

THE ORTHOPAEDIC FORUM

The Hundred Most-Cited Publications in Orthopaedic Knee Research

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Background: Despite its limitations, citation analysis remains one of the best currently available tools for quantifying the impact of articles. Bibliometric studies list the “best-sellers” in a single location, and they have been published frequently in many fields during recent years. The purpose of the present study was to report the qualities and characteristics of citation classics in orthopaedic knee research.

Methods: The database of the Institute for Scientific Information (ISI) was utilized for identification of articles published from 1945 to March 2014. All knee articles that had been published in sixty-five orthopaedic and twenty-nine rheumatology journals and that had been cited at least 200 times were identified. The top 100 were selected for further analysis of authorship, source journal, number of citations, citation rate (both since publication and in 2013), geographic origin, article type, and level of evidence.

Results: The publication dates of the 100 most-cited articles ranged from 1948 to 2007, with the greatest number of articles published in the 1980s. Citations per article ranged from 2640 to 287. All articles were published in eleven of the ninety-four journals. The leading countries of origin were the U.S. followed by the U.K. and Sweden. The two main focus areas were sports traumatology and degenerative disease. The number of citations per article was also greatest for articles published in the 1980s. Basic research articles were cited more quickly, but not more often, than clinical articles. Most articles represented Level-IV evidence, followed by Levels II, III, and I.

Conclusions: This bibliometric study is likely to include a list of intellectual milestones in orthopaedic knee research. It is apparent that a high level of evidence is not mandatory for an article to gain a large number of citations. Bibliometric reports provide a reflection of the quality of cited research published in a specific field and should therefore provoke thinking within the scientific community.

Peer Review: This article was reviewed by the Editor-in-Chief and one Deputy Editor, and it underwent blinded review by two or more outside experts. The Deputy Editor reviewed each revision of the article, and it underwent a final review by the Editor-in-Chief prior to publication. Final corrections and clarifications occurred during one or more exchanges between the author(s) and copyeditors.

Disclosure: None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. None of the authors, or their institution(s), have had any financial relationship, in the thirty-six months prior to submission of this work, with any entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. Also, no author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete **Disclosures of Potential Conflicts of Interest** submitted by authors are always provided with the online version of the article.

Among the various reasons for scientific writing and publishing in many academic medical fields, egotistic motives may dominate over altruistic ones. Alongside the pleasure of seeing one's name on an article is that of seeing it being quoted by others. Authors of articles also indicate the value of prior articles by citing them as references. When an article in a particular field gathers a greater number of citations, that reflects the authors' creativity and the article's impact in the specialty field^{1,2}. The satisfaction of authorship and the pleasure of being quoted are among the rewards of enriching the scientific literature³.

Bibliometric science is statistical and quantitative analysis with the aim of analyzing the scholarly impact and characteristics of publications within a research field. Bibliometric studies fall into the category of systematic reviews and usually appear with titles that attract readers by indicating that they provide the "best-sellers" in a single location. Since Eugene Garfield, the founder of bibliometrics and scientometrics, published the first bibliometric article for *JAMA* (*The Journal of the American Medical Association*) in 1987, a tradition of publishing such articles has evolved. These articles have traditionally been published in general or specialty journals^{1,4,5}, and more recently they have also been appearing in journals with a subspecialty, technique, or even disease-oriented focus⁶⁻¹⁰. The latter is of interest in the era of rising subspecialty communities; the capacity for noting practice-impacting articles and authors increases as the topic becomes more specific.

Bibliometric articles represent a snapshot that provides a cross-sectional view of the current state of the topic;

the process of publishing is continuous and high-quality practice-impacting articles are constantly being produced; therefore, bibliometric articles have a limited half-life that will vary depending on the publishing activity in the particular field. Even groundbreaking discoveries are surpassed by new knowledge.

Information from the Institute for Scientific Information (ISI) has been utilized in many studies as a reliable tool to provide accurate citation information for articles published since 1945. Information is provided in a database that can be accessed electronically via an Internet platform, the Web of Knowledge (Thomson Reuters)¹¹.

Since the first attempts to surgically treat knee osteoarthritis more than a century and a half ago¹², the field of knee surgery has expanded greatly, particularly with milestones in the treatment of degenerative disease and the introduction of arthroscopic and joint-preserving surgery. Bibliometric studies for several orthopaedic fields have been published recently. The aim of the present study was to provide an analysis of the most frequently cited articles in orthopaedic knee research, allowing for a better understanding of the qualities of citation classics as well as highlighting major intellectual milestones in the field of knee research.

Materials and Methods

The ISI Web of Knowledge databases (specifically the Web of Science core collection, BIOSIS previews, MEDLINE, and SciELO Citation Index) were utilized to generate a categorical listing of orthopaedic and rheumatology journals. Rheumatology journals were included to cover a wider range of

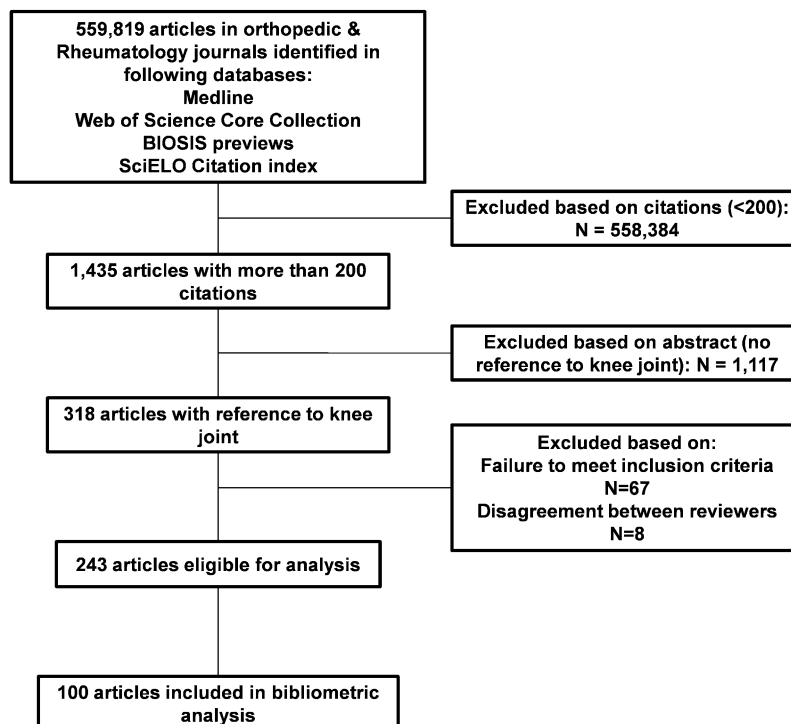


Fig. 1

Flowchart showing the identification of relevant articles.

