

Research of Acupuncture for Neuropathic Pain from 2002 to 2022: a Bibliometric Analysis via VOSviewer

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Abstract

Background: Acupuncture, as a non-drug therapy, has been an effective and safe treatment for neuropathic pain (NP). However, a bibliometric analysis of the global use of acupuncture for NP is rare. **Objective:** This study aimed to demonstrate the state and trend of the global use of acupuncture for NP in recent 20 years. **Method:** Publications relating to acupuncture for NP were retrieved from Web of Science (WoS) database. Reviews were specifically excluded from this study. Vosviewer1.6.16 was used to analyse countries/institutions, cited journals, authors / cited authors, cited references, and keywords. Statistics and centrality analysis were used to reveal publication output, countries/institutions, core journals, active authors, foundation references, hot topics, and frontiers. **Results:** A total of 868 articles were obtained from the WoS database. The number of publications has increased over the last two decades. China was the most productive among countries or regions in the field. Journal articles were the most frequently occurring document type. Kyung Hee University was the most active institution. The six main types of NP using acupuncture treatments were peripheral neuropathy, carpal tunnel syndrome, trigeminal neuralgia, spinal cord, postherpetic neuralgia, and chemotherapy-induced peripheral neuropathy. **Conclusion:** Publications about NP treated with acupuncture had remarkably increased from 2002 to 2022. This study provided an in-depth perspective for research on acupuncture for NP and provides researchers with valuable information to determine the current status, hot spots, and frontier trends.

1 Introduction

Neuropathic pain (NP) is a painful condition caused by an injury or disease of the somatosensory system. In addition to spontaneous pain, nociceptive hypersensitivity, and abnormal pain[1], it is often associated with anxiety, depression, and other painful emotions[2, 3], causing a huge impact on patients' lives. The prevalence of NP in the global population is estimated to be around 7% to 10%[4]. The first-line treatments for NP, such as antidepressants and anticonvulsants, as well as second-line opioids, have been associated with poor efficacy and adverse effect[5-7]. Therefore, it is necessary to explore new treatment methods and strategies.

According to reports from 129 countries, the use of acupuncture has been accepted in 80% of countries[8]. With international recognition of acupuncture and the expansion of its applications, related research has been rapidly developed and some clinical studies have been included in modern medical clinical guidelines[9]. By stimulating specific acupuncture points, acupuncture regulates the qi and blood, unblocks the meridians and channels, and helps to dispel the evil qi and help the body recover. Acupuncture has been widely recognized around the world. In 2016, the United Nations Educational, Scientific and Cultural Organization (UNESCO) listed acupuncture and moxibustion in traditional Chinese medicine in the "World Intangible Cultural Heritage List of Humanities". The large-scale clinical observation results of acupuncture have confirmed that the adverse reactions of acupuncture therapy are small and controllable, and it is a relatively safe physical therapy method[10, 11]. In addition to traditional hand acupuncture treatment, electroacupuncture is also widely used in clinical treatment and basic research. The therapeutic effect of acupuncture on NP

has been generally affirmed and widely used in clinical practice. At the same time, with the help of different chronic NP animal models, the mechanism of acupuncture analgesia has been gradually clarified, providing theoretical support for clinical treatment decisions. However, there is still a lack of attention to the research hotspots, key institutions and researchers, as well as the type and distribution of the relevant research on acupuncture for NP, which needs systematic arrangement to lay the foundation for future supplements and expansion.

Bibliometric analysis is a series of analyses used to evaluate and quantify literature information. A series of analyses on the evaluation and quantification of literature information have been applied in many research fields to determine the core researchers, institutions, and countries, as well as the cooperation between them. Co-occurrence analysis, co-citation analysis, and keyword explosion can reflect global research trends and thematic hotspots[12-14]. Lee et al. and Ma et al. conducted a global bibliometric analysis based on the global Web of Science database and PubMed to assess the development trend of acupuncture[15, 16]. Co-occurrence network maps of authors, keywords, institutions, countries, and subject categories and cited journals were carried out to help analyse research on acupuncture for NP.

