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Efficacy of Topical Tarragon Oil on Pain, Stiffness, and Physical Function in Patients With Knee Osteoarthritis: A Randomized Controlled Trial

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Abstract

Introduction: Knee osteoarthritis is a prevalent musculoskeletal problem. This study was conducted to determine the effect of tarragon oil on pain intensity, stiffness, and physical function of the knee joint in patients with knee osteoarthritis.

Methods: In this clinical trial conducted in Birjand, Iran, convenience sampling and the random allocation method were used to assign 90 patients with knee osteoarthritis to the intervention group (tarragon oil, 3 times per day, every other day), a placebo group (sesame oil, 3 times per day, every other day), and a control group (no intervention) for three weeks. Stiffness, pain, and physical function were assessed using the Western Ontario and McMaster Universities Arthritis Index WOMAC scale at four time points: before, immediately after, one week after, and three weeks after. Data were analyzed using SPSS 19 software and statistical tests, including repeated measures ANOVA, ANOVA, and chi-square at a significance level of $P=0.05$. The trial was registered with the Iranian Registry of Clinical Trials (code: IRCT20220403054396N1).

Results: Patients in the tarragon group showed significant improvements in mean pain, joint stiffness, and physical function of the knee joint at all time points compared to baseline ($P=0.001$). There was a significant difference in stiffness between the tarragon, control, and placebo groups immediately, one week, and three weeks after the intervention. Physical function differed among the groups at one week and three weeks post-intervention. However, no significant difference was found in pain between the three groups at the three observation points.

Conclusion: Tarragon oil can be effective in improving stiffness and physical function in osteoarthritis patients. However, further research is needed due to the limited studies available.

Keywords: Osteoarthritis, Knee joint, Sesame oil, Pain, *Artemisia dracunculus*

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Introduction

Knee osteoarthritis is a common degenerative joint disease that causes disability in the elderly (1). It is a major cause of disability in older adults and, with increasing life expectancy, has become a significant public health challenge (2). The incidence of this disease is approximately 240 cases per 100,000 (3), and it is expected to increase by 60–100% by 2050 (4). Individuals aged 70 years and older are most affected by knee osteoarthritis, and its prevalence is projected to rise with increasing age and obesity (3). With the increasing life expectancy, knee osteoarthritis will pose a significant economic challenge for societies worldwide (1). Symptoms of knee osteoarthritis include pain, reduced joint range of motion, and swelling, which can affect daily activities such as climbing stairs, walking, sitting, and standing, adversely affecting quality of life. This problem motivates healthcare-seeking behavior and is considered a key predictor of disability (5). While there is no definitive cure for this condition, treatment focuses on reducing pain, maintaining joint function, and minimizing disability (6). Therapeutic options range from drug therapy and lifestyle changes to physiotherapy, injections, and surgery in

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severe cases (7).

Given its accessibility, low cost, and natural origins, complementary medicine, including the use of traditional medicinal plants, is often considered an alternative to conventional medicine. Many patients with chronic conditions, such as knee osteoarthritis, find relief in topical herbal treatments that can reduce pain and the need for systemic medications. Some herbal extracts have shown promise in improving pain and mobility in patients with osteoarthritis (8,9). Though further research is needed to confirm their efficacy and safety, Many of these extracts are popular among the public for relieving joint pain. However, the efficacy and safety of many of these methods have not yet been elucidated (8).