TABLE I The 100 Most-Cited Articles in Orthopaedic Knee Research

Rank	Article	Citations	Citations/Year Since Publication	Citations in 2013
1	Altman R, Asch E, Bloch D, Bole G, Borenstein D, Brandt K, Christy W, Cooke TD, Greenwald R, Hochberg M, Howell D, Kaplan D, Koopman W, Longley S, Mankin H, McShane DJ, Medsger T, Meenan R, Mikkelsen W, Moskowitz R, Murphy W, Rothschild B, Segal M, Sokoloff L, Wolfe F. Development of criteria for the classification and reporting of osteoarthritis. Classification of osteoarthritis of the knee. Diagnostic and Therapeutic Criteria Committee of the American Rheumatism Association. <i>Arthritis and Rheumatism</i> . 1986;29(8):1039-49	2640	100	212
2	Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. <i>Clinical Orthopaedics and Related Research</i> . 1989 Nov;248:13-4	1677	67	187
3	Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. <i>Clinical Orthopaedics and Related Research</i> . 1985 Sep;198:43-9	1187	41	132
4	Outerbridge RE. The etiology of chondromalacia patellae. <i>Journal of Bone and Joint Surgery, British Volume</i> . 1961 Nov;43:752-7	1051	20	82
5	Lysholm J, Gillquist J. Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. <i>American Journal of Sports Medicine</i> . 1982 May-Jun;10(3):150-4	986	31	60
6	Wakitani S, Goto T, Pineda SJ, Young RG, Mansour JM, Caplan AI, Goldberg VM. Mesenchymal cell-based repair of large, full-thickness defects of articular cartilage. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1994 Apr;76(4):579-92	862	43	41
7	Fairbank TJ. Knee joint changes after meniscectomy. <i>Journal of Bone and Joint Surgery, British Volume</i> . 1948 Nov;30(4):664-70	823	13	39
8	Kadaba MP, Ramakrishnan HK, Wootten ME. Measurement of lower extremity kinematics during level walking. <i>Journal of Orthopaedic Research</i> . 1990 May;8(3):383-92	798	33	93
9	Hunziker EB. Articular cartilage repair: basic science and clinical progress. A review of the current status and prospects. <i>Osteoarthritis and Cartilage</i> . 2002 Jun;10(6):432-63	772	64	71
10	Ewald FC. The Knee Society total knee arthroplasty roentgenographic evaluation and scoring system. <i>Clinical Orthopaedics and Related Research</i> . 1989 Nov;248:9-12	717	30	64
11	Peterson L, Minas T, Brittberg M, Nilsson A, Sjögren-Jansson E, Lindahl A. Two- to 9-year outcome after autologous chondrocyte transplantation of the knee. <i>Clinical Orthopaedics and Related Research</i> . 2000 May;374:212-34	710	51	32
12	Jordan KM, Arden NK, Doherty M, Bannwarth B, Bijlsma JW, Dieppe P, Gunther K, Hauselmann H, Herrero-Beaumont G, Kaklamanis P, Lohmander S, Leeb B, Lequesne M, Mazieres B, Martin-Mola E, Pavelka K, Pendleton A, Punzi L, Serni U, Swoboda B, Verbruggen G, Zimmerman-Gorska I, Dougados M; Standing Committee for International Clinical Studies Including Therapeutic Trials ESCISIT. EULAR recommendations 2003: an evidence based approach to the management of knee osteoarthritis: report of a Task Force of the Standing Committee for International Clinical Studies Including Therapeutic Trials (ESCISIT). <i>Annals of the Rheumatic Diseases</i> . 2003 Dec;62(12):1145-55	697	63	68
13	Felson DT, Naimark A, Anderson J, Kazis L, Castelli W, Meenan RF. The prevalence of knee osteoarthritis in the elderly. The Framingham Osteoarthritis Study. <i>Arthritis and Rheumatism</i> . 1987 Aug;30(8):914-8	668	25	33
14	Noyes FR, Butler DL, Grood ES, Zernicke RF, Hefzy MS. Biomechanical analysis of human ligament grafts used in knee-ligament repairs and reconstructions. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1984 Mar;66(3):344-52	651	22	24
15	Arendt E, Dick R. Knee injury patterns among men and women in collegiate basketball and soccer. NCAA data and review of literature. <i>American Journal of Sports Medicine</i> . 1995 Nov-Dec;23(6):694-701	641	34	36
16	Mankin HJ. The response of articular cartilage to mechanical injury. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1982 Mar;64(3):460-6	635	20	23

continued

TABLE I (continued)

