

Bibliometric Analysis of 100 Most Highly Cited Publications on Acupuncture for Migraine

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Background: Migraine is a serious global health concern that imposed a huge economic burden on social health care. Over the past few decades, the analgesic effects of acupuncture have been widely recognized, and there is a growing body of research on acupuncture for migraine. Citation analysis is a branch of bibliometrics that helps researchers analyze and identify historical or landmark studies within the scientific literature. Currently, there is no analysis of the 100 most highly cited publications on acupuncture for migraine.

Methods: The 100 most highly cited publications on acupuncture for migraine were screened using the Science Citation Index Expanded of the Web of Science Core Collection database. CiteSpace and VOSviewer programs were used for bibliometric analysis.

Results: A total of 493 publications on acupuncture for migraine were identified. 100 of the most highly cited publications on acupuncture for migraine were published from 1984–2020. These publications were cited 6142 times with an h-index of 44 and 84% were original articles. The highest frequency of citations was 416. A total of 335 authors were involved in the study with 37 lead authors. 212 institutions from 20 countries contributed to the 100 most highly cited publications. The most published studies came from the United States (n=36), followed by China (n=27) and Germany (n=26). The Technical University of Munich published the largest number of papers (n = 15). Top-cited publications mainly came from the Headache (n=13, citations=582). Neuroimaging is gradually emerging as a hot topic of research.

Conclusion: This is the first bibliometric analysis to offer a thorough list of the 100 most highly cited papers on acupuncture for migraine, demonstrating significant progress and emerging trends in this field to assist researchers in determining the direction for further research.

Keywords: acupuncture, bibliometric analysis, citation analysis, migraine, CiteSpace, VOSviewer

Introduction

Migraine is a common primary headache disorder characterized by recurrent headaches associated with nausea, vomiting, photophobia and phonophobia.¹ Currently, the number of migraine sufferers in the world is 1.1 billion, migraine is the second most disabling disease worldwide.^{2,3} The male-to-female prevalence ratio is approximately 1:3.⁴ Compared to 1990, there is a significant increase in annual incidence and age-standardized point prevalence compared to 1990.³ Migraine management is based on oral medications. Migraines have an increased risk of comorbidities than individuals without migraine,⁵ but comorbidities can limit their medication.⁶ When acute treatments are ineffective, there is an increased risk of conversion to chronic migraine.⁷ Chronic migraine severely impacts a patient's quality of life and socioeconomic functioning.⁸

Acupuncture is a component of traditional Chinese medicine consisting in thin needles inserted through the skin at specific points to cure diseases or relieve pain. A recent meta-analysis showed that acupuncture has advantages in improving intracranial blood circulation, reducing the frequency of migraine attacks, and lowering pain scores. Whether

compared with sham acupuncture or traditional medicine, acupuncture has outstanding advantages and fewer adverse reactions.⁹

Bibliometrics is a set of interdisciplinary methods to quantitatively analyze scientific literature.^{10,11} Although the role of citation counts is controversial, it is also increasingly important to identify the most influential studies in a specific field.¹² Citation count is widely used in obstetrics and gynecology,¹³ brain surgery,¹⁴ neuroscience,^{15,16} imaging,¹⁷ gastroenterology¹⁸ and oncology.^{19,20} VOSviewer²¹ and CiteSpace²² are two commonly used programs for analyzing and measuring scientific literature. To date, no bibliometric analysis has been performed on the 100 most highly cited publications on acupuncture for migraine. This study visually analyzes the 100 most highly cited publications on acupuncture for migraine. We also provided a brief historical overview and landmark studies investigating acupuncture for migraine.

Methods

Search Strategy

The Science Citation Index Expanded (SCI-EXPANDED) of Web of Science Core Collection (WoSCC) was retrospectively searched from inception to June 24, 2022. The search strategy was as follows: (TS = (acupuncture*) OR (electroacupuncture) OR (moxibustion) OR (acupoint*)) AND (TS = (migraine*)). Only original studies or review articles published in English were included.

Data Collection

The 100 most highly cited publications on acupuncture for migraine were ranked in descending order of citations. Two researchers reviewed the titles and abstracts, read the full texts when necessary and sought the help of a third researcher when disagreement arose.

Analysis Tools

CiteSpace (6.1.R2) and VOSviewer were used to perform the bibliometric analysis of retrieved articles. CiteSpace parameters were set as follows: Time Slicing from 1984 JAN to 2020 DEC (Years Per Slice = 1), Node Types selecting (Author or Institution or Country or Keyword or Reference), Selection Criteria selecting g-index (k = 25), Pruning selecting (Pathfinder, Pruning Sliced Networks and Pruning Merged Network).

Statistical analysis was performed using IBM SPSS Statistic version 26.0. The Kendall's rank correlation was employed to test for correlations between publication date and citations.²³

Results

Annual Trends of Publications

The 100 most highly cited publications on acupuncture for migraine were cited 6142 times with an h-index of 44 (Table 1). The highest number of cited articles was 416. The oldest study was published in 1984 (Figure 1A). While the year with the highest citation frequency was 2020 (n=664), 2021 and 2019 were ranked second and third (Figure 1B). Most of the historical studies were published in 2017. The most frequently cited study (n=416) was *Acupuncture for patients with migraine: a randomized controlled trial* by Linde et al. The study was published in the 2005 by *Journal of the American Medical Association (JAMA)*. There is a significant correlation between the current citation (measured as the number of citations in 2021) of an article and its publication date ($r=0.357$, $p=0.000<0.01$, Figure 2A). Further, a significant negative trend towards an increased overall citation was observed ($r=-0.223$, $p=0.001<0.01$, Figure 2B). Among the included studies, 83% were original studies and 17% were review articles (Table 2). The research directions belonged to 13 disciplines. The most common disciplines were neuroscience and neurology, internal medicine and complementary medicine.

Author Analysis

A total of 335 authors contributed to the 100 most highly cited publications on acupuncture for migraine. According to the Price Law formula ($M = 0.749\sqrt{N_{max}}$), authors with more than 2.90 publications were considered main authors.

Table I The 100 Most Highly Cited Publications on Acupuncture for Migraine

	Title	Main Author	Corresponding Author	Citations	Citations (2019–2021)	Citations/Year Since Publication
1	Acupuncture for patients with migraine - A randomized controlled trial ²⁴	Linde, K; Streng, A; Jurgens, S	Linde, K	416	47	24.47
2	The impact of patient expectations on outcomes in four randomized controlled trials of acupuncture in patients with chronic pain ²⁵	Linde, Klaus; Witt, Claudia M.; Streng, Andrea	Linde, K	363	62	24.20
3	Efficacy of acupuncture for the prophylaxis of migraine: a multicentre randomised controlled clinical trial ²⁶	Diener, HC; Kronfeld, K; Boewing, G	Diener, HC	252	32	15.75
4	Acupuncture for Chronic Pain: Update of an Individual Patient Data Meta-Analysis ²⁷	Vickers, Andrew J.; Vertosick, Emily A.; Lewith, George	Vickers, AJ	248	209	62.00
5	Acupuncture for migraine prophylaxis ²⁸	Linde, Klaus; Allais, Gianni; Brinkhaus, Benno	Linde, K	231	26	17.77
6	Acupuncture for chronic headache in primary care: large, pragmatic, randomised trial ²⁹	Vickers, AJ; Rees, RW; Zollman, CE	Vickers, AJ	168	21	9.33
7	Medical management of migraine-related dizziness and vertigo ³⁰	Johnson, GD	Johnson, GD	141	17	5.88
8	The Long-term Effect of Acupuncture for Migraine Prophylaxis A Randomized Clinical Trial ³¹	Zhao, Ling; Chen, Jiao; Li, Ying	Liang, FR	136	101	27.20
9	Acupuncture for recurrent headaches: a systematic review of randomized controlled trials ³²	Melchart, D; Linde, K; Fischer, P	Linde, K	135	3	5.87
10	Acupuncture for the prevention of episodic migraine ³³	Linde, Klaus; Allais, Gianni; Brinkhaus, Benno	Linde, K	126	73	21.00
11	On pins and needles? Pediatric pain patients' experience with acupuncture ³⁴	Kemper, KJ; Sarah, R; Silver-Highfield, E	Kemper, KJ	110	14	5.00
12	Evidence-Based Evaluation of Complementary Health Approaches for Pain Management in the United States ³⁵	Nahin, Richard L.; Boineau, Robin; Khalsa, Partap S.	Nahin, RL	102	61	17.00
13	Acupuncture for migraine prophylaxis: a randomized controlled trial ³⁶	Li, Ying; Zheng, Hui; Witt, Claudia M.	Liang, FR	97	27	9.70
14	Clinical research on acupuncture: Part I. What have reviews of the efficacy and safety of acupuncture told us so far? ³⁷	Birch, S; Hesselink, JK; Jonkman, FAM	Birch, S	92	7	5.11

