiğinde grup 4 hariç diğer tedavi gruplarında tedavi öncesine göre uzun süreli takiplerde ağrı şiddetinde anlamlı düzelme olduğu saptandı, gruplar arasında anlamlı fark tespit edilmedi. Tedavi gruplarında SF-36 sonuçları değerlendirildiğinde, tedavi öncesine göre kontrol dönemlerinde SF-36'nın alt gruplarından fiziksel fonksiyon ve ağrı yönünden anlamlı düzelme tespit edildi. Benzer şekilde BDS sonuçları değerlendirildiğinde, tedavi öncesine göre kontrol dönemlerinde depresyon düzeyinde azalma saptandı.

Sonuçlar: Çalışmamızda GE tedavisinin fleksiyon hareket açıklığını artırdığı, buna bağlı olarak depresyon düzeyi ve sağlık durumunda iyileşme sağladığı sonucuna varılmıştır.

Anahtar sözcükler: Diz kontraktürü, eklem hareket açıklığı, sağlık durumu, rehabilitasyon

Introduction

In order for a joint to fulfill its function, it is very important for the joint to have full range of motion (ROM) (1,2). ROM is maintained by repetitive movements performed with activity. However, joint movement gradually becomes restricted as a result of immobilization due to various reasons. Even short term immobilization results in a decrease in ROM (3). Decreases in joint motion due to immobilization without any traumatic or inflammatory cause occur after strict immobilization for a period longer than 4 weeks. (2).

One of the most frequent causes of immobilization is trauma. Among joints responsible for carrying body weight, the knee joint is the most vulnerable to repeated external trauma (1,4). Other causes of immobilization include muscle imbalance, neuromuscular diseases, inflammatory disorders, degenerative processes and prolonged bed rest due to chronic disease (5,6).During periods of extended immobilization, the synovium thickens, scar tissue develops and as a result of periarticular structures and shortening of the joint capsule, restricted mobility leads to joint contracture (7-10).

To minimize the negative effects of contracture, it is critical to correctly determine an appropriate treatment and implement it early. Within the knee contracture treatment protocol includes treatment with superficial and deep heaters, active and passive ROM exercises, progressive resistive exercises, stretching exercises, iontophoresis treatment, serial plastering, splinting, and surgical treatment. (11-14). The best way to mobilize the joint affected tissues such as the capsule, the connective tissue and the synovium must be heated to the patient' s tolerance level. ROM and stretching exercises should be performed either during or immediately after, heat application to the joint and peripheral structures (11,15-18).

Most previous studies of knee tissue have been conducted with animals and data regarding the effectiveness of treating knee contracture with exercise and physiotherapy are currently insufficient. Our purpose in this study was to assess the effects of stretching exercises and different physiotherapy methods on ROM, pain, depression level and health status among patients with knee contracture.

Material and Methods

Forty-four patients diagnosed with knee contracture upon presenting to the clinic were included in this study. Knee contracture was secondary to immobilization after fractures to the femoral shaft, the distal end of the femur, the femoral intercondylar region, the tibial shaft, the proximal end of the tibia or the patella. The etiology was as follows: traffic accidents (17 patients), falling (11 patients), sports injuries (6 patients), and work accidents (2 patients). All patients underwent surgical procedures and used a knee brace before the rehabilitation period.

All patients included in the study had no movement restriction in the hip or ankle joints and no peripheral nerve damage. The criteria of exclusion from the study included neurologic deficits, degenerative changes in the knee joint, pregnancy, existence of structural anomalies in the knee joint, advanced osteoporosis and serious metabolic disease.

Forty patients conforming to the criteria were included in this study. All patients' hip, knee and ankle joints were assessed bilaterally by the same physician through inspection and palpation. Both active and passive knee joint movements were measured in both flexion and extension. Thigh and calf circumference differences were measured, the perimeter of the patella was assessed and a neurologic examination was performed. Written informed consent was obtained from all participants in the study.

