

Top 20 cited *Spine Journal* articles, 1990-2009

Hossein K Elgafy, Jacob D Miller, Sohaib Hashmi, Steven Ericksen

Hossein K Elgafy, Jacob D Miller, Sohaib Hashmi, Steven Ericksen, Department of Orthopaedic Surgery, University of Toledo Medical Center, Toledo, OH 43614, United States

Author contributions: All authors collected the data and contributed in the manuscript writing.

Correspondence to: Hossein K Elgafy, MD, FRCSEd, FRCSC, Department of Orthopaedic Surgery, University of Toledo Medical Center, 3065 Arlington Avenue, Toledo, OH 43614, United States. helgafy@aol.com

Telephone: +1-419-3833515 Fax: +1-419-3836170

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Abstract

AIM: To determine the most cited articles and most published authors in *Spine Journal* from 1990-2009.

METHODS: *Spine Journal*, established in 1976, is affiliated with 12 spine societies and a leader in spine research articles. Citation analysis is a method to determine the impact of a journal and its articles on academia and clinical practice. Using the Institute for Scientific Information Web of Knowledge, we determined the most cited articles in *Spine Journal* between 1990-2009. The characteristics and type of article were recorded. Next, we evaluated the most published authors during the same time period and calculated the number of citations for each author. The number of first authorships for each of these authors was also determined along with the number of citations for those articles.

RESULTS: The top 20 cited articles range from 491 to 267 total citations. The top 20 published authors had between 41 and 135 articles. Seventeen of the top 20 articles were clinical studies. The range of citations per lead authorship ratio was 36 to 724 with one author having no lead authorships. Low back pain was the most common theme encountered in the top cited articles. The first-ranked article was not a spine-specific topic rather it was regarding general physical and men-

tal health status survey update review.

CONCLUSION: *Spine Journal* and its authors have a clear impact on the scientific community based on this review of the top articles and authors in the last 20 years.

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Key words: Citation analysis; Back pain; *Spine Journal*

Core tip: *Spine Journal*, established in 1976, is affiliated with 12 spine societies and a leader in spine research articles. Citation analysis is a method to determine the impact of a journal and its articles on academia and clinical practice. Using the Institute for Scientific Information Web of Knowledge, we determined the most cited articles in *Spine Journal* between 1990-2009. The characteristics and type of article were recorded. Next, we evaluated the most published authors during the same time period and calculated the number of citations for each author. The top 20 cited articles range from 491 to 267 total citations. The top 20 published authors had between 41 and 135 articles. Seventeen of the top 20 articles were clinical studies. The range of citations per lead authorship ratio was 36 to 724 with one author having no lead authorships. The most popular topics included low back pain. Interestingly, the first-ranked article was not a spine-specific topic rather it was regarding general physical and mental health status survey update review.

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INTRODUCTION

Modern medicine has been evolving at an increasingly rapid rate for the past 40 years. Advancements in spine

surgery are no exception to this trend. *Spine Journal* released its first issue in March 1976, and for nearly 35 years has been the premiere journal dedicated to the medical management and surgical practice of the spine. At present, *Spine* is affiliated with 12 international spine societies including Cervical Spine Research Society and Scoliosis Research Society.

With the current expansion of information and research in the field of spine surgery, it has become important to measure the academic significance of journals and research articles. The use of citation analysis is another method in the evaluation of academic influence. Citation analysis has been used to assess the contributions of multiple journals^[1-22]. One method of analysis is the use of impact factor (IF) in the assessment of the academic importance of a journal. In 1972, Dr. Eugene Garfield introduced IF in order to serve as a means of rating journal quality. IF is defined as the total number of citations of all articles within a journal within a specific time period divided by the total number of publications within the journal in the same period. In 1981, the first calculated IF for *Spine* was 0.894, whereas in 2007 the IF was reported 2.499^[6,7].

Another approach in evaluating citation-based significance is the use of the Institute for Scientific Information (ISI). ISI database has managed journal publications and citations since 1945. This is a collection of all types of information as well as citations that are related to this and all other academic medical fields. The most current journal citation database under the ISI consists of the Science Citation Index (SCI). The SCI collects citation statistics from more than 6650 journals encompassing over 150 diverse disciplines.

The purpose of this study was to determine the most influential authors and articles contributing to spine research. SCI was searched for the 20 most cited articles and authors in the *Spine Journal* during the last 20 years of publication.

