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A bibliometric analysis of the 100 most-cited articles in dental materials journals

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ABSTRACT

Background: Bibliometric studies are important as they provide an overview of research and scientific activity in a specific field. But studies of this type to determine the characteristics of the most cited articles in dental materials journals are completely lacking.

Aim: To analyze the characteristics of 100 most-cited articles in dental materials journals since its inception through April 2019.

Materials and methods: Google scholar database was used to retrieve the list of journals titled with the term "dental materials". A search was then conducted under "Publication Name" for each of the selected journals, and the articles were grouped by the category "Times Cited". The 100 highly cited papers published in five journals were contemplated in the eventual inquiry. The final collection was subjected to further scrutiny to determine the nature and characteristics of the documented revelations regard to journal name, year of publication, authors and their country, type of article, and area of research.

Results: The 100 most-cited articles were published between 1985 and 2016 with maximum publications during 2001-05. The number of citations was ranging from 1926to 304. Only Dental Materials (97), Dental Materials Journal (3), shared the list. The United States tops the list with 25 articles followed by Germany (12) and Belgium (11). Dental composites and adhesives were the most commonly addressed topics in dental materials journals.

Conclusion: This bibliometric analysis connoted the evolving and interesting research trends in dental material science.

1. Introduction

The field of dental materials has undergone more of a revolution than an evolution over the past 100 years [1]. Since then, it has acknowledged a good deal interest among clinicians and researchers by showing a shift from traditional silver amalgam to E-max restorations and from Ni-Cr-Co crowns to CAD-CAM zirconium crowns with a lot of innovations in dental materials [2]. The published

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literature in dental materials science is vast and, although easily accessible, clinicians, and researchers may not always assess the quality of publications that they read. Moreover, areas in which research has made dramatic progress may be difficult to identify, the challenge of identifying eminent research from among the multitude of journals and publications remains [3].

The citation index is broadly looked at as a necessary framework to adopt in the context of measuring relevance in scientific production [4,5]. The immensity and citations count received by an article does not embody the nature of its importance in the field of knowledge but cultivates and paves a stronger platform for exploring discourse in clinical practice, scientific assimilation, and furtherance of research in that particular field [5]. In this regard, bibliometric studies are of importance as they enable us to gain an overview and evaluate the intrinsic characteristics of published research in a particular field [6].

Numerous bibliometric studies have been conducted in different areas of material science. Kochhar examined the scientific literature from Indian institutions in various types of materials such as metals and alloys, ceramics, aluminum, glass, composites, polymers during 1980-83 [7]. The growth and size of the publication in the field of material science from 1993-2001 were analyzed by Walke and Dhawan [8]. Recently, a study was conducted to investigate the research and impact of materials science literature for the period of 1999-2008 [9]. However, no systematic investigations of this type have yet been published in the field of dental materials science.

As the practice of dentistry is defined by the current and future developments in the science of dental materials, the aim of this study was, therefore, to analyze the characteristics of 100 most-cited articles in dental materials journals.

2. Materials and methods

In April 2019, we conducted a search using Google Scholar Database to spot the most cited articles in dental material journals. In Google Scholar's metrics section, journals with titles containing the word "dental material" were searched from the publications catalogue. The following six journals were filtered:

i. Dental Materials
ii. Dental Materials Journal
iii. Journal of Dental Materials and Techniques
iv. The Journal of the Japanese Society for Dental Materials and Devices
v. Journal of Dental Biomaterials
vi. International Journal of Dental Materials

Only articles published in the English language were considered in the analysis. For this reason, the articles published in "The Journal of the Japanese Society for Dental Materials and Devices" were excluded as they were in the Japanese language. Then, all the articles published in the remaining five journals were grouped by category; "Times Cited" under "Publication Name". This provides a list of articles published in a given journal from the date of the first issue published until 30th April 2019, listed by citation count.

