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ORIGINAL ARTICLE

Investigating the efficacy of acupoint acupuncture combined with rehabilitation training in knee osteoarthritis treatment: A prospective comparative study informed by systematic acupoint analysis

Yan Li, MD[1], Jiabei Yu, MD[2], Yuhong Liu, MD[2], Lin Zhu, MD[1], Yafang Zhang, MD[3], Ming Jin, MD[4], Chunhua Wu, MD[2], Songyu Li, MD[1], Lanlan Fu, MD[1], Linlin Zheng, MD[5], Shunan Xu, MD[6], Yan Jin, MD[3]

[1]Department of Nursing, Yunnan University of Chinese Medicine, Kunming City, Yunnan Province, China
[2]Department of Nursing, Kunming Medical University, Kunming City, Yunnan Province, China
[3]Department of Orthopaedics, Yan'an Hospital Affiliated to Kunming Medical University, Kunming City, Yunnan Province, China
[4]Department of Geriatrics, Yan'an Hospital Affiliated to Kunming Medical University, Kunming City, Yunnan Province, China
[5]Department of Traditional Chinese Medicine, Yan'an Hospital Affiliated to Kunming Medical University, Kunming City, Yunnan Province, China
[6]Department of Rehabilitation, Yan'an Hospital Affiliated to Kunming Medical University, Kunming City, Yunnan Province, China

In clinical practice, the primary goal in the management of knee osteoarthritis (KOA) is the alleviation of pain and improvement of functional impairment. In Western medicine, pharmacological interventions remain the standard approach for KOA treatment, with nonsteroidal anti-inflammatory drugs (NSAIDs) frequently employed for analgesia. However, their use is limited in certain patient populations, including those with cardiovascular

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Correspondence: Yan Jin, MD. Department of Orthopaedics, Yan'an Hospital Affiliated to Kunming Medical University, Kunming City, Yunnan Province, 650051, China.

E-mail: jiny2025y@163.com

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ABSTRACT

Objectives: This study aims to investigate the clinical effect of acupuncture combined with rehabilitation training in the treatment of knee osteoarthritis (KOA) under unified acupoint intervention.

Patients and methods: In this prospective, comparative study informed by systematic acupoint analysis, the literature related to acupuncture for KOA treatment was retrieved from public databases and the core acupoints were analyzed using the Traditional Chinese Medicine Inheritance Calculation System (TCMICS) software. Eighty-four patients were selected as the participants, and the clinical effect (total efficacy rate), Numeric Rating Scale (NRS) for pain score, American Knee Society Score (AKSS) for knee joint function and the self-care ability score for daily living activities were used to evaluate the treatment effect. The curative effect index was calculated using the AKSS scores.

Results: After analyzing the core acupoints, we selected the Dubi, Zusanli, Yanglingquan, Xuehai, Neixiyan and Liang Qiu acupoints for the acupuncture treatment. The patients were divided into a control group (n = 42 patients undergoing rehabilitation training) and an intervention group (n = 42 patients undergoing acupuncture combined with rehabilitation training). The control group consisted of 15 male and 27 female, with a mean age of 62.90 ± 11.531 (range, 40 to 78) years. The mean course of the disease was 4.07 ± 1.841 years. The intervention group consisted of 16 male and 26 female, with a mean age of 63.95 ± 10.613 (range, 41 to 79) years and a mean disease course of 4.76 ± 2.328 years. There was no significant difference between the groups before treatment ($p > 0.05$). After acupuncture treatment, the 92.85% total efficacy rate (n = 39) was significantly higher than the 73.80% (n = 31) in the control group. The mean AKSS of the control and intervention groups were 64.17 ± 11.148 and 66.67 ± 17.795, respectively, and the mean knee joint articulation scores were 57.40 ± 8.925 and 54.10 ± 10.150 in the two groups, respectively. Following treatment, the scores of knee joint function and knee joint articulation in the intervention group were higher than those in the control group ($p < 0.05$). For AKSS, the mean difference of the control group was 6.030, and the proportion of patients who reached the improvement of minimum clinically significant difference (MCID) standard was 80.95%. The mean difference of the intervention group was 10.98, and the proportion of patients who reached MCID was 100%. Following treatment, the self-care ability score in the intervention group were higher than those in the control group ($p < 0.05$). For modified Barthel Index (MBI), the mean difference of the control group and intervention group were 6.446 and 6.225, all accounting for 100%. The mean NRS scores were significantly decreased from 5.19 ± 1.042 to 1.93 ± 0.640 after one month of acupuncture treatment.

Conclusion: Our study results suggest that acupuncture combined with rehabilitation training based on data mining can relieve patients' pain, accelerate the recovery of their knee joint function and improve their daily living ability, demonstrating high clinical value in practice.

Keywords: Acupuncture, data mining, functional recovery, knee osteoarthritis, rehabilitation training.

comorbidities, a history of upper gastrointestinal bleeding, or frailty. In addition, prolonged use of these agents may lead to reduced therapeutic responsiveness and a range of adverse effects, thereby limiting long-term efficacy and potentially hindering patient recovery.[1]

Current clinical guidelines emphasize physical activity and structured exercise as core non-pharmacological interventions capable of slowing disease progression. Nevertheless, the effectiveness of exercise-based therapy is highly dependent on patient adherence, which often declines over time, thereby reducing its sustained benefit. Consequently, adjunctive treatment modalities such as acupuncture have gained increasing attention. Acupuncture has been reported to produce clinically meaningful improvements in pain reduction and physical function in patients with KOA; however, the overall quality and reliability of the existing evidence remain low.[2]

In the present study, we hypothesized that acupuncture at core knee acupoints screened by data mining combined with standardized rehabilitation training could yield superior pain relief, better knee joint functional recovery and improved activities of daily living compared with rehabilitation training alone in patients with knee osteoarthritis. We, therefore, aimed to investigate the clinical effect of acupuncture combined with rehabilitation training in the treatment of KOA under unified acupoint intervention.

