

The 100 Most Cited Articles on Lumbar Spinal Stenosis: A Bibliometric Analysis

Global Spine Journal
2022, Vol. 12(3) 381–391
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DOI: 10.1177/2192568220952074
journals.sagepub.com/home/gsj



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Abstract

Study Design: Bibliometric analysis.

Objective: With the increasing literature of spine surgery, some pioneering research studies have had a significant impact on the field of lumbar spinal stenosis (LSS). The objective of the authors was to identify and analyze the most frequently cited 100 articles in this field.

Methods: Web of Science was searched to identify 100 top-cited articles related to LSS from 2000 to 2019. Articles on the final list were filtered based on their titles and abstracts. The following information were recorded and analyzed with bibliometric method: article title, first author, year of publication, journal of publication, total number of citations, country, institution, and study topic.

Results: The citation count for final articles on the list ranged from 71 to 2162, with a mean number of 207.7. The journal *Spine* contributed the maximum number of articles (37), followed by *European Spine Journal* (9) and *Pain Physician* (8). There were collectively 80 first authors contributing to articles on the final list. Twelve authors were represented multiple times in the top 100 articles. The most prolific years were 2008 and 2009, each had 11 articles published. With regard to country and region of origin, most articles were from the United States (58). The most cited article was published in *Spine* in 2000 by Fairbank and Pynsent, who discussed the role of the Oswestry Disability Index as an evaluation standard in spinal disorders, including LSS.

Conclusion: The current study analyzed the 100 most cited articles on LSS. It no doubt developed a useful resource with detailed information for many, particularly orthopedic and neurosurgery physicians who want to assimilate research focus and advance of LSS within a relatively short period. Researchers may benefit from emphasis on citation count while citing and evaluating articles and realize the deficiencies when high-level articles appear.

Keywords

bibliometric analysis, citation, most cited articles, lumbar spinal stenosis, LSS

Introduction

Lumbar spinal stenosis (LSS) refers to a series of clinical symptoms caused by narrowing of the spinal canal and compression of dural sac, spinal cord, nerve root or cauda equina nerve.¹ As it is a disease with a slow and progressive nature, patients are initially managed with conservative methods such as acupuncture and physical therapy, while surgery is only considered as an adjunct necessity when there is severe pain or progressive neurological dysfunction.²

At present, there is no literature comparing the relationship between conservative treatment and the natural history of LSS, and there is not enough evidence for patients with LSS to suggest any specific type of nonsurgical treatment.³ The current recommendations for nonsurgical treatment are based on low-evidence studies and expert opinions.⁴

Though studies have shown that surgery improve function and quality of life,^{5,6} most of them are limited by low level of evidence.⁷ In the past few decades, numerous studies have focused on innovative techniques of LSS surgery. Decompression is the most effective operative method, but there are

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different opinions about the ways of decompression and whether it needs fusion. Many scholars seek appropriate operative method continually, but there is still a lack of consensus; the surgical treatment of LSS is controversial as before.

Citation analysis is a systematic approach to identifying the influence of scientific studies.⁸ An article with more frequent citation history may be more influential in its field.⁹ Though there have been bibliometric analyses of spinal disorders¹⁰ and back pain research as a whole,¹¹ little is known about the most frequently cited literature on LSS.

With the rapid development of evaluation and treatment methods addressing the subject, literature on LSS has sprung up, including a large number of researchers, countries, specialties, and scientific journals. But a significantly important work, citation analysis, is often ignored. In this article, the bibliometrics method is used to identify and analyze 100 most cited scientific articles on LSS, in order to understand the research focus and trend and to provide valuable information for medical researchers in this field.

Methods

For this study, all databases and journals were retrieved through Web of Science (WOS) and its Core Collection in order to identify the top 100 cited scientific publications that emphasized on LSS. WOS is a web-based product developed by Thomson Scientific in the United States, which includes citation databases such as Scientific Citation Index (SCI), and uses Information Science Institute Web of knowledge as the retrieval platform.¹² We used the following search command: *lumbar spinal stenosis* OR *lumbar stenosis* OR *lumbar stenosis disorders*, and conducted the search in “basic search” feature under the “title” field with a time limit from January 1, 2000, until November 1, 2019 (a span of 20 years).

There were in total 1934 articles that meet the search criteria initially. To improve the research, all articles were respectively reviewed and evaluated by 2 independent researchers. The finalized dataset included the top 100 most cited original articles and reviews, while it excluded letters, corrections, editorial material, and basic research articles. Any differences in opinion were discussed until they came to a consensus. Finally, the remaining articles were ranked according to the count of citations (Table 1). We recorded and analyzed the following information: article title, first author, year of publication, journal of publication, total number of citations, country, institution, and study topic. Study topic included etiology, pathology, natural history, epidemiology, assessment measure, treatment, and outcome.¹³ Levels of evidence of the articles were classified based on criteria established by the North American Spine Society (<https://www.spine.org/Portals/0/Documents/ResearchClinicalCare/LevelsOfEvidence.pdf>). Remoter articles tend to be cited more frequently, therefore we calculated CY-index (citations per year index) to correct for the time elapsed since publication and rationalize the citation count.

