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*Original Article*

# Effect of warm needle therapy guided by ultrasound on pain relief and improvement of physical function in patients with knee osteoarthritis

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**Abstract:** Background: Conventional treatments for knee osteoarthritis (KOA) often fall short in providing optimal outcomes. Objective: To evaluate the effect of warm needle therapy guided by ultrasound on pain relief and physical function in patients with KOA. Methods: In this retrospective study, the clinical records of patients with KOA undergoing either meloxicam alone or meloxicam combined with warm needle therapy were reviewed. Various parameters, including pain evaluations, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores, range of motion for knee flexion, knee society scores, quality of life scores, inflammatory factor levels, and patient satisfaction were comparatively analyzed. Results: A total of 140 patients were included, including 68 patients treated by Meloxicam and 72 patients treated by Meloxicam and warm needle therapy. Following treatment, the meloxicam combined with warm needle therapy group exhibited lower pain scores (3.62±1.98 vs. 4.38±1.95, P=0.023), improved WOMAC scores (27.82±8.75 vs. 31.25±8.82, P=0.022), increased range of motion (136.82°±8.58° vs. 133.43°±8.86°, P=0.023), higher knee society scores (93.32±7.21 vs. 90.21±7.78, P=0.016), and superior Short Form-36 Health Survey (SF-36) scores (81.24±6.33 vs. 78.43±6.85, P=0.013). Furthermore, a significant reduction in inflammatory factors including interleukin-8 (IL-8), matrix metalloproteinase-3 (MMP-3), Interleukin-1 beta (IL-1β), Tumor Necrosis Factor-alpha (TNF-α), and cyclooxygenase-2 (COX-2) levels was observed in the meloxicam combined with warm needle therapy group compared to the meloxicam alone group (all P<0.05). Patient satisfaction was likewise notably higher in the meloxicam combined with warm needle therapy group (8.43±2.15 vs. 7.58±2.24, P=0.024), with a greater proportion of patients willing to recommend the treatment (81.94% vs. 64.71%, P=0.034). Conclusion: Warm needle therapy guided by ultrasound, in combination with meloxicam, significantly improves pain relief, physical function, inflammatory modulation, and patient satisfaction in KOA patients.

**Keywords:** Knee osteoarthritis (KOA), warm needle therapy, ultrasound guidance, meloxicam, pain relief, knee function, patient satisfaction, inflammatory factor

## Introduction

Knee osteoarthritis (KOA) is a prevalent and debilitating musculoskeletal condition that affects a substantial proportion of the global population, particularly the elderly [1, 2]. It is estimated that approximately 250 million people worldwide are affected by KOA [3]. Noted for progressive joint degeneration, loss of cartilage, and chronic pain, KOA poses significant challenges for both patients and healthcare providers [4]. The impact of KOA extends beyond physical discomfort, affecting quality of life, functional abilities, and imposing economic burdens due to healthcare costs and productivity loss [5, 6].

Diagnosis of KOA typically relies on a blend of clinical symptoms, physical examination, and radiographic findings. According to the American College of Rheumatology (ACR) criteria, KOA is diagnosed with the presence of knee pain and at least one of the following signs: morning stiffness lasting less than 30 minutes, age over 50 years, crepitus with movement, osseous enlargement, and lack of joint warmth [7]. Radiographic confirmation is often achieved with antero-posterior standing radiographs,

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evaluated using the Kellgren-Lawrence (K-L) grading system, which categorizes radiographic OA into five levels [8].

Conventional treatments for KOA primarily focus on pain management, functional improvement, and disease modification [9, 10]. Pharmacologic interventions include nonsteroidal anti-inflammatory drugs (NSAIDs), corticosteroids, and intra-articular hyaluronic acid injections. Physical therapy and exercise are recommended to maintain joint mobility and strengthen knee-supporting muscles. Surgical options such as arthroscopy, osteotomy, and joint replacement are typically reserved for advanced cases. Despite these options, achieving optimal pain relief and physical function recovery remains challenging [11, 12]. The efficacy of conventional treatments varies widely depending on OA stage and individual patient characteristics. NSAIDs and other medications provide symptomatic relief but may come with side effects. Physical therapy and weight loss have shown promise in improving symptoms and delaying OA progression.

Recent research highlights the potential of warm acupuncture therapy, a form of traditional Chinese medicine, in managing KOA [13, 14]. Warm acupuncture therapy involves inserting slender needles into particular anatomical points and applying gentle heat to enhance the therapeutic effects [15, 16]. This approach has been shown to relieve pain and improve physical performance of knee joint [17]. Several randomized controlled trials (RCTs) have demonstrated that warm acupuncture therapy significantly reduces pain scores and improves physical performance compared to conventional treatments alone [18-20]. Additionally, warm acupuncture therapy has been associated with reduced inflammation markers, suggesting an anti-inflammatory mechanism [21]. Given these promising results, warm acupuncture therapy represents a viable complementary option for KOA management.

