



## Most Cited Publications in Cervical Spine Surgery

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# Most Cited Publications in Cervical Spine Surgery

*Yu Chao Lee, Francis Brooks, Simon Sandler, Yun-Hom Yau, Michael Selby, Brian Freeman  
Royal Adelaide Hospital, Adelaide, Australia*

## Abstract

### Purpose

The purpose of this study is to perform a citation analysis on the most frequently cited articles in the topic of cervical spine surgery and report on the top 100 most cited publication in this topic.

### Methods

We used the Thomson Reuters Web of Science to search citations of all articles from 1945 to 2015 relevant to cervical spine surgery and ranked them according to the number of citations. The 100 most cited articles that matched the search criteria were further analyzed by number of citations, first author, journal, year of publication, country and institution of origin.

### Results

The top 100 cited articles in the topic of cervical spine surgery were published from 1952-2011. The number of citations ranged from 106 times for the 100th paper to 1206 times for the top paper. The decade of 1990-1999 saw the most publications. The Journal of Spine published the most articles, followed by Journal of Bone and Joint Surgery America. Investigators from America authored the most papers and The University of California contributed the most publications. Cervical spine fusion was the most common topic published with 36 papers, followed by surgical technique and trauma.

### Conclusion

This article identifies the 100 most cited articles in cervical spine surgery. It has provided insight to the history and development in cervical spine surgery and many of which have shaped the way we practice today.

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## Introduction

Cervical spine surgery owes its advancement to key research which has shaped modern practice. Many papers are published in this area but only a few make a lasting impact to the scientific community.

A citation is recognition of an author's work by their peers and may acknowledge the impact that their work has. Bibliometric analysis has become a popular way of providing an insight into advancements and highlighting key articles in a certain field. Several studies have evaluated the impact that articles have made in their respective field.<sup>1-4</sup> Citation analysis involves evaluating an article based on the number of citations it receives. The list it generates may identify individuals who have contributed greatly to the scientific community.

The purpose of this study is to identify trends and characteristics which make an article highly cited in the field of cervical spine surgery. We performed a citation analysis on the most frequently cited articles in cervical spine surgery using methods validated in other similar published studies.<sup>1-4</sup>

## Methods

The Institute for Scientific information has collected information on journal citations since 1945. Their current system is known as "Science Citation index" and this database was searched using the Thomson Reuters Web of Science for all articles from 1945 to 2015. The search term was "Cervical Spine" and it was limited to the English language. This search was performed in November 2015. The results were then carefully reviewed by two authors (YL and FB) and

only those relevant to the cervical spine were selected. The 100 most cited articles that matched the search criteria were further analyzed by number of citations, first author, journal, year of publication, country and institution of origin and level of evidence. The total numbers of citations were compared to the average yearly citation for each article.

## Results

The 100 most cited articles in the topic of cervical

spine surgery were published from 1952-2011. These papers, their corresponding authors, and number of citations are shown in Table 1. The number of citations ranged from 106 times for the 100th paper to 1206 times for the top paper in a total of 15 journals. The decade of 1990-1999 saw the most publications with 36 articles, followed by 2000-2009 with 33 articles (Table 2). The oldest article was by Bailey<sup>5</sup> published in 1952; and Carragee et al.<sup>6</sup> published the most recent article in 2011.

