100 Most Cited Articles in Fracture Surgery

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Abstract

Citation density is an important method by which to assess an article's impact on a field. We sought to identify the 100 most cited articles in fracture surgery, and highlight their characteristics.

We used the ISI web of science's cited reference search to identify the most cited articles in orthopedic surgery. We then used multiple reviewers to identify the articles that pertained specifically to fracture surgery. Differences were resolved by discussion. We then characterized the level of evidence, decade of publication, type of design, and citation density for each article.

All of the top 100 articles were published in English, the majority (69%) originated from the United States. Sixty-six percent of articles were clinical articles; the remainder were basic science. The most represented topic in the top 100 was hip fractures (12/100 articles). Over half of the clinical articles were level IV. Level of evidence was negatively correlated with date of publication.

Citation number-based identification of important papers will help current practitioners gain insight into past and current trends in their respective fields and provides the foundation for further investigations.

Number and frequency of citation is used frequently in the medical literature as a proxy for the significance of an article or the impact factor of a journal.[1-16] Lefaivre and colleagues[7] tabulated the orthopedic articles that have exerted the most citation influence on the specialty by ranking the 100 most cited works.

In fracture surgery, these same authors searched and tabulated all of the top cited articles contained within the *Journal of Orthopaedic Trauma* within its first 20 years.[17] Interestingly however, in Lefaivre's earlier "top 100" work, only 1 article came from the *Journal of Orthopaedic Trauma*. Fifty-four percent of the most cited articles came from 1 journal—the *Journal of Bone and Joint Surgery American Volume* and only 8 pertained directly to fracture care. This suggests that many of the most important papers in fracture surgery are not represented in either study. As additional evidence for this contention, only 2 of the articles from the *Journal of Orthopaedic Trauma* study had over 100 citations; whereas all 100 studies from the original Lefaivre paper had at least 100.[7,17]

While number of citations is not the only factor in determining an article's relevance, it is arguably our best marker for articles that have been influential in the field. Many highly cited articles have stimulated further standard-breaking investigations and discussions. The purpose of this study was to identify the 100 most cited articles in fracture surgery and their characteristics in order to determine qualities that make an article in this field highly cited.

Materials and Methods

We used the ISI Web of Science (v5.11, Thomson Reuters, Philadelphia, Pennsylvania) under the topic heading "orthopaedics." There are 49 journals categorized under this subheading. These journals cover all subspecialty areas within orthopedics.[18] These journals include general clinical orthopedic journals, subspecialty-specific journals, physical therapy journals, and basic science journals with content related to bone biology, healing, and metabolism. In May of 2011, we searched the Science Citation Index Expanded for citations to articles published in any of the 49 journals previously described by Lefaivre and colleagues.[17]

Of the 49 journals, 44 are published in English. Each of the 49 journals was searched separately using the "cited reference search," through ISI Web of Knowledge.[17] The top 100 cited fracture surgery articles from the 49 journals were recorded. If there was a question regarding the applicability of the article as a fracture manuscript, 3 authors (KB, SN, DD) reviewed the article to confirm that it was relevant. Our goal was to include articles that orthopedic trauma surgeons would find relevant to their practice, and therefore, we excluded articles on spine fracture management, pediatric fracture articles, limb lengthening, hand fractures distal to the wrist, stress fractures, infection articles not specifically related to fracture surgery, and articles which we considered primarily of interest to the arthroplasty community.

Following the methods of Lefaivre and colleagues,[7] each article in the 100 most cited was reviewed and the follow-

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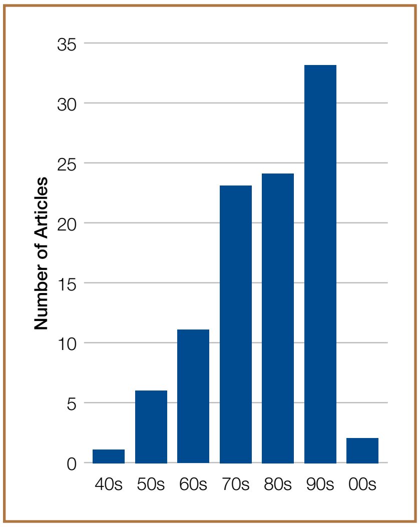

Figure 1. Number of articles in top 100 by decade of publication.

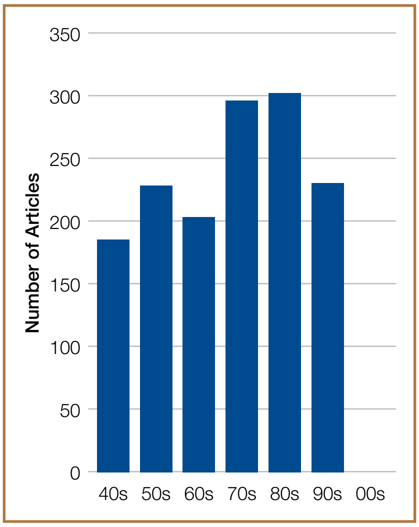

Figure 2. Mean number of articles in top 100 by decade publication.

