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Original Article

Efficacy of Fire Acupuncture in Pain Management after Total Hip Arthroplasty: A Randomized, Double-Blind, Placebo-Controlled Trial

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Abstract:

Objective: As an increasingly popular treatment, fire acupuncture is used to alleviate postoperative pain; however, its therapeutic effects have not been thoroughly investigated. This study aimed to assess the analgesic efficacy of fire acupuncture in patients undergoing unilateral total hip arthroplasty (THA).

Methods: This prospective, randomised controlled study set out to assess the analgesic efficacy of fire acupuncture on patients undergoing unilateral total hip arthroplasty. We enrolled patients scheduled for primary THA and assigned them to either the fire acupuncture group or a sham acupuncture group in a double-blind manner. Outcomes included pain severity, the use frequency and dosage of rescue anesthetic medications, and related biological indicators.

Results: The fire needle group demonstrated significantly lower pain scores at all postoperative time points and required less rescue morphine within 0-24 hours (18.5 ± 6.3 mg vs. 32.4 ± 8.1 mg, $P<0.001$) compared to the sham fire needle group. Additionally, morphine consumption remained significantly lower in the fire needle group during the 24–48 and 48–72 hour periods($P<0.001$). Levels of pro-inflammatory markers (IL-1β, IL-6, TNF-α, CRP) and the neuropeptide Substance P were significantly reduced in the fire needle group (all $P<0.001$). The intervention also led to superior hip function recovery (Harris Hip Score) (all $P<0.001$) and improved quality of life, particularly in bodily pain domains (SF-36) at 1 and 3 months ($P<0.001$). The fire needle group experienced fewer opioid-related side effects (notably nausea). Furthermore, the fire needle treatment itself demonstrated a favorable safety profile, with only minor local adverse events (e.g., minor bleeding: 6.0%, $P>0,05$) and no serious complications such as infection or burns.

Conclusion: Fire needle therapy appears to be effective in reducing postoperative pain, opioid use, and inflammation while promoting early functional recovery after THA. Although fire acupuncture may help to some extent with the pain after total hip replacement surgery, more experimental research needs to be carried out at present**.**

Keywords: Fire needle therapy; Total hip arthroplasty; Postoperative pain; Randomized controlled trial; Functional recovery; Inflammatory cytokines.

Introduction

The problem of postoperative pain management is still prominent in patients who have undergone large-scale surgical procedures such as total knee arthroplasty (TKA) and hip resurfacing. Good postoperative pain management can reduce the risk of deep vein thrombosis, muscle rigidity

during the rehabilitation period, chronic non-specific pain syndrome, etc., and shorten the length of inpatient stay. Although advances have been made in analgesic pharmacotherapies, opioids continue to be the treatment of choice primarily despite their side-effects (including respiratory depression and constipation) and risks (dependence/dependency), which often outweigh these benefits [1-3]. Thus, exploring additional or alternative non-pharmacological approaches with adequate analgesic efficacy becomes urgent as more factors pose a risk [4, 5].

The global burden of hip osteoarthritis and subsequent demand for THA have been rising steadily, driven by aging populations and increasing prevalence of obesity and sedentary lifestyles. Epidemiological data show that millions of hip arthroplasties are performed globally each year, and among those patients, many experience moderate-to-severe postoperative pain affecting functional rehabilitation. For example, post-operative pain level in the first four to seven days after THA has a high correlation with long-term joint function and patients' satisfaction. Considering the large quantity of such procedures and their significant effects on patients' pain management in postoperative care, optimising analgesic regimens is urgently needed to enhance the recovery pace of these people, including those with diabetes, after surgery [5].

At present, the main mode of postoperative analgesia is a combination of multimodal pharmacotherapy including systemically administered opioids, NSAIDs, and local anesthetics. Although these forms are effective, the deficiencies require further research on other approaches. Acupuncture, which can relieve pain through the adjustment of nerve function, falls within one scope we must explore in current medical development. Previous systematic reviews and meta-analysis reports have indicated that acupuncture has been shown to decrease patients' post-operation pain scores as well as their dependency on anesthetics under the condition of peri-operative treatment [1, 6, 7]. There are differences in acupuncture techniques between scholars and variations across different studies [8, 9]; it has not been proven that they all show a positive outcome.

Due to increasing evidence supporting the effect of acupoint needling therapy in treating chronic pain symptoms or populations that require special attention during surgical administration, further investigation and verification are needed [10]. Furthermore, in various forms of acupuncture therapy, fire needle acupuncture using hot needles has received fewer studies and evaluations at present compared with other types [11]. Fire needles are thought to work by combining heat with pressure, thus having a stronger effect on pain perception and inflammation than general acupoints. To date, high-quality randomized controlled trials assessing the efficacy and safety of fire needle acupuncture for acute postoperative pain after THA are lacking, representing a notable gap in the literature [12, 13].