Results

A total of 1934 articles were retrieved according to our search command, and we identified the 100 most cited articles relevant to LSS based on the inclusion criteria. The citation count for final articles on the list ranged from 71 (articles 99 and 100) to 2162 (the top article), with a mean number of 207.7 for each article, and the top 100 articles had been cited 19 703 times in total. All articles were published in 31 different journals (Table 2), with the journal *Spine* contributing the most (37), followed by *European Spine Journal* (9) and *Pain Physician* (8). There were collectively 80 first authors contributing to articles on the final list. Twelve authors were represented multiple times in the top 100 articles (Table 3). Among these 12 individuals, Manchikanti was regarded as the most productive first author with 6 articles on the final list. The second was Atlas with 4 publications, followed by Deyo and Fritz, who each had authored 3 articles. The most prolific years were 2008 and 2009, each had 11 articles published, and followed by the years 2000, 2005, 2006 and 2007, with 9 articles each (Figure 1). There were totally 232 institutions listed in the top 100 articles. The top 4 institutions with the most productive articles were Harvard University, USA with 11 publications, University of Washington, USA with 10 publications, Dartmouth Medical School, USA, and Pain Management Center of Paducah, USA with 6 publications each (Table 4). With regard to country and region of origin, most articles were from the United States (58), followed by Germany (8), Switzerland (4), Sweden (4), Turkey (4), and Sweden (4) (Table 5).

When we analyzed these articles on the basis of study topic, we found that the most common topic was outcome of surgical treatment (27), followed by practice guideline (14), assessment measure (10), epidural injection therapy (10), surgical versus nonsurgical comparison (10), risk factor analysis (6), and outcome of nonoperative treatment (4). The rest topics were mentioned less frequently. When we classified the articles by research design, 57 were identified as clinical outcome studies (such as randomized trials, cohort studies, prospective studies, case series, etc.), 24 were review articles (including systematic reviews and meta-analyses), 11 were staging or prognostic studies, 4 were radiology studies, 2 were anatomical studies, and 2 were technical notes. Based on the criteria of level of evidence, 9 articles were identified as level I evidence, 7 were level II evidence, 13 were level III evidence, 65 were level IV evidence, and none of the articles was level V evidence; levels of evidence were not assigned to 6 studies because they were not on therapeutic, prognostic, or diagnostic topics.

The oldest article on the list was published in 2000 and written by Simotas et al¹⁴ from the Hospital for Special Surgery, USA in *Spine*, which concluded that aggressive nonoperative treatment for spinal stenosis remains a reasonable option. There were 2 most recent articles published in 2016 in the *New England Journal of Medicine*. One was written by Forst et al¹⁵ from Uppsala University, Sweden, indicating that adding spinal fusion did not improve outcomes among patients with LSS. The other was published by Ghogawala et al¹⁶ from

Table 1. 100 Top-Cited Articles on Lumbar Spinal Stenosis (LSS).

Rank	First author	Title	Journal	Total citations	Year	Average citation
1	Fairbank, JC	The Oswestry Disability Index	<i>Spine</i>	2162	2000	108.1
2	Chou, R	Diagnosis and treatment of low back pain: A joint clinical practice guideline from the American College of Physicians and the American Pain Society	<i>Annals of Internal Medicine</i>	1590	2007	122.3
3	Deyo, RA	Primary care—Low back pain	<i>New England Journal of Medicine</i>	1037	2001	54.6
4	Roland, M	The Roland-Morris Disability Questionnaire and the Oswestry Disability Questionnaire	<i>Spine</i>	940	2000	47
5	Deyo, RA	Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults	<i>JAMA Journal of the American Medical Association</i>	648	2010	64.8
6	Weinstein, JN	Surgical versus nonsurgical therapy for lumbar spinal stenosis	<i>New England Journal of Medicine</i>	555	2008	46.3
7	Angst, F	Smallest detectable and minimal clinically important differences of rehabilitation intervention with their implications for required sample sizes using WOMAC and SF-36 quality of life measurement instruments in patients with osteoarthritis of the lower extremities	<i>Arthritis and Rheumatism</i>	404	2001	21.3
8	Amundsen, T	Lumbar spinal stenosis: conservative or surgical management? A prospective 10-year study	<i>Spine</i>	366	2000	18.3
9	Jarvik, JG	Diagnostic evaluation of low back pain with emphasis on imaging	<i>Annals of Internal Medicine</i>	336	2002	18.7
10	Atlas, SJ	Long-term outcomes of surgical and nonsurgical management of lumbar spinal stenosis: 8 to 10 year results from the Maine Lumbar Spine Study	<i>Spine</i>	327	2005	21.8
11	Delitto, A	Low back pain clinical practice guidelines linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association	<i>Journal of Orthopaedic & Sports Physical Therapy</i>	326	2012	40.8
12	Manchikanti, L	Comprehensive evidence-based guidelines for interventional techniques in the management of chronic spinal pain	<i>Pain Physician</i>	308	2009	28
13	Malmivaara, A	Surgical or nonoperative treatment for lumbar spinal stenosis? A randomized controlled trial	<i>Spine</i>	282	2007	21.7
14	Weinstein, JN	Surgical versus nonoperative treatment for lumbar spinal stenosis: four-year results of the Spine Patient Outcomes Research Trial	<i>Spine</i>	253	2010	25.3
15	Zucherman, JF	A multicenter, prospective, randomized trial evaluating the X STOP interspinous process decompression system for the treatment of neurogenic intermittent claudication—two-year follow-up results	<i>Spine</i>	253	2005	16.9
16	Kalichman, L	Spinal stenosis prevalence and association with symptoms: the Framingham Study	<i>Spine Journal</i>	246	2009	22.4
17	Chou, R	Surgery for low back pain: a review of the evidence for an American Pain Society Clinical Practice Guideline	<i>Spine</i>	240	2009	21.8
18	Atlas, SJ	Surgical and nonsurgical management of lumbar spinal stenosis - Four-year outcomes from the Maine lumbar spine study	<i>Spine</i>	234	2000	11.7
19	Friedly, J	Increases in lumbosacral injections in the Medicare population—1994 to 2001	<i>Spine</i>	215	2007	16.5
20	Katz, JN	Lumbar spinal stenosis	<i>New England Journal of Medicine</i>	211	2008	17.6
21	Forsth, P	A randomized, controlled trial of fusion surgery for lumbar spinal stenosis	<i>New England Journal of Medicine</i>	210	2016	52.5
22	Ghogawala, Z	Laminectomy plus fusion versus laminectomy alone for lumbar spondylolisthesis	<i>New England Journal of Medicine</i>	193	2016	48.3
23	Thome, C	Outcome after less-invasive decompression of lumbar spinal stenosis: a randomized comparison of unilateral laminotomy, bilateral laminotomy, and laminectomy	<i>Journal of Neurosurgery—Spine</i>	193	2005	12.9

