

The 100 Most Influential Articles in Cervical Spine Surgery

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Abstract

Study Design Literature review.

Objective To identify and analyze the top 100 cited articles in cervical spine surgery.

Methods The Thomson Reuters Web of Knowledge was searched for citations of all articles relevant to cervical spine surgery. The number of citations, authorship, year of publication, journal of publication, country of publication, and institution were recorded for each article.

Results The most cited article was the classic from 1991 by Vernon and Mior that described the Neck Disability Index. The second most cited was Smith’s 1958 article describing the anterior cervical discectomy and fusion procedure. The third most cited article was Hilibrand’s 1999 publication evaluating the incidence, prevalence, and radiographic progression of symptomatic adjacent segment disease following anterior cervical arthrodesis. The majority of the articles originated in the United States (65), and most were published in *Spine* (39). Most articles were published in the 1990s (34), and the three most common topics were cervical fusion (17), surgical complications (9), and biomechanics (9), respectively. Author Abumi had four articles in the top 100 list, and authors Goffin, Panjabi, and Hadley had three each. The Department of Orthopaedic Surgery at Hokkaido University in Sapporo, Japan, had five articles in the top 100 list.

Conclusion This report identifies the top 100 articles in cervical spine surgery and acknowledges those individuals who have contributed the most to the advancement of the study of the cervical spine and the body of knowledge used to guide evidence-based clinical decision making in cervical spine surgery today.

Keywords

- ▶ cervical spine
- ▶ surgery
- ▶ most-cited
- ▶ literature
- ▶ publication
- ▶ top 100

Introduction

Cervical spine surgery is a rapidly evolving and challenging subspecialty that owes its advancements to many individuals and their pioneering works that have shaped the way we practice modern cervical spine surgery today. One way to distinguish and honor these individuals is by recognizing the impact of their scientific publications. This study is the first to

analyze and quantify the most highly cited articles in cervical spine surgery and to measure their impact on the entire cervical spine literature.

A citation acknowledges the relevance given by the author to the work of others on a topic of interest in which the citation appears.¹ The primary goal of a citation is to credit an author on the work, which they have previously published. The greater the number of citations an author has, the more

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esteemed that author becomes in their particular field of practice. Citation analysis is used to determine the relative importance of medical journals by means of the impact factor, which is determined from the ratio of the number of citations in the current year to articles published in the journal in the 2 preceding years, divided by the number of citable items published in the same 2 years.²⁻⁴ The impact factor has emerged as the marker of the quality and rank of a journal.

A recent publication identified the most cited articles related to the care of spine patients, recognizing the historical advances of this field and allowing for insights into the types of articles that have provided these advances.⁵

The goal of this study is to identify the top 100 articles relevant to cervical spine surgery published in surgical and non-surgery-related journals through an extensive search of the literature using methods validated in other similar, previously published studies.⁶⁻¹¹

Methods

The Thomson Reuters Web of Knowledge, a research platform that provides bibliographic database services, was used to search for citations of all articles from 1900 to 2014 relevant to the cervical spine and published in surgical and nonsurgical journals. The decision on which journals to search was made with the use of Thomson Reuters Journal Citation Report database, which ranks journals according to impact factor.

The search limits and sorting options in the Thomson Reuters Web of Knowledge were used to rank all articles from each journal according to the number of citations. The results were then carefully reviewed and only those relevant to cervical spine surgery were selected. The 100 articles that matched the search criteria were then further analyzed, and the title, first author, journal, year of publication, number of citations, and country and institution of origin were recorded.

Results

A total of 40,315 articles matched the search criteria. Of those, 409 were cited 100 times or more. The top 100 articles, their references, category, and corresponding number of citations are shown in ►Table 1. The top article was cited 826 times; the 100th article, 133 times; and the mean number of citations for the top 100 articles was 203.6. The oldest article was by Rogers,¹² published in 1957. The newest article was published in 2009 by Murrey et al.¹³ Eighty-three percent of the top 100 cited articles were published after 1980, with the 1990s producing the largest number of highly cited articles (35%; ►Table 2). The top 100 articles were published in 18 journals, with the top three journals publishing 72% of the articles (►Table 3). The top journal was *Spine* with 39 articles followed by the *Journal of Bone and Joint Surgery American Volume* with 20 articles and the *Journal of Neurosurgery* with 13 articles. The three most popular categories were cervical spinal fusion with 17 articles, surgical complications with 9 articles, and biomechanics of the cervical spine with 9 articles (►Table 4). Eighty-six first authors contributed to the top 100

articles. Only three authors were credited with three or more publications and only one author, Abumi, had four publications in the top 100 (►Table 5). The top articles originated from nine different countries, with the United States (65%) being the most prolific (►Table 6). There were 61 institutions responsible for the top-cited articles with Hokkaido University in Sapporo, Japan contributing the most articles with five publications in the top 100 (►Table 7).