Artemisia, a plant from the Asteraceae family, includes notable species such as *annua*, *capillaris*, *dracunculus*, and *absinthium*. These species have a long history of use in medicine. For example, *A. annua* has been proven effective for stiffness and movement restriction in osteoarthritis of the knee and pelvis, while *A. absinthium* is used in treating shoulder and back pain. The use of chamomile, also a member of the Asteraceae family, has been validated in clinical trials (10). There is evidence in traditional medicine for the numerous medical uses of *A. dracunculus*, known as tarragon, including antisclerotic, anticonvulsant, antimicrobial, and anti-inflammatory effects, as well as relief from headaches, toothaches, dermatitis, and joint pain. Tarragon essential oil is commonly used in topical oil-based preparations, making it a practical choice for traditional Iranian medicine. The oil is extracted from the leaves and flowers of the plant through steam distillation and contains compounds such as methyl eugenol, estragole, and elemicin. Active metabolites in tarragon include flavonoids, coumarins, and phenolic acids, known for their anti-inflammatory, anti-allergic, and antioxidant properties (11,12). Tarragon is rich in plant compounds effective against pain (13), with no reported acute toxicity or mutagenic activity at doses relevant to human consumption (14).

Many studies on rats have shown that tarragon possesses antibacterial and analgesic properties. Human studies have also indicated its potential antidiabetic effects (15,16). Abedpour's thesis on osteoarthritis showed that tarragon oil extract can alleviate symptoms in the short term (17). Considering the limited research in this field, the promising benefits of tarragon, and the role of community health nurses in utilizing complementary medicine and delivering independent care, this study aimed to provide strong evidence for the effect of tarragon oil on pain severity, stiffness, and knee function in patients with knee osteoarthritis.

Methods

Study Design

This study is a randomized, placebo-controlled clinical trial. The conditions and procedures were consistent across the three groups throughout the study. The CONSORT reporting guideline was followed. The research protocol was registered in the Iranian Registry of Clinical Trials (code: IRCT20220403054396N1). All participants completed an informed consent form before the study.

Preparation of Test Drug and Placebo

Sesame oil (*Sesamum indicum*) was obtained as a placebo and traditional oil base from Barij Essential Oil Pharmaceutical Company. The tarragon plant was identified, and a herbarium was prepared and stored at the Faculty of Pharmacy, Birjand University of Medical Sciences. Tarragon oil was prepared by extracting tarragon essential oil using a Clevenger apparatus. First, 600 g of dried tarragon was boiled in 3.6 liters of water until 1/4 of the water remained. Then, the solids were removed, and the remaining aqueous extract was boiled with an equal amount of sesame oil to introduce soluble compounds in the extract, such as polyphenols and flavonoids, into the oil base. After water removal, the essential oil was added to the prepared oil to prevent the loss of volatile compounds (8). The tarragon essential oil was analyzed using gas chromatography, and the microbial limit of the oil was determined based on pharmaceutical pharmacopeia standards.

Gas-Chromatography-Mass Spectrometry (GC-MS)

The GC-MS investigations were conducted using an Agilent 5975 system with an HP-5ms column (30 m × 0.25 mm internal diameter [ID], 0.25 μm film thickness), coupled to a quadrupole mass detector and a computer equipped with the Wiley 7n library; other details include oven temperature 50 C (5 min), 50–250 °C (3 °C/min), 250 °C (10 min), injector temperature 250 °C, injection volume 1 μL, split ratio 1:20, carrier gas helium at 1.0 mL/min, ionization potential 70 eV, ionization current 150 μA, ion source temperature 280 °C, and mass range 35–465 m/z. Individual compounds were identified by comparing their mass spectra and retention indices (RI) with those of authentic samples and those given in the literature (Adams, R.P. 2007, Identification of Essential Oil Components by Gas Chromatography/Quadrupole Mass Spectrometry, Allured Publishing Corporation, Carol Stream, Illinois, USA). Quantification of the relative amount of the individual components was performed according to the area percentage method without consideration of a calibration factor. Twenty-eight compounds were isolated, and 27 compounds were identified accurately. The major constituent was methyl chavicol (estragol), 82.1%.