Rank	Article	Citations	Citations/Year Since Publication	Citations in 2013
17	Shapiro F, Koide S, Glimcher MJ. Cell origin and differentiation in the repair of full-thickness defects of articular cartilage. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1993 Apr;75(4):532-53	633	30	42
18	Daniel DM, Stone ML, Dobson BE, Fithian DC, Rossman DJ, Kaufman KR. Fate of the ACL-injured patient. A prospective outcome study. <i>American Journal of Sports Medicine</i> . 1994 Sep-Oct;22(5):632-44	595	30	38
19	Bartel DL, Bicknell VL, Wright TM. The effect of conformity, thickness, and material on stresses in ultra-high molecular weight components for total joint replacement. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1986 Sep;68(7):1041-51	580	21	22
20	Insall JN, Ranawat CS, Aglietti P, Shine J. A comparison of four models of total knee-replacement prostheses. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1976 Sep;58(6):754-65	578	21	19
21	Butler DL, Noyes FR, Grood ES. Ligamentous restraints to anterior-posterior drawer in the human knee. A biomechanical study. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1980 Mar;62(2):259-70	565	17	20
22	Salter RB, Simmonds DF, Malcolm BW, Rumble EJ, MacMichael D, Clements ND. The biological effect of continuous passive motion on the healing of full-thickness defects in articular cartilage. An experimental investigation in the rabbit. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1980 Dec;62(8):1232-51	552	16	9
23	Shelbourne KD, Nitz P. Accelerated rehabilitation after anterior cruciate ligament reconstruction. <i>American Journal of Sports Medicine</i> . 1990 May-Jun;18(3):292-9	546	23	14
24	Rodeo SA, Arnoczky SP, Torzilli PA, Hidaka C, Warren RF. Tendon-healing in a bone tunnel. A biomechanical and histological study in the dog. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1993 Dec;75(12):1795-803	545	26	35
25	Hewett TE, Lindenfeld TN, Riccobene JV, Noyes FR. The effect of neuromuscular training on the incidence of knee injury in female athletes. A prospective study. <i>American Journal of Sports Medicine</i> . 1999 Nov-Dec;27(6):699-706	537	36	56
26	Hewett TE, Myer GD, Ford KR, Heidt RS Jr, Colosimo AJ, McLean SG, van den Bogert AJ, Paterno MV, Succop P. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study. <i>American Journal of Sports Medicine</i> . 2005 Apr;33(4):492-501. Epub 2005 Feb 8	529	59	56
27	Noyes FR, Moar PA, Matthews DS, Butler DL. The symptomatic anterior cruciate-deficient knee. Part I: the long-term functional disability in athletically active individuals. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1983 Feb;65(2):154-62	506	16	11
28	Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynon BD. Knee injury and Osteoarthritis Outcome Score (KOOS)—development of a self-administered outcome measure. <i>Journal of Orthopaedic & Sports Physical Therapy</i> . 1998 Aug;28(2):88-96	503	31	105
29	Knutson G, Engebretsen L, Ludvigsen TC, Drogset JO, Grøntvedt T, Solheim E, Strand T, Roberts S, Isaksen V, Johansen O. Autologous chondrocyte implantation compared with microfracture in the knee. A randomized trial. <i>Journal of Bone and Joint Surgery, American Volume</i> . 2004 Mar;86(3):455-64	500	50	52
30	Merchant AC, Mercer RL, Jacobsen RH, Cool CR. Roentgenographic analysis of patellofemoral congruence. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1974 Oct;56(7):1391-96	492	12	17
31	Girgis FG, Marshall JL, Monajem A. The cruciate ligaments of knee joint. Anatomical, functional and experimental analysis. <i>Clinical Orthopaedics and Related Research</i> . 1975 Jan-Feb;106:216-31	480	12	29
32	Buckwalter JA, Mankin HJ. Articular cartilage. Part II: degeneration and osteoarthritis, repair, regeneration, and transplantation. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1997 Apr;79(4):612-32	479	37	22

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TABLE I (continued)

Rank	Article	Citations	Citations/Year Since Publication	Citations in 2013
33	Dawson J, Fitzpatrick R, Murray D, Carr A. Questionnaire on the perceptions of patients about total knee replacement. <i>Journal of Bone and Joint Surgery, British Volume</i> . 1998 Jan;80(1):63-9	453	28	86
34	Markolf KL, Mensch JS, Amstutz HC. Stiffness and laxity of the knee—the contributions of the supporting structures. A quantitative in vitro study. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1976 Jul;58(5):583-94	440	12	13
35	Bentley G, Biant LC, Carrington RW, Akmal M, Goldberg A, Williams AM, Skinner JA, Pringle J. A prospective, randomized comparison of autologous chondrocyte implantation versus mosaicplasty for osteochondral defects in the knee. <i>Journal of Bone and Joint Surgery, British Volume</i> . 2003 Mar;85(2):223-30	431	11	29
36	Solomonow M, Baratta R, Zhou BH, Shoji H, Bose W, Beck C, D'Ambrosia R. The synergistic action of the anterior cruciate ligament and thigh muscles in maintaining joint stability. <i>American Journal of Sports Medicine</i> . 1987 May-Jun;15(3):207-13	425	16	10
37	Woo SLY, Hollis JM, Adams DJ, Lyon RM, Takai S. Tensile properties of the human femur-anterior cruciate ligament-tibia complex. The effects of specimen age and orientation. <i>American Journal of Sports Medicine</i> . 1991 May-Jun;19(3):217-25	423	23	25
38	Tapper EM, Hoover NW. Late results after meniscectomy. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1969 Apr;51(3):517-26 passim	408	9	4
39	Peterson L, Brittberg M, Kiviranta I, Akerlund EL, Lindahl A. Autologous chondrocyte transplantation. Biomechanics and long-term durability. <i>American Journal of Sports Medicine</i> . 2002 Jan-Feb;30(1):2-12	402	34	23
40	Schipplein OD, Andriacchi TP. Interaction between active and passive knee stabilizers during level walking. <i>Journal of Orthopaedic Research</i> . 1991 Jan;9(1):113-9	399	17	53
41	Baratta R, Solomonow M, Zhou BH, Letson D, Chuinard R, D'Ambrosia R. Muscular coactivation. The role of the antagonist musculature in maintaining knee stability. <i>American Journal of Sports Medicine</i> . 1988 Mar-Apr;16(2):113-22	397	16	18
42	Yagi M, Wong EK, Kanamori A, Debski RE, Fu FH, Woo SLY. Biomechanical analysis of an anatomic anterior cruciate ligament reconstruction. <i>American Journal of Sports Medicine</i> . 2002 Sep-Oct;30(5):660-6	393	33	43
43	Johnson RJ, Kettelkamp DB, Clark W, Leaverton P. Factors effecting late results after meniscectomy. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1974 Jun;56(4):719-29	391	10	4
44	Huberti HH, Hayes WC. Patellofemoral contact pressures. The influence of q-angle and tendofemoral contact. <i>Journal of Bone and Joint Surgery, American Volume</i> , 1984 Jun;66(5):715-24	390	130	14
45	Curl WW, Krome J, Gordon ES, Rushing J, Smith BP, Poehling GG. Cartilage injuries: a review of 31,516 knee arthroscopies. <i>Arthroscopy</i> . 1997 Aug;13(4):456-60	388	23	34
46	Sharkey PF, Hozack WJ, Rothman RH, Shastri S, Jacoby SM. Why are total knee arthroplasties failing today? <i>Clinical Orthopaedics and Related Research</i> . 2002 Nov;404:7-13	386	32	54
47	Miyazaki T, Wada M, Kawahara H, Sato M, Baba H, Shimada S. Dynamic load at baseline can predict radiographic disease progression in medial compartment knee osteoarthritis. <i>Annals of the Rheumatic Diseases</i> . 2002 Jul;61(7):617-22	385	32	70
48	Boden BP, Dean GS, Feagin JA Jr, Garrett WE Jr. Mechanisms of anterior cruciate ligament injury. <i>Orthopedics</i> . 2000 Jun;23(6):573-8	384	27	45
49	Hunziker EB, Rosenberg LC. Repair of partial-thickness defects in articular cartilage: cell recruitment from the synovial membrane. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1996 May;78(5):721-33	383	21	23
50	Kurosaka M, Yoshiya S, Andrish JT. A biomechanical comparison of different surgical techniques of graft fixation in anterior cruciate ligament reconstruction. <i>American Journal of Sports Medicine</i> . 1987 May-Jun;15(3):225-9	370	14	10