PATIENTS AND METHODS

This prospective, comparative study informed by systematic acupoint analysis was conducted at Yan'an Hospital Affiliated to Kunming Medical University, Department of Orthopaedics between July 2013 and July 2023. Prior to study, a written informed consent was obtained from each participant. The study protocol was approved by the Medical Ethics Committee of Yan'an Hospital Affiliated to Kunming Medical University (Date: 28.12.2024, No: 2023-250-01). The study was conducted in accordance with the principles of the Declaration of Helsinki. Clinical registration number ITMCTR2025001411.

The key acupoint selections were first determined through published studies, with the HowNet, Wanfang, PubMed and Web of Science databases the major data sources. The keywords for the Chinese search included the terms for 'knee osteoarthritis', 'osteoarthritis', 'senile arthritis', 'acupuncture' and 'needle'. The English search terms included 'knee osteoarthritis', 'age-related arthritis', 'senile osteoarthritis', *'gu-bi* disorders', 'acupuncture' and 'acupuncture therapy'. Inclusion criteria were as follows: (1) study type—KOA-related clinical studies, including randomized controlled trials and observational studies, published in Chinese or English; (2) diagnostic criteria—studies reporting clear diagnostic criteria for KOA based on either Chinese or Western medicine; (3) intervention—acupuncture administered alone or in combination with other therapies, with the control group receiving the same basic treatment and/or alternative standard care comparable to the intervention group; and (4) outcome measures—studies reporting at least two validated efficacy indicators, such as pain scoring scales, knee joint function assessments, and measures of activities of daily living. Exclusion criteria were as follows: (1) case reports, reviews, systematic evaluations, experience summaries, basic research studies, data-mining and doctoral dissertations and conference papers; (2) studies lacking clearly described randomization methods or procedural details; (3) interventions involving fewer than two acupoints; (4) duplicate or repeated publications; and (5) studies reporting no significant therapeutic effect of acupuncture in the outcomes. Data specification method and database construction.

The acupoint names were standardized according to the name and location of acupoints specified in GB/T 12346-2006 edition.[3] The literature with clear acupuncture acupoint treatment for KOA was uploaded into the Traditional Chinese Medicine Inheritance Calculation System (TCMICS) version 3.5 for the database construction, and the input data were checked by two people. The prescription information of these documents was extracted, including meridian and acupoint names, and the extracted data were used for analysis. Subsequently, TCMICS was used to analyze the frequency of acupoint use, the patterns of prescription composition, and potential new prescriptions using the 'Statistical Management', 'Data Analysis', and 'Acupoint Combination' modules. Association rule analysis was used to explore the combinatorial relationships among acupoints. The confidence of an association rule was calculated using the formula: $\text{conf}(X \rightarrow Y) = \sigma(X \cup Y) / \sigma(X)$, where σ denotes the support count within the dataset.[4] The system parameters were configured such that an acupoint combination was included in the analysis only if it appeared in at least

50 prescriptions. In addition, the confidence threshold for identifying key acupoint associations was set at 0.9.

Study population

Patients with KOA who were admitted to our center were screened for eligibility between December 2023 and August 2024. Inclusion criteria for patients were as follows: (1) aged between 40 and 80 years; (2) a confirmed diagnosis of KOA[5] with mild pain (Numerical Rating Scale [NRS] score of 1-3) despite conservative treatment; (3) Kellgren-Lawrence radiographic Grade 1-3; (4) stable vital signs with no acute or severe comorbidities or other conditions that could interfere with disease assessment; (5) conscious and able to communicate without barriers; and (6) voluntary participation with written informed consent obtained. Exclusion criteria were as follows: (1) patients unable to express subjective symptoms due to language barriers or impaired consciousness; (2) with serious comorbid conditions, including significant cardiac, cerebral, hepatic, or renal dysfunction, or malignant tumors; (3) with multiple fractures; (4) who withdrew voluntarily from the study; (5) who were lost to follow-up due to transfer to another hospital or death; and (6) presenting with lower extremity malalignment (varus-valgus deformity).

Treatment methods and grouping

In the control group, patients were treated with rehabilitation training, following the scientific, step-by-step principle from the second day of admission, twice a day, for a total of two weeks. The procedure is as follows: (1) joint range of motion training-swing the calf back and forth with the knee joint as the axis, 10 times on each side, alternately on both sides; (2) hip abduction and adduction training-one knee joint is straight, toes are stretched straight and abduction and adduction are performed 10 times alternately on each side; (3) quadriceps femoris training-straighten both knee joints, hooking the toe to the maximum range, hold for 5 sec and relax, hook and relax once, 10 times as one group, and perform two groups; (4) hamstring muscle training-place a roll of toilet paper in the patient's popliteal fossa and ask them to clamp the toilet paper hard, hold for 5 sec and relax, with 10 times as one group and two groups alternately on each side.

