

# The Application of Acupuncture Therapy for Postoperative Pain Over the Past 20 Years: A Bibliometric Analysis

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**Purpose:** The purpose of this study is to analyze and visualize the research trends on acupuncture therapy for postoperative pain over the past 20 years to identify hotspots and frontiers, and provide new research ideas.

**Methods:** A search of the Web of Science database, with a time frame of 2001–01-01 to 2022–02-28, was conducted to collect literatures related to acupuncture therapy for postoperative pain. A bibliometric analysis and visualization of results was performed using CiteSpace software for the volume of annual publications, journals, countries, institutions, authors, keywords, and references.

**Results:** A total of 840 literatures were eventually included in the analysis. The number of publications has fluctuated upwards each year over the past 20 years and reached a peak in the latest three years. *Evidence-Based Complementary and Alternative Medicine* was the journal with the most relevant publications and *Pain* was the most frequently cited journal. The country with the highest volume of publications was China, and the USA contributed most to the international collaboration. The most prolific and influential authors were Inhyunk Ha and Han JS respectively. The most frequent keyword was “acupuncture”. References with highest frequency or centrality were both systematic evaluations focusing on different acupuncture therapies for postoperative pain relief.

**Conclusion:** The field of acupuncture therapy for postoperative pain is currently in a period of high growth. China and the USA have made the largest contribution to the volume of publications. The most influential institutions and authors are mainly from China and South Korea. The overall collaborative network needs to be strengthened. Electroacupuncture and auricular acupuncture (therapeutic techniques), low back surgery (types of surgery), and “postoperative pain, nausea and vomiting” are research hotspots in this field. Improvement of postoperative life quality, proof of clinical efficacy and evidence-based evaluation are the current research trends and frontiers.

**Keywords:** acupuncture analgesia, pain after surgery, bibliometric analysis, CiteSpace

## Introduction

Postoperative pain foremost refers to the acute pain that occurs immediately after surgery and consists mainly of pain from somatic and visceral trauma caused by surgical operations and pain from inflammatory irritation around nerve endings,<sup>1</sup> which attributes to injurious pain.<sup>2</sup> If it continues to be poorly controlled, pathological remodeling of the central and peripheral nervous system occurs<sup>3</sup> and the nature of the pain changes to neuropathic pain or mixed pain, then it progresses to chronic postoperative pain. More than 300 million patients undergo surgery worldwide each year.<sup>4</sup> Between 30% and up to 80% of patients report moderate to severe pain in the days following surgery, and approximately 20% developing chronic pain.<sup>5</sup> Persistent pain not only affects the patient's recovery and leads to longer hospital stays,<sup>6</sup> but also adds to the psychological burden of the patient, causing anxiety and depression.<sup>7,8</sup> For families and society, both

the direct increase in hospitalization expenses and consumption of medical resources, and the consequent indirect decline of individual labor force and even unemployment,<sup>9</sup> are issues that should not be underestimated.

Currently, pharmacological analgesia remains the dominant modality for the treatment of postoperative pain. Analgesics can meet the requirements of short-term and rapid analgesia, however, their side effects such as the addiction of opioids,<sup>10</sup> the gastrointestinal harm and possible cardiovascular risks of non-steroidal anti-inflammatory drugs (NSAIDs),<sup>11,12</sup> are also evident. Furthermore, although numerous postoperative pain management recommendations have been available over the years, the drugs recommended are generalized for all procedures.<sup>13</sup> The efficacy of pain medication may vary depending on the type of surgical procedure,<sup>14</sup> so it is difficult for specialists to find an effective solution for a particular procedure, and many patients report unsatisfactory results in terms of postoperative pain control.<sup>15</sup> This all indicates to the fact that pharmacological analgesia is not a long-term solution. Searching for green, safe, low adverse effects and targeted analgesia gradually becomes one of the most important concerns of clinicians.

Acupuncture therapy, a series of traditional Chinese medical treatment internationally accepted and applied for its undeniable effectiveness of therapeutic effects in the treatment of various pain-related conditions and nerve disorders,<sup>16,17</sup> is one of the ideal non-pharmacological treatments to control post-operative pain. Studies have found that acupuncture therapy can intervene in pain through mechanisms such as increasing endogenous opioid peptides in the brain,<sup>18,19</sup> modulating abnormal neurological function,<sup>20</sup> and influencing intracellular signaling pathways.<sup>21</sup> A randomized controlled trial (RCT) showed that acupuncture was effective in relieving postoperative pain in patients undergoing hemorrhoidectomy.<sup>22</sup> Another RCT also found that acupuncture therapy was safe and effective in the management of post-caesarean pain.<sup>23</sup>

Bibliometric analysis is a method for evaluating and quantifying literature information using mathematical and statistical methods,<sup>24</sup> which can help to recognize the research advances in a specific field of science comprehensively.<sup>25</sup> This analytical method has been applied to many areas with a large body of research accumulated, including pain management. In one of these studies, Gao et al<sup>26</sup> analyzed the field of acupuncture for analgesia, and it can be seen in this study that acupuncture therapy for postoperative pain has also received considerable attention. However, despite the heat in the clinical and research area, no studies have yet explored current research trends in the treatment of postoperative pain with acupuncture therapy and continued in-depth study of this field using bibliometric analysis is highly warranted.

The approach of bibliometric was applied in this study to analyze the literatures about acupuncture therapy for postoperative pain over the last 20 years, through multiple perspectives such as journals, authors, institutions, countries, keywords, and references. And the results were presented in the form of scientific knowledge maps by using the CiteSpace software, then the maps were further interpreted and analyzed, to gain an intuitive and comprehensive understanding of the research in the field, identify research hotspots and provide new research ideas.

## Methods

### Data Sources and Search Strategy

All data for this study were obtained from the Web of Science (WoS) core collection database on 1 March 2022. The data search strategy included the topics “postoperative pain” and “acupuncture therapy”, with the publications period of the literatures ranging from 2001–01-01 to 2022–02-28. Only English-language papers were included, the country and category of the study were not restricted. Duplicates and articles without full text were excluded. Secondary search for references and relevant reviews in the literatures was conducted in order to avoid omissions. The specific search strategies and results were shown in Table 1. Eventually, 840 articles were obtained.

### Analysis Tool

This research applies CiteSpace (V5.8.R3 64-bits) combined with Excel to organize and visualize data for analysis, including: (1) statistical and descriptive analysis: for parameters such as annual publication volume, authors, countries, institutions and journals; (2) collaborative network analysis: mainly for the three dimensions of countries (regions),

**Table I** The Topic Search Query

Set	Results	Search Query
#1	108,729	TS=((Post*operative Pain) OR (Post*surgical Pain) OR (Pain after Surgery) OR (Pain after Operation) OR (Acute Postoperative Pain) OR (Persistent Postoperative Pain) OR (Chronic Postoperative Pain) OR (Acute Postsurgical Pain) OR (Persistent Postsurgical Pain) OR (Chronic Postsurgical Pain))
#2	284,45	TS=((Acupuncture Therapy) OR (Acupuncture Treatment) OR (Acupotom*) OR (Acupuncture Analgesia) OR (Acupuncture) OR (Manual Acupuncture) OR (Warm Needling) OR (Electroacupuncture) OR (Laser Acupuncture) OR (Acupuncture-moxibustion) OR (moxibustion) OR (Body Acupuncture) OR (Scalp Acupuncture) OR (Auricular Acupuncture) OR (Eye Acupuncture) OR (Acupuncture Point) OR (Acupoint*) OR (Acupressure) OR (Pharmacopuncture) OR (Acupoint Injection) OR (Catgut Embedding) OR (Catgut Implantation at Acupoint) OR (Embedding Thread))
#3	840	#1 AND #2

**Note:** In this table, the “\*” in the column “Search Query” is a wildcard character in the search formula to replace any string for the purpose of expanding the search.

institutions and authors; (3) co-occurrence analysis: for keywords; (4) co-citation analysis: for authors, journals and references; (5) citation burst analysis: mainly for keywords and references; (6) cluster analysis.

The specific parameters for the visualization analysis were set as follows. The threshold of “Top N% per slice” was 50 for all calculations. The time span was from January 2001 to February 2022, and the time slice setting for all analyses conducted with CiteSpace was “1 year per slice”. Clustering labels were extracted by using the LLR algorithm.

