Health Science Reports

WILEY

Health Science Reports Open Access

ORIGINAL RESEARCH OPEN ACCESS

Complementary Repair Therapy as a Trending Topic in Discogenic Pain: A Bibliometric Study Over the Past 40 Years

Zhouyang Hu[1,2] | Lijun Li[3] | Zhipeng Xu[2] | Jianjin Zhang[1,2] | Guoxin Fan[1,2] | Xiang Liao[1]

[1]Guangdong Key Laboratory for Biomedical Measurements and Ultrasound Imaging, National-Regional Key Technology Engineering Laboratory for Medical Ultrasound, School of Biomedical Engineering, Shenzhen University Medical School, Shenzhen, China | [2]Department of Pain Medicine, Shenzhen Nanshan People's Hospital, Shenzhen, China | [3]Department of Spine Surgery, Shanghai East Hospital Affiliated to Tongji University, Shanghai, China

Correspondence: Guoxin Fan (fan06309@163.com) | Xiang Liao (liaoxiang75@email.szu.edu.cn)

Received: 19 August 2024 | **Revised:** 9 February 2025 | **Accepted:** 1 April 2025

Funding: This study was supported by the Science, Technology, and Innovation Commission of Shenzhen Municipality (Grant No. JCYJ20230807115918039), Nanshan District Health Science and Technology Project (Grant No. NS2023002; NS2023044); the Nanshan District Health Science and Technology Major Project (Grant No. NSZD2023023; NSZD2023026); the National Natural Science Foundation of China (Grant No. 82102640), and the National Key Research and Development Program of China (Grant No. 2022YFC3602203) and the Medical Scientific Research Foundation of Guangdong Province of China (Grant No. A2023195). The sponsors played no part in the study design, data collection, data analysis, data interpretation, manuscript writing, or the decision to submit the article for publication.

Keywords: bibliometric analysis | complementary repair | discogenic pain | hotspot | trending topic | web of science

ABSTRACT

Background and Aims: Bibliometric analysis has been frequently employed for visualizing trends within a particular scientific domain. The pain associated with discogenic origins has a significant impact on one's quality of life, but there is currently a lack of bibliometric analysis in the literature. Hence, this study aimed to examine related research in the field and identify the latest topics that are currently trending by conducting a bibliometric analysis.

Methods: The Bibliometrix which developed in the statistical R-packages was used for the data analysis. All related eligible publications were identified, and studies published from 1982 to 2023 were extracted from the Web of Science database.

Results: Disc repair, bone marrow cells, platelet-rich plasma, and the activation of inflammatory responses were identified as the trending topics after analyzing 977 journal articles. The most productive and influential journal was SPINE (Phila Pa 1976), which accounted for the largest publications and highest *H* index. The most productive and locally cited authors were Takahashi K., Ohtori S., and Aoki Y. from Chiba University. The top three productive and globally cited institutions were Chiba University, followed by University of California San Francisco and Korea University. The USA, China, and Japan were demonstrated as the most productive and globally cited countries.

Conclusion: This study performed the first bibliometric analysis on discogenic pain and provided valuable insights into the latest trending topics in the field. Analysis reveals that recent research has primarily focused on complementary and regenerative approaches for repairing painful discs, as well as the role of inflammatory responses in disc pathology.

Zhouyang Hu and Lijun Li contributed equally to this study.

1 | Introduction

Discogenic pain, characterized by neck and shoulder pain, lower back pain, and radiating pain in the lower extremities, is primarily caused by pathological changes within the intervertebral disc [1]. Spine surgeons, pain specialists, and neurosurgeons frequently encounter discogenic pain as it is one of the most common outpatient and inpatient conditions. It has been estimated that about 80% of individuals experience neck or lower back pain at some stage in their lives, with discogenic pain playing a significant role [2, 3]. Recent advances in diagnostic modalities, such as advanced MRI techniques (e.g., T2 mapping and ultrashort time-to-echo) and provocative discography, have enhanced the precision of identifying symptomatic disc lesions [1, 4]. Therapeutically, minimally invasive interventions like annuloplasty and novel neuromodulation techniques are increasingly being explored to address pain. Additionally, complementary repair therapies targeting disc regeneration—such as intradiscal biologic therapies (e.g., platelet-rich plasma or stem cell injections) and tissue-engineered scaffolds,—are emerging as promising strategies to restore disc homeostasis and mitigate degeneration-related pain [5].

Identifying the research topic and the latest trending progress related to discogenic pain remains beneficial for researchers to stay updated on related dynamic changes, avoid subjective biases and misunderstandings, as well as identify knowledge gaps and potential research needs. For example, exploring the management of discogenic pain has been demonstrated currently as a highly interesting topic [6]. Various minimally invasive operations and novel intradiscal injection techniques were introduced and appreciated with promising clinical efficacy [7–10].

An increasing number of researchers are applying bibliometrics to grasp research hotspots and dynamic changes in a certain field. Bibliometrics serve as an influential instrument for unveiling the prevailing situation, trajectory of advancement, knowledge structure, and interdisciplinarity within a specific domain of research [11]. Bibliometrix was introduced as an exceptionally potent and openly accessible tool designed for conducting quantitative research and performing visual analysis within the realm of bibliometrics [12]. It imports bibliographic data from databases such as Scopus, Web of Science (WoS), PubMed, and so forth, allowing for comprehensive analysis and visualization. In addition, bibliometrix also offers a user-friendly web application—Biblioshiny—that enables interactive analysis without coding expertise.

However, after conducting a meticulous literature search, no bibliometric analysis that addressed discogenic pain was found. Therefore, the purpose of this study was to employ Bibliometrix to conduct a bibliometric analysis and data visualization on the trending topic of discogenic pain, and to present relevant hotspots and dynamic changes.

2 | Materials and Methods

2.1 | Search Strategy and Organization

Ethical approval was granted by the Ethics Committee of the local hospital. The data were obtained from the WoS database on August 29, 2023, using the search strategy: Topic = (discogenic pain) OR (discogenic back pain) OR (discogenic low back pain) OR (pain of discogenic origin) OR (discogenic cervical pain) OR (discogenic lumbar pain) OR (discogenic neck pain) OR (lumbosacral discogenic syndrome) OR (cervical discogenic syndrome). The final eligible literature was selected with reference to a formal two-step screening (title and abstract, followed by full text) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Figure 1).

2.2 | Inclusion and Exclusion Criteria of Literature

2.2.1 | Inclusion Criteria

All related eligible publications published from 1982 to 2023 were extracted from the Web of Science database. Documents with their full-text information (including title, author, abstract, keywords, cited references, publication year, journal, and institution name, etc.,) were retrieved and downloaded as the BibTex file format.

2.2.2 | Exclusion Criteria

The retrieved literature type that were not journal articles (e.g., reviews, editorials, opinions, book chapters, letters, news items, conference proceedings, or pure abstracts) were excluded.

2.3 | Bibliometric Analysis

The Bibliometrix package in R (version 4.2.2) and Biblioshiny web application were used for the data analysis and visualization. All downloaded BibTex files were then compressed into a single zip file and imported as instructed into Biblioshiny.

Various aspects of publication productivity, including annual publication rates, journal and author productivity, and impacts were evaluated. To measure productivity, two metrics: the total number of publications and the Hirsch index (*H*-index) were compared. The productivity and influence of different countries were also investigated Productivity was quantified by the total number of publications, while impact was assessed based on the average number of citations per article.

Collaborative relationships between institutions and countries using a collaborative network diagram were demonstrated. The diagram depicted the frequency of collaboration between each entity through connecting lines. Furthermore, the top 10 most cited articles were summarized and analyzed.