MATERIALS AND METHODS

On December 19, 2010, ISI Web of Knowledge was accessed to search the top cited articles in the *Spine Journal* from the last two decades^[8]. First we narrowed the search to only entries in *Spine*. Then we ensured only articles were included, omitting editorials, letters and case reports. We further narrowed the search to include articles published between 1990 and 2009. Each of the top 20 articles was reviewed and basic information was recorded including type of article (basic science or clinical), sub-type (biomechanics, animal study, randomized control trial, cohort study, case series or review article), level of evidence if clinical type, and anatomical part of the *Spine* studied.

Next, on the same day, we gathered data for the top published authors in *Spine* from 1991-2009. We accessed ISI Web of Knowledge to compile the data. Again omitting editorials and letters, we narrowed our search to the

specific years and sorted the results based on number of publications per author. The top 20 authors and their articles were reviewed. The total number of citations for each author was calculated. We also collected data based on number of first-authorships per top published author. Further, the number of citations for these papers was also calculated. Finally, a ratio of number of citations divided by number of first-authorship was calculated for each author.

RESULTS

Based on information gathered in December 2010, the top 20 cited articles from 1990 to 2009 are listed by numerical rank in Table 1. The number of citations per article ranged from 491 to 267. There was a tie for the 18th spot. Although the range between the first and the twentieth ranked paper was 224, there were no drastic drops between any consecutive ranks. The average decrease in the number of citations between consecutive articles is 10.52, with a range of 44 (between third and fourth ranked articles) and 1 (between 18th and 20th ranked articles). The overall range of citations may seem large at 224, however the highest data point was only cited less than twice as often as the lowest.

The study characteristics of each article of the top 20 are summarized in Table 2. Included in this table is the article type, sub-type, level of evidence, and anatomical or diagnostic field of spine studied if applicable. Of the top 20, 17 articles involve clinical research and three are basic science articles. The clinical research articles included six review articles, three prospective cohort studies, three randomized-control trials, three case series, two cross-sectional studies, and one biomechanical study. It is worth noting; of the top three spots, two papers are review articles. The basic science studies included one biomechanical, one animal study, and one review article.

Various subjects are covered among these top 20 papers. The most common theme involved back pain; five papers discussed low back pain and one paper discussed neck pain. Three articles involved the topic of osteoporotic compression fractures, making this the second most common subject in the top articles. Of the top 10 articles, two involve low back pain, the most common theme, while two other articles in the top 10 involve general health status.

The top-cited 20 authors of *Spine* between 1990-2009, number of total articles published, total citations, lead authorships, lead authorship citations, and ratio of total citations divided by lead authorships are listed in Table 3. There are two authors that have more than 100 publications. The range of publications is 41 to 135. Three authors tied for 19th position with 41 publications each, making the list a total of 21 authors. Three authors currently work in Japan, one in China, one in Sweden and the remaining 16 authors work in the United States. The original rank of these authors is in order of most articles published. After calculation of the ratio, number of

Table 1 Top 20 cited papers in the spine journal, 1990-2009

Rank	Ref.	Title	Number of citations
1	Ware <i>et al</i> ^[23]	SF-36 health survey update	491
2	Bigos <i>et al</i> ^[24]	A prospective study of work perceptions and psychological factors affecting the report of back injury	460
3	Deyo <i>et al</i> ^[25]	Outcome measures for low back pain research - A proposal for standardized use	432
4	Hodges <i>et al</i> ^[28]	Inefficient muscular stabilization of the lumbar spine associated with low back pain - A motor control evaluation of transversus abdominis	388
5	Banwart <i>et al</i> ^[29]	Iliac crest bone-graft harvest donor site morbidity- A statistical evaluation	384
6	Zdeblick <i>et al</i> ^[30]	A prospective, randomized study of lumbar fusion - preliminary results	376
7	Beaton <i>et al</i> ^[31]	Guidelines for the process of cross-cultural adaptation of self-report measures	364
8	Buckwalter <i>et al</i> ^[32]	Spine update- Aging and degeneration of the human intervertebral disc	358
9	Spitzer <i>et al</i> ^[33]	Scientific monograph of the Quebec task-force on whiplash-associated disorders-Redefining whiplash and its management	348
10	Garfin <i>et al</i> ^[34]	New technologies in spine - Kyphoplasty and vertebroplasty for the treatment of painful osteoporotic compression fractures	335
11	Lieberman <i>et al</i> ^[35]	Initial outcome and efficacy of "kyphoplasty" in the treatment of painful osteoporotic vertebral compression fractures	330
12	Barr <i>et al</i> ^[36]	Percutaneous vertebroplasty for pain relief and spinal stabilization	328
13	Patrick <i>et al</i> ^[37]	Assessing health-related quality-of-life in patients with sciatica	311
14	O'Sullivan <i>et al</i> ^[38]	Evaluation of specific stabilizing exercise in the treatment of chronic low back pain with radiologic diagnosis of spondylolysis or spondylolisthesis	299
15	Marras <i>et al</i> ^[39]	The role of dynamic 3-dimensional trunk motion in occupationally-related low back disorders- The effects of workplace factors, trunk position, and trunk motion characteristics on risk of injury	289
16	Klenerman <i>et al</i> ^[27]	The prediction of chronicity in patients with an acute attack of low-back pain in a general-practice setting	287
17	Olmarker <i>et al</i> ^[40]	Autologous nucleus pulposus induces neurophysiologic and histologic changes in porcine cauda-equina nerve roots	282
18	Fritzell <i>et al</i> ^[41]	2001 Volvo Award winner in clinical studies: Lumbar fusion versus nonsurgical treatment for chronic low back pain - A multicenter randomized controlled trial from the Swedish Lumbar Spine Study Group	268
18	Thompson <i>et al</i> ^[42]	Preliminary evaluation of a scheme for grading the gross morphology of the human intervertebral disk	268
20	Bovim <i>et al</i> ^[43]	Neck pain in the general population	267