Therefore, VOSviewer was applied to analyse the knowledge map of research, topical issues, and trends regarding acupuncture for NP over the past 20 years. Through bibliometric analysis, this study demonstrated the general research trends in acupuncture for NP; the key journals; contributing countries, institutions and authors and their collaborations, and explored specific types of NP treated with acupuncture and the frontiers of clinical research through an analysis of keywords.

2 Materials and Methods

2.1 Data Acquisition and Search Strategy

Relevant literatures were identified using the Web of Science, which provides comprehensive publication data and high-quality publications about various scientific area worldwide. The publication period considered in this study was from 1 January 2002 to 30 August 2022. The following search terms were employed: TS = (Acupuncture OR Electroacupuncture OR acup* OR "TEAS" OR "Transcutaneous Electrical Acupoint Stimulation" OR "dry needle" OR "fire needle" OR "plum blossom needle") AND TI = (Neuralgia* OR Neurodynia* OR "Neuropathic pain" OR sciatica OR "nerve crush" OR "Nerve pain*" OR "nerve cut" OR "nerve constriction" OR "nerve inflammation" OR "nerve injury" OR "nerve ligation" OR "peripheral neuropathy" OR "chronic constriction injury" OR "diabetic neuropathy" OR "carpal tunnel syndrome"). A total of 1039 articles was identified and reviews (n = 171) were excluded; thus, 868 articles written in English were ultimately included in the final analyses (**Figure 1**).

2.2 Data Analysis

All data from the Web of Science were imported into VOSviewer v.1.6.16 (Centre for Science and Technology Studies, Leiden University, Leiden, The Netherlands), which is commonly used to analyse and visualize relationships among authors, countries, co-citations, and the terms used in the articles. Publications were sorted and systematically assessed according to publication year, research area, journal title, countries, organizational affiliations, and authors. Additionally, the frequencies of keywords extracted from the articles were included in the network analysis. The different nodes represent different countries, institutions, and keywords, while the size of the circle or font reflects the productivity. The link strength between nodes represents increased collaboration between countries, institutions, authors, and co-occurrence.

Before the data were analysed by VOSviewer, a customized "thesaurus" was used to avoid redundancy and synonyms. Some countries with synonyms, such as ("peoples republic of China and "China"), were merged into one word. The same process was performed for author names and keywords. Cleaned and organized data were then imported into VOSviewer.

3 Results

3.1 General Information

3.1.1 Publication Growth and Outputs

The number of published works in the literature per year was shown in **Figure 2**. As can be seen from the graph, although the number of studies fluctuated slightly from 2002 to 2022, the overall number was gradually increasing and peaked in 2020. In particular, the number of published works in the literature have fluctuated from 2015 to date, but all exceeded 50.

3.1.2 Document Types

Sixteen document types were identified in a total of 868 references. The article, as the most popular document type, comprised 90.8% of the total production and was followed by clinical trials, abstracts, case reports, meetings, unspecified, editorial material, proceedings papers, corrections, letters, book chapters, retracted publications, and early access works (**Table 1**).

3.2 Analysis of Journal Distribution

Of the 304 journals identified in this study, Zhongguo Zhen Jiu = Chinese Acupuncture & Moxibustion issued the most articles (6.7%), followed by Zhen Ci Yan Jiu Acupuncture Research (4.7%), and China Journal of Traditional Chinese Medicine and Pharmacy (3.1%; **Table 2**).

Of the 70 research areas that were verified in the present study, the most highly represented research area as judged by the number of articles was neurosciences neurology (35.3% of all articles), followed by general internal medicine (30.3%), integrative complementary medicine (26.3%; **Table 2**).

3.3 Analysis of Countries

A map of active countries in research of acupuncture for NP was generated using VOSviewer (**Figure 3**), 868 publications were published by 18 countries. Each node represents a country, and the size of the node is proportional to the number of published articles. Connections between nodes represent collaborations, and the wider the connection, the tighter the collaboration.

