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ORIGINAL RESEARCH

A Data Mining Study for Analysis of Acupoint Selection and Combinations in Acupuncture Treatment of Carpal Tunnel Syndrome

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Background: Carpal tunnel syndrome (CTS) is the most prevalent upper limb compressive neuropathy. A considerable number of clinical trials and meta-analyses have provided evidence supporting the effectiveness of acupuncture in treating CTS. Nevertheless, the ideal choice of acupoints remains ambiguous.

Objective: A data mining analysis was conducted with the objective of determining the most effective acupoint combinations and selection for CTS.

Methods: A search was conducted across seven Chinese and English electronic bibliographic databases spanning from their inception to March 2023. Selected were clinical trials that evaluated the efficacy of acupuncture therapy for CTS, with or without randomised controlled methods. Data extraction mainly included acupoint prescriptions. Information such as first author, study design and study setting were also extracted. The principal outcomes comprised the clinical manifestations linked to CTS. Statistical descriptions were generated using Excel 2019. The analysis of association rules was conducted using SPSS Modeler 18.0. Using SPSS Statistics 26.0, exploratory factor analysis and cluster analysis were conducted.

Results: 142 trials (including 86 RCTs and 56 non RCTs) were identified, and 193 groups of effective prescriptions involving 68 acupoints were extracted. The most frequently used acupoints were Da-ling (PC7), Nei-guan (PC6), He-gu (LI4), Wai-guan (TE5), and Yang-xi (LI5). The most frequently used meridians were the pericardial meridian and the large intestine meridian. The majority of special acupoints used were Five-shu points and Yuan-source points, with acupoints on the upper limbs being the most frequently used. The core acupoint groups were analyzed and 11 groups of association rules, 8 factors, and 5 effective cluster groups were obtained.

Conclusion: The evidence-based acupoint selection and combinations of acupuncture therapy for carpal tunnel syndrome were provided by the findings of this study.

Keywords: acupuncture, carpal tunnel syndrome, data mining, descriptive statistics, association rule analysis, exploratory factor analysis, cluster analysis

Introduction

Carpal tunnel syndrome (CTS) is a condition affecting the wrist caused by median nerve compression; it often induces discomfort and disability,[1] which is the most common compression neuropathy of the upper limb.[2] The prevalence of it ranges from 2.7% to 6.7% on an annual basis.[1,3] Individuals within the age range of 40 to 60 years are commonly afflicted with this condition, although it can affect individuals of any age.[4] It is frequently identified by sensory loss,

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muscle weakness, and abnormal sensations (dysesthesia) in the hand(s) that are located at the wrist. Consequently, the limitations on functional abilities are substantial. The impact of CTS is not limited to the individual, as it can have broader societal implications. This includes reduced work productivity and limitations in daily activities, which can result in increased healthcare expenditures.[5] At present, open carpal tunnel release is regarded as the favoured therapeutic approach. However, it is important to note that this surgical intervention carries the potential for certain complications.[6]

Acupuncture, being an alternative and complementary therapy, has been employed to mitigate a range of excruciating neuropathic conditions.[7–9] The effectiveness of acupuncture therapy in mitigating pain and improving functional status among patients diagnosed with CTS has been established by a multitude of studies.[10,11] Prior meta-analytic findings have indicated that acupuncture constitutes a viable approach for addressing CTS.[12,13] Some studies have shown that there are differences in neuronal specificity among different acupoints, which may lead to different acupuncture effects.[14,15] For this reason, the selection of acupoints holds significant importance in the therapeutic application of acupuncture. Nevertheless, the choice of acupoints can differ due to the wide range of viewpoints and clinical proficiency exhibited by practitioners of medicine. Currently, a significant number of clinical trials are utilizing acupuncture as a therapeutic intervention for CTS.[11,16,17] The challenge in identifying the optimal treatment option and its application arises from the variations in acupoint selection across various research studies. As a result, there is an absence of accurate data that can specify the most effective combinations and selection of acupoints for the management of CTS. By harnessing the capabilities of data mining technology, individuals may be able to extract valuable insights and information from enormous quantities of documents.[18] Standards for the selection and combinations of acupoints in the treatment of diverse medical conditions, including but not limited to chronic stable angina pectoris,[19] obesity,[20] chemotherapy-induced peripheral neuropathy,[21] tic disorders,[22] amyotrophic lateral sclerosis,[23] pain control[24], and five-phase acupoints,[25] have been established by prior research. This study may provide evidence that the benefits of acupuncture are contingent on the specificity of the acupoints along various meridians and that specificity exists between the acupoints of different meridians. As a result, identifying the norms and characteristics governing the selection and combinations of CTS acupoints is crucial for future clinical practise and research, enabling clinicians and patients to jointly make a more informed decision. By utilising data mining techniques to examine the correlation patterns between acupoints, this study aims to develop a treatment protocol for the application of CTS acupoints that is relatively standardised. Our protocol of this study has been published in the *Journal of Pain Research*.[26]

Methods and Analysis

Study Design and Study Setting

We first established search strategies, screened literatures according to inclusion and exclusion criteria, extracted acupoint prescriptions in literatures, and used statistical methods to conduct descriptive statistical analysis of the frequency of acupoint application, meridian application, site of point application and special point application of the included acupoints, and then conducted association rule analysis, factor analysis and cluster analysis.

Search Methods

A thorough exploration was undertaken of electronic libraries, encompassing both Chinese and English texts, from their establishment until March 2023. PubMed, Embase, Cochrane Library, China National Knowledge Infrastructure (CNKI), Wanfang Database, Chinese Biomedical Literature Database (CBM), and Chongqing VIP Database were among the databases that were searched. The linguistic repertoire was limited to the Chinese and English languages exclusively. Our review utilised a combination of medical subject headings and free-text terms in its search strategy. Examples of search strategies are provided in Table 1, with PubMed serving as an example. The search strategy was modified to accommodate the specific limitations of each database, taking into account their respective characteristics.

Table 1 Search Strategy for PubMed Database

No.	Search terms
#1	MeSH terms: "carpal tunnel syndrome"
#2	Title/Abstract: "carpal tunnel syndrome" OR "syndrome, carpal tunnel" OR "carpal tunnel stenosis" OR "mouse hand" OR "CTS"
#3	#1 OR #2
#4	MeSH terms: "acupuncture therapy" OR "acupuncture" OR "cupping therapy" OR "bloodletting"
#5	Title/Abstract: "needling" OR "needles" OR "needle" OR "pricking blood" OR "blood-letting" OR "bloodletting" OR "cupping" OR "fire acupuncture" OR "warm needling" OR "electro-acupuncture" OR "body acupuncture" OR "electroacupuncture" OR "manual acupuncture" OR "acupuncture" OR "acupuncture therapy" OR "cupping therapy"
#6	#4 OR #5
#7	#3 AND #6

Review Process

Data Screening

Types of Studies

Inclusion criteria: Studies that report on the use of acupuncture therapy as a principal intervention, with or without randomised and/or controlled methods, meet the inclusion criteria. In order to proceed, each cohort or trial must contain more than ten patients. When a duplicate was present, the final publication was utilised.