Inclusion and Exclusion Criteria

The study participants were selected from the Shafa Building affiliated with Birjand University of Medical Sciences, South Khorasan, in 2023. Inclusion criteria included confirmation of knee osteoarthritis by a rheumatologist, a pain score of ≥ 4 on the VAS scale for at least three months, ability to understand and communicate effectively, written informed consent, age between 30 and 70 years, no history of cancer, pregnancy, or coagulation disorders, no ulcers above the knee joint, no acute infections, no severe conditions such

as liver or kidney disease, no peptic ulcers or skin lesions in the knee area, no recent knee surgeries or steroid injections, no lower limb abnormalities, no substance abuse, no radiculopathy or neuropathy, and no other musculoskeletal diseases (including rheumatoid arthritis, septic arthritis, metabolic arthritis, gout, pseudogout, traumatic arthritis, and fibromyalgia).

Exclusion criteria included hospitalization, unwillingness to continue participating in the study, travel, treatment discontinuation, physiotherapy for knee pain, high-dose acetaminophen or other analgesics (> 2 grams/day), glucosamine or chondroitin sulfate use, oral or topical steroids in the past 14 days, and allergies to tarragon or sesame oil.

Safety and Tolerability

Tarragon oil was well tolerated by the study participants, and no adverse events were reported. Additionally, microbial load were measured according to standard pharmacopeia before admission to the study.

Randomization, Blinding, and Allocation Concealment

In this study, 90 patients were randomly allocated to three groups: intervention, placebo, and control. Random allocation was performed using block randomization with Random Allocation Software. The oils were packaged in dark 50 mL bottles, with tarragon oil and sesame oil placed in similar containers. Each participant in the intervention and placebo groups received a bottle containing 50 mL of oil and a weekly schedule. The physicians, researchers, and statisticians were kept blind to the allocation of patients.

Intervention

Patients in both the intervention and placebo groups were instructed to apply 1.5 mL of oil to the affected knee area three times per day, every other day for three weeks. This duration of intervention was based on similar studies to enhance adherence (8). They were trained to apply the medication to their knee and the surrounding tissues, ensuring complete coverage of the skin by the oil. Patients were advised not to massage the area. The control group did not receive any topical oil during the intervention. Before use, patients in the intervention and placebo groups were asked to apply the oils on the inner part of the forearm to check for skin sensitivity. The researcher's contact number was provided to the participants in case any allergies or side effects were experienced. Participants were also reminded of timely intervention through phonecalls. In order to control for the psychological effects, the frequency of contacts and follow-ups were the same for all three groups. Information provided to participants was delivered neutrally, without suggesting therapeutic efficacy, in order to minimize expectation bias.

Outcome Measures

Participants in this study used conventional medications such as NSAIDs, acetaminophen, etc., prescribed by rheumatologists, and recorded their daily analgesic intake. The study variables were assessed using the demographics form (age, sex, weight, height, BMI, residence, education level, occupation, history of allergy, and medications) and the Western Ontario and McMaster Universities Arthritis Index (WOMAC) (18). The WOMAC includes 24 questions in three domains: pain (5 items), joint stiffness (2 items), and physical function (17 items). Each question is scored from 0 to 4, with a higher score indicating more severe symptoms. Data were collected at four time points: before the intervention and immediately, one week, and three weeks after the intervention. The researcher contacted participants to complete the questionnaires.

Sample Size

The sample size was calculated by considering a confidence interval of 95% and a power of 90%. According to similar study. The sample size was determined to be 22 participants in each group. To compensate for an anticipated 25% dropout rate, we recruited 30 patients in each group (19).

Statistical Analysis

Quantitative variables were described using central and dispersion indices, and qualitative variables were described using numbers and percentages. Normality was assessed using the Shapiro–Wilk test, and group homogeneity for quantitative variables was checked using the analysis of variance test and chi-square test for qualitative variables. Changes over time were analyzed using repeated measures ANOVA, checking for sphericity and group-by-time interaction effect. The data were analyzed using SPSS 19.0 at the significance level of $P < 0.05$.