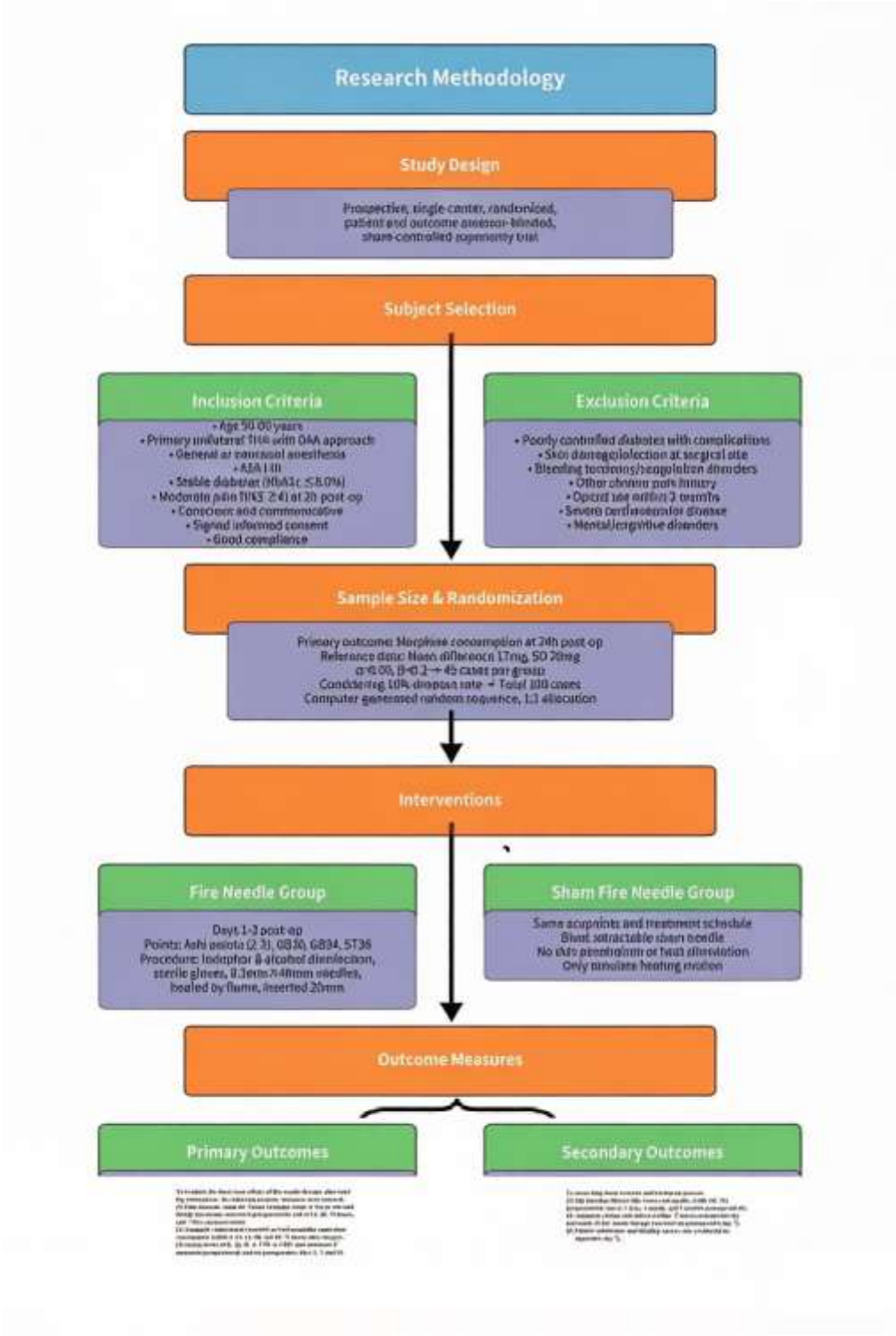
Therefore, a prospective controlled clinical trial will be conducted to compare the analgesic effect among patients treated by hip joint replacement surgery. This approach can limit the impact of potential confounders and randomisation artifacts to enhance the reliability of these results. Intervention: Standardised fire needle acupuncture therapy for the intervention group, and sham fire needle treatments for comparison in the control group aimed at mimicking a real experience without actual medical benefits. Outcomes of interest will cover perioperative pain severity scores, analgesic requirements, as well as markers related to inflammation and immunity (e.g., cytokine profiles in the peripheral blood) [5, 18, 20].

To identify if fire needle acupuncture, a novel intervention, has superior efficacy compared with placebo in alleviating pain and suppressing opioid

levels, thereby reducing pain perception at earlier stages after total hip arthroplasty (THA). The secondary target includes finding any biochemical and immunological changes related to the analgesic effect to provide a reference for further study of these problems in research methods. Lastly, it hopes to provide substantial empirical support and directions for promoting their application in combined therapy for postoperative rehabilitation after orthopedic surgery.

Materials and Methods

A flowchart summarizing the study design and participant progression is presented in Figure 1. The detailed methodology is described below..



Ethical Approval

Ethical Approval and Trial Registration

This prospective, randomized, double-blind, controlled clinical trial was conducted at Hankou Hospital in Wuhan, Hubei Province, China, from January 2025 to March 2026. The study protocol was approved by the Medical Ethics Committee of Hankou Hospital (Approval No. HYLL2025048; Date: 12 January 2025). The study was retrospectively registered with the International Traditional Medicine Clinical Trial Registry(Registration No. [ITMCTR2026001287];on 26 May2026). All methods were performed in accordance with the relevant guidelines and regulations. Informed consent was obtained from all participants.

Study Design

A prospective, randomized, double-blind, placebo-controlled superiority trial design was employed, referencing previously successful acupuncture analgesia RCTs.

Participants

Inclusion Criteria:

(1) Aged between 50 and 80 years;

(2) Scheduled to undergo primary unilateral total hip arthroplasty (THA) via the direct anterior approach (DAA);

(3) Planned for general anesthesia or neuraxial anesthesia;

(4) Classified as American Society of Anesthesiologists (ASA) physical status I, II, or III;

(5) Patients with diabetes mellitus whose blood glucose is well-controlled prior to enrollment (glycated hemoglobin HbA1c ≤ 8.0%);

(6) Presence of moderate or higher resting pain (Visual Analog Scale [VAS] score ≥ 4) at 2 hours after returning to the ward postoperatively;

(7) Alert and conscious, capable of effective communication with researchers;

(8) Voluntarily participate in this study and provide written informed consent;

(9) Good compliance, willing and able to cooperate with completing all intervention treatments and follow-up assessments.

Exclusion Criteria:

(1) Diabetic patients with poorly controlled blood glucose and associated severe complications;

(2) Presence of skin breakdown, infection, or ulceration in the surgical area;

(3) Bleeding tendency or coagulation abnormalities (defined as: International Normalized Ratio >1.5 at screening, or platelet count <80×10⁹/L, or inability to routinely discontinue anticoagulant/ antiplatelet medications preoperatively as per standard practice);

(4) History of chronic pain other than in the hip joint (e.g., severe lumbar disc herniation, severe arthritis, etc.) within 1 month preoperatively, where regular use of analgesic medications may interfere with postoperative pain assessment;

(5) History of opioid use within 3 months preoperatively, or known history of substance abuse;

(6) Severe cardiovascular or cerebrovascular diseases, deemed by the investigator as unsuitable for participation in this study;

(7) Diagnosed with psychiatric or cognitive disorders such as schizophrenia, major depression, or dementia.