The final collection was assessed independently by two reviewers for the following characteristics: citation count, journal name, year of publication, authors affiliation, type of article (review articles, original articles, and systematic reviews/meta-analysis) and area of research (dental adhesives, dental cements, synthetic resins, dental alloys, dental ceramics, root canal filling materials, dental impression materials, dental implants, etc.) Only the first author/ corresponding author affiliation was considered in the analysis. The highest citation density parameter arranged the order of articles that have similar citation counts. A third reviewer's opinion was sought to obtain solidarity when there was disagreement. Descriptive statistics on the characteristics of the most cited articles were undertaken. Data analysis was performed using the Statistical Package for Social Sciences (SPSS, Version 18.0; IBM, Armonk, NY).

3. Results

Table 1 shows the list of 100 most-cited articles in dental materials journals until April 2019. The number of citations ranges from 1926 to 304. The first seven articles of the ranking exceeded 1,000 citations, and each of the first 36 had more than 500 citations. The most-cited paper to date in dental materials science is on "Surface treatments of titanium dental implants for rapid osseointegration" published in "dental materials" in 2007 (Table 1).

The 100 most-cited articles were published in only two

Table 1: List of the100 most-cited articles in dental materials journals

S. No.	Article	Number of Citations
1	Le Guéhennec L, Soueidan A, Layrolle P, Amouriq Y. Surface treatments of titanium dental implants for rapid osseointegration. Dent mater. 2007 Jul 1;23(7):844-54.	1926
2	Denry I, Kelly JR. State of the art of zirconia for dental applications. Dent Mater. 2008 Mar 1; 24(3):299-307.	1585
3	Ferracane JL. Resin composite—state of the art. Dent Mater. 2011 Jan 1;27(1):29-38.	1238
4	Bollenl CM, Lambrechts P, Quirynen M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: a review of the literature. Dent Mater. 1997 Jul 1;13(4):258-69.	1175
5	Breschi L, Mazzoni A, Ruggeri A, Cadenaro M, Di Lenarda R, Dorigo ED. Dental adhesion review: aging and stability of the bonded interface. Dent Mater. 2008 Jan 1;24(1):90-101.	1145
6	Sano H, Shono T, Sonoda H, Takatsu T, Ciucchi B, Carvalho R, Pashley DH. Relationship between surface area for adhesion and tensile bond strength—evaluation of a micro-tensile bond test. Dent Maters. 1994;10(4):236-40.	1094
7	Ferracane JL. Hygroscopic and hydrolytic effects in dental polymer networks. Dent Mater. 2006;22(3):211-22.	1014
8	Peumans M, Kanumilli P, De Munck J, Van Landuyt K, Lambrechts P, Van Meerbeek B. Clinical effectiveness of contemporary adhesives: a systematic review of current clinical trials. Dent Mater. 2005 Sep 1;21(9):864-81.	951
9	Van Meerbeek B, Yoshihara K, Yoshida Y, Mine AJ, De Munck J, Van Landuyt KL. State of the art of self-etch adhesives. Dent Mater. 2011 Jan 1;27(1):17-28.	918
10	Kern M, Wegner SM. Bonding to zirconia ceramic: adhesion methods and their durability. Dent Mater. 1998 Jan 1;14(1):64-71.	877
