Original Article

The 100 most-cited articles in orthodontics: *A bibliometric study*

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ABSTRACT

Objectives: To identify and analyze the 100 most-cited articles in orthodontics indexed in the Web of Science Category of "Dental, Oral Surgery and Medicine" from 1946 to 2016.

Materials and Methods: On hundred articles were identified in a search of the database of the ISI Web of Science and Journal Citation Reports, applying the truncated search term "orthodon*." Records were manually refined and normalized to unify terms and to remove typographical, transcription, and/or indexing errors.

Results: The 100 most-cited articles were published between 1946 and 2012, with numbers of citations ranging from 115 to 881. Of the 251 authors participating, 87.65% published a single work, while three authors published four works. Most of the authors with several citations were from the United States, although the University of Oslo produced the highest number of frequently cited works. Most of the articles were clinical studies, and the most frequently cited topic was mini-implants. It was noted that self-citation could be a potential cause of bias in bibliometric analysis.

Conclusions: This bibliometric citation analysis reveals new, useful, and interesting information about scientific progress in the field of orthodontics. (*Angle Orthod.* 2018;88:785–796.)

KEY WORDS: Bibliometrics; Citation analysis; Orthodontics

INTRODUCTION

Bibliometrics is defined as "the use of statistical methods in the analysis of a body of literature to reveal the historical development of subject fields and patterns of authorship, publication, and use."[1] In the biomedical field, bibliometric studies are of great interest because they make it possible to gain an overview and to evaluate research and scientific activity by calculating bibliometric indicators, which provide information about the quantity of published research in a specific field. Commonly, the quality of articles is assessed by the number of times an article is cited in other publications. In addition, some indicators, such as the impact factor, the immediacy index, and lists of highly cited articles, can help one to assess the quality and popularity (within a field) of the journal that published the article.[2]

Scientific production in dentistry[3,4] and, more specifically, in orthodontics has undergone a progressive increase due to the increasing demand for scientific knowledge regarding procedures and tools. This has been accompanied by a growing number of scientific journals specializing in orthodontics included in the category of "Dentistry, Oral Surgery and Medicine" in the Journal Citation Reports (JCR; property of Clarivate Analytics, Philadelphia, Pa). Within the "Dentistry, Oral Surgery and Medicine" JCR category, only three journals specialized in orthodontics in 2008, while in 2016, the number had risen to eight, almost triple the previous number.

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Table 1. The 100 Top-Cited Articles in Orthodontics, Ordered by Number of Citations (848–115)[1]

Authors	Title	Journal	N° citations	Citation/ year
Houston, WJ*	The analysis of errors in orthodontic measurements	*American Journal of Orthodontics and Dentofacial Orthopedics* 1983;83(5):382–390	848	24.23
Brook, PH; Shaw, WC	The development of an index of orthodontic treatment priority	*European Journal of Orthodontics* 1989;11(3):309–320	399	13.76
Miyawaki, S; Koyama, I; Inoue, M; Mishima, K; Sugahara, T; Takano-Yamamoto, T	Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage	*American Journal of Orthodontics and Dentofacial Orthopedics* 2003;124(4):373–378	390	26.00
Bergland, O; Semb, G; Abyholm, FE	Elimination of the residual alveolar cleft by secondary bone-grafting and subsequent orthodontic treatment	*Cleft Palate Journal* 1986;23(3):175–205	337	10.53
Jokovic, A; Locker, D; Stephens, M; Kenny, D; Tompson, B; Guyatt, G	Validity and reliability of a questionnaire for measuring child oral-health-related quality of life	*Journal of Dental Research* 2002;81(7):459–463	315	19.68
De Vos, W; Casselman, J; Swennen, GRJ**	Cone-beam computerized tomography (CBCT) imaging of the oral and maxillofacial region: A systematic review of the literature	*International Journal of Oral and Maxillofacial Surgery* 2009;38(6):609–625	285	31.66
Reitan, K	Clinical and histologic observations on tooth movement during and after orthodontic treatment	*American Journal of Orthodontics and Dentofacial Orthopedics* 1967;53(10):721–745	277	5.43
Oreilly, MM; Featherstone, JDB	Demineralization and remineralization around orthodontic appliances—an inv ivo study	*American Journal of Orthodontics and Dentofacial Orthopedics* 1987;92(1):33–40	264	8.51
Little, RM; Wallen, TR; Riedel, RA	Stability and relapse of mandibular anterior alignment—1st premolar extraction cases treated by traditional edgewise orthodontics	*American Journal of Orthodontics and Dentofacial Orthopedics* 1981;80(4):349–365	260	7.02
Umemori, M; Sugawara, J; Mitani, H; Nagasaka, H; Kawamura, H	Skeletal anchorage system for open-bite correction	*American Journal of Orthodontics and Dentofacial Orthopedics* 1999;115(2):166–174	258	13.57
Cheng, SJ; Tseng, IY; Lee, JJ; Kok, SH	A prospective study of the risk factors associated with failure of mini-implants used for orthodontic anchorage	*International Journal of Oral & Maxillofacial Implants* 2004;19(1):100–106	254	18.14
Ogaard, B; Rolla, G; Arends, J	Orthodontic appliances and enamel demineralization. 1. Lesion development	*American Journal of Orthodontics and Dentofacial Orthopedics* 1988;94(1):68–73	248	8.26
Frost, HM	Wolff law and bones structural adaptations to mechanical usage—an overview for clinician	*Angle Orthodontist* 1994;64(3):175–188	247	10.29
Miura, F; Mogi, M; Ohura, Y; Hamanaka, H	The super-elastic property of the japanese niti alloy wire for use in orthodontics	*American Journal of Orthodontics and Dentofacial Orthopedics* 1986;90(1):1–10	240	7.50
Park, HS; Jeong, SH; Kwon, OW	Factors affecting the clinical success of screw implants used as orthodontic anchorage	*American Journal of Orthodontics and Dentofacial Orthopedics* 2006;130(1):18–25	231	19.25
Holdaway, RA	A soft-tissue cephalometric analysis and its use in orthodontic treatment planning. 1.	*American Journal of Orthodontics and Dentofacial Orthopedics* 1983;84(1):1–28	231	6.6
Roberts, WE; Helm, FR; Marshall, KJ; Gongloff, RK	Rigid endosseous implants for orthodontic and orthopedic anchorage	*Angle Orthodontist* 1989;59(4):247–256	212	7.31
Ogaard, B	Prevalence of white spot lesions in 19-year-olds—a study on untreated and orthodontically treated persons 5 years after treatment	*American Journal of Orthodontics and Dentofacial Orthopedics* 1989;96(5):423–427	200	6.89
Newman, GV	Epoxy adhesives for orthodontic attachments—progress report	*American Journal of Orthodontics and Dentofacial Orthopedics* 1965;51(12):901–912	194	3.66
Liou, EJW; Pai, BCJ; Lin, JCY	Do miniscrews remain stationary under orthodontic forces?	*American Journal of Orthodontics and Dentofacial Orthopedics* 2004;126(1):42–47	192	13.71