**Table 1. Top 100 cited papers in Cervical Spine Surgery.**

Rank	Authors	Title	Citations	Level of Evidence
1	Frankel et al. <sup>7</sup>	The Value Of Postural Reduction In The Initial Management Of Closed Injuries Of The Spine With Paraplegia And Tetraplegia. I.	1207	3
2	Vernon et al. <sup>9</sup>	The Neck Disability Index - A Study Of Reliability And Validity	959	2
3	Smith et al. <sup>12</sup>	The Treatment Of Certain Cervical-Spine Disorders By Anterior Removal Of The Intervertebral Disc And Interbody Fusion	724	4
4	Hilibrand et al. <sup>23</sup>	Radiculopathy And Myelopathy At Segments Adjacent To The Site Of A Previous Anterior Cervical Arthrodesis	641	2
5	Harms et al. <sup>17</sup>	Posterior C1-C2 Fusion With Polyaxial Screw And Rod Fixation	624	2
6	Hoffman et al. <sup>24</sup>	Validity Of A Set Of Clinical Criteria To Rule Out Injury To The Cervical Spine In Patients With Blunt Trauma.	437	2
7	Silber et al. <sup>25</sup>	Donor Site Morbidity After Anterior Iliac Crest Bone Harvest For Single-Level Anterior Cervical Discectomy And Fusion	399	2
8	Bohlman et al. <sup>26</sup>	Robinson Anterior Cervical Discectomy And Arthrodesis For Cervical Radiculopathy - Long-Term Follow-Up Of 100 And 22 Patients	396	3
9	Carragee et al. <sup>6</sup>	A Critical Review Of Recombinant Human Bone Morphogenetic Protein-2 Trials In Spinal Surgery: Emerging Safety Concerns And Lessons Learned	383	1
10	Boden et al. <sup>27</sup>	Abnormal Magnetic-Resonance Scans Of The Cervical-Spine In Asymptomatic Subjects - A Prospective Investigation	382	3
11	Bohlman <sup>28</sup>	Acute Fractures And Dislocations Of The Cervical-Spine - Analysis Of 300 Hospitalized-Patients And Review Of The Literature	382	2
12	Stiell et al. <sup>29</sup>	The Canadian C-Spine Rule For Radiography In Alert And Stable Trauma Patients	359	2
13	Ranawat et al. <sup>30</sup>	Cervical-Spine Fusion In Rheumatoid-Arthritis	338	3
14	Resnick et al. <sup>31</sup>	Radiographic And Pathologic Features Of Spinal Involvement In Diffuse Idiopathic Skeletal Hyperostosis (Dish)	338	3
15	Bailey et al. <sup>32</sup>	Stabilization Of The Cervical Spine By Anterior Fusion	334	3
16	Boyim et al. <sup>33</sup>	Neck Pain In The General-Population	330	2
17	Hirabayashi et al. <sup>34</sup>	Expansive Open-Door Laminoplasty For Cervical Spinal Stenotic Myelopathy	323	3
18	Payne et al. <sup>35</sup>	The Cervical Spine - An Anatomico-Pathological Study Of 70 Specimens (Using A Special Technique) With Particular Reference To The Problem Of Cervical Spondylosis	291	N/A
19	Schneider et al. <sup>36</sup>	The Syndrome Of Acute Central Cervical Spinal Cord Injury - With Special Reference To The Mechanisms Involved In Hyperextension Injuries Of Cervical Spine	288	4
20	Shields et al. <sup>22</sup>	Adverse Effects Associated With High-Dose Recombinant Human Bone Morphogenetic Protein-2 Use In Anterior Cervical Spine Fusion	287	2
21	Eck et al. <sup>37</sup>	Biomechanical Study On The Effect Of Cervical Spine Fusion On Adjacent-Level Intradiscal Pressure And Segmental Motion	286	N/A
22	Barnsley et al. <sup>38</sup>	Whiplash Injury	286	3
23	Allen et al. <sup>39</sup>	A Mechanistic Classification Of Closed, Indirect Fractures And Dislocations Of The Lower Cervical-Spine	269	3
24	Wright et al. <sup>40</sup>	Vertebral Artery Injury In C1-2 Transarticular Screw Fixation: Results Of A Survey Of The Aans/Cns Section On Disorders Of The Spine And Peripheral Nerves	266	3
25	Pang et al. <sup>41</sup>	Spinal-Cord Injury Without Radiographic Abnormalities In Children	265	3
26	Robinson et al. <sup>13</sup>	The Results Of Anterior Interbody Fusion Of The Cervical Spine	262	3
27	Schrader et al. <sup>42</sup>	Natural Evolution Of Late Whiplash Syndrome Outside The Medicolegal Context	259	3
28	Sen et al. <sup>43</sup>	An Extreme Lateral Approach To Intradural Lesions Of The Cervical-Spine And Foramen Magnum	258	3
29	Jones et al. <sup>44</sup>	Cervical Pedicle Screws Versus Lateral Mass Screws: Anatomic Feasibility And Biomechanical Comparison	247	4