Sample Size: The primary outcome measure was the equivalent consumption of intravenous patient-controlled analgesia (PCA) morphine within 24 hours postoperatively. Based on inter-group differences observed in an ear acupuncture study (mean difference approximately 17 mg,

standard deviation approximately 20 mg), with α set at 0.05 (two-sided) and β at 0.2 (power 80%), it was calculated that approximately 45 patients per group would be needed. Considering an estimated dropout rate of about 10%, a total of 100 patients were planned, randomly assigned in a 1:1 ratio to the fire needle group (n=50) and the sham fire needle group (n=50) (See Table 1).

Table 1: Comparison of Patient Characteristics (Experimental Group vs. Control Group)

Item	Fire needle Group (n=50)	Sham fire needle Group (n=50)	p-value	Statistical Method
Age (years)	68.4 ± 6.2	67.9 ± 5.8	0.652	Independent samples t-test
Gender (Female)	35 (70.0%)	32 (64.0%)	0.520	Chi-square test
Height (cm)	162.5 ± 8.1	161.8 ± 7.9	0.647	Independent samples t-test
Weight (kg)	65.3 ± 9.4	66.1 ± 8.7	0.645	Independent samples t-test
Body Mass Index (BMI, kg/m²)	24.7 ± 2.9	25.2 ± 3.1	0.386	undefined
ASA Classification (I/II/III)	8/32/10	10/30/10	0.831	Chi-square test
Preoperative Comorbidities	undefined	undefined	undefined	undefined
- Hypertension	18 (36.0%)	15 (30.0%)	0.527	Chi-square test
- Diabetes	9 (18.0%)	7 (14.0%)	0.587	Chi-square test
Operated Side (Left/Right)	26/24	24/26	0.847	Chi-square test
Operation Duration (minutes)	95.6 ± 18.3	98.2 ± 17.5	0.458	Independent samples t-test
Intraoperative Blood Loss (ml)	285.4 ± 75.6	298.1 ± 81.2	0.407	Independent samples t-test
Intraoperative Anesthetic Dose (mg)	12.8 ± 3.5	13.2 ± 3.7	0.567	Independent samples t-test

Interventions

Fire Needle Group: Treatment was administered on postoperative days 1, 2, and 3. Acupuncture points were selected based on traditional Chinese medicine theory and practice: 1) Local Ahshi points: 2–3 points were selected at the most tense or painful areas within a region approximately 15 cm from the surgical incision on the affected side's hip and outer thigh. 2) Distal point: GB30 (Huantiao), GB34 (Yanglingquan), and ST36 (Zusanli) on the affected side (chosen because stimulation at these points has been shown to reduce opioid requirements post-THA [14, 15], can alleviate hip pain [6, 13], and modulate sciatic nerve function [6]).

Procedure standardization: After identifying the acupoints, the skin was disinfected twice with iodine followed by once with alcohol. The practitioner wore sterile gloves. Disposable tungsten-manganese alloy fire needles (Hua Tuo brand, diameter 0.3 mm, length 40 mm) were heated until red-hot at the tip in the outer flame of an alcohol lamp, then quickly inserted perpendicularly to a depth of approximately 2-3

mm and immediately withdrawn. Needling at each point once. All procedures are carried out strictly in accordance with aseptic techniques.

Sham Fire Needle Group: The acupoints and treatment times are consistent with those in the fire needle group. A special retractable blunt-tip sham fire needle was adopted; it retracted when touching the skin; thus, there would be no pain from breaking the skin or heat stimulation. The needle was not heated, and an apparent heat treatment operation was added beside the alcohol burner.

All patients received the hospital's standard postoperative multimodal analgesia protocol (including preoperative nerve block, intraoperative incision infiltration, timely administration of non-steroidal anti-inflammatory drugs, and as-needed PCA pump usage).

All acupuncturists were trained under a uniform protocol. This training ensured that non-specific factors—such as the posture during needle insertion, the duration of needle retention, and the nature of practitioner-patient interaction—were consistent between the two groups.

Outcome Measures

Primary Outcome Measures:

To assess the short-term efficacy of fire needle therapy after total hip arthroplasty (THA), the following primary outcomes were evaluated:

(1) **Postoperative Pain Intensity:** Assessed using the Visual Analog Scale (VAS, 0-10 cm) for resting pain and passive movement pain (e.g., lifting the leg at a 30-degree angle). Assessment points: Preoperative (baseline), 24, 48, 72 hours postoperatively, and on postoperative day 7. This method has been used in multiple related RCTs.

(2) **Total Consumption of Rescue Analgesics:** Recorded the total equivalent dosage of morphine (mg) used through PCA pump or additional physician orders within periods 0-24, 24-48, and 48-72 hours postoperativel. This is a key objective measure for evaluating acupuncture analgesia effects.

(3) **Serological markers:** Serological Testing: Serum levels of IL-1β, IL-6, tumor necrosis factor (TNF-α), C-reactive protein (CRP), and substance P were measured 1 day preoperatively and on postoperative days 3, 7, and 14.

Secondary Outcome Measures:

The following secondary outcomes were measured to evaluate long-term recovery and the treatment process:

(1) **Hip Function:** Assessed using the Harris Hip Score preoperatively and on postoperative days 7, 1 month, and 3 months.

(2) **Quality of Life:** Evaluated using the SF-36 preoperatively and at 1 month and 3 months postoperatively.

(3) **Analgesic-Related Side Effects:** Recorded the incidence and severity of nausea, vomiting, skin itching, dizziness, respiratory depression, etc., within 72 hours postoperatively, along with the dose of antiemetics required.

(4) **Safety and tolerance:** Fire needle safety assessments were performed immediately after each fire needle treatment session and at each subsequent follow-up visit. Recorded adverse events included local bleeding, hematoma, infection, persistent pain at the needle site (lasting >24 hours), and burns.

(4) **Patient Satisfaction and Blinding Success Rate:** At the end of the trial, patient satisfaction with pain management was surveyed, and they were asked whether they believed they received true fire needle or sham treatment to assess the effectiveness of blinding.