11	Guazzato M, Albakry M, Ringer SP, Swain MV. Strength, fracture toughness and microstructure of a selection of all -ceramic materials. Part II. Zirconia-based dental ceramics. Dent Mater. 2004 Jun 1;20(5):449-56.	873
12	Tay FR, Pashley DH. Aggressiveness of contemporary self-etching systems: I: Depth of penetration beyond dentin smear layers. Dent Mater. 2001 Jul 1;17(4):296-308.	857
13	Kosmač T, Oblak C, Jevnikar P, Funduk N, Marion L. The effect of surface grinding and sandblasting on flexural strength and reliability of Y-TZP zirconia ceramic. Dent Mater. 1999 Nov 1;15(6):426-33.	821
14	Ruyter IE, Nilner K, Möller B. Color stability of dental composite resin materials for crown and bridge veneers. Dent Mater. 1987 Oct 1;3(5):246-51.	799
15	Kelly JR, Denry I. Stabilized zirconia as a structural ceramic: an overview. Dent Mater. 2008 Mar 1;24(3):289-98.	791
16	Weinmann W, Thalacker C, Guggenberger R. Siloranes in dental composites. Dent Mater. 2005 Jan 1;21(1):68-74.	771
17	Labella R, Lambrechts P, Van Meerbeek B, Vanherle G. Polymerization shrinkage and elasticity of flowable composites and filled adhesives. Dent Mater. 1999 Mar 1;15(2):128-37.	758
18	De Munck J, Vargas M, Van Landuyt K, Hikita K, Lambrechts P, Van Meerbeek B. Bonding of an auto-adhesive luting material to enamel and dentin. Dent Mater. 2004 Dec 1;20(10):963-71.	729
19	Pashley DH, Sano H, Ciucchi B, Yoshiyama M, Carvalho RM. Adhesion testing of dentin bonding agents: a review. Dent Mater. 1995 Mar 1;11(2):117-25.	728
20	Pashley DH, Tay FR, Breschi L, Tjäderhane L, Carvalho RM, Carrilho M, Tezvergil-Mutluay A. State of the art etch-and-rinse adhesives. Dent Mater. 2011 Jan 1;27(1):1-6.	697
21	Pashley DH, Tay FR. Aggressiveness of contemporary self-etching adhesives: Part II: etching effects on unground enamel. Dent Mater. 2001 Sep 1;17(5):430-44.	696
22	Miyazaki T, Hotta Y, Kunii J, Kuriyama S, Tamaki Y. A review of dental CAD/CAM: current status and future perspectives from 20 years of experience. Dent Mater J. 2009;28(1):44-56.	689
23	Bouillaguet S, Troesch S, Wataha JC, Krejci I, Meyer JM, Pashley DH. Microtensile bond strength between adhesive cements and root canal dentin. Dent Mater. 2003 May 1;19(3):199-205.	674
24	Ferracane JL. Correlation between hardness and degree of conversion during the setting reaction of unfilled dental restorative resins. Dent Mater. 1985 Feb 1;1(1):11-4.	665
25	Özcan M, Vallittu PK. Effect of surface conditioning methods on the bond strength of luting cement to ceramics. Dent Mater. 2003 Dec 1;19(8):725-31.	660
26	Wiegand A, Buchalla W, Attin T. Review on fluoride-releasing restorative materials—fluoride release and uptake characteristics, antibacterial activity and influence on caries formation. Dent Mater. 2007 Mar 1;23(3):343-62.	657
27	Moszner N, Salz U, Zimmermann J. Chemical aspects of self-etching enamel–dentin adhesives: a systematic review. Dent Mater. 2005 Oct 1;21(10):895-910.	639
28	Van Noort R. The future of dental devices is digital. Dent Mater. 2012 Jan 1;28(1):3-12.	632
29	Braga RR, Ballester RY, Ferracane JL. Factors involved in the development of polymerization shrinkage stress in resin-composites: a systematic review. Dent Mater. 2005 Oct 1;21(10):962-70.	620