(continued)

Table 1. (continued)

Rank	First author	Title	Journal	Total citations	Year	Average citation
24	Fritz, JM	Subgrouping patients with low back pain: evolution of a classification approach to physical therapy	<i>Journal of Orthopaedic & Sports Physical Therapy</i>	192	2007	14.8
25	Angst, F	Minimal clinically important rehabilitation effects in patients with osteoarthritis of the lower extremities	<i>Journal of Rheumatology</i>	185	2002	10.3
26	Zheng, FY	Factors predicting hospital stay, operative time, blood loss, and transfusion in patients undergoing revision posterior lumbar spine decompression, fusion, and segmental instrumentation	<i>Spine</i>	180	2002	10
27	Zucherman, JF	A prospective randomized multi-center study for the treatment of lumbar spinal stenosis with the X STOP interspinous implant: 1-year results	<i>European Spine Journal</i>	174	2004	10.9
28	Schizas, C	Qualitative grading of severity of lumbar spinal stenosis based on the morphology of the dural sac on magnetic resonance images	<i>Spine</i>	166	2010	16.6
29	Conn, A	Systematic review of caudal epidural injections in the management of chronic low back pain	<i>Pain Physician</i>	163	2009	14.8
30	Yakut, E	Validation of the Turkish version of the Oswestry Disability Index for patients with low back pain	<i>Spine</i>	155	2004	9.7
31	Friedly, JL	A randomized trial of epidural glucocorticoid injections for spinal stenosis	<i>New England Journal of Medicine</i>	151	2014	25.2
32	Aalto, TJ	Preoperative predictors for postoperative clinical outcome in lumbar spinal stenosis—systematic review	<i>Spine</i>	143	2006	10.2
33	Pratt, RK	The reliability of the Shuttle Walking Test, the Swiss Spinal Stenosis Questionnaire, the Oxford Spinal Stenosis Score, and the Oswestry Disability Index in the assessment of patients with lumbar spinal stenosis	<i>Spine</i>	143	2002	7.9
34	Jansson, KA	Health-related quality of life (EQ-5D) before and one year after surgery for lumbar spinal stenosis	<i>Journal of Bone and Joint Surgery—British Volume</i>	142	2009	12.9
35	Fritz, JM	The use of a classification approach to identify subgroups of patients with acute low back pain - Interrater reliability and short-term treatment outcomes	<i>Spine</i>	142	2000	7.1
36	Iguchi, T	Minimum 10-year outcome of decompressive laminectomy for degenerative lumbar spinal stenosis	<i>Spine</i>	141	2000	7.1
37	Manchikanti, L	Comprehensive review of therapeutic interventions in managing chronic spinal pain	<i>Pain Physician</i>	138	2009	12.5
38	Kovacs, FM	Surgery versus conservative treatment for symptomatic lumbar spinal stenosis. A systematic review of randomized controlled trials	<i>Spine</i>	135	2011	15
39	Richards, JC	The treatment mechanism of an interspinous process implant for lumbar neurogenic intermittent claudication	<i>Spine</i>	133	2005	8.9
40	Wilke, HJ	Biomechanical effect of different lumbar interspinous implants on flexibility and intradiscal pressure	<i>European Spine Journal</i>	132	2008	11
41	Genevay, S	Lumbar spinal stenosis	<i>Best Practice & Research: Clinical Rheumatology Medical Care</i>	131	2010	13.1
42	Deyo, RA	Involving patients in clinical decisions—impact of an interactive video program on use of back surgery	<i>Pain Physician</i>	131	2000	6.6
43	Manchikanti, L	Preliminary results of a randomized, equivalence trial of fluoroscopic caudal epidural injections in managing chronic low back pain: Part 4—spinal stenosis	<i>Pain Physician</i>	129	2008	10.8
44	Atlas, SJ	Evaluating and managing acute low back pain in the primary care setting	<i>Journal of General Internal Medicine</i>	129	2001	6.8
45	Kreiner, DS	An evidence-based clinical guideline for the diagnosis and treatment of degenerative lumbar spinal stenosis (update)	<i>Spine Journal</i>	127	2013	18.1