Table 1. Continued

Authors	Title	Journal	N° citations	Citation/ year
Motoyoshi, M; Hirabayashi, M; Uemura, M; Shimizu, N	Recommended placement torque when tightening an orthodontic mini-implant	*Clinical Oral Implants Research* 2006;17(1):109–114	184	15.33
Wise, GE; King, GJ	Mechanisms of tooth eruption and orthodontic tooth movement	*Journal of Dental Research* 2008;87(5):414–434	181	18.10
Poggio, PM; Incorvati, C; Velo, S; Carano, A	"Safe zones": A guide for miniscrew positioning in the maxillary and mandibular arch	*Angle Orthodontist* 2006;76(2):191–197	181	15.08
Linge, L; Linge, BO	Patient characteristics and treatment variables associated with apical root resorption during orthodontic treatment	*American Journal of Orthodontics and Dentofacial Orthopedics* 1991;99(1):35–43	180	6.66
Kuroda, S; Sugawara, Y; Deguchi, T; Kyung, HM; Takano-Yamamoto, T	Clinical use of miniscrew implants as orthodontic anchorage: Success rates and postoperative discomfort	*American Journal of Orthodontics and Dentofacial Orthopedics* 2007;131(1):9–15	176	16
Deguchi, T; Takano-Yamamoto, T; Kanomi, R; Hartsfield, JK; Roberts, WE; Garetto, LP	The use of small titanium screws for orthodontic anchorage	*Journal of Dental Research* 2003;82(5):377–381	176	11.73
Vastardis, H	The genetics of human tooth agenesis: New discoveries for understanding dental anomalies	*American Journal of Orthodontics and Dentofacial Orthopedics* 2000;117(6):650–656	174	9.66
Nance, HN	The limitations of orthodontic treatment. 1. Mixed dentition diagnosis and treatment	*American Journal of Orthodontics and Oral Surgery–Orthodontics* 1947;33(4):177–223	170	2.39
van Noort, R	The future of dental devices is digital	*Dental Materials* 2012;28(1):3–12	168	28
Baccetti, T; Franchi, L; McNamara, JA	An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth	*Angle Orthodontist* 2002;72(4):316–323	166	10.37
Wilcko, WM; Wilcko, T; Bouquot, JE; Ferguson, DJ	Rapid orthodontics with alveolar reshaping: Two case reports of decrowding	*International Journal of Periodontics & Restorative Dentistry* 2001;21(1):9–19	165	9.70
Levander, E; Malmgren, O	Evaluation of the risk of root resorption during orthodontic treatment—a study of upper incisors	*European Journal of Orthodontics* 1988;10(1):30–38	164	5.46
Davidovitch, Z; Nicolay, OF; Ngan, PW; Shanfeld, JL	Neurotransmitters, cytokines, and the control of alveolar bone remodeling in orthodontics	*Dental Clinics of North America* 1988;32(3):411–435	162	5.40
Baccetti, T	A controlled study of associated dental anomalies	*Angle Orthodontist* 1998;68(3):267–274	160	8.00
Arnett, GW; Bergman, RT	Facial keys to orthodontic diagnosis and treatment planning. 1.	*American Journal of Orthodontics and Dentofacial Orthopedics* 1993;103(4):299–312	160	6.40
Uematsu, S; Mogi, M; Deguchi, T	Interleukin (IL)-1 beta, IL-6, tumor necrosis factor-alpha, epidermal growth factor, and beta(2)-microglobulin levels are elevated in gingival crevicular fluid during human orthodontic tooth movement	*Journal of Dental Research* 1996;75(1):562–567	157	7.13
Ngan, P; Kess, B; Wilson, S	Perception of discomfort by patients undergoing orthodontic treatment	*American Journal of Orthodontics and Dentofacial Orthopedics* 1989;96(1):47–53	156	5.37
Panula, K; Finne, K; Oikarinen, K	Incidence of complications and problems related to orthognathic surgery: A review of 655 patients	*Journal of Oral and Maxillofacial Surgery* 2001;59(10):1128–1136	156	9.17
Frank, CA; Nikolai, RJ	A comparative-study of frictional resistances between orthodontic bracket and arch wire	*American Journal of Orthodontics and Dentofacial Orthopedics* 1980;78(6):593–609	154	4.05
Ren, YJ; Maltha, JC; Kuijpers-Jagtman, AM	Optimum force magnitude for orthodontic tooth movement: A systematic literature review	*Angle Orthodontist* 2003;73(1):86–92	154	10.26