Table 1: Continued..,

S. No.	Article	Number of Citations
30	Van Meerbeek B, Peumans M, Poitevin A, Mine A, Van Ende A, Neves A, De Munck J. Relationship between bond-strength tests and clinical outcomes. Dent Mater. 2010 Feb 1;26(2):e100-21.	590
31	Demarco FF, Corrêa MB, Cenci MS, Moraes RR, Opdam NJ. Longevity of posterior composite restorations: not only a matter of materials. Dent Mater. 2012 Jan 1;28(1):87-101.	555
32	Jacobsen T, Söderholm KJ. Some effects of water on dentin bonding. Dent Mater. 1995 Mar 1;11(2):132-6.	542
33	Malacarne J, Carvalho RM, Mario F, Svizero N, Pashley DH, Tay FR, Yiu CK, de Oliveira Carrilho MR. Water sorption/solubility of dental adhesive resins. Dent Mater. 2006 Oct 1;22(10):973-80.	526
34	Asmussen E, Peutzfeldt A. Influence of UEDMA, BisGMA and TEGDMA on selected mechanical properties of experimental resin composites. Dent Mater. 1998 Jan 1;14(1):51-6.	519
35	Camilleri J, Montesin FE, Brady K, Sweeney R, Curtis RV, Ford TR. The constitution of mineral trioxide aggregate. Dent Mater. 2005 Apr 1;21(4):297-303.	513
36	Kleverlaan CJ, Feilzer AJ. Polymerization shrinkage and contraction stress of dental resin composites. Dent Mater. 2005 Dec 1;21(12):1150-7.	507
37	Hikita K, Van Meerbeek B, De Munck J, Ikeda T, Van Landuyt K, Maida T, Lambrechts P, Peumans M. Bonding effectiveness of adhesive luting agents to enamel and dentin. Dent Mater. 2007 Jan 1;23(1):71-80.	497
38	Roberts HW, Toth JM, Berzins DW, Charlton DG. Mineral trioxide aggregate material use in endodontic treatment: a review of the literature. Dent Mater. 2008 Feb 1;24(2):149-64.	486
39	Wolfart M, Lehmann F, Wolfart S, Kern M. Durability of the resin bond strength to zirconia ceramic after using different surface conditioning methods. Dent Mater. 2007 Jan 1;23(1):45-50.	483
40	Nakabayashi N, Takarada K. Effect of HEMA on bonding to dentin. Dent Mater. 1992 Mar 1;8(2):125-30.	477
41	Ferracane JL. Developing a more complete understanding of stresses produced in dental composites during polymerization. Dent Mater. 2005 Jan 1;21(1):36-42.	477
42	Silikas N, Eliades G, Watts DC. Light intensity effects on resin-composite degree of conversion and shrinkage strain. Dent Mater. 2000 Jul 1;16(4):292-6.	474
43	Lassila LV, Tanner J, Le Bell AM, Narva K, Vallittu PK. Flexural properties of fiber reinforced root canal posts. Dent Mater. 2004 Jan 1;20(1):29-36.	473
44	Xie D, Brantley WA, Culbertson BM, Wang G. Mechanical properties and microstructures of glass-ionomer cements. Dent Mater. 2000 Mar 1;16(2):129-38.	471
45	Willems G, Lambrechts P, Braem M, Celis JP, Vanherle G. A classification of dental composites according to their morphological and mechanical characteristics. Dent Mater. 1992 Sep 1;8(5):310-9.	465
46	Buchalla W, Attin T. External bleaching therapy with activation by heat, light or laser—a systematic review. Dent Mater. 2007 May 1;23(5):586-96.	457
47	Beun S, Glorieux T, Devaux J, Vreven J, Leloup G. Characterization of nanofilled compared to universal and microfilled composites. Dent Mater. 2007 Jan 1;23(1):51-9.	450
48	Pest LB, Cavalli G, Bertani P, Gagliani M. Adhesive post-endodontic restorations with fiber posts: push-out tests and SEM observations. Dent Mater. 2002 Dec 1;18(8):596-602.	445
49	Stansbury JW, Dickens SH. Determination of double bond conversion in dental resins by near infrared spectroscopy. Dent Mater. 2001 Jan 1;17(1):71-9.	442
50	Guazzato M, Albakry M, Ringer SP, Swain MV. Strength, fracture toughness and microstructure of a selection of all -ceramic materials. Part I. Pressable and alumina glass-infiltrated ceramics. Dent Mater. 2004 Jun 1;20(5):441-8.	436
51	Jandt KD, Mills RW, Blackwell GB, Ashworth SH. Depth of cure and compressive strength of dental composites cured with blue light emitting diodes (LEDs). Dent Mater. 2000 Jan 1;16(1):41-7.	429
52	Lughi V, Sergo V. Low temperature degradation-aging-of zirconia: A critical review of the relevant aspects in dentistry. Dent Mater. 2010 Aug 1;26(8):807-20.	414
53	Thompson JY, Stoner BR, Piascik JR, Smith R. Adhesion/cementation to zirconia and other non-silicate ceramics: where are we now?. Dent Mater. 2011 Jan 1;27(1):71-82.	409
54	Dammaschke T, Gerth HU, Züchner H, Schäfer E. Chemical and physical surface and bulk material characterization of white ProRoot MTA and two Portland cements. Dent Mater. 2005 Aug 1;21(8):731-8.	407
55	Scherrer SS, Cesar PF, Swain MV. Direct comparison of the bond strength results of the different test methods: a critical literature review. Dent Mater. 2010 Feb 1;26(2):e78-93.	406
56	Kawahara K, Tsuruda K, Morishita M, Uchida M. Antibacterial effect of silver-zeolite on oral bacteria under anaerobic conditions. Dent Mater. 2000 Nov 1;16(6):452-5.	406
57	Van Meerbeek B, Van Landuyt K, De Munck J, Hashimoto M, Peumans M, Lambrechts P, Yoshida Y, Inoue S, Suzuki K. Technique-sensitivity of contemporary adhesives. Dent Mater J. 2005;24(1):1-3.	405
58	Imazato S. Antibacterial properties of resin composites and dentin bonding systems. Dent Mater. 2003 Sep 1;19 (6):449-57.	398