Guided by the principles of evidence-based medicine and a growing body of research supporting the efficacy of acupuncture-based therapies, this study aimed to analyze the effects of ultrasound-guided warm needle therapy on pain reduction and physical performance improvement in KOA patients. Our research contributes to expanding knowledge on integrative treatment approaches for KOA and seeks to clarify the mechanisms underlying the effects of warm needle therapy. This investigation holds implications not only for the refinement of treatment modalities but also for the broader discourse on personalized, patient-centered care in the context of chronic musculoskeletal conditions.

## Materials and methods

### *Ethics statement and study design*

The retrospective cohort study received approval from the Institutional Review Board and Ethics Committee of Zhoukou City Sixth People's Hospital.

The study analyzed case data from patients with KOA who underwent treatment at Zhoukou City Sixth People's Hospital from June 2022 to May 2023. All treatment were in accord with "Chinese Clinical Practice Guidelines in Treating Knee Osteoarthritis by Periarticular Knee Osteotomy" [22]. Patients were categorized into two groups according to the treatment method: the Meloxicam group and the Meloxicam combined with warm needle therapy group. The selection process for warm needle therapy involved several steps to ensure respect for patient preferences. Initially, medical professionals provided comprehensive information about current treatment methods, covering benefits and associated risks, in an accessible way to facilitate patient comprehension. Afterward, treatment decisions were made collaboratively, with open discussions between patients and physicians, taking into consideration the patient's medical condition, personal values, and preferences.

### *Eligibility and grouping criteria*

Inclusion criteria: 1) Patients diagnosed with unilateral KOA in accordance with clinical and radiological diagnostic standards set forth by the American College of Rheumatology [23]; 2) Age ≤80 years; 3) Patients with Kellgren and Lawrence (K-L) grade 3 or lower; 4) Patients with Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score ≤120; 5) No previous alternative therapies or pertinent medications in the past month; 6) Complete medical data.

Exclusion criteria: 1) Patients with limb disability, tumors, critical cardiovascular/cerebrovas-

cular illnesses, acute ligament injury of the knee, rheumatoid arthritis, neurologic disorders, or severe angular deformity of the knee; 2) Patients with imaging evidence of extensive osteophytes and advanced subchondral bone thickening, significant knee soft tissue adhesions, fractures of the knee joint, or torn tendons; 3) Patients with open wounds, poor compliance, loss to follow-up, adverse reactions during treatment, severe organ failures, psychiatric conditions, cognitive deficits, skin infections, or allergy to trial medicines; 4) A past knee operation history or a K-L grade 4.

To ensure comparability between the two groups, all patients were further selected using stratified with sampling based on baseline data.

*Treatment approach*

Participants in the Meloxicam group received a standard dosage of 7.5 mg/day of meloxicam (Sichuan Shenghe Pharmaceutical Co., LTD., Sinopharmary code: H20010305) as part of their regular treatment. This medication was taken after meals with water, with a three-day break between week-long treatment courses.

In the Meloxicam + Warm Needle Therapy group, patients received warm needle therapy in conjunction with meloxicam. The targeted key acupoints included Neixiyan (EX-LE4) and Waixiyan (EX-LE5), Dubi (ST 35), Sanyinjiao (SP 6), Yanglingquan (GB 34), Xuehai (SP 10), Geshu (BL 17), Heding (EX-LE2), and Zusanli (ST 36). Patients were positioned either sitting with the knee bent at 90 degrees or lying in a supine position with the knee flexed at 120 degrees, following standard disinfection procedures. Needle selection was based on muscle laxity, with diameters of 0.3 mm and lengths of 50 or 75 mm. The needle was inserted from Waixiyan to Neixiyan acupoints in both forward and reverse directions, at a depth of 20-30 mm. Various manipulations, such as elevating, placing, and rotating, were performed for one minute, using the feeling of swelling in the knee joints as the reference point. Following this, moxa-burning was applied for approximately 20 minutes to additional acupoints once a sensation of soreness was achieved, after which the needle was removed. Treatments were administered once daily, with each course comprising ten sessions followed by a one-week break. Each patient underwent three treatment courses.

*General information*

General patient information was collected from a systematic retrieval of medical records, including age, body mass index (BMI), smoking and alcohol consumption, presence of hypertension, diabetes, cardiovascular ailments, history of knee surgery and corticosteroid injections, duration of knee pain, K-L grade, and overall health-related support. Furthermore, the subjects underwent antero-posterior standing radiographs and were further graded using the K-L classification, which categorizes the severity of osteoarthritis into five levels.