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TABLE I (continued)

Rank	Article	Citations	Citations/Year Since Publication	Citations in 2013
51	McDevitt CA, Muir H. Biochemical changes in the cartilage of the knee in experimental and natural osteoarthritis in the dog. <i>Journal of Bone and Joint Surgery, British Volume</i> . 1976 Feb;58(1):94-101	369	10	3
52	Peterfy CG, Guermazi A, Zaim S, Tirman PF, Miaux Y, White D, Kothari M, Lu Y, Fye K, Zhao S, Genant HK. Whole-Organ Magnetic Resonance Imaging Score (WORMS) of the knee in osteoarthritis. <i>Osteoarthritis and Cartilage</i> . 2004 Mar;12(3):177-90	369	37	56
53	Gollehon DL, Torzilli PA, Warren RF. The role of the posterolateral and cruciate ligaments in the stability of the human knee. A biomechanical study. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1987 Feb;69(2):233-42	367	14	12
54	Sachs RA, Daniel DM, Stone ML, Garfein RF. Patellofemoral problems after anterior cruciate ligament reconstruction. <i>American Journal of Sports Medicine</i> . 1989 Nov-Dec;17(6):760-5	365	15	8
55	Lotke PA, Ecker ML. Influence of positioning of prosthesis in total knee replacement. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1977 Jan;59(1):77-9	362	10	16
56	Steadman JR, Briggs KK, Rodrigo JJ, Kocher MS, Gill TJ, Rodkey WG. Outcomes of microfracture for traumatic chondral defects of the knee: average 11-year follow-up. <i>Arthroscopy: The Journal of Arthroscopic and Related Surgery</i> . 2003 May-Jun;19(5):477-84	362	33	54
57	Hangody L, Füles P. Autologous osteochondral mosaicplasty for the treatment of full-thickness defects of weight-bearing joints: ten years of experimental and clinical experience. <i>Journal of Bone and Joint Surgery, American Volume</i> . 2003 Apr;85(Suppl 2):25-32	361	33	32
58	Irrgang JJ, Anderson AF, Boland AL, Harner CD, Kurosaka M, Neyret P, Richmond JC, Shelborne KD. Development and validation of the International Knee Documentation Committee Subjective Knee Form. <i>American Journal of Sports Medicine</i> . 2001 Sep-Oct;29(5):600-13	360	28	60
59	Horas U, Pelinkovic D, Herr G, Aigner T, Schnettler R. Autologous chondrocyte implantation and osteochondral cylinder transplantation in cartilage repair of the knee joint. A prospective, comparative trial. <i>Journal of Bone and Joint Surgery, American Volume</i> . 2003 Feb;85(2):185-92	357	32	22
60	Andriacchi TP, Andersson GBJ, Fermier RW, Stern D, Galante JO. A study of lower-limb mechanics during stair-climbing. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1980 Jul;62(5):749-57	355	11	18
61	Noyes FR, DeLucas JL, Torvik PJ. Biomechanics of anterior cruciate ligament failure: an analysis of strain-rate sensitivity and mechanisms of failure in primates. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1974 Mar;56(2):236-53	352	9	10
62	O'Driscoll SW, Keeley FW, Salter RB. Durability of regenerated articular cartilage produced by free autogenous periosteal grafts in major full-thickness defects in joint surfaces under the influence of continuous passive motion. A follow-up report at one year. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1988 Apr;70(4):595-606	348	13	21
63	Levy IM, Torzilli PA, Warren RF. The effect of medial meniscectomy on anterior-posterior motion of the knee. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1982 Jul;64(6):883-8	348	11	15
64	Hughston JC, Andrews JR, Cross MJ, Moschi A. Classification of knee ligament instabilities. Part I. The medial compartment and cruciate ligaments. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1976 Mar;58(2):159-72	346	9	15
65	Insall J, Scott WN, Ranawat CS. The total condylar knee prosthesis. A report of two hundred and twenty cases. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1979 Mar;61(2):173-80	345	10	9
66	Arnoczky SP, Warren RF. Microvasculature of the human meniscus. <i>American Journal of Sports Medicine</i> . 1982 Mar-Apr;10(2):90-5	341	11	23

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TABLE I (continued)