## Charts Interpretation

The nodes in the maps generated by CiteSpace represent the objects being analyzed (such as different authors, institutions, or keywords); the size of the diameter of the nodes reflects the frequency (such as the output or citation frequency); different colors correspond to different years (such as the year of publication); the lines between the nodes indicate the collaboration or co-occurrence relationship between the two, the color of the line indicates the time of the first collaboration and the thickness of the line reflects the strength of the relationship between the two.

## Results

### Annual Publications and Trends

The retrieval of database found that a total of 860 articles have been published in the field of acupuncture therapy for postoperative pain in the past 20 years, and the number and trend of annual articles are shown in [Figure 1](#). 2001 to 2014 could be seen as one phase. During this period, the annual number of articles published showed a fluctuating and slow growth trend, with an annual average of about 24 articles. There were four small peaks of growth successively, but all of them were quickly followed by a fall back. 2015 to the present is another phase. The number of publications in 2015 surged to 60, and after a small rebound, 2016 to 2019 saw a sustained and significantly accelerated increase in the number of publications, with the heat of attention increasing and stabilizing at an average of over 80 publications per year for the period 2019 to 2021, which was the highest record over the past 20 years. Only two months of data are currently available for 2022, but based on the above, it can be deduced that the number of publications this year will also be considerable and the research fever in the field of acupuncture for postoperative pain will continue.

### Analysis of Journals and Cited Journals

#### Journals

The total number of journals that published these 860 articles on acupuncture treatment for postoperative pain was 344 and the top 10 journals with the highest cumulative number of publications were listed in [Table 2](#). The most published journals, accounting for about 14% of the total number of articles published, were *Evidence-Based Complementary and*



**Figure 1** The number of annual publications on acupuncture treatment for postoperative pain.

**Note:** In this figure, the number of articles published in 2022 is marked with an "\*" and indicated by a dashed line, since only two months of data are available for this year.

*Alternative Medicine* (40 articles), *Acupuncture in Medicine* (39 articles), and *Medicine* (38 articles). *Anesthesia and Analgesia* had the highest impact factor (IF) of 5.178, with 21 articles published, ranking 5th.

### Cited Journals

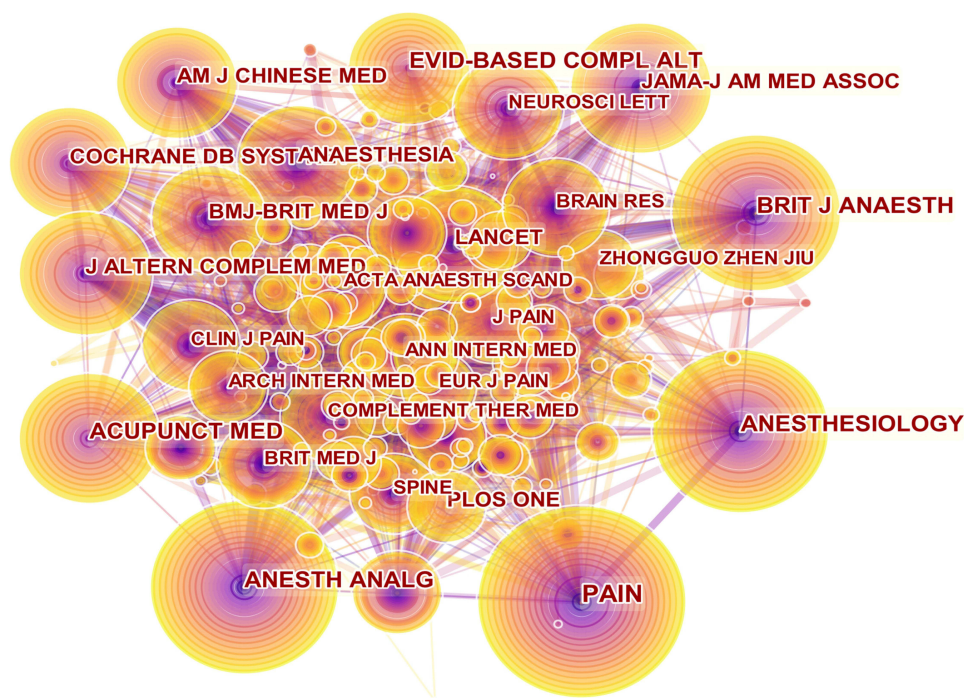
In conjunction with centrality, CiteSpace was used to generate a map of cited journals with 645 nodes and 5770 links (Figure 2), reflecting the co-citation relationships between journals. A node represented a journal, which gave a total of 645 journals involved in co-citation in the field of acupuncture therapy for postoperative pain. Shown in Table 3, the top five contributing journals as cited are *Pain*, *Anesthesia and Analgesia*, *Anesthesiology*, *British Journal of Anaesthesia*, and *Acupuncture in Medicine*. In the cited journal map, the purple ring outside the node reflected the size of the centrality of the journal it represented. Table 4 listed the journals with the highest centrality in the field of acupuncture therapy for postoperative pain, with *Clinical Journal of Pain* and *European Journal of Anaesthesiology* being the top, both at 0.07.

**Table 2** The Top 10 Journals with the Highest Frequency on Acupuncture Treatment for Postoperative Pain

Ranking	Journal	Frequency	% of 840	IF (2020)	Country
1	Evid-Based Compl Alt	40	4.76	2.629	UK
2	Acupunct Med	39	4.64	2.267	UK
3	Medicine	38	4.52	1.889	USA
4	Trials	23	2.74	2.279	UK
5	Anesth Analg	21	2.50	5.178	USA
6	Medical Acupuncture	18	2.14	-	USA
7	Journal of Acupuncture & Meridian Studies	15	1.79	-	Netherlands
8	J Altern Complem Med	15	1.79	2.582	USA
9	Chin J Integr Me	13	1.55	1.978	China
10	Pain Med	13	1.55	3.750	USA

**Note:** In this table, the "-" in the column "IF (2020)" is an omitted symbol since *Medical Acupuncture* and *Journal of Acupuncture & Meridian Studies* do not have impact factors.





**Figure 2** Co-citation map of journals on acupuncture treatment for postoperative pain.

## Analysis of Countries

Statistically, articles on acupuncture therapy for postoperative pain mainly came from 53 countries. The five countries with the highest contribution to the number of articles and the highest centrality were shown in Table 5 respectively, and

**Table 3** Top 5 Cited Journals with the Highest Frequency on Acupuncture Treatment for Postoperative Pain

Ranking	Frequency	Cited Journal	IF (2020)	Country
1	433	Pain	6.961	Netherlands
2	370	Anesth Analg	5.178	USA
3	338	Anesthesiology	7.892	USA
4	327	Brit J Anaesth	9.166	UK
5	292	Acupunct Med	2.267	UK

**Table 4** Top 7 Cited Journals with the Highest Centrality on Acupuncture Treatment for Postoperative Pain

Ranking	Centrality	Cited Journal	IF (2020)	Country
1	0.07	Clin J Pain	3.442	USA
1	0.07	Eur J Anaesth	4.330	UK
2	0.06	J Altern Complement Med	2.582	USA
2	0.06	Brain Res	3.252	Netherlands
2	0.06	Ann Intern Med	25.391	USA
2	0.06	Acta Anaesth Scand	2.105	Denmark
2	0.06	J Pain Symptom Manag	3.612	USA