(Continued)

Table I (Continued).

	Title	Main Author	Corresponding Author	Citations	Citations (2019–2021)	Citations/Year Since Publication
15	Acupuncture and the opioid system: Implications in management of migraine ³⁸	Pintov, S; Lahat, E; Alstein, M	N/A	92	5	3.68
16	Physical treatments for headache: A structured review ³⁹	Biondi, DM	Biondi, DM	89	4	5.24
17	Care and Feeding of the Endocannabinoid System: A Systematic Review of Potential Clinical Interventions that Upregulate the Endocannabinoid System ⁴⁰	McPartland, John M.; Guy, Geoffrey W.; Di Marzo, Vincenzo	McPartland, JM	82	39	10.25
18	Acupuncture in practice: mapping the providers, the patients and the settings in a national cross-sectional survey ⁴¹	Hopton, A. K.; Curnoe, S.; Kanaan, M.	Hopton, AK	82	31	8.20
19	Efficacy of acupuncture for migraine prophylaxis: A single-blinded, double-dummy, randomized controlled trial ⁴²	Wang, Lin-Peng; Zhang, Xiao-Zhe; Guo, Jia	Wang, LP	82	25	7.45
20	Acupuncture in the prophylactic treatment of migraine without aura: A comparison with flunarizine ⁴³	Allais, G; De Lorenzo, C; Quirico, PE	Allais, G	82	20	4.10
21	Cost effectiveness analysis of a randomised trial of acupuncture for chronic headache in primary care ⁴⁴	Wonderling, D; Vickers, AJ; Grieve, R	Wonderling, D	81	7	4.50
22	Acupuncture versus metoprolol in migraine prophylaxis - a randomized trial of trigger point inactivation ⁴⁵	HESSE, J; MOGELVANG, B; SIMONSEN, H	N/A	80	10	2.86
23	The persistence of the effects of acupuncture after a course of treatment: a meta-analysis of patients with chronic pain ⁴⁶	MacPherson, H.; Vertosick, E. A.; Foster, N. E.	MacPherson, H	78	50	15.60
24	Acupuncture in patients with headache ⁴⁷	Jena, S.; Witt, C. M.; Brinkhaus, B.	Willich, SN	72	16	5.14
25	Altered periaqueductal gray resting state functional connectivity in migraine and the modulation effect of treatment ⁴⁸	Li, Zhengjie; Liu, Mailan; Lan, Lei	Zeng, F; Liang, FR	71	37	11.83
26	Acupuncture versus topiramate in chronic migraine prophylaxis: A randomized clinical trial ⁴⁹	Yang, C-P; Chang, M-H; Liu, P-E	Chang, HH	67	19	6.09
27	Influence of Control Group on Effect Size in Trials of Acupuncture for Chronic Pain: A Secondary Analysis of an Individual Patient Data Meta-Analysis ⁵⁰	MacPherson, Hugh; Vertosick, Emily; Lewith, George	MacPherson, H	63	16	7.88
28	Traditional acupuncture in migraine: A controlled, randomized study ⁵¹	Facco, Enrico; Liguori, Aldo; Petti, Filomena	Facco, E	62	12	4.43

29	Acupuncture for Treating Acute Attacks of Migraine: A Randomized Controlled Trial ⁵²	Li Ying; Liang Fanrong; Yang Xuguang	Li, Y	61	21	4.69
30	Acupuncture in migraine prophylaxis: a randomized sham-controlled trial ⁵³	Alecrim-Andrade, J; Maciel-Junior, JA; Cladellas, XC	Alecrim-Andrade, J	58	11	3.63
31	Acupuncture in migraine - Investigation of autonomic effects ⁵⁴	Baecker, Marcus; Grossman, Paul; Schneider, Jens	Backer, M	57	12	4.07
32	Acupuncture versus medical-treatment for migraine and muscle tension headaches ⁵⁵	LOH, L; NATHAN, PW; SCHOTT, GD	N/A	57	0	1.50
33	Management of primary chronic headache in the general population: the Akershus study of chronic headache ⁵⁶	Kristoffersen, Espen Saxhaug; Grande, Ragnhild Berling; Aaseth, Kjersti	Russell, MB	56	18	5.60
34	Use of complementary and alternative medicine in patients suffering from primary headache disorders ⁵⁷	Gaul, C.; Eismann, R.; Schmidt, T.	Gaul, C	55	10	4.23
35	Cost-effectiveness of acupuncture treatment in patients with headache ⁵⁸	Witt, C. M.; Reinhold, T.; Jena, S.	Witt, CM	55	7	3.93
36	Laser acupuncture in children with headache: A double-blind, randomized, bicenter, placebo-controlled trial ⁵⁹	Gottschling, Sven; Meyer, Sascha; Gribova, Inessa	Gottschling, S	53	12	3.79
37	Acupuncture for pain: An overview of Cochrane reviews ⁶⁰	Lee, Myeong Soo; Ernst, Edzard	Lee, MS	51	12	4.64
38	Effectiveness and tolerability of acupuncture compared with metoprolol in migraine prophylaxis ⁶¹	Streng, Andrea; Linde, Klaus; Hoppe, Andrea	Streng, A	51	13	3.19
39	A randomized, controlled trial of acupuncture for chronic daily headache ⁶²	Coeytaux, RR; Kaufman, JS; Kaptchuk, TJ	Coeytaux, RR	50	4	2.94
40	Acupuncture of chronic headache disorders in primary care: randomised controlled trial and economic analysis ⁶³	Vickers, AJ; Rees, RW; Zollman, CE	Vickers, AJ	50	3	2.78
41	A PET-CT study on the specificity of acupoints through acupuncture treatment in migraine patients ⁶⁴	Yang, Jie; Zeng, Fang; Feng, Yue	Liang, FR	49	18	4.90
42	Nonpharmacologic Treatments for Migraine and Tension-Type Headache: How to Choose and When to Use ⁶⁵	Nicholson, Robert A.; Buse, Dawn C.; Andrasik, Frank	Nicholson, RA	48	9	4.36
43	Effects of Long-Term Acupuncture Treatment on Resting-State Brain Activity in Migraine Patients: A Randomized Controlled Trial on Active Acupoints and Inactive Acupoints ⁶⁶	Zhao, Ling; Liu, Jixin; Zhang, Fuwen	Liu, JX	46	23	5.75

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Table 1 (Continued).