30	Abumi et al. <sup>55</sup>	Complications Of Pedicle Screw Fixation In Reconstructive Surgery Of The Cervical Spine	240	3
31	Gore et al. <sup>46</sup>	Roentgenographic Findings Of The Cervical-Spine In Asymptomatic People	237	3
32	Panjabi et al. <sup>47</sup>	Cervical Human Vertebrae - Quantitative 3-Dimensional Anatomy Of The Middle And Lower Regions	235	3
33	Radanov et al. <sup>48</sup>	Long-Term Outcome After Whiplash Injury - A 2-Year Follow-Up Considering Features Of Injury Mechanism And Somatic, Radiologic, And Psychosocial Findings	231	3
34	Grob et al. <sup>49</sup>	Atlantoaxial Fusion With Transarticular Screw Fixation	231	4
35	Hurwitz et al. <sup>50</sup>	Manipulation And Mobilization Of The Cervical Spine - A Systematic Review Of The Literature	230	2
36	Kotani et al. <sup>51</sup>	Biomechanical Analysis Of Cervical Stabilization Systems - An Assessment Of Transpedicular Screw Fixation In The Cervical-Spine	229	3
37	Jull et al. <sup>52</sup>	A Randomized Controlled Trial Of Exercise And Manipulative Therapy For Cervicogenic Headache	228	2
38	Jeanneret et al. <sup>14</sup>	Primary Posterior Fusion-C1/2 In Odontoid Fractures - Indications, Technique, And Results Of Transarticular Screw Fixation	227	3
39	Sambrook et al. <sup>53</sup>	Genetic Influences On Cervical And Lumbar Disc Degeneration - A Magnetic Resonance Imaging Study In Twins	215	3
40	Penning <sup>54</sup>	Normal Movements Of Cervical-Spine	214	4
41	Ylinen et al. <sup>55</sup>	Active Neck Muscle Training In The Treatment Of Chronic Neck Pain In Women - A Randomized Controlled Trial	213	2
42	Davis et al. <sup>56</sup>	The Etiology Of Missed Cervical-Spine Injuries	213	3
43	Mummaneni et al. <sup>57</sup>	Clinical And Radiographic Analysis Of Cervical Disc Arthroplasty Compared With Allograft Fusion: A Randomized Controlled Clinical Trial	212	2
44	Fang et al. <sup>58</sup>	Direct Anterior Approach To The Upper Cervical Spine	212	4
45	Goffin et al. <sup>59</sup>	Intermediate Follow-Up After Treatment Of Degenerative Disc Disease With The Bryan Cervical Disc Prosthesis: Single-Level And Bi-Level	211	3
46	Teresi et al. <sup>60</sup>	Asymptomatic Degenerative Disk Disease And Spondylosis Of The Cervical-Spine - Mr Imaging	210	3
47	Abumi et al. <sup>61</sup>	Transpedicular Screw Fixation For Traumatic Lesions Of The Middle And Lower Cervical-Spine - Description Of The Techniques And Preliminary-Report	209	4
48	Conlon et al. <sup>62</sup>	Rheumatoid Arthritis Of Cervical Spine - An Analysis Of 333 Cases	209	3
49	Rogers <sup>63</sup>	Fractures And Dislocations Of The Cervical Spine - An End-Result Study	209	3
50	Emery et al. <sup>64</sup>	Anterior Cervical Decompression And Arthrodesis For The Treatment Of Cervical Spondylotic Myelopathy - Two To Seventeen-Year Follow-Up	202	3
51	Vaccaro et al. <sup>65</sup>	Early Failure Of Long Segment Anterior Cervical Plate Fixation	198	3
52	Youdas et al. <sup>66</sup>	Reliability Of Measurements Of Cervical-Spine Range Of Motion - Comparison Of 3 Methods	198	3
53	Southwick et al. <sup>67</sup>	Surgical Approaches To The Vertebral Bodies In The Cervical And Lumbar Regions	198	4
54	Buskila et al. <sup>68</sup>	Increased Rates Of Fibromyalgia Following Cervical Spine Injury - A Controlled Study Of 161 Cases Of Traumatic Injury	195	3
55	Goffin et al. <sup>69</sup>	Long-Term Follow-Up After Interbody Fusion Of The Cervical Spine	193	3
56	Stiell et al. <sup>70</sup>	The Canadian C-Spine Rule Versus The Nexus Low-Risk Criteria In Patients With Trauma	193	3
57	Goffin et al. <sup>18</sup>	Preliminary Clinical Experience With The Bryan Cervical Disc Prosthesis	193	3
58	Flanders et al. <sup>71</sup>	Acute Cervical-Spine Trauma - Correlation Of Mr Imaging Findings With Degree Of Neurologic Deficit	193	2
59	Sawin et al. <sup>72</sup>	A Comparative Analysis Of Fusion Rates And Donor-Site Morbidity For Autogeneic Rib And Iliac Crest Bone Grafts In Posterior Cervical Fusions	192	3
60	Clark et al. <sup>73</sup>	Fractures Of The Dens - A Multicenter Study	192	2