The K-L grading system is a widely recognized method for radiographically assessing OA severity. It provides a structured approach to evaluating the extent of joint damage. Grade 0 (Normal): no signs of OA are observed on radiographs; Grade 1 (Questionable): doubtful osteophytes are present, indicating early signs of joint damage; Grade 2 (Mild): osteophytes are visible without joint space narrowing, suggesting mild degenerative changes; Grade 3 (Moderate): moderate joint space narrowing is evident, accompanied by definite osteophyte formation and possible bone sclerosis; Grade 4 (Severe): severe joint space narrowing, accompanied by subchondral bone sclerosis, indicating advanced osteoarthritis.

*Pain score*

Pain levels in each group were assessed prior to and following the treatment utilizing the Visual Analog Scale (VAS). This scale categorizes pain as: absence of pain (0), slight pain (1-3), moderate pain (4-6), strong pain (7-9), and extreme severity (10). The VAS has demonstrated strong reliability, with a high Cronbach's alpha coefficient of 0.94 [24].

*WOMAC score*

The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Score is one of the most frequently used patient self-report assessments for individuals with lower limb osteoarthritis. It was employed to evaluate the physical function of patients before and after treatment. The WOMAC consists of 24 items

across three domains: pain (5 items), stiffness (2 items), and function (17 items), totaling a maximum score of 240 points. Higher scores indicate a more severe condition. The assessment has demonstrated good test-retest consistency, with an intraclass correlation coefficient (ICC) exceeding 0.75 across all sections and items. Furthermore, the internal consistency was also within acceptable limits, evidenced by a Cronbach's alpha score of 0.852 for the pain domain, 0.704 for stiffness, and 0.955 for physical function [25].

*Knee flexion range of motion (ROM)*

Self-passive range of knee flexion was measured using a digital goniometer (Biometrics, Baton Rouge, LA, USA, 2008). This assessment entailed aligning the goniometer's axis with the lateral aspect of the knee joint. The stationary arm was positioned at the midpoint of the femur, between the greater trochanter and the lateral joint space of the knee, while the movable arm aligned with the lateral malleolus of the fibula. Following the initial assessment, the goniometer angle was reset, and the entire process was conducted thrice to ensure accuracy.

*Knee society score (KSS)*

The KSS [26] was employed for assessing patient outcomes, specifically focusing on their walking and stair climbing abilities. This score employs a 0-100 scale, where higher scores signify better knee function. Reliability of the KSS was evaluated using Cronbach's alpha, yielding values of 0.894 and 0.800 for the preoperative and postoperative stages, respectively [27].

*Quality of life scores*

The SF-36 questionnaire includes eight aspects, covering PF (for physical functioning), RP (for role limitations related to physical issues), BP (for bodily pain) [28], GH (for general health perceptions), VT (for vitality or energy levels), SF (social functioning), RE (role emotional), and MH (mental health). Each dimension was scored using a 0-100 scale, with higher scores indicating a better quality of life within that domain. The SF-36 demonstrated good reliability, with a Cronbach's α coefficient of 0.87 [29].

*Inflammatory factor levels*

Prior to and following the treatment, 6 mL fasting venous blood was drawn from each patient for routine blood examination. After blood routine examination, the remaining sample was centrifuged for 12 min at 2,500 r/min, and the resulting supernatant was extracted and stored at a temperature of -20°C for subsequent testing. Serum levels of inflammatory factors such as interleukin-8 (IL-8) (ab214030, Abcam, USA), monocyte chemotactic protein 1 (MCP-1) (ab179886, Abcam, USA), interleukin-1β (IL-1β) (ab214025, Abcam, USA), matrix metalloproteinase-3 (MMP-3) (ab269371, Abcam, USA), and cyclooxygenase-2 (COX-2) (ab267646, Abcam, USA) were determined by an enzyme-linked immunosorbent assay.

*Patient satisfaction*

Patient satisfaction was assessed using questionnaires, allowing for a subjective investigation into their contentment. Ratings for patient satisfaction ranged from 1 to 10, with higher scores reflecting higher levels of satisfaction.

*Statistical analysis*

The power of this study was calculated using G*Power 3.1.9.7, with a two-tailed mode, an effect size of d=0.5, and an α error probability of 0.05, resulting in a power of 0.836. Data analysis was performed using SPSS 29.0 statistical software (SPSS Inc., Chicago, IL, USA). Continuous variables were first tested for normality using the Shapiro-Wilk procedure. Categorical data were represented as [n (%)] and analyzed using the chi-square test. Continuous data with a normal distribution were expressed as mean ± SD and analyzed using independent samples t-tests. The correlation analysis was conducted using the Spearman correlation method. *P*-values less than 0.05 were considered significant.

