IRIS AperTO

UNIVERSITÀ DEGLI STUDI DI TORINO

AperTO - Archivio Istituzionale Open Access dell'Università di Torino

The 50 most-cited articles on clear aligner treatment: A bibliometric and visualized analysis

This is a pre print version of the following article:

Original Citation:

Availability:

This version is available http://hdl.handle.net/2318/1776277.1 since 2021-02-28T00:05:02Z

Published version:

DOI:10.1016/j.ajodo.2020.11.029

Terms of use:

Open Access

Anyone can freely access the full text of works made available as "Open Access". Works made available under a Creative Commons license can be used according to the terms and conditions of said license. Use of all other works requires consent of the right holder (author or publisher) if not exempted from copyright protection by the applicable law.

(Article begins on next page)

17 November 2026

The 50 most-cited articles on clear aligner treatment: A bibliometric and visualized analysis

Alessandro Bruni,[a] Francesca Giulia Serra,[a] Vittorio Gallo,[b] Andrea Deregibus,[b] and Tommaso Castroflorio[b]
Turin, Italy

Introduction: Research on clear aligner treatment (CAT) has increased in recent years. In this study, we aimed to perform a bibliometric and visualized analysis to identify and critically assess the 50 most highly cited articles on CAT. **Methods:** Web of Science was selected as a data source and consulted until March 2020 to identify all articles potentially relevant to the analysis. All the eligible articles were collected until 50 manuscripts were listed. Article-based parameters, journal-based parameters, and author-based parameters were registered to perform the bibliometric analysis. Keywords were automatically harvested from the selected articles to implement the visualized analysis. **Results:** The search identified a total of 378 articles; the total number of citations of the selected articles varied from 15 to 112. The average number of citations per year varied from 1.15 to 13.83. The predominant study design was clinical (31.7%). Over the 15 journals in which the most cited articles were published, the *American Journal of Orthodontics and Dentofacial Orthopedics* published the majority of those included in the list (14) and also received the greatest number of citations (671). A total of 195 authors contributed to the 50 most cited articles; a significant portion of them (26) were unaffiliated with academic institutions. A total of 184 keywords were gathered from the article list. **Conclusions:** The number of citations on CAT is expected to grow steadily in parallel with the rising number of research projects. The present work identifies the most influential articles on CAT and their characteristics, placing emphasis on the journals, the authors, and the topics addressed. (Am J Orthod Dentofacial Orthop 2021;■:e1-e20)

Clear aligner treatment (CAT) has a long-standing history in orthodontics,[1] but the recent advancements in applied biomechanics and the achievements in biomaterials design and engineering have led to its adoption as a suitable technique in dealing with several clinical conditions.

Despite the advantages in patient comfort and acceptability,[2] oral hygiene maintenance[3,4] and esthetics,[5] the efficiency of clear aligners is still under debate, and a broad consensus on their clinical performance has not been reached in academia.[6-9]

As a result, a significant surge in research activities has been observed over recent years, in line with the growing number of publications on CAT.

To evaluate and track the research output in a specific field, we employed several analytical instruments with the final aim of determining the historical trend of a topic and speculating on the direction in which the research is proceeding. Bibliometric analysis is a means by which any measurable information pertaining to published scientific articles can be retrieved, collected, and analyzed. Citations are the primary measure used to quantify the impact—and often the quality—of a publication in a specific area; citations also reveal a connection between authors, groups of researchers, topics of study, or countries.[10] The establishment of a citation ranking list identifies published works that can potentially influence trends in clinical practice and future research.[11] In addition, the use of visualized analyses to map bibliometric networks, often referred to as *science mapping*, can provide an intuitive yet comprehensive overview of a large dataset.[12]

[a]Department of Surgical Sciences, CIR Dental School, Universita degli Studi di Torino, and Department of Mechanical and Aerospace Engineering (DIMEAS), Politecnico di Torino, University of Turin, Turin, Italy.
[b]Department of Surgical Sciences, CIR Dental School, Universita degli Studi di Torino, Turin, Italy.
All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
Please contact authors for data requests.
Address correspondence to: Alessandro Bruni, Department of Surgical Sciences, CIR Dental School, Universita degli Studi di Torino, Via Nizza, 230, and Department of Mechanical and Aerospace Engineering (DIMEAS), Politecnico di Torino, University of Turin, C.so Duca degli Abruzzi, 24, Turin 10129, Italy; e-mail, halex.bruni@gmail.com.
Submitted, May 2020; revised, October 2020; accepted, November 2020.
0889-5406/$36.00
© 2021 by the American Association of Orthodontists. All rights reserved.
https://doi.org/10.1016/j.ajodo.2020.11.029