Exclusion criteria: Reviews, protocols, animal trials, case reports, systematic reviews, and meta-analyses.

Types of Participants

Inclusion criteria: The inclusion criteria encompassed clinical trials in which subjects were identified as having CTS.

Exclusion criteria: Acupuncture was included in the exclusion criteria for CTS postoperative rehabilitation, as we believe that surgery, not acupuncture, is the primary treatment for CTS in this instance.

Intervention Types

Inclusion criteria: The inclusion criteria were modified to meet these requirements. It is necessary to utilise either special acupoints or conventional meridian acupoints when inserting needles and/or performing moxibustion. It was utilised either independently or in combination with other therapeutic approaches, such as moxibustion and acupuncture (eg, Chinese botanicals). Included were studies that compared different acupuncture techniques for CTS.

Exclusion criteria: Needles inserted through the ear, head, wrist, and ankle, as well as other non-body needles, whose theoretical foundations were deemed irrelevant to conventional acupoints.

Types of Outcome Measurements

Inclusion criteria: Studies were required to report a minimum of one clinical outcome that was linked to CTS, such as pain intensity, response rate, or electrophysiological status of the median nerve. Included were studies in which patients who received acupuncture therapy individually or in combination demonstrated larger benefits than those who did not receive acupuncture therapy as the control group.

Exclusion criteria: Trials that exclusively documented physiological or laboratory data. Excluded from controlled trials were studies in which acupuncture therapy, either individually or in combination, failed to produce greater benefits for patients than the control group. Patients whose acupoint prescriptions were either incomplete or non-existent.

Data Collection

Furui Miao conducted a comprehensive assessment of the titles and abstracts retrieved from the literature search and excluded any that appeared to be superfluous, such as research articles centred around case reports, animal experiments, or reviews. The complete texts of the remaining references were gathered and reevaluated to exclude publications that were not pertinent. After that, Cai He and Fangzhi Zhang conducted a formal assessment of the suitability of every other

paper according to the inclusion criteria that were previously mentioned. Disputes were resolved through discussions, according to a third author (Yushan Fan).

Database Establishment and Data Normalization Processing

The imported literature was received by the document manager Endnote×9.2 subsequent to the search. Two members of the research team conducted independent reviews and reevaluations of the literature in accordance with the inclusion and exclusion criteria. Duplicate literature was eliminated using software, and the results were scrutinised to ensure the accuracy of the literature that was included. Excel 2019 was utilised to import the extracted data in order to create the CTS database for prescription of acupuncture treatment. Read the literature included in the study, identify the acupoints used. Information such as first author, study design and study setting were also extracted. By employing strategy[22] which states that "a collection of primary acupoints and a collection of secondary acupoints comprise an acupoint prescription", valid prescriptions were extracted. We standardised the names of the acupoints mentioned in the literature by consulting the "Study of Meridians and Collaterals"[27] and Western Pacific Region and the China National Standard "Naming and Positioning of Acupoints" (GB/T 12346–2006). Additionally, we provided further information regarding the attribution of meridians, site of point, and special point attributions.

Managing Data Absences

To conduct an intention-to-treat assessment of the data, we initiated communication with the original authors, who subsequently furnished any pertinent information that was absent. We exclusively assessed the data that was presently obtainable in cases where comprehensive information was not available in this format.

Analytical Data

Assessment of Literature Quality

Two evaluators (Yujun He and Cai He) assessed the risk of bias of RCTs in the included studies using the "risk of bias" tool from The Cochrane Collaboration.[28] Two researchers conducted separate evaluations of the subsequent factors: random sequence generation, concealment of allocation, blinding of personnel and participants, blinding of outcome assessment, incomplete outcome data, selective reporting, and other forms of bias. Disagreements were resolved with the assistance of a third researcher (Yushan Fan) via negotiation or discussion.

Descriptive Statistics

A PivotTable was generated from the Excel 2019 table containing all acupoint prescriptions from the included literature in order to conduct descriptive statistical analysis on the frequency of acupoint usage, the attribution of meridians, the site of point, and the attribution of special point.

Association Rule Analysis

The Apriori algorithm was applied to SPSS Modeller 18.0 to examine the association principles of high frequency acupoints. The degree of support represented the likelihood that both the anterior and posterior items would occur, whereas the degree of confidence denoted the likelihood that the latter item would occur in the event that the former item appeared. The optimal minimum level of support and confidence were determined through iterative testing; the maximum value for the former was established at 2. After that, a complex network diagram was constructed in order to examine the correlation between the acupoints.

Exploratory Factor Analysis

Exploratory factor analysis was performed using SPSS Statistics 26.0 on the high frequency acupoints, while Bartlett and KMO sphericity tests were applied to the prescription data. When KMO was greater than 0.5 and P was less than 0.05, factor analysis was performed, and the principal factor components were extracted using maximum variance rotation. A value less than KMO 0.5 or P greater than 0.05 precludes factor analysis.

Cluster Analysis

The high frequency acupoints were subjected to cluster analysis using SPSS Statistics 26.0, and the clustering relationship between the acupoints was examined by drawing a cluster analysis tree.

Results

Eligible Studies

A grand total of 2543 pertinent articles were identified (including 592 papers from CNKI, 365 papers from VIP, 601 papers from Wanfang, 633 papers from CBM, 111 papers from PubMed, 193 papers from Embase, 48 papers from Cochrane Library), with 1227 duplicate studies being omitted. We then evaluated the titles and abstracts of the remaining 1316 studies to identify 290 studies that might have been potential candidates. Following the screening of full texts, 142 studies were ultimately included and 148 publications were excluded (Figure 1).

Risk of Bias Assessment

Among the 142 literatures included, 86 were RCTs. The literature quality evaluation of RCTs found that the bias risk mainly came from the failure to describe specific random methods and the implementation of allocation concealment and blind methods (Figure 2).

Frequency of Acupoint Analysis

All included acupoint prescriptions were shown in Supplementary Table 1. A grand total of 193 prescriptions, comprising 68 acupoints, were identified, representing a frequency of 1003. Of these, 56 were conventional acupoints, 7 were non-meridian acupoints, and 5 were experience acupoints that were not associated with any traditional meridians. Da-ling (PC7), Nei-guan (PC6), He-gu (LI4), Wai-guan (TE5), and Yang-xi (LI5) are the five acupoints that are utilised most frequently (Table 2; Figure 3). Da-ling (PC7) was the most commonly used acupoint, accounting for 14.60%.