The list of the top 5 countries was presented in **Table 3**. China had the most publications, followed by the United States of America (U.S.A.), South Korea, Germany, and England.

3.4 Analysis of Institutions

Nearly 197 institutions made contributions to research on acupuncture for NP. To obtain a better visualization, institution collaboration networks depict only 22 institutions, which had at least 6 papers using VOSviewer (**Figure 4**). Each node represents an institution, and the size of the node is proportional to the number of published articles. Connections between nodes represent collaborations, and the wider the connection, the tighter the collaboration.

The list of the top 5 institutions was presented in **Table 3**. Kyung Hee University has published the largest number of studies, followed by the China Academy of Chinese Medical Sciences, Shanghai University of Traditional Chinese Medicine, Fudan University, and Zhejiang Chinese Medical University.

3.5 Analysis of Authors

A co-author map was generated using VOSviewer (**Figure 5**). For better visualization, only 129 authors with more than 3 articles were selected. Each node represents an author and the size of the node is proportional to the number of published articles. Connections between nodes represents collaborations and the wider the connection, the tighter the collaboration. **Table 4** showed the top 5 authors who had published articles related to research on acupuncture for NP. They were active professional authors in the fields from China and South Korea, and their partnerships could be seen in an analysis of authors' collaborative networks using VOSviewer. Seven clusters were formed, and each cluster contained authors who had long-term relationships.

Among the top 5 authors, Jiang Songhe and Tu Wenzhan were from Wenzhou Medical University, Li Jing was from Hubei University of Chinese Medicine, Zhang Li was from Jinan University, and Wang Ke was from Shanghai University of Traditional Chinese Medicine.

3.6 Analysis of Keywords

Keywords from the 868 publications assessed in the present study were analysed using VOSviewer (**Figure 6**). 183 keywords occurred more than 5 times in the title and abstract fields across all the articles. The top three keywords according to the weight of occurrences were acupuncture (224 occurrences), electroacupuncture (206), and neuropathic pain (172), suggesting that electroacupuncture was a common method and hot research topic in the treatment of NP.

In terms of co-occurrence keyword clustering, it could be roughly divided into seven clusters of different colours: Cluster 1 referred to diseases, with primary keywords carpal tunnel syndrome, chemotherapy, and diabetic neuropathy. Cluster 2 referred to the treatment of disease, with primary keywords of antinociception, bee venom treatment, and formalin test. Cluster 3 referred to the neuro-mechanism of NP with primary keywords of beta-endorphin and cumulative effect. Cluster 4 and 5 referred to the clinical research, with primary keywords of rat, receptor, and sensitization. Cluster 6 and 7 referred to the mechanism of the brain MRI, with primary keywords of opioid receptors, cortex, and functional connectivity.

Among all the keywords, 25 keywords occurred more than 20 times in the title and abstract fields across all the articles. **Table 5** showed the occurrences, average publication year, and average citation numbers of the 25 keywords.

The keywords were color-coded by VOSviewer based on the average publication year as shown in **Figure 7**, where purple represents relatively early and yellow represents later average publication years. Among the 25 keywords which occurred more than 20 times, the most recent keywords were “diabetic peripheral neuropathy” and “randomized controlled trial” (average publication year: 2020.1), “chemotherapy” (2018.5), “postherpetic neuralgia” and “chemotherapy-induced peripheral neuropathy” (2018.4). In contrast, the most common keywords in earlier moxibustion studies were “mechanical allodynia” (average publication year: 2011.3), “analgesia” (2013.2), “spinal cord” (2014.2), and “allodynia” (2014.4).

3.6.1 Analysis of Specific Types of NP Treated with Acupuncture

Six main types of NP treated with acupuncture were found among 25 keywords through keywords analysis: peripheral neuropathy (23.2%), carpal tunnel syndrome (20.5%), trigeminal neuralgia (15.3%), spinal cord (15.3%), postherpetic neuralgia (13.7%), chemotherapy-induced peripheral neuropathy (12.1%; **Figure 8**).