Results

1. Pain Assessment and Analgesic Consumption

Postoperative pain and opioid requirements were significantly lower in the fire needle group compared to the sham control group throughout the 72-hour monitoring period.

Patients receiving fire needle acupuncture reported markedly lower pain scores at rest and during passive movement at all assessed postoperative time points (24h, 48h, 72h, and 7 days; all $P< 0.001$; see Table 2 for detailed scores).

Table2: Visual Analogue Scale (VAS) Scores (0-10, higher score indicates more pain)

Assessment Time Point	Fire needle Group (Mean ± SD)	Sham fire needle Group (Mean ± SD)	Intergroup Comparison p-value
Preoperative (Baseline)	4.52 ± 1.23	4.68 ± 1.17	0.514
24 hours postoperatively	5.03 ± 1.15	6.52 ± 1.29	<0.001
48 hours postoperatively	3.68 ± 1.02	5.24 ± 1.11	<0.001
72 hours postoperatively	2.56 ± 0.87	4.03 ± 0.98	<0.001
7 days postoperatively	1.54 ± 0.62	2.89 ± 0.75	<0.001

This subjective pain relief was corroborated by a substantial reduction in supplemental opioid use. Within the critical first 24 hours post-surgery, the cumulative morphine consumption in the fire needle group was nearly halved (18.5 ± 6.3 mg) compared to the control group (32.4 ± 8.1 mg; $P< 0.001$). The analgesic-sparing effect of fire needle therapy persisted during the subsequent 24-48 hour (fire needle: 10.2 ± 4.1 mg vs. sham: 19.8 ± 5.6 mg; $P< 0.001$) and 48-72 hour periods (fire needle: 4.5 ± 2.8 mg vs. sham: 9.3 ± 3.7 mg; $P< 0.001$) (see Table 3).

Table 3: Total Consumption of Rescue Analgesics (mg morphine equivalent)

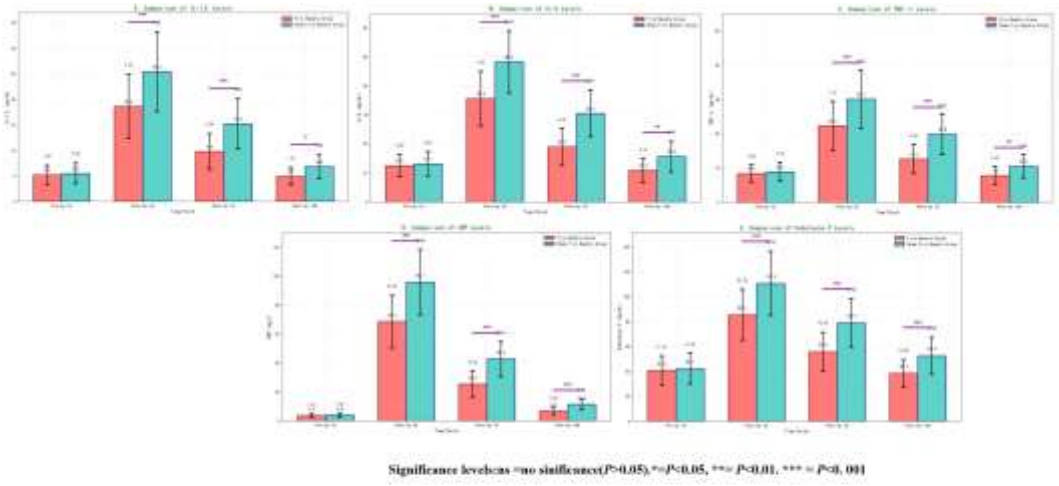
Time Window	Fire needle Group (Mean ± SD)	Sham fire needle Group (Mean ± SD)	Intergroup Comparison p-value
0-24 hours postoperatively	18.5 ± 6.3	32.4 ± 8.1	<0.001
24-48 hours postoperatively	12.1 ± 4.9	24.7 ± 6.5	<0.001
48-72 hours postoperatively	8.3 ± 3.7	16.8 ± 5.2	<0.001
Cumulative (0-72 hours)	38.9 ± 12.4	73.9 ± 16.8	<0.001

2. Serological Inflammatory and Pain Markers

The analgesic effect was paralleled by a significant attenuation of the systemic surgical stress response. As illustrated in Figure 2, serum levels of key pro-inflammatory cytokines—including IL-1β, IL-6, and TNF-α—as well as the acute-phase reactant CRP, were consistently and significantly lower in the fire needle group on postoperative days 3, 7, and 14 compared to baseline and to the sham group (all $P< 0.001$)(see Figure 2)..

Furthermore, the level of Substance P, a neuropeptide critically involved in pain transmission, was also significantly reduced in the

fire needle group postoperatively (all $P< 0.001$), suggesting a modulation of neurogenic inflammation.



Significance levels:ns =no sinificance($P>0.05$), *= $P<0.05$, **= $P<0.01$, *** = $P<0.001$

3. Functional Recovery and Quality of Life

Enhanced pain control translated into improved functional outcomes. Patients in the fire needle group achieved significantly higher Harris Hip Scores at all postoperative assessments (Day 7, 1 month, and 3 months; all $P< 0.001$), indicating better hip joint function and mobility (Table 4).

Table 4 : Harris Hip Score (0-100, higher score indicates better function)

Assessment Time Point	Fire needle Group (Mean ± SD)	Sham fire needle Group (Mean ± SD)	p-value
Preoperative	52.3 ± 9.6	51.8 ± 8.9	0.786
7 days postoperatively	65.4 ± 10.2	58.1 ± 9.7	<0.001
1 month postoperatively	78.9 ± 8.5	70.3 ± 9.1	<0.001
3 months postoperatively	88.6 ± 7.2	82.4 ± 8.3	<0.001

Quality of life, as measured by the SF-36, also showed a more favorable trajectory in the intervention group. While baseline scores for the Bodily Pain (BP) and Physical Function (PF) domains were comparable between groups (all $P> 0.05$), significant differences emerged during follow-up. The fire needle group reported significantly less bodily pain, reflected in higher BP scores at both 1 month (e.g., 75.2 ± 8.4 vs. 68.1 ± 9.1) and 3 months (e.g., 85.5 ± 6.7 vs. 78.9 ± 8.3) postoperatively (both $P< 0.001$). For physical function, although a positive trend was observed at 1 month (70.3 ± 10.5 vs. 65.1 ± 9.8; $P= 0.10$), the advantage in the fire needle group became statistically significant by the 3-month evaluation (82.4 ± 8.7 vs. 76.9 ± 9.2; $P= 0.002$) (Table 5).