When submitting a manuscript, it is important for authors to refer to common journal metrics, such as the journal impact factor (JIF), the 5-year journal impact factor (5-JIF), the Scimago Journal Ranking (SJR) and the Eigenfactor (EF), to decide which journal is right for the proposed research. The JIF measures the average number of citations received by an article in a specific journal during a predefined timeframe (2 years for JIF and 5 years for 5-JIF). In contrast, the SJR and Eigenfactor use an original algorithm to appraise the number of citations received and consider the weight of the source of the citations.[13] Authors choose a particular journal for a variety of reasons; one of the most important is the prestige or impact of the journal. Therefore, these metrics can provide a measure of the supposed quality of the published papers in a specific field.

Author metrics are used to track how often an author's work is cited and demonstrate the reach and impact of a researcher's work for use in grant applications, tenure, promotion, and performance reviews. An author's impact is frequently quantified in terms of the number of citations of their publications. A well-known author-level metrics is the h-index, which is equal to the number of an author's publications (h) that have h or more citations[14] (eg, if the h-index of a scientist is 50, it means that each of the 50 articles of the author has been cited at least 50 times).

Bibliometric analysis has been widely employed in several fields of dentistry,[15-22] including orthodontics,[23-27] but a study identifying and analyzing the most cited articles on CAT has not yet been performed.

The aim of the present bibliometric and visualized analysis is to assess and benchmark research performance, to identify significant trends and underinvestigated areas, and to rank influential men or women, institutions, papers, journals, and countries in the field of CAT. The analysis takes into account all of the aforementioned journal and author metrics.

MATERIAL AND METHODS

The study was designed to answer the following research question: *What are the most cited articles in the field of clear aligner treatment?* The research question was formulated according to the FINER (feasible, interesting, novel, ethical, relevant) criteria.[28]

On March 22, 2020, a computerized database search was performed independently by 2 authors (S.F.G and G.V) to detect all the published papers about CAT. Because of its ability to provide a systematic citation search through multiple repositories,[29] the Web of Science Core Collection (Clarivate Analytics, Philadelphia, Pa) was the source used to identify all potentially relevant studies regardless of the year, type of publication, or language.

The following complex search query was adopted without field restrictions:

(((orthodont OR clear OR removable OR thermoplastic) AND (aligner* OR "aligner* therap*" OR "aligner* treatment*")) OR Invisalign).*

Titles and abstracts were independently screened by 2 authors (S.F.G and G.V), who had been previously instructed how to use the Web of Science platform to assess the eligibility of the studies: articles not directly relevant to CAT were excluded.

The full records of the retrieved publications were downloaded or manually entered into Microsoft Excel spreadsheet software (Microsoft Corp, Redmond, Wash) by each author. The abstract of each article was analyzed manually to check its pertinence. The residual manuscripts were sorted in descending order according to their total number of citations, and among them, only the first 50 were listed. Cohen's kappa (κ) coefficient was calculated to measure the interrater agreement in the selection process.[30] The resulting κ coefficient was 1.0, showing perfect agreement. Any potential disagreement concerning the inclusion of studies would be resolved through discussion and consensus with a third author (C.T).

Bibliometric analysis

Three sets of parameters were independently collected for each article by 2 researchers (S.F.G and G.V): (1) article-based parameters (title, authors, journal, publication year, study design, total citations, average citation per year); (2) journal-based parameters (title, JIF 2018, 5-JIF, SJR, quartile, number of citations, number of manuscripts in top 50, EF), and (3) author-based parameters (name, affiliation/s, h-index, number of articles, authorship position, number of citations).

For the evaluation of the study design of each selected article, the authors used an adapted form, obtained from the classification of different study types proposed by Röhrig et al,[31] integrated with the Cochrane Collaboration glossary definitions.

The JIF, the 5-JIF, and the EF score of each journal included in the list were identified using the Incites Journal Citation Reports (Clarivate Analytics) dataset.

Author's affiliations, country of origin, and h-index data were retrieved in the Scopus (Elsevier BV, Amsterdam, The Netherlands) database. The most productive institutions were identified using author-level fractional

counting[32]; the total citations and the number of manuscripts in the top 50 were equally distributed among the number of their authors to obtain normalized results. All the collected data were subsequently analyzed using Graphpad Prism (version 8.4; GraphPad Software, La Jolla, San Diego, Calif) for descriptive statistics and chart making.