Treatment Methods

Exercise Program: In this study we included patients who had developed soft tissue contracture due to immobilization and the exercise program accordingly determined. Each patient performed one of the following exercise programs: strengthening exercises for antagonist muscles,stretching exercises for agonist muscles and isometric exercises for the hip, knee and ankle.The

exercises were applied by the same physiotherapist, who was blinded to the different treatment groups, five times per week for four weeks (20 sessions total). The stretching exercises consisted of static stretching. Each static stretching exercise was performed an average of five times for 20 second with 15 second resting periods between each repetition. Patients were asked to continue this exercise pattern for three months after discharge from the hospital.

Physiotherapy Program: The physiotherapy program included whirlpool (WP) and ultrasound (US) treatment. The treatments were performed by the same physiotherapist. WP treatment was applied at 38˚C (19). Patients placed their knees in a tank containing hot water for an average of 20 minutes. US treatment was applied to the periarticular region of the knee at a frequency of 1 MHz, an intensity of 1.5 W/cm^2, and a pulse ratio of 1:5 (20).

Physiotherapy treatment was applied once a day, five days per week, for four weeks for a total of 20 seances. Following US and WP treatment, the exercise program was applied.

Patients were randomly divided four 4 different treatment groups: group 1, stretching exercises (SE) only; group 2, SE and WP; group 3, SE and US; group 4, SE, US and WP. All patients were administered 1100 mg naproxen sodium each of the 20 days. Patients did not receive any other treatment during the study.

Assessment Criteria: All patients were evaluated using visual analog scale (VAS; 10 cm scale) to measure pain, the Beck Depression Scale (BDS) to determine depression and a health situation survey (short-form 36 health survey, SF-36) to assess health status before the treatment, during the treatment and at the first and at the third months of the treatment (21-23). Furthermore, at these four study periods, the patients' active and passive knee joint movements were assessed in the flexion direction with goniometry by measuring thigh and calf circumference differences and knee perimeter using a plastic tape measure.

Pain Assessment: Knee pain during activity over the previous seven days was assessed by using a VAS scale, ranging from 0 to 10 (0 points=no pain, 10 points=severe pain) (24, 25).

Depression Assessment: Depression status was assessed by using the BDS. The BDS is arranged as a survey composed of 21 questions. In response to each question, patients are asked to select one sentence out of four possible choices which best applies to them. The four sentences are ordered from a neutral situation (0 points), to the most severe situation (3 points). The highest score possible is 63 points. In our study, scores of 16 points or less were assessed as normal and scores of 17 points or more were assessed as depression (21-23).

Health Status Assessment: Health status was assessed using the SF-36. The SF-36 is composed of 36 questions divided under eight subtitles: physical function, physical capacity, emotional situation, social function, general health, mental health, life and pain. Scores were calculated and health status was determined on a scale of 0 (worst health situation) to 100 (best health situation) (23).

Clinic Measurements: Patients' knee joint movements were measured in the flexion and extension using goniometry. Measurements were performed as follows: while the patient was lying face down, the goniometer's pivot point was placed on the femur's lateral condyle. While holding the fixed arm parallel to the femur's lateral middle line, the patient was asked to bend his or her knee while the moving arm followed the fibula. When the patient was unable to bend his or her knee any further, the final measurement was recorded as the flexion angular value. The extension angular value was measured with the patient's leg fully straightened (26). Using the same methods, passive knee flexion and extension were measured as well. Furthermore, using a plastic tape measure, thigh circumference measurements were obtained 10 cm above the superior side of both patellae, and calf circumference measurements were obtained 10 cm below the inferior side of both patellae. The thigh and calf circumference differences were then determined. Patellae perimeter measurements performed to evaluate and follow the soft tissue swelling around the knee joint. The measurements carried out with plastic tape measure from the middle of patellae in horizontal plane and compared with the uneffected side. All measurements were performed by the same physician in all study periods.

Randomization

The study initially began with 40 patients. Patients selected sealed envelopes and were randomly divided based on the contents of their envelopes into four groups.

Compliance with Treatment

During the study, one patient in group 1 left the study after failing to receive permission to participate from his employer. Two patients in group 2, two patients in group 3, and one patient in group 4 left the study for private reasons. Another patient in group 2 moved to another city, and one patient in group 4 left after falling and suffering knee trauma. The remaining 36 patients completed all controls.

Statistical Analysis

To compare the categorical data of the different treatment groups, the chi-square ($\chi 2$) test was used. Values were compared between treatment groups using the Kruskal-Wallis test. The Wilcoxon marked sequence test was used to perform comparisons within each treatment group in terms of time. A p-value less than 0.05 was considered statistically significant.

