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# A Literature Review on the Clinical Efficacy and Mechanism of Acupuncture in Treating Knee Osteoarthritis

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**Abstract:** ***Knee osteoarthritis (KOA) is a chronic disabling disorder characterized by degenerative changes in articular cartilage. With the aging population, its global prevalence continues to rise, imposing a substantial economic burden on society. Current Western medical treatments primarily include non-steroidal anti-inflammatory drugs and surgery. However, the long-term side effects of medications and the high risks associated with surgery have led patients to seek complementary and alternative medicine (CAM) therapies. As a key component of traditional Chinese medicine, acupuncture has been widely used in the clinical management of KOA due to its significant benefits in pain relief and functional improvement. This review aims to systematically summarize the modern medical mechanisms of acupuncture in treating KOA, common acupuncture techniques and their characteristics, and to discuss the limitations of current research along with future directions. Substantial evidence indicates that acupuncture exerts anti-inflammatory, analgesic, cartilage metabolic regulatory, and joint structure protective effects through multiple targets and pathways, establishing it as a safe and effective non-pharmacological therapy for KOA.***

**Keywords:** Acupuncture, Knee osteoarthritis, Literature review, Analgesia, Anti-inflammatory, Mechanism, Clinical research**.**

## 1. Introduction

Knee osteoarthritis (KOA) is a chronic, progressive degenerative joint disorder highly prevalent among middle-aged and elderly populations. With the aging demographic and increased human lifespan, the incidence of osteoarthritis has not only remained high but continues to grow [1]. Primary symptoms include joint pain accompanied by redness, swelling, warmth, and tenderness, difficulty in climbing stairs and squatting, as well as joint crepitus and effusion. In severe cases, the condition can lead to joint deformity and permanent loss of function, significantly impacting patients' physical health, mental well-being, and quality of life [2].

Modern medicine adopts a stepwise approach to treat KOA, encompassing three main strategies: conservative management (e.g., education, exercise, weight reduction), pharmacological therapy (e.g., paracetamol, NSAIDs, intra-articular injections), and surgical intervention (e.g., total knee arthroplasty). Personalized treatment plans are essential [3]. However, long-term use of nonsteroidal anti-inflammatory drugs (NSAIDs) is limited by gastrointestinal, cardiovascular, and renal side effects [4], while opioid medications carry a significant risk of addiction, requiring cautious use [5]. Although total knee arthroplasty (TKA) is effective for end-stage patients, it involves challenges such as surgical risks, high costs, and prolonged recovery [6]. Consequently, developing safe and effective non-pharmacological therapies has become a major focus in clinical research.

Acupuncture, a treasured practice in traditional Chinese medicine with a history spanning over two millennia, was inscribed on UNESCO's Representative List of the Intangible Cultural Heritage of Humanity in 2010. Rooted in meridian theory and the dynamics of qi and blood, this therapy involves stimulating specific acupoints (e.g., Dubi, Zusanli, Yanglingquan) to unblock meridians, regulate qi and blood flow, and balance yin and yang, embodying the therapeutic principle that "unblocking leads to relief" [7]. Recent advances in modern research have increasingly validated the efficacy of acupuncture in managing KOA. Multiple international guidelines—including those from the American College of Rheumatology (ACR), the European League Against Rheumatism (EULAR), and the Osteoarthritis Research Society International (OARSI)—conditionally recommend acupuncture for KOA management. This systematic review provides a comprehensive overview of relevant literature, offering valuable insights for clinical practice and further research in acupuncture.

## 2. Modern Medical Understanding and Pathological Mechanism of Knee Osteoarthritis

The pathological mechanism of KOA is complex, involving not merely "wear and tear" but the interplay of mechanical, inflammatory, metabolic, and immunological factors.