Visualized analysis

Keywords were extracted automatically from the dataset and used to construct a co-occurrence network on the basis of bibliographic data. Keywords were counted using full counting, meaning that each co-occurrence link had the same weight. To avoid redundancy, 2 authors (B.A and S.F.G) manually inspected and revised all the terms to collate a custom *thesaurus* (Supplementary Material). To include keywords in the analysis dataset, we set the requested minimum number of occurrences of keywords was set to 2. Thus, each identified keyword was tabled jointly with its occurrences and total link strength. VOSviewer (Centre for Science and Technology Studies, Leiden University, Leiden, The Netherlands) was used for keyword mapping. The generated networks consist of nodes, representing the keywords, and edges, representing the relationship between keywords. A distance-based approach was selected to display the network visually; the distance between 2 nodes would approximately indicate the relatedness of the nodes. Similar keywords were grouped in clusters.[33]

Cluster resolution determines the level of detail of the clustering process. The higher the value, the higher the number of keyword subgroups created. The cluster resolution was set to 1.0, which means that small clusters were merged into larger clusters.

RESULTS

The search strategy applied returned a total of 378 papers. Only those unambiguously referred to CAT were used to create the list of the 50 most cited articles, and from those 50 papers, data were extracted. The articles listed were published from 2002 to 2017 inclusive; 2017 was the most frequently occurring publication year in the dataset. All the 50 articles included in the list were written in the English language.

The 50 most cited articles are shown in Table I, listed in descending order according to the total number of citations received. The number of citations collected by each article between 2002 and 2020 varied from 15 to 112, 1724 overall (mean, 34.48; standard deviation [SD], 20.93); the self-citation rate measured for the listed papers was 11%. The annual number of citations collected by all 50 articles included in the list is increasing over time, as shown in Figure 1, from 6 in 2003 to 306 in 2019, with a peak in 2017 with 313 citations. Citations of the current year were not embedded in Figure 1 because they would represent a misleading trend.

Considering the total number of citations, the most-referenced paper, published in 2009 in the *American Journal of Orthodontics and Dentofacial Orthopedics*, is the clinical trial by Kravitz et al entitled "How well does Invisalign work? A prospective clinical study evaluating the efficacy of tooth movement with Invisalign." The average number of citations per year range from 1.15 to 13.83 (mean, 3.87; SD, 2.45), and with regard to this parameter, the most-referenced paper, published in 2015 in *Angle Orthodontist*, is the systematic review by Rossini et al entitled "Efficacy of clear aligners in controlling orthodontic tooth movement: a systematic review."

The majority of the listed papers were classified as clinical study (n = 14), followed by a cohort study (n = 8) and theoretical studies (n = 8). The type of study collecting the highest number of citations was the clinical trial (38%), followed by the cohort study (17%) and the systematic review (14%), as illustrated in Figure 2.

The 50 most cited papers were published in 15 journals, as shown in Table II. The majority of the listed journals (8 of 15) were classified as orthodontic journals. The journal with the most significant number of cited articles was the *American Journal of Orthodontics and Dentofacial Orthopedics* with 14 articles and 671 citations, followed by the *Angle Orthodontist* (with 14 articles and 410 citations) and the *European Journal of Orthodontics* (with 5 articles and 134 citations), as illustrated in Figure 3.

The JIF of scientific journals in which the 50 most cited articles were published varied from 0.181 to 4.440 (mean, 1.71; SD, 1.140), whereas the 5-JIF ranged from 0.457 to 5.183 (mean, 1.96; SD, 1.27). The journal with the highest JIF and 5-JIF is *Dental Materials*, with a single manuscript listed in the 50 most cited articles.

The SJR score varied from 1.94 to 0.25 (mean, 0.84; SD, 0.44) and the EF varied from 0.01853 to 0.00024 (mean, 0.00526; SD, 0.00587). In addition, considering these indicators, *Dental Materials* showed a higher score.

According to their SJR, 8 journals are positioned in the first quartile, 4 in the second quartile, and 3 in the third quartile.