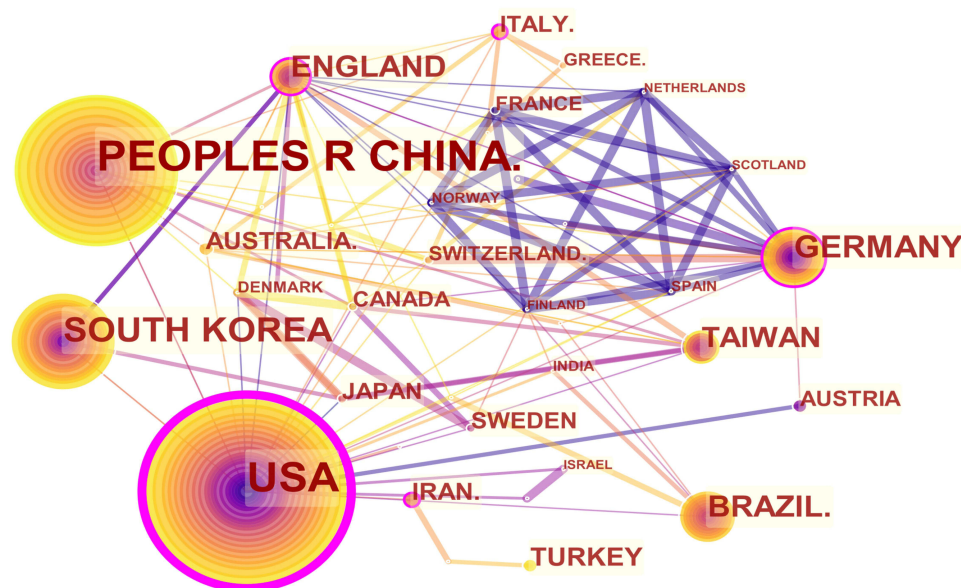
**Table 5** Top 5 Countries with the Highest Frequency and Centrality on Acupuncture Treatment for Postoperative Pain

Ranking	Frequency	Country	Centrality	Country
1	264	China	0.45	USA
2	210	USA	0.15	Germany
3	77	South Korea	0.15	England
4	57	Germany	0.10	Iran
5	47	Brazil	0.10	Italy

a map of country cooperation networks was generated accordingly (Figure 3). As seen from it, China, the top publisher, has a weak chain of partnerships with other countries and need more international cooperation to enhance the global promotion of acupuncture therapy for postoperative pain. As the first of the pivot nodes, the US published a large amount of relevant literature and established collaborative relationships with quite a few countries. In addition, several countries forming a salient hexagonal circle of cooperation were visible in the upper right of the map. The mutual cooperation between these countries was developed early and closely. Meanwhile, they also maintained a certain cooperative relationship with Germany, one of the pivot nodes.

## Analysis of Institutions

The top five institutions in terms of volume and centrality were listed in Table 6. China Medical Univ and Kyung Hee Univ both ranked first with 25 articles, followed by Korea Inst Oriental Med, Chinese Acad Sci and Shanghai Univ Tradit Chinese Med. China Med Univ, which had the highest number of articles, had the the highest centrality meanwhile, and Shanghai Univ Tradit Chinese Med was also tied. The inter-institutional collaboration network was generated accordingly, as shown in Figure 4. During this process, it was found that there were many instances where the names of institutions were not written normally, causing CiteSpace to identify the same institution as a different node. Such cases were all merged manually.

**Figure 3** Map of countries cooperation network on acupuncture treatment for postoperative pain.

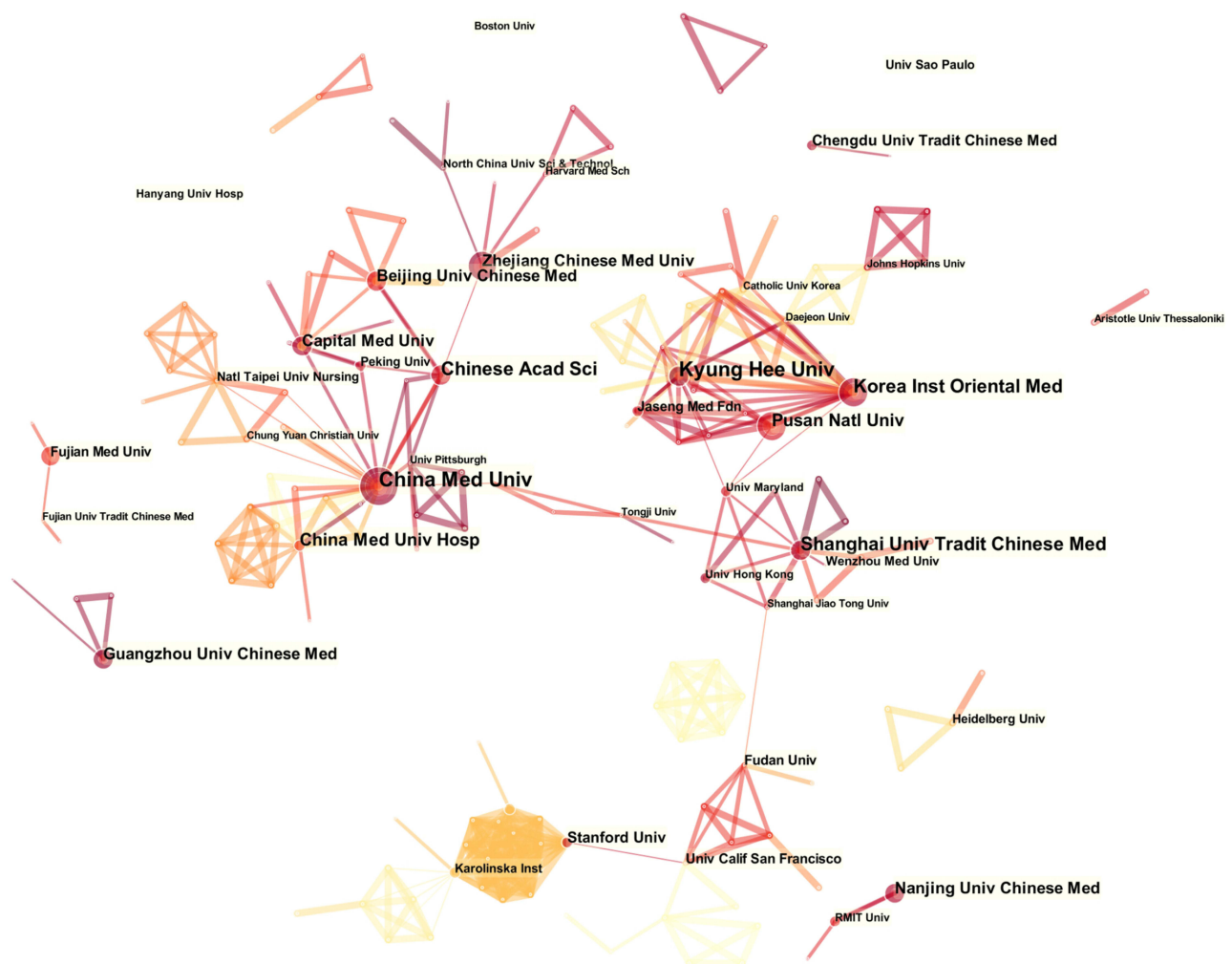
**Table 6** Top 5 Institutions with the Highest Frequency and Centrality on Acupuncture Treatment for Postoperative Pain