Table 1: Continued..,

S. No.	Article	Number of Citations
59	Sarrett DC. Clinical challenges and the relevance of materials testing for posterior composite restorations. Dent Mater. 2005 Jan 1;21(1):9-20.	398
60	Aboushelib MN, Kleverlaan CJ, Feilzer AJ. Microtensile bond strength of different components of core veneered all -ceramic restorations: Part II: Zirconia veneering ceramics. Dent Mater. 2006 Sep 1;22(9):857-63.	394
61	Manhart J, Kunzelmann KH, Chen HY, Hickel R. Mechanical properties and wear behavior of light-cured packable composite resins. Dent Mat. 2000 Jan 1;16(1):33-40.	393
62	Aboushelib MN, De Jager N, Kleverlaan CJ, Feilzer AJ. Microtensile bond strength of different components of core veneered all-ceramic restorations. Dent Mater. 2005 Oct 1;21(10):984-91.	393
63	Opdam NJ, Bronkhorst EM, Roeters JM, Loomans BA. A retrospective clinical study on longevity of posterior composite and amalgam restorations. Dent Mater. 2007 Jan 1;23(1):2-8.	391
64	Frankenberger R, Perdigao J, Rosa BT, Lopes M. 'No-bottle'vs 'multi-bottle'dentin adhesives—a microtensile bond strength and morphological study. Dent Mater. 2001 Sep 1;17(5):373-80.	390
65	Ferracane JL, Condon JR. Rate of elution of leachable components from composite. Dent Mater. 1990;6(4):282-7.	388
66	Ausiello P, Apicella A, Davidson CL. Effect of adhesive layer properties on stress distribution in composite restorations—a 3D finite element analysis. Dent Mater. 2002 Jun 1;18(4):295-303.	381
67	Attin T, Hannig C, Wiegand A, Attin R. Effect of bleaching on restorative materials and restorations—a systematic review. Dent Mater. 2004 Nov 1;20(9):852-61.	377
68	Sanares AM, Itthagarun A, King NM, Tay FR, Pashley DH. Adverse surface interactions between one-bottle light-cured adhesives and chemical-cured composites. Dent Mater. 2001 Nov 1;17(6):542-56.	377
69	Tay FR, Gwinnett JA, Wei SH. Micromorphological spectrum from overdrying to overwetting acid-conditioned dentin in water-free, acetone-based, single-bottle primer/adhesives. Dent Mater. 1996 Jul 1;12(4):236-44.	375
70	Dietschi D, Campanile G, Holz J, Meyer JM. Comparison of the color stability of ten new-generation composites: an in vitro study. Dent Mater. 1994 Nov 1;10(6):353-62.	369
71	Zarone F, Russo S, Sorrentino R. From porcelain-fused-to-metal to zirconia: clinical and experimental considerations. Dent Mater. 2011 Jan 1;27(1):83-96.	369
72	Gerth HU, Dammaschke T, Züchner H, Schäfer E. Chemical analysis and bonding reaction of RelyXUnicem and Bifix composites—a comparative study. Dent Mater. 2006 Oct 1;22(10):934-41.	363