The number of authors contributing to the 50 most cited articles on CAT is 195. The top 10 authors ranked per total citation numbers are listed in Table III. The

ARTICLE IN PRESS

Table I. The 50 most cited articles on CAT, ranked in descending order of number of total citations

Ranking position	*Title*	*Authors*	*Journal*	*Year of publication*	*Study design*	*Total citations*	*Citation density*
1	How well does Invisalign work? A prospective clinical study evaluating the efficacy of tooth movement with Invisalign	Kravitz ND, Kusnoto B, BeGole E, Obrez A, Agran B	American Journal of Orthodontics and Dentofacial Orthopedics	2009	Clinical study (clinical trial)	112	9.33
2	Outcome assessment of Invisalign and traditional orthodontic treatment compared with the American Board of Orthodontics objective grading system	Djeu G, Shelton C, Maganzini A	American Journal of Orthodontics and Dentofacial Orthopedics	2005	Cohort study (historical)	92	5.75
3	Efficacy of clear aligners in controlling orthodontic tooth movement: a systematic review	Rossini G, Parrini S, Castroflorio T, Deregibus A, Debernardi CL	Angle Orthodontist	2015	Systematic review	83	13.83
4	Association of orthodontic force system and root resorption: a systematic review	Roscoe MG, Meira JBC, Cattaneo PM	American Journal of Orthodontics and Dentofacial Orthopedics	2015	Systematic review	71	11.83
5	Invisalign A to Z	Wong BH	American Journal of Orthodontics and Dentofacial Orthopedics	2002	Short communication	61	3.21
6	The treatment effects of Invisalign orthodontic aligners–a systematic review	Lagravere MO, Flores-Mir C	Journal of The American Dental Association	2005	Systematic review	59	3.69

Table I. Continued

Ranking position	*Title*	*Authors*	*Journal*	*Year of publication*	*Study design*	*Total citations*	*Citation density*
7	Activation time and material stiffness of sequential removable orthodontic appliances. Part 1: ability to complete treatment	Bollen AM, Huang G, King G, Hujoel P, Ma T	American Journal of Orthodontics and Dentofacial Orthopedics	2003	Clinical study (RCT)	54	3
8	Forces and moments generated by removable thermoplastic aligners: incisor torque, premolar derotation, and molar distalization	Simon M, Keilig L, Schwarze J, Jung BA, Bourauel C	American Journal of Orthodontics and Dentofacial Orthopedics	2014	Clinical study (clinical trial)	50	7.14
9	Treatment outcome and efficacy of an aligner technique–regarding incisor torque, premolar derotation and molar distalization	Simon M, Keilig L, Schwarze J, Jung BA, Bourauel C	BMC Oral Health	2014	Clinical study (clinical trial)	49	7
10	A comparison of treatment impacts between Invisalign aligner and fixed appliance therapy during the first week of treatment	Miller KB, McGorray SP, Womack R, Qunitero JC, Perelmuter M, Gibson J, Dolan TA, Wheeler TT	American Journal of Orthodontics and Dentofacial Orthopedics	2007	Cohort study (prospective)	47	3.36
11	Invisalign and traditional orthodontic treatment postretention outcomes compared using the American Board of Orthodontics Objective Grading System	Kuncio D, Maganzini A, Shelton C, Freeman K	Angle Orthodontist	2007	Cohort study (historical)	45	3.21

Table I. Continued

Ranking position	*Title*	*Authors*	*Journal*	*Year of publication*	*Study design*	*Total citations*	*Citation density*
12	A comparison between customized clear and removable orthodontic appliances manufactured using RP and CNC techniques	Martorelli M, Gerbino S, Giudice M, Ausiello P	Dental Materials	2013	Clinical study (cross-over trial)	43	5.38
13	Activation time and material stiffness of sequential removable orthodontic appliances. Part 2: dental improvements	Clements KM, Bollen AM, Huang G, King G, Hujoel P, Ma T	American Journal of Orthodontics and Dentofacial Orthopedics	2003	Clinical study (RCT)	43	2.39
14	A comparison of the periodontal health of patients during treatment with the Invisalign (R) system and with fixed lingual appliances	Miethke R, Braunerl K	Journal of Orofacial Orthopedics-Fortschritte Der Kieferorthopadie	2007	Case-control	40	2.86
15	Influence of attachments and interproximal reduction on the accuracy of canine rotation with Invisalign–a prospective clinical study	Kravitz ND, Kusnoto B, Agran B, Viana G	Angle Orthodontist	2008	Clinical study (clinical trial)	39	3
16	Periodontal status of adult patients treated with fixed buccal appliances and removable aligners over one year of active orthodontic therapy	Karkhanechi M, Chow D, Sipkin J, Sherman D, Boylan RJ, Norman RG, Craig RG, Cisneros GJ	Angle Orthodontist	2013	Case-control	38	4.75