A co-occurrence network approach was conducted to understand the research fonts and their associations in the field of discogenic pain with size of a node representing the frequency and the thickness of a line between two nodes reflecting the strength of co-occurrence. Factorial analysis including clustering of a dendrogram was used to identify main research topics and categorize them into separate clusters. The trend of topics

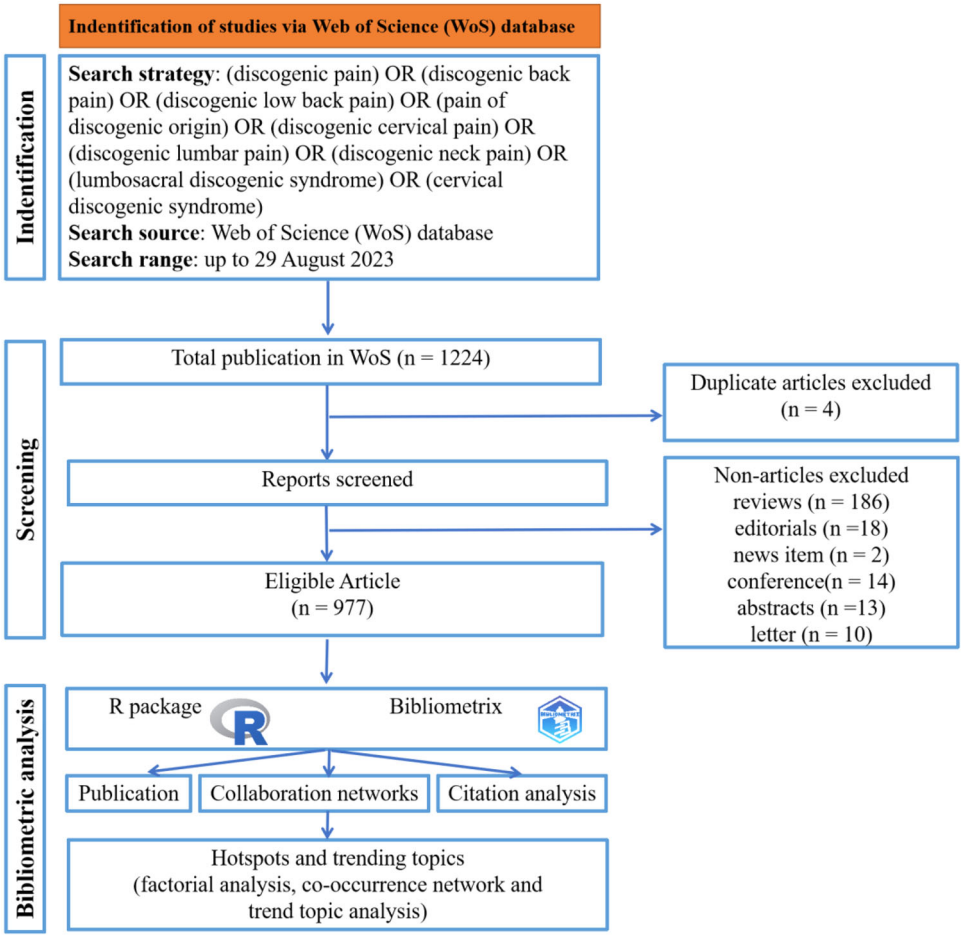

FIGURE 1 | The flowchart of data collection based on PRISMA and bibliometric analysis.

was depicted through a scatter graph, where the *x*-axis represented time and the *y*-axis represented the topic.

Two authors (Z.Y.H. and G.X.F.) independently performed the analysis. Disagreements that emerged were discussed between the two authors until a consensus was reached.

3 | Results

3.1 | Descriptive Analysis

After identifying a total of 1224 documents published from 1982 to 2023, 247 non-article and duplicate records were excluded, leaving 977 journal articles (accounting for 79.8% of the total) for analysis, as presented in flowchart Figure 1 and Table 1. According to the Figure 2, it was evident that since the publication of the first article in 1982, the research output on discogenic pain has shown a consistent growth trend, despite minor fluctuations in certain years (2007 and 2013).

3.1.1 | Journal, Author, Institution and Country Publications

The Journal of SPINE (Phila Pa 1976) maintained an absolute lead in terms of total publications, with 162 articles accounting for 16.6% of all publications (Figure 3). As shown in the source dynamics Figure 4, SPINE (Phila Pa 1976) has demonstrated a phenomenal increase in annual publication volume from 1994 to 2018, rapidly pulling ahead of other journals. The following most productive journals were Pain Medicine, European Spine Journal, Spine Journal, and Pain Physician, all of which had published over 35 articles each. The top five most productive journals published a total of 313 articles, contributing to 32.0% of the total publications. Table 2 listed the top 10 most productive journals with their total productions. In terms of influence, SPINE (Phila Pa 1976) still maintained its leading position with an H-index of 61, surpassing EUROPEAN SPINE JOURNAL and Pain Physician, with *H*-indices of 21 and 20, respectively. Spine Journal and Pain Medicine were closely following behind. The top 10 journals with the highest impact were all well-established journals in the fields of orthopedics, neurosurgery, and pain.

In terms of authors, Takahashi K., Ohtori S., and Aoki Y. from the Department of Orthopedic Surgery at Chiba University have emerged as the leading contributors to the publication production. They also hold the top three positions in terms of local impact, with impressive *H*-indices of 26, 23, and 21, respectively. Notably, Takahashi K. has consistently made significant contributions and garnered a substantial number of citations per year, particularly in 2017, spanning the period from 1996 to 2018 (as shown in Figure 5).

TABLE 1 | The main information of enrolled publications on the study of discogenic pain.

Description	Results
Main information about data	
Timespan	1982:2023
Sources (Journals, Books, etc.)	314
Documents	977
Annual growth rate %	6.46
Document average age	11.4
Average citations per doc	28.8
References	20244
Document contents	
Keywords Plus	1884
Author's Keywords	2160
Authors	
Authors	3619
Authors of single-authored docs	56
Authors collaboration	
Single-authored docs	62
Co-Authors per Doc	5.38
International co-authorships %	17.91
Document types	
Article	977
Non-article	247

The top 10 organizations published a total of 442 papers. Chiba University topped the list with 99 papers published, followed by University of California San Francisco with 62 articles published. The third-ranked institution with 59 published papers was the Korea University, as shown in Table 3. According to the countries of corresponding author, USA has the highest number of articles ($n = 325$), followed by China ($n = 124$) and Japan ($n = 84$). However, Switzerland has the highest multi-country publications (MCP) ratio (0.56), meaning that more than half of its publications involve international co-authors, followed by United Kingdom (0.26) and Netherlands (0.29). Turkey has the lowest MCP ratio (0.045), followed by China (0.089) and Japan (0.095), as shown in Table 3 and Figure 6.

3.1.2 | Collaboration Networks

An institution collaboration network map, presented as Figure 7a, depicted the institutions involved on discogenic pain research. The four largest nodes shown in the map are Chiba University, Stanford University, Korea University, and University of California San Francisco, with three of them maintaining relatively close connections with each other.

The countries with collaborations were represented by a red line whose width was proportional to the number of collaborations, as shown in Figure 7b. The United States dominated the international collaboration network, with the most connections and highest frequency with other countries. Switzerland, Germany, the United Kingdom, and Australia also had significant presence in the network, with high levels of collaboration with each other and the United States. In contrast, China, Japan, Korea, and Turkey appeared to be relatively isolated countries. In addition, as Figure 7c further indicated, North America and Europe had more cross-regional collaboration than Asia-Pacific countries, which tend to collaborated less within their own regions.

3.1.3 | Citation Analysis

In terms of the most locally cited authors, sources, and countries, Manchikanti L., Spine, and the United States ranked first in their respective fields, with a significant lead over the second place. The top 10 most locally cited publications investigating discogenic pain were presented in Table 4. The top-ranked article was an algorithmic approach to the management of chronic discogenic pain by Manchikanti L. et al. published in Pain Physician in 2009, with a total of 104 citations. Notably, Manchikanti L. also has published four other randomized equivalence/controlled trials investigating the outcomes of epidural injections for the management of cervical, thoracic, and lumbar disc-related pain, which were ranked 3rd, 5th, 6th, and 7th on the list, respectively. Coppes M.H. and a team of researchers conducted a study in 1997 on the innervation of painful lumbar discs, which was published in the journal Spine and received the second highest number of citations. The results revealed that severely degenerated human lumbar discs exhibited a more extensive innervation compared to normal discs.

3.2 | Trending Topics

The focus of discogenic pain research has evolved over time. Between 2014 and 2018, studies primarily emphasized diagnosis and treatment. However, in the past 3 years, research priorities have shifted towards *complementary, regenerative approaches and inflammatory mechanisms*. Current trending topics include disc repair techniques, applications of bone marrow cells and platelet-rich plasma (PRP), and investigations into the activation of inflammatory responses (shown as Figure 8). Factorial analysis which presented by the "word map", demonstrated three clusters of research topics regarding discogenic pain (as presented in Figure 9a). Visualized as Figure 9b, three clusters were identified by a dendrogram, namely the underlying pathogenesis (red leaves), the diagnosis and management (blue leaves), and the epidemiology of discogenic pain (green leaves). Co-occurrence network of keywords, visualized as Figure 10, shown the associations between three main topics with different colors representing the belonging cluster, and the thickness of line between terms showing the strength or frequency of the co-occurrence.