73	Ertas E, Gueler AU, Yuecel AC, Koepruelue H, Gueler E. Color stability of resin composites after immersion in different drinks. Dent Mater J. 2006;25(2):371-6.	362
74	Feilzer AJ, De Gee AJ, Davidson CL. Quantitative determination of stress reduction by flow in composite restorations. Dent Mater. 1990 Jul 1;6(3):167-71.	359
75	Schmalz G, Garhammer P. Biological interactions of dental cast alloys with oral tissues. Dent Mater. 2002 Jul 1;18 (5):396-406.	358
76	Lüthy H, Loeffel O, Hammerle CH. Effect of thermocycling on bond strength of luting cements to zirconia ceramic. Dent Mater. 2006 Feb 1;22(2):195-200.	354
77	Goldberg AJ, Burstone CJ. The use of continuous fiber reinforcement in dentistry. Dent Mater. 1992;8(3):197-202.	351
78	Lim BS, Ferracane JL, Sakaguchi RL, Condon JR. Reduction of polymerization contraction stress for dental composites by two-step light-activation. Dent Mater. 2002 Sep 1;18(6):436-44.	345
79	Sundh A, Molin M, Sjögren G. Fracture resistance of yttrium oxide partially-stabilized zirconia all-ceramic bridges after veneering and mechanical fatigue testing. Dent Mater. 2005 May 1;21(5):476-82.	342
80	Watts DC, Cash AJ. Determination of polymerization shrinkage kinetics in visible-light-cured materials: methods development. Dent Mater. 1991 Oct 1;7(4):281-7.	339
81	Oliveira SS, Pugach MK, Hilton JF, Watanabe LG, Marshall SJ, Marshall Jr GW. The influence of the dentin smear layer on adhesion: a self-etching primer vs. a total-etch system. Dent Mater. 2003 Dec 1;19(8):758-67.	339
82	Vichi A, Ferrari M, Davidson CL. Color and opacity variations in three different resin-based composite products after water aging. Dent Mater. 2004 Jul 1;20(6):530-4.	336
83	Lovell LG, Lu H, Elliott JE, Stansbury JW, Bowman CN. The effect of cure rate on the mechanical properties of dental resins. Dent Mater. 2001 Nov 1;17(6):504-11.	335
84	Lung CY, Matinlinna JP. Aspects of silane coupling agents and surface conditioning in dentistry: an overview. Dent Mater. 2012 May 1;28(5):467-77.	333
85	Breschi L, Mazzoni A, Nato F, Carrilho M, Visintini E, Tjäderhane L, Ruggeri Jr A, Tay FR, Dorigo ED, Pashley DH. Chlorhexidine stabilizes the adhesive interface: a 2-year in vitro study. Dent Mater. 2010 Apr 1;26(4):320-5.	331
86	Lanza A, Aversa R, Rengo S, Apicella D, Apicella A. 3D FEA of cemented steel, glass and carbon posts in a maxillary incisor. Dent Mater. 2005 Aug 1;21(8):709-15.	327
87	Luthardt RG, Holzhüter MS, Rudolph H, Herold V, Walter MH. CAD/CAM-machining effects on Y-TZP zirconia. Dent Mater. 2004 Sep 1;20(7):655-62.	326