Results

The study was completed with a total of 36 patients. The mean patient age for each group was as follows: group 1, 36±18.19 years; group 2, 20±13.92 years; group 3, 30±14.66 years; and group 4, 20±12.45 years. There was no statistically significant difference between the four groups in terms of age, sex or body mass index (p>0.05). The demographic characteristics of the groups are provided in Table 1. For each group, the average duration of trauma before treatment was as follows: group 1, 20.8±42.2 months; group 2, 4.4 ±1.6 months; group 3, 22.8±37.8 months; group 4, 15.2±17.4 months.

In-Group Assessment

Significant improvement in VAS values was observed in group 1 and group 2, between pre-treatment and both post-treatment and three months after treatment (group 1: p=0.017 and p=0.031, respectively; group 2: p=0.041 and p= 0.034, respectively). Group 3's VAS values also improved significantly between pre-treatment and post-treatment and between the first and the third months after treatment (p=0.016, p=0.011 and p=0.010, respectively). In group 4, no significant changes in VAS values were detected (p>0.05).

When BDS scores for the four study periods were compared within treatment groups, statistically significant improvements were detected between the pre-treatment period and both the first and third months after treatment (group 1: p=0.052, p=0.024 and p=0.038, respectively; group 2: p=0.034, p=0.042 and p=0.017, respectively; group 3: p=0.028, p=0.024 and p=0.023, respectively; group 4: p=0.008, p=0.012 and p=0.008, respectively).

When treatment groups are compared within themselves in terms of four study period for SF-36's eight sub-groups significant recovery was detected in all four groups between pre-treatment score and the scores in the first and in the third months of controls only in terms of physical function (in group 1 p=0.042, p=0.017, p=0.027 respectively, in group 2 p=0.018, p=0.027, p=0.03 respectively, in group 3 p=0.027, p=0.036, p=0.028 respectively, in group 4 p=0.018, p=0.05, p=0.028 respectively) and pain (in group 1 p=0.007, p=0.012, p=0.018 respectively, in group 2 p=0.009, p=0.01, p=0.01 respectively, in group 3 p=0.027, p=0.026, p=0.011 respectively, in group 4 p=0.016, p=0.02, p=0.027 respectively)

When active flexion angle measurements for the four study periods were compared within treatment groups, statistically significant differences were detected between the measurements performed in the first month and the third month after treatment and the pre-treatment measurements (group 1: p=0.014, p=0.011, and p=0.011, respectively; group 2: p=0.011, p=0.011 and p=0.012, respectively; group 3: p=0.012, p=0.018 and p=0.018, respectively) In group 4, statistically significant differences were detected between the passive flexion angle measurements from both the first month and the third month after treatment and pre-treatment measurements (p=0.007 and p=0.049, respectively), statistically significant differences were also observed between post treatment and pre-treatment active flexion angle measurements (p=0.007). No statistically significant differences were found when comparing active and passive extension angle measurements for the four study periods within treatment groups (p>0.05).

No statistically significant difference between knee joint perimeter values, thigh circumference difference values or calf circumference difference values were detected when comparing between or within the four groups (p>0.05).

Table 1. Demographic characteristics of the groups.

	Group 1 (n=10)	Group 2 (n=8)	Group 3 (n=9)	Group 4 (n=9)	p
Age (average±SD)	36±18.19	20±13.92	30±14.66	20±12.45	0.062
Sex	3 (%30)female	4 (50%)female	3 (33%)female	0 (0%)female	0.133
	7 (70%) male	4 (50%)male	6 (67%)male	9 (100%)male	
BMI (average±SD)	25±4.4	20±7.01	22±4.97	23±6.74	0.438

SD: *Standard deviation,* ***BMI:*** *Body mass index*

Inter-Group Assessment

No statistically significant differences in terms of duration of immobilization, reasons for immobilization, fracture location, contracture type or contracture location were found between the four groups (p>0.05; Table 2).

No significant differences in the changes in VAS values between pre-treatment and either the first or the third month after treatment was observed between treatment groups (p>0.05). Similarly, no statistically significant differences were detected between treatment groups in terms of depression frequency, as determined by BDS scores, in the four study periods (p>0.05; Table 3).