Table 5: Selected SF-36 Quality of Life Scores (0-100, higher is better)

Dimension and Assessment Time Point	Fire needle Group (Mean ± SD)	Sham fire needle Group (Mean ± SD)	p-value

Dimension and Assessment Time Point	Fire needle Group (Mean ± SD)	Sham fire needle Group (Mean ± SD)	p-value
Physical Function (PF) - Preoperative	58.2 ± 12.4	57.6 ± 11.8	0.802
Physical Function (PF) - 1 month postoperatively	70.3 ± 10.5	65.1 ± 9.8	0.10
Physical Function (PF) - 3 months postoperatively	82.4 ± 8.7	76.9 ± 9.2	0.002
Bodily Pain (BP) - Preoperative	48.5 ± 13.1	47.9 ± 12.5	0.815
Bodily Pain (BP) - 1 month postoperatively	75.6 ± 9.8	68.4 ± 10.2	<0.001
Bodily Pain (BP) - 3 months postoperatively	85.2 ± 7.5	79.1 ± 8.6	<0.001

4. Safety, Adverse Events, and Patient-Reported Outcomes

The fire needle intervention demonstrated a favorable safety profile. No serious adverse events, such as infection, burns, or persistent pain at the needling site, were reported. Minor, transient local reactions were infrequent, with minor bleeding occurring in 3 patients (6.0%) and a small hematoma in 1 patient (2.0%) in the fire needle group; these rates did not differ significantly from the sham procedure (all $P > 0.05$, Table 6).

Table 6: Analgesic-Related Side Effects (within 72 hours)

Side Effect Type	Fire needle Group (n, %)	Sham fire needle Group (n, %)	p-value
Nausea	6 (12.0%)	15 (30.0%)	0.028
Vomiting	3 (6.0%)	9 (18.0%)	0.067
Skin Itching	2 (4.0%)	7 (14.0%)	0.081
Dizziness	4 (8.0%)	10 (20.0%)	0.082
Respiratory Depression	0 (0.0%)	1 (2.0%)	0.316

Notably, the reduced opioid consumption in the fire needle group was associated with a clinically meaningful decrease in opioid-related side effects, particularly nausea.

The integrity of the double-blind design was successfully maintained. A similar and non-significant proportion of participants in each group believed they had received the active treatment (fire needle group: 44.0%; sham group: 48.0%; $P = 0.693$), confirming effective blinding. Corresponding with the clinical benefits, patient satisfaction with overall pain management was significantly higher in the fire needle group (90.0% vs. 72.0%; $P = 0.023$) (Table 7).

Table 7：Patient Satisfaction and Blinding Success

Item	Fire needle Group (n, %)	Sham fire needle Group (n, %)	p-value
Satisfaction (≥7/10)	45 (90.0%)	36 (72.0%)	0.023
Blinding Success (correct guess)	22 (44.0%)	24 (48.0%)	0.693

Discussion

Postoperative pain following unilateral total hip arthroplasty remains a substantial problem affecting mobility and functional capacity in the post-operative period. Proper analgesics can be administered to relieve pain; otherwise, unresolved pain could lead to extended hospitalisation duration. Despite the fact that opioids are generally recognised as effective in treating post-surgical pain due to relatively higher doses being used, in practice, other treatments need to precede them at times. Acupuncture is an old healing practice based on Traditional Chinese Medicine that can reduce pain by means such as inserting needles at acupoints. However, to date, the specific effects and underlying mechanisms of acupuncture technique types, such as fire needling, for acute postoperative pain following THA have not been thoroughly studied; therefore, further clinical verification is required.

Based on this prospective, randomised control study, we aimed to evaluate the analgesic effect of fire needling acupuncture on postoperative pain levels and opioid administration in patients after unilateral total hip arthroplasty (THA). Using a double-blind, sham-controlled design in this experiment aimed to eliminate bias and separate the effect of fire needling on acute postoperative pain modulation. Research results indicate that fire needle therapy has significant reductions in pain scores and opioids relative to the sham group, along with attenuated inflammatory cytokines including IL-6 and TNF-α. Thus, it is believed that both pain reduction as a result of therapy and improved resistance (immunity) after surgery have occurred in this case. Following this, the content below analyses the above results from a current analgesic paradigm, further exploring its role in promoting multi-therapy pain relief.

There was an evident decrease in postoperative opioid use in the fire needle group; therefore, some type of analgesia-related effect may be associated with it. Fire needling can produce these effects through adjustments to both the peripheral nociceptive input system and central sensitisation pathways, reducing pain transmission. In line with anaesthesia-related research findings that acupuncture during surgery modulates pain pathways neurologically, releasing endogenous opioids or regulating neurotransmitters for analgesia [2, 3]. Notably, there is a more significant reduction in opioid consumption than what has been shown in previous acupuncture studies; it can be inferred from this phenomenon that thermal stimulation of the fire needle technique activates local blood circulation through heat generation to enhance central inhibition effects via thermosensitive sensory nerves. In addition, opioids may lead to more serious problems for some patients; as indicated in clinical acupoint research on opioids, these drawbacks have reduced accordingly [4]. Nevertheless, mechanistic differences exist among acupuncturists' various types; the unique ability of fire needling to generate controlled inflammatory reactions may also interact with the immune-neural system differently than traditional filiform needles. This multilevel neuro-immune interaction is responsible for the better analgesic effect and differentiating factor in fire needle therapy that helps to regulate pain transmission systems.

