



Fifty top-cited classic papers in orthopaedic oncology: a bibliometric analysis

Hüseyin Bilgehan Çevik¹ · Seyit Ali Gümüştas¹

Received: 11 December 2018 / Published online: 12 March 2019
© Springer-Verlag GmbH Germany, part of Springer Nature 2019

Abstract

Introduction Citation analysis has been used to evaluate the impact of papers in medicine. There has been multitude of orthopaedic oncology-related papers in literature, to our knowledge no citation analysis of orthopaedic oncology papers has been performed. We identified the 50 most-cited orthopaedic oncology papers and evaluated these papers in terms of their time of publication, source journals, countries, institutions, authors, and main topics.

Materials and methods Science citation index expanded was searched in April 2018 for citations of papers published in 77 selected journals since the beginning of the database. The 50 most-cited orthopaedic oncology papers were identified and evaluated.

Results The number of citations for the top 50 papers ranged from 168 to 1162 (mean 308). These papers were published between 1957 and 2010. 1990s was the most productive decade, with 19 papers of the list. All papers were written in English and they were published in a total of 6 journals. The *Journal of Bone and Joint Surgery-Am* published the largest number of papers with 31, followed by *Clinical Orthopaedics and Related Research* with 8. The top 50 papers were created mainly from US and Japan, respectively, with 33 and 5.

Conclusions It is difficult to define the exact impact of a single paper in the literature. In doing citation analysis, it provides us perspective in the history and progress of orthopaedic oncology.

Keywords Top papers · Orthopaedic oncology · Classics · History

Introduction

Orthopaedic oncology is a subspecialty of orthopaedic surgery. Primary or metastatic bone and soft-tissue neoplasms, severe bone and joint defects, and tumor-like conditions are interested areas of orthopaedic oncology [1]. Large number of papers related to orthopaedic surgery, are published in medical journals in every year [2]. A reasonable portion of these is related to orthopaedic oncology. Each orthopaedic oncology-related paper contributes to the improvement of orthopaedic oncology.

There are many ways to evaluate the significance and academic influence of a scientific paper [3]. One of them is number of citation that is a reference to published source. To discuss the academic impact of a study, we may use the citation analysis until a better way is found. Citation analysis is a bibliometric process which evaluates the frequency and patterns of citations in papers [4]. And shortly the impact factor is time-specific citation rate index [5]. Citation analysis and impact factor are used to measure the importance or rank of a paper and a journal, respectively.

In orthopaedic surgery: bibliometric citation analysis studies were performed in the fields of general orthopaedic surgery, spinal oncology, and pediatric orthopaedic surgery [2, 6, 7]. As far as we know, there has not been a bibliometric analysis about the most cited papers in orthopaedic oncology. The objective of the present study is to identify the 50 most-cited papers in orthopaedic oncology and to analyze the basic characteristics.

✉ Hüseyin Bilgehan Çevik
bilgehancevik@gmail.com

Seyit Ali Gümüştas
seyitali_gumustas@yahoo.com

¹ Department of Orthopaedics and Traumatology, Kartal Dr. Lütfi Kırdar Research and Training Hospital, University of Health Sciences, Şemsi Denizler Street, E-5 Highway, Cevizli Region, Kartal, Istanbul, Turkey

Materials and methods

In April 2018, we searched the Science Citation Index Expanded for citations to papers published in any of the 77 journals in the subject category “orthopaedics” of the 2017 Journal Citation Report Science Edition [8]. Of the 77 journals, 74 are published in English, and three are published in another language. Each of the 77 journals was searched separately using the “cited reference search” one of the many options through ISI Web of Knowledge. The top 50 papers were selected for further inspection (Table 1), in which all the selected papers were analyzed for the topics, authorship, institution, country, journal, and decade published of the study [9, 10].

Results

The top five papers were each cited more than 500 times, and the range was from 168 to 1162 citations in the top 50 (Table 1). Only the first paper of the list had over 1000 citations [11]. While most papers were published in the 1990s, 19 papers (Table 2), the papers on the list were published between the years 1957 and 2010. The oldest cited paper was by Lichtenstein et al. [12] and was published in 1957. The newest paper was published in 2010 and was written by Fisher et al. [13]. All the papers were published in English.