### 2.1 Degeneration of Articular Cartilage

Articular cartilage is composed of chondrocytes and extracellular matrix (ECM). Chondrocytes, the only cell type in cartilage, have limited self-repair capacity and are highly vulnerable to damage [8]. In KOA, cartilage—a critical joint structure—is consistently subjected to mechanical stress from body weight and physical activity. Mechanosensitive ion channels in chondrocytes are linked to intercellular biochemical signaling. Mechanical stimuli induce cation mobilization through these channels, regulating chondrocyte metabolism and influencing cartilage homeostasis [9]. These changes alter chondrocyte phenotypic metabolism,

subsequently affecting the composition and quantity of the ECM. This leads to collagen degradation, proteoglycan loss, and upregulated expression of chondrofibril and intermediate layer proteins, reflecting abnormal states of cartilage cells and ECM, and compromised cartilage homeostasis [10].

### 2.2 Synovitis and Immune Response

Synovitis is a hallmark pathological feature of KOA, contributing significantly to knee pain, swelling, and stiffness, while accelerating cartilage degeneration [11]. Damaged chondrocytes and subchondral bone release fragments and crystals that are recognized by synovial macrophages, activating the innate immune system. These immune cells secrete inflammatory cytokines such as tumor necrosis factor-α (TNF-α), interleukin-1β (IL-1β), and IL-6, which play pivotal roles in the pathogenesis of KOA. Notably, IL-1β can independently trigger inflammatory responses and catabolic processes, serving as a key inflammatory cytokine in KOA development by establishing an inflammatory microenvironment [12]. These cytokines not only exacerbate cartilage breakdown but also stimulate synovial hyperplasia, induce synovial effusion, and directly activate sensory nerve endings, resulting in pain and hypersensitivity.

### 2.3 Pain Mechanisms in Knee Osteoarthritis

Pain in KOA arises through multiple mechanisms: Nociceptive Sensitization: The knee is rich in nociceptors. Studies show that lesions in KOA tissues—including cartilage, subchondral bone, synovium, infrapatellar fat pad, meniscus, and ligaments—trigger the release of pro-inflammatory cytokines that directly activate pain receptors [13]. Peripheral Sensitization: Chronic inflammation lowers nociceptive thresholds, leading to heightened sensitivity to non-painful stimuli (allodynia) and an exaggerated pain response to normal joint movements [14]. Central Sensitization: Persistent tissue damage, inflammation, and chronic pain overstimulate central nervous system pain pathways, resulting in central sensitization. This involves disinhibition at spinal and supraspinal levels, increasing spontaneous neuronal activity, lowering activation thresholds, and expanding receptive fields, thereby amplifying pain and tactile sensitivity [15].

### 2.4 Subchondral Bone Changes

Subchondral bone, situated beneath articular cartilage, exhibits pathological features in KOA such as sclerosis, osteophyte formation, and bone marrow lesions (BMLs). Disruption of the balance between bone resorption and formation leads to abnormal bone remodeling. This results in subchondral bone sclerosis and osteophyte formation, which impair joint cushioning, alter biomechanical properties, and accelerate cartilage degeneration [16]. Abnormal bone remodeling changes the joint's biomechanical environment, increasing stress on cartilage, while bone marrow lesions are strongly associated with pain.

## 3. Mechanism of Acupuncture Treatment for KOA: Modern Scientific Interpretation

In traditional Chinese medicine (TCM), KOA falls under the category of Bi syndrome, attributed to deficient vital energy and invasion by external pathogenic factors such as wind, cold, and dampness, which obstruct the meridians and disrupt the flow of qi and blood. Chronic Bi syndrome may lead to depletion of qi and blood, manifesting as qi and blood deficiency or liver-kidney insufficiency. Treatment principles typically involve expelling wind and cold, activating blood circulation to unblock meridians, and nourishing the liver and kidneys. TCM employs multiple modalities for KOA, including herbal medicine, acupuncture, warm needle therapy, small needle knife techniques, and electroacupuncture. Acupuncture stimulates acupoints to activate meridian energy, achieving effects such as tonifying the liver and kidneys, strengthening tendons and bones, dispelling wind and cold, eliminating dampness, unblocking meridians, and promoting blood circulation to resolve stasis. Modern research has elucidated the multi-target mechanisms of acupuncture from the perspectives of neuroendocrinology and immunology.