When SF-36 scores for the eight sub-groups (general health, physical function, physical capacity, pain, life, social function, emotional situation and mental health) were compared between treatment groups, no statistically significant differences were detected for any of the four study periods (p>0.05; Table 4).

While significant improvements in active and passive flexion measurements were identified within treatment groups, no differences were found between treatment

Table 2. Characteristics of treatment groups.

	Group 1 (n=10)	Group 2 (n=8)	Group 3 (n=9)	Group 4 (n=9)	p
Period of staying immobile (month)	20,8±42,2	4,4±1,6	22,8±37,8	15,2±17,4	0,216
Immobilization reasons					0,573
Traffic accident	5 (%50)	3 (%37,5)	4 (%44)	5 (%56)	
Work accident	2 (%20)	0	0	0	
Falling	2 (%20)	3 (%37,5)	3 (%33)	3 (%33)	
Sport injuries	1 (%10)	2 (%25)	2 (%22)	1 (%11)	
Fracture localization					
Femoral shaft	3 (%30)	2 (%25)	3 (%33)	1 (%11)	
Distal end of the femur	3 (%30)	2 (%25)	0	3 (%33)	
Femoral intercondylar region	1 (%10)	2 (%25)	2 (%22)	1 (%11)	
Tibial shaft	0	1 (%12,5)	2 (%22)	0	
Proksimal end of the tibia	0	0	0	1 (%11)	
Patella fracture	1 (%10)	0	0	1 (%11)	
Combined fracture	2 (%20)	1 (%12,5)	2 (%22)	2 (%22)	
Contracture tipi					0,697
Flexion	6 (%60)	6 (%75)	5 (%56)	5 (%56)	
Extension	0	0	1 (%11)	0	
Flexion and extension	4 (%40)	2 (%25)	3 (%33)	4 (%44)	
Contracture place					0,09
Left knee	2 (%20)	4 (%50)	7 (%78)	5 (%56)	
Right knee	8 (%80)	4 (%50)	2 (%22)	4 (%44)	

Table 3. Comparison of control and treatment groups with BDS results.

BDS	Group 1 (n=10) Average± SD	Group 2 (n=8) Average± SD	Group 3 (n=9) Average± SD	Group 4 (n=9) Average± SD	p
Pre-Treatment	15.1±7.46	10.37±6.16	14±6.72	13±2.91	0.469
Post-Treatment	10.6±5.37	6.37±3.29	7.77±4.14	7.66±1	0.28
1st month	9.9±7.29	6.62±3.88	8.11±4.4	7.77±2.1	0.763
3rd month	10.1±7.34	5.37±3.06	7.22±3.38	7.66±2.34	0.387

SD: *Standard deviation*

groups (p>0.05; Table 5). No statistically significant differences were demonstrated between the knee joint perimeter values or thigh or calf circumference differences of the different groups (p>0.05).

No adverse effects related to treatment were observed in treatment group patients. All patients followed the home exercise program up through the third month after treatment.

Table 4. Comparison of SF-36 scores of control and treatment groups.

