

# Evaluation of the effects of dexamethasone iontophoresis, galvanic current, and conservative treatment on pain and disability in patients with knee osteoarthritis and Baker's cyst

Dilek Eker Büyükkşireci<sup>1</sup>, Mehmet Büyükkşireci<sup>2</sup>, Erdal Komut<sup>2</sup>

<sup>1</sup>Department of Physical Medicine and Rehabilitation, Hitit University Erol Olçok Training and Research Hospital, Çorum, Türkiye

<sup>2</sup>Department of Radiology, Hitit University Erol Olçok Training and Research Hospital, Çorum, Türkiye

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## ABSTRACT

**Objectives:** This study aims to evaluate the effectiveness of galvanic current and dexamethasone iontophoresis in the treatment of knee osteoarthritis and Baker's cyst (BC).

**Patients and methods:** This prospective, randomized, controlled, single-blind study included 37 patients (9 males, 28 females; mean age: 57.8±10.3 years; range 40 to 75 years) with knee osteoarthritis and BC, between January and August 2020. The patients were randomized into three groups: the iontophoresis group (n=13), the galvanic current group (n=11), and the control group (n=13). The numerical rating scale (NRS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores and ultrasonographic measurements of BC were recorded at baseline, two weeks, and six weeks. All groups received the same physiotherapy program. Dexamethasone iontophoresis and galvanic current therapy were administered to the patients in the iontophoresis and galvanic current groups, respectively, with a galvanic current at an intensity of 0.1-0.2 mA/cm<sup>2</sup> for 10 days.

**Results:** There was no significant dissimilarity in demographic and clinical characteristics, basal NRS (resting and exercise) and WOMAC scores, and basal cyst volumes between groups. A significant temporal change was found in three groups for resting NRS, exercise NRS, and WOMAC scores and cyst volumes, except for the cyst volume in the control group. There was a notable difference in terms of improvement in cyst volumes between baseline and the second week in the iontophoresis group compared to the galvanic current group (p=0.046). There was a significant improvement in resting NRS and exercise NRS scores between baseline and the second week in the galvanic current group compared to the control group (p=0.015 and p=0.002, respectively). Additionally, a significant improvement was observed in resting NRS and exercise NRS scores between baseline and the second week in the iontophoresis group compared to the control group (p=0.009 and p=0.001, respectively).

**Conclusion:** A significant clinical and functional improvement was detected with dexamethasone iontophoresis in the treatment of patients with knee osteoarthritis and BC.

**Keywords:** Baker's cyst, dexamethasone iontophoresis, osteoarthritis.

Knee osteoarthritis is a common musculoskeletal condition, and a popliteal cyst (Baker's cyst [BC]) often accompanies knee osteoarthritis. Baker's cyst is considered the most common mass in the popliteal

fossa, and the incidence of BC ranges from 10 to 58%.<sup>[1-3]</sup> Baker's cyst is a synovial cyst connected with the knee joint that forms between the tendons of the gastrocnemius and semimembranous muscles.<sup>[4]</sup>

**Corresponding author:** Dilek Eker Büyükkşireci, MD. Hitit Üniversitesi Erol Olçok Eğitim ve Araştırma Hastanesi Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı, 19040 Çorum, Türkiye.

e-mail: dilekeker55@gmail.com

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In the diagnosis of BC, the sensitivity, specificity, and positive and negative predictive value of ultrasonography is 100%.<sup>[3]</sup> The meniscus, ligament lesions, and osteochondral degeneration can cause intra-articular fluid build-up and the formation of a BC. Baker's cyst is usually asymptomatic, and small and painless cysts do not need treatment. However, painful and large cysts can be aspirated, and steroid injections can be performed. Recent studies have shown that ultrasonography-guided aspiration and corticosteroid injection are effective in the treatment of BCs.<sup>[5-8]</sup> Intra-articular steroid injections can cause some complications, such as septic arthritis, tendon, blood vessel and nerve damage, and systemic effects (e.g., hyperglycemia, hypertension).