### 3.1 Regulation of Inflammatory Cytokines

This is a central mechanism through which acupuncture exerts its anti-inflammatory and analgesic effects. Research shows that acupuncture effectively reduces pro-inflammatory factors while enhancing anti-inflammatory cytokines. It regulates metabolic processes in knee tissues, accelerates tissue regeneration, repairs inflamed joint structures, and alleviates inflammatory responses [17].

### 3.2 Activation of Endogenous Pain Systems

Acupuncture signals transmitted to the central nervous system trigger complex neuroregulatory responses: Opioid System: Acupuncture promotes the release of endogenous opioids (e.g., endorphins, enkephalins, dynorphins) from regions such as the periaqueductal gray and spinal dorsal horn. These bind to μ, δ, and κ receptors, inhibiting pain signal transmission. The blockade of acupuncture analgesia by naloxone confirms this mechanism. Monoamine Neurotransmitters: Acupuncture increases serotonin (5-HT) and norepinephrine (NE) levels in the brainstem and spinal cord, inhibiting nociceptive transmission via descending inhibitory pathways. Purinergic System: Local acupuncture stimulation releases adenosine. Regulation of adenosine-metabolizing enzymes extends its extracellular presence, suppressing breakdown and enhancing production, thereby maintaining cartilage metabolic homeostasis [18].

### 3.3 Improvement of Local Microcirculation and Blood Rheology

Acupuncture dilates local blood vessels, accelerates blood flow, reduces blood viscosity, and improves tissue perfusion. This helps remove inflammatory metabolites and delivers more oxygen and nutrients to cartilage and surrounding tissues, promoting repair and alleviating blood stasis. Studies indicate that acupuncture increases blood flow velocity in knee vessels, accelerates clearance of metabolic waste, facilitates tissue repair, and reduces inflammation. These effects collectively improve microcirculatory perfusion, raise skin temperature around the knee, and alleviate pain in KOA [19].

### 3.4 Regulation of Cartilage Metabolism and Delay of Cartilage Degeneration

Growing research focuses on the protective effects of acupuncture on cartilage. Animal studies show that electroacupuncture reduces MMP-13 expression and upregulates TIMP-1 in OA cartilage, slowing ECM degradation. Acupuncture may also modulate signaling pathways such as Wnt/β-catenin and BMP/Smads, which are crucial for chondrocyte differentiation and proliferation, helping maintain cellular homeostasis. Various acupuncture techniques have been shown to delay cartilage degeneration, promote knee joint recovery, alleviate pain, and improve treatment outcomes [20].

### 3.5 Regulation and Remodeling of the Central Nervous System

After acupuncture treatment, abnormal activities in brain regions involved in pain perception and regulation—such as the anterior cingulate cortex, prefrontal cortex, and insula—normalize. This indicates that acupuncture not only suppresses peripheral inflammation but also reverses central sensitization, reshaping the brain's pain processing patterns. Acupuncture' neurophysiological mechanisms involve both central and peripheral stimulation, activating receptors under acupoints to convert physical stimuli into neural signals transmitted through the central nervous system. Studies demonstrate that acupuncture for KOA pain acts through both peripheral and central regulatory mechanisms to achieve therapeutic effects [21].

## 4. Common Methods of Acupuncture Treatment for KOA

Clinical practice features a variety of acupuncture techniques and combinations for KOA.