## Results

*Comparison of demographic and baseline characteristics between the two groups*

A total of 140 cases were retrospectively included in this study, including 68 patients treated by Meloxicam alone and 72 patients

**Table 1.** Comparison of baseline characteristics between the two groups

| Data | Meloxicam (n=68) | Meloxicam + Warm Needle Therapy (n=72) | $t/\chi^2$ | p |
|---|---|---|---|---|
| Age (years) | 60.26±5.63 | 59.98±6.21 | 0.276 | 0.783 |
| BMI (kg/m$^2$) | 28.01±2.98 | 28.15±3.27 | 0.276 | 0.783 |
| Smoking status | | | 0.005 | 0.944 |
| Smoker (%) | 11 (16.18%) | 13 (18.06%) | | |
| Non-smoker (%) | 57 (83.82%) | 59 (81.94%) | | |
| Alcohol intake | | | 0.066 | 0.968 |
| Regular (%) | 17 (25.00%) | 19 (26.39%) | | |
| Occasional (%) | 28 (41.18%) | 30 (41.67%) | | |
| Non-drinker (%) | 23 (33.82%) | 23 (31.94%) | | |
| Hypertension (%) | 11 (16.18%) | 13 (18.06%) | 0.005 | 0.944 |
| Diabetes (%) | 8 (11.76%) | 11 (15.28%) | 0.129 | 0.719 |
| Cardiovascular diseases (%) | 10 (14.71%) | 12 (16.67%) | 0.007 | 0.931 |
| Previous knee surgery (%) | 3 (4.41%) | 6 (8.33%) | 0.361 | 0.548 |
| Previous corticosteroid injection (%) | 12 (17.65%) | 14 (19.44%) | 0.003 | 0.955 |
| Duration of knee pain (years) | 7.23±3.56 | 7.54±3.21 | 0.536 | 0.592 |
| K-L grade | | | 0.945 | 0.624 |
| Grade 1 | 10 (14.71%) | 7 (9.72%) | | |
| Grade 2 | 24 (35.29%) | 29 (40.28%) | | |
| Grade 3 | 34 (50.00%) | 36 (50.00%) | | |
| Health-related support | | | 0.004 | 0.998 |
| Family (%) | 40 (58.82%) | 42 (58.33%) | | |
| Long-term care facility (%) | 15 (22.06%) | 16 (22.22%) | | |
| None (%) | 13 (19.12%) | 14 (19.44%) | | |

Note: BMI: Body Mass Index; K-L grade: Kellgren-Lawrence grade.

treated by Meloxicam and warm needle therapy. There were no significant differences between the two groups in terms of age, BMI, smoking status, alcohol intake, hypertension, diabetes, cardiovascular diseases, previous knee surgery, previous corticosteroid injection, duration of knee pain, K-L grade, or health-related support (all P>0.05, **Table 1**), supporting the comparability between the two groups.

*Comparison of pain scores between the two group before and after treatment*

The baseline pain scores were similar between the two groups (6.82±2.87 vs. 6.78±2.92, t=0.079, P=0.937). However, post-treatment pain scores differed significantly between the two groups, with the Meloxicam + Warm Needle Therapy group showing a significantly lower pain score (3.62±1.98) compared to the Meloxicam group (4.38±1.95) (t=2.292, P=0.023) (**Figure 1**).

*Comparison of physical function (WOMAC score) between the two group before and after treatment*

At baseline, the WOMAC scores were comparable between the two groups (38.15±9.23 vs. 37.92±9.38, t=0.147, P=0.884) (**Figure 2**). However, the Meloxicam + Warm Needle Therapy group displayed a greater improvement in WOMAC score (27.82±8.75) after treatment compared to the Meloxicam group (31.25±8.82) (t=2.309, P=0.022), indicating a significant benefit associated with the addition of warm needle therapy to the treatment regimen.