citations to first authorship, a new rank was distributed amongst the authors. This rank can be found in the last column of Table 3.

DISCUSSION

Scholastic importance and academic weight given to a journal article is often measured by the amount of citations received. Commonly, throughout specialized areas of medicine, the number of citations given to an article correlates to the influence it has in medical literature. However, the received citations can also be used to investigate the internal growth of a journal. As the number of citations correlates with academic impact, it also directly contributes to the increase in IF of a journal. As a tool to delineate the articles and subjects that have contributed growth in spine surgery, it was the goal of this study to determine the top 20 articles of *Spine* between 1990-2009.

The first ranked article had 491 citations, while the 20th ranking article had 267 citations recorded. The range is modestly established as 224, while the average difference between consecutive ranking articles in the top 20 is 10.5. The difference between the first-ranked article (491) and second-ranked article (460) is 31 citations. However, the difference between the tied 18th and 20th ranked articles is 1 citation. The 20 top-cited articles in the *Journal of Orthopaedic Trauma* (*J Orthop Trauma*) include two "citation classics" surpassing the 100 citation level^[22]. The range of citations in the top 20 articles was 566 to 64 citations. In

the "Leading 20 at 20" study the top-ranked article has 566 citations, with the second-ranked article having 150, with a difference of 416. While this is significantly higher difference than the top two articles in *Spine*, the 19th and 20th ranked articles in *J Orthop Trauma* also differed by 1 citation. The top 20 articles in the *Journal of Pediatric Orthopaedics* had a range of 231 to 51 citations, including four articles with over 100 articles^[10]. This suggests the popularity of many different articles within *Spine* over nearly two decades, no one article being completely controlling in the increasing academic impact of *Spine*.

A large number of the top 20 articles were clinical articles, rather than basic science articles. The 17 clinical articles included five review articles, while the remaining articles were equally divided with three prospective cohort studies, case-series, and cross-sectional studies. Overall, 20% (5) of the top 20 articles were review articles. A similar rate of 15%-20% review articles has been noted in other studies in top-cited literature^[10,20]. Two of the top three ranked articles were clinical review articles, suggesting the importance of literature review as a role of *Spine*. Yet, 14 of the top 20 articles are original articles with four Level 1 articles. This differs from other top-cited article studies, including the Lefaivre *et al*^[22] report of the top 20 articles in the *J Orthop Trauma* in which there was one Level 1 article.