61	Cattell et al. <sup>74</sup>	Pseudosubluxation And Other Normal Variations In Cervical Spine In Children . A Study Of 160 Children	191	3
62	Fountas et al. <sup>75</sup>	Anterior Cervical Discectomy And Fusion Associated Complications	190	3
63	Kaiser et al. <sup>76</sup>	Anterior Cervical Plating Enhances Arthrodesis After Discectomy And Fusion With Cortical Allograft	189	3
64	Levine et al. <sup>77</sup>	The Management Of Traumatic Spondylolisthesis Of The Axis	189	3
65	Wada et al. <sup>78</sup>	Subtotal Corpectomy Versus Laminoplasty For Multilevel Cervical Spondylotic Myelopathy - A Long-Term Follow-Up Study Over 10 Years	184	2
66	An et al. <sup>79</sup>	Comparison Between Allograft Plus Demineralized Bone-Matrix Versus Autograft In Anterior Cervical Fusion - A Prospective Multicenter Study	184	2
67	Smucker et al. <sup>80</sup>	Increased Swelling Complications Associated With Off-Label Usage Of Rhbnp-2 In The Anterior Cervical Spine	183	4
68	Boden et al. <sup>81</sup>	Rheumatoid-Arthritis Of The Cervical-Spine - A Long-Term Analysis With Predictors Of Paralysis And Recovery	182	3
69	Murrey et al. <sup>82</sup>	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	181	2
70	Hosono et al. <sup>83</sup>	Neck And Shoulder Pain After Laminoplasty - A Noticeable Complication	181	3
71	Bazaz et al. <sup>84</sup>	Incidence Of Dysphagia After Anterior Cervical Spine Surgery - A Prospective Study	180	3
72	Vasavada et al. <sup>85</sup>	Influence Of Muscle Morphometry And Moment Arms On The Moment-Generating Capacity Of Human Neck Muscles	179	N/A
73	Dickman et al. <sup>86</sup>	The Interspinous Method Of Posterior Atlantoaxial Arthrodesis	178	4
74	Panjabi et al. <sup>87</sup>	Mechanical Properties Of The Human Cervical Spine As Shown By Three-Dimensional Load-Displacement Curves	176	N/A
75	Aker et al. <sup>88</sup>	Conservative Management Of Mechanical Neck Pain: Systematic Overview And Meta-Analysis	175	1
76	Bishop et al. <sup>89</sup>	Anterior Cervical Interbody Fusion Using Autogeneic And Allogeneic Bone Graft Substrate: A Prospective Comparative Analysis	175	2
77	Itoh et al. <sup>90</sup>	Technical Improvements And Results Of Laminoplasty For Compressive Myelopathy In The Cervical-Spine	175	3
78	Pellicci et al. <sup>91</sup>	A Prospective-Study Of The Progression Of Rheumatoid-Arthritis Of The Cervical-Spine	173	2
79	Abumi et al. <sup>92</sup>	Posterior Occipitocervical Reconstruction Using Cervical Pedicle Screws And Plate-Rod Systems	172	3
80	Heller et al. <sup>93</sup>	Comparison Of Bryan Cervical Disc Arthroplasty With Anterior Cervical Decompression And Fusion Clinical And Radiographic Results Of A Randomized, Controlled, Clinical Trial	171	2
81	Abumi et al. <sup>94</sup>	Pedicle Screw Fixation For Nontraumatic Lesions Of The Cervical Spine	171	3
82	Melcher et al. <sup>95</sup>	Biomechanical Testing Of Posterior Atlantoaxial Fixation Techniques	170	N/A
83	Katsuura et al. <sup>96</sup>	Kyphotic Malalignment After Anterior Cervical Fusion Is One Of The Factors Promoting The Degenerative Process In Adjacent Intervertebral Levels	170	3
84	Perry et al. <sup>97</sup>	Total Cervical-Spine Fusion For Neck Paralysis	170	3
85	Matsumoto et al. <sup>98</sup>	Mri Of Cervical Intervertebral Discs In Asymptomatic Subjects	169	3
86	Johnson et al. <sup>99</sup>	Cervical Orthoses - Study Comparing Their Effectiveness In Restricting Cervical Motion In Normal Subjects	167	N/A
87	Richter et al. <sup>100</sup>	Posterior Atlantoaxial Fixation - Biomechanical In Vitro Comparison Of Six Different Techniques	166	N/A
88	Bogduk et al. <sup>101</sup>	Biomechanics Of The Cervical Spine. I: Normal Kinematics	166	N/A
89	Gore et al. <sup>102</sup>	Neck Pain - A Long-Term Follow-Up Of 205 Patients	166	3
90	Torg et al. <sup>103</sup>	Neurapraxia Of The Cervical Spinal-Cord With Transient Quadriplegia	166	3