*Comparison of knee flexion (ROM) between the two group before and after treatment*

At baseline, no significant variations were observed in ROM between the two groups (120.75°±6.34° vs. 121.26°±5.94°, t=0.487,

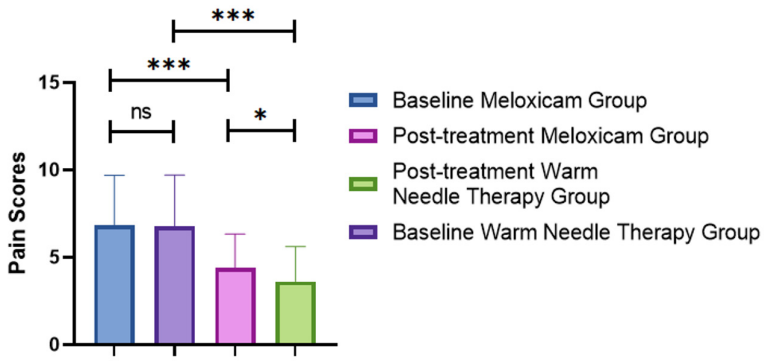


**Figure 1.** Pain scores at baseline and after treatment. Ns: No significant difference; *: P<0.05; ***: P<0.001.

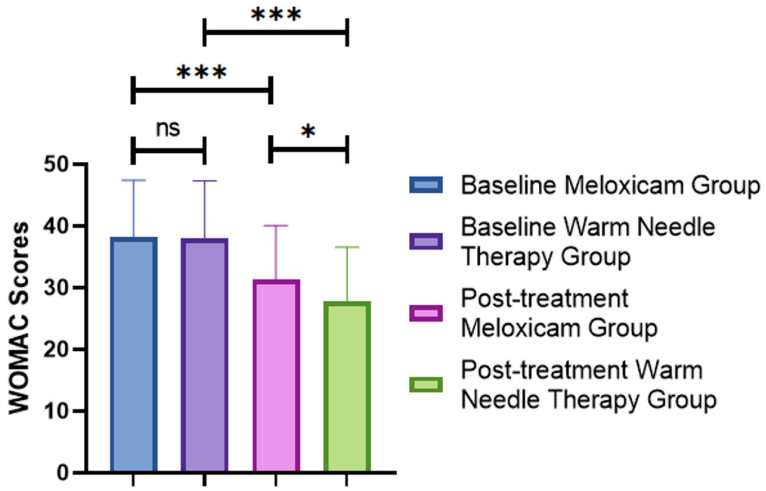


**Figure 2.** Physical function measured by WOMAC scores at baseline and after treatment. WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; Ns: No significant difference; *: P<0.05; ***: P<0.001.

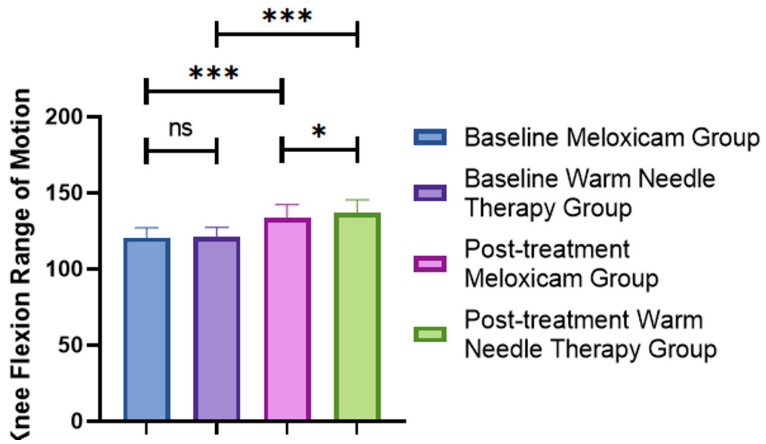


**Figure 3.** Knee flexion range of motion (ROM) at baseline and after treatment. ROM (°): Range of Motion (°); Ns: No significant difference; *: P<0.05; ***: P<0.001.

P=0.627) (**Figure 3**). However, post-treatment, the Meloxicam + Warm Needle Therapy group exhibited a significantly wider ROM (136.82°±8.58°) compared to the Meloxicam group (133.43°±8.86°) (t=2.296, P=0.023), indicating a significant improvement associated with the addition of warm needle therapy to the treatment regimen.

*Comparison of knee function (KSS) between the two group before and after treatment*

At baseline, the KSS was similar between the two groups (80.23±5.67 vs. 81.15±5.44, t=0.982, P=0.328) (**Figure 4**). However, post-treatment, the Meloxicam + Warm Needle Therapy group demonstrated a substantially higher KSS score (93.32±7.21) compared to the Meloxicam group (90.21±7.78) (t=2.450, P=0.016), signifying a significant improvement associated with the addition of warm needle therapy to the treatment regimen.