(continued)

Table 1. (continued)

Rank	First author	Title	Journal	Total citations	Year	Average citation
46	Schnake, KJ	Dynamic stabilization in addition to decompression for lumbar spinal stenosis with degenerative spondylolisthesis	<i>Spine</i>	126	2006	9
47	Grotle, M	Functional status and disability questionnaires: what do they assess? A systematic review of back-specific outcome questionnaires	<i>Spine</i>	126	2005	8.4
48	Ragab, AA	Surgery of the lumbar spine for spinal stenosis in 118 patients 70 years of age or older	<i>Spine</i>	124	2003	7.3
49	Fritz, JM	Examining diagnostic tests: an evidence-based perspective	<i>Physical Therapy</i>	123	2001	6.5
50	Sirvanci, M	Degenerative lumbar spinal stenosis: Correlation with Oswestry Disability Index and MR imaging	<i>European Spine Journal</i>	119	2008	9.9
51	Botwin, KP	Fluoroscopically guided lumbar transforaminal epidural steroid injections in degenerative lumbar stenosis—an outcome study	<i>American Journal of Physical Medicine & Rehabilitation</i>	118	2002	6.6
52	Botwin, KP	Complications of fluoroscopically guided transforaminal lumbar epidural injections	<i>Archives of Physical Medicine And Rehabilitation</i>	118	2000	5.9
53	Sengupta, DK	Degenerative spondylolisthesis—review of current trends and controversies	<i>Spine</i>	116	2005	7.7
54	Schaeren, S	Minimum four-year follow-up of spinal stenosis with degenerative spondylolisthesis treated with decompression and dynamic stabilization	<i>Spine</i>	110	2008	9.2
55	Rosen, DS	Minimally invasive lumbar spinal decompression in the elderly: Outcomes of 50 patients aged 75 years and older	<i>Neurosurgery</i>	107	2007	8.2
56	Whitman, JM	A comparison between two physical therapy treatment programs for patients with lumbar spinal stenosis - A randomized clinical trial	<i>Spine</i>	105	2006	7.5
57	Simotas, AC	Nonoperative treatment for lumbar spinal stenosis—clinical and outcome results and a 3-year survivorship analysis	<i>Spine</i>	102	2000	5.1
58	Watters, WC	Degenerative lumbar spinal stenosis: an evidence-based clinical guideline for the diagnosis and treatment of degenerative lumbar spinal stenosis	<i>Spine Journal</i>	101	2008	8.4
59	Palmer, S	Bilateral decompression of lumbar spinal stenosis involving a unilateral approach with microscope and tubular retractor system	<i>Journal of Neurosurgery</i>	101	2002	5.6
60	Bae, HW	Nationwide trends in the surgical management of lumbar spinal stenosis	<i>Spine</i>	100	2013	14.3
61	Mannion, AF	Predictors of surgical outcome and their assessment	<i>European Spine Journal</i>	99	2006	7.1
62	Koc, Z	Effectiveness of physical therapy and epidural steroid injections in lumbar spinal stenosis	<i>Spine</i>	95	2009	8.6
63	Ghogawala, Z	Prospective outcomes evaluation after decompression with or without instrumented fusion for lumbar stenosis and degenerative Grade I spondylolisthesis	<i>Journal of Neurosurgery—Spine</i>	95	2004	5.9
64	Verhoof, OJ	High failure rate of the interspinous distraction device (X-STOP) for the treatment of lumbar spinal stenosis caused by degenerative spondylolisthesis	<i>European Spine Journal</i>	94	2008	7.8
65	Kondrashov, DG	Interspinous process decompression with the X-STOP device for lumbar spinal stenosis: a 4-year follow-up study	<i>Journal of Spinal Disorders & Techniques</i>	93	2006	6.6
66	Noponen-Hietala, N	Sequence variations in the collagen IX and XI genes are associated with degenerative lumbar spinal stenosis	<i>Annals of the Rheumatic Diseases</i>	90	2003	5.3
67	Steurer, J	Quantitative radiologic criteria for the diagnosis of lumbar spinal stenosis: a systematic literature review	<i>BMC Musculoskeletal Disorders</i>	88	2011	9.8
68	Suri, P	Does this older adult with lower extremity pain have the clinical syndrome of lumbar spinal stenosis?	<i>JAMA Journal of the American Medical Association</i>	88	2010	8.8
69	Rahman, M	Comparison of techniques for decompressive lumbar laminectomy: the minimally invasive versus the “classic” open approach	<i>Minimally Invasive Neurosurgery</i>	88	2008	7.3