The 50 papers originated from 7 countries with the US (33), Japan (5) and Italy (4) being the most productive (Table 3). There were 21 institutions in charge of the top cited papers, with The Mayo Clinic, Rochester (eight); Harvard University, Boston (seven); Istituto Rizzoli, Bologna (four); University of Chicago (four); and University of Florida, Gainesville (four) topping the list (Table 4). The 50 papers were published in 6 of the 77 journals (Table 3), led by the Journal of Bone and Joint Surgery American Volume (JBJS-Am) (31) and followed by the Spine (8) and Clinical Orthopaedics and Related Research (CORR) (8) (Table 5). The top author was W. F. Enneking, with lead authorship in four papers and first author of most cited paper in the top 50 list. Two authors published three papers and six other authors had two lead authorships (Table 6).

Discussion

The most cited paper in orthopaedic oncology was “A System for the Functional Evaluation of Reconstructive Procedures After Surgical Treatment of Tumors of the

Musculoskeletal System” by Enneking et al., that introduced “the standardized system of end result reporting of various surgical alternatives after limb salvaging and ablative procedures for musculoskeletal tumors” and was published in 1993 in CORR [11]. That paper was not one of “The 100 classics papers of orthopaedic surgery” that published in 2008 [14]. But now definitely it is one of the classic papers of orthopaedics. The second most-cited paper on the list was also by Enneking et al. and also published in the CORR, and described “A system for surgical staging of musculoskeletal sarcoma” that now bears his name, which is used in the staging of musculoskeletal sarcomas [15]. That paper was one of “The 100 classics papers of orthopaedic surgery”, and still is [14]. Also these two papers written by Enneking et al. that are classics of orthopaedic oncology. The third most-cited paper was by Goldenberg et al. and published experiences of 218 cases of giant-cell tumor of bone [16].

There are mutual topics among many of the papers on this list (Table 7). We ranked the papers by their topics. So we detected relative importance placed on the varied research areas by orthopaedic surgeons. Most of the 50 top-cited papers are written about giant cell tumor of bone (eight), followed by staging-scoring of tumors (seven), bone sarcomas (six), and spinal metastases (five). Also there are papers written in two times about allografts, biopsy techniques, bone cysts, chordomas, multiple hereditary exostosis, osteoid osteomas, and reconstruction procedures.

A few of the classification systems used in orthopaedic oncology are also included in this list. Examples of these are the Enneking classification for bone and soft-tissue tumors [17], Tomita classification for vertebral metastases [18], Tokuhashi score for prognostic scoring for spinal metastases [19], Weinstein–Boriani–Biagini classification for metastatic spine tumors [20].

As was noted in our results, top-50 list has publications from only six journals. Orthopaedic journals with the highest impact factors were preferred for the top-cited papers (Table 5). The impact factor is a ratio between citations and recent citable published items [21]. Because the paper citation rates determine the journal impact factor [22], the correlation between journal with superior impact factor and top cited papers is reasonable.

To our knowledge, the present study is the first to identify the classic papers of orthopaedic oncology surgery. Orthopaedic surgeons could be inspired by this list in their future studies. In doing so, it provides us perspective in the history and progress of orthopaedic oncology. Recognition of cornerstones of orthopaedic oncology may guide future investigations.