Discussion

This study identifies the authors and topics that made the greatest impact in the field of cervical spine surgery over the course of the last century and the beginning of this century. Through the identification of these classic works, we gain an insight into the history, development, and current trends in cervical spine surgery. The findings of this study identify the articles responsible for the most important developments in this field.

The most cited article in cervical spine surgery is the classic 1991 work by Vernon and Mior describing the Neck Disability Index (NDI),¹⁴ a patient-reported outcome measure designed to evaluate neck-specific disability. The NDI is a modification of the Oswestry Low Back Pain Disability Index. It is a patient-completed, condition-specific functional status questionnaire with 10 items concerning pain and activities of daily living including personal care, reading, lifting, headache, concentration, sleeping, work status, driving, and recreation.¹⁵ The NDI has been translated into over 22 languages and is reliable, valid, and responsive in many patient populations including patients with acute and chronic conditions, as well as those suffering from neck pain associated with musculoskeletal dysfunction, whiplash-associated disorders, and cervical radiculopathy.¹⁶

The second most cited article was from 1958 by Smith and Robinson,¹⁷ describing a surgical procedure for the removal of cervical intervertebral disks and for fusion of the cervical spine by the anterior approach. This article also outlined the indications for this procedure and reported the results from their first 14 patients. Smith and Robinson's procedure is known today as the anterior cervical discectomy and fusion (ACDF), the current standard of care for patients with cervical spondylotic radiculopathy or myelopathy. Twenty-five of the top 100 articles described various aspects of the ACDF including indications, complications, technique, and outcomes.

The third most cited article was the 1999 work of Hilibrand et al,¹⁸ describing the incidence, prevalence, and radiographic progression of symptomatic adjacent segment disease, defined as the development of new radiculopathy or myelopathy referable to a motion segment adjacent to the site of a previous anterior arthrodesis of the cervical spine. In their work, the authors opined that the risk of adjacent segment disease following cervical arthrodesis is related to the natural history of cervical spondylosis rather than to failure of the operative technique and that it is probably unaffected by the operative management. This topic has been controversial and of great debate with over 200 published articles in the literature and four articles in the top 100 list.¹⁸⁻²¹

Table 1 The top 100 articles in cervical spine surgery

Rank	Article	Category	Citations
1	Vernon H, Mior S. The Neck Disability Index: a study of reliability and validity. <i>J Manipulative Physiol Ther</i> 1991;14(7):409–415	Outcome measure	826
2	Smith GW, Robinson RA. The treatment of certain cervical-spine disorders by anterior removal of the intervertebral disc and interbody fusion. <i>J Bone Joint Surg Am</i> 1958;40-A(3):607–624	Fusion	654
3	Hilibrand AS, Carlson GD, Palumbo MA, et al. Radiculopathy and myelopathy at segments adjacent to the site of a previous anterior cervical arthrodesis. <i>J Bone Joint Surg Am</i> 1999;81(4):519–528	Adjacent segment disease	549
4	Harms J, Melcher RP. Posterior C1–C2 fusion with polyaxial screw and rod fixation. <i>Spine</i> 2001;26(22):2467–2471	Fusion	530
5	Hoffman JR, Mower WR, Wolfson AB, et al. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. National Emergency X-Radiography Utilization Study Group. <i>N Engl J Med</i> 2000;343(2):94–99	Trauma	387
6	Bohlman HH. Acute fractures and dislocations of the cervical spine. An analysis of three hundred hospitalized patients and review of the literature. <i>J Bone Joint Surg Am</i> 1979;61(8):1119–1142	Fracture	373
7	Bohlman HH, Emery SE, Goodfellow DB, et al. Robinson anterior cervical discectomy and arthrodesis for cervical radiculopathy. Long-term follow-up of one hundred and twenty-two patients. <i>J Bone Joint Surg Am</i> 1993;75(9):1298–1307	Fusion	361
8	Boden SD, McCowin PR, Davis DO, et al. Abnormal magnetic-resonance scans of the cervical spine in asymptomatic subjects. A prospective investigation. <i>J Bone Joint Surg Am</i> 1990;72(8):1178–1184	Operative guidelines	352
9	Ranawat CS, O'Leary P, Pellicci P, et al. Cervical spine fusion in rheumatoid arthritis. <i>J Bone Joint Surg Am</i> 1979;61(7):1003–1010	Fusion	324
10	Bailey RW, Badgley CE. Stabilization of the cervical spine by anterior fusion. <i>J Bone Joint Surg Am</i> 1960;42(4):565–594	Fusion	317
11	Stiell IG, Wells GA, Vandemheen KL, et al. The Canadian C-spine rule for radiography in alert and stable trauma patient. <i>JAMA</i> 2001;286(15):1841–1848	Trauma	311
12	Payne EE, Spillane JD. The cervical spine; an anatomic-pathological study of 70 specimens (using a special technique) with particular reference to the problem of cervical spondylosis. <i>Brain</i> 1957;80(4):571–596	Anatomic study	286
13	Hirabayashi K, Watanabe K, Wakano K, et al. Expansive open-door laminoplasty for cervical spinal stenotic myelopathy. <i>Spine</i> 1983;8(7):693–699	Laminoplasty	283
14	Schneider RC, Thompson JM, Bebin J. The syndrome of acute central cervical spinal cord injury. <i>J Neurol Neurosurg Psychiatry</i> 1958;21(3):216–227	Spinal cord injury	273
15	Robinson RA, Walker AE, Ferlic DC, et al. The results of anterior interbody fusion of the cervical spine. <i>J Bone Joint Surg Am</i> 1962;44(8):1569–1587	Fusion	256
16	Gore DR, Sepic SB. Anterior cervical fusion for degenerated or protruded discs. A review of one hundred forty-six patients. <i>Spine</i> 1984;9(7):667–671	Fusion	248
17	Allen BL Jr, Ferguson RL, Lehmann TR, et al. A mechanistic classification of closed, indirect fractures and dislocations of the lower cervical spine. <i>Spine</i> 1982;7(1):1–27	Fracture classification	247
18	Wright NM, Laurysen C. Vertebral artery injury in C1–2 trans-articular screw fixation: results of a survey of the AANS/CNS section on disorders of the spine and peripheral nerves. <i>J Neurosurg</i> 1998;88(4):634–640	Complications	245