(continued)

Table 1. (continued)

Rank	First author	Title	Journal	Total citations	Year	Average citation
70	Haig, AJ	Electromyographic and magnetic resonance imaging to predict lumbar stenosis, low-back pain, and no back symptoms	<i>Journal of Bone and Joint Surgery—American Volume</i>	87	2007	6.7
71	Manchikanti, L	The preliminary results of a comparative effectiveness evaluation of adhesiolysis and caudal epidural injections in managing chronic low back pain secondary to spinal stenosis: a randomized, equivalence controlled trial	<i>Pain Physician</i>	86	2009	7.8
72	Lurie, JD	Reliability of readings of magnetic resonance imaging features of lumbar spinal stenosis	<i>Spine</i>	86	2008	7.2
73	Goel, A	Facetal distraction as treatment for single- and multilevel cervical spondylotic radiculopathy and myelopathy: a preliminary report. Technical note	<i>Journal of Neurosurgery—Spine</i>	85	2011	9.4
74	Ikuta, K	Short-term results of microendoscopic posterior decompression for lumbar spinal stenosis. Technical note	<i>Journal of Neurosurgery—Spine</i>	85	2005	5.7
75	Toyone, T	Patients' expectations and satisfaction in lumbar spine surgery	<i>Spine</i>	83	2005	5.5
76	Dai, LY	Single-level instrumented posterolateral fusion of lumbar spine with beta-tricalcium phosphate versus autograft - A prospective, randomized study with 3-year follow-up	<i>Spine</i>	80	2008	6.7
77	Knutsson, B	Obesity is associated with inferior results after surgery for lumbar spinal stenosis	<i>Spine</i>	79	2013	11.3
78	Parr, AT	Caudal epidural injections in the management of chronic low back pain: a systematic appraisal of the literature	<i>Pain Physician</i>	78	2012	9.8
79	Cavusoglu, H	Midterm outcome after unilateral approach for bilateral decompression of lumbar spinal stenosis: 5-year prospective study	<i>European Spine Journal</i>	78	2007	6
80	Costa, F	Degenerative lumbar spinal stenosis: analysis of results in a series of 374 patients treated with unilateral laminotomy for bilateral microdecompression	<i>Journal of Neurosurgery—Spine</i>	78	2007	6
81	Borenstein, DG	Epidemiology, etiology, diagnostic evaluation, and treatment of low back pain	<i>Current Opinion in Rheumatology</i>	78	2001	4.1
82	Manchikanti, L	Results of 2-year follow-up of a randomized, double-blind, controlled trial of fluoroscopic caudal epidural injections in central spinal stenosis	<i>Pain Physician</i>	77	2012	9.6
83	Lee, JB	An interspinous process distractor (X STOP) for lumbar spinal stenosis in elderly patients—preliminary experiences in 10 consecutive cases	<i>Journal of Spinal Disorders & Techniques</i>	76	2004	4.8
84	Oertel, MF	Long-term results of microsurgical treatment of lumbar spinal stenosis by unilateral laminotomy for bilateral decompression	<i>Neurosurgery</i>	75	2006	5.4
85	Atlas, SJ	Spinal stenosis—surgical versus nonsurgical treatment	<i>Clinical Orthopaedics and Related Research</i>	75	2006	5.4
86	Christie, SD	Dynamic interspinous process technology	<i>Spine</i>	75	2005	5
87	Korovessis, P	Rigid, semirigid versus dynamic instrumentation for degenerative lumbar spinal stenosis: a correlative radiological and clinical analysis of short-term results	<i>Spine</i>	75	2004	4.7
88	Sanden, B	Smokers show less improvement than nonsmokers two years after surgery for lumbar spinal stenosis: a study of 4555 patients from the Swedish Spine Register	<i>Spine</i>	74	2011	8.2
89	Sobottke, R	Interspinous implants (X STOP [®] , Wallis [®] , Diam [®]) for the treatment of LSS: is there a correlation between radiological parameters and clinical outcome?	<i>European Spine Journal</i>	74	2009	6.7
90	Pao, JL	Clinical outcomes of microendoscopic decompressive laminotomy for degenerative lumbar spinal stenosis	<i>European Spine Journal</i>	74	2009	6.7
91	de Graaf, I	Diagnosis of lumbar spinal stenosis: A systematic review of the accuracy of diagnostic tests	<i>Spine</i>	74	2006	5.3
92	Delpont, EG	Treatment of lumbar spinal stenosis with epidural steroid injections: a retrospective outcome study	<i>Archives of Physical Medicine and Rehabilitation</i>	74	2004	4.6

(continued)

Table 1. (continued)