Table I. Continued

Ranking position	*Title*	*Authors*	*Journal*	*Year of publication*	*Study design*	*Total citations*	*Citation density*
17	Esthetic orthodontic treatment using the Invisalign appliance for moderate to complex malocclusions	Boyd RL	Journal of Dental Education	2008	Case series	38	2.92
18	A novel pressure film approach for determining the force imparted by clear removable thermoplastic appliances	Barbagallo LJ, Shen G, Jones AS, Swain MV, Petocz P, Darendeliler MA	Annals of Biomedical Engineering	2008	Case series	36	2.77
19	Initial forces and moments delivered by removable thermoplastic appliances during rotation of an upper central incisor	Hahn W, Engelke B, Jung K, Dathe H, Fialka-Fricke J, Kubein-Meesenburg D, Sadat-Khonsari R	Angle Orthodontist	2010	Theoretical study (analytical measurement procedure)	35	3.18
20	Structural conformation and leaching from in vitro aged and retrieved Invisalign appliances	Schuster S, Eliades G, Zinelis S, Eliades T, Bradley TG	American Journal of Orthodontics And Dentofacial Orthopedics	2004	Theoretical study (analytical measurement procedure)	35	2.06
21	Braces versus Invisalign®: gingival parameters and patients' satisfaction during treatment: a cross-sectional study	Azaripour A, Weusmann J, Mahmoodi B, Peppas D, Gerhold-Ay A, Van Noorden CJF, Willershausen B,	BMC Oral Health	2015	Case-Control	33	5.5
22	Invisalign® treatment in the anterior region: were the predicted tooth movements achieved?	Krieger E, Seiferth J, Marinello I, Jung BA, Wriedt S, Jacobs C, Wehrbein H	Journal of Orofacial Orthopedics-Fortschritte Der Kieferorthopadie	2012	Cohort study (historical)	33	3.67

Table I. Continued

Ranking position	*Title*	*Authors*	*Journal*	*Year of publication*	*Study design*	*Total citations*	*Citation density*
23	Periodontal health during clear aligners treatment: a systematic review	Rossini G, Parrini S, Castroflorio T, Deregibus A, Debernardi CL	European Journal of Orthodontics	2015	Systematic review	31	5.17
24	Adult patients' adjustability to orthodontic appliances. Part I: a comparison between Labial, Lingual, and Invisalign ™	Shalish M, Cooper-Kazaz R, Ivgi I, Canetti L, Tsur B, Bachar E, Chaushu S	European Journal of Orthodontics	2012	Clinical study (clinical trial)	31	3.44
25	Effects of mechanical properties of thermoplastic materials on the initial force of thermoplastic appliances	Kohda N, Iijima M, Muguruma T, Brantley WA, Ahluwalia KS, Mizoguchi I	Angle Orthodontist	2013	Theoretical study (analytical measurement procedure)	30	3.75
26	Activation time and material stiffness of sequential removable orthodontic appliances. Part 3: premolar extraction patients	Baldwin D, K, King G: Ramsay D, S, Huang G, Bollen AM	American Journal of Orthodontics and Dentofacial Orthopedics	2008	Clinical study (RCT)	28	2.15
27	Periodontal health in teenagers treated with removable aligners and fixed orthodontic appliances	Abbate GM, Caria MP, Montanari P, Mannu C, Orru G, Caprioglio A, Levrini L	Journal of Orofacial Orthopedics-Fortschritte Der Kieferorthopadie	2015	Clinical study (RCT)	25	4.17

ARTICLE IN PRESS

Table I. Continued

Ranking position	*Title*	*Authors*	*Journal*	*Year of publication*	*Study design*	*Total citations*	*Citation density*
28	Initial force systems during bodily tooth movement with plastic aligners and composite attachments: a three-dimensional finite element analysis	Gomez JP, Peña FM, Martínez V, Giraldo DC, Cardona CI	Angle Orthodontist	2015	Theoretical study (analytical measurement procedure)	25	4.17
29	Torquing an upper central incisor with aligners-acting forces and biomechanical principles	Hahn W, Zapf A, Dathe H, Fialka-Fricke J, Fricke-Zech S, Gruber R, Kubein-Meesenburg D, Sadat-Khonsari R	European Journal of Orthodontics	2010	Theoretical study (analytical measurement procedure)	25	2.27
30	Initial forces generated by three types of thermoplastic appliances on an upper central incisor during tipping	Hahn W, Fialka-Fricke J, Dathe H, Fricke-Zech S, Zapf A, Gruber R, Kubein-Meesenburg D, Sadat-Khonsari R	European Journal of Orthodontics	2009	Theoretical study (analytical measurement procedure)	25	2.08
31	Cytotoxicity and estrogenicity of Invisalign appliances	Eliades T, Pratsinis H, Athanasiou AE, Eliades G, Kletsas D	American Journal of Orthodontics and Dentofacial Orthopedics	2009	Cell study	24	2
32	Orthodontic treatment with a series of removable appliances	Chenin DA, Trosien AH, Fong PF, Miller RA, Lee RS	Journal of The American Dental Association	2003	Case series	24	1.33
33	Root resorption following treatment with aligners	Brezniak N, Wasserstein A	Angle Orthodontist	2008	Single case report	23	1.77
34	Ultrastructure and morphology of biofilms on thermoplastic orthodontic appliances in 'fast' and 'slow' plaque formers	Low B, Lee W, Seneviratne CJ, Samaranayake LP, Hagg U	European Journal of Orthodontics	2011	Clinical study (clinical trial)	22	2.2