For the intervention group, acupuncture with specific points was performed alongside the rehabilitation training. The acupuncture points were the Dubi, Zusanli, Yanglingquan, Xuehai, Neixiyan and Liang Qiu (Figure 1). The operating steps were as follows: (1) the patient sitting

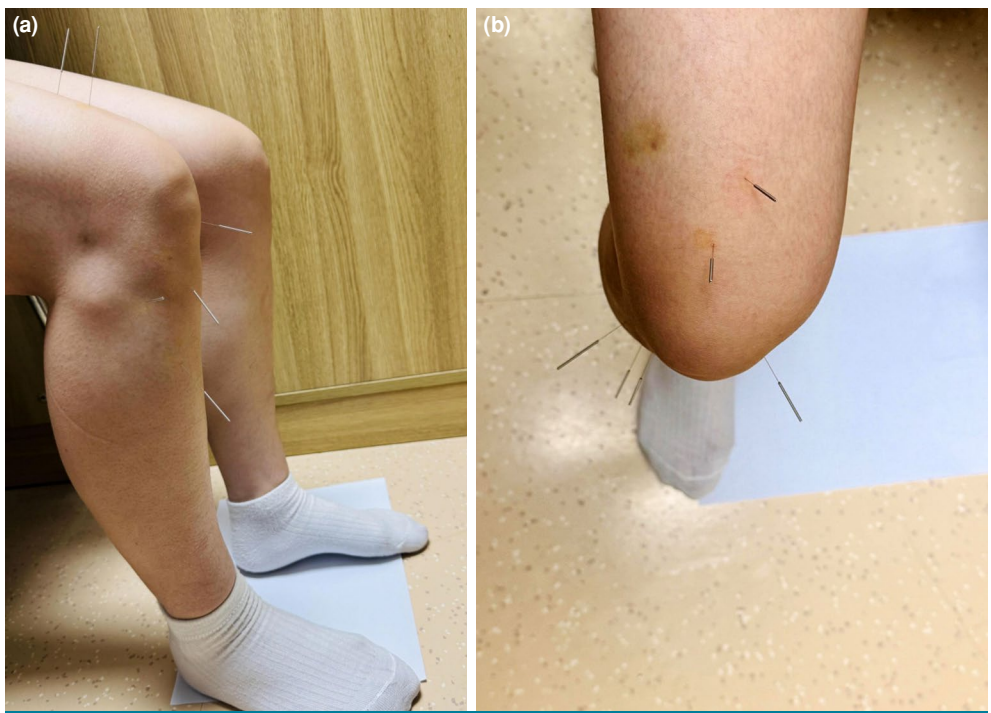


FIGURE 1. Localization of acupuncture points around the knee joint. **(a)** Side and **(b)** front.

position, relaxing their lower limbs and fully exposing the affected limb; (2) the acupuncture site was disinfected with iodophor, and the sterile acupuncture needle was prepared by the assistant; (3) the needle was inserted, twisted and switched after each acupuncture point; (4) this was performed once a day for 15 to 20 min each time, with a total of seven days as a course of treatment and a total of two courses of treatment.

Observation indicators

The nimodipine method and knee joint function scores of the American Knee Society Score (AKSS) were used to calculate the curative effect index,[6] whereby the curative effect index = (pre-treatment integral-post-treatment integral) / pre-treatment integral × 100%. A curative effect index of ≥ 90% is considered significantly effective; a curative effect index of 70-90% is considered effective; and a curative effect index of < 30% is considered ineffective. Total efficacy rate = (significantly effective cases + effective cases) / total cases × 100%.

The pain score was evaluated using the NRS,[7] with 0-10 indicating different degrees of pain (0 = painless, 1-3 = mild pain, 4-7 = moderate pain, 8-10 = severe pain).

The AKSS[8] was used to assess knee joint function. The full score is 100, and the evaluation items include stability, mobility and pain when walking on the flat ground or climbing stairs. The higher the score is, the better the knee joint function. It consists of two parts, knee and function subscores.

The self-care ability score was used to assess daily living ability, using the modified Barthel Index (MBI) scale.[9] The total score is 100. The higher the score is, the stronger the ability to manage daily living and the lower the dependence. Cronbach's alpha (α) coefficient of content consistency reliability of the current Chinese version of the BI scale is > 0.92, the Guttman split-half coefficient is 0.86-0.90 and the test-retest reliability coefficient in all fields is > 0.82, indicating good reliability.

In addition to analyzing inter-group differences, the clinical relevance of the improvements was assessed by determining the proportion of patients in each group who achieved the Minimum Clinically Important Difference (MCID). Accordingly, established MCID thresholds from the literature were used: an increase of ≥ 9 points for the AKSS (patients with an improvement of at least 9 points for AKSS-knee and 10 points for AKSS-function scores experience a clinically important change)[10] and an increase of ≥ 5.34 points for the MBI.[11]

Statistical analysis

Study power analysis and sample size calculation were performed using the G*Power version 3.1.9.7 software (Heinrich Heine University Düsseldorf, Düsseldorf, Germany). The effect size (Cohen's d = 0.65) was estimated based on a previously conducted unpublished pilot study involving 20 patients with KOA, which compared the same acupuncture-rehabilitation intervention versus rehabilitation alone. The primary outcome measured in the pilot study was the change in the NRS pain score after one month of treatment. The pilot results indicated a mean NRS reduction of 2.8 points in the intervention group versus 1.9 points in the control group, with a pooled standard deviation of 1.4, yielding an effect size of d = 0.64, rounded to 0.65 for conservative sample size estimation. Setting the alpha error probability to 0.05 and the power (1-β) to 0.80 for a two-tailed independent samples t-test, the analysis indicated that a total sample size of approximately 78 participants (39 per group) would be required. Accounting for a potential dropout rate of 10%, we attempted to recruit a total of 86 participants. Finally, 84 participants were enrolled and completed the study, which is close to the calculated target and provides adequate power for the primary analysis.