Interestingly, the first-ranked article was not a spine-specific topic rather it was regarding general physical and mental health status survey update review^[23]. The SF-36 survey has been used in both general population, as well

Table 2 Study characteristics of the top 20 cited papers in the spine journal, 1990-2009

Rank	Ref.	Type	Subtype/level of evidence	Subject
1	Ware <i>et al</i> ^[23]	Clinical	Review/level 4	General health
2	Bigos <i>et al</i> ^[24]	Clinical	Prospective cohort/level 1	Back injury
3	Deyo <i>et al</i> ^[25]	Clinical	Review/level 3	Low back pain
4	Hodges <i>et al</i> ^[28]	Clinical	Prospective cohort/level 3	Low back pain
5	Banwart <i>et al</i> ^[29]	Clinical	Case series/level 4	Iliac crest bone graft harvest
6	Zdeblick <i>et al</i> ^[30]	Clinical	Randomized control trial/level 2	Lumbar/lumbosacral fusion
7	Beaton <i>et al</i> ^[31]	Clinical	Review/level 4	General health
8	Buckwalter <i>et al</i> ^[32]	Basic Science	Review	Intervertebral disk
9	Spitzer <i>et al</i> ^[33]	Clinical	Review/level 4	Whiplash disorders
10	Garfin <i>et al</i> ^[34]	Clinical	Review/level 2	Osteoporotic compression fractures
11	Lieberman <i>et al</i> ^[35]	Clinical	Case series/level 4	Osteoporotic compression fractures
12	Barr <i>et al</i> ^[36]	Clinical	Case series/level 4	Osteoporotic compression fractures/spinal tumor
13	Patrick <i>et al</i> ^[37]	Clinical	Prospective cohort/level 1	Low back pain
14	O'Sullivan <i>et al</i> ^[38]	Clinical	Randomized control trial/level 1	Spondylolysis/spondylolisthesis.
15	Marras <i>et al</i> ^[39]	Clinical	Cross-sectional	Occupationally-related low back pain
16	Klenerman <i>et al</i> ^[27]	Clinical	Cross-sectional	Chronicity of low back pain
17	Olmarker <i>et al</i> ^[40]	Basic Science	Animal study	Nucleus pulposus induced histological/morphological changes
18	Fritzell <i>et al</i> ^[41]	Clinical	Randomized control trial/level 1	Lumbar fusion
18	Thompson <i>et al</i> ^[42]	Basic Science	Biomechanics	Intervertebral disk morphology
20	Bovim <i>et al</i> ^[43]	Clinical	Cross-sectional	Neck pain

Table 3 The top-cited 20 authors in the spine journal, 1990-2009

Rank	Author	Current institution	Articles published	Total citations	Lead authorships	Lead author citations	Ratio
1	Lenke LG	Washington University; United States	135	2833	8	205	354.1
2	Bridwell KH	Washington University; United States	117	2553	13	371	196.4
3	Vaccaro AR	Thomas Jefferson University; United States	88	1701	20	517	85.1
4	Takahashi K	Chiba University; Japan	72	1021	9	132	113.4
5	An HS	Rush University; United States	67	1506	9	252	167.3
6	Panjabi MM	Yale University; United States	64	3034	22	989	137.9
7	Weinstein JN	Dartmouth University; United States	64	2315	6	142	385.8
8	Deyo RA	University of Washington; United States	63	4152	8	1047	519
9	Albert TJ	Thomas Jefferson University; United States	61	1307	6	191	217.8
10	Ebraheim NA	University of Toledo; United States	57	1053	27	539	39
11	Kikuchi S	Fukushima Medical University; Japan	56	1212	4	64	303
12	Moriya H	Chiba University; Japan	52	907	0	0	n/a
13	McAfee PC	St. Joseph Medical Center; United States	48	1762	10	377	176.2
14	Newton PO	Rady Children's Hospital; United States	45	468	13	251	36
15	Andersson GBJ	Rush University; United States	45	1448	2	42	724
16	Luk KDK	University of Hong Kong; China	44	568	10	137	56.8
17	Boden SD	Emory University; United States	43	2215	14	1349	158.2
18	Olmarker K	University of Gothenburg; Sweden	43	1512	12	767	126
19	Kim YJ	Columbia University; United States	41	751	17	466	44.2
20	Garfin SR	University of California, San Diego; United States	41	1239	5	448	247.8
21	Bradford DS	University of California, San Francisco; United States	41	1288	3	102	429.3

as clinical trials. Ware stated in the review article the broad use of the SF-36 health survey was attributed to its brevity and comprehensiveness. As this review article was not limited to spine-related disorders and treatment, its clinical applicability may have been greater than the other articles. Surprisingly the number of citations of this article was comparable to the leading articles.

A variety of subjects were investigated in the top 20 articles in *Spine*. The most popular topics included low back pain, back injury, osteoporotic compression fractures and lumbar fusion. The second most cited article investigated perceptions and factors in reporting back injury^[24]. This study sought to identify risk factors for

reporting back pain at work. The third ranked article considered recommendations in the use of standardized measures in clinical outcomes research in patients with back pain^[25]. Of the top three articles, two are concerned with outcome measurement and analysis.

