

OPEN

Fifty Most-cited Articles on Lateral Epicondylitis of the Elbow

Hasani W. Swindell, MD
 David P. Trofa, MD
 Manish S. Noticewala, MD
 Matthew J. Grosso, MD
 Robert L. Parisien, MD
 William N. Levine, MD
 Christopher S. Ahmad, MD

From the Department of Orthopedic Surgery, Columbia University Medical Center, New York, NY (Dr. Swindell, Dr. Trofa, Dr. Noticewala, Dr. Grosso, Dr. Levine, and Dr. Ahmad); Department of Orthopedics, Boston University Medical Center, Boston University, Boston, Massachusetts (Dr. Parisien).

Correspondence to Dr. Ahmad:
 csa4@columbia.edu

JAAOS Glob Res Rev 2018;2:e004

DOI: 10.5435/
 JAAOSGlobal-D-18-00004

Copyright © 2018 The Authors. Published by Wolters Kluwer Health, Inc. on behalf of the American Academy of Orthopaedic Surgeons. This is an open-access article distributed under the terms of the Creative Commons Attribution-Non Commercial-No Derivatives License 4.0 (CCBY-NC-ND), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.

Abstract

Introduction: Citation number can be used as a marker of a scientific article's influence. This study sought to determine and characterize the most-cited investigations on lateral epicondylitis and identify the most influential studies pertaining to this pathology.

Methods: The Institute for Scientific Information Web of Science database was queried for articles investigating lateral epicondylitis, and the 50 most-cited articles were selected. For each article, number of citations, citation density, journal, publication year, country of origin, language, article type, article subtype, and level of evidence were recorded.

Results: Citation numbers ranged from 72 to 332 (mean, 127.4), and densities ranged from 1.6 to 34.0 (mean, 9.4). Articles were published across 26 different journals. Most articles (41) were clinical, with randomized controlled trials (29.3%) being the most commonly cited articles.

Discussion: Compared with previous investigations looking at citation density within orthopaedics, the most commonly cited clinical articles on lateral epicondylitis had a high percentage of level I or II evidence (39.0%). This compilation of the literature can aid in establishing reading curriculums for trainees in both orthopaedic residencies and fellowships. This is a Level V study.

The number of times an article has been cited has often been used as a marker of the academic influence the article has on its area of medical expertise.¹ Although the number of total citations is not the only variable determining an article's importance or impact, it provides some insights into identifying landmark scientific investigations within a field and can provide residency and fellowship directors with a collection of articles that may warrant inclusion into a standardized reading curriculum. Citation analysis has been used pre-

viously to identify influential works among various medical specialties.^{2–12} Within the orthopaedic literature, Lefavre et al⁶ provided one of the first exhaustive investigations into the 100 most-cited articles in orthopaedic surgery using citation analysis. Using similar techniques, studies have been conducted with similar aims across several orthopaedic subspecialties such as shoulder surgery, pediatric orthopaedic surgery, fracture surgery, anterior cruciate ligament (ACL) research, and rotator cuff repair research.^{13–17} To our knowledge, no

investigation on the most-cited works on lateral epicondylitis, or “tennis elbow,” has been performed; this is a subject in which treatment strategies continue to be debated by experts today. The purpose of this study was to determine the 50 most-cited articles on lateral epicondylitis and to better characterize these works as a way to evaluate the current literature on this common orthopaedic condition.

Methods

Using previously described methods,^{6,13,14,16} a systematic query of the Institute for Scientific Information Web of Science database (v5.22.3; Thomson Reuters) was performed using the Advanced Search tool on October 13, 2016. The authors expanded the search to include all journals, not only those listed under the Web of Science Category of “Orthopedics.” The authors searched for all published articles with a topic listed as “lateral epicondylitis,” or “tennis elbow.” The retrieved articles were sorted according to the total number of citations, and the 50 most-cited articles were selected for analysis. The full text of each article was individually evaluated by two authors to ensure that the reviewed material was related to lateral epicondylitis.