Table 1 Top 50 papers in orthopaedic oncology

Rank	Author	Number of citations
1	Enneking WF, Dunham W, Gebhardt MC, Malawar M, Pritchard DJ (1993) A system for the functional evaluation of reconstructive procedures after surgical treatment of tumors of the musculoskeletal system. <i>Clinical orthopaedics and related research</i> 286):241–246	1162
2	Enneking WF, Spanier SS, Goodman MA (1980) A system for the surgical staging of musculoskeletal sarcoma. <i>Clinical Orthopaedics and Related Research</i> ® 153:106–120	921
3	Goldenberg RR, Campbell CJ, Bonfiglio M (1970) Giant-cell tumor of bone: an analysis of two hundred and eighteen cases. <i>JBJS</i> 52(4):619–664	597
4	Campanacci M, Baldini N, Boriani S, Sudanese A (1987) Giant-cell tumor of bone. <i>The Journal of bone and joint surgery American volume</i> 69(1):106–114	571
5	Dahlin DC, Coventry MB (1967) Osteogenic sarcoma: a study of six hundred cases. <i>JBJS</i> 49(1):101–110	530
6	Tomita K, Kawahara N, Kobayashi T, Yoshida A, Murakami H, Akamaru T (2001) Surgical strategy for spinal metastases. <i>Spine</i> 26(3):298–306	497
7	Enneking WF (1986) A system of staging musculoskeletal neoplasms. <i>Clinical orthopaedics and related research</i> (204):9–24	467
8	Mankin HJ, Lange TA, Spanier SS (1982) The hazards of biopsy in patients with malignant primary bone and soft-tissue tumors. <i>J Bone Joint Surg Am</i> 64(8):1121–1127	379
9	Tokuhashi Y, Matsuzaki H, Oda H, Oshima M, Ryu J (2005) A revised scoring system for preoperative evaluation of metastatic spine tumor prognosis. <i>Spine</i> 30(19):2186–2191	369
10	Mankin HJ, Mankin CJ, Simon MA (1996) The Hazards of the Biopsy, Revisited.: For the Members of the Musculoskeletal Tumor Society. <i>JBJS</i> 78(5):656–663	352
11	Mankin HJ, Gebhardt MC, Jennings LC, Springfield DS, Tomford WW (1996) Long-term results of allograft replacement in the management of bone tumors. <i>Clinical Orthopaedics and Related Research</i> (1976–2007) 324:86–97	350
12	McKenna RJ, Schwinn CP, Soong K, Higinbotham NL (1966) Sarcomata of the osteogenic series (osteosarcoma, fibrosarcoma, chondrosarcoma, parosteal osteogenic sarcoma, and sarcomata arising in abnormal bone): an analysis of 552 cases. <i>JBJS</i> 48(1):1–26	347
13	Simon MA, Aschliman M, Thomas N, Mankin H (1986) Limb-salvage treatment versus amputation for osteosarcoma of the distal end of the femur. <i>The Journal of bone and joint surgery American volume</i> 68(9):1331–1337	342
14	Marcove RC, MikÉ V, Hajek JV, Levin AG, Hutter RV (1970) Osteogenic sarcoma under the age of twenty-one: a review of one hundred and forty-five operative cases. <i>JBJS</i> 52(3):411–423	332
15	Rosenthal DI, Hornicek FJ, Wolfe MW, Jennings LC, Gebhardt MC, Mankin HJ (1998) Percutaneous radiofrequency coagulation of osteoid osteoma compared with operative treatment. <i>JBJS</i> 80(6):815–821	331
16	Enneking WF, Dunham W (1978) Resection and reconstruction for primary neoplasms involving the innominate bone. <i>The Journal of bone and joint surgery American volume</i> 60(6):731–746	306
17	Tokuhashi Y, Matsuzaki H, Toriyama S, Kawano H, Ohsaka S (1990) Scoring system for the preoperative evaluation of metastatic spine tumor prognosis. <i>Spine</i> 15(11):1110–1113	300
18	Mirels H (1989) Metastatic disease in long bones. A proposed scoring system for diagnosing impending pathologic fractures. <i>Clinical orthopaedics and related research</i> (249):256–264	298
19	Schmale GA, Conrad EU, Raskind WH (1994) The natural history of hereditary multiple exostoses. <i>JBJS</i> 76(7):986–992	294
20	Harris W, Dudley HR, Barry R (1962) The natural history of fibrous dysplasia: an orthopaedic, pathological, and roentgenographic study. <i>JBJS</i> 44(2):207–233	289
21	Ackerman LV (1958) Extra-osseous localized non-neoplastic bone and cartilage formation (so-called myositis ossificans): clinical and pathological confusion with malignant neoplasms. <i>JBJS</i> 40(2):279–298	286
22	Tomita K, Kawahara N, Baba H, Tsuchiya H, Fujita T, Toribatake Y (1997) Total en bloc spondylectomy: a new surgical technique for primary malignant vertebral tumors. <i>Spine</i> 22(3):324–333	280
23	Rougraff BT, Simon MA, Kneisl JS, Greenberg DB, Mankin HJ (1994) Limb salvage compared with amputation for osteosarcoma of the distal end of the femur. A long-term oncological, functional, and quality-of-life study. <i>JBJS</i> 76(5):649–656	277
24	Simon M, Enneking W (1976) The management of soft-tissue sarcomas of the extremities. <i>The Journal of bone and joint surgery American volume</i> 58(3):317–327	275
25	Boriani S, Weinstein JN, Biagini R (1997) Primary bone tumors of the spine: terminology and surgical staging. <i>Spine</i> 22(9):1036–1044	258
26	McDonald DJ, Sim F, McLeod R, Dahlin D (1986) Giant-cell tumor of bone. <i>The Journal of bone and joint surgery American volume</i> 68(2):235–242	247
27	Wong DA, Fornasier VL, MacNab I (1990) Spinal metastases: the obvious, the occult, and the impostors. <i>Spine</i> 15(1):1–4	245
28	Murphy FP, Dahlin DC, Sullivan CR (1962) Articular synovial chondromatosis. <i>JBJS</i> 44(1):77–86	241