Table 1. Continued

Authors	Title	Journal	N° citations	Citation/ year
Artun, J; Brobakken, BO	Prevalence of carious white spots after orthodontic treatment with multibonded appliances	*European Journal of Orthodontics* 1986;8(4):229–234	154	4.81
Zachrisson, BU	Posttreatment evaluation of direct bonding in orthodontics	*American Journal of Orthodontics and Dentofacial Orthopedics* 1977;71(2):173–189	153	3.73
Meikle, MC	The tissue, cellular, and molecular regulation of orthodontic tooth movement: 100 years after Carl Sandstedt	*European Journal of Orthodontics* 2006;28(3):221–240	151	12.58
Bishara, SE; VonWald, L; Laffoon, JF; Warren, JJ	Effect of a self-etch primer/adhesive on the shear bond strength of orthodontic brackets	*American Journal of Orthodontics and Dentofacial Orthopedics* 2001;119(6):621–624	149	8.76
Wehrbein, H; Merz, BR; Diedrich, P; Glatzmaier, J	The use of palatal implants for orthodontic anchorage—Design and clinical application of the orthosystem	*Clinical Oral Implants Research* 1996;7(4):410–416	149	6.77
Cattaneo, PM; Dalstra, M; Melsen, B	The finite element method: A tool to study orthodontic tooth movement	*Journal of Dental Research* 2005;84(5):428–433	147	11.30
Bishara, SE	Impacted maxillary canines—a review	*American Journal of Orthodontics and Dentofacial Orthopedics* 1992;101(2):159–171	145	5.57
Semb, G	A study of facial growth in patients with unilateral cleft-lip and palate treated by the Oslo CLP team	*Cleft Palate–Craniofacial Journal* 1991;28(1):1–21	145	5.37
Ericson, S; Kurol, J	Resorption of incisors after ectopic eruption of maxillary canines: A CT study	*Angle Orthodontist* 2000;70(6):415–423	143	7.94
Zachrisson, BU	Cause and prevention of injuries to teeth and supporting structures during orthodontic treatment	*American Journal of Orthodontics and Dentofacial Orthopedics* 1976;69(3):285–300	141	3.35
Czochrowska, EM; Stenvik, A; Bjercke, B; Zachrisson, BU	Outcome of tooth transplantation: Survival and success rates 17–41 years posttreatment	*American Journal of Orthodontics and Dentofacial Orthopedics* 2002;121(2):110–119	140	8.75
Scheurer, PA; Firestone, AR; Burgin, WB	Perception of pain as a result of orthodontic treatment with fixed appliances	*European Journal of Orthodontics* 1996;18(4):349–357	140	6.36
Kuroda, S; Yamada, K; Deguchi, T; Hashimoto, T; Kyung, HM; Takano-Yamamoto, T	Root proximity is a major factor for screw failure in orthodontic anchorage	*American Journal of Orthodontics and Dentofacial Orthopedics* 2007;131(4):S68–S73	139	12.63
Paquette, DE; Beattie, JR; Johnston, LE	A long-term comparison of nonextraction and premolar extraction edgewise therapy in borderline Class II patients	*American Journal of Orthodontics and Dentofacial Orthopedics* 1992;102(1):1–14	138	5.30
Brezniak, N; Wasserstein, A	Orthodontically induced inflammatory root resorption. Part I: The basic science aspects	*Angle Orthodontist* 2002;72(2):175–179	138	8.62
Tanne, K; Sakuda, M; Burstone, CJ	3-Dimensional finite-element analysis for stress in the periodontal tissue by orthodontic forces	*American Journal of Orthodontics and Dentofacial Orthopedics* 1987;92(6):499–505	135	4.35
Bell, WH; Epker, BN	Surgical-orthodontic expansion of maxilla	*American Journal of Orthodontics and Dentofacial Orthopedics* 1976;70(5):517–528	135	3.21
Sischo, L; Broder, HL	Oral health-related quality of life: What, why, how, and future implications	*Journal of Dental Research* 2011;90(11):1264–1270	135	19.28
Wataha, JC	Alloys for prosthodontic restorations	*Journal of Prosthetic Dentistry* 2002;87(4):351–363	135	8.43
Bishara, SE; Burkey, PS; Kharouf, JG	Dental and facial asymmetries—a review	*Angle Orthodontist* 1994;64(2):89–98	135	5.62
Ohmae, M; Saito, S; Morohashi, T; Seki, K; Qu, H; Kanomi, R; Yamasaki, K; Okano, T; Yamada, S; Shibasaki, Y	A clinical and histological evaluation of titanium mini-implants as anchors for orthodontic intrusion in the beagle dog	*American Journal of Orthodontics and Dentofacial Orthopedics* 2001;119(5):489–497	133	7.82