4 | Discussion

4.1 | Most Influential Literature

The first algorithmic approach involved the management of discogenic pain by Manchikanti L. et al., in Pain Physician was

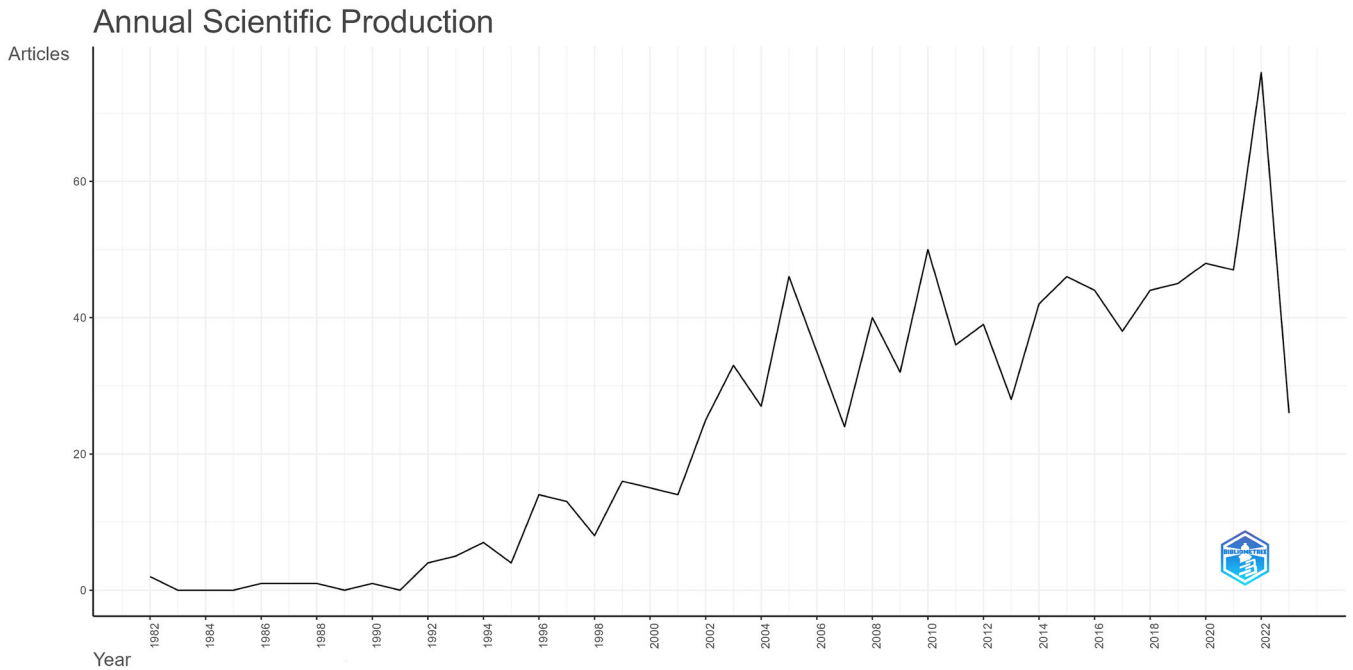

FIGURE 2 | Annual productivity overtime in the field of discogenic pain.

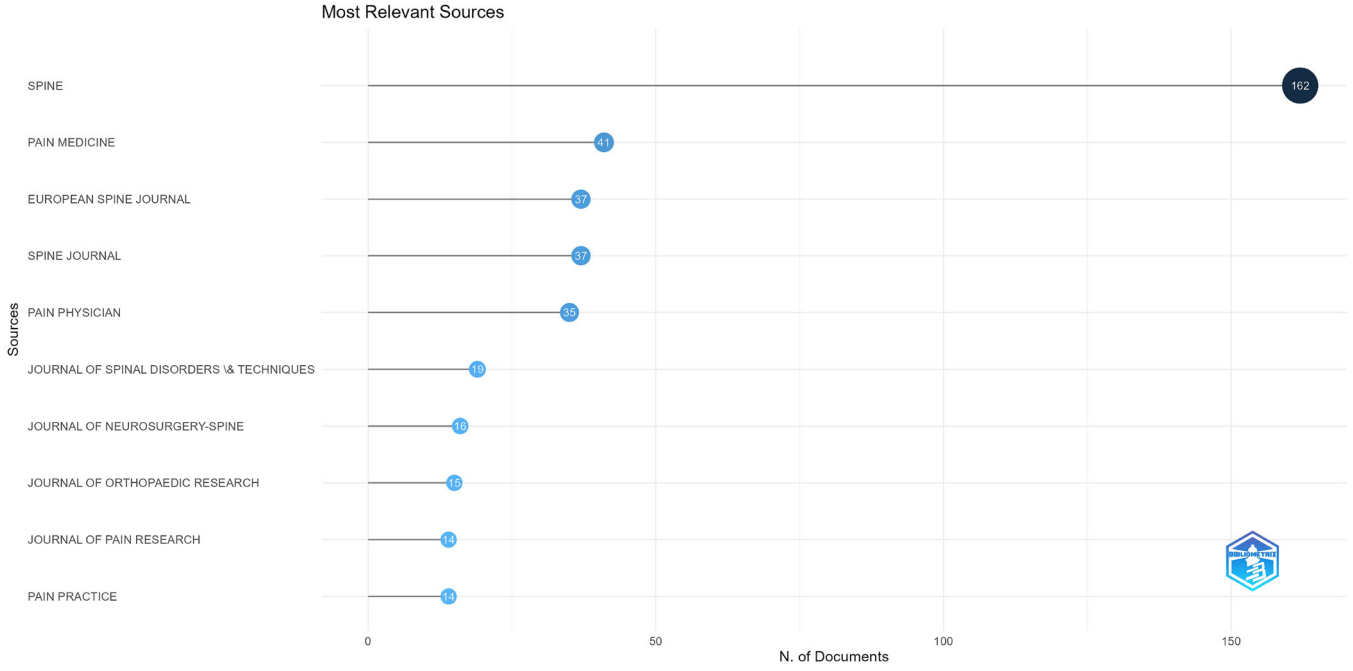

FIGURE 3 | Journal production ranking on discogenic pain.

identified as the most local cited paper [13]. This study proposed a stepwise algorithm for the diagnosis and treatment of various spinal pain conditions, including discogenic pain, with interventions such as facet joint injections, epidural injections, and surgical referral depending on the specific condition and symptoms. Following their ongoing endeavors, they have designed groundbreaking randomized controlled trials (RCTs) on epidural injections for the management of discogenic neck [14], thoracic [15], and low back pain [16, 17], all of which have had significant local impacts.

The most global cited paper was an investigation by Burke J.G. et al., published in the Journal Of Bone Joint Surgery in 2002 [18]. For the first time, this study used disc samples from patients with disc herniation and compared the levels of inflammatory mediators in disc tissue from patients with sciatica and low back pain. The results showed that discs from patients with discogenic low back pain expressed higher levels of interleukin-6 (IL-6) and IL-8 compared to those experiencing sciatica, suggesting that inflammation in the disc might act as a major source of pain. In their subsequent research [19], the