The research trend was considered by average publication year. The spinal cord was the oldest (average publication year: 2014.2) and chemotherapy-induced peripheral neuropathy was the most recent (2018.4). The impact of research was extracted by average citation number. Spinal cord had the highest citation number (average citation number: 15.8) and trigeminal neuralgia had the lowest citation number (0.6; **Table 5**).

3.7 Features of the Top 10 Most Cited Publications

The top 10 publications on acupuncture for NP are listed in **Table 6** according to the number of citations. The citations of these publications accounted for 19.7% (1540) of the total quantity of citations. The study “EFNS guidelines on neurostimulation therapy for neuropathic pain” by [17] published in 2007 in European Journal of Neurology was the most cited one (457 citations). Among the top 10 articles, three [17-19] was published in a journal with IF >6 (Pain; Journal of Neurology; European Journal of Neurology), four [18, 20-22] were published in journals with 5 < IF [?]6 (Experimental Neurology; Human Brain Mapping), and three [23-25] were published in journals with 1 < IF [?]5 (Archives of Physical Medicine and Rehabilitation; Plos One; Acupuncture in Medicine).

4 Discussion

Neuropathic pain afflicts up to 7% of the world’s population. Acupuncture is highly effective as a non-pharmacological external treatment for neuropathic pain and is gaining wider acceptance worldwide. The current study provided a bibliometric analysis of publications on acupuncture for NP from 2002 to 2022, and found that the most commonly used type of acupuncture is electroacupuncture, and five of the six most

studied specific types of NP are peripheral neuropathy. The mechanism of acupuncture in treating neuralgia had been continuously confirmed by research[26]. A number of studies[27, 28] had shown that, the CCKa receptors in the hypothalamus and parafascicular nucleus and the CCKb receptors in the periaqueductal gray matter of the midbrain were related to electroacupuncture analgesia. Neuropathic pain rats with low CCKa receptor function were more sensitive to electroacupuncture treatment than normal rats. In addition, one bibliometric study from 2005 to 2019 provided perspectives of studies on exercise and NP[29], demonstrating the possibility of non-pharmacological treatment of NP. One review examined the trends of NP field studies and compared the quantity and quality of NP studies in China with other developed countries[30]. This study synthesized the global literature on acupuncture for NP over the past two decades, analysed the overall research trends, and identified specific types of acupuncture for neuropathic pain and then tried to explain the mechanisms. The results could provide suggestions to patients, scholars, educators, medical doctors, funding agencies, and policy makers.

4.1 Global Trends

Our bibliometric analysis published over the last two decades showed that the total number of articles per year has increased steadily during this period. The most well-represented research areas based on the number of articles were neurosciences neurology, general internal medicine, and integrative complementary medicine. Over one-third of the research articles on acupuncture for NP (35.3%) concerned neurosciences neurology, and the major journals that published research on acupuncture for NP were generally related to complementary and alternative medicine.

By analysing keywords, research trends in a particular field of study and the crucial content of published articles could be identified. In the present study, a network analysis based on the occurrence of keywords revealed the trends in research on acupuncture for NP and provided information about the types of studies conducted. Two main types of studies were identified: basic studies demonstrating the mechanisms of acupuncture treatment or safety observations, and clinical studies investigating the efficacy of acupuncture for specific types of neuropathic pain. The main keywords used in the basic studies type were rat, sensitization, and expression, whereas the main keywords in the clinical studies were randomized controlled trial. These analyses of keywords showed the overarching trends in research on acupuncture for NP.