91	Sakaura et al. <sup>102</sup>	C5 Palsy After Decompression Surgery For Cervical Myelopathy - Review Of The Literature	165	3
92	Wang et al. <sup>103</sup>	Increased Fusion Rates With Cervical Plating For Two-Level Anterior Cervical Discectomy And Fusion	165	3
93	Matsunaga et al. <sup>104</sup>	Strain On Intervertebral Discs After Anterior Cervical Decompression And Fusion	165	N/A
94	Wainner et al. <sup>105</sup>	Reliability And Diagnostic Accuracy Of The Clinical Examination And Patient Self-Report Measures For Cervical Radiculopathy	163	3
95	Coe et al. <sup>106</sup>	Biomechanical Evaluation Of Cervical Spinal Stabilization Methods In A Human Cadaveric Model	162	N/A
96	Tan et al. <sup>107</sup>	Morphometric Evaluation Of Screw Fixation In Atlas Via Posterior Arch And Lateral Mass	161	N/A
97	Resnick et al. <sup>108</sup>	Anatomic Suitability Of The C1-C2 Complex For Pedicle Screw Fixation	161	4
98	Bailey <sup>5</sup>	The Normal Cervical Spine In Infants And Children	161	3
99	Resnick et al. <sup>109</sup>	C1-C2 Pedicle Screw Fixation With Rigid Cantilever Beam Construct: Case Report And Technical Note	160	4
100	Hacker et al. <sup>110</sup>	A Prospective Randomized Multicenter Clinical Evaluation Of An Anterior Cervical Fusion Cage	160	2

The Spine Journal published the most articles (48 articles), followed by the Journal of Bone and Joint Surgery, America. The top two journals published 57% of all articles (Table 3). Investigators from America authored 52 of the 100 articles, followed by authors from Japan with 13 articles and Germany with 7 articles (Table 4). The institution that contributed the most was the University of California with 9 publications in the top 100 (Table 5). A total of 9 authors contributed  $\geq 3$  publications with Abumi, K and Bohlmann H, having 5 publications in the top 100 (Table 6).