	Title	Main Author	Corresponding Author	Citations	Citations (2019–2021)	Citations/Year Since Publication
44	Acupuncture modulates the abnormal brainstem activity in migraine without aura patients ⁶⁷	Li, Zhengjie; Zeng, Fang; Yin, Tao	Liang, FR	44	34	8.80
45	Adverse events associated with acupuncture: three multicentre randomized controlled trials of 1968 cases in China ⁶⁸	Zhao, Ling; Zhang, Fu-wen; Li, Ying	Liang, FR	43	11	3.91
46	Alternative Headache Treatments: Nutraceuticals, Behavioral and Physical Treatments ⁶⁹	Sun-Edelstein, Christina; Mauskop, Alexander;	Mauskop, A	43	13	3.91
47	Acupuncture in migraine prevention - A randomized sham controlled study with 6-months posttreatment follow-up ⁷⁰	Alecrim-Andrade, Jerusa; Maciel-Junior, Jayme Antunes; Carne, Xavier	Alecrim-Andrade, J	43	11	3.07
48	Efficacy of Acupuncture for Acute Migraine Attack: A Multicenter Single Blinded, Randomized Controlled Trial ⁷¹	Wang, Lin-Peng; Zhang, Xiao-Zhe; Guo, Jia	Wang, LP	42	17	4.20
49	Update on the prophylaxis of migraine ⁷²	Schuerks, Markus; Diener, Hans-Christoph; Goadsby, Peter	Diener, HC	42	6	3.00
50	Complementary and integrative medicine in the management of headache ⁷³	Millstine, Denise; Chen, Christina Y.; Bauer, Brent	Millstine, D	41	31	8.20
51	Variability in the diagnosis and point selection for persons with frequent headache by Traditional Chinese Medicine acupuncturists ⁷⁴	Coeytaux, Remy R.; Chen, Wunian; Lindemuth, Catherine E.	Coeytaux, RR	41	8	2.56
52	Acupuncture for Pain ⁷⁵	Kelly, Robert B.; Willis, Joel	Kelly, RB	39	25	13.00
53	Acupuncture for the Management of Chronic Headache: A Systematic Review ⁷⁶	Sun, Yanxia; Gan, Tong J.	Gan, TJ	39	4	2.79
54	Guidelines for the nonpharmacologic management of migraine in clinical practice ⁷⁷	Pryse-Phillips, WEM; Dodick, DW; Edmeads, JG	Pryse-Phillips, WEM	39	3	1.63
55	Survey on treatments for primary headaches in 13 specialized juvenile Headache Centers: The first multicenter Italian study ⁷⁸	Toldo, Irene; Rattin, Martina; Perissinotto, Egle	Toldo, I	37	11	7.40
56	Ear acupuncture in the treatment of migraine attacks: a randomized trial on the efficacy of appropriate versus inappropriate acupoints ⁷⁹	Allais, Gianni; Romoli, Marco; Rolando, Sara	Allais, G	37	10	3.36
57	Individual patient data meta-analysis of acupuncture for chronic pain: protocol of the Acupuncture Trialists' Collaboration ⁸⁰	Vickers, Andrew J.; Cronin, Angel M.; Maschino, Alexandra C.	Vickers, AJ	37	5	3.08

58	Acupuncture versus placebo versus sumatriptan for early treatment of migraine attacks: a randomized controlled trial ⁸¹	Melchart, D; Thormaehlen, J; Hager, S	Melchart, D	37	2	1.95
59	Manual acupuncture versus sham acupuncture and usual care for prophylaxis of episodic migraine without aura: multicentre, randomised clinical trial ⁸²	Xu, Shabei; Yu, Lingling; Luo, Xiang	Wang, W	35	21	17.50
60	Designing an acupuncture study: The nationwide, randomized, controlled, German acupuncture trials on migraine and tension-type headache ⁸³	Molsberger, AF; Boewing, G; Diener, HC	Molsberger, AF	34	5	2.13
61	Complementary and alternative medicine (CAM) use in an Italian cohort of pediatric headache patients: the tip of the iceberg ⁸⁴	Dalla Libera, D.; Colombo, B.; Pavan, G.	Dalla Libera, D	33	15	4.13
62	Costs and consequences of acupuncture as a treatment for chronic pain: A systematic review of economic evaluations conducted alongside randomised controlled trials ⁸⁵	Ambrosio, E. M. M.; Bloor, K.; MacPherson, H.	MacPherson, H	32	7	3.20
63	Acupuncture in headache: A critical review ⁸⁶	Manias, P; Tagaris, G; Karageorgiou, K	Manias, P	32	2	1.45
64	Non-pharmacological approach to migraine prophylaxis: part II ⁸⁷	Schiapparelli, Paola; Allais, Gianni; Gabellari, Ilaria Castagnoli	Allais, G	31	3	2.58
65	An fMRI-based neural marker for migraine without aura ⁸⁸	Tu, Yiheng; Zeng, Fang; Lan, Lei	Kong, J	30	23	15.00
66	The effects of acupuncture treatment on the right frontoparietal network in migraine without aura patients ⁸⁹	Li, Kuangshi; Zhang, Yong; Ning, Yanzhe	Ren, Y	30	16	4.29
67	Traditional and evidence-based acupuncture in headache management: Theory, mechanism, and practice ⁹⁰	Zhao, CH; Stillman, MJ; Rozen, TD	Zhao, CH	30	7	1.76
68	Role of the needling per se in acupuncture as prophylaxis for menstrually related migraine: a randomized placebo-controlled study ⁹¹	Linde, M; Fjell, A; Carlsson, J	Linde, M	30	1	1.76
69	Acupuncture for analgesia in the emergency department: a multicentre, randomised, equivalence and non-inferiority trial ⁹²	Cohen, Marc M.; Smit, De Villiers; Andrianopoulos, Nick	Cohen, MM	29	21	5.80
70	Electroacupuncture stimulation at sub-specific acupoint and non-acupoint induced distinct brain glucose metabolism change in migraineurs: a PET-CT study ⁹³	Yang, Mingxiao; Yang, Jie; Zeng, Fang	Xie, HJ	29	17	3.63
71	Acupuncture for Pain ⁹⁴	Kelly, Robert B.	Kelly, RB	29	8	2.23

(Continued)

Table I (Continued).