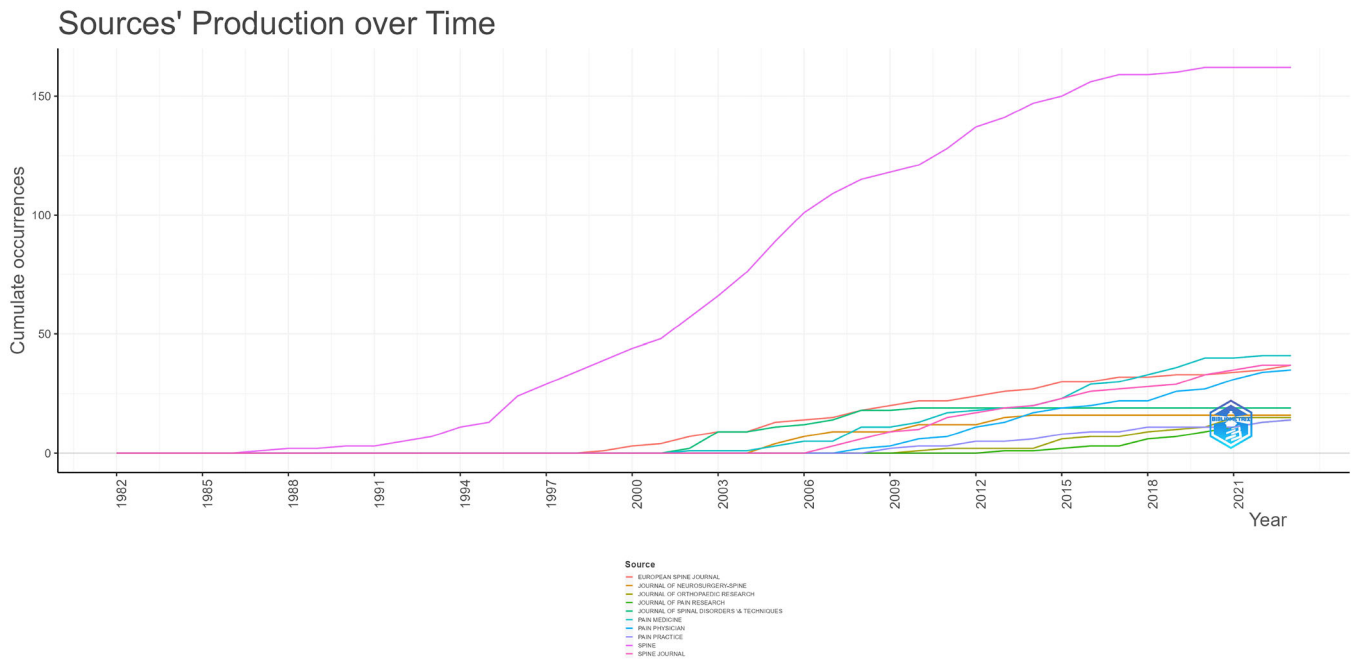

FIGURE 4 | Dynamical volume of the top 10 journal publications.

ability of human herniated intervertebral discs to produce pro-inflammatory chemokines like monocyte chemoattractant protein-1 and IL-8 was determined, which explained the inward growth of granulation tissue in spontaneous resorption of herniated discs. We thus encourage researchers in related fields to follow the work of the abovementioned scholars and contribute to the advancement of the effect of inflammatory mediators in relation to the development of discogenic pain.

4.2 | Trending Topics

In the current trend of discogenic pain, research placed greater emphasis on specific areas such as disc repair, bone marrow cells, PRP, and activation of inflammatory response. The responsibility of disc repair makes it the primary target in the management of discogenic pain. Conservative treatments such as oral analgesics, acupuncture, exercise therapy, and cognitive behavioral therapy were not novel [6]. However, caution must be exercised in the overuse, misuse, and long-term use of pain medications. Furthermore, there has been currently a lack of corresponding evidence-based research to determine which conservative treatment option was superior to another for this specific indication [1, 6, 20].

In the analysis, we found that the intradiscal injection of PRP and bone marrow cells has recently gained significant attention and was determined to be one of the most promising therapies for reversing disc degeneration and alleviating discogenic pain [1, 6, 21–24]. It has been demonstrated that painful discs formed vascularized granulation tissue in the annular fissure, which is characterized by the growth of nerves deep into the fissure [25, 26]. Continuous degeneration of the nucleus pulposus (NP) and annulus fibrosus (AF) resulted in the loss of copious amounts of proteoglycans and collagen, while also producing various pro-inflammatory cytokines, such as ILs, TNF-α, and prostaglandin E, among others [27]. These factors caused harmful stimulation to nerves that grown into the impaired or degenerated intervertebral disc, resulting in persistent pain [25]. PRP injection has been widely implemented in the treatment of musculoskeletal disorders due to its safety and potential to promote tissue healing. A meta-analysis has yielded Level 3 evidence, indicating that intradiscal PRP injection is beneficial for the treatment of discogenic low back pain [21]. The follow-up discovered that after 6 months of PRP injection, the effect size (SMD) for Visual Analogue Scale reduction of lower back pain reached −0.964. The study indicated that the effectiveness of PRP injection in reducing discogenic pain and promoting intervertebral disc healing can largely be ascribed to the elevated levels of transforming growth factor-β, insulin-like growth factor, and basic fibroblast growth factor present in the injection. Additionally, PRP effectively inhibited the inflammatory effects of TNF-α and IL-1, which were known to contribute to pain mediation [22]. Nevertheless, given that intradiscal injection is an invasive procedure, related risks such as infection, the NP protrusion resulting from iatrogenic injury, and accidental puncture of adjacent nerves around the intervertebral disc, remained significant concerns [1, 6].

Few materials have received as much attention in the field of regenerative medicine as bone marrow cells, with mesenchymal stem cells (MSCs) being the most extensively researched and clinically applied due to their unique repair capabilities [28]. For example, in patients suffering from lumbar disc degeneration and chronic low back pain, significant clinical improvements in pain and disability have been achieved through treatment with MSCs [21, 24, 29]. The primary factor for the significant therapeutic impact of MSCs on discogenic pain is their capacity to differentiate into functional intervertebral disc tissue and facilitate tissue restoration by modulating the inflammatory response [29]. First, following injection, MSCs demonstrated the capability to differentiate into NP cells,

TABLE 2 | Top 10 most productive and influential journals on discogenic pain research.

Production Ranking	Journal	Articles (n)	Influence ranking	Journal	TC[a]	*H*-index	2022IF[b]	Quartile[c]
1	Spine	57	1	Spine	10610	61	3.0	Q2
2	Pain Medicine	52	2	European Spine Journal	1465	21	2.8	Q2
3	European Spine Journal	52	3	Pain Physician	1101	20	3.7	Q2
4	Spine Journal	42	4	Spine Journal	1115	20	4.5	Q1
5	Pain Physician	41	5	Pain Medicine	1370	18	3.1	Q2
6	Journal of Spinal Disorders & Techniques	39	6	Journal of Spinal Disorders & Techniques	454	13	1.9	Q3
7	Journal Of Neurosurgery Spine	39	7	Journal of Neurosurgery Spine	490	11	2.8	Q2
8	Journal of Orthopaedic Research	34	8	Journal of Bone and Joint Surgery	1188	9	5.3	Q1
9	Journal of Pain Research	33	9	Journal of Orthopaedic Research	335	8	2.8	Q2
10	Pain Practice	30	10	Pain	451	7	7.4	Q1

[a]TC = total citation.
[b]IF = impact factor.
[c]Source from: Journal Citation Reports 2023.