For each of the 50 most-cited articles, the following characteristics were recorded: citation number, citation density, journal, publication year, country of origin, and language. Citation density was defined as the numbers of citations per year since the

date of publication. Two independent evaluators characterized each article by type, including basic science, clinical, or diagnostic. Clinical articles were further subtyped as a systematic review or meta-analysis, randomized controlled trial, prospective or retrospective cohort study, case-control study, case series, cross-sectional study, review article, or expert opinion. The classification system developed by *The Journal of Bone and Joint Surgery* (JBJS) was used to determine the level of evidence for each clinical article.¹⁸ Interobserver agreement for analyzed subjective variables was 100% for article type, 100% for subtype, and 97.5% for level of evidence. Discrepancies between authors were resolved using consensus. The obtained results were analyzed to determine which characteristics were common among the included articles.

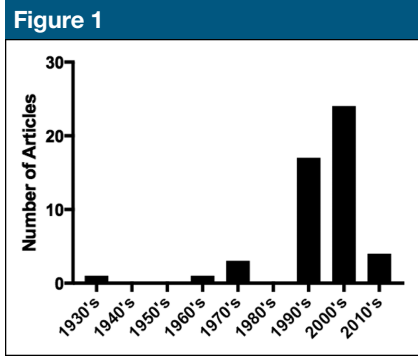
Results

A list of the 50 most-cited publications on lateral epicondylitis and their respective number of citations and citation densities can be found in Supplemental Digital Content 1 (see Table 1, <http://links.lww.com/JG9/A11>). In total, these articles were cited a combined 6,368 times in the literature. The number of citations ranged from 72 to 332 citations (mean, 127.4 ± 59.5), and citation densities ranged from 1.6 to 34.0 citations per year (mean, 9.4 ± 7.3). The two articles with the greatest number of citations were “Treatment of chronic elbow tendinosis with

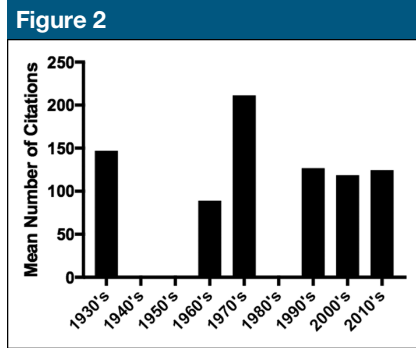
buffered platelet-rich plasma” by Mishra and Pavelko¹⁹ (332 citations) and “Tennis elbow: The surgical treatment of lateral epicondylitis” by Nirschl and Pettrone²⁰ (314 citations). The randomized controlled trial titled “Positive effect of an autologous platelet concentrate in lateral epicondylitis in a double-blind randomized controlled trial: Platelet-rich plasma versus corticosteroid injection with a 1-year follow-up” by Peerbooms et al²¹ had the greatest citation density (34.0 citations per year) in this investigation.

The top 50 articles on lateral epicondylitis were published in 26 different journals, 13 of which only had a single publication on the list (see Supplemental Digital Content 2, Table 2, <http://links.lww.com/JG9/A12>). The largest number of articles ($n = 7$; 14%) were published in *The American Journal of Sports Medicine* (AJSM) followed by *The Journal of Bone and Joint Surgery—American Volume* (JBJS-AM) ($n = 6$; 12%). The publication years ranged between 1936 and 2013 (Figure 1). By decade, 48% were published in the 2000s, 34% from the 1990s, and 6% from the 1970s. Articles published in the 1970s had the greatest mean number of citations (211.3), whereas those published in the 2010s had the greatest mean citation density (25.6) (Figure 2). Over the past 3 decades, the citation density for articles on lateral epicondylitis has grown such that the mean citation density rose from 6.03 in the 1990s to 10.1 in the 2000s and 25.63 in the 2010s.