Rank	Article	Citations	Citations/Year Since Publication	Citations in 2013
67	Aglietti P, Buzzi R, Zaccherotti G, De Biase P. Patellar tendon versus doubled semitendinosus and gracilis tendons for anterior cruciate ligament reconstruction. <i>American Journal of Sports Medicine</i> . 1994 Mar-Apr;22(2):211-8	338	16	4
68	Andriacchi TP, Galante JO, Fermier RW. The influence of total knee-replacement design on walking and stair-climbing. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1982 Dec;64(9):1328-35	329	10	13
69	Pridie KH, Gordon G. A method of resurfacing osteoarthritic knee joints. <i>Journal of Bone and Joint Surgery, British Volume</i> . 1959 Jan;41(3):618-9	329	6	11
70	Messier SP, Loeser RF, Miller GD, Morgan TM, Rejeski WJ, Sevick MA, Ettinger WH Jr, Pahor M, Williamson JD. Exercise and dietary weight loss in overweight and obese older adults with knee osteoarthritis: the Arthritis, Diet, and Activity Promotion Trial. <i>Arthritis and Rheumatism</i> . 2004 May;50(5):1501-10	326	33	41
71	Peat G, McCarney R, Croft P. Knee pain and osteoarthritis in older adults: a review of community burden and current use of primary health care. <i>Annals of the Rheumatic Diseases</i> . 2001 Feb;60(2):91-7	324	13	41
72	Wakitani S, Imoto K, Yamamoto T, Saito M, Murata N, Yoneda M. Human autologous culture expanded bone marrow mesenchymal cell transplantation for repair of cartilage defects in osteoarthritic knees. <i>Osteoarthritis and Cartilage</i> . 2002 Mar;10(3):199-206	324	27	43
73	Lohmander LS, Englund PM, Dahl LL, Roos EM. The long-term consequence of anterior cruciate ligament and meniscus injuries: osteoarthritis. <i>American Journal of Sports Medicine</i> . 2007 Oct;35(10):1756-69. Epub 2007 Aug 29	324	46	78
74	Noyes FR, Bassett RW, Grood ES, Butler DL. Arthroscopy in acute traumatic hemarthrosis of the knee. Incidence of anterior cruciate tears and other injuries. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1980 Jul;62(5):687-95, 757	322	10	11
75	Insall JN, Joseph DM, Msika C. High tibial osteotomy for varus gonarthrosis. A long-term follow-up study. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1984 Sep;66(7):1040-8	322	11	12
76	Lohmander LS, Ostenberg A, Englund M, Roos H. High prevalence of knee osteoarthritis, pain, and functional limitations in female soccer players twelve years after anterior cruciate ligament injury. <i>Arthritis and Rheumatism</i> . 2004 Oct;50(10):3145-52	319	32	69
77	Jeffery RS, Morris RW, Denham RA. Coronal alignment after total knee replacement. <i>Journal of Bone and Joint Surgery, British Volume</i> . 1991 Sep;73(5):709-14	317	14	38
78	Walker PS, Erkman MJ. The role of the menisci in force transmission across the knee. <i>Clinical Orthopaedics and Related Research</i> . 1975;109:184-92	316	8	25
79	O'Driscoll SW, Keeley FW, Salter RB. The chondrogenic potential of free autogenous periosteal grafts for biological resurfacing of major full-thickness defects in joint surfaces under the influence of continuous passive motion. An experimental investigation in the rabbit. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1986 Sep;68(7):1017-35	315	11	18
80	Kennedy JC, Alexander IJ, Hayes KC. Nerve supply of the human knee and its functional importance. <i>American Journal of Sports Medicine</i> . 1982 Nov-Dec; 10(6):329-35	314	10	9
81	Moreland JR, Bassett LW, Hanker GJ. Radiographic analysis of the axial alignment of the lower-extremity. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1987 Jun;69(5):745-9	312	12	31
82	Pendleton A, Arden N, Dougados M, Doherty M, Bannwarth B, Bijlsma JW, Cluzeau F, Cooper C, Dieppe PA, Günther KP, Hauselmann HJ, Herrero-Beaumont G, Kaklamanis PM, Leeb B, Lequesne M, Lohmander S, Mazieres B, Mola EM, Pavelka K, Semi U, Swoboda B, Verbruggen AA, Weseloh G, Zimmermann-Gorska I. EULAR recommendations for the management of knee osteoarthritis: report of a task force of the Standing Committee for International Clinical Studies Including Therapeutic Trials (ESCIIT). <i>Annals of the Rheumatic Diseases</i> . 2000 Dec;59(12):936-44	312	22	26

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TABLE I (continued)

Rank	Article	Citations	Citations/Year Since Publication	Citations in 2013
83	Markolf KL, Burchfield DM, Shapiro MM, Shepard MF, Finerman GA, Slaughterbeck JL. Combined knee loading states that generate high anterior cruciate ligament forces. <i>Journal of Orthopaedic Research</i> . 1995 Nov;13(6):930-5	311	16	31
84	Murray DW, Goodfellow JW, O'Connor JJ. The Oxford medial unicompartmental arthroplasty: a ten-year survival study. <i>Journal of Bone and Joint Surgery, British Volume</i> . 1998 Nov;80(6):983-9	310	22	32
85	Daniel DM, Stone ML, Sachs R, Malcom L. Instrumented measurement of anterior knee laxity in patients with acute anterior cruciate ligament disruption. <i>American Journal of Sports Medicine</i> . 1985 Nov-Dec;13(6):401-7	309	11	21
86	Ritter MA, Faris PM, Keating EM, Meding JB. Postoperative alignment of total knee replacement. Its effect on survival. <i>Clinical Orthopaedics and Related Research</i> . 1994 Feb;299:153-6	309	15	27
87	Grood ES, Stowers SF, Noyes FR. Limits of movement in the human knee. Effect of sectioning the posterior cruciate ligament and posterolateral structures. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1988 Jan;70(1):88-97	308	12	12
88	Marder RA, Raskind JR, Carroll M. Prospective evaluation of arthroscopically assisted anterior cruciate ligament reconstruction. Patellar tendon versus semitendinosus and gracilis tendons. <i>American Journal of Sports Medicine</i> . 1991 Sep-Oct;19(5):478-84	307	23	4
89	Insall JN, Hood RW, Flawn LB, Sullivan DJ. The total condylar knee prosthesis in gonarthrosis. A five to nine-year follow-up of the first one hundred consecutive replacements. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1983 Jun;65(5):619-28	306	10	7
90	Insall J, Falvo KA, Wise DW. Chondromalacia patellae. A prospective study. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1976 Jan;58(1):1-8	305	8	5
91	Krause WR, Pope MH, Johnson RJ, Wilder DG. Mechanical changes in the knee after meniscectomy. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1976 Jul;58(5):599-604	301	8	15
92	Evans EM, Freeman MA, Miller AJ, Vernon-Roberts B. Metal sensitivity as a cause of bone necrosis and loosening of the prosthesis in total joint replacement. <i>Journal of Bone and Joint Surgery, British Volume</i> . 1974 Nov;56(4):626-42	301	8	5
93	Baratz ME, Fu FH, Mengato R. Meniscal tears: the effect of meniscectomy and of repair on intraarticular contact areas and stress in the human knee. A preliminary report. <i>American Journal of Sports Medicine</i> . 1986 Jul-Aug;14(4):270-5	300	11	22
94	Coventry MB, Ilstrup DM, Wallrichs SL. Proximal tibial osteotomy. A critical long-term study of eighty-seven cases. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1993 Feb;75(2):196-201	295	14	17
95	Barrett DS, Cobb AG, Bentley G. Joint proprioception in normal, osteoarthritic and replaced knees. <i>Journal of Bone and Joint Surgery, British Volume</i> . 1991 Jan;73(1):53-6	294	13	13
96	Brittberg M, Nilsson A, Lindahl A, Ohlsson C, Peterson L. Rabbit articular cartilage defects treated with autologous cultured chondrocytes. <i>Clinical Orthopaedics and Related Research</i> . 1996 May;326:270-83	294	16	6
97	Fukubayashi T, Torzilli PA, Sherman MF, Warren RF. An in vitro biomechanical evaluation of anterior-posterior motion of the knee. Tibial displacement, rotation, and torque. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1982 Feb;64(2):258-64	293	9	5
98	Minas T, Nehrer S. Current concepts in the treatment of articular cartilage defects. <i>Orthopedics</i> . 1997 Jun;20(6):525-38	293	17	8
99	Insall JN, Lachiewicz PF, Burstein AH. The posterior stabilized condylar prosthesis: a modification of the total condylar design. Two to four-year clinical experience. <i>J Bone Joint Surg Am</i> . 1982 Dec;64(9):1317-23	292	10	22
100	Clancy WG, Nelson DA, Reider B, Narechania RG. Anterior cruciate ligament reconstruction using one-third of the patellar ligament, augmented by extra-articular tendon transfers. <i>Journal of Bone and Joint Surgery, American Volume</i> . 1982 Mar;64(3):352-9	292	9	4