(Continued)

Table 1 (Continued)

Rank	Article	Category	Citations
19	Pang D, Pollack IF. Spinal cord injury without radiographic abnormality in children—the SCIWORA syndrome. <i>J Trauma</i> 1989;29(5):654–664	Spinal cord injury	241
20	Eck JC, Humphreys SC, Lim TH, et al. Biomechanical study on the effect of cervical spine fusion on adjacent-level intradiscal pressure and segmental motion. <i>Spine</i> 2002;27(22):2431–2434	Adjacent segment disease	238
21	Shields LB, Raque GH, Glassman SD, et al. Adverse effects associated with high-dose recombinant human bone morphogenetic protein-2 use in anterior cervical spine fusion. <i>Spine</i> 2006;31(5):542–547	Complications	227
22	Hurwitz EL, Aker PD, Adams AH, et al. Manipulation and mobilization of the cervical spine. A systematic review of the literature. <i>Spine</i> 1996;21(15):1746–1759	Manipulation	224
23	Jones EL, Heller JG, Silcox DH, et al. Cervical pedicle screws versus lateral mass screws. Anatomic feasibility and biomechanical comparison. <i>Spine</i> 1997;22(9):977–982	Instrumentation	223
24	Grob D, Jeanneret B, Aebi M, et al. Atlanto-axial fusion with transarticular screw fixation. <i>J Bone Joint Surg Br</i> 1991;73(6):972–976	Fusion	219
25	Reinhaus E, Waldbaur H, Seeling W. Spinal epidural abscess: a meta-analysis of 915 patients. <i>Neurosurg Rev</i> 2000;23(4):175–204	Infection	218
26	Jeanneret B, Magerl F. Primary posterior fusion C1/2 in odontoid fractures: indications, technique, and results of transarticular screw fixation. <i>J Spinal Disord</i> 1992;5(4):464–475	Fusion	214
27	Panjabi MM, Duranceau J, Goel V, et al. Cervical human vertebrae. Quantitative three-dimensional anatomy of the middle and lower regions. <i>Spine</i> 1991;16(8):861–869	Anatomic study	213
28	Gore DR, Sepic SB, Gardner GM. Roentgenographic findings of the cervical spine in asymptomatic people. <i>Spine</i> 1986;11(6):521–524	Epidemiology	212
29	Kotani Y, Cunningham BW, Abumi K, et al. Biomechanical analysis of cervical stabilization systems. An assessment of transpedicular screw fixation in the cervical spine. <i>Spine</i> 1994;19(22):2529–2539	Instrumentation	211
30	Abumi K, Shono Y, Ito M, et al. Complications of pedicle screw fixation in reconstructive surgery of the cervical spine. <i>Spine</i> 2000;25(8):962–969	Complications	210
31	Rogers WA. Fractures and dislocations of the cervical spine; an end-result study. <i>J Bone Joint Surg Am</i> 1957;39-A(2):341–376	Fracture	208
32	Reid DC, Henderson R, Saboe L, et al. Etiology and clinical course of missed spine fractures. <i>J Trauma</i> 1987;27(9):980–986	Fracture	207
33	Fang HSY, Ong GB. Direct anterior approach to the upper cervical spine. <i>J Bone Joint Surg Am</i> 1962;44-A:1588–1604	Surgical approach	206
34	Davis JW, Phreaner DL, Hoyt DB, et al. The etiology of missed cervical spine injuries. <i>J Trauma</i> 1993;34(3):342–346	Trauma	205
35	Goffin J, Van Calenbergh F, van Loon J, et al. Intermediate follow-up after treatment of degenerative disc disease with the Bryan Cervical Disc Prosthesis: single-level and bi-level. <i>Spine</i> 2003;28(24):2673–2678	Cervical disk replacement	199
36	Cattell HS, Filtzer DL. Pseudosubluxation and other normal variations in the cervical spine in children. A study of one hundred and sixty children. <i>J Bone Joint Surg Am</i> 1965;47(7):1295–1309	Epidemiology	186
37	Abumi K, Itoh H, Taneichi H, et al. Transpedicular screw fixation for traumatic lesions of the middle and lower cervical spine: description of the techniques and preliminary report. <i>J Spinal Disord</i> 1994;7(1):19–28	Instrumentation	185