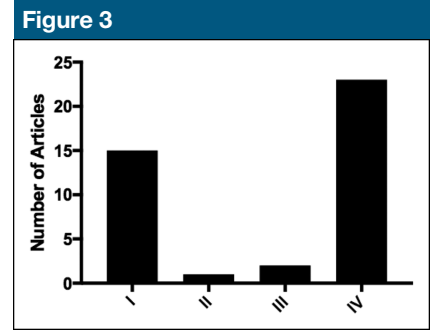
Dr. Grosso or an immediate family member has received research or institutional support from Stryker. Dr. Levine or an immediate family member serves as an unpaid consultant to Zimmer Biomet and serves as a board member, owner, officer, or committee member of the *Journal of the American Academy of Orthopaedic Surgeons*. Dr. Ahmad or an immediate family member has received royalties from and serves as a paid consultant to Arthrex; has stock or stock options held in At Peak; has received research or institutional support from Arthrex, Major League Baseball, and Stryker; has received nonincome support (such as equipment or services), commercially derived honoraria, or other non-research-related funding (such as paid travel) from Lead Player; and serves as a board member, owner, officer, or committee member of *Orthopedics Today*. None of the following authors or any immediate family member has received anything of value from or has stock or stock options held in a commercial company or institution related directly or indirectly to the subject of this article: Dr. Swindell, Dr. Trofa, Dr. Noticewala, and Dr. Parisien.



Graph showing the number of 50 most-cited articles on lateral epicondylitis by decade of publication.



Graph showing the mean number of citations of 50 most-cited articles on lateral epicondylitis by decade of publication.



Graph showing the number of 50 most-cited clinical articles on lateral epicondylitis by level of evidence.

The top 50 articles were published in, or originated from, 14 different countries. Articles were most commonly published in the United States (26%), followed by equal contributions from the Netherlands (16%) and England (16%) (see Supplemental Digital Content 3, Table 3, <http://links.lww.com/JG9/A13>). Six investigators were the lead authors on more than one investigation, with Nirschl RP being the only lead author on three investigations. Lead authors with two investigations on the top 50 list included Connell DA, Palmer K, Rompe JD, Smidt N, and Verhaar J.

Clinical, basic science, and diagnostic investigations made up 82%, 12%, and 6%, respectively, of the identified article subtypes (see Supplemental Digital Content 4, Table 4, <http://links.lww.com/JG9/A14>). Among clinical investigations, the most common subtypes found included randomized controlled trials (n = 12; 29.3%) and reviews (n = 8; 19.5%). Most clinical articles met the standard for level IV evidence (n = 23; 56.1%), whereas 36.6%, 2.4%, and 4.8% of studies fit criteria for level I, II, and III evidence, respectively (Figure 3).

Discussion

Lateral epicondylitis affects 1% to 3% of the population and is the most

commonly diagnosed musculoskeletal condition of the elbow.²¹⁻²³ A number of treatment options have been developed for tennis elbow, yet the optimal management remains controversial. As such, it is important to identify and characterize the most widely cited investigations on lateral epicondylitis to provide practitioners with the studies that have helped our understanding of this pathology and provided evidence for various treatment options.

Our study identified the 50 most-cited articles pertaining to lateral epicondylitis. It should be noted that this list cannot be comprehensive because only two measures of impact (ie, citation number and density) were used as a proxy for academic influence. Citation frequency has been used as a marker of an article's impact on a specific specialty because it is an indicator of readership and influence on further research.²⁴⁻²⁷ We are aware that several articles may have been excluded despite having a significant impact on the understanding of lateral epicondylitis. However, we feel that this list includes a number of articles that have greatly contributed to the understanding of the pathoanatomy and surgical and nonsurgical treatments of lateral epicondylitis, which is evidenced by the fact that five of the articles in this top 50 cited

list were also included in the American Shoulder and Elbow Surgeons elbow curriculum guide on lateral epicondylitis.²⁸

Mishra and Pavelko¹⁹ had the most-cited article (332 citations), with the second highest citation density (33.2 citations per year), followed by the landmark publication on the surgical treatment of lateral epicondylitis by Nirschl et al²⁰ (314 citations).^{16,26} Mishra and Pavelko¹⁹ investigated the efficacy of platelet-rich plasma (PRP) injections as a modality for the non-surgical management of lateral epicondylitis. Previously, nonsurgical management involved rest, NSAID medications, bracing treatment, physical therapy, extracorporeal shock wave therapy, and botulinum toxin; however, the superiority and efficacy of these treatments are unclear.^{29,30} This article's position as a platform for the continued evaluation of PRP therapy can explain its high citation number. This claim is further supported by the inclusion of four other articles on our list comparing PRP with other injectable modalities (ie, corticosteroids, whole blood, and saline).^{21,31-33} This includes the randomized controlled trial by Perbooms et al²¹ comparing PRP with corticosteroid injections for the treatment of lateral epicondylitis, which was found to have the highest citation density in this investigation (34.0 citations per

year). These authors found that PRP was more effective than corticosteroids, with regard to pain reduction and increased function, with 24% and 22% more patients treated with PRP having improved visual analog scale and Disabilities of the Arm and Shoulder scale scores, respectively.²¹