TABLE II Journals in Which the 100 Most-Cited Articles Were Published

Journal	No. of Articles	First Issue
J Bone Joint Surg Am	42	1889/1948
Am J Sports Med	20	1976
J Bone Joint Surg Br	10	1919
Clin Orthop Relat Res	9	1953
Ann Rheum Dis	4	1939
Arthritis Rheum	4	1958
J Orthop Res	3	1983
Osteoarthritis Cartilage	3	1993
Arthroscopy	2	1985
Orthopedics	2	1978
J Orthop Sport Phys Ther	1	1979

potentially relevant articles. Ninety-four journals (twenty-nine rheumatology and sixty-five orthopaedic), ranging from general clinical to subspecialty and basic science journals, were identified. The search was conducted in November 2013 and was updated in March 2014.

Allocation of Articles and Eligibility Criteria

An initial assumption was made that the 100th most-cited article in the list would have at least 200 citations. The Web of Knowledge was used to identify all articles in rheumatology and orthopaedic journals; articles in these two groups were pooled and sorted in descending order according to the number of citations. Articles with fewer than 200 citations were then excluded.

Next, titles and abstracts were screened to exclude articles that did not pertain to the knee joint. The remaining articles were subsequently reviewed for eligibility by two independent investigators (S.S.A. and M.A.). Articles were included, regardless of their type or level of evidence, on the basis of a thematic focus on one or more of the following: (1) laboratory basic research involving any anatomic component of the knee joint; (2) biomechanical investigation of the knee joint; (3) knee joint kinematics; (4) diagnosis of a knee-related disorder; (5) a knee scoring, rating, or classification system; (6) therapy for a knee-related disorder; and (7) epidemiological investigation related to the knee. Articles were excluded if the primary focus did not involve the knee joint. If only one of the investigators deemed an article eligible, it was not included. The eligible articles were then sorted in descending order on the basis of the number of citations, and the 100th rank was the last to be considered for this analysis (Fig. 1).

Data Extraction

All articles were reviewed by the two independent investigators for retrieval of the journal name, publication date, first and last authors, year of publication, geographic origin, total number of citations of the article, overall citation rate (total citations/article age), current citation rate (measured as the number of citations in the year 2013), research nature (sports traumatology, degenerative disease, scoring system, kinematic/biomechanical, imaging, or anatomic), and level of evidence (I through V for clinical articles, according to the guidelines specified in this journal¹³). The two investigators disagreed regarding the characteristics of seventeen articles; these were reevaluated and discussed with a third investigator (S.K.).

Statistical Analysis

The Shapiro-Wilk test was used to test the distribution of individual variables for normality. Normally distributed data are presented as the mean and the standard deviation, and skewed data are presented as the median and the range. One-way ANOVA (analysis of variance) was used to test for differences involving normally distributed data, and the Kruskal-Wallis test was used for

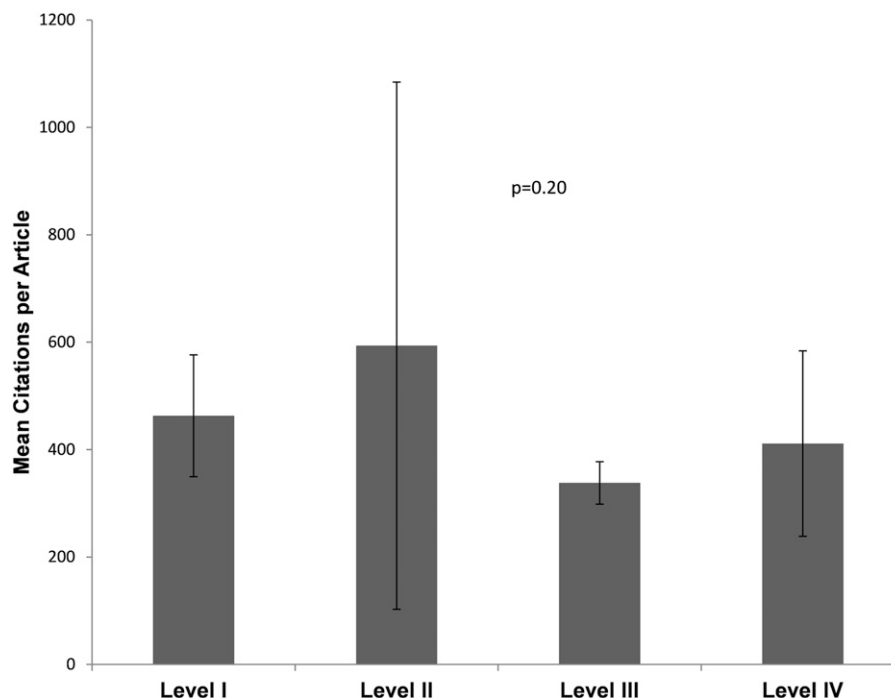


Fig. 2

Bar graph showing the mean number of citations (and standard deviation) for the most-cited articles according to the level of evidence.

TABLE III Countries from Which the Articles in the Most-Cited List Originated

Country	No. of Articles
U.S.	63
U.K.	11
Sweden	10
Canada	5
Japan	4
Switzerland	2
Germany	1
Norway	1
Hungary	1
France	1
Italy	1

skewed data. The Mann-Kendall trend test was used to test for time-dependent trends. The Spearman rank was utilized to test for correlations among variables. A p value of <0.05 was considered significant. WinSTAT (version 2012.1; R. Fitch Software, Bad Krozingen, Germany) was utilized for the statistical analysis.

Source of Funding

No external funding was received in support of this study.

Results

A total of 559,819 articles were listed in the orthopaedic and rheumatology journals in the ISI Web of Knowledge, and 0.26% (1435) possessed at least 200 citations. The publication dates of the 100 most-cited articles ranged from 1948 to 2007, and the total number of citations per article ranged from 2640 to 287 (Table I). Although no language restrictions were imposed during the search process, all of these articles had been published in English. Sixty-three of the 100 articles were clinical and thirty-seven were basic research; the articles in these two groups did not differ significantly with respect to total citations per article (median = 365 [range = 287 to 2640] and median = 370 [range = 292 to 862], respectively; $p = 0.23$).