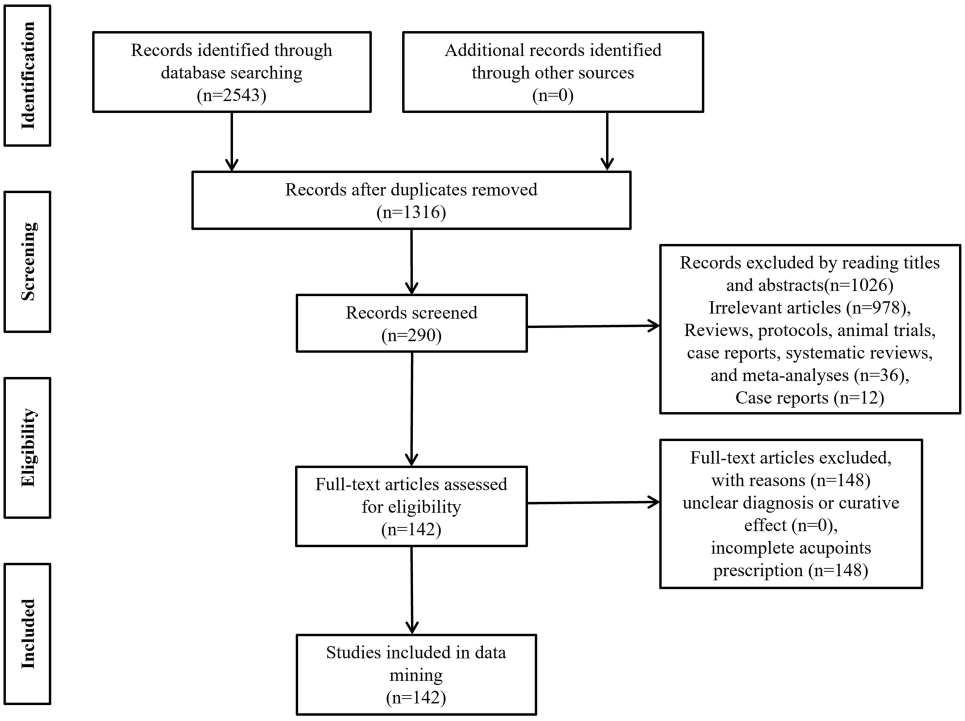

Figure 1 Flow diagram of the study selection process.

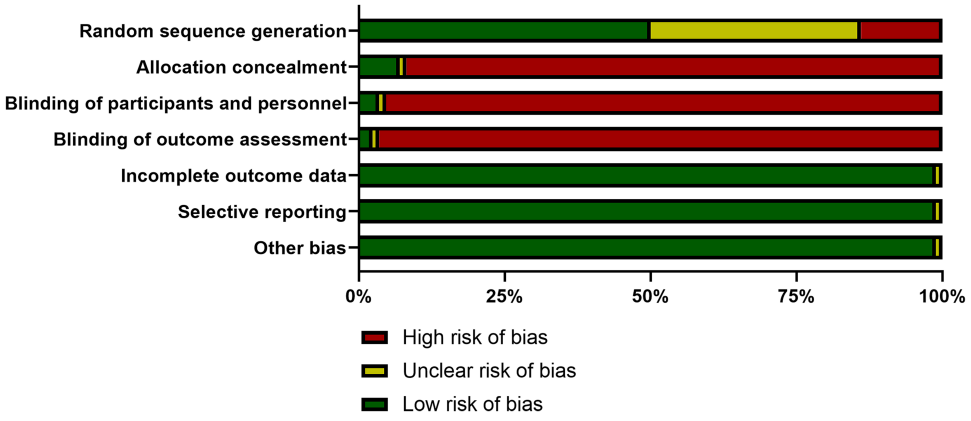

Figure 2 Risk of bias assessment.

Frequency of Meridian Analysis

The analysis of the meridian application provided insights into the distribution of the chosen acupoints, encompassing the frequency and proportion of acupoints along each meridian, the quantity and proportion of acupoints utilised, as well as the nomenclature and frequency of each acupoint. The results showed that the frequency of use of the pericardial meridian was the highest, 343 times (34.20%). The second most used meridian was the large intestine meridian, 232 times (23.13%), and the frequency of other meridians was significantly less than them. In terms of the amount of acupoints, the large intestine meridian and extra points were the most, comprising 12 acupoints (17.65%) (Table 3; Figure 4).

Distribution of Acupoint Analysis

The distribution of acupoint analysis showed that the acupoints of the upper limbs were most used, with a frequency of 976 times (97.31%), comprising 54 acupoints (79.41%). The frequency and amount of acupoints in other sites were less (Table 4).

Table 2 Frequency of Acupoint Application for CTS Treatment

NO.	Acupoint	Frequency	
1	PC7	141	14.06%
2	PC6	122	12.16%
3	LI4	72	7.18%
4	TE5	64	6.38%
5	LI5	64	6.38%
6	LI11	46	4.59%
7	PC8	45	4.49%
8	TE4	43	4.29%
9	Ashi	37	3.69%
10	LI10	35	3.49%
11	LU10	31	3.09%
12	SI5	25	2.49%
13	HT7	23	2.29%
14	LU5	18	1.79%
15	LU8	18	1.79%
16	PC5	16	1.60%
17	EX-UE8	14	1.40%
18	PC3	12	1.20%

(*Continued*)

Table 2 (Continued).

NO.	Acupoint	Frequency	
19	EX-UE9	11	1.10%
20	LU7	11	1.10%
21	LU9	11	1.10%
22	TE3	10	1.00%
23	LU6	9	0.90%
24	HT3	9	0.90%
25	SI4	8	0.80%
26	SP6	8	0.80%
27	EX-UE2	8	0.80%
28	PC4	7	0.70%
29	TE2	6	0.60%
30	LI6	6	0.60%
31	SI3	5	0.50%
32	TE10	5	0.50%
33	SI6	4	0.40%
34	HT8	3	0.30%
35	LR3	3	0.30%
36	LR4	3	0.30%
37	ST36	3	0.30%
38	SI8	3	0.30%
39	BL23	3	0.30%
40	LI12	3	0.30%
41	HT2	3	0.30%
42	Bizhong	3	0.30%
43	EX-UE11	3	0.30%
44	EX-UE10	3	0.30%
45	SI7	2	0.20%
46	HT5	2	0.20%
47	LI2	1	0.10%
48	LI3	1	0.10%
49	LI7	1	0.10%
50	LU11	1	0.10%
51	TE6	1	0.10%
52	BL13	1	0.10%
53	BL15	1	0.10%
54	GV3	1	0.10%
55	Shuiqu	1	0.10%
56	EX-B2	1	0.10%
57	LI8	1	0.10%
58	LI13	1	0.10%
59	LI8	1	0.10%
60	TE8	1	0.10%
61	TE9	1	0.10%
62	EX-LE11	1	0.10%
63	Wuhu	1	0.10%
64	ST24	1	0.10%
65	Shangfengshidian	1	0.10%
66	GV12	1	0.10%
67	GV11	1	0.10%
68	GV13	1	0.10%