There was a relatively obvious decrease in IL-6 after fire needle therapy, which suggests that it may have some kind of anti-inflammatory function. The key proinflammatory cytokine IL-6 drives immune cell infiltration and sensitises nociceptors to enhance postoperative pain and impede tissue reconstruction [5]. IL-6 levels have been reduced, indicating a possible attenuation of inflammation by fire needle therapy; for example, it has been shown that treatment with fire needles can reduce the activity of NF-κB and subsequently decrease cytokine synthesis [5, 19, 20]. In addition, fire needling can alter

macrophage phenotype by polarising them towards a more anti-inflammatory M2 state through the modulation of macrophage subsets in osteoarthritis models via SDF-1/CXCR4 signalling [6, 25]. This is an immunomodulatory action that decreases local tissue inflammation to achieve a condition favourable for healing. Due to the increase in levels of heat stress-related protein synthesis during treatment; therefore, it has a significant impact on inflammation. Therefore, this study has expanded upon previous mechanisms in the immune system and demonstrates how fire needling can alter these pathways to promote postoperative recovery [18].

The strong reduction in TNF-α after treatment demonstrates the immune-regulatory function of fire needling for postoperative pain control. TNF-α is the key cytokine of system-wide or localised inflammatory response that stimulates nociceptive sensation and neuroinflammation to enhance pain sensation [5]. Downregulation of TNF-α by fire needling might be achieved via suppression of Toll-like receptor 4 (TLR4) and subsequent activation of MyD88/NF-kappaB pathways observed in animal models of autoimmune arthrosis following treatment with fire needling [5, 16, 19]. In addition, cytokines regulate to inhibit the level of IL-6 and reduce inflammation in collaboration. Compared to traditional acupuncture methods, combining mechanical and thermal stimuli in fire needling might produce a stronger anti-inflammatory effect through activation of the cholinergic anti-inflammation pathway, which is demonstrated in some rheumatoid arthritis studies that acupuncture affects several immunity-related targets [7, 17]. Multidirectional immune regulation is shown here, which helps ensure its effectiveness; therefore, fire needling can possibly limit the first-line inflammation under organ system levels and cause systemic adjustments [18].Supporting this, stimulation of the vagus nerve–cholinergic anti-inflammatory axis has been shown to directly reduce pain signals and opioid use [19]. This pathway likely underlies the stronger analgesic effect seen in our fire needle group. For example, Liu et al. found that electroacupuncture at specific acupoints activates this vagal pathway, significantly lowering both inflammatory pain and opioid requirements in postsurgical patients [19].

Reduction of C-reactive protein (CRP) provides biochemistry data to prove that fire needling can regulate inflammation after surgery. CRP is an acute-phase reactant that indicates the degree of inflammation; it positively relates to pain and tissue damage [5]. Based on the data in this paper, there is an increase in CRP after surgery due to factors including inflammation [5]. It matches meta-analysis findings that show acupuncture's ability to reduce surgical inflammatory response [1, 20]. Fire needling's temperature component can enhance the traditional effects more specifically due to localised erythema induction during heating; it does not fully utilise conventional acupuncture mechanisms [7, 21]. Additionally, reduced CRP indicates systemic regulation of the inflammatory network; through brain-immune cross-talk mediated by the hypothalamic-pituitary-adrenal system and endogenous glucocorticoids. These pathways can weaken inflammation to improve the treatment of pain in rehabilitation. Therefore, fire needling regulates the inflammatory response at all levels after surgery based primarily on biochemistry [22].

The improved Harris Hip Score in the fire needle group suggests that, apart from pain relief, it may enhance functional rehabilitation via an all-systemic biological mechanism. Functional upgrades may involve immunomodulatory effects of fire needling in addition to anti-inflammation; it creates an ideal tissue environment for wound recovery through regulatory functions on cellular energy metabolic pathways or expressions of genes related to tissue renewal [7, 23-25, 26].

Activation of the signalling pathway involved in fire needle stimulation, including JAK1/STAT6/PPAR-γ activation can enhance macrophages' transition towards a quiescent state and reduce matrix metallopeptidases (MMPs) levels that degrade extracellular matrices [6, 26]. In addition, fire needling can impact the production of systemic biorhythmical genes through miRNA-mediated apoptosis regulation in tissues [7, 25]. Therefore, according to the above-regulated molecule mechanisms, acupuncture at specific points strengthens the joint through modification of immun-inflammatory and differentiation-related gene groups. The systemic perspective of the functional improvement indicates that it has transformed from symptom-based analgesia to tissue regeneration enhancement and is regarded as an all-encompassing therapy for rehabilitation after surgery [26].

Furthermore, the reduction in Substance P observed in our study aligns with findings that fire needle acupuncture reduces pain-related neuropeptides in inflammatory pain models [27], potentially through modulation of TRPV1 expression in dorsal root ganglia [28]. This dual action on both inflammatory cytokines and neuropeptides likely contributes to the superior gait function and mobility improvements seen in our patients, similar to outcomes reported in knee osteoarthritis trials [29]. The high patient satisfaction and cost-effectiveness observed also mirror results from chronic pain studies utilizing fire needle therapy [30, 31]. Regarding the study design, the effectiveness of our blinding protocol is supported by recent systematic reviews on blinding efficacy in acupuncture trials [32] and the validity of sham devices used [33]. The thermal component of fire needling likely induces heat shock proteins, which play a crucial role in its analgesic effect [34], and may even influence systemic responses through gut microbiota modulation as suggested by emerging research [26]. Finally, while this study focused on acute postoperative outcomes, the potential for long-term efficacy warrants future investigation, building on follow-up data from chronic pain cohorts [35].

Limitations

The main deficiencies of this study are twofold. Firstly, due to a smaller number of participants, this study's conclusions might be less robust and wider-ranging; thus, more extensive research would typically follow. In other words, in terms of follow-up data for the short-term effects on post-operation pain relief and functional rehabilitation provided by this study is lacking; due to the demographic differences among the participants, there may be an issue of group variation affecting other effects; therefore, it is not advisable to extend these findings to a wider range of clinics at present.The post-commencement registration of this trial represents another limitation, as it may carry a risk of reporting bias despite prior ethical clearance. Moving forward, prospective trial registration is essential to mitigate such concerns.