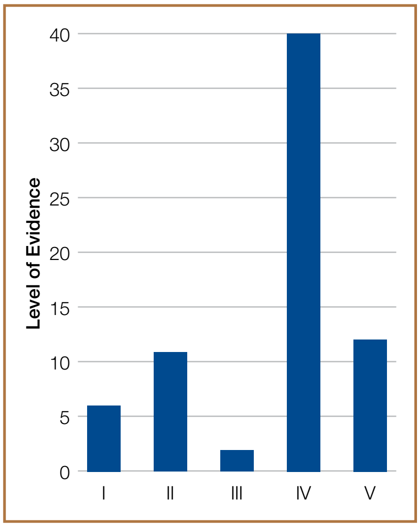

Figure 3. Number of clinical articles by level of evidence.

ing information was recorded: authors, year of publication, source journal of the article, geographic origin of the authors (where there was more than one country of origin, the country of origin was considered that of the first author if not specifically listed), article type (basic science, clinical research), article subtype (basic science, clinical-randomized and non-randomized controlled trials, prospective cohort study, case series, review article, diagnostic studies, cost analyses, case report, or expert opinion), and level of evidence for clinical articles based on guidelines published by *The Journal of Bone and Joint Surgery American Volume*.[19] Review articles were considered expert opinion (level V) unless they were systematically performed. Three authors (KB, SN, DD) reviewed each article independently and determined a level of evidence. Agreement for levels of evidence was excellent[20] interclass correlation coefficient for single measures 0.89 (0.85, 0.92). Any discrepancy between authors was resolved by consensus. All articles were also categorized by topic into one of the following groups: shoulder, humerus, elbow, forearm, distal radius, pelvic ring and acetabulum, hip, femur, knee, tibia and proximal tibia, ankle, foot, basic science, general management, and complications of trauma.

A Spearman's rho was used to test correlations between variables when both variables were continuous. Descriptive statistics and frequencies were calculated. All statistics were performed with SPSS statistical software (Version 16.0; SPSS Inc; Chicago, Illinois).

Results

The number of citations in the top 100 articles ranged from 157 to 1252 (**Table I**). The publication years of the top 100 articles spanned from 1949 to 2005, with the 1990s accounting for the majority of articles (33%) (**Figure 1**). The 2000s had the greatest mean number of citations (306.5) by decade of publication (**Figure 2**). All articles in the top 100 were published in English. The selected articles were published in 9 of the 49 journals, including general and subspecialty journals (**Table II**) with most articles published in the *Journal of Bone and Joint Surgery American Volume* (63/100).

Articles originated from 11 countries. The number of articles by country of origin was led by the United States (n = 69); followed by the United Kingdom (n = 13); Canada (n = 4); Finland and Switzerland (n = 3 each); France and Sweden (n = 2 each), and Brazil, China, the Netherlands, and South Africa (n = 1 each). The top first author was C Neer and O Bostman, with lead authorship in 3 articles in the top 100 list. Several authors (Bone L; Cook S; Cooney W; Einhorn T; Goodship A; Gustilo R; Sarmiento A; and Mubarak S) had 2 lead authorships.

The majority of the papers (66) were clinical, the remainder were basic science (34). The most common type of clinical study was an uncontrolled case series (38) (**Table III**), and the most common level of evidence was IV (40/66; **Figure 3**). The most common subject area of the most cited articles was hip fractures (12), followed by distal radius (9), and general management and complications of trauma (7 each) (**Figure 4**).

There were 7 randomized controlled or pseudo-randomized controlled trials in the top 100 list. Level of evidence was negatively correlated with year of publication (rho value -266; P = .007). Interestingly, level of evidence was not strongly correlated with citation density, or number of.[21] When articles within the top 100 were analyzed by citation density (mean number of citations per year), the BMP-2 Evaluation in Surgery for Tibial Trauma (BESTT) group[21] was the top article (45.5 citations/year), and Gustilo and Andersen[22] (35.7 citations/year) was the second in addition to being the most cited fracture surgery article overall. Citation density increased with increasing decade (**Figure 5**).