4.2 Research Focuses

In the current study, six main types of NP using acupuncture treatments were demonstrated: peripheral neuropathy, carpal tunnel syndrome, trigeminal neuralgia, spinal cord injury, postherpetic neuralgia, and chemotherapy-induced peripheral neuropathy. Among the six types, one was related to central nervous system disease, while the other five were concerned with the peripheral nervous system. On the other hand, the bibliometric analysis provided the overall map of the usage of acupuncture in diverse NP types and contributes to exploring research trends and identifying new areas for research. The impact of research was considered by citation number, this study found that the spinal cord had the highest citation number among the six main diseases referred above. This might be associated with the fact in which many clinical trials were conducted on spinal cord injury with acupuncture treatments in the early periods[31, 32]. Analysis of these trends would find core target diseases related to NP of acupuncture treatment and offer the latest insights on the state of the art of this research field[33].

The peripheral mechanisms of acupuncture for nerve pain were becoming clearer. Peripheral nerve injury can mediate peripheral sensitization through a variety of different pathways and that acupuncture could exert analgesic effects by affecting different aspects of peripheral sensitization. It had been shown that in constriction injury (CCI) rats, electroacupuncture was administered to the foot and the acupuncture point, and local activation of the high mobility group protein B1 and its receptor CD24 (HMGB 1-CD24) signalling pathway was observed[34, 35], and acupuncture promoted the release of neuroactive mediators at the acupuncture point to mediate the analgesic effect, suggesting that acupuncture could have a local analgesic effect by affecting the acupuncture point.

It had also been observed that acupuncture could improve abnormal median nerve conduction in carpal tun-

nel syndrome[36-38], suggesting that acupuncture could act on sensory afferent axons and improve ectopic spontaneous axonal firing. In the dorsal root ganglion (DRG) and trigeminal ganglion regions, abnormal neuronal function mediated the development of chronic NP, and electroacupuncture mediated analgesia by improving abnormal DRG neuronal function. On the one hand, acupuncture affected receptors or channels on the cell membrane of DRG neurons[39-41], and on the other hand, it modulated pain-related bioactive substances to provide analgesia[42, 43]. In addition, there was growing evidence that endogenous opioid peptides and their receptors were closely associated with the relief of NP by acupuncture, and there were four major families of endogenous opioid peptides in the peripheral and central nervous system: endorphins, enkephalins, dynorphins, and orphan peptides, which selectively bind to μ , δ , κ and orphan peptide receptors[44-46]. In the periphery, acupuncture had been shown to increase local β -endorphin expression at acupuncture points[34, 47]; it could increase plasma β -endorphin[22, 48]. The levels of μ , δ , and κ receptors were all involved in acupuncture's role in alleviating chemotherapy induced neuropathic pain[49-51]. The above studies suggested that endogenous opioid peptides and their receptors were also involved in the peripheral mechanism of acupuncture in relieving NP.

Based on the above studies, this paper concluded that acupuncture could act to relieve NP by affecting DRG neuronal plasticity, opioid peptides, and their receptors, endogenous nociceptive modulation systems, glial cells and cytokines, spinal synaptic plasticity, and other bioactive substances.

The review of the literature revealed that, compared to acupuncture for the relief of other pains, such as inflammatory pain, the mechanisms of acupuncture for the relief of chronic NP in the supraspinal higher centres and brain neural circuits were less well-understood and required more research investment.

4.3 Strengths and Limitations

This study was the first bibliometric analysis that included a large number of publications concerning acupuncture treatment for NP from the WoS database from 2002 to 2022. The 868 articles evaluated were derived from several global academic journals, and their results were considered. Aside from the distribution of countries/regions, institutions, and authors, the references, keywords, and citation bursts were also analysed.

The publications were collected from only one specific database (WoS). Thus, some publications from other databases, such as PubMed and EBSCO, were possibly missed. However, given the essential number of publications included in this analysis, a large part of research on acupuncture for NP was most likely included. In addition, only the articles published in the English language were considered, a feature that might have induced some bias in the analysis. The last limitation was that per capita analysis was not considered when comparing countries with different sizes and populations. This omission might produce a research bias.