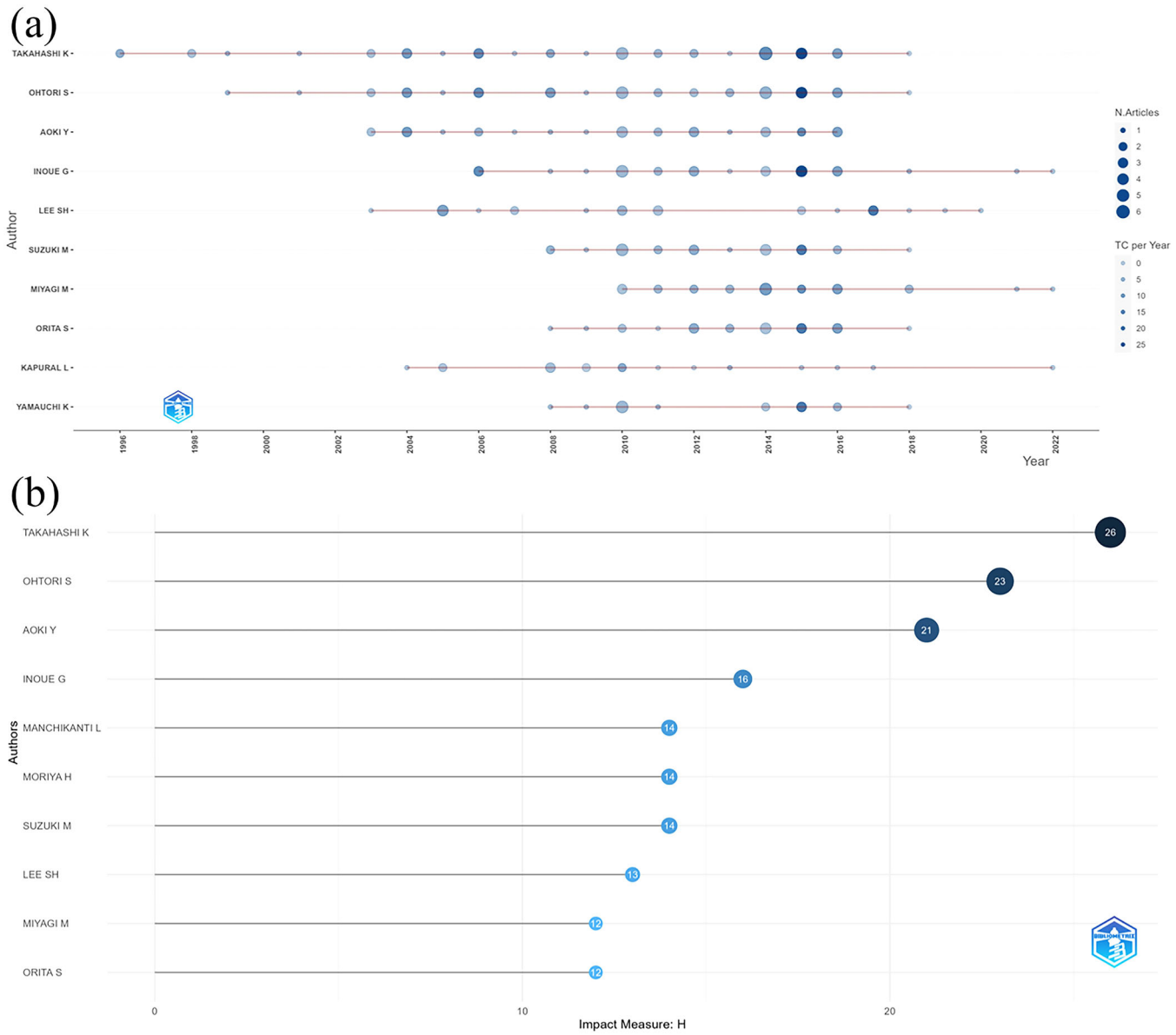

FIGURE 5 | The overtime productivity and impact of authors on discogenic pain. (a) Productivity of top 10 authors; (b) Impact of authors with *H*-indexes.

TABLE 3 | The top 10 most productive institutions and countries.

Rank	Affiliation	Articles	Country	Articles	SCP[a]	MCP[b]	MCP__Ratio
1	Chiba Univ	99	USA	325	271	54	0.17
2	Univ Calif San Francisco	62	China	124	113	11	0.09
3	Korea Univ	59	Japan	84	76	8	0.10
4	McGill Univ	48	Korea	55	43	12	0.22
5	Univ Pittsburgh	32	United Kingdom	50	37	13	0.26
6	Univ Zurich	32	Germany	36	32	4	0.11
7	Cedars Sinai Med CTR	28	Australia	30	25	5	0.17
8	Rush Univ	28	Switzerland	27	12	15	0.56
9	Maastricht Univ	27	Netherlands	24	17	7	0.29
10	Stanford Univ	27	Turkey	22	21	1	0.05

[a]SCP = single-country publication rate.
[b]MCP = multi-country publication rate.

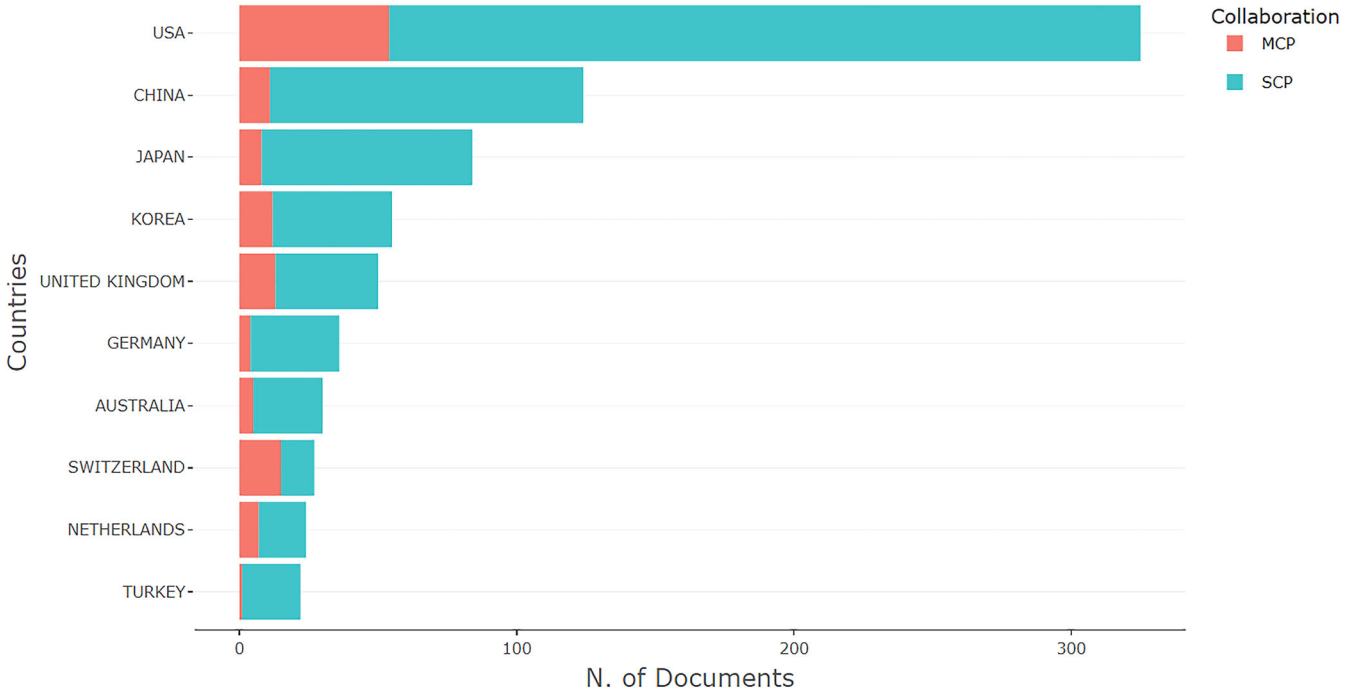

FIGURE 6 | Top 10 productive countries divided by single country publications (SCPs) and multiple country publications (MCPs) according to corresponding author on discogenic pain.

directly participating in the repair process of the degenerated disc. Research has indicated that MSCs can also undergo differentiation into fibroblasts, thereby contributing to the strengthening of the AF [23]. The recovery of disc height following repair led to a corresponding increase in the stability of the associated spinal segments [24]. In addition, injected MSC has been investigated to elicit an analgesic effect by inhibiting nociceptors [29] and suppressing the expression of inflammatory molecules [27], including IL-1β, IL-6, IL-17, and TNF, which were integral to pain signaling processes. In a meta-analysis incorporating nine studies (including one randomized controlled trial and eight prospective cohort studies), involving a total of 245 patients, it was observed that individuals who underwent MSC therapy exhibited significant reductions in VAS scores, with a mean difference of 41.62. There was also a pooled mean difference of 22.04 in the Oswestry Disability Index scores from baseline to the final follow-up [23].

In addition, minimally invasive surgical repair techniques such as percutaneous spinal annuloplasty (also known as thermal annuloplasty, TA) [10], transcutaneous electrical nerve stimulation (TENS) [7], and dorsal root ganglion stimulation (DRGS) [30] have also received some attention due to their proven efficacy. TA is a procedure that adopted an endoscope for the identification and treatment of the high-intensity zone (HIZ) by coagulating and modulating with a bipolar radio pulse. In the pathological investigation of HIZs, the presence of inflammatory granulation tissue was observed at the site of HIZ [31]. These inflammatory tissues generated pro-inflammatory cytokines and mediators that sensitize the nociceptors within the disc, leading to the sensation of pain [26, 32]. According to a recent meta-analysis which involved 7 RCTs and a total of 655 participants, TENS was demonstrated to have a significant positive impact on pain intensity and disability in individuals with back and/or neck pain [8]. DRGS, on the other hand, represented a special type of neuromodulation that delivered targeted pain relief by stimulating specific nerves within the ganglion [30]. Research suggested that DRGS targeted both segmental and non-segmental neuropathic disc sensory afferents at the affected level of the nerve, which cannot be effectively reached using traditional spinal cord stimulation techniques [9].

4.3 | Limitations

There were several limitations in this study. Firstly, all the included publications were sourced from a single database, which is the largest comprehensive multidisciplinary core journal database. However, it is important to acknowledge that relying solely on one database may introduce some potential limitations that could influence the findings of the study. Secondly, the citation counts of the articles may vary over time. Our analysis was based on articles and their citations up to 2023, but the citation numbers may change in the coming months or years. Thirdly, detecting self-citations and citations among colleagues proves to be a challenging task. This limitation should be noted as it can result in inflated citation counts, potentially leading to inaccurate estimations of the influence of documents and journals. Finally, the inclusion of literature only in English introduced a potential bias. The language limitation may result in the exclusion of research outputs from non-English speaking authors and regions, leading to an incomplete and potentially biased evaluation of research in certain fields or regions of this topic.