Table 1 (continued)

Rank	Author	Number of citations
29	Sung H, Kuo D, Shu W, Chai Y, Liu C, Li S (1982) Giant-cell tumor of bone: analysis of two hundred and eight cases in Chinese patients. <i>The Journal of bone and joint surgery American volume</i> 64(5):755–761	231
30	Parrish FF (1973) Allograft replacement of all or part of the end of a long bone following excision of a tumor: report of twenty-one cases. <i>JBJS</i> 55(1):1–22	228
31	Rock MG, Pritchard DJ, Reiman HM, Soule E, Brewster R (1984) Extra-abdominal desmoid tumors. <i>The Journal of bone and joint surgery American volume</i> 66(9):1369–1374	216
32	Lee FY, Mankin HJ, Fondren G, Gebhardt MC, Springfield DS, Rosenberg AE, Jennings CL (1999) Chondrosarcoma of bone: an assessment of outcome. <i>JBJS</i> 81(3):326–338	209
33	Boriani S, Bandiera S, Biagini R, Bacchini P, Boriani L, Cappuccio M, Chevalley F, Gasbarrini A, Picci P, Weinstein JN (2006) Chordoma of the mobile spine: fifty years of experience. <i>Spine</i> 31(4):493–503	209
34	Malawer MM, Chou LB (1995) Prosthetic survival and clinical results with use of large-segment replacements in the treatment of high-grade bone sarcomas. <i>JBJS</i> 77(8):1154–1166	206
35	Solomon L (1963) Hereditary multiple exostosis. <i>The Journal of Bone and Joint Surgery British volume</i> 45(2):292–304	200
36	O'Donnell RJ, Springfield DS, Motwani HK, Ready JE, Gebhardt MC, Mankin HJ (1994) Recurrence of giant-cell tumors of the long bones after curettage and packing with cement. <i>JBJS</i> 76(12):1827–1833	199
37	Henderson ED, Dahlin DC (1963) Chondrosarcoma of bone—a study of two hundred and eighty-eight cases. <i>JBJS</i> 45(7):1450–1458	198
38	Coley WB (1991) The Classic: The treatment of malignant tumors by repeated inoculations of erysipelas with a report of ten original cases. <i>Clinical Orthopaedics and Related Research</i> ® 262:3–11	196
39	Bauer HC, Wedin R (1995) Survival after surgery for spinal and extremity metastases: prognostication in 241 patients. <i>Acta orthopaedica Scandinavica</i> 66(2):143–146	195
40	Damron TA, Ward WG, Stewart A (2007) Osteosarcoma, chondrosarcoma, and Ewing's sarcoma: national cancer database report. <i>Clinical Orthopaedics and Related Research</i> ® 459:40–47	190
41	Larsson S, LoRENTZON R, Boquist L (1975) Giant-cell tumor of bone. A demographic, clinical, and histopathological study of all cases recorded in the Swedish Cancer Registry for the years 1958 through 1968. <i>The Journal of bone and joint surgery American volume</i> 57(2):167–173	188
42	Fisher CG, DiPaola CP, Ryken TC, Bilsky MH, Shaffrey CI, Berven SH, Harrop JS, Fehlings MG, Boriani S, Chou D (2010) A novel classification system for spinal instability in neoplastic disease: an evidence-based approach and expert consensus from the Spine Oncology Study Group. <i>Spine</i> 35(22):E1221–E1229	186
43	Campanacci M, Capanna R, Picci P (1986) Unicameral and aneurysmal bone cysts. <i>Clinical orthopaedics and related research</i> (204):25–36	181
44	Tomita K, Kawahara N, Baba H, Tsuchiya H, Nagata S, Toribatake Y (1994) Total en bloc spondylectomy for solitary spinal metastases. <i>International orthopaedics</i> 18(5):291–298	181
45	Fuchs B, Dickey ID, Yaszemski MJ, Inwards CY, Sim FH (2005) Operative management of sacral chordoma. <i>JBJS</i> 87(10):2211–2216	180
46	Kneisl J, Simon M (1992) Medical management compared with operative treatment for osteoid-osteoma. <i>The Journal of Bone and Joint Surgery American</i> 74(2):179–185	179
47	Rock MG, Pritchard DJ, Unni KK (1984) Metastases from histologically benign giant-cell tumor of bone. <i>The Journal of Bone and Joint Surgery American</i> 66(2):269–274	177
48	Dahlin DC, Coventry MB, Scanlon PW (1961) Ewing's sarcoma: a critical analysis of 165 cases. <i>JBJS</i> 43(2):185–192	171
49	Lichtenstein L (1957) Aneurysmal bone cyst: observations on fifty cases. <i>JBJS</i> 39(4):873–882	170
50	Blackley H, Wunder J, Davis A, White L, Kandel R, Bell R (1999) Treatment of giant-cell tumors of long bones with curettage and bone-grafting. <i>JBJS</i> 81(6):811–820	168