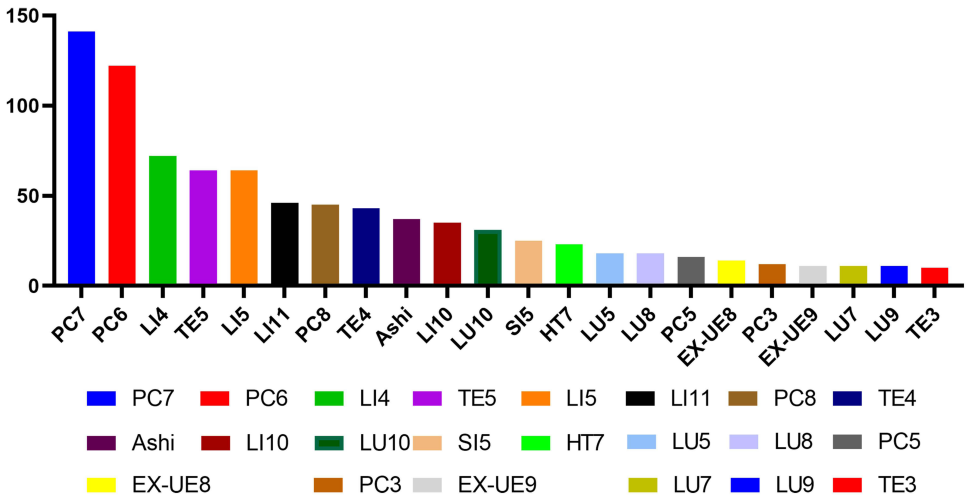

Figure 3 Frequency of acupoint application for CTS treatment.

Frequency of Special Acupoints Analysis

The frequency of usage, the quantities, and the varieties of acupoints that were included in acupuncture prescriptions were all illustrated in the results of the analysis of special acupoints. Specifically, 43 of 68 acupoints were designated as such. Five-shu points comprised the preponderance of the special acupoints utilised. Yuan-source points, Luo-connecting point, Eight-confluent points, and Back-Shu points were also frequently used (Table 5).

Association Rule Analysis

Association rules analysis were analyzed on the included acupoints by using SPSS Modeler 18.0 software. After repeated tests, we found that setting the minimum support degree of 10% and the minimum confidence level of 90% was the best. According to the set conditions, a total of 11 groups of acupoints meeting the conditions were analyzed. In terms of acupoint combinations, the top five combinations with the highest support were [Nei-guan (PC6)] ≥ [Da-ling (PC7)], [Yang-xi (LI5), Nei-guan (PC6)] ≥ [Da-ling (PC7)], [Wai-guan (TE5), Nei-guan (PC6)] ≥ [Da-ling (PC7)], [Lao-gong

Table 3 Frequency of Meridian Application for CTS Treatment

Meridian	Frequency		Amount		Acupoints
Pericardial meridian	343	34.20%	6	8.82%	PC7 (141), PC6 (122), PC8 (45), PC5 (16), PC3 (12), PC4 (7)
Large intestine meridian	232	23.13%	12	17.65%	LI4 (72), LI5 (64), LI11 (46), LI10 (35), LI6 (6), LI12 (3), LI2 (1), LI3 (1), LI8 (1), LI13 (1), LI7 (1), LI8 (1)
Sanjiao meridian	131	13.06%	8	11.76%	TE5 (64), TE4 (43), TE3 (10), TE2 (6), TE10 (5), TE8 (1), TE9 (1), TE6 (1)
Pulmonary meridian	99	9.87%	7	10.29%	LU10 (31), LU5 (18), LU8 (18), LU7 (11), LU9 (11), LU6 (9), LU11 (1)
Extra points	84	8.37%	12	17.65%	Ashi (37), EX-UE8 (14), EX-UE9 (11), EX-UE2 (8), Bizhong (3), EX-UE11 (3), EX-UE10 (3), EX-LE11 (1), EX-B2 (1), Shangfengshidian (1), Shuiqu (1), Wuhu (1)
Lung meridian	47	4.69%	6	8.82%	SI5 (25), SI4 (8), SI3 (5), SI6 (4), SI8 (3), SI7 (2)
Heart meridian	40	3.99%	5	7.35%	HT7 (23), HT3 (9), HT2 (3), HT8 (3), HT5 (2)
Spleen meridian	8	0.80%	1	1.47%	SP6 (8)
Liver meridian	6	0.60%	2	2.94%	LR3 (3), LR4 (3)
Bladder meridian	5	0.50%	3	4.41%	BL23 (3), BL13 (1), BL15 (1)
Stomach meridian	4	0.40%	2	2.94%	ST36 (3), ST24 (1)
Du meridian	4	0.40%	4	5.88%	GV12 (1), GV11 (1), GV13 (1), GV3 (1)

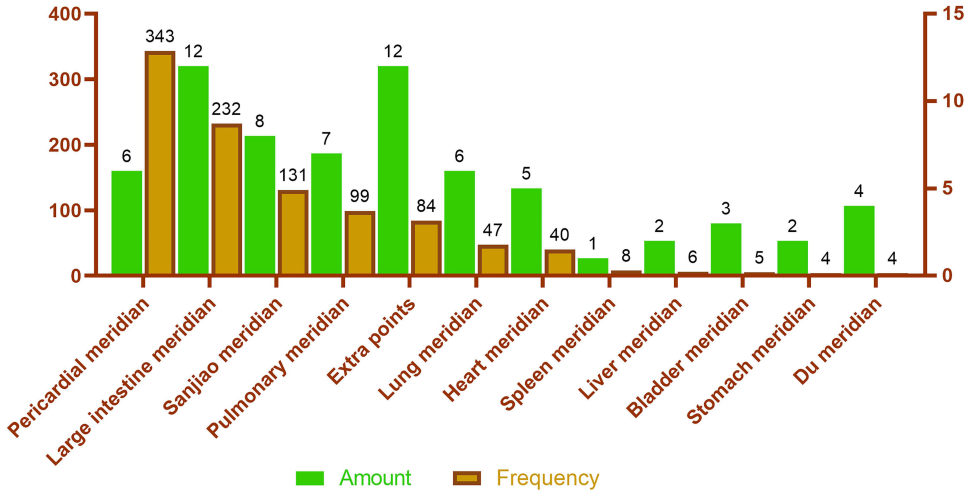

Figure 4 Frequency of Meridian application for CTS treatment.

(PC8), Nei-guan (PC6)] ≥ [Da-ling (PC7)], and [Lao-gong (PC8), Da-ling (PC7)] ≥ [Nei-guan (PC6)] (Table 6). The complex network diagram showed that the core group was "Da-ling (PC7) and Nei-guan (PC6)" (Figure 5).