Table 1: Continued..,

S. No.	Article	Number of Citations
88	Perdigão J. Dentin bonding—Variables related to the clinical situation and the substrate treatment. Dent Mater. 2010 Feb 1;26(2):e24-37.	323
89	Ardlin BI. Transformation-toughened zirconia for dental inlays, crowns and bridges: chemical stability and effect of low-temperature aging on flexural strength and surface structure. Dent Mater. 2002 Dec 1;18(8):590-5.	322
90	Halvorson RH, Erickson RL, Davidson CL. Energy dependent polymerization of resin-based composite. Dent Mater. 2002 Sep 1;18(6):463-9.	322
91	Traini T, Mangano C, Sammons RL, Mangano F, Macchi A, Piattelli A. Direct laser metal sintering as a new approach to fabrication of an isoelastic functionally graded material for manufacture of porous titanium dental implants. Dent Mater. 2008 Nov 1;24(11):1525-33.	320
92	Stansbury JW, Idacavage MJ. 3D printing with polymers: Challenges among expanding options and opportunities. Dent Mater. 2016 Jan 1;32(1):54-64.	316
93	Ørstavik D, Nordahl I, Tibballs JE. Dimensional change following setting of root canal sealer materials. Dent Mater. 2001 Nov 1;17(6):512-9.	310
94	Koibuchi H, Yasuda N, Nakabayashi N. Bonding to dentin with a self-etching primer: the effect of smear layers. Dent Mater. 2001 Mar 1;17(2):122-6.	308
95	Frankenberger R, Tay FR. Self-etch vs etch-and-rinse adhesives: effect of thermo-mechanical fatigue loading on marginal quality of bonded resin composite restorations. Dent Mater. 2005 May 1;21(5):397-412.	308
96	Braem M, Finger W, Van Doren VE, Lambrechts P, Vanherle G. Mechanical properties and filler fraction of dental composites. Dent Mater. 1989 Sep 1;5(5):346-9.	308
97	Laurent P, Camps J, De Méo M, Déjou J, About I. Induction of specific cell responses to a Ca3SiO5-based posterior restorative material. Dent Mater. 2008 Nov 1;24(11):1486-94.	306
98	Bottino MC, Thomas V, Schmidt G, Vohra YK, Chu TM, Kowolik MJ, Janowski GM. Recent advances in the development of GTR/GBR membranes for periodontal regeneration—a materials perspective. Dent Mater. 2012 Jul 1;28 (7):703-21.	305
99	Armstrong S, Geraldeli S, Maia R, Raposo LH, Soares CJ, Yamagawa J. Adhesion to tooth structure: a critical review of "micro" bond strength test methods. Dent Mater. 2010 Feb 1;26(2):e50-62.	304
100	De Gee AJ, Feilzer AJ, Davidson CL. True linear polymerization shrinkage of unfilled resins and composites determined with a linometer. Dent Mater. 1993 Jan 1;9(1):11-4.	304

journals. The journal with the most significant number of articles cited was "dental materials" with 97 articles, followed by "dental materials journal" with three articles. Three journals did not have an article from the top 100 (Table 2).

Among the list, 40 articles were published during 2001-05, followed by2006-2010 with 25 articles. The most popular articles were original articles (65) and review articles (30). The predominant area of research in dental materials science was dental composites (42), dental adhesives (30) followed by research on ceramics (19). The majority of the articles were published from the United States (25), Germany (12) followed by Belgium (11). In quantitative terms, the author, with most articles (irrespective of whether they were corresponding or co-authors), was Pashley DH (9 articles) followed by Lambrechts Pand Tay FR (8 articles each). A total of 54 authors from 19 countries have contributed to citation classics in dental material science (Table 3).

4. Discussion

To the best of our knowledge, this is the first of its kind to explore the 100 most-cited articles in dental material journals. A bibliometric study of the most widely cited publications helps the discipline to identify important advances. It also offers us a longitudinal view of the speciality's conceptual development and identifies the scientific indicators in a particular area that may be behind the journals, researchers, institutions, or nations [10]. The current list of 100 most cited articles is considered classic because each of them had earned over 300 citations [11]. The number was greater for articles in the field of endodontics, which counts between 554 and 87 citations [12]. It was also much higher than orthodontic research, which ranged from 545 to 89 [4]. The citations are on par with articles published in periodontics, which ranged from 2307 to 229 [13]. Hence, it may be said that the amount of research in dental material science is much greater than endodontics and orthodontics.

Table 2: Distribution of the 100 most-cited articles in dental material journals.

Sl. No	Name of the journal	No. of articles	Scimago Journal metrics	Country, publisher, and Year of origin
1	Dental Materials	97	H index: 123 SJR 2017: 2.11	Netherlands, Elsevier, 1985.
2	Dental Materials Journal	03	H index: 47 SJR 2017: 0.57	Japan, Japanese Society for Dental Materials and Devices, 1988.
3	Journal of Dental Materials and Techniques	00	-	Iran, Mashhad University of Medical Sciences, 2012.
4	Journal of Dental Biomaterials	00	-	Iran, Shiraz University of Medical Sciences, 2014.
5	International Journal of Dental Materials	00	-	India, International Journal of Dental Materials, 2019.