Statistical analysis was performed using the SPSS version 25.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were presented in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. If the data of two independent samples conformed to normality and variance homogeneity, the t-test was used; if they did not conform, the non-parametric test was used. Repeated and continuous measurement data were analyzed using variance of repeated measurements; the chi-square (χ^2) test or non-parametric test was used for counting data, and the rank sum test was used for grade data. A two-sided p value of <0.05 was considered statistically significant.

RESULTS

Literature retrieval results

A total of 2,505 items of literature were retrieved from the database, and 287 items were finally

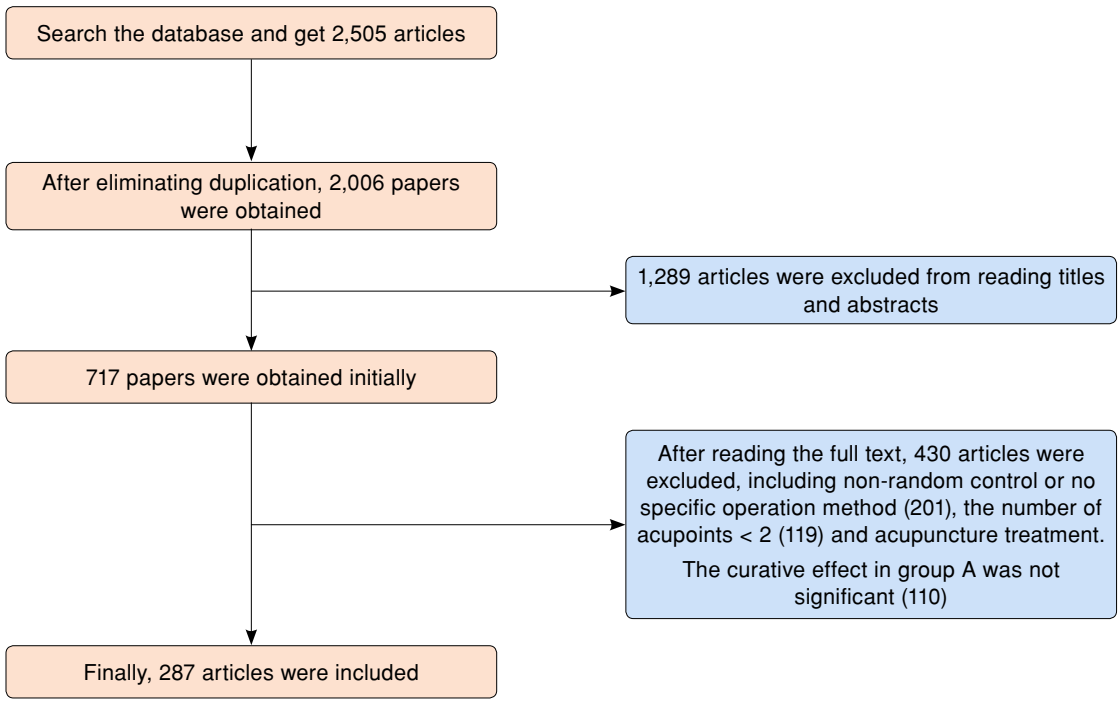


FIGURE 2. Literature screening flowchart acupoints.

included following layer-by-layer screening (Figure 2).

Acupoint frequency statistics

The frequency analysis of acupoints revealed that among 287 acupuncture prescriptions for KOA, 63 acupoints were used 1,951 times. The five most frequently used acupoints were Dubi, Yanglingquan, Zusanli, Neixiyan and Xuehai, accounting for 11.63%, 11.28%, 11.23%, 10.76% and 10.40%, respectively. The top 10 high-frequency (> 50) acupoints are shown in Table I.

Analysis of the law of acupoint grouping based on association rules

The choice of acupoints used in the prescriptions involved in previous studies and the basis for the combination of these acupoints were analyzed. The association rules between acupoints were also summarized. As shown in Figure 3a, a total of 176 acupoint combinations and 75 association rules were identified, involving nine acupoints. When the frequency threshold was set to 100 and the confidence level to 0.9, 53 acupoint combinations and eight

TABLE I
The top 10 high-frequency acupoints for knee osteoarthritis treatment

Serial number	Name of acupoints	Frequency (times)	Proportion (%)
One	Dubi	227	11.63
Two	Yanglingquan	220	11.28
Three	Zusanli	219	11.23
Four	Neixiyan	210	10.76
Five	Xuehai	203	10.40
Six	Liang Qiu	178	9.12
Seven	Yinlingquan	143	7.33
Eight	Heding	99	5.07
Nine	Ashi point	87	4.50