Exploratory Factor Analysis

An exploratory factor analysis was conducted on acupoints that occurred more than ten times, utilising the statistical software IBM SPSS Statistics 26.0. KMO and Bartlett's sphericity test results suggested that exploratory factor analysis was suitable (Table 7). The principal component was analyzed, and 8 common factors of eigenvalue > 1 were extracted from the gravel map (Figure 6). The total variance contribution rate of the extracted common factors was 67.27%, which showed good explanatory ability and could represent most of the original information. Factor loading after orthogonal rotation with Kaiser standardization was applied, and acupoints with absolute value of load coefficient > 0.5 were selected to enter the common factor extraction table (Table 8). At the same time, the space load diagram after rotation was obtained (Figure 7). The spatial positions of Yang-chi (TE4), Wai-guan (TE5), and Yang-gu (SI5) in the Figure 7 were close, which could explain common factor 2; The spatial positions of Tai-yuan (LU9) and Shen-men (HT7) were close, which could explain common factor 5;

Table 4 Frequency of Site of Point Application for CTS Treatment

Site of points	Frequency		Amount		Acupoints
Points of upper limbs	976	97.31%	54	79.41%	PC7 (141), PC6 (122), LI4 (72), LI5 (64), TE5 (64), LI11 (46), PC8 (45), TE4 (43), Ashi (37), LI10 (35), LU10 (31), SI5 (25), HT7 (23), LU5 (18), LU8 (18), PC5 (16), EX-UE8 (14), PC3 (12), LU7 (11), LU9 (11), EX-UE9 (11), TE3 (10), LU6 (9), HT3 (9), SI4 (8), EX-UE2 (8), PC4 (7), LI6 (6), TE2 (6), SI3 (5), TE10 (5), SI6 (4), ST36 (3), LI12 (3), SI8 (3), HT2 (3), HT8 (3), Bizhong (3), EX-UE11 (3), EX-UE10 (3), SI7 (2), HT5 (2), LI2 (1), LI3 (1), LI8 (1), LI13 (1), LI7 (1), LI8 (1), LU11 (1), TE8 (1), TE9 (1), TE6 (1), EX-LE11 (1), Wuhu (1)
Points of lower limbs	15	1.50%	4	7.35%	SP6 (8), LR3 (3), LR4 (3), Shuiqu (1)
Points of back	5	0.50%	5	5.88%	BL13 (1), BL15 (1), GV12 (1), GV11 (1), GV13 (1)
Points of lumbosacral	4	0.40%	2	2.94%	BL23 (3), GV3 (1)
Points of chest and abdomen	2	0.20%	2	2.94%	ST24 (1), Shangfengshidian (1)
Points of head and neck	1	0.10%	1	1.47%	EX-B2 (1)

Table 5 Frequency of Special Acupoints for CTS Treatment

Special point		Frequency		Amount		Acupoints
Five-shu points	Shu-stream points	194	15.37%	7	13.46%	PC7 (141), HT7 (23), LU9 (11), TE3 (10), SI3 (5), LR3 (3), LI3 (1)
	Jing-river points	127	10.06%	6	11.54%	LI5 (64), SI5 (25), LU8 (18), PC5 (16), LR4 (3), TE6 (1)
	He-sea points	96	7.61%	7	13.46%	LI11 (46), LU5 (18), PC3 (12), HT3 (9), TE10 (5), ST36 (3), SI8 (3)
	Ying-spring points	86	6.81%	5	9.62%	PC8 (45), LU10 (31), TE2 (6), HT8 (3), LI2 (1)
	Jing-well points	1	0.08%	1	1.92%	LU11 (1)
	Total	504	39.94%	26	50.00%	
Yuan-source points		301	23.85%	6	11.54%	PC7 (141), LI4 (72), TE4 (43), HT7 (23), LU9 (11), SI4 (8), LR3 (3)
Luo-connecting points		207	16.40%	6	11.54%	PC6 (122), TE5 (64), LU7 (11), LI6 (6), SI7 (2), HT5 (2)
Eight confluent points		202	16.01%	4	7.69%	PC6 (122), TE5 (64), LU7 (11), SI3 (5)
Xi-cleft points		21	1.66%	4	7.69%	LU6 (9), PC4 (7), SI6 (4), LI7 (1)
Eight convergent points		11	0.87%	1	1.92%	LU9 (11)
Crossing points		8	0.63%	1	1.92%	SP6 (8)
Back-shu points		5	0.40%	3	5.77%	BL23 (3), BL13 (1), BL15 (1)
Lower he-sea points		3	0.24%	1	1.92%	ST36 (3)

Table 6 Association Rules of Acupoints for CTS Treatment

NO.	Latteritem	Formeritem	Frequency	Support (%)	Confidence (%)	Lift
1	PC7	PC6	122	63.21	90.16	1.23
2	PC7	LI5 - PC6	40	20.73	90.00	1.23
3	PC7	TE5 - PC6	36	18.65	94.44	1.29
4	PC7	PC8 - PC6	34	17.62	94.12	1.29
5	PC6	PC8 - PC7	34	17.62	94.12	1.49
6	PC7	LU10 - PC6	27	13.99	92.59	1.27
7	PC6	LU10 - PC7	27	13.99	92.59	1.46
8	TE4	SI5	25	12.95	96.00	4.31
9	TE5	TE4 - PC7	25	12.95	96.00	2.90
10	TE4	SI5 - TE5	21	10.88	100.00	4.49
11	PC7	LI11 - PC6	20	10.36	95.00	1.30

The spatial positions of Qu-ze (PC3) and Yu-ji (LU10) were close, which could explain common factor 6; The spatial positions of Jing-qu (LU8) and Zhong-zhu (TE3) were close, which could explain common factor 8.

Cluster Analysis

The acupoints that exhibited frequencies exceeding tenfold underwent cluster analysis using the IBM SPSS Statistics 26.0 software. The outcomes were an icicle chart (Figure 8) and tree charts (Figure 9). By using a clustering algorithm with a distance scale of 21.25, 22 acupoints with frequencies >10 were clustered into a total of 5 major clusters as follows: Cluster 1, Yang-chi (TE4), Yang-gu (SI5), Wai-guan (TE5), Lie-que (LU7), He-gu (LI4), Yang-xi (LI5), Lao-gong (PC8), Wai-lao-gong (EX-UE8), Yu-ji (LU10), Jian-shi (PC5) and Qu-ze (PC3); Cluster 2, Shou-san-li (LI10), Chi-ze (LU5), Qu-chi (LI11), and Ashi; Cluster 3, Ba-xie (EX-UE9); Cluster 4, Jing-qu (LU8), Zhong-zhu (TE3); Cluster 5, Da-ling (PC7), Nei-guan (PC6), Shen-men (HT7) and Tai-yuan (LU9).