	Title	Main Author	Corresponding Author	Citations	Citations (2019–2021)	Citations/Year Since Publication
72	Non-pharmacological approaches to chronic headaches: transcutaneous electrical nerve stimulation, laser therapy and acupuncture in transformed migraine treatment ⁹⁵	Allais, G; De Lorenzo, C; Quirico, PE	Allais, G	29	9	1.53
73	Acupuncture for Migraine Prevention ⁹⁶	Da Silva, Arnaldo Neves	Da Silva, AN	28	7	4.00
74	Complementary and Integrative Medicine for Episodic Migraine: an Update of Evidence from the Last 3 Years ⁹⁷	Wells, Rebecca Erwin; Beuthin, Justin; Granetzke, Laura	Wells, RE	27	26	9.00
75	The altered right frontoparietal network functional connectivity in migraine and the modulation effect of treatment ⁹⁸	Li, Zhengjie; Lan, Lei; Zeng, Fang	Liang, FR	27	23	5.40
76	Acupuncture for chronic pain within the research program of 10 German Health Insurance Funds - Basic results from an observational study ⁹⁹	Weidenhammer, W.; Streng, A.; Linde, K.	Weidenhammer, W	27	6	1.80
77	Acupuncture in an outpatient clinic in China: A comparison with the use of acupuncture in North America ¹⁰⁰	Xu, XQ	Xu, XQ	26	0	1.24
78	Attitudes towards complementary and alternative medicine in chronic pain syndromes: a questionnaire-based comparison between primary headache and low back pain ¹⁰¹	Gaul, Charly; Schmidt, Thomas; Czaja, Eva	Gaul, C	25	6	2.27
79	Acupuncture for Frequent Migraine: A Randomized, Patient/Assessor Blinded, Controlled Trial with One-Year Follow-Up ¹⁰²	Wang, Yanyi; Xue, Charlie Changli; Helme, Robert	Zheng, Z	24	14	3.43
80	Acupuncture for chronic headaches - An epidemiological study ¹⁰³	Melchart, D; Weidenhammer, W; Streng, A	Linde, K	24	3	1.50
81	Acupuncture versus valproic acid in the prophylaxis of migraine without aura: a prospective controlled study ¹⁰⁴	Facco, E.; Liguori, A.; Petti, F.	Facco, E	23	10	2.56
82	A Rational Approach to the Management of Chronic Migraine ¹⁰⁵	Evans, Randolph W.	Evans, RW	23	1	2.56
83	Clinical Efficacy and Safety of Electroacupuncture in Migraine Treatment: A Systematic Review and Network Meta-Analysis ¹⁰⁶	Li, Xinyi; Dai, Qianqian; Shi, Zhaofeng	Tian, GH	22	16	7.33
84	Acupuncture in primary headache treatment ¹⁰⁷	Schiapparelli, Paola; Allais, Gianni; Rolando, Sara	Allais, G	22	3	2.00
85	Effect of Acupressure and Trigger Points in Treating Headache: a Randomized Controlled Trial ¹⁰⁸	Hsieh, Lisa Li-Chen; Liou, Horng-Huei; Lee, Liang-Huei	Chen, THH	22	3	1.83

86	Antagonism of cannabinoid receptor 1 attenuates the anti-inflammatory effects of electroacupuncture in a rodent model of migraine ¹⁰⁹	Zhang, Hui; He, Shengdong; Hu, Youping	Zhang, H	21	16	3.50
87	Non-pharmacological management of migraine during pregnancy ¹¹⁰	Airola, Gisella; Allais, Gianni; Gabellari, Ilaria Castagnoli	Allais, G	21	5	1.75
88	Treatment in a randomized multicenter trial of acupuncture for migraine (ART migraine) ¹¹¹	Linde, Klaus; Streng, Andrea; Hoppe, Andrea	Linde, K	21	4	1.31
89	Acupuncture for migraine without aura: a systematic review and meta-analysis ¹¹²	Xu, Jia; Zhang, Fu-qing; Pei, Jian	Pei, J	20	17	5.00
90	Verum versus sham manual acupuncture for migraine: a systematic review of randomised controlled trials ¹¹³	Yang, Yan; Que, Qinghui; Ye, Xiaode	Zheng, GH	20	12	3.33
91	Randomized controlled trial to treat migraine with acupuncture: design and protocol ¹¹⁴	Li, Ying; Liang, Fanrong; Yu, Shuguang	Liang, FR	20	1	1.43
92	Acupuncture in migraine - long-term outcome and predicting factors ¹¹⁵	BAISCHER, W	N/A	20	1	0.74
93	Integration of White Matter Network Is Associated with Interindividual Differences in Psychologically Mediated Placebo Response in Migraine Patients ¹¹⁶	Liu, Jixin; Ma, Shaohui; Mu, Junya	Zhang, M	19	15	3.80
94	A migraine management training program for primary care providers: an overview of a survey and pilot study findings, lessons learned, and considerations for further research ¹¹⁷	Minen, Mia; Shome, Ashna; Halpern, Audrey	Minen, M	19	16	3.17
95	Acupuncture decreases matrix metalloproteinase-2 activity in patients with migraine ¹¹⁸	Cayir, Yasemin; Ozdemir, Gokhan; Celik, Mine	Cayir, Y	19	10	2.38
96	Acupuncture in migraine prophylaxis in Czech patients: an open-label randomized controlled trial ¹¹⁹	Musil, Frantisek; Pokladnikova, Jitka; Pavelek, Zbysek	Pokladnikova, J	18	15	4.50
97	Complementary and Integrative Medicine for Neurologic Conditions ¹²⁰	Wells, Rebecca Erwin; Baute, Vanessa; Wahbeh, Helane	Wells, RE	18	16	3.60
98	Ear acupuncture in the control of migraine pain: selecting the right acupoints by the "needle-contact test" ¹²¹	Romoli, M; Allais, G; Airola, G	Allais, G	18	8	1.06
99	Acupuncture Reversible Effects on Altered Default Mode Network of Chronic Migraine Accompanied with Clinical Symptom Relief ¹²²	Zou, Yan; Tang, Weijun; Li, Xiang	Li, J	17	11	5.67
100	Brain Structural Properties Predict Psychologically Mediated Hypoalgesia in an 8-Week Sham Acupuncture Treatment for Migraine ¹²³	Liu, Jixin; Mu, Junya; Liu, Qianqian	Zhang, M	17	14	3.40

Notes: N/A indicates that the article is not marked. Main authors are the top three authors of the paper.

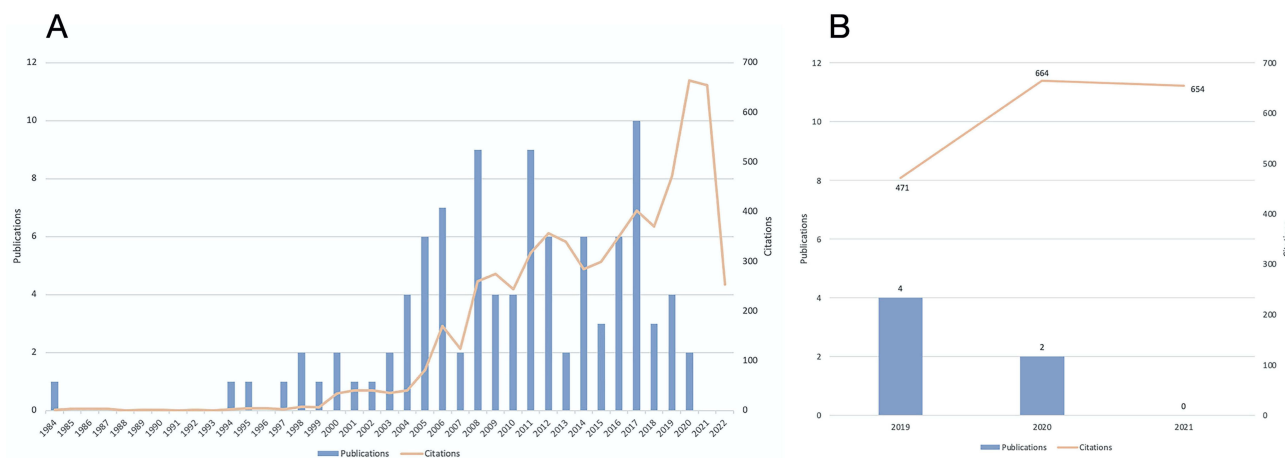


Figure 1 (A) Annual trends of the 100 most highly cited publications on acupuncture for migraine. (B) The top 3 years with the highest citation frequency.