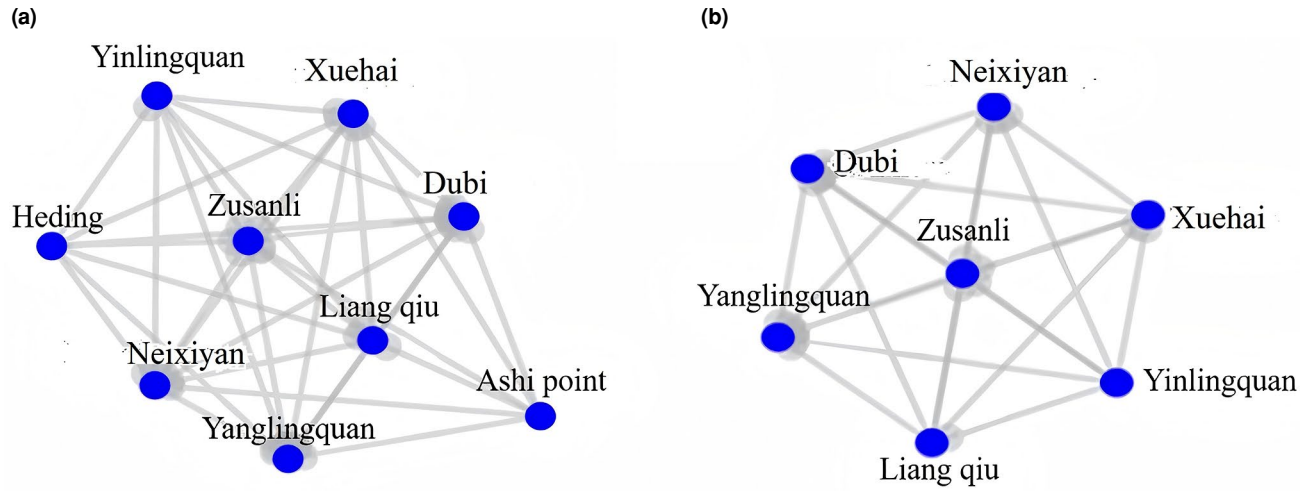


FIGURE 3. The law of acupoint grouping based on association rules **(a)**. Nine acupoints. **(b)** Seven acupoints.

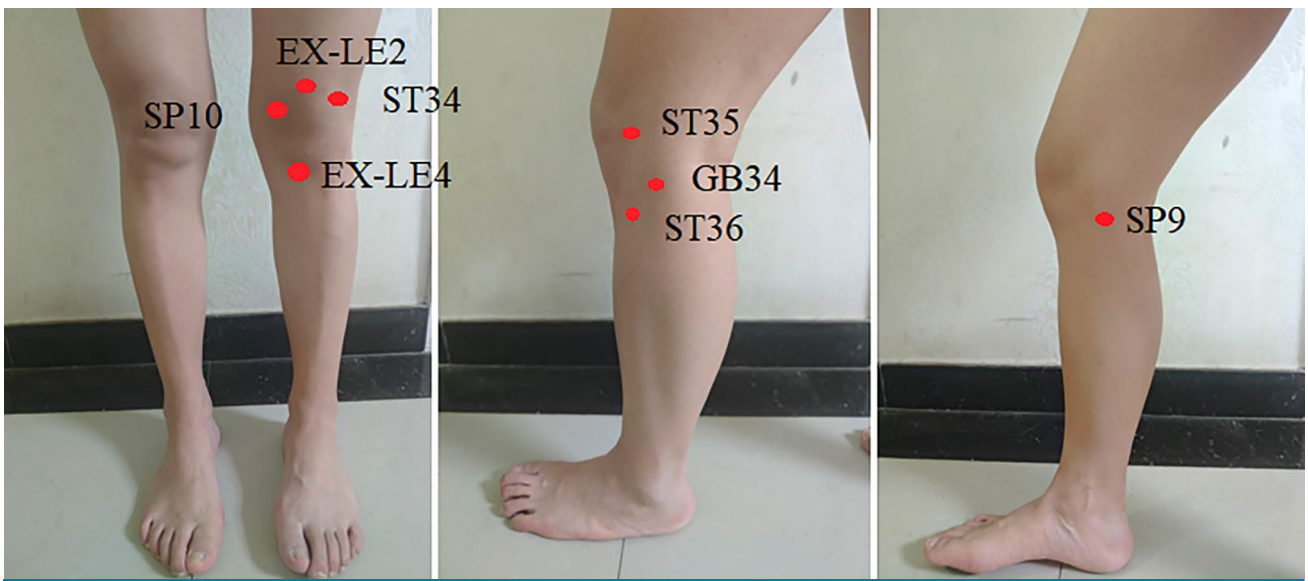


FIGURE 4. The location of acupoints: ST35: Dubi; GB34: Yanglingquan; SP9: Yinlingquan; ST36: Zusanli; EX-LE4: Neixiyan; SP10: Xuehai; ST34: Liangqiu; EX-LE2: Heding.

association rules were obtained, involving seven acupoints (Figure 3b). The acupoint locations are shown in Figure 4. Based on the information obtained from these two settings, and according to the frequency ranking, the top 20 core acupoint combinations (Table II) and the top 20 association rules (Table III) were identified. Among them, the top five acupoint combinations were *'Dubi-Neixiyan'*, *'Yanglingquan-Zusanli'*, *'Yanglingquan-Dubi'*, *'Yanglingquan-Xuehai'* and *'Dubi-Zusanli'*. The top 6 places with the highest confidence were *'Dubi-Zusanli-Liang Qiu-Yinlingquan → Yanglingquan'*, *'Yanglingquan-Zusanli-Neixiyan-Heding → Dubi'*, *'Dubi-Xuehai-Liang Qiu-Yinlingquan → Yanglingquan'* and *'Yanglingquan-Dubi-Xuehai-Heding'*.

Cluster-based analysis of the law of acupoint grouping

Based on the pattern of acupoint combinations, those with a relatively high frequency of occurrence were summarized and subjected to cluster analysis;

TABLE II
Core acupoints combination of KOA treated by acupuncture and moxibustion

Serial number	Acupoint combination	Frequency (times)
One	Dubi-Neixiyan	186
Two	Yanglingquan-Zusanli	180
Three	Yanglingquan-Dubi	170
Four	Yanglingquan-Xuehai	162
Five	Dubi-Zusanli	162
Six	Yanglingquan-inner knee eye	159
Seven	Zusanli-Xuehai	158
Eight	Zusanli-Neixiyan	155
Nine	Xuehai-Liang Qiu	153
Ten	Yanglingquan-Liang Qiu	148
Eleven	Dubi-Xuehai	148
Twelve	Yanglingquan-Dubi-Neixiyan	143
Thirteen	Neixiyan-Xuehai	143
Fourteen	Zusanli-Liang Qiu	142
Fifteen	Yanglingquan-Dubi-Zusanli	138
Sixteen	Dubi-Zusanli-Neixiyan	136
Seventeen	Yanglingquan-Zusanli-Xuehai	136
Eighteen	Dubi-Liang Qiu	135
Nineteen	Yanglingquan-Yinlingquan	132
Twenty	Neixiyan-Liang Qiu	128

KOA, knee osteoarthritis.