The most articles were published in the field of sports traumatology (forty-four), followed by degenerative disease and arthroplasty (twenty-five), biomechanics and kinematics (eighteen), scoring systems (seven), imaging (three), and anatomy (three). The clinical articles involved randomized clinical trials (three), clinical outcome studies (forty), cross-sectional

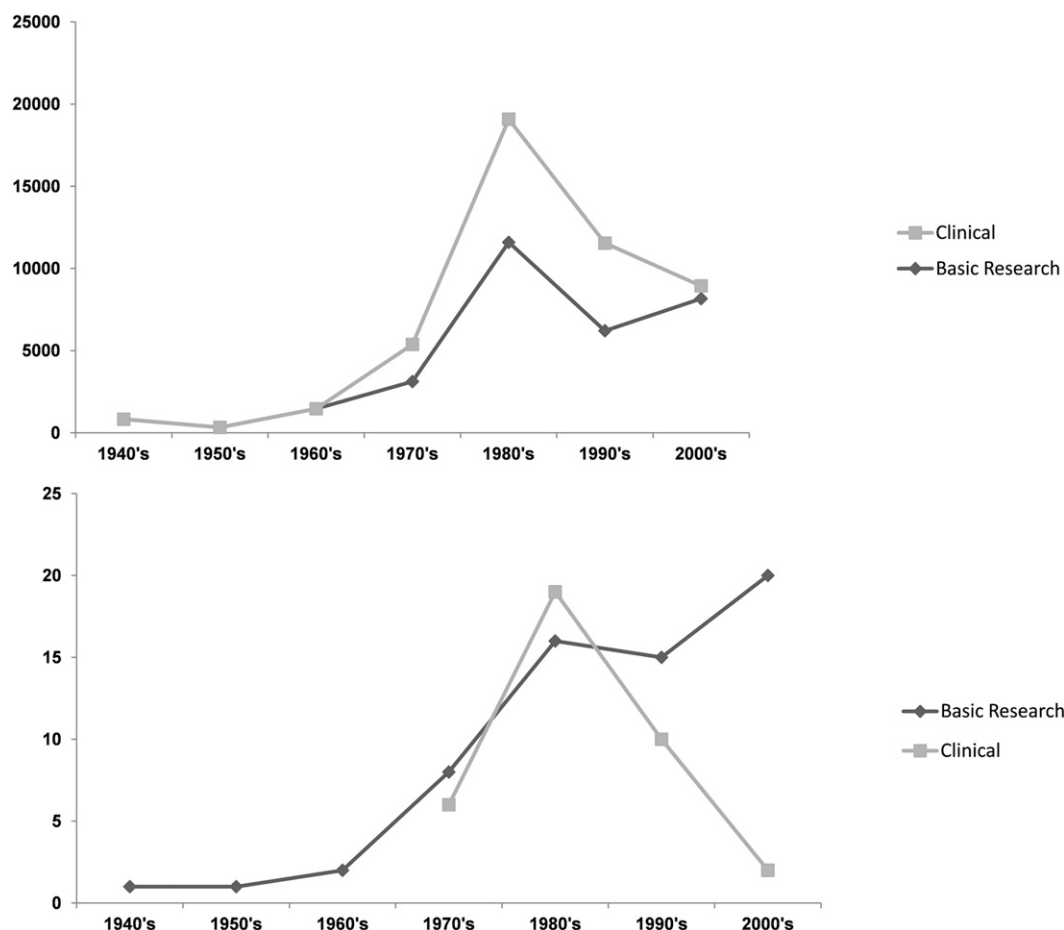


Fig. 3

Number of most-cited articles published (bottom) and total number of citations of those articles (top) according to publication date.

TABLE IV First and Last Authors with Multiple Articles in the Most-Cited List

Frequent First Authors	No. of Articles	Frequent Last Authors	No. of Articles
Insall, JN	7	Warren, RF	5
Noyes, FR	4	Noyes, FR	2
Daniel, DM	2	Butler, DL	2
Andriacchi, TP	2		
Hewett, TE	2		
Hunziker, EB	2		
O'Driscoll, SW	2		
Peterson, L	2		

studies (four), questionnaire development (eight), reviews (four), expert opinions (two), surgical techniques (one), and epidemiology (one).

The greatest number of studies (twenty-eight, with a mean of 411 ± 173 citations per article) represented Level-IV evidence, followed by II (twenty-four, with 594 ± 490 citations), III (five, with 338 ± 39 citations), I (four, with 463 ± 113 citations), and V (two, with 1197 ± 769 citations). One-way ANOVA showed no significant difference in citations per article among the various levels of evidence ($p = 0.20$) (Fig. 2).

Overall, the greatest number of articles in the list (thirty-five) had a publication date in the 1980s, followed by the 1990s (twenty-five) and 2000s (twenty-two). The pattern for basic research articles differed somewhat, as the majority of articles

were published in the decade prior to the current one (2000s) (Fig. 3). The mean number of citations per article was also greatest for articles published in the 1980s (545) followed by the 1990s (462) and 2000s (406). The current citation rate of an article was greater for more recent articles ($p < 0.001$, Mann-Kendall test) (Fig. 4). The total number of citations and the overall citation rate were positively correlated ($r = 0.6$, $p < 0.001$). The total number of citations and the current citation rate showed no correlation ($r = 0.00$, $p = 0.2$).

The 100 most-cited articles were published in eleven of the ninety-four journals that had been considered. Nine of the eleven journals were American and two were British; nine fell under the orthopaedic category and two under the rheumatology category (Table II). All eleven journals had an impact factor that was within the top quartile of its category.

Articles originated from eleven countries, led by the U.S. (sixty-three) followed by the U.K. (eleven), Sweden (ten), Canada (five), Japan (four), Switzerland (two), and Germany, Norway, Hungary, France, and Italy (one each) (Table III). All articles originating from the U.K. were published in two British journals, the *Journal of Bone & Joint Surgery, British Volume*, and the *Annals of the Rheumatic Diseases*. Sixty-two of the sixty-three articles originating from the U.S. were published in American journals and one was published in a British journal.

There were eight authors with multiple first authorships and three with multiple last authorships in the list of 100 most-cited articles (Table IV). John Insall had seven first authorships in the field of degenerative joint disease, and the seven articles were cited a total of 3825 times. Frank Noyes had four first authorships and two last authorships, with a total of 2676 citations.