Table 1 (Continued)

Rank	Article	Category	Citations
38	Emery SE, Bohlman HH, Bolesta MJ, et al. Anterior cervical decompression and arthrodesis for the treatment of cervical spondylotic myelopathy. Two to seventeen-year follow-up. <i>J Bone Joint Surg Am</i> 1998;80(7):941–951	Fusion	185
39	Bagby GW. Arthrodesis by the distraction-compression method using a stainless steel implant. <i>Orthopedics</i> 1988;11(6):931–934	Fusion	184
40	Goffin J, Casey A, Kehr P, et al. Preliminary clinical experience with the Bryan Cervical Disc prosthesis. <i>Neurosurgery</i> 2002;51(3):840–845; discussion 845–847	Cervical disk replacement	181
41	Vaccaro AR, Falatyn SP, Scuderi GJ, et al. Early failure of long segment anterior cervical plate fixation. <i>J Spinal Disord</i> 1998;11(5):410–415	Complications	179
42	Sawin PD, Travnelis VC, Menezes AH. A comparative analysis of fusion rates and donor-site morbidity for autogeneic rib and iliac crest bone grafts in posterior cervical fusions. <i>J Neurosurg</i> 1998;88(2):255–265	Fusion	178
43	Clark CR, White AA 3rd. Fractures of the dens. A multicenter study. <i>J Bone Joint Surg Am</i> 1985;67(9):1340–1348	Fracture	174
44	Mummaneni PV, Burkus JK, Haid RW, et al. Clinical and radiographic analysis of cervical disc arthroplasty compared with allograft fusion: a randomized controlled clinical trial. <i>J Neurosurg Spine</i> 2007;6(3):198–209	Cervical disk replacement	169
45	Dickman CA, Sonntag VK, Papadopoulos SM, et al. The interspinous method of posterior atlantoaxial arthrodesis. <i>J Neurosurg</i> 1991;74(2):190–198	Fusion	169
46	Boden SD, Dodge LD, Bohlman HH. Rheumatoid arthritis of the cervical spine. A long-term analysis with predictors of paralysis and recovery. <i>J Bone Joint Surg Am</i> 1993;75(9):1282–1297	Rheumatoid arthritis	168
47	Stiell IG, Clement CM, McKnight RD, et al. The Canadian C-spine rule versus the NEXUS low-risk criteria in patients with trauma. <i>N Engl J Med</i> 2003;349(26):2510–2518	Trauma	167
48	Perry J, Nickel VL. Total cervical spine fusion for neck paralysis. <i>J Bone Joint Surg Am</i> 1959;41-A(1):37–60	Fusion	166
49	Levine AM, Edwards CC. The management of traumatic spondylolisthesis of the axis. <i>J Bone Joint Surg Am</i> 1985;67(2):217–226	Trauma	166
50	Kaiser MG, Haid RW Jr, Subach BR, et al. Anterior cervical plating enhances arthrodesis after discectomy and fusion with cortical allograft. <i>Neurosurgery</i> 2002;50(2):229–236	Cervical plating	166
51	Wada E, Suzuki S, Kanazawa A, et al. Subtotal corpectomy versus laminoplasty for multilevel cervical spondylotic myelopathy: a long-term follow-up study over 10 years. <i>Spine</i> 2001;26(13):1443–1447	Laminoplasty	164
52	Pellicci PM, Ranawat CS, Tsairis P, et al. A prospective study of the progression of rheumatoid arthritis of the cervical spine. <i>J Bone Joint Surg Am</i> 1981;63(3):342–350	Rheumatoid arthritis	164
53	Johnson RM, Hart DL, Simmons EF, et al. Cervical orthoses. A study comparing their effectiveness in restricting cervical motion in normal subjects. <i>J Bone Joint Surg Am</i> 1977;59(3):332–339	Orthoses	164
54	Bishop RC, Moore KA, Hadley MN. Anterior cervical interbody fusion using autogeneic and allogeneic bone graft substrate: a prospective comparative analysis. <i>J Neurosurg</i> 1996;85(2):206–210	Bone graft	163
55	Abumi K, Kaneda K. Pedicle screw fixation for nontraumatic lesions of the cervical spine. <i>Spine</i> 1997;22(16):1853–1863	Instrumentation	161