*Comparison of quality of life (SF-36 scores) between the two group before and after treatment*

The baseline SF-36 scores were comparable between the two groups (67.83±4.32 vs. 68.15±4.53, t=0.425, P=0.671) (**Table 2**). Nevertheless, post-treatment, the Meloxicam + Warm Needle Therapy group demonstrated a significantly higher total SF-36 score (81.24±6.33) compared to the Meloxicam alone group (78.43±6.85) (t=2.514, P=0.013), highlighting a significant improvement associated with the addition

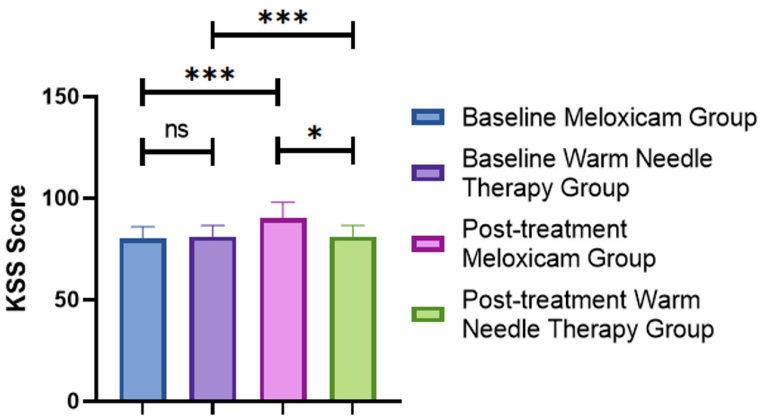


**Figure 4.** Knee function assessment (KSS) at baseline and after treatment. KSS: Knee Society Score; Ns: No significant difference; *: P<0.05; ***: P<0.001.

of warm needle therapy to the treatment regimen.

*Comparison of inflammatory factor levels between the two groups before and after treatment*

At baseline, no significant differences were observed in the levels of IL-8, MMP-3, IL-1β, TNF-α, or COX-2 between the two groups (all P>0.05, **Table 3**). However post-treatment, greater reductions in the levels of IL-8, MMP-3, IL-1β, TNF-α, and COX-2 were observed in the Meloxicam + Warm Needle Therapy group compared to the Meloxicam group (all P<0.05), indicating a significant anti-inflammatory effect associated with the addition of warm needle therapy to the treatment regimen.

*Comparison of patient satisfaction between the two groups before and after treatment*

Regarding patient satisfaction, the Meloxicam + Warm Needle Therapy group demonstrated a significantly higher satisfaction level (8.43± 2.15) compared to the Meloxicam group (7.58±2.24) (t=2.275, P=0.024) (**Table 4**). Additionally, a higher proportion of patients in the Meloxicam + Warm Needle Therapy group expressed willingness to recommend the treatment (81.94%) compared to the Meloxicam group (64.71%) ($\chi^2$=4.495, P=0.034), indicating a higher level of satisfaction and willingness to recommend the combined treatment approach.

*Correlation analysis between warm needle therapy and post-treatment pain relief and physical function*

Correlation analysis identified several significant associations between the combination of Warm Needle Therapy and post-treatment outcomes (**Table 5**). Post-treatment pain scores showed a modest but statistically significant negative correlation with Warm Needle Therapy (r=-0.191, P=0.024), as did the post-treatment WOMAC score (r=-0.193, P=0.022). Conversely, post-treatment ROM and KSS [26] both exhibited positive correlations with the therapy, with respective correlation coefficients of r=0.192 (P=0.023) and r=0.205 (P=0.015). Moreover, the SF-36 score showed a significant positive correlation with Warm Needle Therapy (r= 0.210, P=0.013). Furthermore, post-treatment levels of inflammatory factors, including IL-8, MMP-3, IL-1β, TNF-α, and COX-2, all demonstrated significant negative correlations with Warm Needle Therapy, with correlation coefficients falling between -0.208 and -0.196 and *p*-values between 0.014 to 0.020. Additionally, patient-reported satisfaction revealed a positive correlation with Warm Needle Therapy (r=0.190, P=0.024), as did the likelihood of recommending the treatment (r=0.195, P=0.021). These findings collectively suggest a meaningful contribution of Warm Needle Therapy guided by ultrasound to pain relief, physical function enhancement, and inflammatory modulation in patients with knee osteoarthritis.

## Discussion

Knee osteoarthritis (KOA) is a debilitating condition that affects a significant portion of the elderly population [30, 31]. Patients often experience chronic pain and a decrease in physical function due to the progressive nature of the disease [32]. While various treatment modalities exist, achieving optimal pain relief and improvement in physical function remains a challenge. We aimed to assess the effect of warm needle therapy guided by ultrasound on pain relief and the enhancement of physical

**Table 2.** Comparison of quality of life (SF-36) between the two groups before and after treatment

| Data | Meloxicam (n=68) | Meloxicam + Warm Needle Therapy (n=72) | t | p |
|---|---|---|---|---|
| Baseline SF-36 score | 67.83±4.32 | 68.15±4.53 | 0.425 | 0.671 |
| Post-treatment SF-36 score | 78.43±6.85 | 81.24±6.33 | 2.514 | 0.013 |
| t | 10.793 | 14.269 | | |
| *P* value | <0.001 | <0.001 | | |

Note: SF-36: Short Form-36 Health Survey.