Based on our findings, we suggest that future research on discogenic pain should address the following aspects: (1) Monitoring the dynamic research on complementary repair

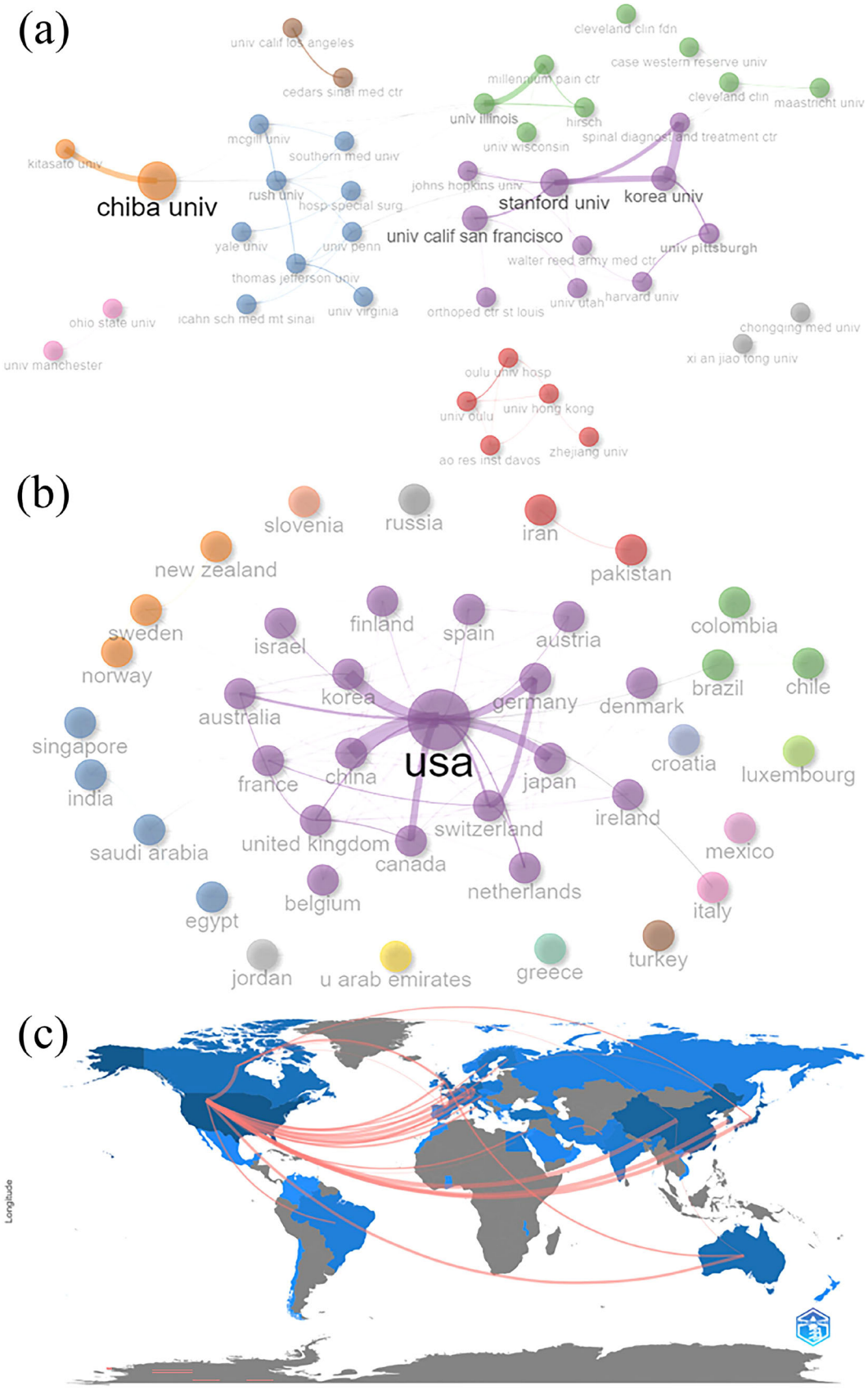

FIGURE 7 | Collaboration networks on discogenic pain. (a) Institutional structure; (b) Countries' structure and (c) Countries' collaboration world map.

TABLE 4 | List of the top 10 most global and 10 local cited articles on discogenic pain.

Items	Document (First author, year, journal)	DOI[a]	TC[b]
TOP 10 most GLOBAL cited	Burke J.G., 2002, J Bone Joint Surg-Br Vol	10.1302/0301-620X.84B2.12511	496
	Kuslich S.D., 1998, Spine	10.1097/00007632-199806010-00019	333
	Depalma M.J., 2011, Pain Med	10.1111/j.1526-4637.2010.01045.x	310
	Coppes M.H., 1997, Spine	10.1097/00007632-199710150-00005	305
	Sive J.I., 2002, J Clin Pathol-Mol Pathol	10.1136/mp.55.2.91	299
	Zigler J., 2007, Spine	10.1097/BRS.0b013e318054e377	297
	Mayer H.M., 1993, J Neurosurg	10.3171/jns.1993.78.2.0216	291
	Micheli L.J., 1995, Arch Pediatr Adolesc Med	10.1001/archpedi.1995.02170130017004	287
	Weiler C, 2005, Spine	10.1097/01.brs.0000149186.63457.20	281
	Rajaraman V, 1999, J Neurosurg	10.3171/spi.1999.91.1.0060	263
TOP 10 most LOCAL cited	Manchikanti L., 2009, Pain Physician	PMID: 19668283	104
	Coppes M.H., 1997, Spine	10.1097/00007632-199710150-00005	91
	Manchikanti L., 2008, Pain Physician	PMID: 19057626	69
	Depalma M.J., 2011, Pain Med	10.1111/j.1526-4637.2010.01045.x	58
	Manchikanti L., 2010, Pain Physician-a	PMID: 24077199	57
	Manchikanti L., 2010, Pain Physician-b	PMID: 21102973	57
	Manchikanti L., 2010, Pain Physician-c	PMID: 20648213	57
	Saal J.S., 2000, Spine	10.1097/00007632-200002010-00021	48
	Schellhas K.P., 1996, Spine	10.1097/00007632-199601010-00018	47
	Ohtori S., 1999, Spine	10.1097/00007632-199911150-00002	44

[a]DOI: digital object identifier.
[b]TC: total citation; PMID (PubMed Unique Identifier) was filled when no DOI can be found.

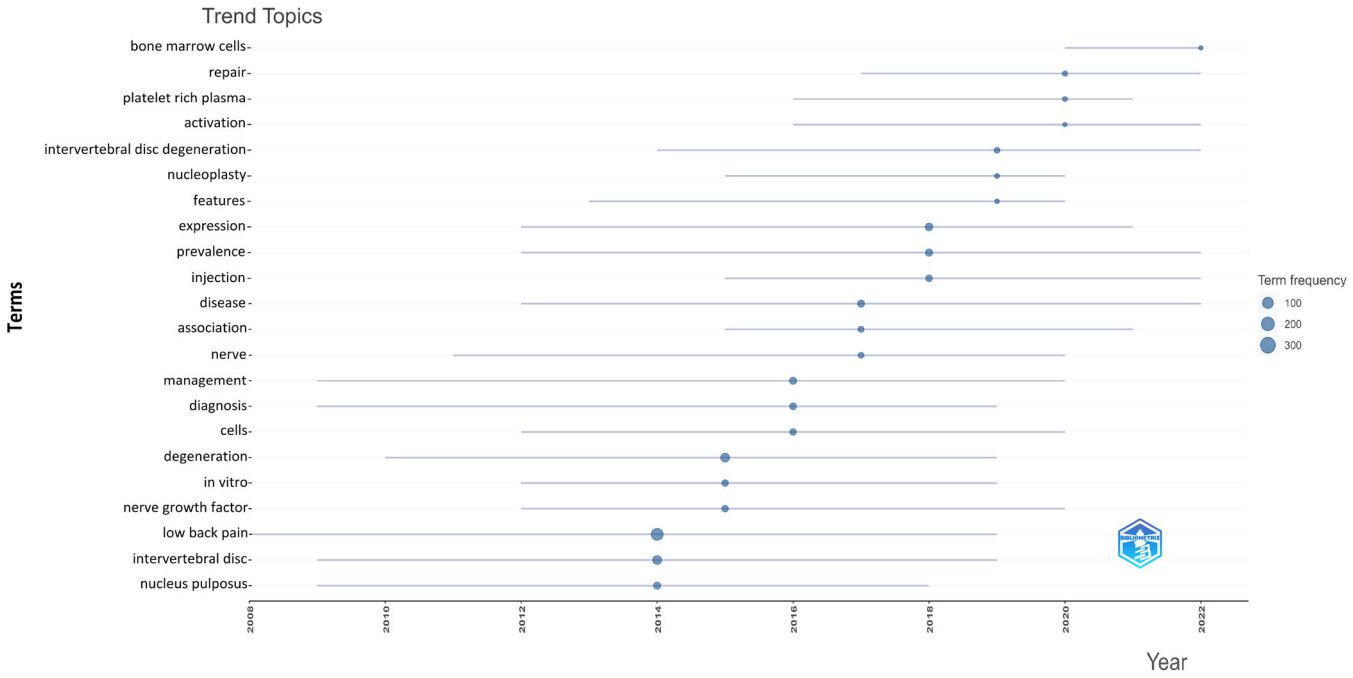

FIGURE 8 | Keywords of trending topics on discogenic pain.