Discussion

The number of times an article is cited after publication is only

Table I. **Top 100 Most Cited Fracture Surgery Articlesa**

Rank	Article	Number of Citations/ (Citation Density)
1	Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. *J Bone Joint Surg Am.* 1976;58(4):453-458.	1252 (35.8)
2	Albrektsson T, Bránemark PI, Hansson HA, Lindström J. Osseointegrated titanium implants. Requirements for ensuring a long-lasting, direct bone-to-implant anchorage in man. *Acta Orthop Scand.* 1981;52(2):155-170.	833 (27.8)
3	Younger EM, Chapman MW. Morbidity at bone graft donor sites. *J Orthop Trauma.* 1989;3(3):192-195.	759 (34.5)
4	Neer CS 2nd. Displaced proximal humeral fractures. I. Classification and evaluation. *J Bone Joint Surg Am.* 1970;52(6):1077-1089.	617 (15.0)
5	Yasko AW, Lane JM, Fellinger EJ, Rosen V, Wozney JM, Wang EA. The healing of segmental bone defects, induced by recombinant human bone morphogenetic protein (rhBMP-2). A radiographic, histological, and biomechanical study in rats. *J Bone Joint Surg Am.* 1992;74(5):659-670.	520 (27.4)
6	McKibbin B. The biology of fracture healing in long bones. *J Bone Joint Surg Br.* 1978;60-B(2):150-162.	481 (14.6)
7	Knirk JL, Jupiter JB. Intraarticular fractures of the distal end of the radius in young adults. *J Bone Joint Surg Am.* 1986;68(5):647-659.	420 (16.8)
8	Goodship AE, Kenwright J. The influence of induced micromovement upon the healing of experimental tibial fractures. *J Bone Joint Surg Br.* 1985;67(4):650-655.	414 (15.9)
9	Winquist RA, Hansen ST Jr, Clawson DK. Closed intramedullary nailing of femoral fractures. A report of five hundred and twenty cases. *J Bone Joint Surg Am.* 1984;66(4):529-539.	412 (15.3)
10	Govender S, Csimma C, Genant HK, et al. Recombinant human bone morphogenetic protein-2 for treatment of open tibial fractures: a prospective, controlled, randomized study of four hundred and fifty patients. *J Bone Joint Surg Am.* 2002;84A(12):2123-2134.	410 (45.6)
11	Gartland JJ Jr, Werley CW. Evaluation of healed Colles' fractures. *J Bone Joint Surg Am.* 1951;33-A(4):895-907.	397 (6.6)
12	Heckman JD, Ryaby JP, McCabe J, Frey JJ, Kilcoyne RF. Acceleration of tibial fracture-healing by non-invasive, low-intensity pulsed ultrasound. *J Bone Joint Surg Am.* 1995;76(1):26-34.	362 (21.3)
13	Neer CS 2nd. Displaced proximal humeral fractures. I. Classification and evaluation. *J Bone Joint Surg Am.* 1970;52(6):1077-1089.	337 (8.2)
14	Bone LB, Johnson KD, Weigelt J, Scheinberg R. Early versus delayed stabilization of femoral fractures. A prospective randomized study. *J Bone Joint Surg Am.* 1989;71(3):336-340.	323 (14.7)
15	Matsen FA, Winquist RA, Krugmire RB. Diagnosis and management of compartmental syndromes. *J Bone Joint Surg Am.* 1980;62(2):286-291.	313 (10.1)
16	Tile M. Pelvic ring fractures: should they be fixed?. *J Bone Joint Surg Br.* 1988;70(1):1-12.	311 (13.5)
17	Lieberman JR, Daluiski A, Stevenson S, et al. The effect of regional gene therapy with bone morphogenetic protein-2-producing bone-marrow cells on the repair of segmental femoral defects in rats. *J Bone Joint Surg Am.* 1999;81(7):905-917.	310 (25.8)
18*	Bonnarens F, Einhorn TA. Production of a standard closed fracture in laboratory animal bone. *J Orthop Res.* 1984;2(1):97-101.	306 (11.3)
	Böstman O, Hirvensalo E, Mäkinen J, Rokkanen P. Foreign-body reactions to fracture fixation implants of biodegradable synthetic polymers. *J Bone Joint Surg Br.* 1990;72(4):592-596.	306 (14.6)
20	Böstman OM. Absorbably impants for the fixation of fractures. *J Bone Joint Surg Am.* 1991;73(1):148-153.	305 (15.3)
21*	Barnes R, Brown JT, Garden RS, Nicoll EA. Subcapital fractures of the femur. A prospective review. *J Bone Joint Surg Br.* 1976;58(1):2-24.	304 (8.7)
	Cooney WP, Dobyns JH, Linscheid RL. Complications of Colles' fractures. *J Bone Joint Surg Am.* 1980;62(4):613-619.	304 (9.8)
23	Judet R, Judet J, Letournel E. Fractures of the acetabulum: classification and surgical approaches for open reduction. Preliminary report. *J Bone Joint Surg Am.* 1964;46:1615-1646.	294 (6.3)
24	Einhorn TA. Enhancement of fracture-healing. *J Bone Joint Surg Am.* 1995;77(6):940-956.	290 (18.1)
25	Miller CW. Survival and ambulation following hip fracture. *J Bone Joint Surg Am.* 1978;60(7):930-934.	280 (8.5)
26	Rubin CT, Lanyon LE. Kappa Delta Award paper. Osteoregulatory nature of mechanical stimuli: function as a determinant for adaptive remodeling in bone. *J Orthop Res.*1987;5(2):300-310.	278 (11.6)
27	Goodship AE, Lanyon LE, McFie H. Functional adaptation of bone to increased stress. An experimental study. *J Bone Joint Surg Am.* 1979;61(4):539-546.	275 (8.6)
28*	Cook SD, Baffes GC, Wolfe MW, Sampath TK, Rueger DC, Whitecloud TS 3rd. The effect of recombinant human osteogenic protein-1 on healing of large segmental bone defects. *J Bone Joint Surg Am.* 1994;76(6):827-838.	273 (16.1)
	Matta JM. Fractures of the acetabulum: accuracy of reduction and clinical results in patients managed operatively within three weeks after the injury. *J Bone Joint Surg Am.* 1996;78(11):1632-1645.	273 (18.2)
30	Mubarak SJ, Owen CA, Hargens AR,Garetto LP, Akeson WH. Acute compartment syndromes: diagnosis and treatment with the aid of the wick catheter. *J Bone Joint Surg Am.* 1978;60(8):1091-1095.	268 (8.1)
	Mubarak SJ, Hargens AR, Owen CA, Garetto LP, Akeson WH. The wick catheter technique for measurement of intramuscular pressure. A new research and clinical tool. *J Bone Joint Surg Am.* 1976;58(7):1016-1020.	262 (7.5)
32	Kempf I, Grosse A, Beck G. Closed locked intramedullary nailing. Its application to comminuted fractures of the femur. *J Bone Joint Surg Am.* 1985;67(5):709-720.	255 (9.8)
33	Rowe CR. Prognosis in dislcoations of the shoulder. *J Bone Joint Surg Am.* 1956;38(5):957-977.	252 (4.6)
34*	Nicoll EA. Fractures of the tibial shaft. A survey of 705 cases. *J Bone Joint Surg Br.* 1964;46(3):373-387.	248 (5.3)
	Rhinelan.Fw. The normal microcirculation of diaphyseal cortex and its response to fracture. *J Bone Joint Surg Am.* 1968;50(4):784-800.	248 (5.8)