In iontophoresis, ionized substances are transferred to target tissues through the skin using electrical polarization. Thus, dexamethasone iontophoresis can provide anti-inflammatory effects without reaching systemic concentration in the blood.<sup>[9]</sup> If dexamethasone iontophoresis is effective, the treatment of BCs accompanying knee osteoarthritis without steroid injections can be successful.

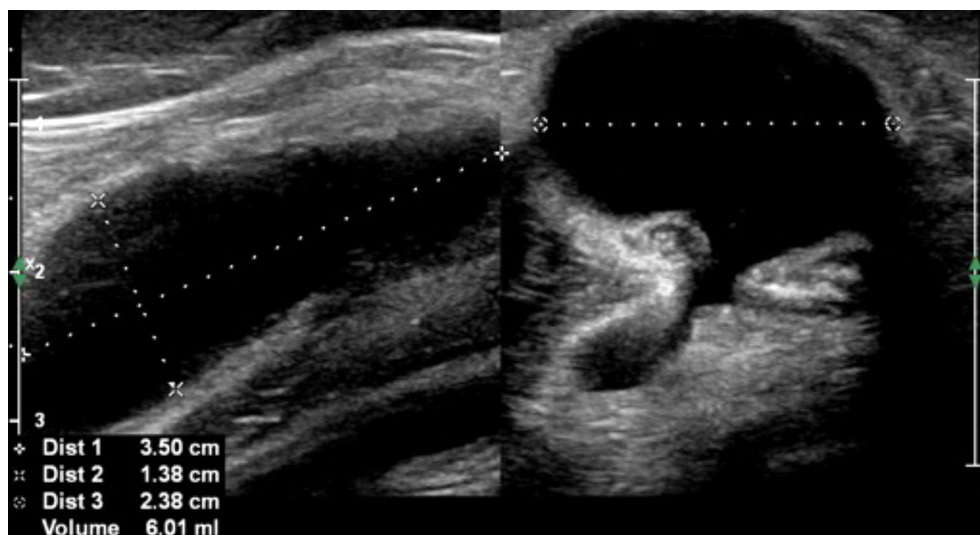
To our knowledge, no study has investigated the efficacy of dexamethasone iontophoresis in patients with knee osteoarthritis and BC. The study aimed to evaluate the effectiveness of dexamethasone iontophoresis and galvanic current on pain and disability in the treatment of knee osteoarthritis and BC.

## PATIENTS AND METHODS

This prospective, randomized, controlled, single-blind study was conducted on 37 patients (9 males, 28 females; mean age: 57.8±10.3 years; range 40 to 75 years) with knee osteoarthritis and BC at the Hitit University Erol Olçok Training and Research Hospital between January and August 2020. The patients were randomized into three groups: the iontophoresis group (n=13), the galvanic current group (n=11), and the control group (n=13).

Patients who had neurological and rheumatological diseases, trauma, a history of knee or lower extremity joint surgery, hip and ankle pain or disability, a history of steroid injection in the last three months, and contraindications of galvanic current and dexamethasone were excluded from the study.

Demographic and clinical characteristics of all patients were recorded. The osteoarthritis grade of all patients was evaluated according to the Kellgren-Lawrence classification. Additionally, the numerical rating scale (NRS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores were recorded at baseline, two weeks, and six weeks. Ultrasonographic (Affiniti 70, Philips Healthcare, Amsterdam) measurements of BCs were performed by a blinded radiologist with a 7-11 MHz linear probe at baseline, two weeks, and six weeks. Three measurements were recorded in transverse, axial, and longitudinal sections, and



**Figure 1.** Ultrasonographic images of a Baker's cyst.

the device automatically calculated the cyst volume (Figure 1).