Results

From January to February 2023, 94 patients were assessed for eligibility, and finally, 90 eligible patients returned their signed informed consent forms. These patients were randomly assigned to three groups: intervention, placebo, and control. The study had 29 participants in the intervention group, 28 in the placebo group, and 30 in the control group, all of whom completed the study. The study flowchart is presented in Figure 1. The groups were similar in demographic variables (Table 1).

Table 2 shows the results of the repeated measures ANOVA, including the effects of time, group, and the interaction effect of time and group on pain, stiffness, and knee function. The time × group interaction was not significant for knee pain. Therefore, the main effects of time and group were analyzed separately.

Table 3 shows the statistical analysis of the main study variables, including the three WOMAC domains, for the four time points. The ANOVA test showed significant differences in joint stiffness between the three groups at all time points after the intervention and in knee function only at 1 week and 3 weeks after the intervention. However, there was no significant difference in pain between the groups at any time point. All groups were homogeneous in the three domains before the intervention. The results of the repeated measures ANOVA showed significant changes

Table 1. Comparison of demographic characteristics between the three study groups

Demographic data				Group *P*-valua
(Mean ± SD)	**Control (*N* = 30)**	**placebo (*N* = 30)**	**Tarragon (*N* = 30)**	
Age (years)	56.20 ± 8.34	57.86 ± 10.01	53.16 ± 9.08	0.12***
Children	3.4 ± 1.4	3.9 ± 2.6	3.1 ± 1.32	0.42***
BMI (kg/m^2)	29.97 ± 3.71	28.55 ± 4.69	28.32 ± 5.17	0.32***
	Frequency (%)	**Frequency (%)**	**Frequency (%)**	***P* value**
Gender				0. 21*
Female	23 (76.6)	28 (93.3)	27 (90.0)	
Male	7 (23.3)	2 (6.7)	3 (10.0)	
Life style				0.52**
With wife	3 (10.0)	9 (30.0)	5 (16.6)	
With wife & children	22 (73.4)	17 (56.7)	21 (70.0)	
With children	4 (13.3)	3 (10.0)	2 (6.7)	
With parents	1 (3.3)	1 (3.3)	2 (6.7)	
Location				0.11*
City	26 (86.7)	26 (86.7)	30 (100)	
Village	4 (13.3)	4 (13.3)	0 (0)	
Marital status				0.89**
Single	1 (3.3)	2 (6.6)	3 (10.0)	
Married	29 (96.7)	28 (93.4)	27 (90.0)	
Housing situation				0.38**
Tenant	2 (6.7)	1 (3.3)	3 (10.0)	
Owner	28 (93.3)	29 (96.7)	25 (83.3)	
Relative's house	0 (0)	0 (0)	2 (6.7)	
Job				0.75**
Government employee	3 (10.0)	4 (13.3)	5 (16.7)	
Self-employed	1 (3.3)	2 (6.7)	2 (6.7)	
Homemaker	19 (63.4)	18 (60.0)	18 (60.0)	
Retired	7 (23.3)	6 (20.0)	5 (16.7)	
Education				0.06*
Illiterate	7 (23.3)	9 (30.0)	1 (3.3)	
Elementary	9 (30.0)	9 (30.0)	9 (30.0)	
High school diploma	5 (16.7)	6 (20.0)	12 (40.0)	
Associate Degree	1 (3.3)	3 (10.0)	1 (3.3)	
Bachelor's degree and higher	8 (26.7)	3 (10.0)	7 (23.4)	

*Chi-square test **: Fishers exact test ***: ANOVA

Table 2. Repeated measures ANOVA results for the effects of time × group interaction on pain, stiffness, and physical function