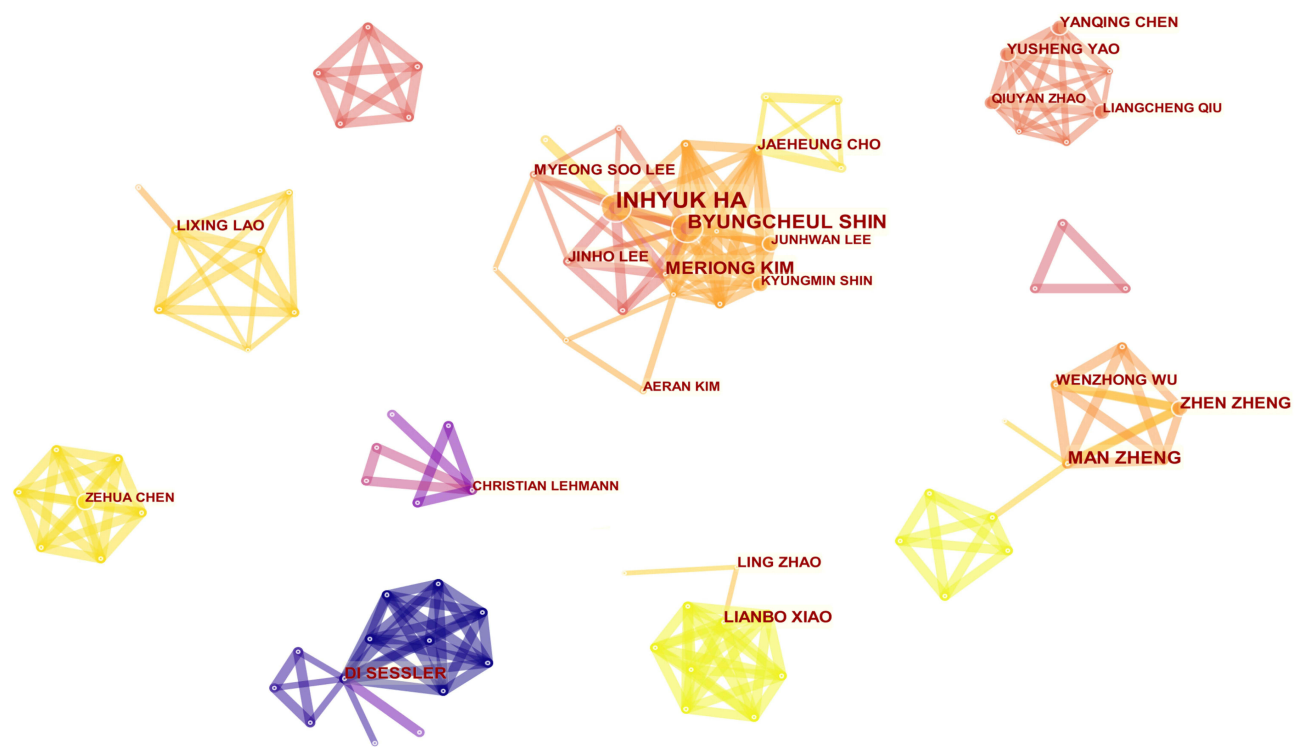
Ranking	Frequency	Institution	Ranking	Centrality	Institution
1	25	China Med Univ	1	0.09	China Med Univ
1	25	Kyung Hee Univ	1	0.09	Shanghai Univ Tradit Chinese Med
2	16	Korea Inst Oriental Med	2	0.08	Tongji Univ
3	15	Chinese Acad Sci	2	0.08	Taipei Med Univ
3	15	Shanghai Univ Tradit Chinese Med	3	0.07	Shanghai Jiao Tong Univ

## Analysis of Authors and Cited Authors

### Authors

A total of 623 authors contributed to these 840 articles in the field of acupuncture therapy for postoperative pain and a map was generated using CiteSpace to show the collaborative relationships between the different authors (Figure 5). The nodes marked with names in the graph were the authors with three or more publications. And the authors with more than five publications, seven in total, were the core authors in this field. The most prolific author was Inhyunk Ha, with 10 publications. With him at the center, the graph presented a collaborative block linking up highly productive authors

**Figure 4** Map of inter-institutional collaboration network on acupuncture treatment for postoperative pain.



**Figure 5** Map of authors cooperation network on acupuncture therapy for postoperative pain.

such as Byungcheul Shin (8 publications) and Meriong Kim (6 publications). Man Zheng was also active, with 6 publications, and he was part of the same team as Zhen Zheng, who had 5 publications. Lianbo Xiao and Di Sessler also had 5 publications. The map also manifested some loosely linked teams, most of which were multiple authors of the same paper. The collaborations between the different teams were less. Other relevant information about core authors were listed in Table 7. The “Year” column in the table manifested when the author first published, reflecting how early the author had been interested in the field. The “Nationality” column showed that the core authors were mainly from Korea and China. Moreover, the “Author” and “Country” modules were overlaid to obtain a new graph (Figure 6), where the distribution of authors by nationality can also be observed.

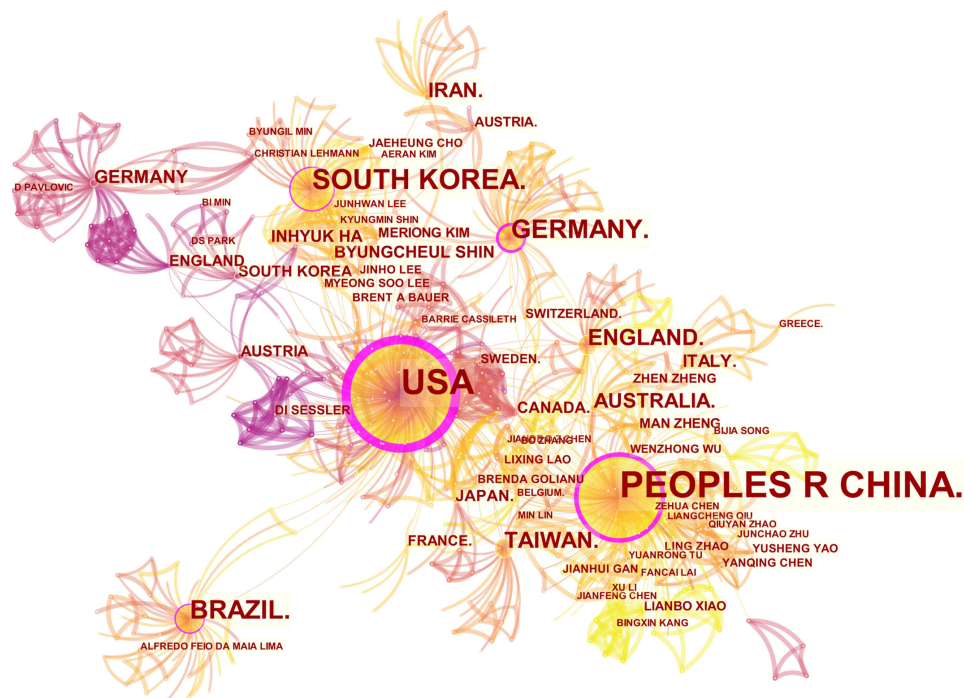
Cited Authors

In combination with centrality and applying “pathfinder” and “pruning sliced networks”, CiteSpace was used to generate a co-citation map of authors from the field of acupuncture therapy for postoperative pain with 745 nodes and 2824 connected lines

**Table 7** Top 7 Authors with the Highest Frequency on Acupuncture Treatment for Postoperative Pain

Ranking	Frequency	Author	Year	Nationality
1	10	Inhyuk Ha	2014	Korea
2	8	Byungcheul Shin	2014	Korea
3	6	Man Zheng	2017	China
3	6	Meriong Kim	2014	Korea
4	5	Lianbo Xiao	2019	China
4	5	Zhen Zheng	2017	Australia
4	5	Di Sessler	2001	USA



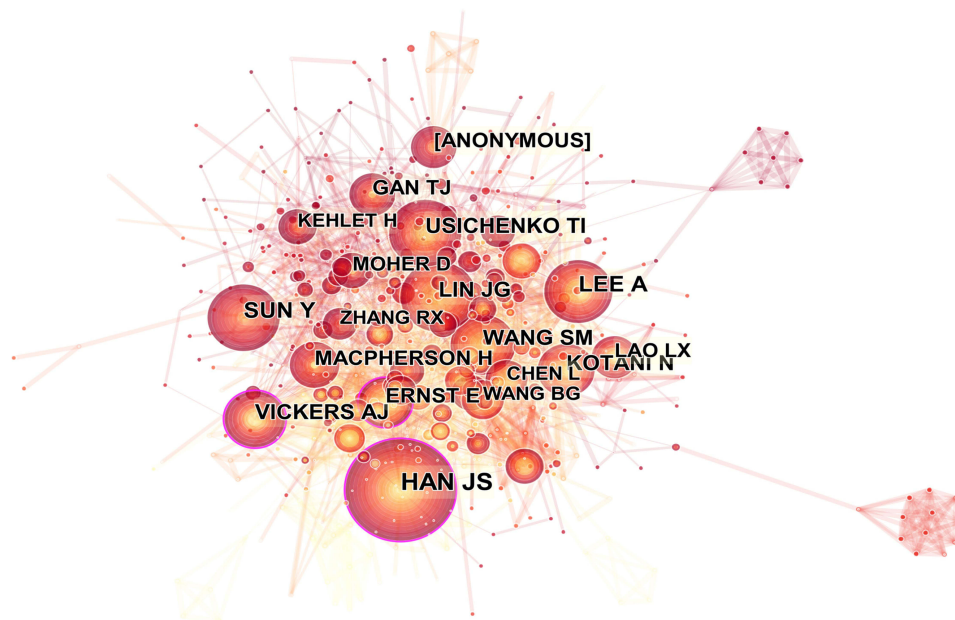


**Figure 6** Authors-countries collaboration map on acupuncture therapy for postoperative pain.

(Figure 7). The five most frequently co-cited authors whose articles had the highest impact were Han JS, Sun Y, Lee A, Lin JG and Wang SM, listed in Table 8. The seven authors with the highest centrality were demonstrated in Table 9, with four of them, Han JS, Vickers AJ, Wang SM and Ernst E, having centrality greater than or equal to 0.1.