(Continued)

Table 1 (Continued)

Rank	Article	Category	Citations
56	Hosono N, Yonenobu K, Ono K. Neck and shoulder pain after laminoplasty. A noticeable complication. <i>Spine</i> 1996;21(17):1969–1973	Laminoplasty	161
57	Goffin J, Geusens E, Vantomme N, et al. Long-term follow-up after interbody fusion of the cervical spine. <i>J Spinal Disord Tech</i> 2004;17(2):79–85	Fusion	159
58	Richter M, Schmidt R, Claes L, et al. Posterior atlantoaxial fixation: biomechanical in vitro comparison of six different techniques. <i>Spine</i> 2002;27(16):1724–1732	Biomechanics	157
59	Torg JS, Pavlov H, Genuario SE, et al. Neurapraxia of the cervical spinal cord with transient quadriplegia. <i>J Bone Joint Surg Am</i> 1986;68(9):1354–1370	Spinal cord injury	157
60	Wang JC, McDonough PW, Endow KK, et al. Increased fusion rates with cervical plating for two-level anterior cervical discectomy and fusion. <i>Spine</i> 2000;25(1):41–45	Cervical plating	155
61	Coe JD, Warden KE, Sutterlin CE 3rd, et al. Biomechanical evaluation of cervical spinal stabilization methods in a human cadaveric model. <i>Spine</i> 1989;14(10):1122–1131	Biomechanics	155
62	Itoh T, Tsuji H. Technical improvements and results of laminoplasty for compressive myelopathy in the cervical spine. <i>Spine</i> 1985;10(8):729–736	Laminoplasty	154
63	Saunders RL, Bernini PM, Shirreffs TG Jr. Central corpectomy for cervical spondylotic myelopathy: a consecutive series with long-term follow-up evaluation. <i>J Neurosurg</i> 1991;74(2):163–170	Corpectomy	153
64	Connolly PJ, Esses SI, Kostuik JP. Anterior cervical fusion: outcome analysis of patients fused with and without anterior cervical plates. <i>J Spinal Disord</i> 1996;9(3):202–206	Cervical plating	152
65	Schneider RC, Livingston KE, Cave AJ, et al. “Hangman’s fracture” of the cervical spine. <i>J Neurosurg</i> 1965;22:141–154	Fracture	150
66	Melcher RP, Puttlitz CM, Kleinstueck FS, et al. Biomechanical testing of posterior atlantoaxial fixation techniques. <i>Spine</i> 2002;27(22):2435–2440	Biomechanics	150
67	Smucker JD, Rhee JM, Singh K, et al. Increased swelling complications associated with off-label usage of rhBMP-2 in the anterior cervical spine. <i>Spine</i> 2006;31(24):2813–2819	Bone morphogenetic protein	147
68	Katsuura A, Hukuda S, Saruhashi Y, et al. Kyphotic malalignment after anterior cervical fusion is one of the factors promoting the degenerative process in adjacent intervertebral levels. <i>Eur Spine J</i> 2001;10(4):320–324	Adjacent segment disease	147
69	Matsumoto M, Fujimura Y, Suzuki N, et al. MRI of cervical intervertebral discs in asymptomatic subjects. <i>J Bone Joint Surg Br</i> 1998;80(1):19–24	Disk degeneration	146
70	Panjabi MM, Dvorak J, Duranceau J, et al. Three-dimensional movements of the upper cervical spine. <i>Spine</i> 1988;13(7):726–730	Biomechanics	146
71	Berne JD, Velmahos GC, El-Tawil Q, et al. Value of complete cervical helical computed tomographic scanning in identifying cervical spine injury in the unevaluable blunt trauma patient with multiple injuries: a prospective study. <i>J Trauma</i> 1999;47(5):896–902	Trauma	145
72	Abumi K, Takada T, Shono Y, et al. Posterior occipitocervical reconstruction using cervical pedicle screws and plate-rod systems. <i>Spine</i> 1999;24(14):1425–1434	Instrumentation	145
73	Hadley MN, Dickman CA, Browner CM, et al. Acute axis fractures: a review of 229 cases. <i>J Neurosurg</i> 1989;71(5):642–647	Fracture	143