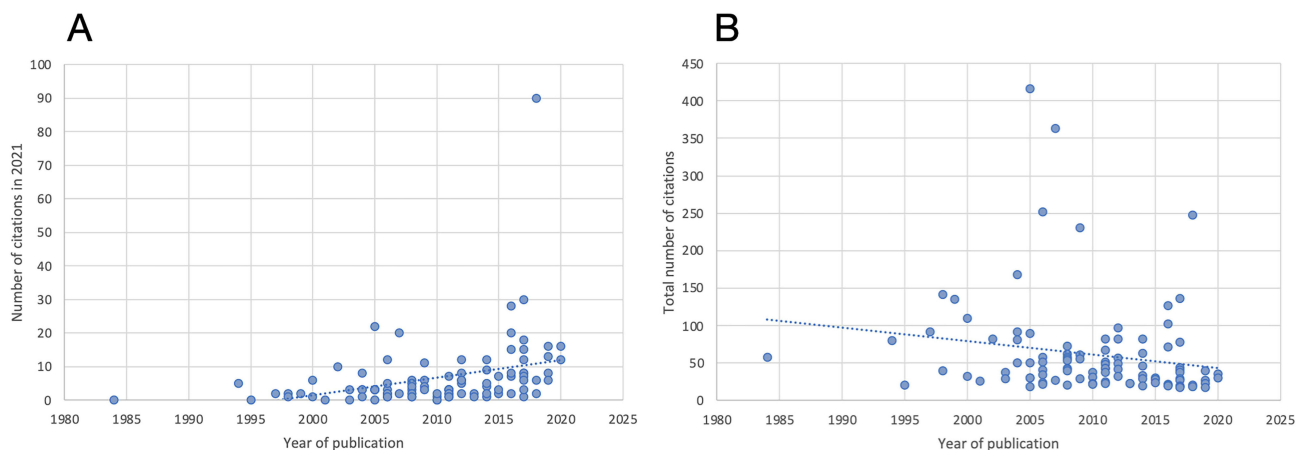


Figure 2 Association of (A) current (2021= last full year) citation rate and (B) overall citations with the year of publication.

There were 34 main authors and 19 authors with at least five publications (Table 3). A total of 15 papers were published by Linde K, who was the largest contributor with 1914 cumulative citations. About 12 and 10 papers were published by Liang FR and Allais G, respectively. Figure 3 shows the co-linear mapping between authors. The authors were roughly divided into three groups: Liang FR, Linde K and Allais G. The authors on Liang FR’s team work closely together. The Linde K team has the largest number of members, and there is a collaboration between the Allais G and Linde K teams.

Table 2 Document Types and Research Areas for the 100 Most Highly Cited Publications on Acupuncture for Migraine

Variable	Results Counts
Document Types	
Articles	83
Review Articles	17
Research Areas	
Neurosciences Neurology	51
General Internal Medicine	23
Integrative Complementary Medicine	16

(Continued)

Table 2 (Continued).

Variable	Results Counts
Anesthesiology	10
Research Experimental Medicine	5
Science Technology Other Topics	4
Pediatrics	3
Psychiatry	2
Radiology Nuclear Medicine Medical Imaging	2
Health Care Sciences Services	1
Otorhinolaryngology	1
Surgery	1

Table 3 Main Authors with More Than Five Publications of the 100 Most Highly Cited Publications on Acupuncture for Migraine

Rank	Author	Publications	Corresponding Author Frequency	Country	Institution
1	Linde, K	15	7	Germany	Tech Univ Munich
2	Liang, FR	12	8	China	Chengdu Univ Tradit Chinese Med
3	Allais, G	10	7	Italy	Univ Turin
4	Li, Y	9	1	China	Chengdu Univ Tradit Chinese Med
5	Melchart, D	9	1	Germany	Tech Univ
6	Witt, CM	8	1	Germany	Charite Univ Med Berlin
7	Benedetto, C	7	0	Italy	Univ Turin
8	Brinkhaus, B	7	0	Germany	Charite
9	Vickers, AJ	7	4	USA	Mem Sloan Kettering Canc Ctr
10	Airola, G	6	0	Italy	Univ Turin
11	Lan, L	6	0	China	Hunan Univ Tradit Chinese Med
12	MacPherson, H	6	3	England	Univ York
13	Streng, A	6	1	Germany	Tech Univ Munich
14	Weidenhammer, W	6	1	Germany	Tech Univ Munich
15	Zeng, F	6	1	China	Chengdu Univ Tradit Chinese Med
16	Hoppe, A	5	0	Germany	Tech Univ Munich
17	Willich, SN	5	1	Germany	Charite Univ Med Berlin
18	Yang, Jie	5	0	China	Chengdu Univ Tradit Chinese Med
19	Zheng, H	5	0	China	Chengdu Univ Tradit Chinese Med
20	Chang, XR	4	0	China	Hunan Univ Tradit Chinese Med
21	Gong, QY	4	0	China	Sichuan Univ

(Continued)

Table 3 (Continued).

Rank	Author	Publications	Corresponding Author Frequency	Country	Institution
22	Kong, J	4	1	USA	Massachusetts General Hospital and Harvard Medical School
23	Lewith, G	4	0	England	Univ Southampton
24	Li, ZJ	4	0	China	Chengdu Univ Tradit Chinese Med
25	Liu, ML	4	0	China	Hunan Univ Chinese Med
26	Rolando, S	4	0	Italy	Univ Turin
27	Dong, MK	3	0	China	Chengdu Univ Tradit Chinese Med
28	Liu, JX	3	1	China	Xidian Univ
29	Guo, TP	3	0	China	Chengdu Univ Tradit Chinese Med
30	Gao, Yujie	3	0	China	Chengdu Univ Tradit Chinese Med
31	Diener, HC	3	2	Germany	Univ Duisburg Essen
32	McCarney, R	3	0	England	Univ London Imperial Coll Sci Technol & Med
33	Mana, Ornella	3	0	Italy	Univ Turin
34	Pfaffenrath, V	3	0	Germany	University of Essen

Country and Institution Analysis

According to the results of the analysis, 20 countries were involved in studies on acupuncture for migraine (Figure 4). The most published studies came from the United States (n=36), followed by China (n=27) and Germany (n=26) (Table 4).

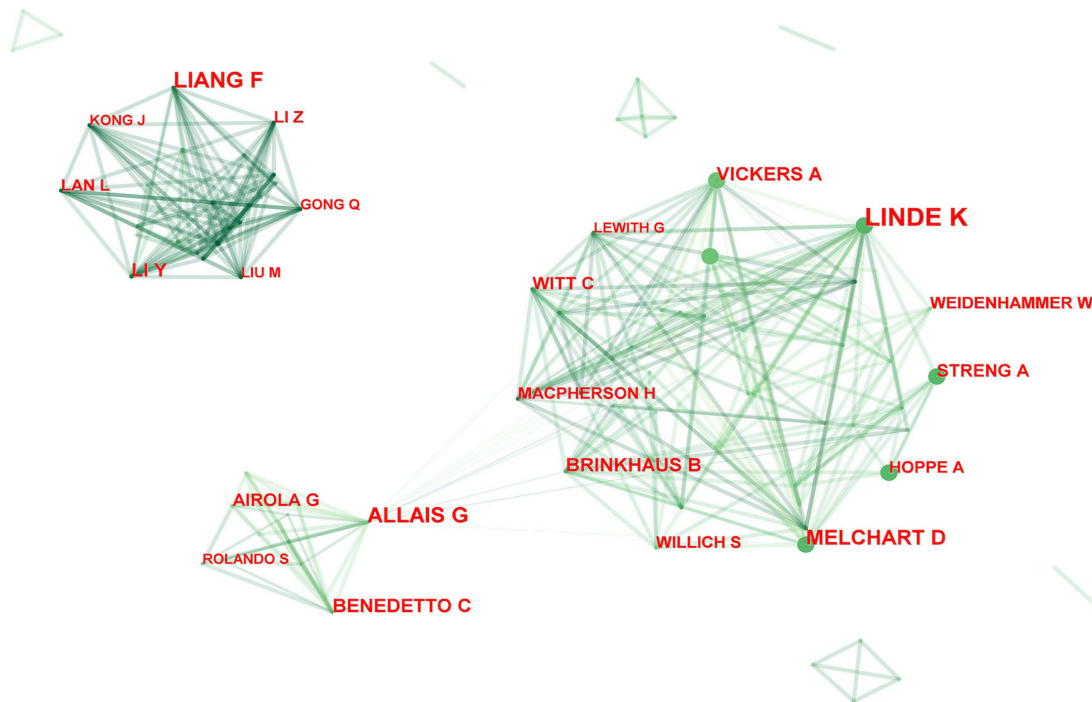


Figure 3 The author-collaboration network of the 100 most highly cited publications on acupuncture for migraine.