The article titled “Tennis elbow: The surgical treatment of lateral epicondylitis” was also a foundational study that identified the characteristic histologic findings of fibroblastic invasion and vascular infiltration at the origin of the extensor carpi radialis brevis.²⁰ These findings were later found to be consistent with the pattern of repetitive microinjury and attempted healing.³⁴ The study also described a surgical approach, with elements still in practice today, involving incision of the extensor carpi radialis brevis origin and visualization and subsequent débridement of pathologic lesions. Last, the study provided initial outcome data in favor of surgical intervention and reassuring prognosis for return to sport.

Most articles included in our study were published in either *AJSM* or *JBJS-AM*, both well-regarded, high-impact orthopaedic journals based on the most recent (2016) Thomas Reuters Journal Citation Report.³⁵ *JBJS-AM* had the highest impact factor of journals under the category “Orthopedics” with a score of 5.163, and *AJSM* was ranked third, with an impact factor of 4.517. Previous studies have examined the impact factor of orthopaedic journals and cite *AJSM* as the specialized orthopaedic journal with the greatest impact factor and *JBJS-AM* as the general orthopaedic journal with the greatest impact factor.³⁶ In addition to their inclusion in high-impact journals, many of the articles on our most-cited list were performed under rigorous study designs as supported by their designations as level I studies. This scenario is in contrast to

previous orthopaedic citation analyses. For instance, the number of level I and II evidence studies included in the top 50 articles published on ACL research, femoroacetabular impingement, and shoulder surgery were 6, 0, and 9, respectively.^{16,17,37} Furthermore, in an investigation on the 100 most-cited articles in orthopaedic surgery, Lefaivre et al⁶ found that <10 articles were level I or II evidence. The reason for the relatively high number of level I and II evidence articles in the current investigation is twofold. First, compared with other orthopaedic pathologies, lateral epicondylitis is often successfully treated nonsurgically, making comparative investigations significantly easier for investigators to perform. As such, all 12 randomized controlled trials included in this investigation looked at various nonsurgical treatments. Second, there has been a more recent emphasis on evidence-based investigations, and most of the level I studies included in this list were published between 1996 and 2013.^{6,16} This fact is in contrast to previous investigations reviewing the classic articles published on ACL research, shoulder surgery, and general orthopaedic surgery, which found that the most studies were published in the 1990s, 1970s, and 1970s, respectively.^{6,16,17} Interestingly, despite the recent, high-quality works on comparative treatments for lateral epicondylitis, the literature remains inconclusive on the ideal management.³⁸

There are several limitations to our study. The small number of articles included on our list increases the possibility of excluding high-impact investigations on this subject. The specific inclusion of only 50 articles was selected because this value has been used in previous citation analyses of orthopaedic and clinical subspecialties.^{13,16,17,37} Furthermore, to fulfill the ultimate purpose of serving as a reading curriculum for orthopaedic training programs, 50 articles were felt

to be both appropriate and manageable for a postgraduate orthopaedic trainee. Our chosen measures of impact also exclude some cardinal articles on lateral epicondylitis, to which we would recommend future efforts to identify alternative measures of influence other than citation density (ie, inclusion in high-impact journals). There is also a risk that crossover studies examining specific treatments may extend over several disciplines or conditions and also affect citation density. For example, there is the possibility that citation analyses of PRP may include an abundance of lateral epicondylitis articles because this treatment is commonly implicated in its management. In addition, our list selectively includes only peer-reviewed articles and excludes any lectures, presentations, textbooks, or non-peer-reviewed literature that contributes to our knowledge of lateral epicondylitis.