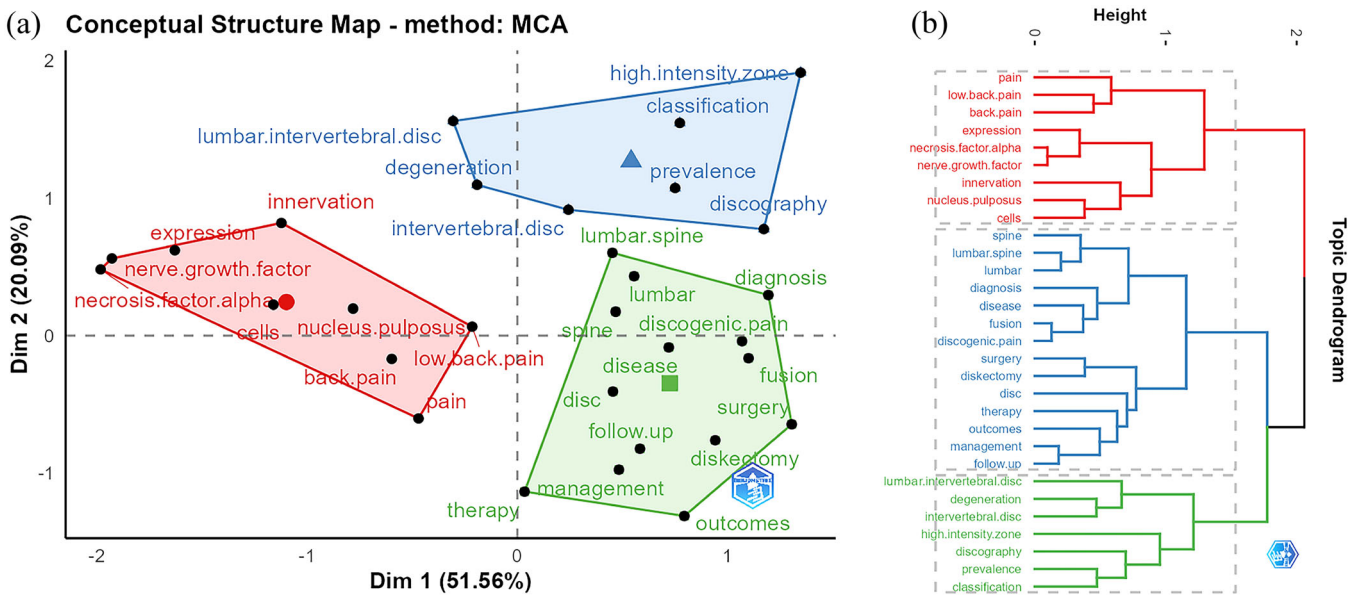

FIGURE 9 | Factorial analysis and dendrogram visualization of research topics on discogenic pain. (a) The conceptual structure diagram presenting three topic clusters; (b) The topic dendrogram that shows the hierarchical relationship between the topics.

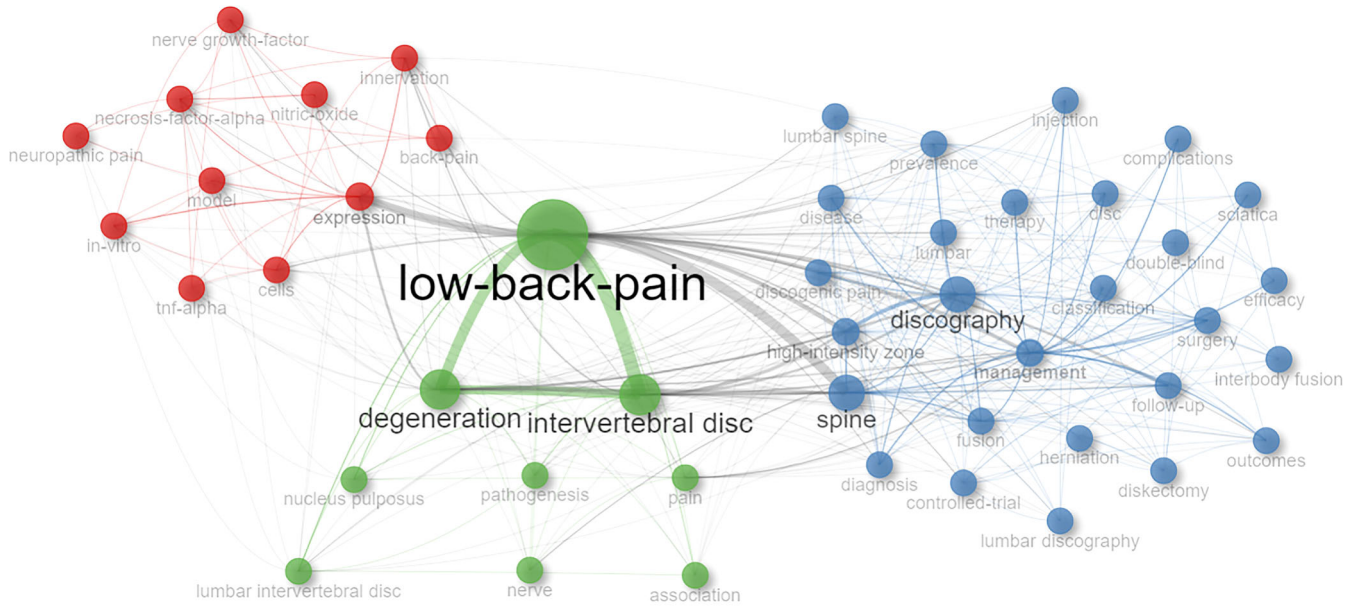

FIGURE 10 | Co-occurrence network of keywords on discogenic pain.

therapy, with a particular focus on the involved research teams and recent advancements regarding investigating MSCs and PRP in managing discogenic pain; (2) Strengthening collaboration and communication among researchers from diverse regions and disciplines, with a particular emphasis on Asia-Pacific countries; (3) Conducting high-quality RCTs with large population to provide evidence-based guidelines for clinical practice.

5 | Conclusions

This study performed the first bibliometric analysis on discogenic pain and provided valuable insights into the latest trending topics in the field. Predominant trending topics in recent years have centered on complementary and regenerative approaches for repairing painful discs, as well as the role of inflammatory responses in disc pathology.

Author Contributions

Zhouyang Hu: conceptualization, writing – original draft, funding acquisition. **Lijun Li:** formal analysis, writing – original draft, writing – review and editing. **Zhipeng Xu:** methodology. **Jianjin Zhang:** methodology, software. **Guoxin Fan:** supervision, conceptualization, writing – review and editing, funding acquisition. **Xiang Liao:** writing – review and editing, funding acquisition, supervision, formal analysis.

Acknowledgments

This study was supported by the Science, Technology, and Innovation Commission of Shenzhen Municipality (Grant No. JCYJ20230807115918039), Nanshan District Health Science and Technology Project (Grant No. NS2023002; NS2023044); the Nanshan District Health Science and Technology Major Project (Grant No. NSZD2023023; NSZD2023026); the National Natural Science Foundation of China (Grant No. 82102640), and the National Key Research and Development Program of China (Grant No. 2022YFC3602203) and the Medical Scientific Research Foundation of Guangdong Province of China (Grant No. A2023195). The sponsors played no part in the study design, data collection, data analysis, data interpretation, manuscript writing, or the decision to submit the article for publication.

Ethics Statement

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Shenzhen Nanshan People's Hospital.