TABLE III
Association rules of acupuncture treatment of KOA

Serial number	Rule	Confidence level
One	Dubi-Zusanli-Liang Qiu-Yinlingquan → Yanglingquan	0.96
Two	Yanglingquan-Zusanli-Neixiyan-Heding → Dubi	0.96
Three	Dubi-Xuehai-Liang Qiu-Yinlingquan → Yanglingquan	0.96
Four	Yanglingquan-Dubi-Xuehai-Heding → Zusanli	0.96
Five	Dubi-Liang Qiu-Yinlingquan → Yangling quan	0.96
Six	Dubi-Neixiyan-Liang Qiu-Yinlingquan → Yanglingquan	0.96
Seven	Dubi-Zusanli-Xuehai-Heding → Yanglingquan	0.95
Eight	Dubi-Yinlingquan → Yanglingquan	0.95
Nine	Dubi-Zusanli-Neixiyan-Liang Qiu-Yinling quan → Yanglingquan	0.95
Ten	Dubi-Neixiyan-Xuehai-Liang Qiu-Yinling quan → Yanglingquan	0.95
Eleven	Zusanli-Liang Qiu-Heding → Xuehai	0.95
Twelve	Dubi-Zusanli-Xuehai-Liang Qiu-Yinling quan → Yanglingquan	0.95
Thirteen	Dubi-Xuehai-Yinlingquan → Yanglingquan	0.94
Fourteen	Yanglingquan-Xuehai-Heding → Zusanli	0.94
Fifteen	Dubi-Zusanli-Yinlingquan → Yanglingquan	0.94
Sixteen	Yanglingquan-Xuehai-Liang Qiu-Heding → Zusanli	0.94
Seventeen	Yanglingquan-Zusanli-Liang Qiu-Heding → Xuehai	0.94
Eighteen	Liang Qiu-Heding → Xuehai	0.94
Nineteen	Yanglingquan-Neixiyan-Heding → Dubi	0.94
Twenty	Dubi-Neixiyan-Yinlingquan → Yanglingquan	0.94

KOA, knee osteoarthritis.

five cluster groups were obtained: cluster 1 (C1) of *Yanglingquan-Heding-Tianzhu-Xuehai*; C2 of *Liang Qiu-Zusanli*; C3 of *Ququan-Xuehai-Neixiyan*; C4 of *Eye-Yanglingquan-Liang Qiu-Zusanli*; and C5 of *Yanglingquan-Dubi-Neixiyan-Shenshu-Zusanli-Yinlingquan*.

Participants' characteristics

A total of 84 patients with KOA were included in this study. In general, a sample size should be five to 10 times the number of survey items. In this study, both the AKSS and the self-care ability scale comprised four dimensions; therefore, the required sample size was estimated to be 20-40 participants, which met this requirement. Based on a random number table, the participants were divided into a control group and an intervention group, with 42 in each group (Table IV). The control group consisted of 15 male and 27 female, with a mean age of 62.90 ± 11.531 (range, 40 to 78) years. The mean course of the disease was 4.07 ± 1.841 years. The intervention group consisted of 16 male and 26 female, with a mean age of 63.95 ± 10.613 (range, 41 to 79) years and a mean disease course of 4.76 ± 2.328 years (Table IV). The control group received routine rehabilitation treatment, whereas the intervention group was given routine rehabilitation plus acupuncture treatment. Before the treatment, there was no significant difference in general characteristics of the patients between the two groups ($p > 0.05$) (Table IV).

Clinical comparison of the two groups of patients

The participants in this study did not experience any complications or adverse reactions. Improvement of any symptoms in patients was considered effective. The total efficacy rate of patients in the intervention group was 92.85%, whereas that of patients in the control group was 73.80%, with a significant difference ($p < 0.05$) (Table V).

Comparison of pre- and post-treatment NRS scores between the two groups

Pain scores were calculated for patients in both groups. On the day of admission, the mean pain score was 5.38 ± 0.962 in the control group

TABLE IV
Comparison of general data between two groups of patients

	Control group (n = 42)			Intervention group (n = 42)				
	n	%	Mean ± SD	n	%	Mean ± SD	Statistic	*p*
Age (year)			62.90 ± 11.531			63.95 ± 10.613	t = 1.598	0.114
Sex							χ^2 = 0.051	0.821
Male	15	35.71		16	38.10			
Female	27	64.29		26	61.90			
Course of disease (year)			4.07 ± 1.841			4.76 ± 2.328	t = 1.513	0.134
Kellgren-Lawrence radiographic grade								
I	12	28.5		13	30.95		χ^2 = 0.149	0.538
II	21	50.00		22	52.38			
III	9	21.43		7	16.67			

SD, standard deviation.

TABLE V
Comparison of clinical efficacy between two groups of patients

	Intervention group (n = 42)		Control group (n = 42)			
	n	%	n	%	χ value	*p* value
Show effect	13		18			
Effective	18		21		5.486	0.019
Be invalid	11		3			
Total effective rate	31	73.80	39	92.85		

and 5.19 ± 1.042 in the intervention group, with no statistically significant difference between the groups (p = 0.871) (Table VI). After treatment, the mean pain score in the intervention group decreased to 1.93 ± 0.640, compared to 2.95 ± 0.731 in the control group at one month after the admission, indicating a statistically significant difference between the groups ($p < 0.05$) (Table VI). These results showed that acupuncture was effective in relieving pain.