## Keywords Co-Occurrence Analysis

The 840 articles of acupuncture therapy for postoperative pain brought together a total of 517 keywords. “Pathfinder” and “pruning sliced networks” applied, a co-occurrence map of keywords, Figure 8, was generated. The 10 most frequently



**Figure 7** Co-citation Map of Authors on Acupuncture Therapy for Postoperative Pain.

**Table 8** Top 5 Cited Authors with the Highest Frequency on Acupuncture Treatment for Postoperative Pain

Ranking	Frequency	Cited Author	Nationality
1	151	Han JS	China
2	103	Sun Y	USA
3	94	Lee A	China
4	88	Lin JG	China
5	87	Wang SM	China

**Table 9** Top 6 Cited Authors with the Highest Centrality on Acupuncture Treatment for Postoperative Pain

Ranking	Centrality	Cited Author	Nationality
1	0.17	Han JS	China
2	0.16	Vickers AJ	USA
3	0.10	Wang SM	China
3	0.10	Ernst E	UK
4	0.08	Gan TJ	USA
4	0.08	Ezzo J	USA

occurring words have been listed in Table 10, and 6 keywords occurred more than 100 times. Of interest were the “electroacupuncture” ranked 4th and “auricular acupuncture” ranked 8th. The frequency of these two keywords about therapeutic techniques was particularly high. Meanwhile, the keyword “auricular acupuncture” and two keywords related to electroacupuncture research, “electrical stimulation” and “electrical nerve stimulation”, had a high centrality (Table 11).

Further clustering based on the co-occurrence map resulted in a total of 12 clusters presented in Figure 9. The five largest clusters were “#0 postoperative nausea”, “#1 spinal nerve ligation”, “#2 systematic review”, “#3 postoperative ileus”, “#4 gi endoscopy”, “#5 undergoing autologous hematopoietic stem cell transplantation”. These were the most talked about topic in this area. Transforming the map into a Timeline view (Figure 10) allowed to observe the evolution of hot spots in the field of acupuncture therapy for postoperative pain research over the last 20 years.

## References Co-Citation Analysis

A total of 855 references were extracted from the 840 articles of acupuncture therapy for postoperative pain to analyze cited references. The earliest cited literature was published in 1996 and the most recent reference was published in 2020. The five most frequently cited publications were listed in Table 12. Three of these were systematic reviews, one clinical randomized controlled trial, and one review. *The Efficacy of Acupuncture in Post-Operative Pain Management: A Systematic Review and Meta-Analysis* by Wu MS et al,<sup>27</sup> published in 2016 topped the list with 44 citations. Table 13 demonstrated the top 5 papers ranked according to centrality. Three of these were clinical randomized controlled trials, one was a systematic review, and one was a review article. Written by Sun Y et al, *Acupuncture and related techniques for postoperative pain: a systematic review of randomized controlled trials*,<sup>28</sup> published in 2008 had the highest centrality of 0.22.

As shown in Figure 11, there was a co-citation map of references generated by CiteSpace. All references marked on the graph were those with more than 8 citations, and it can be seen that a large number of highly cited literatures were





**Figure 8** Co-occurrence map of keywords on acupuncture therapy for postoperative pain.

published in the last 10 years. Based on this, 19 valid clusters were obtained (Figure 12). The five largest clusters were #0 acupuncture analgesia, #1 evidence-based nonpharmacologic strategies, #2 postoperative complication, #3 randomized controlled trial, #4 ambulatory anesthesia, #5 capsicum plaster.

**Table 10** Top 10 Keywords with the Highest Frequency on Acupuncture Treatment for Postoperative Pain

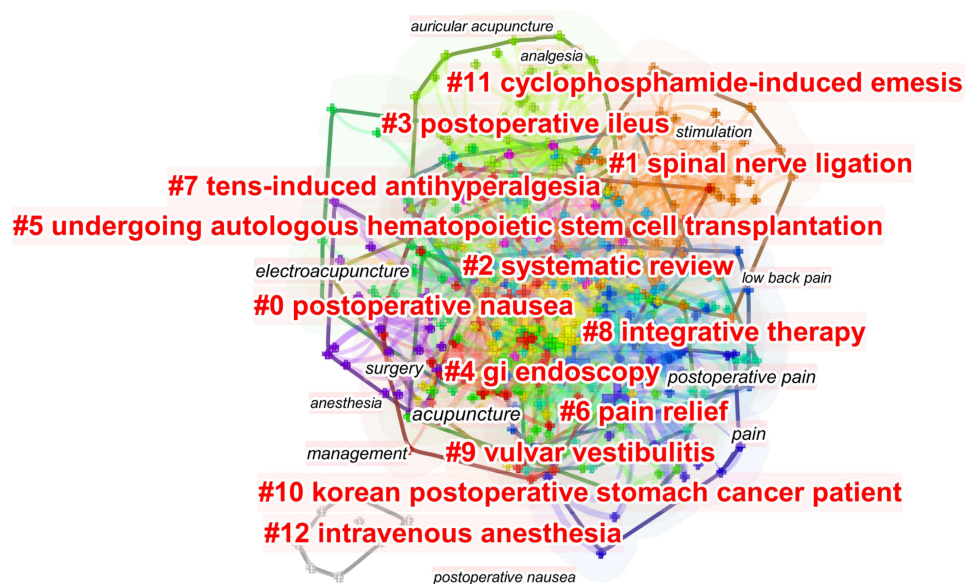
Ranking	Frequency	Keyword
1	216	Acupuncture
2	164	Postoperative pain
3	148	Pain
4	139	Electroacupuncture
5	104	Surgery
5	104	Management
6	68	Stimulation
7	61	Analgesia
8	53	Auricular acupuncture
9	51	Low back pain

**Table 11** Top 11 Keywords with the Highest Centrality on Acupuncture Treatment for Postoperative Pain

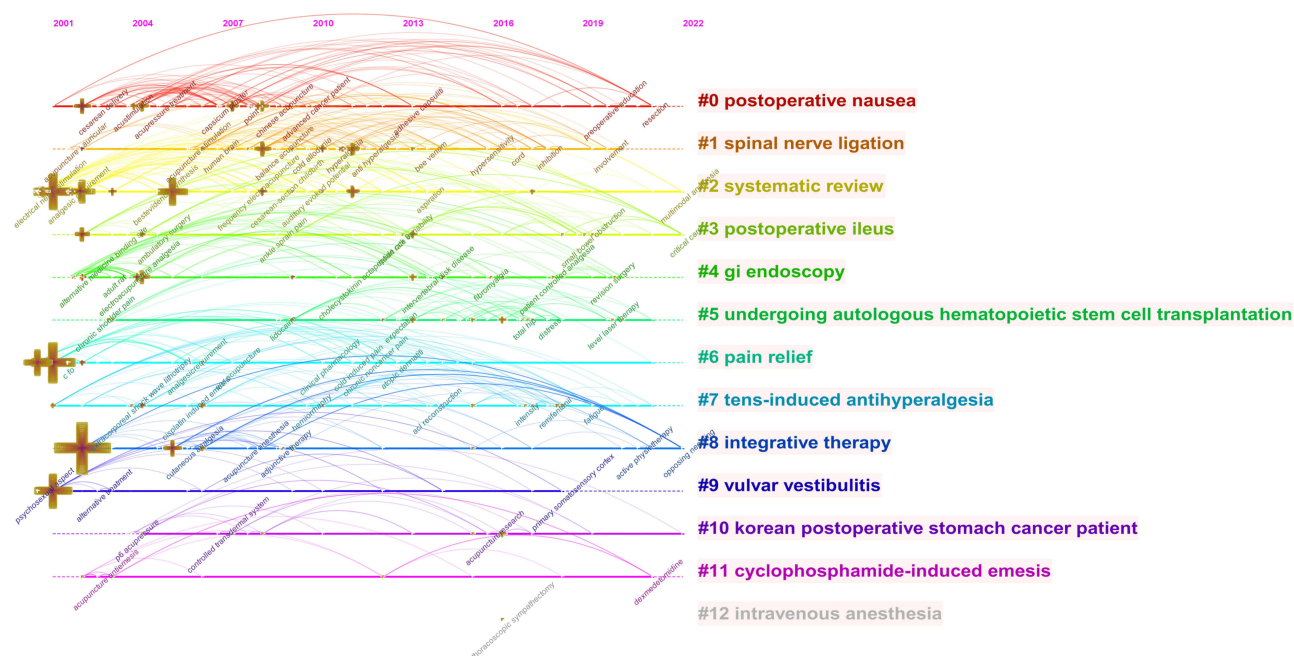
Ranking	Centrality	Keyword
1	0.14	Postoperative pain
2	0.13	Pain
2	0.13	Auricular acupuncture
3	0.12	Surgery
3	0.12	Analgesia
4	0.11	Electrical stimulation
5	0.10	Anesthesia
6	0.09	Low back pain
6	0.09	Neuropathic pain
6	0.09	Electrical nerve stimulation
6	0.09	Acupressure