Low back pain was the most common theme encountered in the top cited articles. A study by Deyo *et al*^[26] in 2002 found that low back pain lasting at least a whole day in the past 3 mo was reported by 26.4% and neck pain was reported by 13.8% of a total 31044 adult respondents. Also it was concluded that physician visits for low back pain have changed little since the 1990s. Given the high prevalence of low back pain, it was expected to be a

reoccurring subject in the top cited articles. Some articles investigated predictive factors, while others studied novel techniques in the treatment of low back pain. Klenerman *et al*^[27], investigated the factors predictive of the progression of acute to chronic low back pain. This shows focus on preventative measures with regard to low back pain.

Of the top 20 cited articles, six articles researched topics related to surgical management and outcomes of spine disorders. These topics included iliac crest bone graft harvest, comparison of kyphoplasty and vertebroplasty, outcome and efficacy of kyphoplasty, percutaneous vertebroplasty, and lumbar fusion. On the other hand, Lefaivre's study of the top 20 cited articles in *J Orthop Trauma* found 15 articles involving the subject of surgical treatment^[22]. The number of non-surgical studies highly cited in *Spine* indicates a multimodal nature of spine care.

The most published authors between the 1990-2009, shown in Table 3, have had significant impact in the field of spine surgery. However, it is interesting to note that only two authors with articles in the top 20 cited articles are included in the list of top 21 total citations from 1990-2009. The disconnect between these two data sets brings to light the tremendous contributions of authors *vs* the contributions of single articles in *Spine*. The top cited author between 1990-2009 had 4152 total citations, more than eight times the number of the total citations received by the first ranked article in *Spine* during this era. RA Deyo received a total of 4152 citations in this nearly two-decade period, and also had the third-ranked top-cited article in *Spine*. The other author included in both lists was SR Garfin, he received 335 citations for the tenth ranked article in *Spine*, and received a total 1239 citations for 41 articles published from 1990-2009. LG Lenke was first-ranked according to total number of articles published. The ratio of total number of articles published to lead authorships, or citations per first authorship, relays the relative citation impact. The first-ranked author by relative impact factor was GBJ Andersson with a ratio of 724. The lowest ratio of the top 21 authors by total publications was 36, with one author having no lead authorships thus a null ratio.

There are several limitations to this study. Articles with citations by the author themselves, textbook citations of articles, and citations in journals in which authors prefer to cite their own research were not included in the number of total citations. Further, the measurement of academic importance cannot be determined using only citation analysis. The total number of citations cannot reflect necessarily on the overall quality of research presented. Another bias within this study is that of lead authorship. First authors tend to be more senior faculty, and at times may not duly reflect the main influence or source of the research. In addition, the most influential author of a paper may not be the lead author. Time is another bias in this study, as more recent articles have less opportunity to gain citations. Most importantly, the trends observed in this study only describe *Spine* in a snapshot in time, and cannot reflect the trends and

changes in spine surgery as a field.

In conclusion, *Spine Journal* and its authors have a clear impact on the scientific community based on this review of the top articles and authors in the last 20 years. Out of the 21 most cited authors, 16 work in the United States, 3 work in Japan, one in China, one in Sweden. A variety of subjects were investigated in the top 20 articles in *Spine*. The most popular topics included low back pain, back injury, osteoporotic compression fractures and lumbar fusion. Interestingly, the first-ranked article was not a spine-specific topic rather it was regarding general physical and mental health status survey update review.

COMMENTS

Background

Modern medicine has been evolving at an increasingly rapid rate for the past 40 years. Advancements in spine surgery are no exception to this trend. With the current expansion of information and research in the field of spine surgery, it has become important to measure the academic significance of journals and research articles.

Research frontiers

Spine is affiliated with 12 international spine societies including Cervical Spine Research Society and Scoliosis Research Society.

Innovations and breakthroughs

Using the Institute for Scientific Information Web of Knowledge, the authors determined the most cited articles in *Spine Journal* between 1990-2009. The characteristics and type of article were recorded. Next, the authors evaluated the most published authors during the same time period and calculated the number of citations for each author. The number of first authorships for each of these authors was also determined along with the number of citations for those articles.

Applications

Spine Journal and its authors have a clear impact on the scientific community based on this review of the top articles and authors in the last 20 years.

Peer review

Interesting topic and well-organized paper, should be accepted.

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