Rank	First author	Title	Journal	Total citations	Year	Average citation
93	Szpalski, M	Lumbar spinal stenosis in the elderly: an overview	<i>European Spine Journal</i>	74	2003	4.4
94	Fisher, MA	Electrophysiology of radiculopathies	<i>Clinical Neurophysiology</i>	74	2002	4.1
95	Siebert, E	Lumbar spinal stenosis: syndrome, diagnostics and treatment	<i>Nature Reviews Neurology</i>	73	2009	6.6
96	Siddiqui, M	One-year results of X STOP interspinous implant for the treatment of lumbar spinal stenosis	<i>Spine</i>	73	2007	5.6
97	Sengupta, DK	Lumbar spinal stenosis: treatment strategies and indications for surgery	<i>Orthopedic Clinics of North America</i>	72	2003	4.2
98	Benoist, M	The natural history of lumbar degenerative spinal stenosis	<i>Joint Bone Spine</i>	72	2002	4
99	Manchikanti, L	Lumbar interlaminar epidural injections in central spinal stenosis: preliminary results of a randomized, double-blind, active control trial	<i>Pain Physician</i>	71	2012	8.9
100	Podichetty, VK	Complications associated with minimally invasive decompression for lumbar spinal stenosis	<i>Journal of Spinal Disorders & Techniques</i>	71	2006	5.1

Lahey Hospital & Medical Center, USA, suggesting that additional spinal fusion to lumbar decompression provides no significant improvement on Oswestry Disability Index (ODI) of patients with spondylolisthesis and LSS.

The most cited article with 2162 citations was titled "The Oswestry Disability Index" by Fairbank and Pynsent in *Spine* in 2000.¹⁷ The article concluded that the ODI remained a valid and vigorous measure of spinal disorders, including LSS. The second most cited article was published by Chou et al¹⁸ in the *Annals of Internal Medicine* in 2007, with 1590 total citations. In this article, 7 recommendations were proposed to diagnose and treat patients suffering from low back pain, such as LSS. The 2001 study by Deyo et al¹⁹ published in the *New England Journal of Medicine* was the third most cited, which discussed the primary care of low back pain, including LSS.

The highest ranking article in CY-index was the same as the second one in total citation count, with 122.3 citations per year.¹⁸ This was followed by the most cited article mentioned above, whose CY-index was 108.1.¹⁷ The third was a 2010 article written by Deyo et al²⁰ in *JAMA Journal of the American Medical Association* with an CY-index of 64.8, which discussed the increasing frequency of fusion procedures for spinal stenosis and its association with higher risk of major complications, 30-day mortality, and resource use.

Discussion

In recent years, the incidence of LSS has significantly increased, especially in the middle aged and elderly. With the constant development and transformation of LSS in treatment concepts and techniques, abundant literature has emerged, being helpful to improve the field. But the volume of literature also brings the problem of aggravating the burden that researchers have on identifying studies of significant contributions. Bibliometric or citation analysis helps in estimating scientific impact and quantifying characteristics of publications

by predecessors.²¹ Our purpose was to conduct a study that covered the top 100 cited articles on LSS, and gain insight into the quality of these published work.

In our study, we found that articles on the top list were published by researchers in a variety of specialties consisting of orthopedic, neurosurgery, neurology, pathology, radiology, and even internal medicine. Compared with other fields in which most influential articles are published in few journals,²² the most cited articles on LSS were published in 31 different journals, indicating the multidisciplinary nature of LSS study.

The article that had been most cited was a retrospective review by Fairbank and Pynsent¹⁷ in 2000 in *Spine*, focusing on the ODI and analyzing its reliability. Since the ODI was established, it had been the most commonly recommended specific outcome measure. Although ODI was a universally recognized standard, there was no strong evidence or research to support this measure. In the landmark study, the authors identified all published versions of the ODI and made a systematic review in order to provide curves for power calculations in studies using the ODI. Thus, it can be seen that an appropriate evaluation standard or scoring system of spinal disorders, including LSS, was drawing more attention of researchers since 2000. The final results of the article showed that the ODI remained a valid and vigorous outcome measure, which is still regarded as the classic gold standard today. These may explain why this article was ranked at the top position with a total of 2162 citations.

The second most cited article was a practice guideline by Chou et al¹⁸ in 2007 in the *Annals of Internal Medicine*. With the increasing aging of the society, low back pain caused by spinal diseases (LSS as a common problem) has become a symptom related reason second to upper respiratory diseases, which attracted more attention. However, there had been few consensus on the appropriate clinical evaluation and management of low back pain, whether within or between specialties.²³

Table 2. Journal Distribution of the 100 Top Cited Articles on Lumbar Spinal Stenosis.

Journal	No. of Articles
<i>Spine</i>	37
<i>European Spine Journal</i>	9
<i>Pain Physician</i>	8
<i>New England Journal of Medicine</i>	6
<i>Journal of Neurosurgery–Spine</i>	5
<i>Spine Journal</i>	3
<i>Journal of Spinal Disorders & Techniques</i>	3
<i>Neurosurgery</i>	2
<i>Journal of Orthopaedic & Sports Physical Therapy</i>	2
<i>JAMA Journal of The American Medical Association</i>	2
<i>Archives of Physical Medicine and Rehabilitation</i>	2
<i>Annals of Internal Medicine</i>	2
<i>Physical Therapy</i>	1
<i>Orthopedic Clinics of North America</i>	1
<i>Nature Reviews Neurology</i>	1
<i>Minimally Invasive Neurosurgery</i>	1
<i>Medical Care</i>	1
<i>Journal of Rheumatology</i>	1
<i>Journal of Neurosurgery</i>	1
<i>Journal of General Internal Medicine</i>	1
<i>Journal of Bone and Joint Surgery–British Volume</i>	1
<i>Journal of Bone and Joint Surgery–American Volume</i>	1
<i>Joint Bone Spine</i>	1
<i>Current Opinion in Rheumatology</i>	1
<i>Clinical Orthopaedics and Related Research</i>	1
<i>Clinical Neurophysiology</i>	1
<i>BMC Musculoskeletal Disorders</i>	1
<i>Best Practice & Research: Clinical Rheumatology</i>	1
<i>Arthritis and Rheumatism</i>	1
<i>Annals of the Rheumatic Diseases</i>	1
<i>American Journal of Physical Medicine & Rehabilitation</i>	1