Variable	**Stiffness**						**Pain**						**Physical function**					
Test	***SS***	***df***	***MS***	***F***	***P* value**	**Effect size**	***SS***	***df***	***MS***	***F***	***P* value**	**Effect size**	***SS***	***df***	***MS***	***F***	***P* value**	**Effect size**
Group	161.71	2	80.85	11.08	<0.0001	0.209	144.58	2	72.29	2.13	0.124	0.048	1673.84	2	836.92	3.37	0.03	0.896
Time	76.60	1	76.60	122.36	<0.0001	0.593	207.69	1	207.69	64.25	<0.0001	0.433	1980.08	1	1980.08	88.31	<0.0001	0.513
Time × group	93.66	2	46.58	74.41	<0.0001	0.639	93.166	2	4.82	1.49	0.23	0.034	2079.74	2	1039.97	46.38	<0.0001	0.525

SS: sum of squares; *df*: degrees of freedom; *MS*: mean square

in the mean scores of pain, joint stiffness, and knee function in the tarragon group over time. In contrast, the placebo and control groups indicated no significant change in the mean score of physical function over time. Additionally, the change in joint stiffness over time was not significant in the control group.

Discussion

The present study demonstrated that topical application of tarragon oil significantly improved joint stiffness and physical function in patients with knee osteoarthritis compared with placebo and control groups. The reduction in stiffness was evident immediately after the intervention

Table 3. Comparison of outcome measures among the three study groups

	Control group (*N* = 30)	Placebo group (*N* = 28)	Intervention group (*N* = 29)	*P* value* (between groups)	Post hoc test results	Effect size
Stiffness						
Baseline	3.40 ± 1.54	3.92 ± 1.56	3.93 ± 1.43	0.298		0.17
Immediately after	3.40 ± 1.54	3.57 ± 1.56	2.27 ± 1.33	0.003	I vs. P *P* = 0.002 I vs. C *P* = 0.00 C vs.P *P* = 0.68	0.39
1 week	3.36 ± 1.58	3.50 ± 1.45	1.31 ± 1.25	< 0.0001	I vs. P *P* = 0.000 I vs. C *P* = 0.000 C vs. P *P* = 0.72	0.71
3 weeks	3.30 ± 1.57	3.42 ± 1.61	0.68 ± 0.64	< 0.0001	I vs. P *P* = 0.000 I vs. C *P* = 0.000 C vs. P *P* = 0.79	0.92
P value** (within groups)	0.81	0.03	< 0.0001			
Post hoc test results		B vs. IM = 0.093 B vs. 1W = 0.030 B vs. 3W = 0.048 1W vs. 3W = 1.000	B vs. IM = 0.00 B vs. 1W = 0.00 B vs. 3W = 0.00 1W vs. 3W = 0.004			
Effect size	0.007	0.122	0.796			
Physical function						
Baseline	22.96 ± 5.67	27.10 ± 9.77	26.44 ± 10.24	0.15		0.21
Immediately after	22.90 ± 5.68	26.10 ± 9.60	24.75 ± 10.72	0.39		0.15
1 week	22.30 ± 5.83	24.53 ± 9.92	17.93 ± 8.38	0.01	I vs. P *P* = 0.009 I vs. C *P* = 0.106 C vs. P *P* = 0.55	0.33
3 weeks	22.30 ± 5.79	24.46 ± 10.31	11.41 ± 5.91	< 0.0001	I vs. P *P* = 0.000 I vs. C *P* = 0.000 C vs. P *P* = 0.52	0.76
P value** (within groups)	0.093	0.071	< 0.0001			
Post hoc test Results			B vs. IM = 0.064 B vs. 1W = 0.000 B vs. 3W = 0.000 1W vs. 3W = 0.000			
Effect size	0.084	0.1	0.758			
pain						
Baseline	7.28 ± 3.79	8.71 ± 3.11	8.34 ± 2.80	0.16		0.22
Immediately after	7.23 ± 2.78	8.17 ± 3.11	7.75 ± 3.13	0.58		0.13
1 week	5.76 ± 3.25	7.60 ± 3.31	6.48 ± 3.07	0.09		0.23
3 weeks	5.23 ± 3.13	7.28 ± 3.79	5.96 ± 3.08	0.10		0.25
P value** (within groups)	< 0.0001	< 0.0001	< 0.0001			
	B vs. 1W = 0.003 B vs. 3W = 0.000 1W vs. 3W = 0.62	B vs. IM = 0. 26 B vs. 1W = 0.060 B vs. 3W = 0.027 1W vs. 3W = 1.000	B vs. IM = 0.063 B vs. 1W = 0.000 B vs. 3W = 0.000 1W vs. 3W = 0.31			
Effect size	0.376	0.17	0.46			