5 Conclusion

The two decades bibliometric analyses indicated that acupuncture research concerning NP is in a booming period of development. China and the United States are the countries with the highest number of publications, and closer attention is recommended to paid in hot spots such as acupuncture, electroacupuncture, and peripheral neuropathy.

Declarations

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Author contributions

WL carried out the investigation, data curation, formal analysis, and the writing of the original draft. LH performed investigation, data curation, and formal analysis. KL and CW were responsible for the conceptualisation, methodology, data curation, writing – review and editing, and supervision. All authors agree to be accountable for all aspects of this work.

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Additional File

Table 1 Document types for documents on acupuncture for NP

Table 2 Top 10 journals related to research on acupuncture for NP

Table 3 Top 5 countries and institutions which performed research on acupuncture for NP

Table 4 Information of top 5 active authors contributing to research on acupuncture for NP

Table 5 Occurrences, average publication year, and average citations of 25 keywords that have occurred over 20 times in the title or abstract fields across all articles

Table 6 Top 10 articles with the most citations

Figure Legend

Figure 1 Flow chart of bibliometric analysis

Figure 2 The number of annual publications

Figure 3 Map of active countries in research on acupuncture for NP

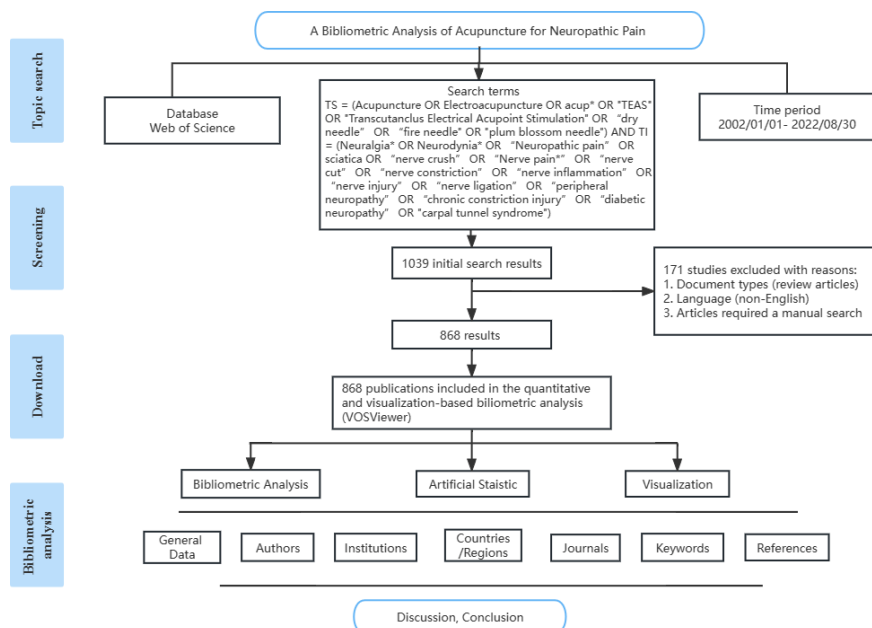
Figure 4 Map of active institutions on research on acupuncture for NP