	Group 1 (n=10) Average± SD	Group 2 (n=8) Average± SD	Group 3 (n=9) Average± SD	Group (n=9) Average±SD	p
Pre-Treatment					
Physical function	44±41.28	46.25±32.59	23.33±19.84	57.77±20.17	0.194
Physical capacity	30±48.30	50±53.45	22.22±44.09	33.33±50	0.681
Pain	41±20.78	37.5±7.07	52.22±13.94	40±8.66	0.135
General health	48±9.48	54.37±7.28	55.55±9.16	59.44±9.82	0.092
Life	73±17.35	69.37±11.16	66.11±18.67	56.66±7.5	0.058
Social function	46.1±8.44	46.75±8.79	49.88±8.84	45.83±6.25	0.737
Emotional situation	56.6±49.8	75±46.29	48.11±50.32	55.55±52.70	0.712
Mental health	66.4±12.24	68.5±4.98	62.66±10.95	57.33±6.92	0.05
Post-Treatment					
Physical function	54.5±48.73	78.75±17.06	48.88±34.07	81.11±13.86	0.339
Physical capacity	50±52.70	87.50±35.35	44.44±52.70	44.44±52.70	0.24
Pain	26±21.18	21.25±8.34	33.33±16.58	27.77±13.94	0.513
General health	55.50±11.16	50±10.35	52.22±10.34	54.44±8.81	0.423
Life	72±13.37	70±8.01	65±16.77	60.55±9.5	0.13
Social function	42.4±8.8	42.12±6.52	52.72±15.08	47.05±8.36	0.267
Emotional situation	90±31.62	75±46.29	48.11±50.32	88.88±33.33	0.114
Mental health	64±6.53	67±8.48	68.88±9.54	67.55±6.14	0.431
1st month					
Physical function	56.5±46.9	74.37±21.61	53.88±33.05	81.11±27.13	0.23
Physical capacity	80±42.16	87.50±35.35	80.55±39.08	55.55±52.70	0.423
Pain	26±18.37	21.25±8.34	37.77±18.55	17.77±19.86	0.079
General health	57.5±11.36	56.87±10.99	60±12.5	51.66±11.45	0.581
Life	67±13.16	74.37±7.28	64.44±12.61	60.55±14.88	0.17
Social function	46.2±6.12	43.75±6.68	44.38±9.13	45.72±6.41	0.917
Emotional situation	90±31.62	75±46.29	81.48±37.67	77.77±44.09	0.853
Mental health	65.6±6.31	66.5±7.69	68.44±6.76	67.11±8.89	0.822
3rd month					
Physical function	56±46.47	75±22.36	54.44±32.05	84.44±25.30	0.126
Physical capacity	80±42.16	87.50±35.35	80.55±39.08	55.55±52.70	0.423
Pain	27±20.57	17.5±12.81	32.22±18.55	18.88±19	0.254
General health	58.5±9.44	56.87±10.32	60±12.5	49.44±17.93	0.596
Life	67.5±12.07	70.62±10.83	66.66±12.74	52.22±21.95	0.128
Social function	46.25±6.03	43.75±6.68	44.44±9.08	41.50±17.63	0.828
Emotional situation	90±31.62	75±46.29	81.48±37.67	77.77±44.09	0.853
Mental health	65.6±6.31	67.5±8.92	69.77±6.96	57.33±23.15	0.292

SD: *Standard deviation*

Table 5. Comparison of knee range of motion measurements in control and treatment groups.

	Group 1 (n=10) Average± SD	Group 2 (n=8) Average± SD	Group 3 (n=9) Average± SD	Group 4 (n=9) Average± SD	p
Pre-Treatment					
Active flexion	82±24.28	66.37±30.03	67.77±45.28	65±26.45	0.434
Passive flexion	84.5±24.77	68.12±30.11	71.11±43.14	67.77±27.96	0.448
Active extension	2.5±4.85	3.75±7.44	3.88±6.97	5.55±10.13	0.971
Passive extension	3.5±5.29	2.5±7.07	2.77±5.65	5.55±10.13	0.738
Post-Treatment					
Active flexion	98.5±29.91	88.12±35.34	94.44±39.79	88.88±26.66	0.81
Passive flexion	105.5±33.78	91.87±37.02	103.88±38.95	96.11±25.09	0.681
Active extension	1±3.16	0.62±1.76	1.11±3.33	1.11±3.33	1
Passive extension	1.3±2.83	0	0	0	0.148
1st month					
Active flexion	101±30.34	88.12±31.84	101.11±33.23	85±31.22	0.662
Passive flexion	107±33.76	91.87±32.5	107.22±33.17	87.77±31.53	0.445
Active extension	0.8±2.52	0.62±1.76	2.22±4.4	1.11±3.33	0.823
Passive extension	0.8±2.52	0	1.66±5	0	0.601
3rd month					
Active flexion	102.5±31.2	98.75±33.24	102.77±34.65	74.44±37.45	0.253
Passive flexion	107.5±34.09	101.25±33.24	107.22±33.17	91.66±31.72	0.662
Active extension	0.8±2.52	0	2.22±4.4	1.11±3.33	0.527
Passive extension	0.8±2.52	0	1.66±5	0	0.601

SD: *Standard deviation*

Discussion

In this study, we clinically demonstrated that SE and different physiotherapy methods provide positive improvement in knee flexion joint movement, depression level and health status to patients diagnosed with knee contracture. Values were improved post-treatment compared to pre-treatment, as well as, in the long-term, through the third month after treatment. However, heat application before SE provided no additional benefit.