Table I continues on the next page

Rank	Article	Number of Citations/ (Citation Density)
36	Lu-Yao GL, Keller RB, Littenberg B, Wennberg JE. Outcomes after displaced fractures of the femoral neck. A meta-analysis of one hundred and six published reports. *J Bone Joint Surg Am.* 1994;76(1):15-25.	245 (14.4)
37	Uhthoff HK, Jaworski ZF. Bone loss in response to long-term immobilisation. *J Bone Joint Surg Br.* 1978;60(3):420-429.	238 (7.2)
38	Gerhart TN, Kirkerhead CA, Kriz MJ, Holtrop ME, Hennig GE, Hipp J, et al. Healing segmental femoral defects in sheep using recombinant human bone morphogenetic protein. *Clin Orthop Relat Res.* 1993;(293):317-326.	235 (13.1)
39*	Kristiansen TK, Ryaby JP, McCabe J, Frey JJ, Roe LR. Accelerated healing of distal radial fractures with the use of specific, low-intensity ultrasound. A multicenter, prospective, randomized, double-blind, placebo-controlled study. *J Bone Joint Surg Am.* 1997;79(7):961-973.	234 (16.7)
	Sanders R, Fortin P, Dipasquale T, Walling A. Operative treatment in 120 displaced intraarticular calcaneal fractures. Results using a prognostic computed tomography scan classification. *Clin Orthop.* 1993;(290):87-95.	234 (13.0)
41	Cummings SR, Rubin SM, Black D. The future of hip fractures in the United States. Numbers, costs, and potential effects of post-menopausal estrogen. *Clin Orthop.* 1990;(252):163-166.	232 (11.0)
42	Gustilo RB, Merkow RL, Templeman D. The management of open fractures. *J Bone Joint Surg Am.* 1990;72(2):299-304.	229 (10.9)
43	Evans EB, Eggers GWN, Butler JK, Blumel J. Experimental immobilization and remobilization of rat knee joints. *J Bone Joint Surg Am.* 1960;42(5):737-758.	224 (4.4)
44	Bassett CAL, Mitchell SN, Gaston SR. Treatment of ununited tibial diaphyseal fractures with pulsing electromagnetic fields. *J Bone Joint Surg Am.* 1981;63(4):511-523.	216 (7.2)
45*	Allman FL Jr. Fractures and ligamentous injuries of the clavicle and its articulation. *J Bone Joint Surg Am.*1967;49(4):774-784.	215 (4.9)
	Broberg MA, Morrey BF. Results of delayed excision of the radial head after fracture. *J Bone Joint Surg Am.* 1986;68(5):669-674.	215 (8.6)
	Cook SD, Baffes GC, Wolfe MW, Sampath TK, Rueger DC. Recombinant human bone morphogenetic protein=7 induces healing in a canine long-bone segmental defect model. *Clin Orthop.* 1994;(301):302-12.	215 (12.6)
48	White BL, Fisher WD, Laurin CA. Rate of mortality for elderly patients after hip fracture of the hip in the 1980s. *J Bone Joint Surg Am.* 1987;69(9):1335-1340.	212 (8.8)
49	Tonino AJ, Davidson CL, Klopper PJ, Linclau LA. Protection from stress in bone and its effects. Experiments with stainless steel and plastic platesin dogs. *J Bone Joint Surg Br.* 1976;58(1):107-113.	211 (6.0)
50*	Bostrom MPG, Lane JM, Berberian WS, Missri AAE, Tomin E, Weiland A, et al. Immunolocalization and expression of bone morphogenetic proteins 2 and 4 in fracture healing. *J Orthop Res.* 1995;13(3):357-367.	210 (13.1)
	Patzakis MJ, Harvey JP Jr, Ivler D. The role of antibiotics in the management of open fractures. *J Bone Joint Surg Am.* 1974;56(3):532-541.	210 (5.7)