The primary outcome measurement was the WOMAC, which is used in the evaluation of knee and hip osteoarthritis.<sup>[10]</sup> There are 24 questions and three subscales (five questions for the evaluation of pain, two questions for the evaluation of stiffness, and 17 questions for the evaluation of physical function) in the WOMAC.<sup>[11]</sup> In the study, questions were rated on a five-level Likert scale, and the total score was calculated as follows: (total point $\times$ 100)/96. The WOMAC has validity and reliability in the Turkish population.<sup>[12]</sup>

The NRS is a subjective scale in which individuals determine their pain on an 11-point numerical scale ('0' indicates no pain and '10' describes worst pain).<sup>[13]</sup> We assessed the rest and exercise pain of the patients with NRS at baseline, two weeks, and six weeks. The NRS is one of the scales that can be used to evaluate pain in Turkish patients.<sup>[14]</sup>

The assignment of patients randomization was made with a computer program by a physiotherapist, and researchers were blinded to the patients' groups. Oral paracetamol treatment was given to all patients three times a day for 10 days. The same physiotherapy program was applied to all groups. The physiotherapy program consisted of hot packs, transcutaneous electrical nerve stimulation (TENS) for 10 min, and exercises (knee range of motion, stretching,

isometric quadriceps femoris exercises, and hamstring muscle strengthening; 10 repeats a set with one set a day) for 10 days. All exercises were done under the supervision of a physiotherapist. In addition to the physiotherapy program, dexamethasone iontophoresis (1 mg dexamethasone per 1 g of dexamethasone %0.1 sterile ophthalmic pomade) was performed for 10 min a day for 10 days in the iontophoresis group. The anodal (active) electrode, with topical dexamethasone administered under it, was placed on the popliteal fossa, and a nonactive electrode was placed on the gastrocnemius muscles 10 cm distal to the anode. A galvanic current was applied at an intensity of 0.1-0.2 mA/cm<sup>2</sup> (ES-522; ITO Physiotherapy and Rehabilitation, 2 channel low and medium frequency Electrotherapy, ITO Co. Ltd., Tokyo, Japan) for iontophoresis.

Since a galvanic current is used in iontophoresis as the electrotherapy modality, it was also administered to the galvanic current group to distinguish whether the efficacy was due to dexamethasone iontophoresis or galvanic current. In addition to the physiotherapy program, the patients in the galvanic current group received galvanic current for 10 min a day for 10 days. The anodal electrode was placed on the popliteal fossa, and the nonactive electrode was placed on the gastrocnemius muscles 10 cm distal to the anode. The galvanic current was applied with the same electrotherapy device and at an intensity of 0.1-0.2 mA/cm<sup>2</sup> in the galvanic current group.