Cervical spine fusion was the most common topic published with 36 articles, followed by articles on surgical technique and trauma (Table 7). When the level of evidence is reviewed, we found that the most

common level of evidence was 3 with only two articles being level 1 (Figure 1). We found that only 24 articles were rated as level 1 or 2 with the remainder being rated as 3 and 4 (Table 1).

Comparison was made between the total number of citations with the average number of citations per year. There was a variation in the ranking with 7 articles ranked in the top 10 by total number of citations and also ranked in the top 10 when ranked by average

**Table 2. Publication dates.**

Decade of publication	Number of Articles
Pre-1970	13
1970-1979	5
1980-1989	12
1990-1999	36
2000-2009	33
After 2010	1

**Table 3. Top Journals of Publication.**

Journal	Impact factor	Number of articles
Spine	3.024	37
Journal of Bone and Joint Surgery (America)	5.28	20
Journal of Neurosurgery	3.737	6
Radiology	6.867	4

**Table 4. Country of Origin for Top articles.**

Country of Origin	Number of Articles
USA	52
Japan	13
Germany	7
Canada	5
Australia	4

**Table 5. Top institutions of origin of articles.**

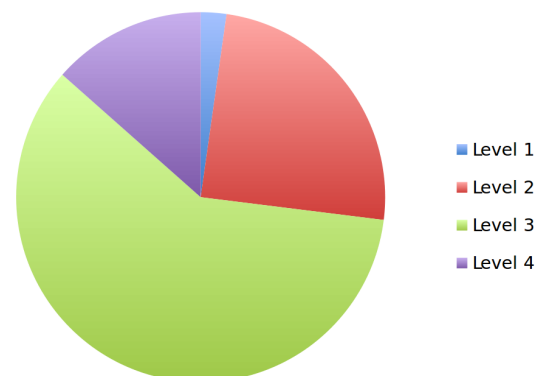
Institution	Number of Articles
University of California Group	9
Emory University	6
Case Western Reserve University	5
Hokkaido University	5

**Table 6. Top authors.**

Author	Number of authorship
Abumi, K	5
Bohlmann, H H	5
Kaneda, K	4

**Table 7. Most popular topic ranked by number of papers.**

Topic	No. of papers
Fusion	36
Surgical Technique	19
Trauma	17
Complications	16
Grafting	13



**Fig. 1. Level of Evidence.**



(Table 8).

## Discussion

This study identifies the most cited papers on the cervical spine. It provides the features which make an article likely to be highly cited and highlights the journals which may allow work to be cited.

The top most cited paper with 1206 citations is the work by Frankel et al.<sup>7</sup> on postural reduction in the management of closed injuries of the spine with paraplegia or tetraplegia. While such treatment method is less common, their work on classifying neurological impairment became the basis of the spinal assessment in spinal cord injury patients as part of the American Spinal Injury Association (ASIA) neurological impairment scale.<sup>8</sup> In their initial description, complete and incomplete spinal cord injuries were subdivided into five categories, without detailing assessment of motor or sensory function.<sup>7</sup> This was subsequently modified by the ASIA with the addition of key muscle function, key sensory points and presence of sacral sparing added as part of assessment to clarify zones of partial preservation.<sup>8</sup> This allows greater precision and consistency in defining the extent of spinal cord injury amongst clinicians and researchers.

The second most cited paper is the work by Vernon and Moir,<sup>9</sup> describing the neck disability index

(NDI), which became the first instrument designed to assess self-rated disability in patients with neck pain. Vernon modelled the NDI on the Oswestry Low Back Pain Disability Questionnaire with the permission of the authors.<sup>10</sup> Since 1991, the NDI has become the most widely used questionnaire for neck pain, with 959 citations, translation into over 20 languages, and a widely used outcome measure in clinical studies.<sup>11</sup> The NDI has been useful for prognostication of outcome following whiplash injury, with several studies reporting a low initial NDI predicting recovery and a high score predicting chronicity.<sup>11</sup> In addition, high NDI score (>15/50) at 3-36 months following injury strongly correlates with physiological dysfunction such as muscular dysfunction and central sensitization.<sup>11</sup>