Table 1 (Continued)

Rank	Article	Category	Citations
74	Hacker RJ, Cauthen JC, Gilbert TJ, et al. A prospective randomized multicenter clinical evaluation of an anterior cervical fusion cage. <i>Spine</i> 2000;25(20):2646–2654	Interbody devices	142
75	White AA 3rd, Johnson RM, Panjabi MM, et al. Biomechanical analysis of clinical stability in the cervical spine. <i>Clin Orthop Relat Res</i> 1975;109:85–96	Biomechanics	142
76	Matsunaga S, Kabayama S, Yamamoto T, et al. Strain on intervertebral discs after anterior cervical decompression and fusion. <i>Spine</i> 1999;24(7):670–675	Adjacent segment disease	142
77	Panjabi MM, Crisco JJ, Vasavada A, et al. Mechanical properties of the human cervical spine as shown by three-dimensional load-displacement curves. <i>Spine</i> 2001;26(24):2692–2700	Biomechanics	141
78	Woodring JH, Lee C. Limitations of cervical radiography in the evaluation of acute cervical trauma. <i>J Trauma</i> 1993;34(1):32–39	Trauma	140
79	Bogduk N, Mercer S. Biomechanics of the cervical spine. I: Normal kinematics. <i>Clin Biomech</i> 2000;15(9):633–648	Biomechanics	140
80	Goel VK, Clausen JD. Prediction of load sharing among spinal components of a C5–C6 motion segment using the finite element approach. <i>Spine</i> 1998;23(6):684–691	Biomechanics	140
81	Fountas KN, Kapsalaki EZ, Nikolakakos LG, et al. Anterior cervical discectomy and fusion associated complications. <i>Spine</i> 2007;32(21):2310–2317	Complications	139
82	Riley LH Jr, Robinson RA, Johnson KA, et al. The results of anterior interbody fusion of the cervical spine. Review of ninety-three consecutive cases. <i>J Neurosurg</i> 1969;30(2):127–133	Fusion	139
83	Tew JM Jr, Mayfield FH. Complications of surgery of the anterior cervical spine. <i>Clin Neurosurg</i> 1976;23:424–434	Complications	138
84	Friedenberg ZB, Miller WT. Degenerative disc disease of the cervical spine. A comparative study of asymptomatic and symptomatic patients. <i>J Bone Joint Surg Am</i> 1963;45(6):1171–1178	Disk degeneration	138
85	Seichi A, Takeshita K, Ohishi I, et al. Long-term results of double-door laminoplasty for cervical stenotic myelopathy. <i>Spine</i> 2001;26(5):479–487	Laminoplasty	137
86	Baskin DS, Ryan P, Sonntag V, et al. A prospective, randomized, controlled cervical fusion study using recombinant human bone morphogenetic protein-2 with the CORNERSTONE-SR allograft ring and the ATLANTIS anterior cervical plate. <i>Spine</i> 2003;28(12):1219–1224	Bone morphogenetic protein	137
87	Macdonald RL, Fehlings MG, Tator CH, et al. Multilevel anterior cervical corpectomy and fibular allograft fusion for cervical myelopathy. <i>J Neurosurg</i> 1997;86(6):990–997	Corpectomy	137
88	Murrey D, Janssen M, Delamarter R, et al. Results of the prospective, randomized, controlled multicenter Food and Drug Administration investigational device exemption study of the ProDisc-C total disc replacement versus anterior discectomy and fusion for the treatment of 1-level symptomatic cervical disc disease. <i>Spine J</i> 2009;9(4):275–286	Cervical disk replacement	136
89	Hu R, Mustard CA, Burns C. Epidemiology of incident spinal fracture in a complete population. <i>Spine</i> 1996;21(4):492–499	Epidemiology	136
90	Resnick DK, Benzel EC. C1–C2 pedicle screw fixation with rigid cantilever beam construct: case report and technical note. <i>Neurosurgery</i> 2002;50(2):426–428	Fusion	136
91	Resnick DK, Lapsiwala S, Trost GR. Anatomic suitability of the C1–C2 complex for pedicle screw fixation. <i>Spine</i> 2002;27(14):1494–1498	Instrumentation	135