### 4.1 Acupuncture

Acupuncture is a convenient, efficient, and cost-effective treatment widely used for KOA. Stimulating specific acupoints can improve knee function; local acupoint stimulation enhances microcirculation, promotes absorption of inflammatory mediators, and alleviates joint pain [22]. Lin Yanping et al. [23] applied acupuncture based on the "bone-preserving" theory to treat KOA with phlegm-stasis obstruction syndrome, achieving a 96. 43% effective rate. Therapeutic outcomes are influenced by needle insertion parameters such as angle, amplitude, force, depth, and retention time. Chen Tingting et al. [24] showed that electroacupuncture enhances cartilage self-repair and delays joint degeneration, with different waveforms producing distinct effects. Liu Huifeng's [25] clinical trial compared warm acupuncture with conventional acupuncture, finding that warm needle therapy yielded better outcomes in pain reduction, knee function improvement, synovial membrane thickness reduction, and joint mobility. Debates continue regarding whether warm acupuncture, electroacupuncture, or conventional acupuncture is more effective. Zhang Jiwei's [26] meta-analysis indicated that warm needle therapy provides better pain relief than acupuncture alone, though both showed similar effectiveness rates. Compared to electroacupuncture, warm needle therapy offered greater relief from joint stiffness but no significant differences in pain reduction, efficacy rates, or WOMAC scores.

### 4.2 Small Needle Knife

The small needle knife technique has gained popularity in recent years. It involves cutting and separating diseased tissues to release soft tissue adhesions, reduce intraosseous pressure, improve local circulation, delay chondrocyte degeneration, and raise pain thresholds, thereby alleviating discomfort and restoring knee joint biomechanical balance [27]. It also enhances blood supply to soft tissues, inhibits inflammatory mediator release, reduces tissue inflammation, and minimizes inflammatory damage, contributing to pain relief and improved clinical outcomes [28]. Clinical trials by Xu Cong et al. [29] demonstrated that small needle knife therapy for KOA is safe, significantly alleviates pain, and improves knee function. No severe complications were reported, with only a 3.75% incidence of mild adverse events.

### 4.3 Warm Needle Acupuncture

Moxibustion, first documented in the Nei Jing, generates heat through burning to raise local tissue temperature. This accelerates blood circulation, increases metabolic rate, and helps eliminate inflammatory substances, thereby reducing knee joint edema and hyperplasia while promoting functional recovery [30]. Common techniques include moxa cone therapy, indirect moxibustion, thunder-fire moxibustion, and heat-sensitive moxibustion. Yang Shengya [31] conducted a clinical trial on KOA patients with cold-dampness obstruction syndrome, showing that moxibustion effectively reduced pain and improved joint function based on VAS and symptom scores. Liu Minjie [32] found that thunder-fire moxibustion significantly reduced pain and enhanced knee function. Hu Xiaomei et al. [33] demonstrated that heat-sensitive moxibustion improves clinical outcomes, suppresses inflammation, reduces pain, restores joint function, and enhances quality of life in KOA patients.

### 4.4 Electroacupuncture

Electroacupuncture (EA) combines traditional acupuncture with modern electrical stimulation, showing promising clinical efficacy for KOA. EA stimulation enhances local blood flow, improves microcirculation, promotes metabolic waste clearance, and reduces inflammatory responses. Zhang Hui's study [34] combined EA with warm needle therapy, showing significant pain relief, improved joint mobility, enhanced bone metabolism, and reduced disease severity. Chen Si's research [35] used triple-needle EA combined with TCM directional drug permeation therapy, which increased overall success rates, lowered TCM syndrome scores, reduced inflammatory markers, and improved knee function compared to drug permeation alone.

### 4.5 Transcutaneous Acupoint Electrical Stimulation

Transcutaneous acupoint electrical stimulation (TAES) integrates TCM acupoint therapy with Western electrical stimulation, offering a novel, effective analgesic approach. For KOA patients, TAES allows customized stimulation

intensity to improve outcomes. Yang Jie [36] showed that TAES has overall effectiveness comparable to warm needle acupuncture, with superior immediate pain relief. This technique avoids repeated needle insertions, addressing needle phobia and improving patient acceptance. Stimulation of Ashi points and other acupoints helps regulate meridian flow, improve blood circulation, and resolve stasis. TCM attributes joint pain in KOA to blood stasis; electrical stimulation activates blood circulation and resolves stasis, significantly reducing pain. Combined with conventional therapies, TAES enhances intra-articular microcirculation, provides substantial pain relief, and accelerates recovery. Lian Zhansheng et al. [37] found that combining hyaluronate injections with TAES significantly improved quality of life, reduced pain, and promoted knee joint recovery. With technological advances, TAES devices have become portable and user-friendly, enabling home use and remote medical supervision, addressing challenges in healthcare access and resource distribution in China.