## Citation Burst Analysis

Burst keywords refer to keywords that have seen a spike in citations over a period and represent the research hotspot for the corresponding time. The 840 included articles were measured via CiteSpace and a total of 16 burst keywords were extracted, as shown in Figure 13. These keywords first appeared in 2001 or before, but the burstness began and ended at different times (shown as the red bars). Among them, “postoperative nausea” had the highest value of burst intensity, with a “Strength” of 8.36. Keywords having the longest duration of the burstness were “acupuncture analgesia” and “trial”, both beginning in 2008 and ending in 2016. The three latest burst keywords, “pain relief” from 2018, “systematic review” from 2019 and “osteoarthritis” from 2020, have been still ongoing.



**Figure 9** Cluster map of keywords co-occurrence on acupuncture therapy for postoperative pain.



**Figure 10** Timeline map of keywords co-occurrence on acupuncture therapy for postoperative pain.

A reference citation burst is a surge in the frequency of the reference being cited over a period, which can help to identify areas at the forefront of current research. A total of 15 references of citation burst were extracted for this study and were displayed in [Figure 14](#). Four references with the latest burstness were identified. An article by Zhang RX published in 2014<sup>29</sup> and an article by Lee A published in 2015<sup>30</sup> both began bursting in 2017, with the former ending bursting in 2019 and the latter in 2020. The next burst reference was the same as the most frequently cited article (Wu MS, 2016),<sup>27</sup> and meanwhile it had the highest value of burst intensity (15.32). This reference and another one by Chou R were both published in 2016,<sup>31</sup> with their citation bursts beginning in 2018 and continuing until now.

## Discussion

### General Information on Publications

The 840 publications included spanned the period from January 2001 to February 2022. Analysis of the annual volume of literature published revealed that the volume of publications in the field of acupuncture for postoperative pain had

**Table 12** Top 5 Cited References with the Highest Frequency on Acupuncture Treatment for Postoperative Pain

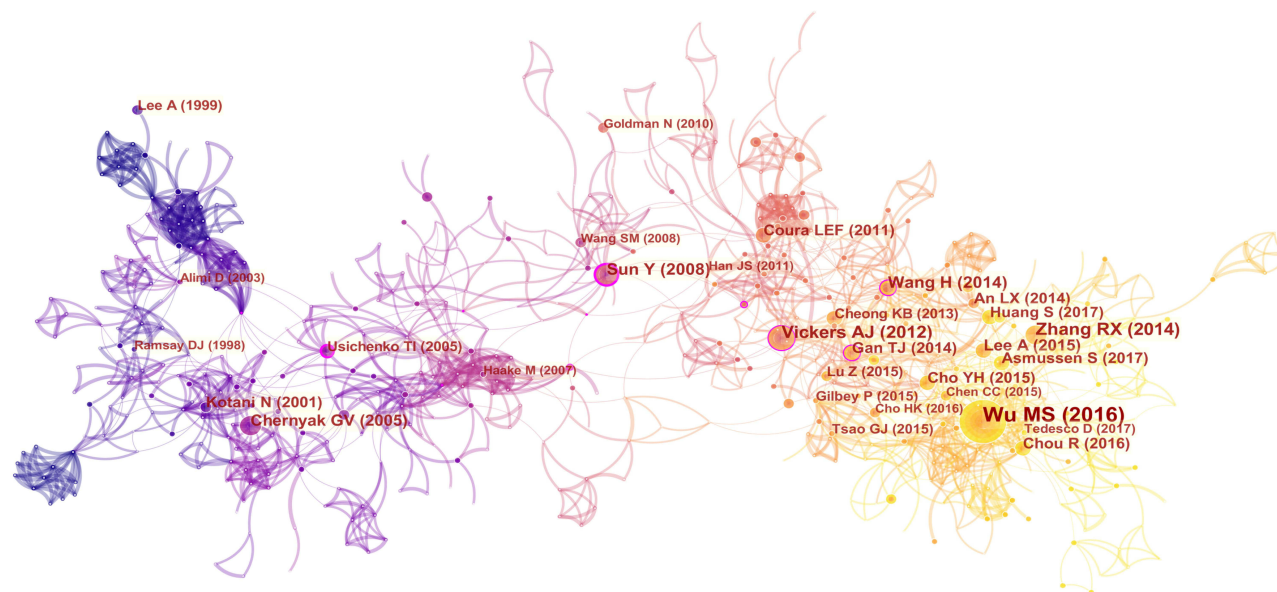
Ranking	Frequency	Cited Reference	Representative Author (Publication Year)	Type
1	44	The Efficacy of Acupuncture in Post-Operative Pain Management: A Systematic Review and Meta-Analysis	Wu MS (2016) <sup>27</sup>	SR/MA
2	23	Acupuncture for Chronic Pain Individual Patient Data Meta-analysis	Vickers AJ (2012) <sup>49</sup>	SR/MA
2	23	Mechanisms of Acupuncture-Electroacupuncture on Persistent Pain	Zhang RX (2014) <sup>29</sup>	Review
4	20	Acupuncture and related techniques for postoperative pain: a systematic review of randomized controlled trials	Sun Y (2008) <sup>28</sup>	SR/MA
5	19	Transcutaneous electric acupoint stimulation reduces intra-operative remifentanyl consumption and alleviates postoperative side-effects in patients undergoing sinusotomy: a prospective, randomized, placebo-controlled trial	Wang H (2014) <sup>50</sup>	RCT