52	Joyce ME, Jingushi S, Bolander ME. Transforming growth factor-beta in the regulation of fracture repair. *Orthop Clin North Am.* 1990;21(1):199-209.	209 (10.0)
53	McCalden RW, McGeough JA, Barker MB, Courtbrown CM. Age-related changes in the tensile properties of cortical bone. The relative importance of changes in porosity, mineralization, and microstructure. *J Bone Joint Surg Am.* 1993;75(8):1193-1205.	206 (11.4)
54	Duarte LR. The stimulation of bone growth by ultrasound. *Arch Orthop Trauma Surg.* 1983;101(3):153-159.	204 (7.3)
55	Keel M, Trentz O. Pathophysiology of polytrauma. *Injury.* 2005;36(6):691-709.	203 (33.8)
56	Sarmiento A, Pratt GW, Berry NC, Sinclair WF. Colles' fractures. Functional bracing in supination. *J Bone Joint Surg Am.* 1975;57(3):311-317.	200 (5.6)
57	Ramsey PL, Hamilton W. Changes in tibiotalar area of contact caused by lateral talar shift. *J Bone Joint Surg Am.* 1976;58(3):356-357.	198 (5.7)
58	Holmes RE, Bucholz RW, Mooney V. Porous hydroxyapatite as a bone-graft substitute in metaphyseal defects. A histometric study. *J Bone Joint Surg Am.* 1986;68(6):904-911.	197 (7.9)
59	Thompson VP, Epstein HC. Traumatic dislocation of the hip: A survey of two hundred and four cases covering a period of twenty-one years. *J Bone Joint Surg Am.* 1951;33:746-792.	194 (3.2)
60*	Ciarelli MJ, Goldstein SA, Kuhn JL, Cody DD, Brown MB. Evaluation of orthogonal mechanical properties and density of human trabecular bone from the major metaphyseal regions with materials testing and computed tomography. *J Orthop Res.* 1991;9(5):674-682.	192 (9.6)
	Einhorn TA, Lane JM, Burstein AH, Kopman CR, Vigorita VJ. The healing of segmental bone defects induced by demineralized bone matrix. A radiographic biomechanical study. *J Bone Joint Surg Am.* 1984;66(2):274-279.	192 (7.1)
62*	Bradway JK, Amadio PC, Cooney WP. Open reduction and internal fixation of displaced, comminuted intra-articular fractures of the distal end of the radius. *J Bone Joint Surg Am.* 1989;71(6):839-847.	190 (8.6)
	Schatzker J, McBroom R. The tibial plateau fracture. The Toronto experience 1968—1975. *Clin Orthop.* 1979;(138):94-104.	190 (5.9)
64	Yang KH, Parvizi J, Wang SJ, Lewallen DG, Kinnick RR, Greenleaf JF, et al. Exposure to low-intensity ultrasound increases aggrecan gene expression in a rat femur fracture model. *J Orthop Res.* 1996;14(5):802-809.	189 (12.6)
65	Bridle SH, Patel AD, Bircher M, Calvert PT. Fixation of intertrochanteric fractures of the femur. A randomized prospective comparison of the gamma nail and the dynamic hip screw. *J Bone Joint Surg Br.* 1991;73(2):330-334.	187 (9.4)
66*	Caudle RJ, Stern PJ. Severe open fractures of the tibia. *J Bone Joint Surg Am.* 1987;69(6):801-807.	186 (7.8)
	Pilla AA, Mont MA, Nasser PR, et al. Non-invasive low-intensity pulsed ultrasound accelerates bone healing in the rabbit. *J Orthop Trauma.* 1990;4(3):246-253.	186 (8.9)

*Two or more citations tied for the same rank.
Table I (ranks 67-100) continues online, see "100 Most Cited Articles in Fracture Surgery."