Conclusion

In terms of overall results, our experiment indicates that fire needling significantly reduces anesthetic requirements after surgery while promoting muscle strength improvement more efficiently and selectively; especially it strengthens hip-related muscle groups. These results indicate that fire needling may be useful for the nonpharmacological treatment of pain in clinical settings. Based on existing studies, in the future we can further identify specific mechanisms through investigation into how it produces effects; also expect enhanced influences at other stages during illness progression to become clearer.

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Authors' Contributions

Congjun Wang performed the majority of the experimental work and drafted the manuscript. Shibo Feng and Xufeng Chen were responsible for data curation and management. The study was originally designed by Kai Chen, who also provided critical revisions to the manuscript. Statistical analysis and data interpretation were conducted by Kai Chen and Congjun Wang. All authors reviewed the manuscript, provided intellectual input, and approved the final version for submission**.**

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Availability of Data and Materials

The datasets supporting the conclusions of this article are available within the article and its supplementary materials.

Declarations

Ethics Approval and Consent to Participate

This study was conducted in accordance with the principles outlined in the Declaration of Helsinki. Ethical approval was granted by the Ethics Committee of Hankou Hospital (Approval No. HYLL2025048; Date: 12 January 2025). Prior to participation, all subjects were provided with a detailed explanation of the study, and written informed consent was obtained. Participants were assured of their voluntary involvement, the right to withdraw at any time, and the confidentiality of their data. This study was retrospectively registered with the Chinese Clinical Trial Registry (Registration No. ChiCTR, on 20 April 2026)..

Consent for Publication: Not applicable.

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References

1. Henrik Kehlet, Troels S Jensen, Clifford J Woolf. Persistent postsurgical pain: risk factors and prevention. Lancet . 2006 May 13;367(9522):1618-25. doi: 10.1016/S0140-6736(06)68700-X.
2. Manchikanti L, Kaye AD, Boswell MV, et al. Pain States, the Opioid Epidemic, and the Role of Radiologists. Pain Physician. 2022;25 (2S):S1-S10. doi:10.36076/ppj.2022/25/S1
3. Mark R Jones, Alan D Kaye, Laxmaiah Manchikanti, et al. Pain States, the Opioid Epidemic, and the Role of Radiologists. Curr Pain Headache Rep . 2018 Feb 23;22(3):20. doi: 10.1007/s11916-018-0672-x
4. David A Edwards, Traci L Hedrick, Jennifer Jayaram, et al. American Society for Enhanced Recovery and Perioperative Quality Initiative Joint Consensus Statement on Perioperative Management of Patients on Preoperative Opioid Therapy. Anesth Analg . 2019 Aug;129(2):553-566. doi: 10.1213/ANE. 0000000000004018.
5. Kira K Tanghe 1, Zodina A Beiene 2, Stephanie I Cheng, et al. A systematic review of pre-operative and intra-operative acupuncture in total hip and knee arthroplasty. Acupunct Med . 2025 Dec;43 (6):307-315. doi:10.1177/096452842514003 84.
6. Ruixin Zhang, Lixing Lao, Ke Ren, et al. Mechanisms of acupuncture-electroacupuncture on persistent pain. Anesthesiology . 2014 ;120(2):482-503. doi: 10.1097/ALN.0000000000000101.
7. Ningning Liu, Gaihong Liu, Xiaoli Chang, et al.Combining various acupuncture therapies with multimodal analgesia to enhance postoperative pain management following total knee arthroplasty: a network meta-analysis of randomized controlled trials. Front Neurol . 2024 Mar 18:15:1361037. doi: 10.33 89/fneur.2024.1361037.

8. Juanhong Pan, Song Jin, Quan Xie, et al. Acupuncture for Chronic Prostatitis or Chronic Pelvic Pain Syndrome: An Updated Systematic Review and Meta-Analysis. Pain Res Manag . 2023 Mar 14:2023:7754876. doi: 10.1155/2023/7754876.
9. Seojung Ha, Suji Lee, Bonhyuk Goo, et al. Safety of Thread-Embedding Acupuncture: A Multicenter, Prospective, Observational Pilot Study. Healthcare (Basel) . 2024 Nov 29;12 (23):2396. doi: 10.3390/healthcare12 232396.
10. Vickers AJ, Vertosick EA, Lewith G, et al. Acupuncture for Chronic Pain: Update of an Individual Patient Data Meta-Analysis. J Pain. 2018 May;19(5):455-474. doi:10.1016 /j.jpain.2017.11.005.
11. Liu Liu, Xiao-Ying Sun, Yi Lu , et al. Fire Needle Therapy for the Treatment of Psoriasis: A Quantitative Evidence Synthesis. J Altern Complement Med . 2021 Jan; 27 (1):24-37. doi: 10.1089/acm.2019.0409.
12. Yuan-Jie Gao, Jing-Qing Sun, Xue-Si Hou,et al. Point-pricking method with fire needle for knee osteoarthritis: a randomized controlled trial. Zhen Ci Yan Jiu. 2022 Oct 25;47(10): 9 02-6. doi: 10.13702/j.1000-0607.20210745.
13. Jing Sun, Yi Liang, Kai-Tao Luo, et al.Efficacy of Different Acupuncture Techniques for Pain and Dysfunction in Patients with Knee Osteoarthritis: A Randomized Controlled Trial. Pain Ther . 2025 Apr;14(2):737-751. doi: 10.1007/s401 22-025-00713-x.
14. Jianhua Wang, Weisheng Peng, Fei Huang, et al. Acupuncture vs. Chinese Medicine for Knee Osteoarthritis: Systematic Review and Meta-Analysis. Pain Manag Nurs . 2025 ; 26 (6):679-688. doi: 10.1016/j.pmn.2025.06.017
15. Hai-Tao Cao, Wan Zhang, Cheng Luo, et al. Effect of Wrist-Ankle Acupuncture on Postoperative Analgesia after Total Knee Arthroplasty. Chin J Integr Med . 2023 Mar; 29(3):253-257. doi: 10.1007/s11655-022-34 63-5.
16. Hee-Don Lim, Min-Hee Kim, Chan-Yong Lee, et al. Anti-inflammatory effects of acupuncture stimulation via the vagus nerve. PLoS One. 2016 Mar 18;11(3):e0151882. doi: 10.1371/journal.pone.0151882.
17. Rafael Torres-Rosas, Ghassan Yehia, Geber Peñe, et al. Dopamine mediates vagal modulation of the immune system by electroacupuncture. Nat Med . 2014 Mar; 20(3):291-5. doi: 10.1038/nm.3479.
18. Si-Qi Du, Xue-Rui Wang, Wen Zhu , et al. Acupuncture inhibits TXNIP-associated oxidative stress and inflammation to attenuate cognitive impairment in vascular dementia rats. CNS Neurosci Ther . 2018 Jan;24(1):39-46. doi: 10.1111/cns.12773.
19. Liu S, Wang Z, Su Y, et al. A neuroanatomical basis for electroacupuncture to drive the vagal–adrenal axis. Nature. 2021;598(7882):641-645. doi:10.1038/s4158 6-021-04001-4.
20. Zhi-Min Zhang, Hai-Dong Wang, Hao-Lin Li ,et al. Study on the underlying mechanism of acupotomy in inhibiting bone destruction in collagen-induced arthritis rats based on OPG/RANKL/NF-κB signaling pathway. Zhen Ci Yan Jiu . 2026 Jan 25;51(1):68-76. doi: 10.13702/j.1000-0607.20241155.
21. Jing-Chun Zeng, Yi-Zu Liao, Jing-Jing Li, et al. Clinical efficacy of fire needling combined with cupping therapy on herpes zoster of acute stage and the effect on Th17/Treg cellular immune balance. Zhongguo Zhen Jiu . 2023;12;43(10):1128-1133. doi:10.13703/j. 0255-2930.20221005-k0004.
22. Janita Pak Chun Chau, Suzanne Hoi Shan Lo, Xingfeng Yu, et al. Effects of Acupuncture on the Recovery Outcomes of Stroke Survivors with Shoulder Pain: A Systematic Review. Front Neurol . 2018 Jan 31:9:30. doi: 10.3389/fneur.2018.00030.
23. XingYu Liang, Xi Chen, XueMei Li, et al. Efficacy and safety of therapies related to acupuncture for acute herpes zoster: A