Table 3. Authors With Multiple Publications.

Author	No. of Articles
Manchikanti, L	6
Atlas, SJ	4
Deyo, RA	3
Fritz, JM	3
Angst, F	2
Botwin, KP	2
Chou, R	2
Ghogawala, Z	2
Sengupta, DK	2
Weinstein, JN	2
Zucherman, JF	2
Friedly, JL	2

In this article, the authors proposed 7 recommendations that covered the evaluation and treatment of low back pain. Though this study was published later than most of other top ranked ones, its total citations was still the second (1590), while the CY-index was the highest (122.3), indicating that it was paid more attention than the most cited article. It is also worth mentioning that although the article was relevant to

orthopedics, it was published in an internal medicine journal. Thus, its cross-specialty influence and importance can be seen.

The third most cited article was a primary care article by Deyo et al¹⁹ in the *New England Journal of Medicine* in 2001, also focusing on low back pain caused by various spinal disorders, including LSS. Those years, there had been excessive imaging and surgery for low back pain in the United States, and many physicians believed the existence of “overmedicalization.”²⁴ This study comprehensively introduced the primary care of low back pain. Most important, it pointed out that bed rest was not recommended for the treatment of low back pain or sciatica, and surgery was most successful for those with sciatica or pseudo-claudication that continued after nonsurgical therapy had been tried. These have been regarded as guidelines up to now.

As a more in-depth analysis of the 5 most cited articles, we found that their study topics mainly focused on assessment measure, health-related quality of life, and outcome of surgical treatment. Assessment measure, which is widely used in clinical practice and even in common use in society, can help both doctors and patients have an intuitive and quantitative understanding of the severity of the disease, thus the articles on this topic have higher citations. Though the topic of health-related quality of life was rarely mentioned (only 3%) on the top 100 list, there were 2 articles on this topic in the 5 most cited articles, indicating a very high frequency, which may imply that spine surgeons and the lay population pay more attention to this topic, but relevant studies or their total citations are relatively few. In addition, the study design and methods of the 5 most cited articles were all appropriate, including systematic reviews and retrospective cohort studies based on validated studies or literature of high-quality evidence.

When searching the literature, we set a time limit from 2000 to 2019. The final list demonstrated that almost 50% of the top cited articles (49/100) on LSS were published between 2005 and 2009. These 5 years were the most prolific period. One possible explanation is that aggravation of global aging may have led to the increase of lumbar degenerative diseases accompanied by low back pain. Another potential explanation is that the increasingly advanced imaging examination methods may improve the diagnosis. Along with people’s demanding requirements for quality of life and motor function, experts conducted more studies on this topic. The second most cited article with the highest CY-index by Chou R is the best proof.

According to the result, we found that most articles were published in *Spine* (37/100). It should be noted that the contribution of a journal may owing to its years and/or frequency of publication.²⁵ *Spine* is a peer-reviewed, biweekly periodical and is recognized as a leading journal in the field of spine. It provides forums for advanced progress in diagnosis and treatment, in order to reduce the incidence of spinal disorders in humans. Experts discuss current opinions in various disciplines related to spinal disorders, including anatomy, physiology, biochemistry, and biomechanics. By virtue of long-time circulation since 1976 and enormous impact in the field of