Our chosen measures of influence are also at risk of confounding effects. For one, self-citation driven by partnering authors, journals, recency, article exposure time, and journal impact factor characterizes a phenomenon described by Lefaivre et al⁶ where the scientific community tends to favor the ongoing citation of articles because of a record of previous citations, rather than for content or quality. This fact would produce inflated citation rates and give an inaccurate assessment of an article’s influence. There is also a question of publication bias where positive or controversial study results attract more attention and thus increased citations compared with studies reporting negative or no significant results. Although still possible, in high-impact orthopaedic journals such as *JBJS*, this bias seems to be reduced.³⁹

Conclusion

This study identifies the 50 most-cited articles on lateral epicondylitis or

“tennis elbow” and includes foundational investigations that have provided knowledge and understanding of the underlying etiology, pathophysiology, and treatment. This list may be used to aid in the education of orthopaedic residency and fellowship trainees because it serves as a source for establishing a reading curriculum on lateral epicondylitis. Many of the articles included were randomized controlled trials showing the modern-day emphasis on evidence-based medicine to evaluate outcomes for a condition for which the optimal management remains controversial.

References

- Adam D: The counting house. *Nature* 2002;415:726-729.
- Baltussen A, Kindler CH: Citation classics in critical care medicine. *Intensive Care Med* 2004;30:902-910.
- Brandt JS, Downing AC, Howard DL, Kofinas JD, Chasen ST: Citation classics in obstetrics and gynecology: The 100 most frequently cited journal articles in the last 50 years. *Am J Obstet Gynecol* 2010;203:355.e1-355.e7.
- Dubin D, Häfner AW, Arndt KA: Citation classics in clinical dermatologic journals: Citation analysis, biomedical journals, and landmark articles, 1945-1990. *Arch Dermatol* 1993;129:1121-1129.
- Fenton JE, Roy D, Hughes JP, Jones AS: A century of citation classics in otolaryngology: Head and neck surgery journals. *J Laryngol Otol* 2002;116:494-498.
- Lefavre KA, Shadgan B, O'Brien PJ: 100 Most cited articles in orthopaedic surgery. *Clin Orthop Relat Res* 2011;469:1487-1497.
- Loonen MPJ, Hage JJ, Kon M: Plastic surgery classics: Characteristics of 50 top-cited articles in four plastic surgery journals since 1946. *Plast Reconstr Surg* 2008;121:320e-327e.
- Ohba N, Nakao K, Isashiki Y, Ohba A: The 100 most frequently cited articles in ophthalmology journals. *Arch Ophthalmol* 2007;125:952-960.
- Ollerton JE, Sugrue M: Citation classics in trauma. *J Trauma* 2005;58:364-369.
- Paladugu R, Schein M, Gardezi S, Wise L: One hundred citation classics in general surgical journals. *World J Surg* 2002;26:1099-1105. Accessed on January 7, 2017.
- Ponce FA, Lozano AM: Highly cited works in neurosurgery: Part I: The 100 top-cited papers in neurosurgical journals. *J Neurosurg* 2010;112:223-232.
- Tsai Y-L, Lee C-C, Chen S-C, Yen Z-S: Top-cited articles in emergency medicine. *Am J Emerg Med* 2006;24:647-654.
- Baldwin KD, Kovatch K, Namdari S, Sankar W, Flynn JM, Dormans JP: The 50 most cited articles in pediatric orthopedic surgery. *J Pediatr Orthop B* 2012;21:463-468.
- Baldwin KD, Namdari S, Donegan D, Kovatch K, Ahn J, Mehta S: 100 most cited articles in fracture surgery. *Am J Orthop (Belle Mead NJ)* 2013;42:547-552.
- Kraeutler MJ, Freedman KB, MacLeod RA, Schrock JB, Tjoumakaris FP, McCarty EC: The 50 most cited articles in rotator cuff repair research. *Orthopedics* 2016;39:e1045-e1051.
- Namdari S, Baldwin K, Kovatch K, Huffman GR, Glaser D: Fifty most cited articles in orthopedic shoulder surgery. *J Shoulder Elb Surg* 2012;21:1796-1802.