Although there are many causes of knee contracture, one of the most common causes is immobilization (27-30). A joint may be immobilized due to factors including fractures requiring a brace, inflammatory diseases such as rheumatoid arthritis, paralysis, spasticity or muscle diseases (31, 32). Previous studies have demonstrated that, immobilization causes deterioration in the structure of collagen fibrils, shortening of the ligaments and joint capsule, and fibrosis, leading to contracture (33-36). Also, degeneration of articular cartilage, which is mostly irreversible, occurs as a result of immobilization (37). Patients developing knee contracture due to immobilization were included in this study. Most of the patients developed contracture as a result of a fracture caused by trauma. The causes of trauma included primarily traffic accidents, followed by occupational accidents, falls and sports injury. In order to objectively assess treatment responses, patients with similar etiopathogeneses were included in the study.

In a previous study, the knees of healthy mice and rabbits were immobilized and two weeks after immobilization, the development of knee contracture was detected (38). Furthermore in the serial observations of 2-12 weeks after immobilization, a progressive increase in the severity of contracture over time was observed (36). Therefore, for immobile patients, it is very important to start physical activity and ROM exercises early, in order to ensure appropriate positioning and to regularly position patients in a prone position (2, 7). Even a single movement of the joint each day may prevent contracture development (8). The earliest any patient included in our study received treatment was two months after trauma,

thus significant degeneration arose in these patients' joint cartilage, collagen fibers and periarticular structures. Although most of the patients in group 1 and group 2 involved into rehabilitation very late, the range of motion increase, health status andpsychologic significantly improved after treatment. This situation indicates us that the physical therapy andrehabilitation programme which consists both stretching exercises and physical therapy modalities, if applied in the early period may be more effective. Therefore to prevent contracture in immobile patients, it is highly important that patients be made aware of and begin an appropriate physiotherapy and rehabilitation program as soon as possible.

If preventive treatment methods are not applied properly, contracture may develop. In such cases, patients should be treated with an appropriate physiotherapy and rehabilitation program. Physiotherapy and rehabilitation with superficial and deep heaters (hot packs, US, WP, hydrotherapy, etc), ROM exercises, progressive resistive exercises, SE, iontophoresis treatment, serial plastering and splinting are commonly used in knee contracture treatment (39-41). If success cannot be achieved using conservative treatments, surgical methods may be used as well (42-44).

Stretching exercises (SE) are a basic physiotherapy treatment for contracture (45, 46, 47, 48). ROM increases with stretching and pain and adhesion decrease (49, 50). If stretching is not performed, collagen fibers shorten progressively (51). The simplest and most common type of stretching used for increasing muscle flexibility is static stretching (52, 53). In a previous study which assessed the effects of SE on humans, long-term stretching with low resistance was found to be more effective (54).

Heat application, another alternative for contracture treatment, increases the extension capacity of collagen. Heat may be applied superficially or deeply. Through heat application, stretching of scar tissue and adhesion is facilitated (13, 38, 39). We determined the patient treatments for our study based on this information. To determine the effectiveness of both deep and superficial heat separately, we created different treatment groups for each. Paraffin wax and whirlpool can be used as superficial heating agents before strectching exercises. In our study we prefered whirlpool theraphy for superficial heating before strectching exercises. The most important reason of this is the easy use of whirlpool for the lower extremity joints like knee according to the paraffin wax. The purpose of each treatment program was to decrease pain complaints and to improve patients' depression level and health statuses.

Currently, only a limited number of studies on knee contracture exist. Therefore although our study contains a small number of patients, it provides important information on the subject of knee contracture. In the present study, knee contracture was most frequently observed in the form of flexion contracture. The most common cause of immobilization, leading to knee contracture, was a traffic accident and the trauma most often affected the femoral shaft.

Among contracture patients, pain complaints may arise in daily life and during rehabilitation programs, negatively affecting the treatment programs. As previous studies were largely performed on rats, pain was not assessed. In our study, all the treatment groups except group 4 experienced a significant improvement in pain severity in the long-term compared to pre-treatment. This situation may be associated with low pain severity of patients in group 4 before treatment. Since there was no significant difference between the groups, it was observed that same level of pain reduction could be achieved through SE alone.