Table 1. Continued

Authors	Title	Journal	N° citations	Citation/ year
Boyne, PJ; Sands, NR	Combined orthodontic-surgical management of residual palato-alveolar cleft defects	*American Journal of Orthodontics and Dentofacial Orthopedics* 1976;70(1):20–37	132	3.14
Aboudara, C; Nielsen, I; Huang, JC; Maki, K; Miller, AJ; Hatcher, D	Comparison of airway space with conventional lateral headfilms and 3-dimensional reconstruction from cone-beam computed tomography	*American Journal of Orthodontics and Dentofacial Orthopedics* 2009;135(4):468–479	132	14.66
Saito, M; Saito, S; Ngan, PW; Shanfeld, J; Davidovitch, Z	Interleukin-1-beta and prostaglandin-e are involved in the response of periodontal cells to mechanical-stress in vivo and in vitro	*American Journal of Orthodontics and Dentofacial Orthopedics* 1991;99(3):226–240	132	4.88
Periago, DR; Scarfe, WC; Moshiri, M; Scheetz, JP; Silveira, AM; Farman, AG	Linear accuracy and reliability of cone beam CT derived 3-dimensional images constructed using an orthodontic volumetric rendering program	*Angle Orthodontist* 2008;78(3):387–395	132	13.20
Ogaard, B; Rolla, G; Arends, J; Tencate, JM	Orthodontic appliances and enamel demineralization. 2. Prevention and treatment of lesions	*American Journal of Orthodontics and Dentofacial Orthopedics* 1988;94(2):123–128	132	4.40
Zachrisson, S; Zachrisson, BU	Gingival condition associated with orthodontic treatment	*Angle Orthodontist* 1972;42(1):26–34	131	2.84
Sarver, DM	The importance of incisor positioning in the esthetic smile: The smile arc	*American Journal of Orthodontics and Dentofacial Orthopedics* 2001;120(2):98–111	131	7.70
Burstone, CJ; Pryputniewicz, RJ	Holographic determination of centers of rotation produced by orthodontic forces	*American Journal of Orthodontics and Dentofacial Orthopedics 1980; 77(4): 396–409*	131	3.44
Tweed, CH	The Frankfort-mandibular plane angle in orthodontic diagnosis, classification, treatment planning, and prognosis	*American Journal of Orthodontics and Oral Surgery–Orthodontics* 1946;32(4):175–230	130	1.80
Motoyoshi, M; Yoshida, T; Ono, A; Shimizu, N	Effect of cortical bone thickness and implant placement torque on stability of orthodontic mini-implants	*International Journal of Oral & Maxillofacial Implants* 2007;22(5):779–784	128	11.63
Burstone, CJ; Bai, Q; Morton, JY	Chinese niti wire—a new orthodontic alloy	*American Journal of Orthodontics and Dentofacial Orthopedics* 1985;87(6):445–452	127	3.84
Arnett, GW; Bergman, RT	Facial keys to orthodontic diagnosis and treatment planning. 2.	*American Journal of Orthodontics and Dentofacial Orthopedics* 1993;103(5):395–411	126	5.04
Wennstrom, JL; Lindhe, J; Sinclair, F; Thilander, B	Some periodontal tissue-reactions to orthodontic tooth movement in monkeys	*Journal of Clinical Periodontology* 1987;14(3):121–129	125	4.03
Bays, RA; Greco, JM	Surgically assisted rapid palatal expansion—an outpatient technique with long-term stability	*Journal of Oral and Maxillofacial Surgery* 1992;50(2): 10–113	125	4.80
Michieli, S; Miotti, B	Lengthening of mandibular body by gradual surgical-orthodontic distraction	*Journal of Oral Surgery* 1977;35(3):187–191	123	3.00
Block, MS; Hoffman, DR	A new device for absolute anchorage for orthodontics	*American Journal of Orthodontics and Dentofacial Orthopedics* 1995;107(3):251–258	123	5.59
Geiger, AM; Gorelick, L; Gwinnett, AJ; Benson, BJ	Reducing white spot lesions in orthodontic populations with fluoride rinsing	*American Journal of Orthodontics and Dentofacial Orthopedics* 1992;101(5):403–407	122	4.69
Andreasen, GF; Hilleman, TB	Evaluation of 55 cobalt substituted nitinol wire for use in orthodontics	*Journal of the American Dental Association* 1971;82(6):1373–1375	122	2.59
Alhashimi, N; Frithiof, L; Brudvik, P; Bakhiet, M	Orthodontic tooth movement and de novo synthesis of proinflammatory cytokines	*American Journal of Orthodontics and Dentofacial Orthopedics* 2001;119(3):307–312	122	7.17
Brezniak, N; Wasserstein, A	Root resorption after orthodontic treatment. 2. Literature-review	*American Journal of Orthodontics and Dentofacial Orthopedics* 1993;103(2):138–146	122	4.88

Table 1. Continued

Authors	Title	Journal	N° citations	Citation/ year
Grieve, WG; Johnson, GK; Moore, RN; Reinhardt, RA; Dubois, LM	Prostaglandin-e (pge) and interleukin-1-beta (il-1-beta) levels in gingival crevicular fluid during human orthodontic tooth movement	*American Journal of Orthodontics and Dentofacial Orthopedics* 1994;105(4):369–374	120	5.00
Fuss, Z; Tsesis, I; Lin, S	Root resorption—diagnosis, classification and treatment choices based on stimulation factors	*Dental Traumatology* 2003;19(4):175–182	120	8.00
Mizrahi, E	Enamel demineralization following orthodontic treatment	*American Journal of Orthodontics and Dentofacial Orthopedics* 1982;82(1):62–67	120	3.33
Sameshima, GT; Sinclair, PM	Predicting and preventing root resorption: Part I. Diagnostic factors	*American Journal of Orthodontics and Dentofacial Orthopedics* 2001;119(5):505–510	120	7.05
Kusy, RP	A review of contemporary archwires: Their properties and characteristics	*Angle Orthodontist* 1997;67(3):197–207	120	5.71
Cevidanes, LHS; Bailey, LJ; Tucker, GR; Styner, MA; Mol, A; Phillips, CL; Proffit, WR; Turvey, T	Superimposition of 3D cone-beam CT models of orthognathic surgery patients	*Dentomaxillofacial Radiology* 2005;34(6):369–375	119	9.15
Brezniak, N; Wasserstein, A	Root resorption after orthodontic treatment. 1. Literature-review	*American Journal of Orthodontics and Dentofacial Orthopedics* 1993;103(1):62–66	119	4.76
Geurtsen, W	Biocompatibility of dental casting alloys	*Critical Reviews in Oral Biology & Medicine* 2002;13(1):71–84	118	7.37
Weltman, B; Vig, KWL; Fields, HW; Shanker, S; Kaizar, EE	Root resorption associated with orthodontic tooth movement: A systematic review	*American Journal of Orthodontics and Dentofacial Orthopedics* 2010;137(4):462–476	118	14.75
Thilander, B; Rubio, G; Pena, L; de Mayorga, C	Prevalence of temporomandibular dysfunction and its association with malocclusion in children and adolescents: An epidemiologic study related to specified stages of dental development	*Angle Orthodontist* 2002;72(2):146–154	118	7.37
Glenn, G; Sinclair, PM; Alexander, RG	Nonextraction orthodontic therapy—posttreatment dental and skeletal stability	*American Journal of Orthodontics and Dentofacial Orthopedics* 1987;92(4):321–328	118	3.80
Freudenthaler, JW; Haas, R; Bantleon, HP	Bicortical titanium screws for critical orthodontic anchorage in the mandible: A preliminary report on clinical applications	*Clinical Oral Implants Research* 2001;12(4):358–363	118	6.94
Guerrero, CA; Bell, WH; Contasti, GI; Rodriguez, AM	Mandibular widening by intraoral distraction osteogenesis	*British Journal of Oral & Maxillofacial Surgery* 1997;35(6):383–392	118	5.61
Roberts, WE; Chase, DC	Kinetics of cell-proliferation and migration associated with orthodontically-induced osteogenesis	*Journal of Dental Research* 1981;60(2):174–181	117	3.16
Quimby, ML; Vig, KWL; Rashid, RG; Firestone, AR	The accuracy and reliability of measurements made on computer-based digital models	*Angle Orthodontist* 2004;74(3):298–303	116	8.28
Kokich, VO; Kokich, VG; Kiyak, HA	Perceptions of dental professionals and laypersons to altered dental esthetics: Asymmetric and symmetric situations	*American Journal of Orthodontics and Dentofacial Orthopedics* 2006;130(2):141–151	115	9.58
Ludlow, JB; Laster, WS; See, M; Bailey, LJ; Hershey, HG	Accuracy of measurements of mandibular anatomy in cone beam computed tomography images	*Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology* 2007;103(4):534–542	115	10.45
Buchter, A; Wiechmann, D; Koerdt, S; Wiesmann, HP; Piffko, J; Meyer, U	Load-related implant reaction of mini-implants used for orthodontic anchorage	*Clinical Oral Implants Research* 2005;16(4):473–479	115	8.84
Kravitz, ND; Kusnoto, B	Risks and complications of orthodontic miniscrews	*American Journal of Orthodontics and Dentofacial Orthopedics* 2007;131(4):S43–S51	115	10.45

[1] * Article with the highest total number of citations; ** Article with the highest number of citations per year.