#### 4.6 Personalization of Treatment

TCM emphasizes syndrome differentiation. Clinicians should tailor acupoint selection based on patterns: Cold-dampness obstruction: add moxibustion at Shenshu (BL23) and Guanyuan (CV4). Liver-kidney deficiency: add Ganshu (BL18), Shenshu (BL23), and Taixi (KI3). Qi-blood stagnation: add Geshu (BL17), Hegu (LI4), and Taichong (LR3) [38]. A typical treatment course involves 2–3 sessions per week, with 8–12 sessions constituting one cycle.

## 5. Safety

Acupuncture is extremely safe. Adverse reactions are rare and mild, primarily including minor bleeding, bruising, transient pain, or needle fainting. Serious adverse events (e.g., pneumothorax or organ injury) are exceedingly rare when performed by trained practitioners. Compared to the significant risks of NSAIDs, acupuncture's safety profile is highly favorable.

## 6. Discussion, Limitations, and Future Prospects

Despite accumulating evidence, several challenges and controversies remain in acupuncture research for KOA.

#### 6.1 Discussion and Controversies

Placebo Effect: Designing an ideal sham acupuncture control is methodologically challenging. Whether non-invasive superficial needling is inert or physiologically active remains debated. Clinically, patients may prioritize symptom improvement and safety over distinguishing "specific" from "non-specific" effects. Individualization vs. Standardization: While personalized treatment is central to acupuncture, it conflicts with the standardized protocols required in randomized controlled trials (RCTs). Balancing efficacy with methodological rigor in large-scale studies is complex.

#### 6.2 Current Research Limitations

Inconsistent Study Quality: Some RCTs have small sample sizes, difficulties in blinding, and short follow-up periods. Mechanistic Research Gaps: Most mechanistic studies rely on animal models, with limited human evidence. Mechanisms related to cartilage metabolism and central nervous system remodeling need further exploration. Insufficient Long-Term Data: Most studies focus on short-term outcomes; long-term effectiveness and cost-effectiveness beyond one year require more robust data.

#### 6.3 Future Research Directions

Conduct more rigorous RCTs using improved sham controls, effective blinding, and multicenter, large-sample long-term follow-up. Explore mechanisms using omics technologies (proteomics, metabolomics), molecular imaging, and neuroscience to elucidate acupuncture's action network from a systems biology perspective. Identify efficacy-predicting biomarkers (e.g., genotypes, TCM patterns, fMRI features) for precision medicine. Optimize treatment protocols by comparing different acupuncture methods, stimulation parameters, frequency, and duration. Develop integrated treatment models combining acupuncture with exercise, physical therapy, medication, and other interventions.

## 7. Conclusion

Based on current evidence, acupuncture for KOA has a solid scientific foundation and clear clinical efficacy. Through multi-target mechanisms—including regulating inflammatory factors, activating endogenous pain modulation, improving microcirculation, adjusting cartilage metabolism, and remodeling the central nervous system—it effectively alleviates pain, improves knee function, enhances quality of life, and reduces reliance on analgesics. Acupuncture is highly safe with minimal adverse reactions. Despite methodological controversies, it is widely recognized as an effective non-pharmacological therapy and included in international guidelines. Future high-quality basic and clinical research will further clarify its mechanisms and optimize protocols, enabling acupuncture to play a vital role in stepped care for KOA and global public health, offering a safe, effective, and patient-friendly option for millions.

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