(Continued)

Table 1 (Continued)

Rank	Article	Category	Citations
92	Ebraheim N, Rollins JR Jr, Xu R, et al. Anatomic consideration of C2 pedicle screw placement. <i>Spine</i> 1996;21(6):691–695	Instrumentation	135
93	Coyne TJ, Fehling MG, Wallace MC, et al. C1–C2 posterior cervical fusion: long-term evaluation of results and efficacy. <i>Neurosurgery</i> 1995;37(4):688–692	Fusion	135
94	Tan M, Wang H, Wang Y, et al. Morphometric evaluation of screw fixation in atlas via posterior arch and lateral mass. <i>Spine</i> 2003;28(9):888–895	Biomechanics	134
95	Ludwig SC, Kramer DL, Balderston RA, et al. Placement of pedicle screws in the human cadaveric cervical spine: comparative accuracy of three techniques. <i>Spine</i> 2000;25(13):1655–1667	Instrumentation	134
96	Hadley MN, Browner C, Sonntag VK. Axis fractures: a comprehensive review of management and treatment in 107 cases. <i>Neurosurgery</i> 1985;17(2):281–290	Fracture	134
97	Sakaura H, Hosono N, Mukai Y, et al. C5 palsy after decompression surgery for cervical myelopathy: review of the literature. <i>Spine</i> 2003;28(21):2447–2451	Complications	133
98	Bazaz R, Lee MJ, Yoo JU. Incidence of dysphagia after anterior cervical spine surgery: a prospective study. <i>Spine</i> 2002;27(22):2453–2458	Complications	133
99	Yonenobu K, Hosono N, Iwasaki M, et al. Neurologic complications of surgery for cervical compression myelopathy. <i>Spine</i> 1991;16(11):1277–1282	Complications	133
100	Hukuda S, Mochizuki T, Ogata M, et al. Operations for cervical spondylotic myelopathy. A comparison of the results of anterior and posterior procedures. <i>J Bone Joint Surg Br</i> 1985;67(4):609–615	Procedure comparison	133

Cervical spinal fusion was the most popular topic in the top 100 articles with a total of 18 works dedicated to it. Of those, seven studies involved the atlantoaxial cervical spine and eleven studies involved the subaxial cervical spine. The most important subaxial cervical spine fusion study is the previously mentioned description of the ACDF by Smith and Robinson. Clinical results and long-term outcomes after the ACDF account for six of the top 100 cervical spine articles and outline the impact ACDF has had in cervical spine surgery.^{22–27} Of the seven studies describing fusion of the atlantoaxial spine, the most impactful was the fourth most cited article in the top 100 by Harms and Melcher describing a novel technique of atlantoaxial stabilization using C1 lateral mass screws with C2 pedicle screws,²⁸ known today as the Goel or Harms technique.^{29,30} The 26th most cited article,

Table 2 Publication dates

Decade	No. of articles
1950s	5
1960s	7
1970s	5
1980s	16
1990s	35
2000s	32

published in 1992, described the indications, techniques and results of posterior C1–C2 fusion in unstable odontoid fractures.³¹ Coyne et al described the long-term results and efficacy of C1–C2 posterior cervical fusion.³²

The cervical spine is a complex three-dimensional structure with unique kinematic properties. The understanding of the normal biomechanical properties of the cervical spine is of utmost importance for evaluating clinical cases of cervical instability, which may require surgical intervention. The importance of this topic has made it the second most popular topic in the top 100 list. The 70th study on the list of top 100

Table 3 Top journals of publication

Journal	Impact factor ^a	No. of articles
<i>Spine</i>	2.159	39
<i>Journal of Bone and Joint Surgery, American Volume</i>	3.234	20
<i>Journal of Neurosurgery</i>	2.739	13
<i>Journal of Spinal Disorders & Techniques</i>	1.767	5
<i>Neurosurgery</i>	3.298	4
<i>Journal of Trauma</i>	2.348	4

^aAs of July 31, 2012.