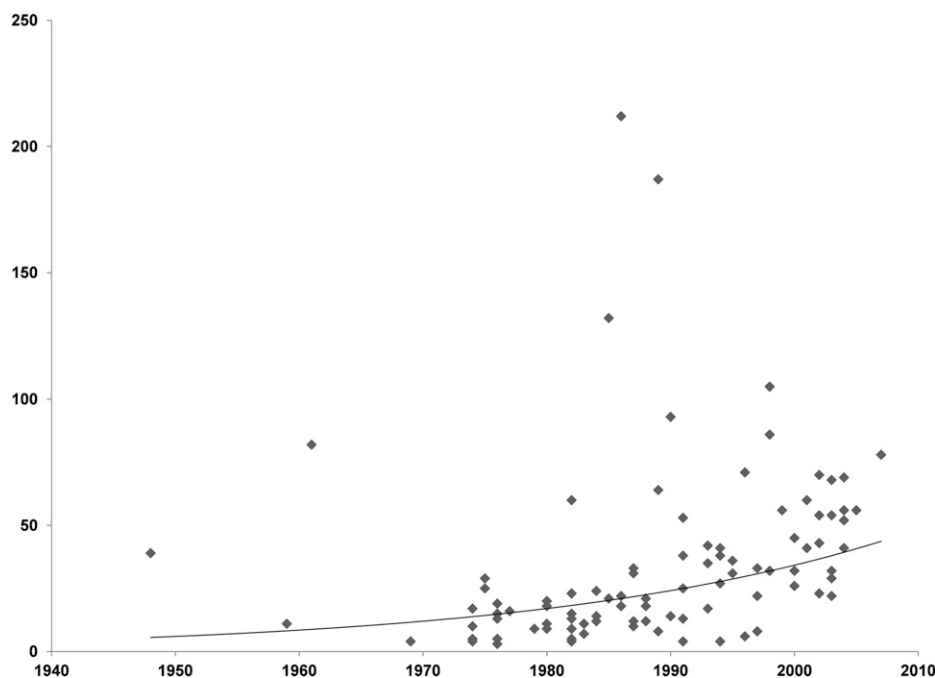


Fig. 4

Current (2013) citation rate for the most-cited articles according to the publication date of the article.

Discussion

The number of citations an article has is a valuable measure of the impact that the article either has or had on the topic it deals with, and this number has therefore become valued as an instrument for the assessment of authors or journals². However, we emphasize that the overall citation number relates primarily to the impact that an article had during a time interval, rather than to the quality of the article; even the greatest papers started with zero citations. Also, knowledge is surpassed by new knowledge; even true “classics” naturally lose the spotlight position with time and gradually lose frequency of citations, a phenomenon known as “obliteration by incorporation.”⁴ This could be clearly observed for the clinical articles in our analysis (Fig. 1); the most articles in the list (35%) were published in the 1980s, followed by the 1990s and 2000s. The older an article gets, the more time is provided for it to be cited, but at the same time the current citation rate shows a decreasing trend as an article gets older. The situation was somewhat different for the basic research articles in the list, as the most articles were published during the decade prior to the current one; however, for both types of articles, the total number of citations was greatest for articles published in the 1980s (Fig. 3). This indicates that basic research is often cited more quickly but not more often than clinical research.

Knee surgery evolved over a century and a half ago when surgeons attempted to treat knee osteoarthritis, but the field subsequently widened greatly after the development of arthroplasty procedures and the introduction of sports medicine and joint-preserving surgery¹². Browsing through the top-100 list shows that most articles fall into two subject areas, degenerative disease and sports traumatology; correspondingly, individuals who were first or last authors of multiple articles in the list also commonly showed a focus on one of these two areas. The leading country of origin was the U.S., similar to the case in other medical fields (e.g., general surgery¹, general orthopaedics⁵, urology¹⁴, critical care medicine¹⁵, emergency medicine¹⁶, and sepsis research¹⁷). This is likely a consequence of the U.S. population size and research budgets. Correction on the basis of population size has been attempted by the authors of some bibliometric studies¹⁸ to eliminate that effect and thus gain a clearer picture of the research activity of smaller countries while still revealing the impact of authors who have published multiple frequently cited articles. Another major confounding factor must also be noted: authors of articles published in European journals tend to cite other articles published in European journals, and American scientists are also prone to citing their national colleagues¹⁹. In our study, the most-cited knee articles from the U.S. were published almost exclusively in American journals and articles from the U.K. were exclusively published in British journals. English-language journals from these two countries have the highest rank in orthopaedics, and their resulting attractiveness to authors of high-quality material would serve to perpetuate the predominance of these American and British journals²⁰⁻²². The 100 most-cited articles in knee surgery were published in only eleven journals, and more than eighty of the articles were published in four journals. The

American Volume of the *Journal of Bone & Joint Surgery* topped the list with forty-two articles, which could also be partially explained by the fact that the first issue of this journal was published in 1889.

Similar to the situation reported in previous bibliometric studies⁶⁻¹⁰, the top-100 list of knee articles does not consist largely of articles with a high level of evidence. Rather, the greatest number of articles in the list represented Level-IV clinical outcome studies (case series). This highlights the fact that a novel concept that was initially presented in the form of a small case series or cohort study could still gain attention by the medical community.

Scoring systems are frequently utilized in the methodology of research articles and were therefore frequently cited. We observed this in the knee literature as well, as all of the knee scoring systems that we are aware of were represented in the list.

Although bibliometric studies provide a valuable snapshot of articles that have attracted citations, it is important to keep in mind that treatment philosophies change, especially in rapidly developing fields such as surgery, and not every article that had once been of importance has the same value today. Criticizing a published article typically requires citing it, demonstrating that a citation does not always indicate a positive value. Furthermore, selecting articles on the basis of a different definition of a classic may result in a different list. We therefore emphasize the necessity of referring to “citation classics” when using the number of citations as a tool for quantifying article impact in bibliometric studies.

In conclusion, despite its limitations, citation analysis remains one of the best currently available tools for quantifying the impact of scientific articles on their field. Bibliometric studies have been published frequently in many fields during the last few years, although the first studies appeared decades ago⁴. These studies provide a valuable source of intellectual milestones for readers who are relatively new to the field, and they provide a reminder of those milestones for the senior reader or author. Bibliometric studies analyze the characteristics of well-cited publications, and the results reflect the quality of prior scientific research and could therefore provoke thinking and rethinking within the target community. Periodic updates of bibliometric studies are necessary to include the more recent “rising stars.”²³ The present study focusing on knee orthopaedics revealed that the majority of the most-cited articles were published in two of the top-ranked journals. Sports traumatology and degenerative disease were the two areas to which most of the articles belonged, and individuals who authored multiple articles in the list often showed a focus on one of these two areas. ■

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