**Table 13** Top 5 Cited References with the Highest Centrality on Acupuncture Treatment for Postoperative Pain

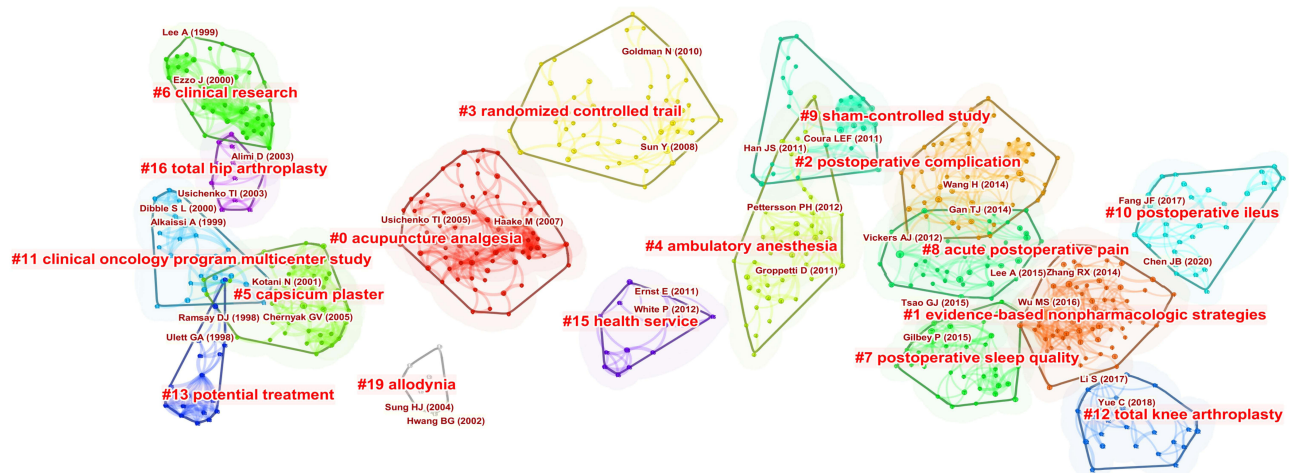
Ranking	Centrality	Cited Reference	Representative Author (Publication Year)	Type
1	0.22	Acupuncture and related techniques for postoperative pain: a systematic review of randomized controlled trials	Sun Y (2008) <sup>28</sup>	SR/MA
2	0.21	Auricular acupuncture for pain relief after total hip arthroplasty – a randomized controlled study	Usichenko TI (2005) <sup>51</sup>	RCT
3	0.18	Acupuncture analgesia: Areas of consensus and controversy	Han JS (2011) <sup>34</sup>	Review
4	0.17	Auricular acupuncture for pain relief after ambulatory knee surgery: a randomized trial	Usichenko TI (2007) <sup>52</sup>	RCT
4	0.17	Pain control after total knee arthroplasty: a randomized trial comparing local infiltration anesthesia and continuous femoral block	Affas F (2011) <sup>53</sup>	RCT

increased to varying degrees each year. This increase was relatively steady in the early stage, more prominent after 2015, and stabilized at its highest level during the latest 3 years. This indicates that the field is in a period of rapid development and has great scope for exploration and research value. From the analysis of journals, the impact factors (IF) of the top ten journals with the highest cumulative number of publications are generally low. This indicates that the influence of acupuncture techniques for postoperative pain control in international applications is still relatively limited, and the quality of relevant publications needs to be improved. The highly cited journals mainly reflect the sources of journals that are the knowledge base of the relevant literatures. Most of them are comprehensive medical journals that serve as a bridge of knowledge between conventional and complementary alternative therapies, and they are more influential, with having a higher impact factor.

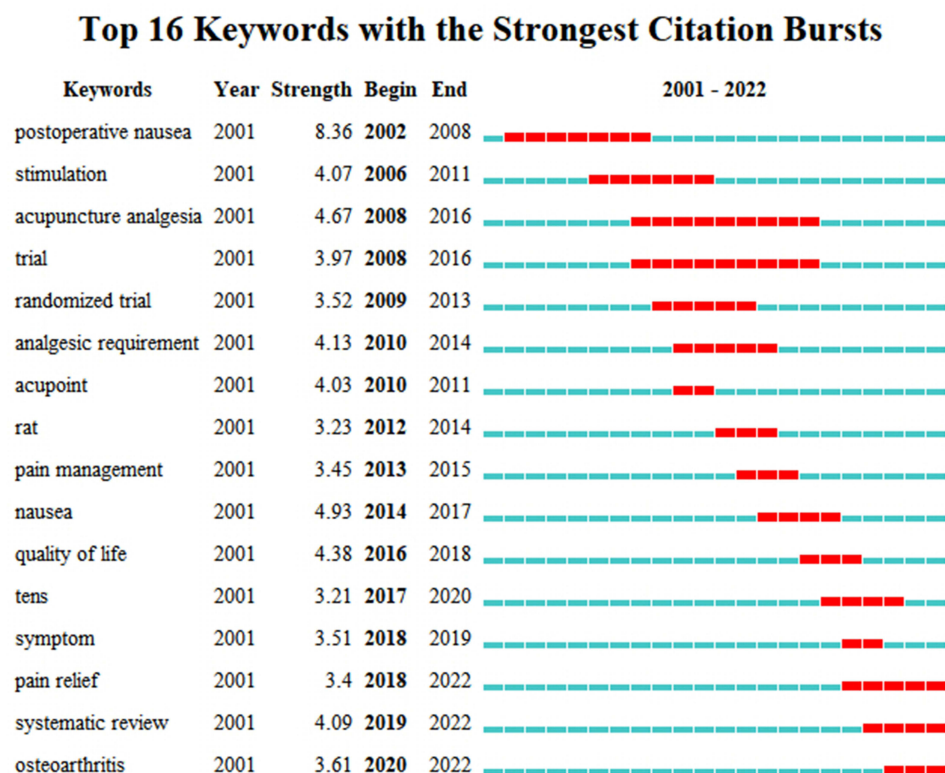
In terms of the number of national publications, the contributions of China and USA are the most prominent. The parameters of the cooperation map show that the density of national collaborative networks is not low, which means that to some extent an international environment for collaborative research in the field of acupuncture for postoperative pain has been formed, with European and American countries such as the USA, UK and Germany playing a larger role, while Asian countries, represented by China and Korea, have more fragmented links. Institutions in Chinese and Korean are the

**Figure 11** Co-citation map of references on acupuncture therapy for postoperative pain.





**Figure 12** Cluster map of references co-citation on acupuncture therapy for postoperative pain.



**Figure 13** Top 16 keywords with the strongest citation bursts.

main locations for research in this field. Medical schools and their affiliated medical institutions are the main institutional form. None of the top five institutions in the centrality ranking has a value above 0.10, suggesting that even the representative institutions are only collaborating on a small scale.

In terms of authors, Inhyuk Ha and his partners have published the most articles, focusing on the application of acupuncture therapy for postoperative pain in the low back, with the most influential article being cited 42 times. This meta-analysis has provided evidence to support the use of acupuncture for acute pain occurring within one week of back surgery.<sup>32</sup> From China, Man Zheng is member of a research team investigating the role of acupuncture therapy in

### Top 15 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	2001 - 2022
Lee A, 1999, ANESTH ANALG, V88, P1362, DOI 10.1097/00005539-199906000-00031, DOI	1999	6.63	2002	2004	
Kotani N, 2001, ANESTHESIOLOGY, V95, P349, DOI 10.1097/00005542-200108000-00015, DOI	2001	8.59	2003	2006	
Chernyak GV, 2005, ANESTHESIOLOGY, V102, P1031, DOI 10.1097/00005542-200505000-00024, DOI	2005	8.35	2006	2009	
Usichenko TI, 2005, PAIN, V114, P320, DOI 10.1016/j.pain.2004.08.021, DOI	2005	5.72	2006	2009	
Sun Y, 2008, BRIT J ANAESTH, V101, P151, DOI 10.1093/bja/aen146, DOI	2008	10.53	2009	2013	
Coura LEF, 2011, ACUPUNCT MED, V29, P16, DOI 10.1136/aim.2010.003251, DOI	2011	6.09	2012	2016	
Vickers AJ, 2012, ARCH INTERN MED, V172, P1444, DOI 10.1001/archinternmed.2012.3654, DOI	2012	9.13	2013	2017	
Wang H, 2014, BRIT J ANAESTH, V112, P1075, DOI 10.1093/bja/aeu001, DOI	2014	6.62	2015	2019	
An LX, 2014, AM J CHINESE MED, V42, P1099, DOI 10.1142/S0192415X14500682, DOI	2014	5.54	2015	2017	
Gan TJ, 2014, ANESTH ANALG, V118, P85, DOI 10.1213/ANE.0000000000000002, DOI	2014	5.21	2015	2019	
Cheong KB, 2013, PLOS ONE, V8, P0, DOI 10.1371/journal.pone.0082474, DOI	2013	5.04	2015	2018	
Zhang RX, 2014, ANESTHESIOLOGY, V120, P482, DOI 10.1097/ALN.0000000000000101, DOI	2014	11.18	2017	2019	
Lee A, 2015, COCHRANE DB SYST REV, V0, P0, DOI 10.1002/14651858.CD003281.pub4, DOI	2015	6.63	2017	2020	
Wu MS, 2016, PLOS ONE, V11, P0, DOI 10.1371/journal.pone.0150367, DOI	2016	15.32	2018	2022	
Chou R, 2016, J PAIN, V17, P131, DOI 10.1016/j.jpain.2015.12.008, DOI	2016	5.67	2018	2022	

Figure 14 Top 15 references with the strongest citation bursts.

perioperative pain prevention, particularly in thoracic and abdominal surgery. A randomized controlled trial conducted by the team demonstrated that in patients undergoing gynecological laparoscopy surgeries, a single electroacupuncture session within 24 hours before surgery was effective in preventing postoperative pain.<sup>33</sup> The author who has the highest frequency of being cited and centrality is Han JS, whose most cited paper is a review published in Pain in 2011,<sup>34</sup> which focuses on the consensus and controversy surrounding the research on the efficacy and mechanisms of acupuncture-related therapy, including the selection of acupoints, stimulation methods and intensity, and neurological effects, providing a reference for both clinical application and trial protocols.