**Table 3.** Comparison of inflammatory factor levels between the two groups before and after treatment

| Data | Time | Meloxicam (n=68) | Meloxicam + Warm Needle Therapy (n=72) | t | P |
|---|---|---|---|---|---|
| IL-8 levels (pg/mL) | Baseline | 34.65±8.12 | 33.71±8.26 | 0.681 | 0.497 |
| | Post-treatment | 23.22±7.83 | 19.98±7.54 | 2.494 | 0.014 |
| t (Baseline vs. Post) | | 8.356 | 10.417 | | |
| P (Baseline vs. Post) | | <0.001 | <0.001 | | |
| MMP-3 levels (ng/mL) | Baseline | 14.81±7.23 | 13.67±7.58 | 0.912 | 0.363 |
| | Post-treatment | 9.83±3.58 | 8.34±3.36 | 2.533 | 0.012 |
| t (Baseline vs. Post) | | 5.090 | 5.455 | | |
| P (Baseline vs. Post) | | <0.001 | <0.001 | | |
| IL-1β levels (pg/mL) | Baseline | 56.73±10.25 | 56.59±10.46 | 0.081 | 0.936 |
| | Post-treatment | 48.63±9.78 | 44.49±9.96 | 2.484 | 0.014 |
| t (Baseline vs. Post) | | 4.715 | 7.109 | | |
| P (Baseline vs. Post) | | <0.001 | <0.001 | | |
| TNF-α levels (ng/mL) | Baseline | 2.36±0.59 | 2.45±0.13 | 1.295 | 0.199 |
| | Post-treatment | 1.13±0.42 | 0.95±0.44 | 2.406 | 0.017 |
| t (Baseline vs. Post) | | 14.005 | 27.742 | | |
| P (Baseline vs. Post) | | <0.001 | <0.001 | | |
| COX-2 levels (pg/mL) | Baseline | 20.26±5.24 | 19.35±5.16 | 1.031 | 0.304 |
| | Post-treatment | 14.23±4.68 | 12.32±4.89 | 2.355 | 0.020 |
| t (Baseline vs. Post) | | 7.078 | 8.391 | | |
| P (Baseline vs. Post) | | <0.001 | <0.001 | | |

Note: IL-8: Interleukin-8; MMP-3: Matrix Metalloproteinase-3; IL-1β: Interleukin-1 beta; TNF-α: Tumor Necrosis Factor-alpha; COX-2: Cyclooxygenase-2.

**Table 4.** Comparison of patient satisfaction between the two groups

| Data | Meloxicam (n=68) | Meloxicam + Warm Needle Therapy (n=72) | $t/\chi^2$ | P |
|---|---|---|---|---|
| Satisfaction Level (1-10) | 7.58±2.24 | 8.43±2.15 | 2.275 | 0.024 |
| Would Recommend (Y/N) | 44 (64.71%)/24 (35.29%) | 59 (81.94%)/13 (18.06%) | 4.495 | 0.034 |

Note: Y/N: Yes/No.

function in patients with KOA. Our findings offer insight into the benefits of this combined therapeutic approach.

Our results indicate that the combination of meloxicam with warm needle therapy, guided by ultrasound, led to a significant reduction in pain and improved physical function compared to meloxicam alone. Notably, the post-treatment pain scores, WOMAC scores for physical function, knee flexion range of motion, knee society scores, and quality of life scores all showed significant improvements in the group receiving the combined therapy. These findings

**Table 5.** Correlation analysis between the warm needle therapy and post-treatment pain relief and physical function

| Data | r | P |
|---|---|---|
| Post-treatment pain score | -0.191 | 0.024 |
| Post-treatment WOMAC score | -0.193 | 0.022 |
| Post-treatment ROM | 0.192 | 0.023 |
| Post-treatment KSS score | 0.205 | 0.015 |
| Post-treatment SF-36 score | 0.210 | 0.013 |
| Post-treatment IL-8 levels (pg/mL) | -0.208 | 0.014 |
| Post-treatment MMP-3 levels (ng/mL) | -0.211 | 0.012 |
| Post-treatment IL-1β levels (pg/mL) | -0.207 | 0.014 |
| Post-treatment TNF-α levels (ng/mL) | -0.200 | 0.018 |
| Post-treatment COX-2 levels (pg/mL) | -0.196 | 0.020 |
| Satisfaction Level (1-10) | 0.190 | 0.024 |
| Would Recommend (Y/N) | 0.195 | 0.021 |

Note: WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; ROM: Range of Motion; KSS Score: Knee Society Score; SF-36: Short Form-36 Health Survey.

align with the results reported by Zhang et al. [41], who found that acupuncture, including warm needle therapy, significantly reduced pain intensity and improved physical function in patients with KOA.