Table I. Continued

Ranking position	*Title*	*Authors*	*Journal*	*Year of publication*	*Study design*	*Total citations*	*Citation density*
35	Evaluation of Invisalign treatment effectiveness and efficiency compared with conventional fixed appliances using the Peer Assessment Rating index	Gu J, Tang JS, Skulski B, Fields HW, Beck FM, Firestone AR, Kim DG, Deguchi T	American Journal of Orthodontics and Dentofacial Orthopedics	2017	Case-Control	21	5.25
36	Maxillary molar distalization with aligners in adult patients: a multicenter retrospective study	Ravera S, Castroflorio T, Garino F, Daher S, Cugliari G, Deregibus A	Progress In Orthodontics	2016	Cohort study (historical)	21	4.2
37	Accuracy of Invisalign® treatments in the anterior tooth region	Krieger E, Seiferth J, Saric I, Jung BA, Wehrbein H,	Journal of Orofacial Orthopedics-Fortschritte Der Kieferorthopadie	2011	Cohort study (historical)	20	2
38	Short-term chemical and physical changes in Invisalign appliances	Gracco A, Mazzoli A, Favoni O, Conti C, Ferraris P, Tosi G, Guarneri MP	Australian Orthodontic Journal	2009	Theoretical study (analytical measurement procedure)	20	1.67
39	Clinical limitations of Invisalign	Phan X, Ling PH	Journal of The Canadian Dental Association	2007	Short communication	20	1.43
40	Efficiency, effectiveness and treatment stability of clear aligners: a systematic review and meta-analysis	Zheng M, Liu R, Ni Z, Yu Z	Orthodontics & Craniofacial Research	2017	Methanalysis	18	4.5
41	In-vivo von Mises strains during Invisalign treatment	Vardimon AD, Robbins D, Brosh T	American Journal of Orthodontics and Dentofacial Orthopedics	2010	Clinical study (clinical trial)	18	1.64

Table I. Continued

Ranking position	*Title*	*Authors*	*Journal*	*Year of publication*	*Study design*	*Total citations*	*Citation density*
42	Discomfort associated with Invisalign and traditional brackets: a randomized, prospective trial	White DW, Julien KC, Jacob H, Campbell PM, Buschang PH	Angle Orthodontist	2017	Clinical study (RCT)	17	4.25
43	Twitter analysis of the orthodontic patient experience with braces vs Invisalign	Noll D, Mahon B, Shroff B, Carrico C, Lindauer SJ	Angle Orthodontist	2017	Cross-sectional study	15	3.75
44	The combined use of computer-guided, minimally invasive, flapless corticotomy and clear aligners as a novel approach to moderate crowding: a case report	Cassetta M, Altieri F, Pandolfi S, Giansanti M	Korean Journal of Orthodontics	2017	Single case report	15	3.75
45	The predictability of transverse changes with Invisalign	Houle JP, Piedade L, Todescan R, Pinheiro FH	Angle Orthodontist	2017	Cohort study (historical)	15	3.75
46	Orthodontically induced external apical root resorption in patients treated with fixed appliances vs removable aligners	Iglesias-Linares A, Sonnenberg B, Solano B, Yanez-Vico RM, Solano E, Lindauer SJ, Flores-Mir C	Angle Orthodontist	2017	Case-Control	15	3.75
47	Stress relaxation properties of four orthodontic aligner materials: a 24-hour in vitro study	Lombardo L, Martines E, Mazzanti V, Arreghini A, Mollica F, Siciliani G	Angle Orthodontist	2017	Theoretical study (analytical measurement procedure)	15	3.75
48	The effectiveness of the Invisalign appliance in extraction cases using the ABO model grading system: a multicenter RCT	Li W, Wang S, Zhang Y	International Journal of Clinical and Experimental Medicine	2015	Clinical study (RCT)	15	2.5