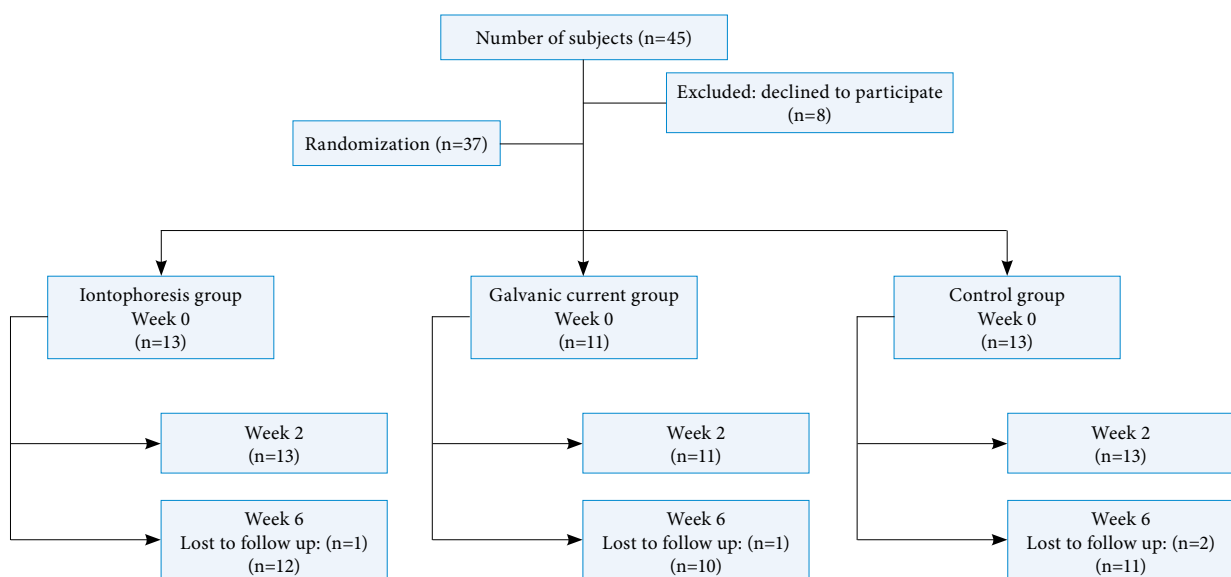


Figure 2. Flowchart of the participants.

The anodal electrode was chosen as a 5×5 electrode, and the cathodal electrode was twice the size of the anode to prevent skin burn in both groups. Any complication that occurred was recorded. The control group received only the physiotherapy program. Four patients did not attend the six-week follow-up. However, as we used an intention-to-treat analysis, the data of 37 patients were analyzed (Figure 2).

### Statistical analysis

A minimum of 10+2 patients for each group was calculated taking into account the dropout rate using the clinCalc.com power analysis program (<https://clincalc.com/stats/samplesize.aspx>). The sample size was computed with 80% power and 5% significance to detect a 10.5 points change in the WOMAC.<sup>[15]</sup> The IBM SPSS version 21.0 software (IBM Corp., Armonk, NY, USA) was used in the statistical analyses. Visual (histogram and probability graphs) and analytical (Shapiro-Wilk tests) methods were utilized as normality tests. Variables were presented as the mean ± standard deviation (SD) for normally distributed variables, the median and interquartile range for non-normally distributed variables, and frequency tables for ordinal variables. The chi-square and Fischer exact tests were used to compare the groups for categorical variables. For normally distributed numerical variables, one-way analysis of variance (ANOVA) was utilized in the comparison of three groups, and independent samples t test was utilized to compare two groups. For the ANOVA, the Levene test was utilized to assess the homogeneity of variances. When an overall significance was observed, Tukey's test was utilized as a pairwise post hoc test. If the numerical variables were non-normally distributed, the Kruskal-Wallis test was utilized for the comparison of three groups, and the Mann-Whitney U test and Bonferroni correction were utilized in the pairwise comparisons. The temporal change of the non-normally distributed parameters was determined by the Friedman test. In case of necessity, the Wilcoxon test and Bonferroni correction were utilized for pairwise comparisons. The Mann-Whitney U test and independent samples t-test were used for intergroup differences in the temporal changes. A *p* value of <0.05 was considered statistically significant.

The reliability was assessed in terms of the internal consistency of the WOMAC subscales (pain, stiffness, and function) in our study. Internal consistency determines the extent to which items within a scale are correlated with each other.<sup>[16]</sup>

The Cronbach alpha statistic was investigated to anticipate the average of the correlations between items within a dimension.<sup>[17]</sup> A value of >0.8 is usually regarded as acceptable.<sup>[18]</sup>

## RESULTS

A total of 45 patients were invited to the study. This study was conducted on 37 patients with knee osteoarthritis and BC (Figure 2).

Cronbach's alpha for the pain, stiffness, and physical function subscales of the WOMAC were found to be 0.908, 0.952, and 0.964, respectively. All patients were right-hand dominant. Age, sex, weight, height, and body mass index were similar between groups (Table 1). Additionally, pain duration and Kellgren-Laurens classifications, basal NRS (resting), basal NRS (exercise), and WOMAC scores, and basal cyst volumes were similar between groups (Table 1).