Table 4 Most popular topics ranked by numbers of articles

Category	No. of articles
Cervical fusion	18
Biomechanics	9
Complications	9
Instrumentation	8
Fracture	8
Trauma	7
Laminoplasty	5
Adjacent segment disease	4
Cervical disk replacement	4

Table 5 Top authors and topics of publication

First author	No. of articles	Topic
K. Abumi	4	Complications, instrumentation
J. Goffin	3	Cervical disk replacement, fusion
M.M. Panjabi	3	Anatomy, biomechanics

was by Panjabi et al,³³ evaluating the mechanical properties of the human cervical spine in 16 human cadaveric specimens. This study revealed that the greatest degree of flexion occurred at C1–C2 (12.3 degrees), whereas the greatest degree of extension was observed at C0–C1 (20.2 degrees), and that with axial moment loading, rotation at C1–C2 was the largest (56.7 degrees). Four studies in the top 100 list examined the biomechanical stability of various anterior and posterior cervical spine fixation techniques.^{34–37}

The third most common topic published in the top 100 cervical spine articles was surgical complications. As in every surgical specialty, complications and their avoidance remain an important topic of discussion and research.

Modern advances in technology and surgical instrumentation have allowed for the introduction of novel surgical

Table 6 Countries of origin

Country of origin	No. of articles
United States of America	65
Japan	16
Canada	6
Germany	4
Belgium	3
Switzerland	2
China	2
United Kingdom	1
Australia	1

Table 7 Top institutions of origin of articles

Institution	Location	No. of articles
Hokkaido University	Sapporo, Japan	5
Case Western Reserve University	Cleveland, Ohio, United States	4
Emory University	Atlanta, Georgia, United States	4
Osaka University	Suita, Japan	4
Yale University	New Haven, Connecticut, United States	4
University of Wisconsin-Madison	Madison, Wisconsin, United States	4

devices and techniques. A small number of these devices and techniques can have profound and sometimes long-lasting impact in their respective fields. Cervical laminoplasty, a motion-sparing posterior cervical technique for the treatment of myelopathy, was developed in 1977 and first described by Hirabayashi et al.³⁸ This unique technique has given the spine surgeon an alternative to the posterior arthrodesis procedure, a topic with five articles in the top 100 list. In hopes to eliminate the incidence of adjacent-level disease following anterior cervical arthrodesis, in 2007, the first cervical artificial disk device was approved for use by the United States Food and Drug Administration (FDA). Although it is too early to conclude on the long-term impact of this technology in cervical spine surgery, it has been the topic of intense research as evidenced by the presence of five articles in the top 100 list.^{38–42}

The oldest article, by Rogers,¹² was published in 1957 and described the management of acute fractures and dislocations of the cervical spine. The most recent article, published in 2009, was by Murrey et al,¹³ and it described the results of the prospective, randomized, controlled, multicenter, FDA investigational device exemption study of the ProDisc-C (DePuy Synthes, Raynham, Massachusetts, United States) total disk replacement versus ACDF for the treatment of one-level symptomatic cervical disk disease. The 100th article on the list is by Hukuda et al,⁴³ comparing the results of anterior and posterior procedures for the treatment of cervical spondylotic myelopathy.

Of the top-cited articles, 17 were published before 1980. Previous articles have suggested that the older an article is, the more likely it is that it would be cited. However, this idea may not be completely true as one of the more important problems of this type of analysis is the phenomenon of “obliteration by incorporation.” This phenomenon describes the process whereby data from truly classic articles becomes cited less frequently as it is absorbed into the body of current knowledge. Some of the truly classic articles can sometimes be found referenced in top-cited articles.

In this study, the journal *Spine* produced the largest number of articles in the top 100 list. It must be noted that

when evaluating contributions by various journals, those journals with bimonthly publications and those that have been in circulation for the longest time have more chance of being cited by other authors. Another limitation to this study is the inability to assess the true lead author of each article. For this reason, the first author was assumed to be the primary contributor to the work, and so the first author was used to create the ranking of authors according to the number of publications. A final limitation to this study is the problem of incomplete citing, which is described as the erroneous manner in which some citations are made in an effort to convince or persuade the readership of that particular journal, instead of giving credit to those who most significantly influenced the work.

Conclusion

To our knowledge, this study is the first to identify the top 100 classic articles in cervical spine surgery. This study gives a unique insight into the development and trends of this challenging subspecialty within spine surgery in the 20th and early 21st centuries. This work identifies those individuals who have made the greatest contributions to the ever-growing body of knowledge that guides everyday clinical decision making in the field of cervical spine surgery. Furthermore, the classic articles identified in this study are the ones that have had the most impact, and as such, will be the most remembered.

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