- Voleti PB, Tjoumakaris FP, Rotmil G, Freedman KB: Fifty most-cited articles in anterior cruciate ligament research. *Orthopedics* 2015;38:e297-e304.
- Obremsky WT, Pappas N, Attallah-Wasif E, Tornetta P, Bhandari M: Level of evidence in orthopaedic journals. *J Bone Joint Surg* 2005;87:2632.
- Mishra A, Pavelko T: Treatment of chronic elbow tendinosis with buffered platelet-rich plasma. *Am J Sports Med* 2006;34:1774-1778.
- Nirschl RP, Pettrone FA: Tennis elbow: The surgical treatment of lateral epicondylitis. *J Bone Joint Surg* 1979;61:832-839.
- Peerbooms JC, Sluimer J, Bruijn DJ, Gosens T: Positive effect of an autologous platelet concentrate in lateral epicondylitis in a double-blind randomized controlled trial: Platelet-rich plasma versus corticosteroid injection with a 1-year follow-up. *Am J Sports Med* 2010;38:255-262.
- Allander E: Prevalence, incidence, and remission rates of some common rheumatic diseases or syndromes. *Scand J Rheumatol* 1974;3:145-153.
- Verhaar JA: Tennis elbow: Anatomical, epidemiological and therapeutic aspects. *Int Orthop* 1994;18:263-267.
- Cheek J, Garnham B, Quan J: What's in a number? Issues in providing evidence of impact and quality of research(ers). *Qual Health Res* 2006;16:423-435.
- Garfield E: Citation analysis as a tool in journal evaluation. *Science* 1972;178:471-479.
- Moed HF: New developments in the use of citation analysis in research evaluation. *Arch Immunol Ther Exp (Warsz)* 2009;57:13-18.
- Raghupathi W, Nerur S: Research themes and trends in health information systems. *Methods Inf Med* 2008;47:435-442.
- American Shoulder and Elbow Surgeons: Elbow curriculum. www.ases-assn.org/?p=elbow-curr. Accessed June 27, 2018.
- Altay T, Günel I, Öztürk H: Local injection treatment for lateral epicondylitis. *Clin Orthop Relat Res* 2002;398:127-130.
- Keizer SB, Rutten HP, Pilot P, Morré HHE, v Os JJ, Verburg AD: Botulinum toxin injection versus surgical treatment for tennis elbow: A randomized pilot study. *Clin Orthop Relat Res* 2002;401:125-131.
- Gosens T, Peerbooms JC, van Laar W, den Ouden BL: Ongoing positive effect of platelet-rich plasma versus corticosteroid injection in lateral epicondylitis: A double-blind randomized controlled trial with 2-year follow-up. *Am J Sports Med* 2011;39:1200-1208.
- Krogh TP, Fredberg U, Stengaard-Pedersen K, Christensen R, Jensen P, Ellingsen T: Treatment of lateral epicondylitis with platelet-rich plasma, glucocorticoid, or saline. *Am J Sports Med* 2013;41:625-635.
- Thanasas C, Papadimitriou G, Charalambidis C, Paraskevopoulos I, Papanikolaou A: Platelet-rich plasma versus autologous whole blood for the treatment of chronic lateral elbow epicondylitis: A randomized controlled clinical trial. *Am J Sports Med* 2011;39:2130-2134.
- Kraushaar BS, Nirschl RP: Tendinosis of the elbow (tennis elbow): Clinical features and findings of histological, immunohistochemical, and electron microscopy studies. *J Bone Joint Surg* 1999;81:259-278.
- Thomas Reuters: Journal Citation Reports. 2016. <http://www.webofknowledge.com>. Accessed January 17, 2017.
- Siebelt M, Siebelt T, Pilot P, Bloem RM, Bhandari M, Poolman RW: Citation analysis of orthopaedic literature; 18 major orthopaedic journals compared for impact factor and SCImago. *BMC Musculoskelet Disord* 2010;11:4.
- Lee S, Shin J, Haro M, et al: Fifty most cited articles for femoroacetabular impingement and hip arthroscopy. *Front Surg* 2015;2:41.
- Sims SEG, Miller K, Elfar JC, Hammert WC: Non-surgical treatment of lateral epicondylitis: A systematic review of randomized controlled trials. *Hand (N Y)* 2014;9:419-446.
- Okike K, Kocher MS, Mehlman CT, Heckman JD, Bhandari M: Publication bias in orthopaedic research: An analysis of scientific factors associated with publication in the *Journal of Bone and Joint Surgery (American Volume)*. *J Bone Joint Surgery Am* 2008;90:595-601.