A statistically significant temporal change was shown in three groups for NRS (resting), NRS (exercise), and WOMAC scores and cyst volumes, except for the cyst volume in the control group (Table 2). There was a significant improvement in resting NRS and exercise NRS scores at the second and sixth weeks in the iontophoresis group ( $p=0.001$ ,  $p=0.002$ ;  $p=0.001$ ,  $p=0.002$ , respectively). A significant improvement was found in resting NRS and exercise NRS scores at the second and sixth weeks in the galvanic current group ( $p=0.003$ ,  $p=0.007$ ;  $p=0.003$ ,  $p=0.008$ , respectively). In addition, a significant improvement was discovered in resting NRS and exercise NRS scores at the second and sixth weeks in the control group ( $p=0.003$ ). There was a significant improvement in WOMAC scores at the second and sixth weeks in the iontophoresis, galvanic current, and control groups ( $p=0.002$ ,  $p=0.004$ ;  $p=0.003$ ,  $p=0.003$ ;  $p=0.003$ ,  $p=0.003$ , respectively). There was also a significant improvement in cyst volumes at the second and sixth weeks in the iontophoresis and galvanic current groups ( $p=0.047$ ,  $p=0.033$ ;  $p=0.003$ ,  $p=0.003$ , respectively).

A significant dissimilarity was found in the improvement of cyst volumes between baseline and the second week in the iontophoresis group compared to the galvanic current group (Table 2). A notable difference was found in terms of improvement in resting NRS and exercise NRS scores between baseline and the second week in the galvanic current group compared to the control group (Table 2).

**TABLE 1**  
Patients' demographic and clinical characteristics

	Iontophoresis group (n=13)			Galvanic current group (n=11)			Control group (n=13)			p		
	n	%	Mean±SD	Median	Min-Max	n	%	Mean±SD	Median		Min-Max	
Age (year)			52.61±7.37					62±11.9			0.058*	
Sex											0.076†	
Male	6	46.2				2	18.2					
Female	7	53.8				9	81.8					
High (cm)			166±3.4					162.3±3.5			0.082*	
Weight (kg)			72.2±4.5					68.6±5.6			0.125*	
BMI (kg/m <sup>2</sup> )			25.35	24.95-27.94				25.81	24.38-28.57	26.44	25.16-27.51	0.872‡
Painful knee											0.760¶	
Right	9	69.2				6	54.5					
Left	4	30.8				5	45.5					
Pain duration (week)					8	4-10				8	3.5-12	0.376‡
Kellgren Lawrence Classification												0.904†
Grade 0	0	0				0						
Grade I	8	61.5				45.5						
Grade II	5	38.5				45.5						
Grade III	0	0				9.1						
Grade IV	0	0				0						
NRS (resting) score			6.6±1.8					7.3±1.3			7.5±1.9	0.411*
NRS (exercise) score			7.2±1.6					7.5±1.3			7.6±1.7	0.797*
WOMAC score			48.2±26.0					50.0±22.1			66.1±22.7	0.126*
Cyst volume (mL)			2.94	1.98-8.71				1.80	0.94-4.90	6.60	0.45-14.35	0.075‡

SD: Standard deviation; BMI: Body mass index; NRS: Numerical rating scale; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; \* One-way ANOVA test; † Fischer exact test; ‡ Kruskal-Wallis test; ¶ Chi-square test.