ARTICLE IN PRESS

Table I. Continued

Ranking position	Title	Authors	Journal	Year of publication	Study design	Total citations	Citation density
49	Variables affecting orthodontic tooth movement with clear aligners	Chisari JR, McGorray SP, Nair MR, Wheeler TT	American Journal of Orthodontics and Dentofacial Orthopedics	2014	Cohort study (historical)	15	2.14
50	The clear plastic appliance–a biomechanical point of view	Brezniak N	Angle Orthodontist	2008	Editorial	15	1.15

most-referenced author was Jung BA, an author of 4 papers, with a total number of 152 citations.

The h-index of each author varied from 1 to 78 (mean, 12.9; SD, 12.9); the first and the second position of the list were occupied by authors recognized with an h-index of 11, whereas the author in the third position had an h-index of 2.

The distribution of authors per country displayed a clear predominance in the United States (n = 67), followed by Italy (n = 36), and Germany (n = 30). The countries less represented were the United Kingdom, India, Sweden, and Denmark (n = 1).

Most of the authors are affiliated with no institutions (n = 26), followed by Johannes Gutenberg Universität Mainz (n = 12), Universität Göttingen (n = 10) and Ohio State University (n = 10) (Table IV).

Among the institutions, Albert Einstein College of Medicine of Yeshiva University had the highest author-weighted citations percentage (7.9%).

A total of 184 terms were automatically identified from the 50 most cited articles; of the 93 keywords obtained by merging the redundant terms through a custom thesaurus, 37 terms occurred a minimum of 2 times. A keyword cooccurrences map was generated, as shown in Figure 4. Cluster analysis on the basis of terms occurrence identified 5 clusters with 243 links and a total link strength of 466. The most representative keyword was *Invisalign*, with 25 occurrences and a total link strength of 104.

DISCUSSION

The introduction of clear aligners has been one of the greatest breakthroughs in orthodontic practice. The popularity of CAT has been steadily growing so that not even the uncertainty surrounding their capability to perform[6-9] has hindered their large-scale adoption as observed by the relevant rise in market share in recent years.[34] This has sparked academic interest and resulted in a significant surge in research activities; CAT has turned into one of the most debated subjects among the orthodontic scientific community. Therefore, the main contribution of the present research was to define the main trends of academic activity.

According to the authors, the present study is the first bibliometric analysis exploring the 50 most cited articles in clear aligner orthodontics and one of the very few in the field of dentistry. The sample size was set to 50 manuscripts to provide a manageable and meaningful number of articles to be analyzed, according to several comparable published works.[15,35,36]

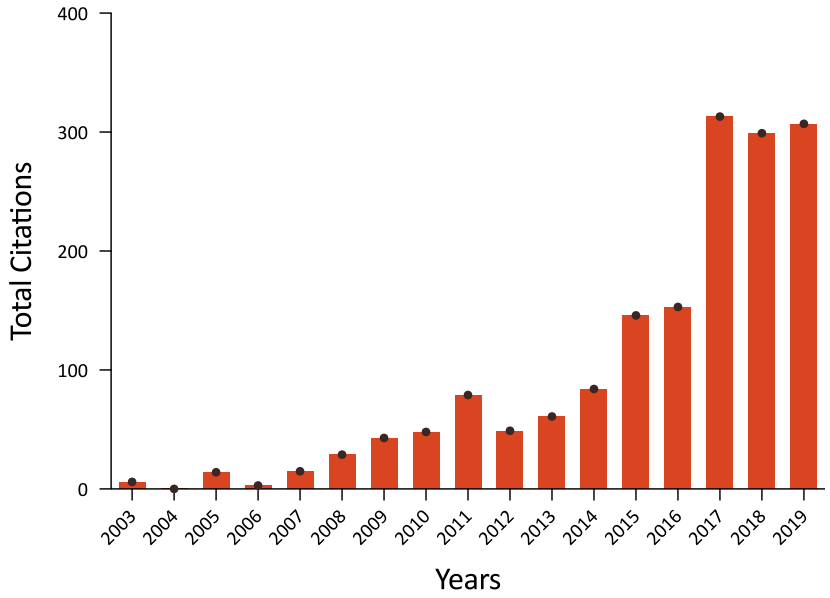

Fig 1. The number of total citations per year (2003-2019).