The observed reduction in pain scores and improvement in physical function can be attributed to several mechanisms related to warm needle therapy. Acupuncture and similar techniques have long been recognized for their role in alleviating chronic pain and improving the quality of life in individuals with chronic musculoskeletal conditions [33, 34]. Research has documented the modulatory effects of acupuncture on pain perception, local blood flow, and cytokine levels [35, 36]. Warm needle therapy, which uses heated acupuncture needles, is believed to enhance the therapeutic effects compared to traditional acupuncture [37, 38]. The additional warmth generated during needle insertion and manipulation is hypothesized to enhance tissue microcirculation, muscle relaxation, and local metabolism, contributing to the observed pain relief and improved physical function in our study. This aligns with the findings of Lee et al. [43], who reported that patients receiving acupuncture experienced a significant improvement in pain and function compared to those receiving sham acupuncture or conventional therapy alone.

The significant reduction in inflammatory factors, including IL-8, MMP-3, IL-1β, TNF-α, and COX-2 in the group receiving warm needle therapy, indicates an anti-inflammatory effect associated with this treatment modality. This anti-inflammatory effect aligns with previous studies suggesting that acupuncture and related techniques can modulate the release of pro-inflammatory cytokines and reduce local inflammation [39]. The observed decrease in inflammatory factors may contribute to the reduction in pain and the improvement in physical function among patients receiving warm needle therapy.

The effect of warm needle therapy on inflammatory modulation may involve multiple mechanisms. The thermal effect of the heated needle, coupled with the therapeutic activation of specific acupoints, may trigger a localized anti-inflammatory response [40]. Additionally, acupuncture may trigger paracrine signaling, involving the release of endogenous opioids, neuropeptides, and neurotransmitters, which may help regulate the local inflammatory milieu. Furthermore, recent advancements in the understanding of neuro-immune interactions in the context of acupuncture have shed light on the potential mechanisms through which acupuncture can exert systemic anti-inflammatory effects [41]. The reductions in inflammatory factors observed in our study further underscore the complex interplay between acupuncture-based therapies and the modulation of inflammatory responses in KOA.

The significantly higher satisfaction levels and a greater willingness to recommend the treatment in the group receiving warm needle therapy provide valuable insight into the patient's experience and treatment adherence. Patient-reported outcomes are invaluable in understanding the holistic impact of interventions, particularly in chronic conditions such as KOA [42]. The higher satisfaction levels and the willingness to recommend the combined treatment approach underscore the importance of patient-centered care and the potential for warm needle therapy to address not only the physical symptoms but also the overall patient experience. The warmth generated during the therapy, in addition to its potential therapeutic effects, may contribute to a more comfortable

and pleasant experience, as noted in similar studies [44].

The personalized approach of traditional Chinese medicine, which emphasizes a holistic understanding of the patient's condition and the use of individualized treatment strategies, may also influence the patient's perception of the therapy. Furthermore, the involvement of patients in shared decision-making, as emphasized in the treatment approach outlined in our methods, may have contributed to a greater sense of autonomy and empowerment for the patients, leading to increased satisfaction with their treatment experience.

While our study presents valuable insight into the benefits of ultrasound-guided warm needle therapy in the management of KOA, several limitations should be acknowledged. First, the retrospective nature of the study may introduce inherent biases and confounding variables. Future prospective studies with larger sample sizes and randomized controlled designs would provide more robust evidence of the efficacy of warm needle therapy. Additionally, the lack of long-term follow-up data in our study limits our understanding of the sustained effects of the combined therapy.

Furthermore, the specific mechanisms underlying the observed effects of warm needle therapy on pain relief, physical function, and inflammatory modulation warrant further investigation. Advanced imaging techniques and molecular studies may provide insights into the neurobiological, immunological, and biochemical pathways involved in the response to warm needle therapy. Additionally, exploring the potential synergistic effects of warm needle therapy with other established modalities for KOA management, such as physical therapy and pharmacologic interventions, deserves further exploration.

## Conclusion

The findings of this study highlight the positive effect of warm needle therapy guided by ultrasound in enhancing pain relief, physical function, and inflammatory modulation in patients with KOA. This study not only offers valuable insight into the clinical implications of integrating warm needle therapy into the management of KOA but also provides a robust foundation for further research and clinical implementation, fostering the advancement of patient-centric care for KOA management.

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## Disclosure of conflict of interest

None.

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