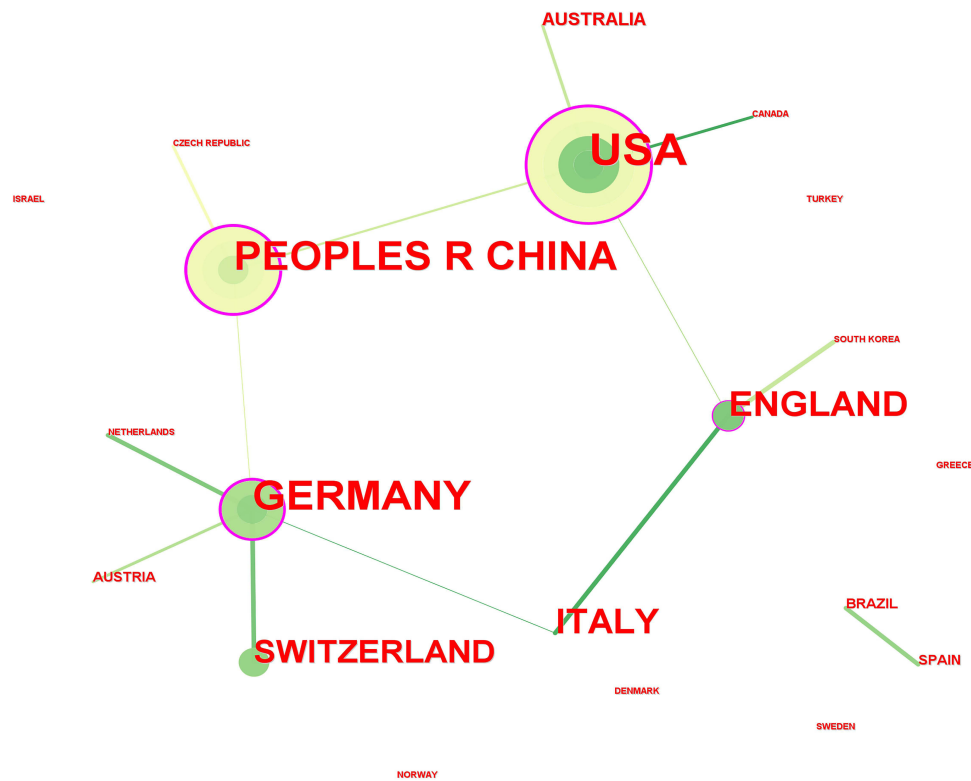


Figure 4 The country-collaboration network of the 100 most highly cited publications on acupuncture for migraine. The node radius represents the number of published documents, and the larger the number of published documents, the larger the radius. The color is related to the year of publication, and the darker the color, the larger the year. A node with a purple outer ring is a critical node, meaning that the centrality of the mediation is greater than 0.1.

A total of 212 institutions were involved in publishing at least one study on acupuncture for migraine (Figure 5). A total of 19 institutions published more than three papers, with the top five publishers being the Technical University of Munich (n = 15), the Chengdu University of Traditional Chinese Medicine (n = 13), Charité University Hospital of Berlin (n = 13), the Memorial Sloan Kettering Cancer Center (n = 9) and the University Hospital of Zurich (n = 9).

Table 4 Countries of the 100 Most Highly Cited Publications on Acupuncture for Migraine

Rank	Countries	Publications
1	USA	36
2	Peoples R China	27
3	Germany	26
4	England	15
5	Italy	15
6	Switzerland	12
7	Australia	3
8	Austria	2
9	Brazil	2
10	Spain	2
11	Turkey	1
12	Canada	1
13	Czech Republic	1
14	Denmark	1
15	Greece	1

(Continued)

Table 4 (Continued).

Rank	Countries	Publications
16	Israel	1
17	Netherlands	1
18	Norway	1
19	South Korea	1
20	Sweden	1

Journal Analysis

The 100 most highly cited publications on acupuncture for migraine were published in 50 journals (Table 5). *Headache* published 13 papers and was the most contributing journal. Based on the 2021 Impact Factor (IF), 11 journals with an IF more than 10 published 16 highly cited publications with 1789 citations, accounting for 29.13% of the total citations. Among them, *BMJ-British Medical Journal* published the largest number of papers (n=3), followed by *Canadian Medical Association Journal* (n=2), *Cochrane Database of Systematic Reviews* (n=2), and *Journal of Internal Medicine* (n=2). Encouragingly, one article with 416 citations was published in the *JAMA* (IF=157.335, Q1).

Keyword Analysis

We found 140 keywords (Figure 6). The most popular keywords were “acupuncture”, “migraine”, “headache”, “randomized controlled trial”, “pain”, “complementary medicine”, “prophylaxis”, “alternative medicine”, “meta-analysis” and “treatment”. The average $S = 0.8431 > 0.7$ indicated that the ten clusters were reliable (Figure 7).

Analysis of Co-Cited Literature

The co-cited literatures were divided into 14 clusters (Figure 8A). In the timeline view, clustering #5 (fMRI-based neural marker) is the main focus of recent studies (Figure 8B). The node represents references, the abscissa represents the year of initial reference, and the ordinate represents cluster. Node and font size are positively correlated with reference frequency. The most cited article was published by Linde K in 2005.

Discussion

Basic Information Analysis

We analyzed the year of publication, frequency of citations, and disciplinary distribution of these publications. Among the 100 most highly cited publications, the earliest heavily cited study was published in 1984, and after a decade of silence, at least 1 highly cited paper was consistently published starting in 1994 (excluding 1996), reaching its highest level in 2017 (n=10). A publication by Linde K published in 2005 had the highest citation frequency (n=416). Research in the field of acupuncture for migraine has been frequently cited in the last three years, indicating a continued increase in interest in the field. This study covered a wide range of disciplines- neurology,³² general medicine,²⁹ complementary medicine,¹⁰⁶ anesthesiology²⁵ and pediatrics.³⁴ These results suggest that the analgesic effects of acupuncture are of interest to multiple disciplines, and that acupuncture is used not only in adult migraine but also plays an active therapeutic role in childhood migraine.