The third most cited paper is by Smith and Robinson,<sup>12</sup> who first describe the anterior approach to the cervical spine in the treatment of symptomatic cervical spondylosis. The authors suggested that disc degeneration, osteophyte formation and foraminal stenosis resulted in brachalgia. In their series of 14 patients who underwent anterior approach and interbody fusion with autologous iliac crest graft they reported symptomatic improvement.<sup>12</sup> In their subsequent article on 55 patients with longer follow-up, which is also one of the top articles, Robinson continued to report good success with the anterior interbody fusion of cervical spine with low complication rates.<sup>13</sup> This technique has since become the

**Table 8. Comparison of rank by number of citations per year and total citations.**

Authors	Title	Average per Year	Rank by average	Rank by Total
Carragee et al. <sup>6</sup>	A critical review of recombinant human bone morphogenetic protein-2 trials in spinal surgery: emerging safety concerns and lessons learned	76.6	1	9
Harms et al. <sup>17</sup>	Posterior C1-C2 fusion with polyaxial screw and rod fixation	41.6	2	5
Vernon et al. <sup>9</sup>	The neck disability index – A study of reliability and validity	38.36	3	2
Hilibrand et al. <sup>23</sup>	Radiculopathy and myelopathy at segments adjacent to the site of a previous anterior cervical arthrodesis	37.71	4	4
Silber et al. <sup>25</sup>	Donor site morbidity after anterior iliac crest bone harvest for single-level anterior cervical discectomy and fusion	30.69	5	7
Shields et al. <sup>22</sup>	Adverse effects associated with high-dose recombinant human bone morphogenetic protein-2 use in anterior cervical spine fusion	28.7	6	20
Hoffman et al. <sup>24</sup>	Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma.	27.31	7	6
Murrey et al. <sup>81</sup>	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	25.86	8	69
Frankel et al. <sup>7</sup>	The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. I.	25.68	9	1
Heller et al. <sup>91</sup>	Comparison of BRYAN Cervical Disc Arthroplasty With Anterior Cervical Decompression and Fusion Clinical and Radiographic Results of a Randomized, Controlled, Clinical Trial	24.43	10	80

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gold standard for the treatment of cervical spondylosis and cervical myelopathy.

In contrast to previous studies where 1980s was the most prolific decade for articles,<sup>3</sup> the decades of 1990s saw the most publications in cervical spine surgery. This is similar to papers published in Foot and ankle surgery,<sup>4</sup> sports medicine,<sup>11</sup> shoulder surgery<sup>12</sup> and spine surgery.<sup>13</sup> These two decades coincided with the development of improved instrumentation and surgical technique for managing cervical instability and reflect the relatively young field of spinal surgery. In 1992, Jeanneret and Magerl<sup>14</sup> (ranked 38) described the trans-articular atlantoaxial screw fixation technique for treating unstable odontoid fractures, which was alternate to the then more popular Gallie<sup>15</sup> or Brooks<sup>16</sup> type posterior fusion technique which lacked primary stability for treatment of unstable C2 peg fractures. In 2001, Harms and Melcher<sup>17</sup> (ranked 5) described another technique for treating the atlantoaxial joint instability with posterior atlas and axis screw-rod fixation and fusion. Both the Magerl and Harms methods remained popular techniques to date, demonstrating high fusion rate for treating C2 fractures. The decade of 2000-2009 saw an improvement in cervical disc arthroplasty design and increasing use for treating cervical myelopathy or radiculopathy. Goffin et al.<sup>18</sup> in 2002 (ranked 45) described their preliminary experience with the Bryan Disc Replacement, reporting on the safety of the device and favorable results at short term follow-up. Proponents of cervical disc arthroplasty argue that maintenance of motion avoids adjacent segment degeneration. More than 15 designs of cervical disc arthroplasty are undergoing ongoing clinical trials to determine its efficacy.<sup>19</sup>