Table I. Top 100 Most Cited Fracture Surgery Articlesa

Rank	Article	Number of Citations/ (Citation Density)
	Whitesides TE, Haney TC, Morimoto K, Harada H. Tissue pressure measurements as a determinant for the need of fasciotomy. *Clin Orthop.* 1975;(113):43-51.	186 (5.2)
69*	Evans EM. The treatment of trochanteric fractures of the femur. *J Bone Joint Surg Br.* 1949;31B(2):190-203.	184 (3.0)
	Hawkins LG. Fractures of the neck of the talus. *J Bone Joint Surg Am.* 1970;52(5):991-1002.	184 (4.5)
	Stewart MJ, Milford LW. Fracture-dislocation of the hip; an end-result study. *J Bone Joint Surg Am.* 1954;36(A:2):315-342.	184 (3.2)
72*	Böstman OM. Osteolytic changes accompanying degredation of absorbable fracture fixation impants. *J Bone Joint Surg Br.* 1991;73(4):679-682.	183 (9.2)
	Wang SJ, Lewallen DG, Bolander ME, Chao EYS, Ilstrup DM, Greenleaf JF. Low intensity ultrasound treatment increases strength in a rat femoral fracture model. *J Orthop Res.* 1994;12(1):40-47.	183 (10.8)
74*	McQueen M, Caspers J. Colles fracture: does the anatomical result affect the final function?. *J Bone Joint Surg Br.* 1988;70(4):649-651.	182 (7.9)
	Peltier LF. Complications associated with fractures of the pelvis. *J Bone Joint Surg Am.* 1965;47(5):1060-1069.	182 (4.0)
76*	Bacorn RW, Kurtzke JF. Colles' Fracture A stuy of two thousand cases from the New York State Workmen's Compensation Board. *J Bone Joint Surg Am.* 1953;35(3):643-658.	181 (3.1)
	Goshima J, Goldberg VM, Caplan AI. The ostoegenic potential of culture-expanded rat marrow mesenchymal cells assayed in vivo in calcium phosphate ceramic blocks. *Clin Orthop.* 1991;(262):298-311.	181 (9.1)
78	Baumgaertner MR, Curtin SL, Lindskog DM, Keggi JM. The value of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip. *J Bone Joint Surg Am.* 1995;77(7):1058-1064.	180 (11.3)
79*	Court-Brown CM, Christie J, McQueen MM. Closed intramedullary tibial nailing. Its use in closed and type I open fractures. *J Bone Joint Surg Br.* 1990;72(4):605-611.	179 (8.5)
	Leung KS, So WS, Shen WY, Hui PW. Gamma nails and dynamic hip screws for peritrochanteric fractures. A randomized prospective study in elderly patients. *J Bone Joint Surg Br.* 1992;74(3):345-351.	179 (9.4)
	Zuckerman JD, Skovron ML, Koval KJ, Aharonoff G, Frankel VK. Postoperative complications and mortality associated with operative delay in older patients who have a fracture of the hip. *J Bone Joint Surg Am.* 1995;77(10):1551-1556.	179 (11.2)
82*	Sidor ML, Zuckerman JD, Lyon T, Koval K, Cuomo F, Schoenberg N. The Neer classification system for the proximal humeral fractures. An assessment of interobserver reliability and intraobserver reproducibility. *J Bone Joint Surg Am.* 1993;75(12):1745-1750.	178 (9.9)
	Siebenrock KA, Gerber C. The reproducibility of classification of fractures of the proximal end of the humerus. *J Bone Joint Surg Am.* 1993;75(12):1751-1755.	178 (9.9)
84*	Harrington KD, Sim FH, Enis JE, Johnston JO, Dick HM, Gristina AG. Methylmethacrylate as an adjunct in internal fixation of pathological fractures. Experience with three hundred and seventy-five cases. *J Bone Joint Surg Am.* 1976;58(8):1047-1055.	177 (5.1)
	Newton-John HF, Morgan DB. The loss of bone with age, osteoporosis, and fractures. *Clin Orthop.* 1970;71:229-252.	177 (4.3)
86	Repo RU, Finlay JB. Survival of articular cartilage after controlled impact. *J Bone Joint Surg Am.* 1977;59(8):1068-1076.	176 (5.1)
87	Denis F, Davis S, Comfort T. Sacral fractures: an important problem. Retrospective analysis of 236 cases. *Clin Orthop.* 1988;(227):67-81.	175 (7.6)
88	Boyd RJ, Burke JF, Colton T. A double-blind clinical trial of prophylactic antibiotics in hip fractures. *J Bone Joint Surg Am.* 1973;55(6):1251-1258.	174 (4.6)
89*	Bone LB, Johnson KD. Treatment of tibial fractures by reaming and intramedullary nailing. *J Bone Joint Surg Am.* 1986;68(6):877-887.	171 (6.8)
	Klein MP, Rahn BA, Frigg R, Kessler S, Perren SM. Reaming versus non-reaming in medullary nailing: interference with cortical circulation of the canine tibia. *Arch Orthop Trauma Surg.* 1990;109(6):314-316.	171 (8.1)
91	Urist MR, Dowell TA, Hay PH, Strates BS. Inductive substrates for bone formation. *Clin Orthop.* 1968;59:59-96.	170 (4.0)
92	Alffram PA, Bauer GC. Epidemiology of fractures of the forearm. A biomechnical investigation of bone strength. *J Bone Joint Surg Am.* 1962;44-A:105-114.	169 (3.4)
93	Lotz JC, Hayes WC. The use of quantitative computed tomography to estimate risk of fracture of the hip from falls. *J Bone Joint Surg Am.* 1990;72(5):689-700.	168 (8.0)
94	Reddi AH, Wientroub S, Muthukumaran N. Biologic principles of bone induction. *Orthop Clin North Am.* 1987;18(2):207-212.	167 (7.0)
95	Cooney WP 3rd, Linscheid RL, Dobyns JH. External pin fixation for unstable Colles' fractures. *J Bone Joint Surg Am.* 1979;61(6):840-845.	166 (5.2)
96	Neer CS, Grantham SA, Shelton ML. Supracondylar fracture of the adult femur a study of one hundred and ten cases. *J Bone Joint Surg Am.* 1967;49(4):591-613.	164 (3.7)
97	Kennedy JC. Complete dislocation of the knee joint. *Can Med Assoc J.* 1963;45(5):889-904.	163 (3.4)
98	Johnson JTH. Neuropathic fractures and joint injuries pathogenesis and rationale of prevention and treatment. *J Bone Joint Surg Am.* 1967;49(1):1-30.	160 (3.6)
99*	McLaughlin HL. Posterior dislocation of the shoulder. *J Bone Joint Surg Am.* 1952;34(3):584-590.	159 (2.7)
	Sarmiento A, Schaeffer JF, Beckerman L, Latta LL, Enis JE. Fracture healing in rat femora as affected by functional weight-bearing. *J Bone Joint Surg Am.* 1977;59(3):369-375.	159 (4.6)