Consent

All authors state here that the details of any images, videos, recordings, etc. in the work can be published. All authors have actively contributed to its content, have thoroughly read it, agree with its contents, and confirm that the work presented in the manuscript is honest.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

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

Transparency Statement

The lead author Guoxin Fan, Xiang Liao affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

References

1. K. Fujii, M. Yamazaki, J. D. Kang, et al., "Discogenic Back Pain: Literature Review of Definition, Diagnosis, and Treatment," *JBMR Plus* 3, no. 5 (2019): e10180.

2. B. Peng and M. J. DePalma, "Cervical Disc Degeneration and Neck Pain," *Journal of Pain Research* 11 (2018): 2853–2857.

3. J. K. Freburger, G. M. Holmes, R. P. Agans, et al., "The Rising Prevalence of Chronic Low Back Pain," *Archives of Internal Medicine* 169, no. 3 (2009): 251–258.

4. I. Ogon, T. Takebayashi, H. Takashima, et al., "Analysis of Chronic Low Back Pain With Magnetic Resonance Imaging T2 Mapping of Lumbar Intervertebral Disc," *Journal of Orthopaedic Science* 20, no. 2 (2015): 295–301.

5. M. De Simone, A. Choucha, E. Ciaglia, et al., "Discogenic Low Back Pain: Anatomic and Pathophysiologic Characterization, Clinical Evaluation, Biomarkers, AI, and Treatment Options," *Journal of Clinical Medicine* 13, no. 19 (2024): 5915.

6. E. Remotti, C. Nduaguba, P. A. Woolley, et al., "Review: Discogenic Back Pain: Update on Treatment," *Orthopedic Reviews* 15 (2023): 84649.

7. A. Khadilkar, D. O. Odebiyi, L. Brosseau, and G. A. Wells, "Transcutaneous Electrical Nerve Stimulation (TENS) Versus Placebo for Chronic Low-Back Pain," *Cochrane Database of Systematic Reviews* 2008, no. 4 (2008): Cd003008.

8. L. Resende, E. Merriwether, É. P. Rampazo, et al., "Meta-Analysis of Transcutaneous Electrical Nerve Stimulation for Relief of Spinal Pain," *European Journal of Pain* 22, no. 4 (2018): 663–678.

9. J. W. Kallewaard, C. Edelbroek, M. Terheggen, A. Raza, and J. W. Geurts, "A Prospective Study of Dorsal Root Ganglion Stimulation for Non-Operated Discogenic Low Back Pain," *Neuromodulation: Technology at the Neural Interface* 23, no. 2 (2020): 196–202.

10. J. H. Lee and S. H. Lee, "Clinical Efficacy of Percutaneous Endoscopic Lumbar Annuloplasty and Nucleoplasty for Treatment of Patients With Discogenic Low Back Pain," *Pain medicine (Malden, Mass.)* 17, no. 4 (2016): 650–657.

11. I. Zupic and T. Čater, "Bibliometric Methods in Management and Organization," *Organizational Research Methods* 18, no. 3 (2014): 429–472.

12. M. Aria and C. Cuccurullo, "Bibliometrix: An R-Tool for Comprehensive Science Mapping Analysis," *Journal of Informetrics* 11, no. 4 (2017): 959–975.

13. L. Manchikanti, S. Helm, V. Singh, et al., "M.V. Boswell, An Algorithmic Approach for Clinical Management of Chronic Spinal Pain," *Pain Physician* 12, no. 4 (2009): E225–E264.

14. L. Manchikanti, K. A. Cash, V. Pampati, B. W. Wargo, and Y. Malla, "Cervical Epidural Injections in Chronic Discogenic Neck Pain Without Disc Herniation or Radiculitis: Preliminary Results of a Randomized, Double-Blind, Controlled Trial," *Pain Physician* 13, no. 4 (2010): E265–E278.

15. L. Manchikanti, K. A. Cash, C. D. McManus, V. Pampati, and R. M. Benyamin, "A Preliminary Report of a Randomized Double-Blind, Active Controlled Trial of Fluoroscopic Thoracic Interlaminar Epidural Injections in Managing Chronic Thoracic Pain," *Pain Physician* 13, no. 6 (2010): E357–E369.

16. L. Manchikanti, K. A. Cash, C. D. McManus, V. Pampati, and H. S. Smith, "Preliminary Results of a Randomized, Equivalence Trial of Fluoroscopic Caudal Epidural Injections in Managing Chronic Low Back Pain: Part 1—Discogenic Pain Without Disc Herniation or Radiculitis," *Pain Physician* 11, no. 6 (2008): 785–800.

17. L. Manchikanti, K. A. Cash, C. D. McManus, V. Pampati, and R. M. Benyamin, "A Randomized, Double-Blind, Active-Controlled Trial of Fluoroscopic Lumbar Interlaminar Epidural Injections in Chronic Axial or Discogenic Low Back Pain: Results of 2-Year Follow-Up," *Pain Physician* 16, no. 5 (2013): 491–504.

18. J. G. Burke, R. W. G. Watson, D. McCormack, F. E. Dowling, M. G. Walsh, and J. M. Fitzpatrick, "Intervertebral Discs Which Cause Low Back Pain Secrete High Levels of Proinflammatory Mediators," *Journal of Bone and Joint Surgery. British Volume* 84, no. 2 (2002): 196–201.

19. J. G. Burke, R. W. G. Watson, D. McCormack, F. E. Dowling, M. G. Walsh, and J. M. Fitzpatrick, "Spontaneous Production of Monocyte Chemoattractant Protein-1 and Interleukin-8 by the Human Lumbar Intervertebral Disc," *Spine* 27, no. 13 (2002): 1402–1407.

20. B. G. Peng, "Pathophysiology, Diagnosis, and Treatment of Discogenic Low Back Pain," *World Journal of Orthopedics* 4, no. 2 (2013): 42–52.

21. J. Sanapati, L. Manchikanti, S. Atluri, et al., "Do Regenerative Medicine Therapies Provide Long-Term Relief in Chronic Low Back Pain: A Systematic Review and Metaanalysis," *Pain Physician* 21, no. 6 (2018): 515–540.

22. M. C. Chang and D. Park, "The Effect of Intradiscal Platelet-Rich Plasma Injection for Management of Discogenic Lower Back Pain: A Meta-Analysis," *Journal of Pain Research* 14 (2021): 505–512.

23. W. Zhang, D. Wang, H. Li, et al., "Mesenchymal Stem Cells Can Improve Discogenic Pain in Patients With Intervertebral Disc

Degeneration: A Systematic Review and Meta-Analysis," *Frontiers in Bioengineering and Biotechnology* 11 (2023): 1155357.

24. V. Y. L. Leung, D. M. K. Aladin, F. Lv, et al., "Mesenchymal Stem Cells Reduce Intervertebral Disc Fibrosis and Facilitate Repair," *Stem Cells* 32, no. 8 (2014): 2164–2177.

25. F. J. Lyu, H. Cui, H. Pan, et al., "Painful Intervertebral Disc Degeneration and Inflammation: From Laboratory Evidence to Clinical Interventions," *Bone Research* 9, no. 1 (2021): 7.

26. S. Ohtori, Y. Takahashi, K. Takahashi, et al., "Sensory Innervation of the Dorsal Portion of the Lumbar Intervertebral Disc in Rats," *Spine* 24, no. 22 (1999): 2295–2299.

27. L. Miguélez-Rivera, S. Pérez-Castrillo, M. L. González-Fernández, et al., "Immunomodulation of Mesenchymal Stem Cells in Discogenic Pain," *Spine Journal* 18, no. 2 (2018): 330–342.

28. Y. Han, X. Li, Y. Zhang, Y. Han, F. Chang, and J. Ding, "Mesenchymal Stem Cells for Regenerative Medicine," *Cells* 8, no. 8 (2019): 886.

29. L. Miranda, M. Quaranta, F. Oliva, and N. Maffulli, "Stem Cells and Discogenic Back Pain," *British Medical Bulletin* 146, no. 1 (2023): 73–87.

30. M. F. Esposito, R. Malayil, M. Hanes, and T. Deer, "Unique Characteristics of the Dorsal Root Ganglion as a Target for Neuromodulation," supplement, *Pain Medicine* 20, no. S1 (2019): S23–S30.

31. K. P. Schellhas, S. R. Pollei, C. R. Gundry, and K. B. Heithoff, "Lumbar Disc High-Intensity Zone. Correlation of Magnetic Resonance Imaging and Discography," *Spine* 21, no. 1 (1996): 79–86.

32. S. C. Jha, K. Higashino, T. Sakai, et al., "Clinical Significance of High-Intensity Zone for Discogenic Low Back Pain: A Review," *Journal of Medical Investigation* 63, no. 1–2 (2016): 1–7.