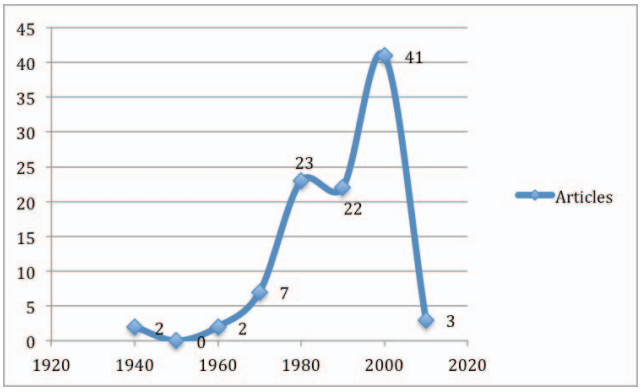

Figure 1. Number of articles per year.

Numerous bibliometric studies have been conducted in different areas of biomedical research to determine the characteristics of the most highly cited articles and to register information about authors, topics, and journals.[5–10] Several bibliometric studies have analyzed the top 100 most-cited articles in dentistry, endodontics, and implant dentistry.[7–9] Each of these articles analyzed citations, authors, countries, and institutions, following different methodologies and searching in different databases according to the field under investigation. In orthodontics, only one bibliometric study has been published,[10] but this only extracted data from three orthodontic journals and did not include bibliometric analysis, the lack of which could be a source of bias.[11] For this reason, the present study set out to identify and perform bibliometric analysis of the 100 most-cited articles in the field of orthodontics, indexed in the Web of Science Category of "Dental, Oral Surgery, and Medicine" from 1946 to 2016.

MATERIALS AND METHODS

The most-cited articles in orthodontics were identified by conducting a database search in the Science Citation Index Expanded of the Web of Science (property of Clarivate Analytics). The search term used was the truncated term "orthodon*," entered in the topic field, with no restrictions regarding the year of publication. The types of retrieved documents were limited to original articles and reviews (article or review), discarding other texts, such as editorials, letters, proceedings, etc. The search was performed on October 16, 2017. The results were sorted according to the number of citations per article, and the first 150 works registered were selected and exported to a text file. This text file was imported into Microsoft Access to create a database. A manual review was then performed by two authors (BT and VPG). Whenever a disagreement arose, a third reviewer (AAA) made the definitive decision. Any articles not related to the field of orthodontics were discarded. After the manual review, only the top 100 most-cited articles were included, discarding the rest.

Subsequently, a manual edit of the Microsoft Access database was made in order to unify terms (authors, institutions) and to remove any typographic or indexing errors. First, author normalization was performed, and whenever it was not clear whether different authors shared the same name, their institutional affiliation was investigated. Similar criteria were applied to normalize institutional data; only macroinstitutions (universities, hospitals, etc) were registered, while departments, research units, etc, were eliminated. After the manual edit, the evaluators established the type (basic, clinical, or review) and the field of study. This analysis was based on information included in the abstract and, if necessary, the whole work.

The following variables were analyzed by two other authors (RLD and AVI): the journal in which the article was published, the year of publication, number of authors, organizations, country of origin, and topic. The abstract of each article was retrieved to manually check its pertinence. The type and field of study were determined according the method described by Fardi et al.[9]

RESULTS

The 100 most-cited articles in orthodontics are shown in Table 1, listed in order according to the total number of citations received and the number of citations per year. As shown in Figure 1, the 100 most-cited articles in orthodontics were published between 1946 and 2012, the first decade of the new millennium being the most productive (41 out of 100 articles). Table 2 shows the 21 scientific journals in which the 100 most-cited articles in orthodontics were published.

The number of authors participating in the 100 most-cited articles was 251; only 31 were responsible for two or more articles (Table 3). The authors of the 100 most-cited articles in orthodontics worked in institutions in 22 different countries (Table 4). The distribution of these countries by continent was as follows: 12 European countries, four American countries, four Asian, one African, and one Australian.

Table 5 shows the 42 institutions that published two or more articles on the list of the 100 most-cited articles in orthodontics. Table 6 shows not only the type of article but also the field of study.

DISCUSSION

When an article appears on the list of the 100 most-cited articles in orthodontics, this supposes that the article has marked a milestone in the development of orthodontics. In theory, the quality of an article is

Table 2. The 21 Journals in Which the Top 100 Cited Articles Were Published (Orthodontic Journals Highlighted in Boldface)[1]