* Two or more citations tied for the same rank.

one measure of its importance. The ranking of the 100 most cited fracture articles is by no means an exclusive list of all publications, which have had an impact on fracture surgery. Many of the top 100 articles provide historical perspective or grew out of "hot trends" that were present in years past. However, few would debate the ongoing value of the Gustilo and Andersen[22] series on open fractures or Neer's classic paper[4] on proximal humerus fractures. Manuscripts like these are timeless, as indicated by the fact that they are among the most cited in fracture surgery and that they continue to be highly cited even today. Interestingly, many of the more recent top cited articles are a higher level of evidence than those in the past. This suggests that the field of fracture surgery is moving in the direction of more rigorous investigation.

Additionally, demographics of the top 100 articles were analyzed. The rationale for this analysis was to determine which articles have the potential to become important in fracture surgery and lay foundation for future work. The vast majority of articles in our top 100 originated in the United States. This is consistent with previous manuscripts in anesthesia,[3] plastic surgery,[9] general surgery,[12] and Lefaivre and colleagues' previous orthopedic work[7] indicating that authors from this region may be at an advantage in either funding or authorship access to highly cited journals. About one-third of the manuscripts were published in the last 2 decades. This is impressive considering these articles had less time to accumulate citations and further suggests that fracture surgery research is a fast moving investigative field. The majority (63%) of the fracture related works were published in the *Journal of Bone and Joint Surgery American Volume.* This is not surprising, since fracture surgery constitutes a part of almost every orthopedic surgeon's practice, and the *Journal of Bone and Joint Surgery* is the most widely read orthopedic journal. Additionally, the majority of articles (40%) were level IV evidence. This will likely change with the ever-growing focus on evidence-based medicine and increased focus on level of evidence within the field. We expect that with time, studies with higher levels of evidence will supplant "classic" articles currently in the top 100.

Finally, we also considered citation density, which we defined as number of citations per year. We believe this method helps to equalize the current impact of the cited article on the field. It is possible that there are articles with a higher density, which are not included in our top 100 list. However, our goal was more to identify "classic" fracture surgery articles rather than identify ones, which have the most impact on the current literature.