*: *P* value is calculated by one-way ANOVA test for between-group comparison.
**: *P* value is calculated by repeated-measures ANOVA test for within-group comparison
Abbreviations: I: intervention; P: placebo; C: control; B: baseline; IM: immediately after; 1W: 1 Week; 3W: 3 Weeks

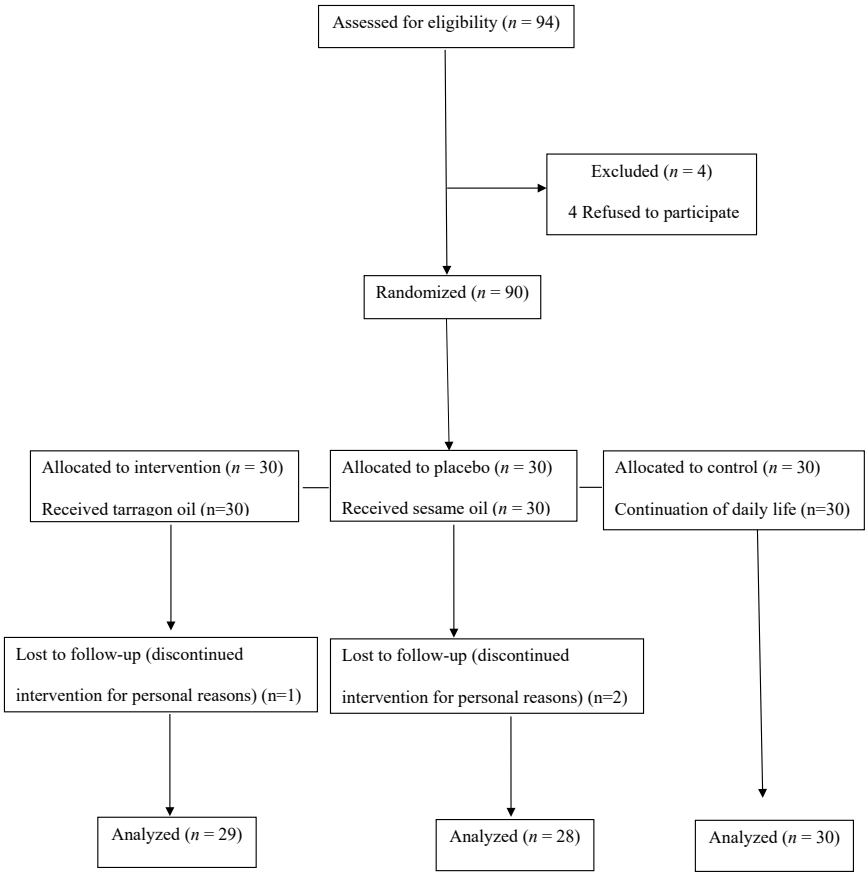


Figure 1. Study flow diagram

and persisted throughout the three-week follow-up period. Functional improvement was observed from the first week and continued until week three. Although pain scores decreased across all groups, the between-group differences did not reach statistical significance over the study period.

This outcome may be attributed to the pharmacological properties of tarragon oil, potentially linked to compounds identified through GC–MS analysis. The primary components of the formulation included flavonoids, phenolic compounds, alkaloids, tannins, and essential oils, all of which have been previously associated with anti-inflammatory and analgesic activities. These compounds are believed to exert their effects through modulation of inflammatory pathways, attenuation of neural pain signaling, and inhibition of prostaglandin synthesis (20,21).