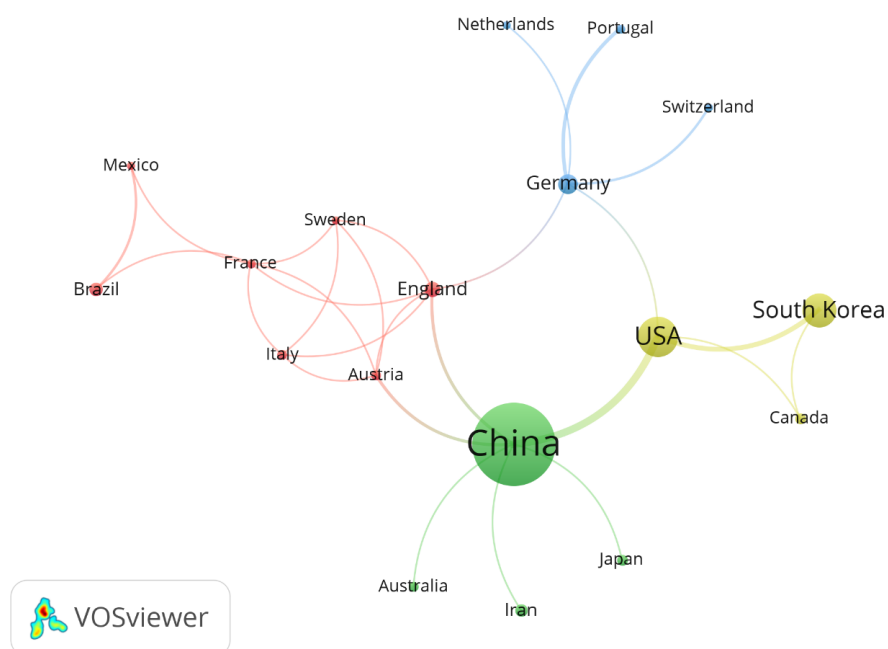
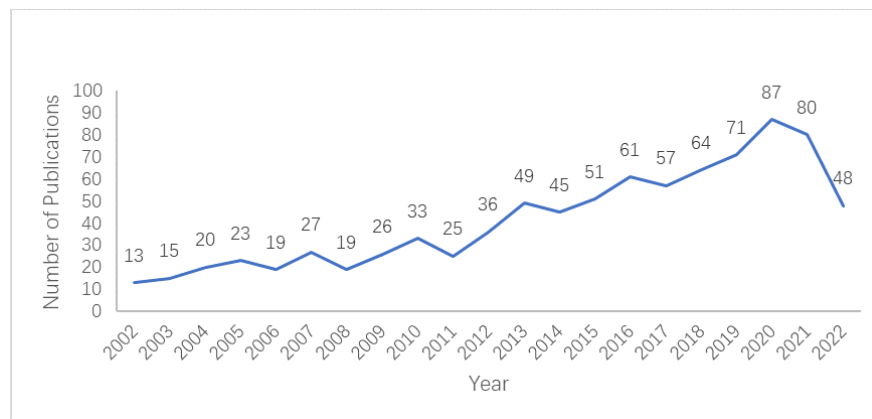
Figure 5 Map of active authors contributing to research on acupuncture for NP