Comparison of pre- and post-treatment AKSS scores between the two groups

The mean knee subscores in the control and intervention groups were 64.17 ± 11.148 and 66.67 ± 17.795, respectively, while function subscores were 57.40 ± 8.925 and 54.10 ± 10.150, respectively. There was no statistically significant difference between the groups before treatment ($p > 0.05$) (Table VII). However, after treatment, both knee and function subscores were significantly higher in the intervention group compared to the control group ($p < 0.05$), indicating a significant inter-group difference. The mean difference was 6.030 in the control group and 10.98 in the intervention group. In addition, 80.95% of patients in the control group and 100% of patients in the intervention group achieved the MCID.

Comparison of pre- and post-treatment MBI scores between the two groups

Before treatment, the mean self-care ability scores were 79.95 ± 14.045 in the control group and 79.69 ± 17.318 in the intervention group, with no statistically significant difference between the groups (p = 0.940). After treatment, the

TABLE VI
Comparison of pain scores between the two groups before and after treatment

	Control group (n = 42)	Intervention group (n = 42)		
	Mean ± SD	Mean ± SD	*t* value	*p* value
Admission day	5.38 ± 0.962	5.19 ± 1.042	0.871	0.386
7 days in hospital	4.17 ± 0.794[a]	3.60 ± 0.798[a]	3.290	0.001
Admission for 1 month	2.95 ± 0.731[ab]	1.93 ± 0.640[ab]	6.830	<0.001

SD, standard deviation; [a], means that compared with the day of admission, $p < 0.05$, and [b], means that compared with the 7 days in hospital, $p < 0.05$.

TABLE VII
Comparison of knee joint function scores between the two groups

	Control group (n = 42)	Intervention group (n = 42)		
	Mean ± SD	Mean ± SD	*t* value	*p* value
Knee score				
Before treatment	64.17 ± 11.148	66.67 ± 17.795	–0.772	0.443
After treatment	80.24 ± 6.803[a]	87.62 ± 8.500[a]	–4.394	< 0.001
Function score				
Before treatment	57.40 ± 8.925	54.10 ± 10.150	1.582	0.117
After treatment	76.55 ± 6.656[a]	84.02 ± 5.515[a]	–5.605	< 0.001

SD, standard deviation; [a], means that compared with before treatment, $p < 0.05$.

TABLE VIII
Comparison of self-care ability scores between the two groups

	Control group (n = 42)	Intervention group (n = 42)		
	Mean ± SD	Mean ± SD	*t* value	*p* value
Before treatment	79.95 ± 14.045	79.69 ± 17.318	0.076	0.940
After treatment	87.60 ± 11.449[a]	92.24 ± 9.109[a]	–2.057	0.043

SD, standard deviation; [a], means that compared with before treatment, $p < 0.05$.

self-care ability score in the intervention group was significantly higher than that in the control group, and the between-group difference was statistically significant ($p < 0.05$) (Table VIII). The mean difference was 6.446 in the control group and 6.225 in the intervention group, with a 100% attainment rate of the MCID in both groups.

DISCUSSION

In the present study, we determined the acupoint combinations with the highest frequency, including the *Dubi, Zusanli, Yanglingquan, Xuehai, Neixiyan* and *Liang Qiu*, and assessed the good effect of these acupoints in KOA treatment. The results of a frequency analysis of acupuncture showed that these points are used more frequently, which is different from the results obtained by Yang Qian.[12] Among these acupoints, the typical and crucial points, including *Xuehai* (SP 10), *Zusanli* (ST 36), *Yanglingquan* (GB 34) and *Liang Qiu* (ST 34), were recommended in several systematic reviews and treatment guidelines due to their demonstrated therapeutic effects. According to the meridian theory of traditional Chinese medicine (TCM), the Dubi and Neixiyan, which are located in the depressions on both sides of the patellar ligament, are common tender points in KOA and play a key role in the 12 meridians running through the whole body for knee pain treatment.[13] Acupuncture at this point can regulate *qi* and dredge channels for reducing swelling, dispelling cold/wind and activating collaterals.[14] Yanglingquan is the joint point of the gallbladder meridian, the joint point of the gallbladder and fu-organs and the tendon meeting of the *Bahui* point.[15] *Zusanli* is the confluence point of the Foot-*Yangming* meridian and the confluence point below the stomach fu-organs. The spleen and stomach are regarded as the source of qi and blood biochemistry, and the Yangming meridian is rich in qi and blood, having the effect of tonifying both.[16] *Xuehai* is the place where blood gathers, which can turn blood into qi, and has the functions of regulating blood, expelling wind and removing dampness.[17] *Liang Qiu* can also be used as the main point for the treatment of KOA. Acupuncture at this point can also enrich blood and replenish qi, which is of great benefit in the recovery of knee joint function.[3] This evidence of TCM channels and collaterals provides important theoretical evidence for our research.

The acupoint combination *'Dubi-Neixiyan'* is the most common combination used. A previous study reported acupuncture at the *Dubi* and *Neixiyan* points with *Leihuowen* for KOA, with wind/cold entering collaterals, exhibiting a good effect for improving the knee joint function of patients.[18] Acupuncture can be used in conjunction to treat KOA with high efficacy, including at the *Dubi, Neixiyan, Yinling Spring, Yangling Spring, Xuehai* and *Liang Qiu* acupoints. The evidence shows that the curative effect of this acupoint combination is exact and reliable. Furthermore, the association rules of *Dubi-Zusanli-Liang Qiu-Yinlingquan* → *Yanglingquan*, *Yanglingquan-Zusanli-Neixiyan-Heding* → *Dubi*, *Dubi-Xuehai-Liang Qiu-Yinlingquan* → *Yanglingquan-Dubi-Xuehai-Heding* → *Zusanli Dubi* are recommended in this study.