Notably, the estragole content recognized for its potential anti-arthritic properties was higher in the present formulation (82.1%) compared with reported levels in French tarragon (76.46%), which may have contributed to the observed clinical effects (22). However, given the topical mode of administration, it should also be considered that emollient properties and the warming sensation associated with oil application may also have contributed to symptom relief. Therefore, the therapeutic benefits observed in this study may reflect both pharmacological activity and the intrinsic characteristics of topical oil formulations (23).

The current findings are consistent with previous investigations on other species of the Asteraceae family, such as *Artemisia absinthium* and *Artemisia annua*, which have shown efficacy in improving osteoarthritis symptoms when used orally and topically. These plants contain compounds like flavonoids and coumarins, similar to tarragon, which may contribute to their beneficial effects. Basiri's study showed that *Artemisia absinthium* ointment can alleviate osteoarthritis symptoms (24), and Simon et al. found that *Artemisia annua* is also effective in reducing osteoarthritis symptoms (10). A systematic review of herbal oils used in arthritis management further reported that ashwagandha, shallaki, ginger, turmeric, akarkara (*Anacyclus pyrethrum*), clove (*Syzygium aromaticum*), camphor (*Cinnamomum camphora*), peppermint (*Mentha piperita*), and garlic (*Allium sativum*) possess anti-inflammatory, analgesic, antioxidant, and circulation-enhancing properties that may alleviate pain, stiffness, and joint swelling while improving mobility and overall joint health (23). Moreover, Abedpur's thesis has specifically supported the beneficial role of tarragon oil in alleviating osteoarthritis symptoms (17).

Among the strengths of the present study was the phytochemical characterization of the formulation using gas chromatography–mass spectrometry (GC–MS), which enabled identification of the major bioactive constituents. In addition, optimization of the oil formulation to obtain the most effective composition represents a methodological strength. Another notable advantage was the assessment of clinical outcomes at multiple time points using the WOMAC index, a validated and widely used instrument for

evaluating pain, stiffness, and physical function in patients with knee osteoarthritis. The use of a repeated-measures design enhanced the reliability of outcome evaluation.

Despite these promising findings, the absence of statistically significant pain reduction between groups warrants consideration. This may be explained by the relatively short duration of intervention, dosage parameters, or participant-related factors. The multidimensional nature of pain and the influence of neurological and cognitive components on osteoarthritis pain may also explain the absence of a statistically significant reduction in pain. Moreover, with topical administration, analgesic compounds may not adequately penetrate to reach the deep pain receptors within the joint, while still exerting beneficial effects on stiffness and physical function. This observation is supported by previous studies demonstrating that the application of topical compounds in conjunction with massage may enhance stimulation of deep pain receptors. Additionally, in several studies, the analgesic effects of such compounds emerged only after four weeks of intervention.

The primary limitation of this study is the short follow-up period. Given that osteoarthritis is a chronic and progressive condition, short-term evaluation may not adequately reflect long-term therapeutic outcomes. Larger-scale randomized controlled trials with extended follow-up durations are required to confirm these findings. Therefore, it is suggested that its efficacy on knee OA should be evaluated in future studies with a larger sample size and longer intervention and follow-up duration.

Conclusion

Tarragon oil can be effective in improving osteoarthritis symptoms, making it a cost-effective and safe treatment option due to its potential benefits. However, we recommend future studies with larger sample sizes and longer intervention periods. Exploring the combination of tarragon oil with massage therapy in osteoarthritis cases across different regions in Iran and the world can validate the efficacy of tarragon oil as a complementary treatment.

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Competing Interests

All contributing authors declare no conflicts of interest.

Data Availability Statement

The data supporting the findings of this study are available upon request from the corresponding author. The data are not publicly available because of privacy or ethical restrictions.

Ethical Approval

Written informed consent was obtained from all patients. The type of treatment and medication provided was beneficial and not harmful to the patients. The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of Birjand University of Medical Sciences (IR.BUMS.REC.1401.350).

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