## Research Hotspots and Frontiers

Keywords and references reflect the content of the research from different aspects. Observed in the spatial dimension, the level of their frequency, centrality and burst intensity, and clustering distribution can suggest research hotspots. And in the temporal dimension, the dynamic changes of them can reflect research trends and help identify research frontiers.

### Highly Concerned Treatment Techniques and Types of Surgery

Based on the frequency and centrality of the keywords, it can be determined that electroacupuncture and auricular acupuncture are probably the therapeutic techniques that have received the most attention from researchers in this field. A multicenter randomized controlled trial demonstrated that electroacupuncture combined with conventional care was superior to conventional care alone for the relief of non-acute pain following back surgery.<sup>35</sup> Another randomized controlled trial also showed that auricular acupuncture could provide postoperative analgesia and reduce the application of analgesic medication and was safe to perform.<sup>36</sup>

Studies on the control of postoperative pain with acupuncture have covered a variety of surgical types, including low back surgery, osteoarthritis surgery, lung cancer surgery, cardiac surgery, brain surgery, laparoscopic surgery, tonsillectomy, hysterectomy, total knee replacement, hip replacement, caesarean section, oral surgery, spinal surgery, shoulder and neck surgery, gastric cancer surgery, and anorectal surgery. The studies on chronic lower back pain due to the aftermath of low back surgery are the most, with 58 occurrences of related keywords.

### Hot Research Topics and Directions

The results of clustering and burstness of keywords revealed a consistently high level of concern for postoperative nausea. The largest cluster was “postoperative nausea”. Of the 16 burst keywords, “postoperative nausea” was the keyword with the earliest occurrence (beginning in 2002) and the greatest intensity of burstness. Moreover, the keyword



“nausea” had a second citation burst in 2014. Both nausea and pain are the most common complications after surgery. Meanwhile, there is also a degree of causality between the two. Opioid analgesics have been found to be one of the main causes of postoperative nausea and vomiting.<sup>37,38</sup> The problem of nausea can be addressed to a great extent if postoperative pain can be relieved with minimal use of such medications. Acupuncture therapy has attracted the attention of researchers as an excellent complementary and alternative therapy. A systematic review by Pouy S et al showed that acupuncture therapy can prevent and reduce the occurrence of post-tonsillectomy pain and nausea in pediatric patients.<sup>39</sup> A popular direction of research derived from this research hotspot is PC6 acupoint stimulation. The acupoint of Neiguan (PC6), located on the pericardium meridian, is a specific point for the treatment of nausea and vomiting.<sup>40</sup> Studies on the relief of postoperative complications of pain and nausea have been conducted as early as 1996 by applying pressure to the Neiguan point.<sup>41</sup> A systematic review and meta-analysis by Cheong KB et al demonstrated the safety and effectiveness of acupuncture stimulation of the PC6 acupoint or with the combination of other acupuncture points to alleviate postoperative vomiting associated with anesthetic analgesia.<sup>42</sup>

In addition, transcutaneous electrical nerve stimulation (TENS) is another hot direction of research in this field, as reflected in the keyword clustering and burstness. This technique is also combined with auricular acupuncture techniques.<sup>43</sup> A similar technique arising from the disciplinary crossover is transcutaneous electrical acupoint stimulation (TEAS).<sup>44–46</sup>

### Research Trends and Forefront

From an overall perspective, keywords whose burstness occurred in the first decade mainly reflected a concentrated discussion of postoperative pain management and acupuncture analgesic techniques, with the main form of research being mostly RCTs. In the recent decade the main focus has been on pain symptom relief and postoperative quality of life, with a gradual increase in the number of systematic reviews. Moreover, animal experiments, as well as mechanism-related studies, also have a place, as evidenced by the burst keyword “rat” and the second largest cluster “#1 spinal nerve ligation” (a kind of rat modelling technique). Looking at the three newest burst keywords, “pain relief” shows the constant attention received by the topic of postoperative pain management. The rise in heat of “systematic review” reflects the development of evidence-based medicine in this field. 2020 saw the burstness of the term “osteoarthritis”, indicating that in the last two years acupuncture analgesic techniques have started to be used in osteoarthritis surgery more often and intensive research has been conducted.<sup>47,48</sup>

The citation status of the references also manifests a distinctly evidence-based medical color. The most influential literatures in this field are of a variety which is dominated by RCTs and systematic reviews of clinical studies. In the results of clusters, both “#1 evidence-based nonpharmacologic strategies” and “#3 randomized controlled trial” have a relatively large size. The most frequently cited reference suggested that certain modes of acupuncture did have implications for alleviating postoperative pain and reducing opioid use.<sup>27</sup> That acupuncture could control acute postoperative pain and reduce the side effects of pharmacological analgesia was supported by the reference with the highest centrality.<sup>28</sup>

According to the newest burst references, electroacupuncture could alleviate pain by activating a range of bioactive substances including opioids, N/OFQ, 5-hydroxytryptamine, norepinephrine and others.<sup>29</sup> Lee A et al evaluate the preventive effect of several methods of stimulating the PC6 acupoint on nausea and vomiting resulted from surgical analgesia and anesthesia.<sup>30</sup> This fits in with the direction of research embodied in the keywords. The last is a guideline on postoperative pain management published in 2016.<sup>31</sup> In this guideline, TENS is supported by moderate quality evidence and is recommended as a complementary therapy. In contrast, the effectiveness of other acupuncture therapies remains controversial, although there is adequate evidence for their safety. However, most of their citations and evidence are of results published before 2005 and their evidence needs to be updated. This suggests that the current focus in the field of acupuncture therapy for postoperative pain is still on proving the effectiveness of acupuncture therapy and that there is a long way to go in terms of conducting high quality clinical research.

### Conclusion

In this study, the analysis of annual volume of publications and journals suggests that the field of acupuncture therapy for postoperative pain relief is currently in a period of rapid development. The analysis from country to institution to author

shows a progressively more microscopic perspective of observation and consistency is evident among them: there may be more localized individual collaborations, but the overall collaborative network is not yet mature. In terms of keywords and references, electroacupuncture and auricular acupuncture (therapeutic techniques), low back surgery (types of surgery), “postoperative pain, nausea and vomiting” and their derivatives are research hotspots in this field. Improvement of postoperative life quality, proof of clinical efficacy and evidence-based evaluation are the current research trends and frontiers. Overall, the field of acupuncture for postoperative pain has great potential for development, and more international exchanges and collaborations as well as high-quality research results are needed in the future.

## Strength and Limitation

The strength of this study is that literatures on acupuncture therapy for postoperative pain were analyzed by applying bibliometrics and visualization for the first time, and the results were interpreted from multiple perspectives, with the information presented in the macroscopic perspective sufficiently explored, revealing the research hotspots and trends in the field. The limitation of this study is that only literature from the Web of Science was analyzed. This is because CiteSpace cannot combine and analyze data from multiple sources at the same time, and other databases cannot export the corresponding citation formats for citation analysis.

## Abbreviations

NSAIDs, non-steroidal anti-inflammatory drugs; RCT, randomized controlled trial; WoS, Web of Science; IF, impact factor; TENS, transcutaneous electrical nerve stimulation; TEAS, transcutaneous electrical acupoint stimulation.

## Data Sharing Statement

The raw data of this article was collected from the online database WoS, which can be obtained directly by logging in or contacting the authors.

## Ethics Approval and Informed Consent

This study did not contain any human or animal test subjects. Thus, the requirement for ethics approval was waived.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors report no potential conflicts of interest in this work.

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