The cluster analysis of acupoints revealed that *Dubi-Zusanli-Yanglingquan-Xuehai-Neixiyan-Liang Qiu* belonged to a large category. Combined with the analysis of acupoint usage frequency and association rules, these can be considered the core acupoints for acupuncture treatment of KOA. Clinical treatment can be based on the combination of acupoints obtained by cluster analysis and association rule analysis to improve the curative effect; however, treatment should also be designed according to the specific syndromes of patients in the clinic.

Acupuncture treatment of KOA is mainly based on lower limb acupuncture points, with local acupuncture points of the knee joint as the main stimulation site. More local acupuncture points are also used,[19] with *Dubi, Zusanli, Yanglingquan, Xuehai, Neixiyan* and *Liang Qiu* as the core acupoints. The results of acupoint frequency and regularity of acupoint grouping obtained in this study can provide a reference for clinical acupuncture treatment of KOA.

Knee osteoarthritis belongs to the category of 'bone arthralgia', 'pain arthralgia' and 'knee arthralgia' in TCM, and is more common in middle-aged and elderly individuals. The causes of KOA are mostly deficiency of vital energy and insecurity of external defense, and patients can easily feel the evil of wind, cold and dampness, which hinders the circulation of qi and blood, thus forming a pathological state of phlegm and blood stasis.[20] More specifically, cytokines, inflammatory factors (e.g., interleukin-1 beta, tumor necrosis factor-alpha), chemicals and signaling pathways are activated under frailty and poor circulation of qi and blood conditions, affecting cartilage degradation. Ultimately, pain, heaviness, soreness and numbness may appear in the bones, joints and muscles around the knee joint.[21] Previous studies using animal models revealed that acupuncture is an effective

method for inhibiting these inflammatory factors and the mitogen-activated protein kinase (MAPK) pathway in synovial fluid and cartilage. In addition, acupuncture therapy, as a form of TCM external treatment, has a definite curative effect on KOA and has unique advantages, such as economic safety, simplicity and fewer adverse reactions.

In the current study, the pain score of the intervention group was lower than that of the control group after seven and 30 days of follow-up. One underlying reason for this is the imbalance of the length or strength of lower limb muscles in patients with KOA, leading to abnormal joint movement mode and increased joint stress. Therefore, individualized muscle imbalance assessment and corrective rehabilitation training are extremely important to improve the motor ability of the lower limbs and relieve pain. Acupuncture regulates the circulation of qi and blood in the meridians and promotes local blood circulation by stimulating the points around the knee joint *(Dubi, Zusanli, Yanglingquan, Xuehai, Neixiyan* and *Liang Qiu)*.

A comprehensive treatment scheme can be formed by combining the law of acupuncture point selection based on data mining with rehabilitation training. Acupuncture treatment can relieve pain and improve joint function by stimulating specific points, regulating qi and blood and dredging meridians. Rehabilitation training can enhance muscle strength and improve joint stability through functional training, thus consolidating the effect of acupuncture treatment. This comprehensive treatment method can significantly improve the therapeutic effect for patients with KOA and relieve pain.

According to related research, KOA can cause joint deformity, meniscus rupture and other related diseases, and its main pathological changes include damage to articular cartilage and other injuries. Several studies have revealed the mechanism of acupuncture in treating KOA, which is related to regulating the immune response, inhibiting the expression of inflammatory factors, down-regulating the content of serum nitric oxide and delaying the degeneration of knee cartilage.[22,23] Our study results are consistent with these theories in that acupuncture promotes the blood circulation in bone, alleviating the degeneration of cartilage joints and improving the function of the knee joint through decreasing the inflammatory factors.

Furthermore, the long disease course of KOA promotes the production of negative emotions in patients, leading to a decline in compliance and the effects of standalone physical exercise and activity.[24] Regulating qi and blood is beneficial in delaying cartilage degeneration.[25] The MCID for AKSS is defined as an increase of at least nine points.[10] The MCID for BMI is defined as an increase of at least 5.34 points.[11] The results of this study are consistent with previous studies, which demonstrates the clinical significance of our findings. Overall, we demonstrated the favorable effect of acupuncture combined with rehabilitation training through stimulating meridians and dredging the knee meridians.

This study adopted a new treatment model, which is of great significance for improving the efficacy of TCM therapy. In this model, by analyzing existing data, including academic papers and medical cases, the usage patterns of TCM or acupoints are summarized to develop more effective treatment plans. The combination of multiple therapies has also been proven to be beneficial for improving therapeutic efficacy.

However, this study has certain limitations that should be acknowledged. First, in the data mining stage, there was no restriction on the TCM classification of KOA, indicating some risk of bias. Future research should focus on the development of in-depth data mining technology, evidence-based medicine support and interdisciplinary cooperation to improve the treatment effect and the quality of life of patients. Second, in the clinical application stage, the samples in this study were relatively small and insufficient. Further multi-center, large-scale clinical trials are needed for more precise reference in clinical treatment.

In conclusion, our study results suggest that acupuncture combined with rehabilitation training based on data mining can relieve patients' pain, accelerate the recovery of their knee joint function and improve their daily living ability, demonstrating high clinical value in practice. Future well-designed, randomized-controlled trials with larger sample sizes are warranted to further validate these findings and explore the long-term effects of this combined intervention.

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

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