Table 2 Most popular papers cited by decade

Rank	Decade	Number of papers
1	1990s	19
2	1980s	11
3	1960s	6
4	1970s	6
5	2000s	5
6	1950s	2
7	2010s	1

Table 3 Countries of origin of the most cited papers

Rank	Country	Number of papers
1	USA	33
2	Japan	5
3	Italy	4
4	Canada	3
5	Sweden	2
6	South Africa	2
7	China	1

Table 4 Institutions most represented by top cited papers

Rank	Institution	Number of papers
1	Mayo Clinic	8
2	Massachusetts General and Harvard University, Boston	7
3	Instituto Rizzoli, Bologna	4
4	University of Chicago	4
5	University of Florida, Gainesville	4
6	Kanazawa University	3
7	Washington University	3
8	Memorial Sloan Kettering Cancer Center, New York	2
9	Nihon University School of Medicine, Tokyo	2
10	University of the Witwatersrand, Johannesburg	2
11	University of Toronto	2

Table 5 Journals that published the most cited papers

Rank	Journal	Number of papers
1	JBJS (Am)	31
2	Spine	8
3	CORR	8
4	Acta Orthopaedica Scandinavica	1
5	International Orthopaedics	1
6	JBJS (Br)	1

Table 6 Authors with more than one of the most cited papers

Rank	Author	Number of first name papers
1	Enneking, WF	4
2	Mankin, HJ	3
3	Tomita, K	3
4	Boriani, S	2
5	Campanacci, M	2
6	Dahlin, DC	2
7	Rock, MG	2
8	Simon, MA	2
9	Tokuhashi, Y	2

Table 7 Most popular topics ranked by number of papers

Rank	Topic	Number of papers
1	Giant cell tumor of bone	8
2	Staging-scoring	7
3	Bone sarcomas	6
4	Spinal metastases	5
5	Aneurysmal bone cyst	2
6	Allografts	2
7	Biopsy techniques	2
8	Bone cysts	2
9	Chordomas	2
10	Hereditary multiple exostosis	2
11	Osteoid osteomas	2
12	Reconstruction procedures	2

Compliance with ethical standards

Conflict of interest The authors have no conflict of interests.