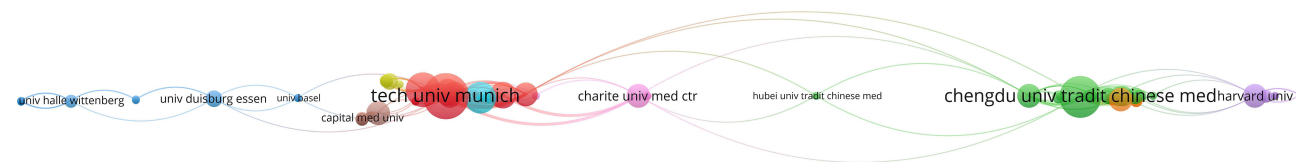


Figure 5 The organization cooperation network of the 100 most highly cited publications on acupuncture for migraine.

Table 5 Journals of the 100 Most Highly Cited Publications on Acupuncture for Migraine

Rank	Journal	Publications	Citations	IF	JCI Quartile	5 Year IF
1	Headache	13	582	5.311	Q1	5.082
2	Cephalalgia	8	499	6.075	Q1	5.837
3	Neurological Sciences	7	191	3.83	Q2	3.495
4	Pain	4	576	7.926	Q1	8.085
5	Acupuncture In Medicine	3	191	1.976	Q3	2.188
6	BMJ British Medical Journal	3	167	96.2	Q1	64.7
7	Clinical Journal of Pain	3	157	3.423	Q2	4.228
8	Journal Of Alternative And Complementary Medicine	3	132	2.381	Q2	2.724
9	PLoS One	3	100	3.752	Q1	4.069
10	Trials	3	60	2.728	Q3	2.754
11	American Family Physician	2	357	5.305	Q1	7.361
12	American Journal of Chinese Medicine	2	136	6.005	Q1	5.05
13	BMC Complementary And Alternative Medicine	2	117	4.782	Q1	4.479
14	Canadian Medical Association Journal	2	90	16.859	Q1	14.137
15	Cochrane Database of Systematic Reviews	2	86	12.008	Q1	11.956
16	Complementary Therapies in Medicine	2	74	3.335	Q2	3.416
17	Current Treatment Options in Neurology	2	68	3.972	Q3	3.799
18	Human Brain Mapping	2	59	5.399	Q1	5.805
19	Journal Of Headache and Pain	2	44	8.588	Q1	7.085
20	Journal Of Internal Medicine	2	36	13.068	Q1	11.396
21	Anesthesia And Analgesia	1	416	6.627	Q1	6.041
22	BMJ Open	1	252	3.006	Q1	3.586
23	British Medical Journal	1	248	17.215 (2012)	Q1	15.88
24	Chinese Journal Of Integrative Medicine	1	168	2.626	Q2	2.395
25	Current Pain and Headache Reports	1	141	3.904	Q3	4.11
26	European Journal of Paediatric Neurology	1	136	3.692	Q1	3.398
27	Evidence Based Complementary and Alternative Medicine	1	110	2.65	Q2	3.014
28	Forschende Komplementarmedizin Und Klassische Naturheilkunde	1	102	1.417 (2006)	Q2	N/A
29	Health Technology Assessment	1	92	4.106	Q1	5.026
30	Jama Internal Medicine	1	82	44.409	Q1	32.295
31	Jama Journal of The American Medical Association	1	71	157.335	Q1	101.13
32	Journal of Integrative Medicine Jim	1	57	3.951	Q1	3.543
33	Journal of Neurology Neurosurgery and Psychiatry	1	51	13.654	Q1	12.011
34	Journal of Pain	1	50	5.383	Q1	7.04
35	Journal of Translational Medicine	1	44	8.44	Q1	7.547
36	Lancet Neurology	1	42	59.935	Q1	50.844
37	Laryngoscope	1	39	2.97	Q2	3.195
38	Mayo Clinic Proceedings	1	37	12.299	Q1	11.26
39	Medical Clinics of North America	1	30	6.912	Q1	6.029
40	Medical Journal of Australia	1	29	12.776	Q1	9.863
41	Minerva Anestesiologica	1	29	3.396	Q2	2.888
42	Neural Plasticity	1	27	3.144	Q3	4.651
43	Neuroimage Clinical	1	26	4.891	Q2	5.692
44	Neurology	1	24	11.8	Q1	11.602
45	Neuropsychiatric Disease and Treatment	1	23	2.989	Q3	3.482
46	Pain Medicine	1	21	3.637	Q1	3.721
47	Pediatric Neurology	1	20	4.21	Q2	3.744
48	Pediatrics	1	18	9.703	Q1	9.398
49	Scientific Reports	1	18	4.996	Q1	5.516
50	Southern Medical Journal	1	17	0.81	Q3	1.134

Note: "N/A" was assigned when the researchers unable to get information from the Journal Citation Report (2021).

Abbreviations: IF, Impact factors; JCI, Journal Citation Indicator.

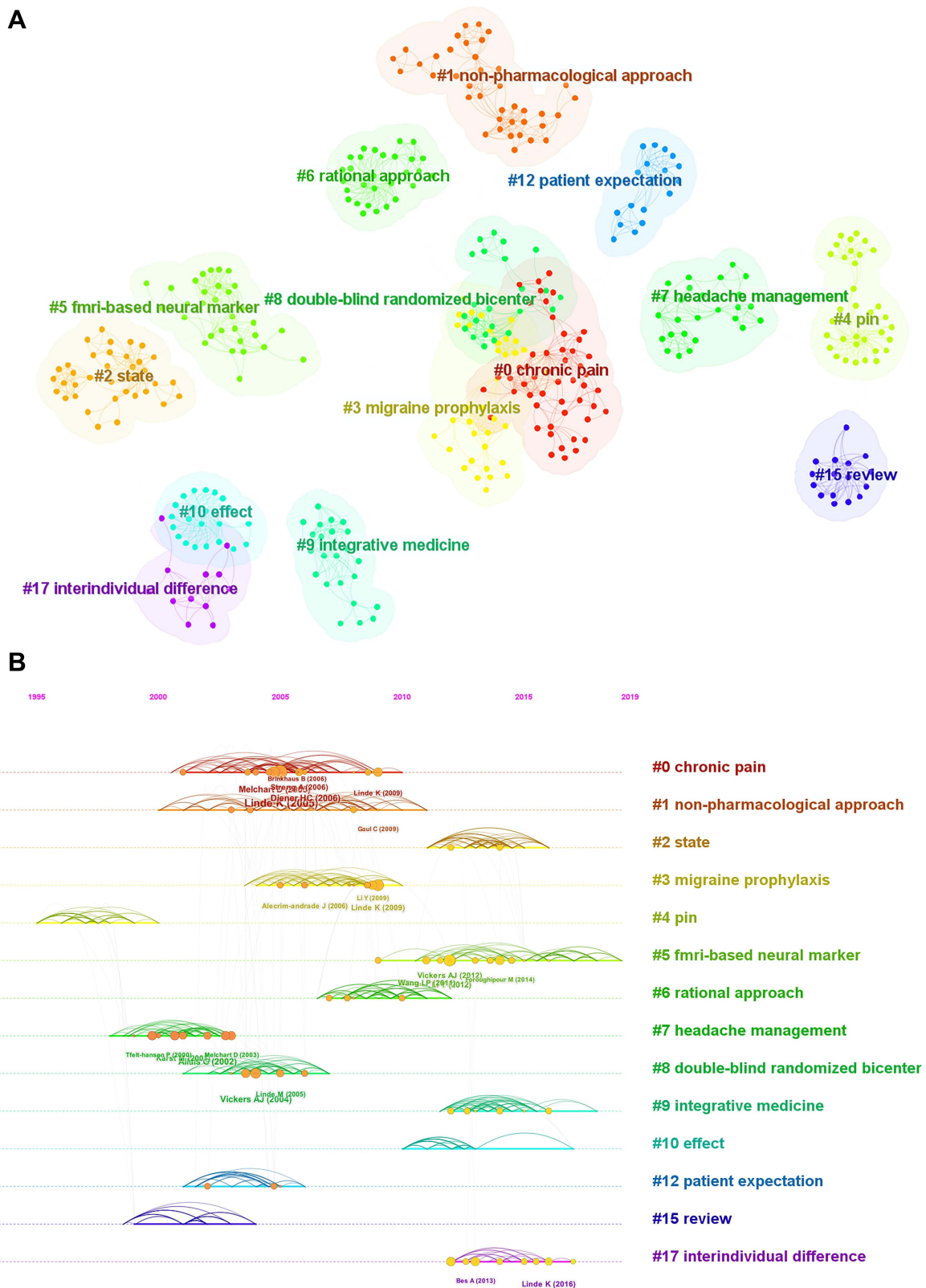


Figure 8 (A) Cluster map of co-cited reference based on label clusters with title terms. **(B)** Timeline view of co-cited references of the 100 most highly cited publications on acupuncture for migraine.