Cervical fusion was the most popular topic with 36 papers featured in the 100 articles we reviewed. Anterior fusion was the most commonly described technique and is currently the gold standard for treating mid to lower cervical spine disorder ranging from fracture-dislocation, instability and degenerative disc disease. Popularized by Smith and Robinson,<sup>12</sup> the technique saw a trend to improve fusion rates through grafting which is the 5<sup>th</sup> most common topic. Bishop et al.<sup>20</sup> (ranked 76) use of allograft and An et al.<sup>21</sup> (ranked 66) used allograft plus demineral-

ized bone matrix for anterior cervical fusion but found this not to be superior, with high rates of pseudoarthrosis and graft collapse. More recent interest has been the use of BMP and its association with higher complication rates. Interestingly complications as a subject ranked 4<sup>th</sup> in this study. Published in 2006 and ranked 20, Shields et al.<sup>22</sup> reported the adverse effects associated with high-dose recombinant human bone morphogenetic protein-2 use in anterior cervical spine fusion. This was one of the first studies that reported on the adverse events associated with rhBMP-2 in cervical spine surgery, including life threatening events such as delayed haematoma, soft tissue swelling and airway compromise. This is contrary to initial industry sponsored rhBMP-2 on its use reporting a 0% adverse event rate.<sup>6</sup>

Classification systems and outcome tools have been found in other citation analysis to be prominent features. The top two articles in this analysis are describing classification systems and outcome tools respectively. This shows the importance to have a well validated outcome tool in clinical research as it allows the effect of a treatment to be assessed between studies and allows direct comparison of one technique with another.

The most popular journal for publication was the Spine Journal. This highlights its role as a journal for both neurosurgical and orthopaedic spinal surgeons to read. Nearly two thirds of the 100 most cited articles were published in just two journals. The journal of Bone and Joint Surgery, America was the second most popular destination for research. These two journals both have high impact and highlight the need to publish work in a high impact journal.

The United States was the country with the most number of articles included in the 100 articles we reviewed. This is similar to results from many previous bibliometric analysis papers.<sup>3,4,11,12,13</sup> Japan featured as the second most prolific nation and this relates to their role in the development and advancement of the laminoplasty technique for the management of cervical cord compression.

All the papers which included randomized trials

were published since the year 2000, highlighting an improvement in the quality of research being performed. The papers which were of lower level of evidence all tended to be published earlier. This shows that the quality of research being performed has improved as better understanding of clinical research is developed. The most common level of evidence were 3 and 4 which are similar to other orthopedic bibliometric analysis papers.<sup>111,112,113</sup> This highlights the difficulty that we have in surgical specialties in performing good randomized control trials.

A similar bibliometric analysis has been published on the cervical spine by Ruegsegger et al.<sup>114</sup> They performed a bibliometric analysis using the same database but a different key word search. This we believe is why our independent study results differ to theirs. Their method, we feel, will have resulted in the exclusion of some key articles we included.

Previous papers on bibliometric analysis have restricted their analysis to the journals with higher impact factor. We did not restrict our search by this, as it may create a list which excludes key articles. As a result, we feel our citation analysis is more powerful. Some question the use of citation analysis as a scientific tool. We feel these lists are beneficial for junior clinicians and researchers alike as it highlights key features of research and provides a historic account of the developments. Whilst some articles will be highly cited due to their controversial nature however we feel that these are likely to be few compared with those that advance the specialty. Previous papers have highlighted the unfair advantage that ranking by total citations can give an article which has been published for a long time. This can be seen in our comparison of articles by number of citations per year. Carragee et al.<sup>6</sup> article has an average citation of 76.6 per year compared with Frankel et al.,<sup>7,25,68</sup>. We see articles on cervical disc arthroplasty advancing significantly when we rank by average per year. This highlight that these papers are important now and are likely to feature in bibliometric analysis in the future.

## Conclusion

This article shows the journals which are likely to

provide an author with high levels of readership and potentially high citation. It provides an insight to the development of modern cervical spine surgery. With continued development of surgical implant technology and research methods the features of this list will change to reflect these newer techniques and approaches. This article provides a current insight into the most cited cervical spine papers.

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## Disclosures & COI

The authors declare no relevant financial disclosures.

## Corresponding Author

Yu Chao Lee, The Spinal Unit, Department of Orthopaedics and Trauma, Royal Adelaide Hospital, Adelaide, SA, Australia. ychao83@hotmail.com.

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