Ethical approval This paper does not need ethical committee statement because it is a bibliometric analysis.

References

- Puri A (2014) Orthopedic oncology—“the challenges ahead”. *Front Surg* 1:27
- Lefavre KA, Shadgan B, O'Brien PJ (2011) 100 most cited articles in orthopaedic surgery. *Clin Orthop Relat Res* 469(5):1487–1497
- Garfield E (1979) Is citation analysis a legitimate evaluation tool? *Scientometrics* 1(4):359–375
- Garfield E (1972) Citation analysis as a tool in journal evaluation. *Science* 178(4060):471–479

5. Garfield E (2006) The history and meaning of the journal impact factor. *JAMA* 295(1):90–93
6. De la Garza-Ramos R, Benvenuti-Regato M, Caro-Osorio E (2016) The 100 most-cited articles in spinal oncology. *J Neurosurg Spine* 24(5):810–823
7. Kavanagh R, Kelly J, Kelly P, Moore D (2013) The 100 classic papers of pediatric orthopaedic surgery: a bibliometric analysis. *JBJS* 95(18):e134
8. Xing D, Zhao Y, Dong S, Lin J (2018) Global research trends in stem cells for osteoarthritis: a bibliometric and visualized study. *Int J Rheum Dis* 21(7):1372–1384
9. Paladugu R, Schein M, Gardezi S, Wise L (2002) One hundred citation classics in general surgical journals. *World J Surg* 26(9):1099–1105
10. Luo P, Xu D, Wu J, Chen Y-H, Pfeifer R, Pape H-C (2017) The top 100 cited of injury-international journal of the care of the injured: a bibliometric analysis. *Injury* 48(12):2625–2633
11. Enneking WF, Dunham W, Gebhardt MC, Malawar M, Pritchard DJ (1993) A system for the functional evaluation of reconstructive procedures after surgical treatment of tumors of the musculoskeletal system. *Clin Orthop Relat Res* 286:241–246
12. Lichtenstein L (1957) Aneurysmal bone cyst: observations on fifty cases. *JBJS* 39(4):873–882
13. Fisher CG, DiPaola CP, Ryken TC, Bilsky MH, Shaffrey CI, Berven SH, Harrop JS, Fehlings MG, Boriani S, Chou D (2010) A novel classification system for spinal instability in neoplastic disease: an evidence-based approach and expert consensus from the Spine Oncology Study Group. *Spine* 35(22):E1221–E1229
14. Kelly J, Glynn R, O’Brian D, Felle P, McCabe J (2010) The 100 classic papers of orthopaedic surgery: a bibliometric analysis. *J Bone Jt Surg Br* 92(10):1338–1343
15. Enneking WF, Spanier SS, Goodman MA (1980) A system for the surgical staging of musculoskeletal sarcoma. *Clin Orthop Relat Res* 153:106–120
16. Goldenberg RR, Campbell CJ, Bonfiglio M (1970) Giant-cell tumor of bone: an analysis of two hundred and eighteen cases. *JBJS* 52(4):619–664
17. Enneking WF (1986) A system of staging musculoskeletal neoplasms. *Clin Orthop Relat Res* 204:9–24
18. Tomita K, Kawahara N, Kobayashi T, Yoshida A, Murakami H, Akamaru T (2001) Surgical strategy for spinal metastases. *Spine* 26(3):298–306
19. Tokuhashi Y, Matsuzaki H, Toriyama S, Kawano H, Ohsaka S (1990) Scoring system for the preoperative evaluation of metastatic spine tumor prognosis. *Spine* 15(11):1110–1113
20. Boriani S, Weinstein JN, Biagini R (1997) Primary bone tumors of the spine: terminology and surgical staging. *Spine* 22(9):1036–1044
21. Hecht F, Hecht BK, Sandberg AA (1998) The journal “impact factor”: a misnamed, misleading, misused measure. *Cancer Genet Cytogenet* 104(2):77–81
22. Seglen PO (1997) Why the impact factor of journals should not be used for evaluating research. *BMJ Br Med J* 314(7079):498

Publisher’s Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.