	Journal Title	ISSN	Position (Q)	IP 2016	No. of Articles
1	***American Journal of Orthodontics and Dentofacial Orthopedics***	**0889-5406**	**44/90 (Q2)**	**1.472**	**51**
2	***Angle Orthodontist***	**0003-3219**	**52/90 (Q3)**	**1.366**	**14**
3	*Journal of Dental Research*	0022-0345	2/90 (Q1)	4.755	7
4	***European Journal of Orthodontics***	**0141-5387**	**36/90 (Q2)**	**1.622**	**5**
5	*Clinical Oral Implants Research*	0905-7161	6/90 (Q1)	3.624	4
6	*International Journal of Oral & Maxillofacial Implants*	0882-2786	22/90 (Q1)	2.263	2
7	*Journal of Oral and Maxillofacial Surgery*	0278-2391	31/90 (Q2)	1.916	2
8	*Cleft Palate–Craniofacial Journal*	1055-6656	64/90 (Q3)	1.133	2
9	*British Journal of Oral & Maxillofacial Surgery*	0266-4356	61/90 (Q3)	1.218	1
10	*Critical Reviews in Oral Biology & Medicine**	1045-4411			1
11	*Dental Clinics of North America**	0011-8532			1
12	*Dental Materials*	0109-5641	4/90 (Q1)	4.070	1
13	*Dental Traumatology*	1600-4469	48/90 (Q3)	1.413	1
14	*Dentomaxillofacial Radiology*	0250-832X	38/90 (Q2)	1.594	1
15	*International Journal of Oral and Maxillofacial Surgery*	0901-5027	30/90 (Q2)	1.918	1
16	*International Journal of Periodontics & Restorative Dentistry*	0198-7569	66/90 (Q3)	1.113	1
17	*Journal of Clinical Periodontology*	0303-6979	8/90 (Q1)	3.477	1
18	*Journal of Oral Surgery**	0022-3255			1
19	*Journal of Prosthetic Dentistry*	0022-3913	25/90 (Q2)	2.095	1
20	*Journal of the American Dental Association*	0002-8177	23/90 (Q2)	2.150	1
21	*Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology**	1079-2104			1

[1] * This journal is not in JCR in 2016. Impact Factor (IP), Quartile Position (Q).

Table 3. The 31 Most Common Authors of the Top 100 Cited Articles in Orthodontics

	Author Name	Institution	Country	No. of Articles	As First author	Citation
1	**Takano-Yamamoto, T**	**Tohoku University**	**Japan**	**4**	**0**	**881**
2	**Deguchi, T**	**The Ohio State University**	**United States**	**4**	**1**	**648**
3	**Zachrisson, BU**	**University of Oslo**	**Norway**	**4**	**2**	**565**
4	Ogaard, B	University of Oslo	Norway	3	3	580
5	Roberts, WE	University of the Pacific	United States	3	2	505
6	Ngan, PW	Ohio State University	United States	3	1	450
7	Bishara, SE	University of Iowa	United States	3	3	429
8	Saito, S	Showa University	Japan	3	1	397
9	Burstone, CJ	University of Connecticut	United States	3	2	393
10	Brezniak, N	Israel Defence Forces	Israel	3	3	379
11	Wasserstein, A	Israel Defence Forces	Israel	3	0	379
12	Semb, G	University of Oslo	Norway	2	1	482
13	Mogi, M	Aichi-Gakuin University	Japan	2	0	397
14	Arends, J	University of Groningen	The Netherlands	2	0	380
15	Rolla, G	University of Oslo	Norway	2	0	380
16	Baccetti, T	University of Florence	Italy	2	2	326
17	Kuroda, S	Okayama University	Japan	2	2	315
18	Kyung, HM	Kyungpook National University	Korea	2	0	315
19	Motoyoshi, M	Nihon University	Japan	2	2	312
20	Shimizu, N	Nihon University	Japan	2	0	312
21	Kanomi, R	Tohoku University	Japan	2	0	309
22	Davidovitch, Z	The Ohio State University	United States	2	1	294
23	Shanfeld, JL	University of Pennsylvania	United States	2	0	294
24	Arnett, GW	University of California	United States	2	2	286
25	Bergman, RT	University of California	United States	2	0	286
26	Firestone, AR	The Ohio State University	United States	2	0	256
27	Bell, WH	University of Texas	United States	2	1	253
28	Thilander, B	University of Göteborg	Sweden	2	1	243
29	Sinclair, PM	University of Göteborg	Sweden	2	0	238
30	Bailey, LJ	University of North Carolina	United States	2	0	234
31	Vig, KW	The Ohio State University	United States	2	0	234

Bold type means just the titles.

Table 4. The 22 Countries of Origin of the Authors of the Top 100 Cited Articles in Orthodontics

	Country	No. of Articles	Citation	Citations/Article
1	United States	49	7245	147.86
2	Norway	13	2360	181.54
3	Japan	12	2245	187.08
4	United Kingdom	3	1415	471.66
5	The Netherlands	5	939	187.80
6	Sweden	5	672	134.40
7	Italy	4	630	157.50
8	South Korea	3	546	182.00
9	Israel	4	499	124.75
10	Taiwan	2	446	223.00
11	Germany	3	382	127.33
12	Canada	1	315	315.00
13	Belgium	1	285	285.00
14	Finland	1	156	156.00
15	New Zealand	1	151	151.00
16	Denmark	1	147	147.00
17	Switzerland	1	140	140.00
18	China	1	127	127.00
19	South Africa	1	120	120.00
20	Austria	1	118	118.00
21	Colombia	1	118	118.00
22	Venezuela	1	118	118.00

reflected by its recognition by the scientific community and how it generated change in clinical practice, generated discussion, or triggered new directions in research.[9]

The aims of this bibliometric study were to identify and analyze the 100 most-cited articles in orthodontics indexed in the Web of Science Category of "Dental, Oral Surgery and Medicine" from 1946 to 2016. Bibliometric analysis is the only valid tool for this type of study, as it makes it possible to perform a reliable search in the Science Citation Index (SCI) database and include all potentially valid articles.

The only study[10] published to date to have analyzed the 100 most-cited articles in orthodontics did not include adequate bibliometric analysis and may not have included all of the most-cited papers. The articles included in the earlier analysis were published in only three SCI dental journals.[11] Moreover, the study lacked a predefined search strategy, and its inclusion criteria were such that it may have omitted some articles.[10] The present study adopted a more thorough methodology, using the topic word "orthodon*" to search in the Web of Science and then ranking the articles by the number of citations and applying detailed criteria to the selection process, as recommended by other authors.[11] This bibliometric process was more laborious but may be considered more reliable.