Due to the decrease in joint range of motion, knee contracture patients have trouble performing daily activities and may become dependent on others; as a result, patients' psychological statuses are often negatively affected. In the present study, all of the treatment groups demonstrated significant improvement in their BDS scores in the long-term compared to pre-treatment. Accordingly, as knee joint range of motion approaches normal levels, the depression level of the patient improves as well.

The knee joint bears the weight of the body, enables an individual to stand straight, provides the ability to balance and walk and plays a first degree role in active life. Therefore, since knee contracture leads to function loss, it significantly affects socioeconomic factors as well (55, 56). In our study, significant improvement in health status, measured using SF-36 sub-group scores for physical function and pain, was observed in all treatment groups in the long-term compared to pre-treatment. Thus according to our results, the same functional improvement may be accomplished through SE alone without heat application.

In the literature, a small number of studies exist that address knee contracture rehabilitation and most of them were performed on animals. In one such study, electric stimulation and placebo were compared in 33 rats that had been surgically altered to have flexion knee contracture. No significant difference in ROM was detected between the electric stimulation rats and the placebo rats (57). In another study of 48 rats with surgically-induced knee contracture, laser treatment and whirlpool treatment were compared and whirlpool treatment was found to be more effective in improving ROM (58). In a study similar to ours performed on rats with

knee contracture, rats were divided into three groups. The first group was treated with stretching alone; the second group was treated with stretching and infrared; and the third group was treated with stretching and US treatment. Significantly higher improvement in ROM was detected in the groups treated with both stretching and infrared or US compared to the group treated only with stretching. However no significant difference between the US and infrared groups was detected (59). During daily activities, knee ROM and flexion in particular is very important. A knee extension-flexion ROM of 0-67° is required for walking, 0-83° is required for climbing up stairs, 0-90° is required for climbing down stairs, 0-93° is required for sitting and 0-106° is required for tying shoes (4). In our study, asignificant increase in knee flexion ROM was detected within all treatment groups post-treatment and in long-term tracing, but no significant differences between the treatment groups were detected. The lack of significant improvement in the extension direction may be associated with the low number of patients. In contrast to past studies, many of which have suggested that stretching performed after heat application is more effective, our study found that the application of superficial and deep heat prior to SE did not provide additional improvement in ROM. Performing SE alone, without heat application, provides similar results in terms of both time and cost.

To our best knowledge, previous studies on knee contracture have been mostly conducted in animals; in contrast, our study enrolled human subjects with knee contracture resulting exclusively from immobilization as confirmed by etiological assessment. Although our study has a small sample size, we sought to evaluate each therapeutic modality separately by having as many study groups as possible. As this study was conducted in humans, the severity of pain, joint ROM, depression level and health status and their interrelationship could also be assessed, all of which were not adequately studied in previous trials and patients were followed for three months. We believe that, reduction of pain or increased range of motion alone is not sufficient and achieving and sustaining improvements in the level of depression and health status is considerably important for daily life activities. As such, in this study, treatment with superficial and deep heaters alone or in combination with stretching exercises was compared with stretching exercises alone. While an overall significant improvement was found in various parameters for all groups, equivalent improvement was observed in the group receiving only stretching exercises. We think that, this is a remarkable result because in contrast to what was advocated in many prior studies, no additional benefit of superficial or deep heaters could be observed when they were used before stretching exercises. Thus, adequate therapeutic effect could be achieved by using stretching exercises alone in patients developing knee contracture after immobilization, with a potential reduction in consumed time and cost.

Our study was restricted by the low number of patients. The physician performing the examinations and assessments during the study periods was not blinded to the study and thus also limited our study.

Our study provides important information regarding knee contracture treatment because the study was performed on patients, assessed healthand depression level and included long-term tracing. In our study, SE application increased flexion mobility and as a result, both depression level and health status improved. No additional benefit was observed when heat was applied prior to SE. Accordingly, in order to increase ROM and improve psychological and health status, SE alone are sufficient in terms of both time and cost. However, to provide more accurate information, more comprehensive studies with larger numbers of patients are required.

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