Table 3: Characteristics of the 100 most-cited articles in dental material journals

	Characteristics	Number of articles
Year of publication	1985-1990	05
	1991-1995	09
	1996-2000	11
	2001-2005	40
	2006-2010	25
	2011-2015	09
	2015- to date	01
Type of article	Review articles	30
	Original articles	65
	Systematic reviews	05
Area of research	Dental composites	42
	Dental adhesives	30
	Dental ceramics	19
	Dental cements	09
	Endodontic materials	08
	Dental alloys	06
	Dental synthetic resins	03
	Dental implants	02
	Other materials	03
Country	USA	25
	Germany	12
	Belgium	11
	Italy	09
	Netherlands	08
	Japan	06
	UK	05
	Switzerland	04
	Sweden, Brazil	03
	Denmark, Norway, France, Australia,China	02
	Turkey, Slovenia, Finland, Liechtenstein	01
Authors	Pashley DH	09
	Lambrechts P, Tay FR	08
	Ferracane JL,VanMeerbeek B	07
	De Munck J	06
	Van Landuyt K,Feilzer AJ, Davidson CL	05
	Peumans M	04

The present analysis witnessed that the "dental material" journal alone had a more significant share with a meager contribution from “dental material journal”. It was also noted that journals with a higher H index contributed to the top 100. This indicates the researcher’s propensity to cite articles published in strong metric journals. The year of publication of an article matters for reasons for an increasing number of citations over time [10]. Typically, it is not cited until one or two years after publication, reaches a limit after three or ten years, then decreases [14]. This accounts for a minimum number of articles in the top 100 from the year 2015 onwards.

The research in dental material science was centered on dental composites with 40 articles from the top 100. With the introduction of usage of hybrid composites for rehabilitation in the 1980s, there has been an increase in the number of citations for research on composite materials [15]. The revolution in adhesive dentistry during the 1980s and 90s led to the maximum citations for research on dental adhesives [16]. Research on ceramics had swiftly increased in the 1990s and is continuing till date with the introduction of new techniques. Hence from this analysis, it is understood that with the dawning of a new field of study in each decade, research on those recent advances was more cited in comparison to other fields.

Interestingly, only two articles were related to dental implants; however, the research on dental implants is high on the other end. This could be possible that the research on dental implants is being published more widely in other journals than in dental material journals. In recent years, the interest in systematic reviews, their production, and their publication, has been growing as they became foundational to evidence-based dental practice [17,18]. But only 5% of the top 100 articles are systematic reviews. This indicates a paucity and needs for systematic reviews and Meta-analysis in focused areas of dental material science.

Our geographic analysis concurs with previously published data on highly cited articles in health research. The most-cited dental material research is concentrated exclusively in North America and Western Europe. A similar trend has been observed in citation analysis of other dental fields like Endodontics [12], Periodontology [13], implantology [19], and orthodontics [20] as well as in other medical specialities [21-24]. This phenomenon can be explained in part by an accumulative geographical advantage, as citations come more frequently from institutions based in the same country [20]. Another possible cause is the movement of eminent scholars from various parts of the world to these regions [21]. These results reflect the disproportionate impact of the United States on dental material science due to eminent scholars and the financial support provided to them [25].

The present study has a few limitations, along with the inherent problems of citation analysis. Bibliometric analysis, as with any method chosen, does not cover the entirety of scientific production. This is considered to be an important limitation of the present study as our search strategy did not identify articles published in other journals. These articles could not be included in the analysis, as it will be impractical to isolate them from among the innumerable journals. Self-citations and negative citations need to be considered for a meritorious analysis. It is often a common trend to cite the articles that were already cited many times or based on a popularity scale without any understanding of their current relevance and applicability. Finally, the study results need to be dealt with caution as the citation rates may be biased towards top-ranked journals and well-known scholars and can't be used for comparisons. We, therefore, think, how highly cited papers can yield to less biased measures that can complement citation rates.

5. Conclusions

The present bibliometric study provided valuable insights into the characteristics of highly cited articles in dental material journals. The 100 most-cited articles are considered important as they can provide information on advances, areas of most intense research and the future objectives in the field of dental material science.

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