PRISMA systematic review and network meta-analysis. Medicine (Baltimore) . 2024 May 17;103(20):e38006. doi: 10.1097/MD. 0 000000 000038006.

24. Cihui Huang, Linling Xie, Yunxin Lin, et al. Effectiveness and safety of fire needle on periarthritis of shoulder: Protocol for a systematic review and meta-analysis. Medicine (Baltimore) . 2019 May;98(20): e15673. doi:10.1097/MD.000000000001567 3.
25. Xinle Wang, Kaixuan Zhang, Xingxing Lin, et al. Efficacy of acupuncture-based adjunctive therapies in alleviating spasticity and motor function in patients with post-stroke spasticity: A systematic review and network meta-analysis. Complement Ther Med . 2025 Dec:95:103282. doi: 10.1016/j. ctim.2025.103282.
26. Jiangyan Wei, Xin Yang, Luopeng Zhao, et al. Fire needling acupuncture attenuates synovial inflammation and cartilage degeneration in knee osteoarthritis via SDF-1/CXCR4-mediated macrophage polarization. Clin Rheumatol . 2025 Oct;44(10):4283-4299. doi: 10.1007/s10067-025-07612-8.
27. Cong Chen, Xuhao Li, Shiyou Lu, et al. Acupuncture for clinical improvement of endometriosis-related pain: a systematic review and meta-analysis.Arch Gynecol Obstet . 2024 Oct;310(4):2101-2114. doi: 10. 1007/s00404-024-07675-z.
28. Jing-Chun Zeng, Yue-Xuan Chen, Jing-Jing Li, et al. Mechanism of analgesic effect of fire needle on peripheral sensitization in rats with neuropathic pain induced by chemotherapy. Zhen Ci Yan Jiu . 2023 Nov 25;48(11):1095-1102. doi: 10.13702/j.1000-0607.20221165.
29. Yi-Jun Feng, Bing-Quan Wang, Lu-Lu Cao, et al. Efficacy of Fire-Needle Therapy in Improving Neurological Function Following Cerebral Infarction and Its Effect on Intestinal Flora Metabolites. Int J Gen Med . 2024 Feb 2:17:387-399. doi: 10.2147/IJGM.S450027.
30. Shao-Kang Li, Jie Zhao, Xiao-Wen Cao, et al. Core stability training combined with acupuncture in treatment of chronic nonspecific low back pain: a prospective randomized controlled trial. Zhen Ci Yan Jiu . 2022 Feb 25;47(2):160-4. doi: 10.13702/j. 1000-0607.201050.
31. Mina Wang, Xiaobai Xu, Bingcong Zhao, et al. Fire Needling Therapy of Different Frequencies versus External Diclofenac Diethylamine Emulgel for Knee Osteoarthritis: Study Protocol for a Pilot Randomized Controlled Trial. J Pain Res . 2023 Apr 24:16:1381-1390. doi: 10.2147/JPR. S408084.
32. Mingjie Tang, Yinghong Li, Man Lu, et al. Efficacy and safety of acupuncture in the treatment of Meniere's disease: a systematic review and meta-analysis. Front Med (Lausanne) . 2024 Dec 11:11:1463821. doi: 10.3389/fmed.2024.1463821.
33. Sung Min Lim, Eunji Go. A systematic review of sham acupuncture validation studies. BMC Complement Med Ther . 2024 Jun 5;24(1):215. doi: 10.1186/s12906-024-04 506-1.
34. Junning Zhang, Yuehan Ren, Weizhen Wu,et al. Fire needle therapy for the treatment of cancer pain: a protocol for the systematic review and meta-analysis. Front Neurol . 2024 Sep 15:15:1358859. doi: 10.3389/fneur. 20 24.1358859.
35. Yuanjie Gao, Lu Liu , Bin Li, et al. Evaluation of the efficacy and safety of fire needle compared to filiform needle on knee osteoarthritis: study protocol for a randomized controlled trial. Trials . 2020 4;21(1):911. doi: 10.1186/s13063-020-04827-9.