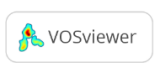
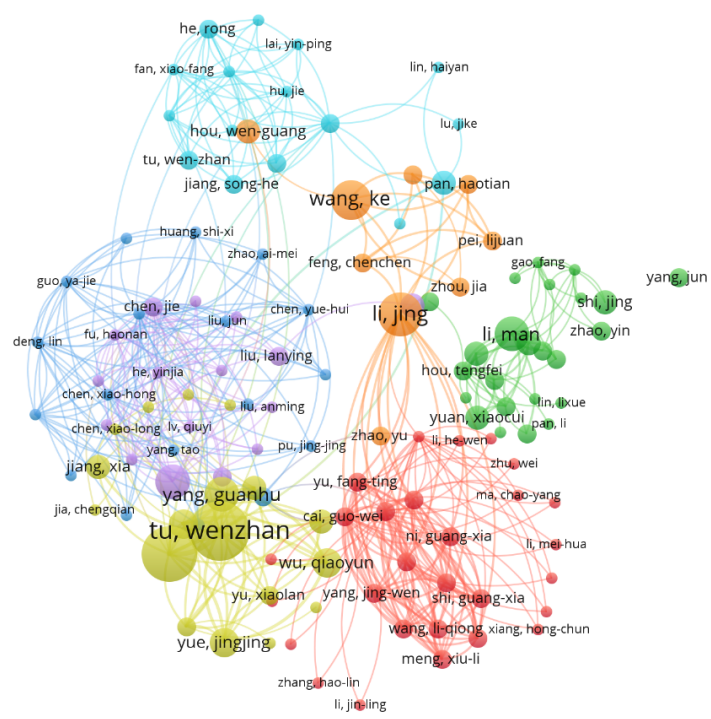
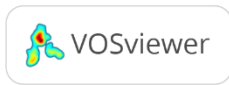
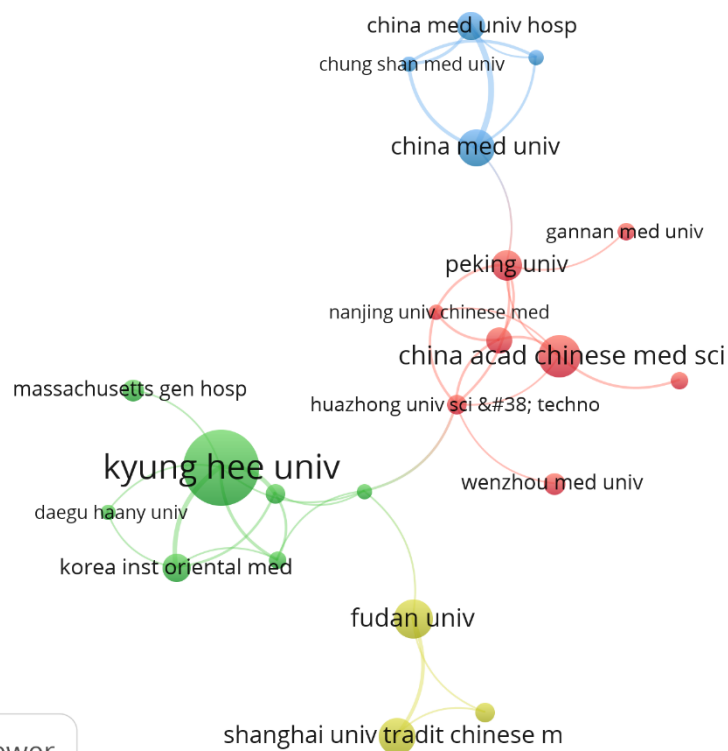
Figure 6 Mapping of keywords concerning acupuncture for NP

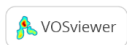
Figure 7 Distribution of keywords according to the average publication year

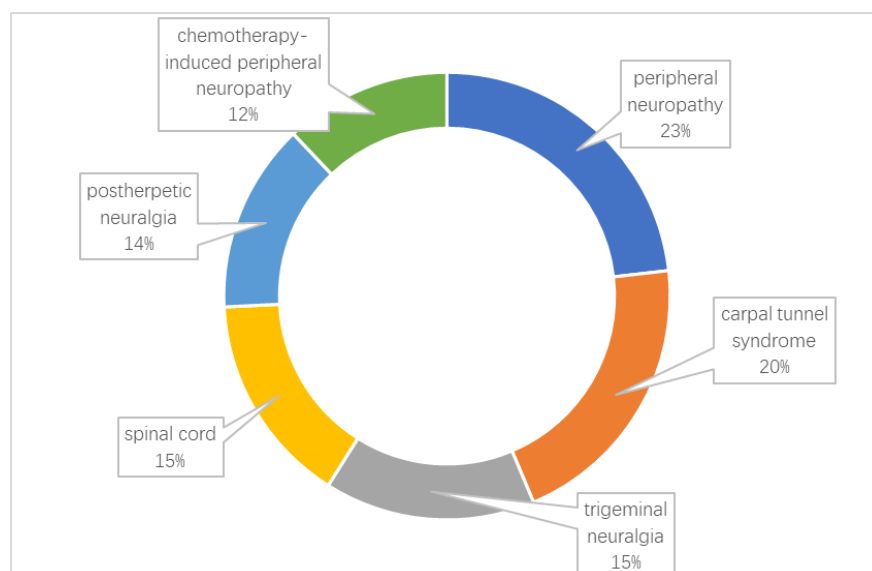
Figure 8 Six main types of NP treated with acupuncture











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