A total of 50 journals were involved in publishing the 100 most cited publications. Sixteen papers were published in journals with an IF greater than 10, and 54 papers were published in journals with an IF greater than 5. The two most published journals were *Headache* (n = 13) and *Cephalalgia* (n = 8), both of which are leading journals in clinical neurology. In addition, several articles were published in top journals such as *JAMA* (IF = 157.355), *BMJ-British Medical Journal* (IF = 96.2) and *Lancet Neurology* (IF = 59.935). Journals with high partition and high IF have a high academic impact and high-quality papers are usually published in such journals. In the present study, most of the journals belonged to the JCI Quartile Q1 (n=32), and these results suggest that the field of acupuncture for migraine has attracted wide attention from researchers and the quality of publications is excellent.

We analyzed the distribution of authors, countries/regions, and institutions for these publications. A total of 335 authors were involved in this study. The top three most prolific authors were Linde K, Liang FR and Allais g. Linde K was one of the most influential authors, publishing papers with 31.16% of the total citations. The most cited publications also came from Linde K. A total of 20 countries and 212 institutions were involved in the study, and the United States was found to have the highest number of publications, followed by China and Germany. Research institutions from the US, China, and Germany published more than 73% of the 100 highly cited publications. Among the top five institutions publishing the most articles, Germany and the US each had two institutions, and only one institution from China was selected. It is noteworthy that since the first highly cited paper from China was published in the SCI-E database in 2008, Chinese scholars have published 22 articles so far. This represents 32.35% of the top 100 cited articles (n = 68) and 948 citations, accounting for 28.15% of the total citations after 2008 (n = 3367). China is gradually becoming the most influential country in the field of acupuncture for migraine treatment.

Research Hotspots

By removing the subject terms (acupuncture and migraine) and the disciplinary terms (complementary medicine and alternative medicine), the main keywords were “headache”, “randomized controlled trial”, “migraine”, “pain”, “prophylaxis”, “chronic pain”, “meta-analysis”, “systematic review” and “treatment”.

Clinical Studies

The 100 most highly cited studies investigated different types of migraine, such as migraine without aura,⁴³ chronic migraine⁴⁹ or menstrually related migraine.⁹¹ Regarding the acupuncture techniques, the conventional acupuncture, ear acupuncture, laser acupuncture and electroacupuncture achieved good results. Romoli et al¹²¹ published a case report documenting the ability of ear acupuncture to reduce pain in migraine patients until 24 hours. A randomized trial confirmed the efficacy of ear acupuncture for migraine.⁷⁹ Gottschling et al⁵⁹ investigated the efficacy of laser acupuncture vs placebo for the treatment of childhood headache. The results showed a significant reduction in the average number of headaches per month in children treated with laser acupuncture. Other studies investigated the optimal selection of acupuncture points. In 37 patients with frequent headaches, most of the subjects were found to have the “liver stagnation and qi stagnation” syndrome, with the optimal acupuncture points being Tai Chong (LR3), He Gu (LI4) and Bai Hui (DU20).⁷⁴ Interestingly, the clinical efficacy of several combinations of acupuncture points differed.⁶⁴

Systematic Reviews and Meta-Analyses

Systematic reviews and meta-analyses played a major role in this study. The results of the most cited controlled trials showed no difference between acupuncture and sham acupuncture in migraine patients.²⁴ However, newer systematic reviews with more high-quality studies suggested a beneficial effect of acupuncture for migraine. Two systematic reviews published by Linde et al^{28,33} demonstrated that acupuncture is comparable to, and perhaps even more effective than, prophylactic medications, but long-term studies are lacking. In addition, a few systematic reviews focused on chronic pain. A meta-analysis of high-quality trials showed that about 90% of the positive effects of acupuncture on chronic pain, including headache and migraine, lasted up to 12 months.⁴⁶ The beneficial effects and long-term efficacy of acupuncture are supported by scientific evidence so far. Furthermore, acupuncture has been listed in several guidelines for migraine treatment.^{65,77,87,110}

Future Trends

The field of acupuncture for migraine has progressed since 2008. Increasing cooperation between countries has contributed to further developments. Since 2008, China ranks first among all countries in terms of number of publications and citations. China is gradually becoming one of the most influential countries investigating acupuncture for migraine. Despite the conventional use of acupuncture as a treatment, research in the field has not been limited to efficacy. The 100 most highly cited publications covered studies on the pathogenesis of migraine, acupoints specificity and the mechanisms of acupuncture. The continued interest of researchers has contributed to the diversity and innovation in this area.

The clustering #5 is the most relevant topic in the 100 most highly cited publications. Only two studies focused on biomarkers, one of them was conducted in animals.¹⁰⁹ In recent years, there has been an increasing number of studies using neuroimaging. Liang FR as the most represented corresponding authors previously combined neuroimaging with acupuncture. Li et al⁹⁸ suggested that the resting state functional connectivity (rs-fc) of right frontoparietal network (rFPN) was abnormal in brain regions of migraine patients compared to healthy individuals. The rs-fc of rFPN improved after acupuncture treatment and the improvement was positively correlated with headache relief. Different acupuncture points induced different levels of cerebral glucose metabolism in pain-related brain regions.⁶⁴ The changes in brain glucose metabolism were correlated with acupuncture points by PET-CT.⁹³ Using machine learning and fMRI, some researchers identified a neural marker to distinguish migraine patients without aura from healthy individuals.⁸⁸ These neuroimaging-related studies exploring the pathogenesis of migraine provided new ideas on the mechanisms of central analgesia in acupuncture.

Limitations

This study is affected by some limitations. First, the subject of this study concerns the 100 most highly cited publications on acupuncture for migraine. The recent articles with high citation potential or the latest finding may not be included. Second, acupuncture is widely used in China, Japan, and Korea. Publications using non-English languages were not included because we focused solely on English-language studies. Third, this study only searched the WOS database, possibly missing some highly cited papers.

Conclusion

This is the first bibliometric analysis of the 100 most highly cited papers on acupuncture for migraine. The USA, China and Germany are the most influential countries. The Technical University of Munich is the most prestigious institution in the field, while Headache is the leading journal. Clinical research is the focus of this field. Future research will focus on the mechanism exploration of acupuncture for migraine, and pairing these treatments with neuroimaging will undoubtedly become popular.

Acknowledgment

We thank all the authors of the original studies included in this analysis.

Author Contributions

XS designed the study. XS and JQW performed the search and analyzed the data. XS, JQW, LB and WZ contributed to the literature review. All authors contributed to the article and approved the submitted version. 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.

Funding

There is no funding to report.

Disclosure

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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