Discussion

CTS is the most prevalent upper limb nerve entrapment syndrome.[29] It is caused by elevated carpal tunnel pressure; however, the precise aetiology remains unknown.[30] The space between the carpal bones and the flexor retinaculum of the transverse palmar ligament is where compression of the median nerve occurs. CTS is distinguished by the presence of

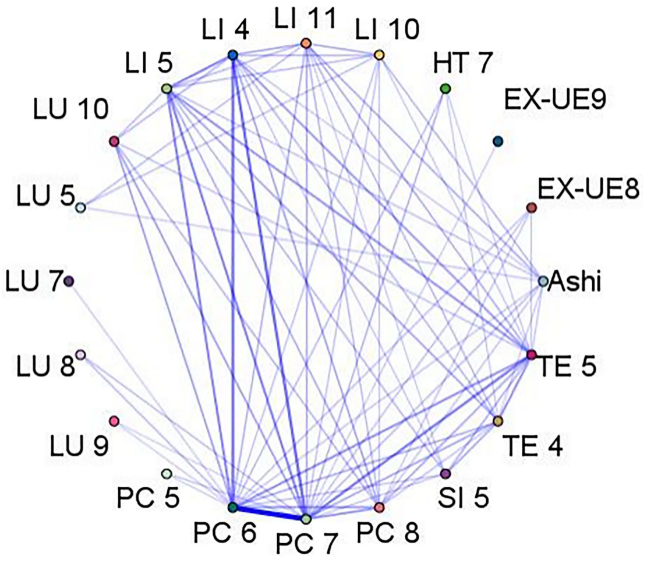

Figure 5 Core acupoint network of acupuncture treatment for CTS.

numbness, tingling, hand irritation, muscular atrophy, and weakness. CTS is transmissible across all age groups, ethnicities, and professions.[31] For CTS, surgical and noninvasive treatment options are available.[31] The American Society of Orthopaedic Surgeons recommends orthotics, local steroid injections, ultrasound, and oral corticosteroids as precautionary medical measures.[29,32,33] Conservative treatment is recommended for individuals with moderate to intermediate CTS;[2,34] In cases of electrophysiologically severe disease or when conservative treatment has failed, surgery or a combination of surgery and conservative treatment is advised.[35]

As a fundamental component of traditional Chinese medicine, acupuncture is extensively employed to alleviate discomfort. Regarding CTS, acupuncture has been suggested as a potentially beneficial treatment.[36] In numerous clinical studies, acupuncture's efficacy in the treatment of CTS has been established, and it possesses enduring curative properties.[37–40] Acupuncture is a mild treatment with relatively fewer adverse reactions and costs.[41] Although acupuncture is associated with adverse effects such as hypodermal haemorrhage, in contrast to the gastrointestinal adverse effects associated with NSAIDs, acupuncture may be an alternate approach for patients who cannot endure the harmful effects on the digestive system.[42] Acupuncture exerts its analgesic properties through the regulation of affective and cognitive processing regions of the brain, as well as by stimulating endorphins, serotonin, and acetylcholine.[43,44] Acupuncturists commonly employ needle manipulation to induce "deqi", a sensation of heaviness, paralysis, and pain at special acupoints that correlates with discernible alterations in functional magnetic resonance imaging (fMRI) signals.[45] Nevertheless, acupuncturists select various acupoints according to their individual intuition and experience. As a result, the optimal acupoint combinations and selection for the treatment of CTS are not universally accepted. Therefore, it is necessary to analyze existing research through statistical knowledge in order to determine the optimal selection and combinations of acupoints.

To examine the fundamental regulations, data mining technology represents a viable and auspicious methodology. Data mining technology is responsible for identifying correlations among individual data points, calculating the frequency of each database item, and establishing connections with other entities.[46] The technologies of data mining

Table 7 KMO and Bartlett's Sphericity Test Results

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	Bartlett's Test of Sphericity		
	Approx. Chi-Square	df	*P*
0.616	1170.776	231	0

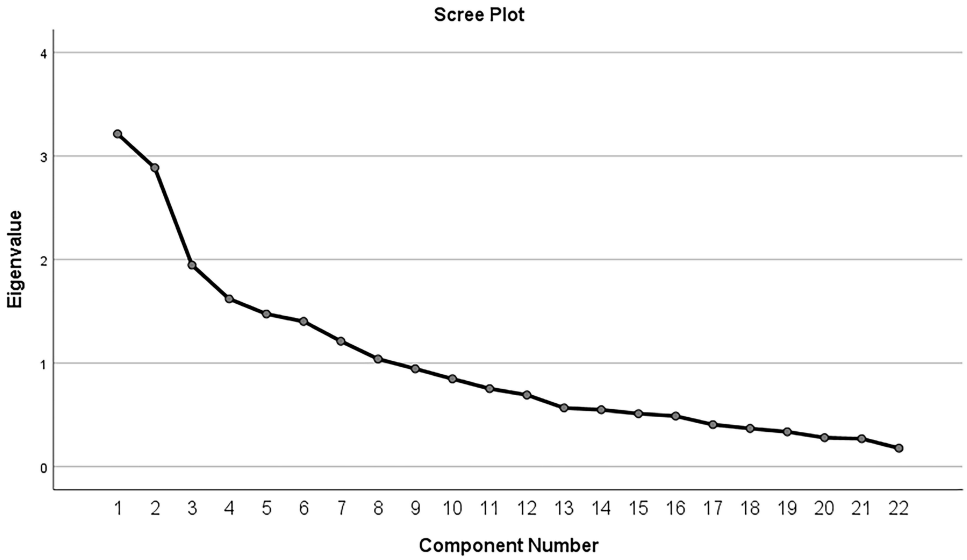

Figure 6 Gravel map of common factor extraction of acupuncture treatment for CTS.

illuminate which aspects are most relative. It is possible to determine which acupoints, meridians, special points, and sites are frequently utilised in the acupuncture treatment of CTS through the application of descriptive statistical analysis. Agrawal et al introduced association rule mining as an unsupervised machine learning technique.[47] The Apriori algorithm is classified as an association rule algorithm and is capable of generating frequent item sets by adjusting the size of frequent sets based on their characteristics. The Apriori algorithm utilises the type variable function to generate distinct association outcomes contingent upon the degree of support, confidence, and the value of the preceding item across various conditions. A support degree denotes the extent to which a particular rule is universally applicable, while a confidence degree signifies the credibility of said rule. Both are essential elements in the analysis of association principles. In this study, the support degree of association rules pertains to the likelihood that two acupoints are utilised simultaneously. Conversely, the confidence degree denotes the probability that acupoint X is utilised concurrently with acupoint Y.[20] Clustering analysis is an extensively employed instrument for knowledge discovery.[48] A multivariate analysis technique wherein samples are categorised.[49] Cluster analysis is essential because it enables the identification of population structure, a term that is frequently applied in the analysis of multiparameter data.[50] It has the capability to exhibit the internal structure of data and classify the outcomes of distinct observations according to the degree of similarity in the internal structure.[51] In 1904, Charles Spearman introduced the idea of exploratory factor analysis. It was made via the Varimax Rotation Major Components method.[52] Its basic assumption is that dimensionality reduction in multivariate statistical analysis can be used to combine multiple sets of observable variables with high correlation and semantic overlap into a small number of potentially independent elements. A useful method for figuring out how many