This study is not without its limitations. First, selecting 100 as the number of articles to list is arbitrary. There are important and influential articles that were undoubtedly excluded; however, any number of articles would be equally

Table II. Number of Articles by Source Journal

Journal of Bone and Joint Surgery - American	63
Journal of Bone and Joint Surgery - British	13
Clinical Orthopaedics and Related Research	10
Journal of Orthopedic Research	6
Journal of Orthopedic Trauma	2
Orthopedic Clinics of North America	2
Archives of Orthopedic and Trauma Surgery	2
Acta Orthopaedica Scandinavica	1
Injury	1

Table III. Clinical Articles Classified by Study Type

Randomized/Quasi Randomized Controlled Trial	7
Cohort Study	7
Case Series	39
Expert Opinion/Review	12
Basic Science	30
Cost Analysis	1
Diagnostic Study	4

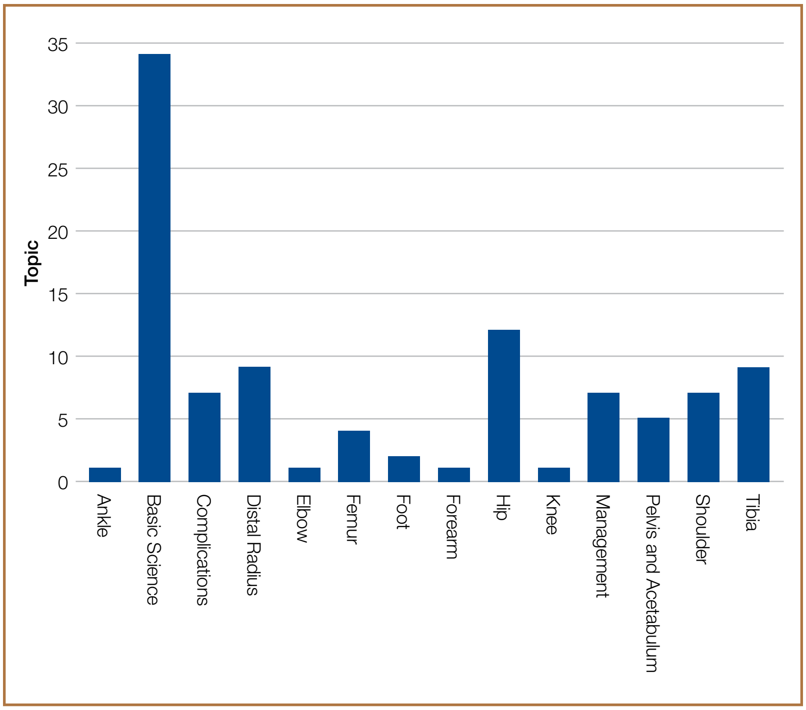

Figure 4. Classification of articles on the top 100 list by topic.

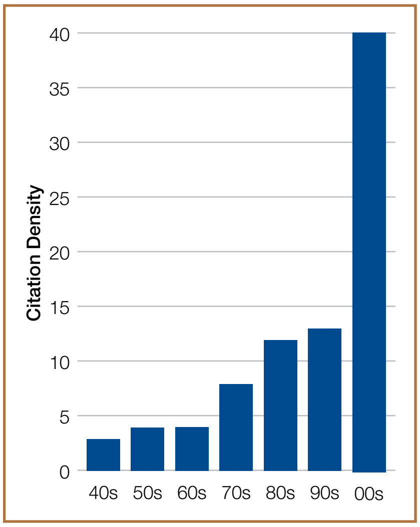

Figure 5. Citation density by decade in the top 100.

arbitrary. Second, total number of citations or citation density can be influenced by a number of factors. We did not consider author self-citations, and so, high-volume authors may be more likely to cite their own work and thereby increase their overall number of citations. Similarly, authors may be more likely to cite articles in journals in which they seek publication; this is a source of bias that we are unable to control. Furthermore, our search included 49 journals categorized under the topic heading of "orthopaedics" in Web of Science, of which 44 journals were written in English; and so, there may be additional articles and/or citations in journals that we were unable to evaluate. In the same vein, we are unable to determine citations in textbooks, lectures, or other web-based resources. Third, as has been discussed, the variable of time is important when considering the overall number of citations with older articles having a clear advantage. Last, no classification is perfect. We used 3 reviewers and compared their agreement on important factors such as which articles to include, what the article level of evidence was, and what type of study the article constituted. Finally, as noted by Lefaivre and colleagues,[7] certain theories have more traction in the medical community than others, thus resulting in a greater momentum in terms of future publications or citations (Kuhnian philosophy).[23] This philosophy notes that an article may be cited merely because it is highly cited, not through any inherent quality of the work itself. Although this is an interesting concept, which is probably applicable in some cases, it is not quantifiable. As the goal of our study was to utilize total number of citations as a means of creating a list of highly–influential fracture surgery articles, we do not believe that these limitations significantly influence our list.

Despite these limitations, citation number-based identification of important papers will help current practitioners gain insight into past and current trends in their respective fields and provides the foundation for further investigations. Going forward, our field should actively discuss and develop systems to better measure the impact of published articles to the science and practice of our field.

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An accompanying commentary by Peter D. McCann, MD is available online. See, "100 Most Cited Articles in Fracture Surgery."