**TABLE 2**  
Intergroup differences in the temporal changes of resting NRS, exercise NRS, and WOMAC scores and cyst volumes

	Iontophoresis group (n=13)		Galvanic current group (n=11)		Control group (n=13)		Baseline-Second week	Baseline-Sixth week
	Median	Min-Max	Median	Min-Max	Median	Min-Max	<i>p</i>	<i>p</i>
<b>NRS (resting) score</b>								
Baseline	7	5-8	7	6-8	8	6-9	0.931 <sup>†,a</sup>	0.639 <sup>0,a</sup>
Second week	2	1.5-4	3	2-5	5	3.5-7	0.015 <sup>†,b</sup>	0.254 <sup>0,b</sup>
Sixth week	1	0.5-2.5	2	2-7	4	2.5-6	0.009 <sup>†,c</sup>	0.064 <sup>0,c</sup>
<i>p</i>	<b>&lt;0.001‡</b>		<b>0.003‡</b>		<b>&lt;0.001‡</b>			
<b>NRS (exercise) score</b>								
Baseline	8	5.5-8	8	6-8	8	6.5-9	0.573 <sup>†,a</sup>	0.149 <sup>0,a</sup>
Second week	3	1.5-4	3	3-5	5	4-7.5	0.002 <sup>†,b</sup>	0.241 <sup>0,b</sup>
Sixth week	2	1-2	3	2-7	5	3-7	0.001 <sup>†,c</sup>	0.008 <sup>0,c</sup>
<i>p</i>	<b>&lt;0.001‡</b>		<b>0.001‡</b>		<b>&lt;0.001‡</b>			
<b>WOMAC score</b>								
Baseline	45.83	23.95-68.72	41.60	28.12-75	70.8	58.32-81.77	0.434 <sup>0,a</sup>	0.434 <sup>0,a</sup>
Second week	17.7	10.42-29.68	16.60	7.29-45.83	62.5	33.82-68.85	0.059 <sup>0,b</sup>	0.059 <sup>0,b</sup>
Sixth week	6.25	4.16-18.22	16.60	7.29-31.25	50	27-65.1	0.064 <sup>0,c</sup>	0.064 <sup>0,c</sup>
<i>p</i>	<b>&lt;0.001‡</b>		<b>&lt;0.001‡</b>		<b>&lt;0.001‡</b>			
<b>Cyst volume (mL)</b>								
Baseline	2.94	1.98-8.71	1.80	0.94-4.90	6	0.45-14.35	0.046 <sup>0,a</sup>	0.147 <sup>0,a</sup>
Second week	1.30	0.56-3.95	1	0-2.70	1.95	0.44-9.10	0.601 <sup>0,b</sup>	0.664 <sup>0,b</sup>
Sixth week	1	0.20-4	0	0-1	3	0.85-8.25	0.369 <sup>0,c</sup>	0.191 <sup>0,c</sup>
<i>p</i>	<b>&lt;0.001‡</b>		<b>0.028‡</b>		<b>0.273‡</b>			

NRS: Numerical rating scale; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; ‡: Friedman test; a: P value for intergroup differences of temporal changes between the iontophoresis and galvanic current groups (a value of <0.017 is considered significant); b: P value for intergroup differences of temporal changes between the galvanic current and control groups (b value of <0.017 is considered significant); c: P value for intergroup differences of temporal changes between the iontophoresis and control groups (c value of <0.017 is considered significant); †: Independent samples t-test; 0: Mann-Whitney U test.

In the comparison of the iontophoresis group with the control group, a significant dissimilarity was found in terms of improvement in resting NRS scores between baseline and the second week, whereas this difference was also present at the sixth week for exercise NRS scores (Table 2). No complications occurred in any group.

## DISCUSSION

This study demonstrated that dexamethasone iontophoresis or galvanic current may lead to significant improvements in the physiotherapy program of patients with knee osteoarthritis and BC. A significant temporal change was found in the pain and function of all groups. Additionally, in the galvanic current and iontophoresis groups, a significant temporal change was observed in cyst

volumes at the sixth week. However, we did not find a significant temporal change in cyst volume in the control group. In the galvanic current group and the iontophoresis group, the decrease in NRS (resting and exercise) scores was higher than in the control group at the second week. Furthermore, in the iontophoresis group, the decrease in cyst volumes was higher than in the galvanic current group at the second week.