Table 8 Common Factor Extraction

Component	Eigenvalues	Variance %	Cumulative %	Acupoints (Load Coefficient)
1	3.21	14.61	14.61	LU5 (0.82), LI10 (0.76), LI11 (0.74), Ashi (0.70), PC7 (−0.55)
2	2.89	13.12	27.73	TE4 (0.87), TE5 (0.76), SI5 (0.75)
3	1.95	8.85	36.58	EX-UE8 (0.74), PC8 (0.65), PC6 (0.52)
4	1.62	7.37	43.95	LI4 (0.78), LI5 (0.64), PC5 (−0.50)
5	1.48	6.70	50.65	LU9 (0.87), HT7 (0.80)
6	1.40	6.38	57.03	PC3 (0.76), LU10 (0.57)
7	1.21	5.51	62.54	LU7 (0.79)
8	1.04	4.73	67.27	LU8 (0.77), TE3 (0.63)

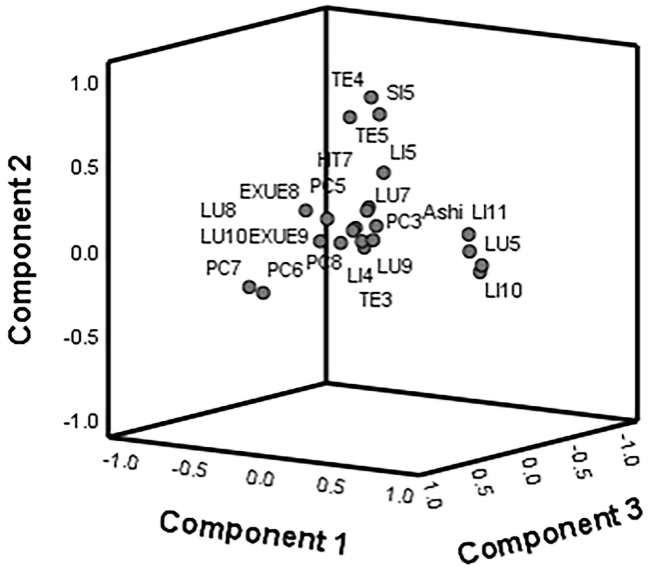

Figure 7 Space load diagram after rotation of acupuncture treatment for CTS.

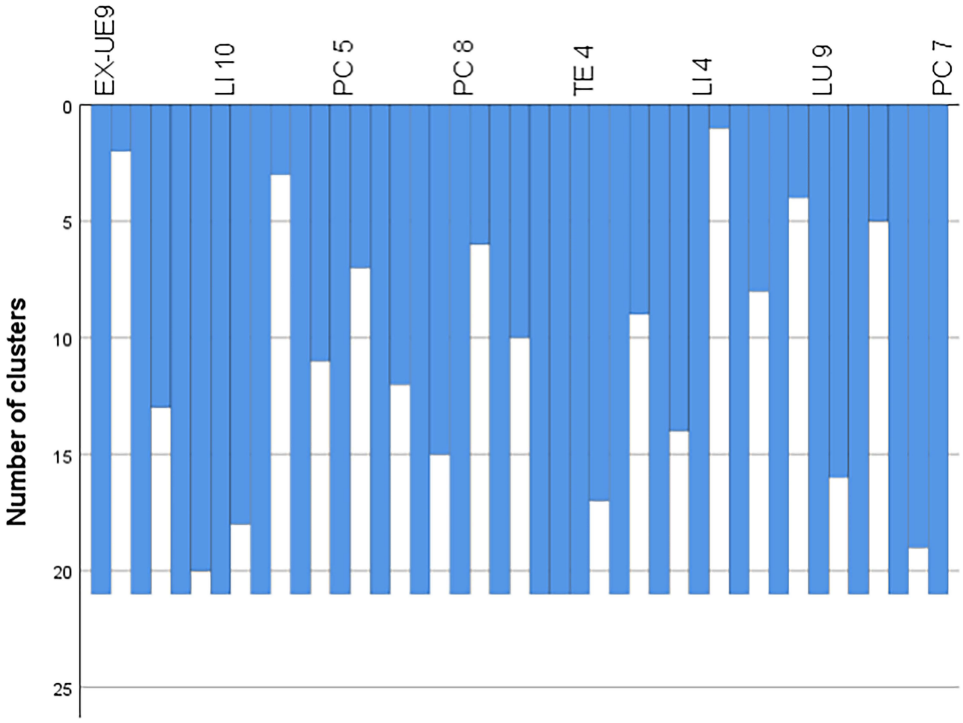

Figure 8 Icicle chart of the cluster analysis of acupuncture for CTS.

variables make up a construct is exploratory factor analysis.[53] The best acupoint combinations and selection for CTS were discovered using our suggested technique, which can offer clinical evidence-based medicine.

We used data mining technology to summarize the acupuncture treatment of CTS acupoint selection and combinations rules. The five most commonly used acupoints of CTS in descending order were Da-ling (PC7), Nei-guan (PC6),

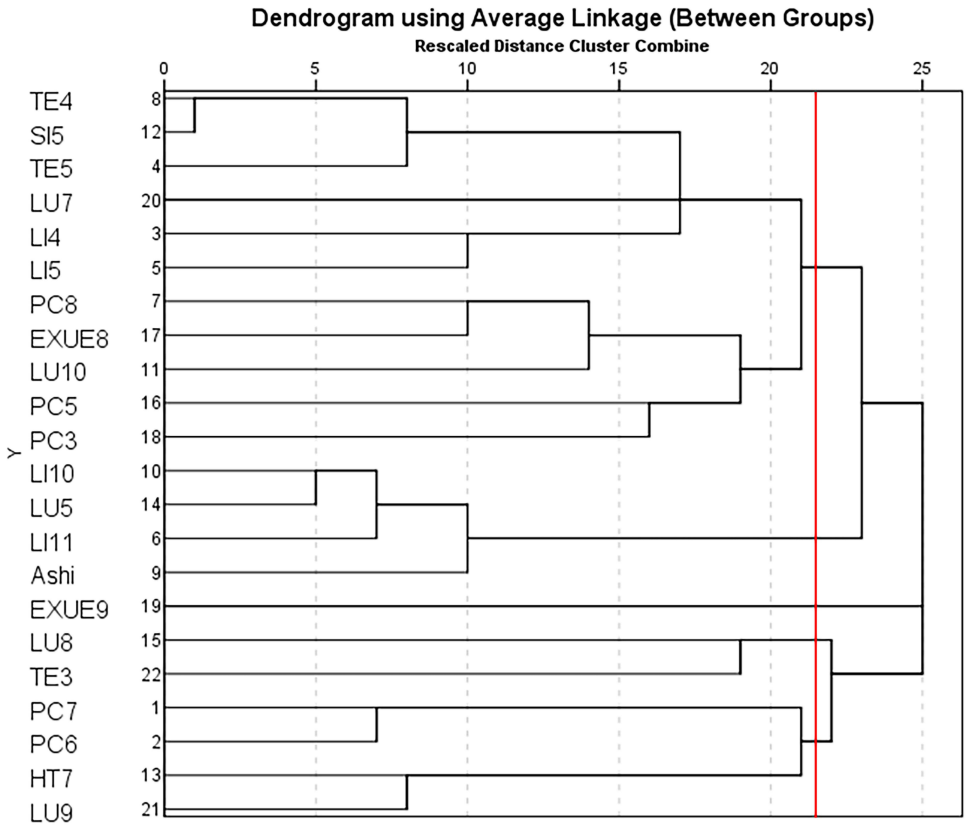

Figure 9 Tree chart of the cluster analysis of acupuncture for CTS.
Note: The red line in the figure represents the clustering divided at a distance scale of 21.25. The Y symbol between PC3 and LI10 only represents where it is in the middle position.