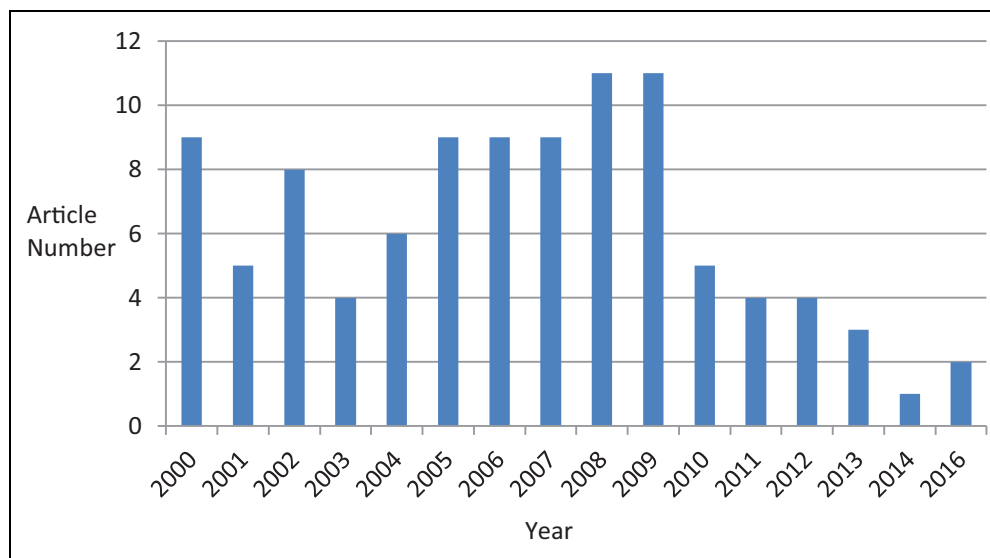


Figure 1. Publishing years of the 100 top cited articles on spinal deformity.

Table 4. Institutions With Multiple Publications of the 100 Top Cited Articles on Lumbar Spinal Stenosis.

Institution	No. of Articles
Harvard University, USA	11
University of Washington, USA	10
Dartmouth Medical School, USA	6
Pain Management Center of Paducah, USA	6
Brigham and Women’s Hospital, USA	5
Massachusetts General Hospital, USA	5
Dartmouth-Hitchcock Medical Center, USA	4
Millennium Pain Center, USA	4
University of Louisville, USA	4
University of Miami, USA	4
University of Pittsburgh, USA	4
Vanderbilt University, USA	4
Hospital for Special Surgery, USA	3
Medical College of Wisconsin, USA	3
Nuffield Orthopedic Center, England	3
Stanford University, USA	3
University of California, San Francisco, USA	2
University of Kentucky, USA	2
Uppsala University, Sweden	2
William Beaumont Hospital, USA	2

Table 5. Countries of the 100 Top Cited Articles on Lumbar Spinal Stenosis.

Country	No. of Articles
USA	58
Germany	7
Japan	4
Sweden	4
Turkey	4
Switzerland	4
England	3
Holland	2
Norway	2
Finland	2
Scotland	2
Greece	1
Belgium	1
Italy	1
India	1
Spain	1
China	1
Taiwan, China	1
France	1

spine, its frequent appearance on the top list is not difficult to explain.

Based on level-of-evidence classification, most of the articles (65%) belonged to level IV evidence, while only 9% were level I and 7% were level II evidence. Though this observation indicated a lack of high-quality evidence for the research of LSS, it must be pointed out that it is quite difficult to conduct randomized controlled trials. We have also noticed relatively few articles of level III evidence (case-control or retrospective comparative studies). They allow multivariate analysis or direct comparison of interventions, which may be the future

progress and trends in LSS. In addition, we believe that the low frequency of high-level evidence studies was not simply due to less application of randomized controlled trials, their less citation than studies with lower levels of evidence was also a noticeable reason.

As a bibliometric citation analysis, we agree that it is an effective method to measure the impact of articles. However, our current study has several limitations. First is its relatively single database (WOS) for searching literature. Though it is a multidisciplinary comprehensive database covering the field of natural science and access to global academic information, there are differences in indexing among various present

databases such as InCites, MEDLINE, and those should be taken into consideration in future. Second, though WOS is a worldwide database used for citation analysis, its main language is English, which means literature written in other languages are not included and may cause several relevant articles to be missed. Third, self-citation is probably the most controversial factor of citation analysis, which can be divided into 2 circumstances: authors citing their own articles to increase citation counts, and authors citing more articles from the journals in which they hope to publish their research. This may skew citation analysis and make audience confused about whether articles are more influential or just frequently self-cited. We need further study to analyze the frequency of self-citation and its impact on articles. Fourth, the citation count does not completely reflect an article's impact, the level of evidence is also a very important criterion. But in our article, we did not classify the level of evidence. That should be improved in the further study. Finally, it is reasonable that articles published in influential journals and by well-known authors have more potential to be cited and have a wider audience. This may lead to "advertising effect" and probably omit real high-quality articles. Despite these limitations, our study has several advantages. First, it is the first bibliometric analysis on LSS, one of the most common spinal disorders, which has attracted increasing attention. Second, our analysis can help researchers identify high-quality articles and provide some insights on the characteristics of study on LSS.

Conclusion

The current study analyzed the 100 most cited articles on LSS according to their authors, institutions, countries, and journals, as well as identified their important contributions to this field. Though our bibliometric analysis did not address the quality of a scientific report, it no doubt developed a useful resource with detailed information for many, particularly orthopedic and neurosurgery physicians who want to assimilate research focus and advance of LSS within a relatively short period. Researchers may benefit from emphasis on citation count while citing and evaluating articles and realize the deficiencies when high-level articles appear. In addition, we need more high-quality studies on LSS such as well-designed randomized trials, in order to affect future practice patterns and allow physicians to better understand LSS and determine the treatment strategy.

Author Contributions

Chongqing Xu and Mengchen Yin designed the study. Yinjie Yan collected the data. Mengchen Yin performed the data analysis. Chongqing Xu wrote the manuscript. Wen Mo revised the manuscript. Wen Mo decided to submit the manuscript for publication. All authors read and approved the final manuscript.


Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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