The 100 most-cited articles in orthodontics were cited between 115 and 848 times each (a mean of 169.93); the most cited article was published in 1983.[12] Of the 100 articles, 18 were cited over 200 times, which indicates their high scientific impact. In addition to considering the total number of citations, calculating the number of citations per year also provided useful information, as older works obviously may have received more citations simply because they have been available longer.[12] When the articles were placed in order according to the number of citations per year, a different article from the one receiving the most citations appeared in first place, an article published in 2009.[13] The most-cited article overall received an average of 24.23 citations per year, while the latter received 31.66 citations per year.[13]

Regarding the number of citations per article, these varied between 115 and 399 citations, with the exception of the most-cited article, which received 848 citations. These numbers were similar to the most-cited articles in other fields, such as periodontics, in which the most frequently cited works had between 100 and 346 citations.[14] However, in fields such as cardiology, the numbers of citations are eight or 10 times higher, ranging between 815 and 3932 citations. Such disciplines have higher numbers of scientific journals and more published articles, which may be an indicator of greater research activity in these fields.[5]

The 100 most-cited articles in orthodontics were published between 1946 and 2012, with almost half (44 articles) published since the year 2000. The fact that more recent articles received more citations could also be related to the fact that the total number of articles has increased since the year 2000. The one other similar study only included articles published after 1975, which made it difficult to compare results with the present work, as the two studies covered different periods. In the present study, it was the publication dates of the articles themselves that defined the period analyzed, rather than a decision by the authors.

The 100 most-cited articles were published in a total of 21 scientific journals. Not all of the most-cited articles were published in journals specializing in orthodontics, some being published in journals dealing with other dental specialties, such as surgery, periodontics, or dental materials. This reflects the increasingly multidisciplinary nature of treatment involving orthodontics. The number of scientific journals publishing orthodontic research included in the category of "Dentistry, Oral Surgery and Medicine" in the JCR (property of Clarivate Analytics) has almost tripled, from three in 2008 to eight in 2016. Nevertheless, the list compliled only included three journals specializing in orthodontics alone, which published 70 out of the 100 most-cited articles.

Most of the 251 authors who contributed to the 100 most-cited articles in orthodontics (87.65%, 220 authors) were involved in a single article, 7.97% (7 authors) had two articles, 3.19% (8 authors) three

Table 5. The 42 Institutions of Origin With Two or More Top-Cited Articles

	Institution	No. of Articles	Citation	Citation/Article	Country
1	University of Oslo	10	2107	210.7	Norway
2	**The Ohio State University**	**9**	**1166**	**129.5**	**United States**
3	**University of North Carolina**	**9**	**1073**	**119.2**	**United States**
4	**University of Iowa**	**7**	**925**	**132.14**	**United States**
5	Showa University	6	795	132.5	Japan
6	Okayama University	5	1271	254.2	Japan
7	**St Louis University**	**5**	**760**	**152**	**United States**
8	**University of Washington**	**4**	**671**	**167.75**	**United States**
9	**University of Texas**	**4**	**534**	**133.5**	**United States**
10	Tel Aviv University	4	480	120	Israel
11	General Hospital St Jan Bruges	3	855	285	Belgium
12	Kyungpook National University	3	546	182	South Korea
13	**University of Michigan**	**3**	**498**	**166**	**United States**
14	Nihon University	3	496	165.3	Japan
15	**University of California, Los Angeles**	**3**	**456**	**152**	**United States**
16	**Louisville University**	**3**	**396**	**132**	**United States**
17	University of Nebraska, Medical Center	3	360	120	The Netherlands
18	University College London	2	798	399	United Kingdom
19	University of Toronto	2	630	315	Canada
20	**Eastman Dental Center**	**2**	**528**	**264**	**United States**
21	Tohoku University	2	516	258	Japan
22	National Taiwan University Hospital	2	508	254	Taiwan
23	**South Colorado Clinic**	**2**	**494**	**247**	**United States**
24	Chang Gung University	2	384	192	Taiwan
25	State University Groningen	2	380	190	The Netherlands
26	**Indiana University**	**2**	**352**	**176**	**United States**
27	**University of the Pacific**	**2**	**329**	**164.5**	**United States**
28	National Dental Eastman Institute	2	328	164	Sweden
29	University of Florence	2	326	163	Italy
30	Oulu University Hospital	2	312	156	Finland
31	**New York University**	**2**	**309**	**154.5**	**United States**
32	**Louisiana State University**	**2**	**304**	**152**	**United States**
33	**Cottage Hospital**	**2**	**286**	**143**	**United States**
34	**Loma Linda University**	**2**	**286**	**143**	**United States**
35	**St Francis Hospital**	**2**	**286**	**143**	**United States**
36	**Medical College Georgia**	**2**	**270**	**135**	**United States**
37	Karolinska Institute	2	244	122	Sweden
38	**SUNY Stony Brook University**	**2**	**244**	**122**	**United States**
39	University of Gothenburg	2	243	121.5	Sweden
40	**Baylor College of Dentistry**	**2**	**236**	**118**	**United States**
41	University Vienna	2	236	118	Austria
42	Hannover Medical School	2	233	116.5	Germany

Bold type means just the titles.

articles, and, lastly, 1.2% (3 authors) had four articles. Regarding the latter three authors, T Takano-Yamamoto (Tohoku University, Japan) had the largest number of citations (881), with an article about screws for orthodontic anchorage; T Deguchi (Ohio State University, Columbus, Ohio) had 648 citations, with two articles about orthodontic anchorage and one about dental movement; and BU Zachrisson (University of Oslo, Norway) received the third highest number of citations for three articles on different subjects.

The authors of the 100 most-cited articles in orthodontics came from 22 different countries. Almost half of the most-cited articles (49) were by authors based in the United States, although in terms of the average numbers of citations per article, authors from the UK received the highest mean number per article (471.66 citations).

Forty-two institutions published two or more articles on the list. The University of Oslo (10), The Ohio State University (9), and the University of North Carolina (9) were the three with the most articles that appeared.