He-gu (LI4), Wai-guan (TE5), and Yang-xi (LI5). Da-ling (PC7), Nei-guan (PC6), and Wai-guan (TE5) are located near the median nerve.[54] Because the onset of CTS is associated with median nerve compression, the purpose of choosing Da-ling (PC7), Nei-guan (PC6), and Wai-guan (TE5) is to reduce the pressure at the acupoint. As the pathogenesis of CTS in TCM is qi stagnation and blood stasis, He-gu (LI4), which has the effect of regulating qi and promoting blood circulation, was selected by acupuncturist.[55] Yang-xi (LI5) is located at the wrist, and acupuncture at Yang-xi (LI5) is to restore the function of the wrist joint.

The most frequently used meridians were the pericardial meridian and the large intestine meridian. In general, the selection of acupoints along the course of meridians is the basic principle in the treatment of acupuncture.[56] The pericardial meridian is located at the midline of the forearm, as is the median nerve.[57] TCM believes that the large intestine meridian has more qi and blood than other meridians, so the reason to choose the large intestine meridian is also to regulate qi and blood circulation. The most frequently used site of points was acupoints of upper limbs. Distal acupoints are often selected for acupuncture, but this situation is a little rare in this study. We speculated that this might be related to the pathogenesis of CTS. The pathogenesis of CTS is not closely related to zang and fu, but mainly lies in local qi stagnation and blood stasis. Therefore, distal acupoints were rarely used to adjust the function of zang and fu. The most frequently used special acupoints were Five-shu points and Yuan-source points. Five-shu points are five important acupoints for qi changes of meridians, and acupuncture at Five-shu points is conducive to the flow of qi in meridians. The Yuan-source points are the place where the Qi of the viscera passes and stays, which can also adjust the circulation of Qi.

According to the results of association rule analysis, [Nei-guan (PC6) plus Da-ling (PC7)], [Yang-xi (LI5), Nei-guan (PC6) plus Da-ling (PC7)], [Wai-guan (TE5), Nei-guan (PC6) plus Da-ling (PC7)], [Lao-gong (PC8), Nei-guan (PC6)

plus Da-ling (PC7)], and [Lao-gong (PC8), Da-ling (PC7) plus Nei-guan (PC6)] were common combinations in acupoint combinations. The complex network diagram showed that the core group was Da-ling (PC7) and Nei-guan (PC6).

According to the results of exploratory factor analysis and cluster analysis, we have got 8 factors and 5 clusters. These factors or clusters followed the principles of the embodiment of travel qi and blood circulation, collaterals and pain relief based on the theory of TCM.

Our research results found that acupuncture treatment for CTS mainly selects acupoints around the wrist joint. There are two functioning states for acupoints in humans: the sensitization state and the rest state. The acupoints on the surface of the human body become sensitive when it is unwell. External stimulation of the sensitised acupoints causes more internal activation, which may indicate the value of local acupuncture at the site of the discomfort.[58] There was evidence of both effects observed (ie, individuals with CTS reported experiencing greater "deqi" sensations at both local and distal acupoints induced by electroacupuncture in comparison to healthy controls, and duller sensations at distal acupoints than at local ones). This may have been due to the known sensitization of peripheral receptors and neurogenic inflammation specific to the lesion in CTS patients, and this phenomenon is positively correlated with the severity of dysfunction.[59] These details might explain why practitioners of acupuncture treat CTS at local acupoints like Nei-guan (PC6) and Da-ling (PC7). Distal acupoints, however, can resist hyperalgesia by affecting neural plasticity, according to a study from recent years.[60] This could be the rationale behind the inclusion of rather far-off acupoints in the therapy of CTS, including Qu-chi (LI11) and Chi-ze (LU5). When we analyzed the data, we discovered that a few clinical studies only utilize distal acupoints, while most studies only use local acupoints, and some studies combine local acupoints and distal acupoints. Given that the distal acupoints are also useful in choosing acupoints for CTS, but that this area of study is currently understudied, it may offer guidance for future research on acupoints selection for CTS.

Limitations

Our investigation had several constraints. A number of literature reviews examined acupuncture as an adjunctive treatment for CTS; however, the calibre of the studies incorporated in the reviews was substandard. These results must be validated in subsequent randomised controlled trials employing more stringent designs. Furthermore, the precise mechanisms by which acupoint combinations are utilised to treat CTS remained obscure. Thirdly, the utilisation of rating scales, such as the VAS score, as the principal criterion for evaluating the efficacy of this condition could potentially yield skewed outcomes due to their subjective nature. Fourthly, other non Chinese and English literature as well as grey literature were not included, which may lead to some bias. Ultimately, due to the lack of standardisation in research information, certain studies failed to provide precise details regarding the duration, frequency, and magnitude of stimulation.

Conclusions

Acupoints Da-ling (PC7), Nei-guan (PC6), He-gu (LI4), Wai-guan (TE5), and Yang-xi (LI5) were the most frequently utilised for the treatment of CTS. The meridians that were most commonly employed were the pericardial and large intestine meridians. Five-shu points and Yuan-source points comprised the majority of special points utilised, with upper limb acupoints being the most frequently applied. "Da-ling (PC7) and Nei-guan (PC6)" stood in conjunction with the main acupoints. Clinically, on the basis of the selection of the above core acupoints, acupuncturists should add or subtract other factors or cluster acupoints according to the specific conditions of the disease. However, the results of this experiment were theoretical and need to be confirmed by further experiments.

Abbreviations

CTS, Carpal tunnel syndrome; CNKI, China National Knowledge Infrastructure; CBM, Chinese Biomedical Literature Database; VIP, Chongqing VIP Database.

Data Sharing Statement

All data generated or analyzed during this study are included in this published article and supplementary materials "Supplementary Table 1".

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Author Contributions

Each of the authors has made noteworthy contributions to the work being reported, encompassing the areas of conceptualization, research design, execution, analysis, and interpretation, or a combination thereof. They have been involved in the drafting, revising, or reviewing of the article, have given their approval for the version to be published, and have consented to submitting the manuscript to the journal. Furthermore, they have agreed to take responsibility for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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