In the literature, we did not find any study evaluating the effectiveness of iontophoresis and galvanic current in knee osteoarthritis patients.

In a study, the effectiveness of adding the dexamethasone phonophoresis to TENS and exercise was compared with ultrasound therapy, TENS, and exercise.<sup>[19]</sup> A greater improvement was found in the group that received dexamethasone phonophoresis.

Similarly, the present study combined dexamethasone iontophoresis and galvanic current with TENS and exercise and discovered that iontophoresis and galvanic current were effective in patients with knee osteoarthritis and BC. However, we also investigated the efficacy of iontophoresis and did not find any difference between galvanic current and iontophoresis. In another study, Boyaci et al.<sup>[20]</sup> compared the effect of ketoprofen phonophoresis, ultrasound therapy, and short-wave diathermy in knee osteoarthritis. They found that phonophoresis, ultrasound therapy, and short-wave diathermy were effective, and there was no significant difference between these regarding pain and function. Differently from this study, we used dexamethasone iontophoresis and compared iontophoresis with galvanic current and standard physiotherapy program. Additionally, the patients in our study had a BC accompanying knee osteoarthritis. Furthermore, we applied the iontophoresis onto the popliteal fossa, unlike in other studies. Therefore, if we had included only patients with knee osteoarthritis and applied the iontophoresis onto the anterior knee, we could have obtained better results in pain and function.

The efficacy of dexamethasone iontophoresis was researched in some musculoskeletal diseases, such as lateral epicondylitis and carpal tunnel syndrome, in the literature.<sup>[9,21]</sup> Some studies demonstrated that dexamethasone iontophoresis is effective in the treatment of lateral epicondylitis, while others showed that it is not effective in the treatment of lateral epicondylitis.<sup>[9,21]</sup> The effectiveness of dexamethasone iontophoresis and galvanic current were investigated in patients with lateral epicondylitis, and it was discovered that dexamethasone iontophoresis was more successful than galvanic current.<sup>[21]</sup> In our study, both dexamethasone iontophoresis and galvanic current were effective in the treatment of knee osteoarthritis and BC. In the iontophoresis and galvanic current groups, there were similar improvements in pain and disability compared to the control group. However, we found that the decrease in cyst volume was more prominent in the iontophoresis group compared to the galvanic current group at the second week. These results could be related to the degree of inflammation since lateral epicondylitis could be more inflammatory than knee osteoarthritis. Thus, dexamethasone iontophoresis could have been more successful than galvanic current in lateral epicondylitis patients. In another study that compared the standard treatment with dexamethasone iontophoresis added to the

standard treatment and ultrasonophoresis added to the standard treatment in subacromial impingement syndrome patients, adding ultrasonophoresis to the standard treatment was more effective than the others.<sup>[22]</sup> However, unlike in our study, sodium diclofenac was the topical agent in this study.

The main limitations of the study are that the patients were not blinded to treatment and the control group received paracetamol, hot packs, TENS, and an exercise program. Additionally, the potential central sensitization and the effect of physical therapy on it were not evaluated, though these factors might have been influential in the decrease of pain levels.

In conclusion, dexamethasone iontophoresis was found to support a more notable clinical and functional improvement in the treatment of patients with knee osteoarthritis and BC.

**Ethics Committee Approval:** This study protocol was approved by the Hitit University Clinical Research Ethics Committee (date: 11.12.2019, no: 132). The study was conducted in accordance with the principles of the Declaration of Helsinki.

**Patient Consent for Publication:** A written informed consent was obtained from each patient.

**Data Sharing Statement:** The data that support the findings of this study are available from the corresponding author upon reasonable request.

**Author Contributions:** All authors contributed equally to the article. Final manuscript was approved by all the authors.

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