Most of the articles cited were clinical studies (69), 18 were systematic literature reviews, and the remaining 13 were of some other (basic) type. The most frequent field of study was microscrews (18 articles), followed by biological and biomechanical studies (15). The topics of the 100 most-cited articles in orthodontics changed over time. Articles from the 1940s (two articles) dealt with topics such as cephalometry and mixed dentition treatment. The 100 most-cited articles

Table 6. Categorization of Articles in Terms of Manuscript Type (Basic, Clinical, or Review) and Field of Study (27 Items)

		Type of Manuscript, No.				
	Field of Study	Basic	Clinical	Review	Total	Citation, No.
1	Adhesion		2	1	3	496
2	Airway		1		1	132
3	Assessing index		2	1	3	849
4	Asymmetries			1	1	135
5	Biomechanics and biology	3	8	4	15	2358
6	Cephalometry	2	1		3	1209
7	Class II treatment		1		1	138
8	Cleft lip and/or palate		3		3	614
9	Corticotomies		1		1	165
10	Demineralizacion		7		7	1240
11	Esthetic smile		1		1	131
12	Facial stetic	1	1		2	286
13	Friction		1		1	154
14	Genetics	1	1		2	334
15	Growth and development	1			1	166
16	**Mini-implants**		**17**	**1**	**18**	**3274**
17	Injuries/discomfort		4		4	568
18	Maxillary canines		1	1	2	288
19	Mixed dentition treatment	1			1	170
20	New technologies		4	2	6	935
21	Orthognathic surgery		5		5	657
22	Perception esthetics		1		1	115
23	Root resoption	1	3	4	8	1081
24	Stability orthodontic treatment		2		2	378
25	Temporomandibular joint		1		1	118
26	Transplanted teeth		1		1	140
27	Wire	3		3	6	862
		13	**69**	18	100	

Bold type means just the titles.

did not include any articles published during the 1950s. Then, during the 1960s (two articles) and 1970s (seven articles), the field of study shifted to topics such as adhesion, biomechanics and biology, cleft lip and/or palate, injuries/discomfort, and orthognathic surgery. During the 1980s (23 articles) and 1990s (22 articles), the field of study expanded to include new topics such as assessment indices, asymmetries, Class II treatment, demineralization, facial esthetics, friction, genetics, implants, maxillary canines, root resorption, and the stability of orthodontic treatment. In the first decade of the new millennium (41 articles), new topics appeared, such as corticotomies, new technologies, temporomandibular joint, transplanted teeth, and numerous articles involving implants. Since 2010, only three articles appeared on the list; their topics were root resorption, new technologies, and assessment indices.

This study had several limitations that should be noted. First, by using the truncated search term "orthodon*," it is possible that some articles may have escaped attention. It was thought that if an article did not include this truncated term in the "Topic" field (Title, Abstract and Keywords), there was only the tiniest possibility that the subject of the article could be related to orthodontics. Additional general terms could have been used in order to increase the reliability of the search, but it is doubtful that this would have identified more articles. The search identified several articles that did not deal with topics related to orthodontics but which included the truncated term in the abstract; these were later discarded. Second, self-citation can be a cause of potential bias in bibliometrics. However, among these 100 articles, the self-citation rate was only 0.6%, which is much lower than the rate reported for articles in general medicine (5.97%).[5] This limitation has been noted by several authors,[15] generating some controversy as to whether counting self-citation is valid or not, as self-citation is an easy means of increasing a journal's "impact" factor.[16,17]

CONCLUSIONS

- This bibliometric citation analysis provided new, useful, and interesting information about scientific progress in the field of orthodontics.
- The 100 most-cited articles were published in a total of 21 scientific journals.
- Most of the articles cited were clinical studies, and the most frequent field of study was microscrews.

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REFERENCES

1. Levine-Clark M, Carter TM. *ALA [Glossary] of Library & Information Science,* 4th ed. Chicago, Ill: American Library Association; 2013.
2. Luo F, Sun A, Erdt M, Raamkumar AS, Theng YL. Exploring prestigious citations sourced from top universities in bibliometrics and altmetrics: a case study in the computer science discipline. *Scientometrics*. 2018: 114(1): 1–17.
3. Jayaratne YS, Zwahlen RA. The evolution of dental journals from 2003 to 2012: a bibliometric analysis. *PLoS One*. 2015;10:e0119503.
4. Tarazona B, Vidal-Infer A, Alonso-Arroyo A. Bibliometric analysis of the scientific production in implantology (2009–2013). *Clin Oral Implants Res*. 2017;28:864–870.
5. Khan MS, Usman MS, Fatima K, Hashmani N, Siddiqi TJ, Riaz H, Khan AR, Khosa F. Characteristics of highly cited articles in interventional cardiology. *Am J Cardiol*. 2017;120:2100–2109.
6. Sweileh WM. Bibliometric analysis of medicine-related publications on refugees, asylum-seekers, and internally displaced people: 2000–2015. *BMC Int Health Hum Rights*. 2017;17:7.
7. Feijoo JF, Limeres J, Fernández-Varela M, Ramos I, Diz P. The 100 most cited articles in dentistry. *Clin Oral Investig*. 2014;18:699–706.
8. Fardi A, Kodonas K, Gogos C, Economides N. Top-cited articles in endodontic journals. *J Endod*. 2011;37:1183–1190.
9. Fardi A, Kodonas K, Lillis T, Veis A. Top-cited articles in implant dentistry. *Int J Oral Maxillofac Implants*. 2017;32:555–564.
10. Hui J, Han Z, Geng G, Yan W, Shao P. The 100 top-cited articles in orthodontics from 1975 to 2011. *Angle Orthod*. 2013;83:491–499.
11. Yan BX. Re: the 100 top-cited articles in orthodontics from 1975 to 2011 by Jifang Hui, Zongkai Han, Guannan Geng, Weijun Yan and Ping Shao. *Angle Orthod*. 2013;83:365.
12. Houston WJ. The analysis of errors in orthodontic measurements. *Am J Orthod*. 1983;83:382–390.
13. De Vos W, Casselman J, Swennen GR. Cone-beam computerized tomography (CBCT) imaging of the oral and maxillofacialregion: a systematic review of the literature. *Int J Oral Maxillofac Surg*. 2009;38:609–625.
14. Nieri M, Saletta D, Guidi L, Buti J, Franceschi D, Mauro S, Pini-Prato G. Citation classics in periodontology: a controlled study. *J Clin Periodontol*. 2007;34:349–358.
15. Corbella S, Francetti L, Taschieri S, Weinstein R, Del Fabbro M. Analysis of the 100 most-cited articles in periodontology. *J Investig Clin Dent*. 2017;8(3): *e12222*.
16. Moustafa K. Aberration of the citation. *Account Res*. 2016;23:230–244.
17. Kulkarni AV, Aziz B, Shams I, Busse JW. Author self-citation in the general medicine literature. *PLoS One*. 2011;6:e20885.