Number of citations

From the available data, the authors identified a progressive increase in the number of citations over the years, along with a rising total number of publications in accordance with the growing interest in this subject (Fig 1). The improvements in aligner biomechanics and the common demand for esthetic treatments have encouraged the diffusion of the CAT and consequently have supported their academic attractiveness.

The majority of the articles included in this analysis were published from 2000 to 2010. It is reported that, on average, a scientific paper starts being cited 1 or 2 years after publication, reaching the maximum citation rate 7-10 years after publication[37] and that the highest recognition of relevant articles occurs during a chronological interval of 10-20 years.[23] Therefore, the potential impact of recently published papers is frequently underestimated. The average number of citations per year was the indicator used to identify the high potential impact of recently published articles that have had insufficient time to accumulate a large volume of total citations.[38] The indicator was calculated by dividing the total number of citations by the number of years since publication and was introduced to avoid any bias

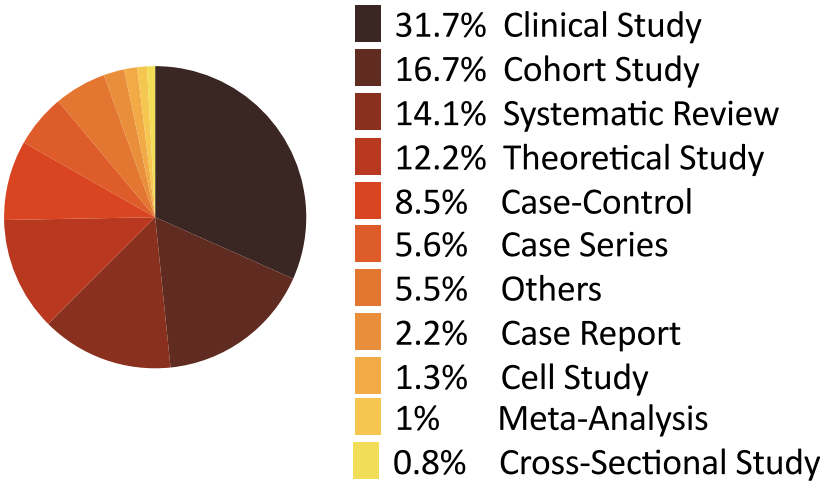

Fig 2. Distribution of the study design in the 50 most cited articles on CAT.

Table II. Journals that published the 50 most cited articles on CAT ranked in descending order of number of total citations

Ranking position	*Journal title*	*JIF (2018)*	*5-JIF*	*EF*	*SJR*	*Quartile*	*No. of citations*	*No. of manuscripts in top 50*
1	American Journal of Orthodontics and Dentofacial Orthopedics	1.911	2.333	0.00667	1.15	Q1	671	14
2	Angle Orthodontist	1.880	2.009	0.00461	1.25	Q1	410	14
3	European Journal of Orthodontics	1.841	2.023	0.00361	1.06	Q1	134	5
4	Journal of Orofacial Orthopedics-Fortschritte Der Kieferorthopadie	0.972	1.088	0.00088	0.62	Q2	118	4
5	Journal of The American Dental Association	2.572	2.493	0.00405	0.74	Q1	83	2
6	BMC Oral Health	2.048	2.393	0.00532	0.92	Q1	82	2
7	Dental Materials	4.440	5.183	0.01318	1.94	Q1	43	1
8	Journal of Dental Education	1.506	1.473	0.00198	0.42	Q2	38	1
9	Annals of Biomedical Engineering	3.474	3.607	0.01574	1.07	Q1	36	1
10	Progress In Orthodontics	1.381	NA	0.00154	0.86	Q2	21	1
12	Journal of The Canadian Dental Association	0.759	0.457	0.00028	0.25	Q3	20	1
11	Australian Orthodontic Journal	0.269	0.462	0.00024	0.34	Q3	20	1
13	Orthodontics & Craniofacial Research	0.946	1.595	0.00125	0.7	Q2	18	1
14	Korean Journal Of Orthodontics	1.476	1.523	0.00103	1.05	Q1	15	1
15	International Journal of Clinical and Experimental Medicine	0.181	0.744	0.01853	0.27	Q3	15	1

Q, quartile.

arising from older manuscripts accruing a higher number of citations over time[20] and providing a fairer comparison for junior academics. Citations of the current year were not embedded in Figure 1 because they would represent a misleading trend.

The number of total citations obtained from the 50 most cited articles in CAT was still minimal compared with other medical disciplines in which a publication cited more than 400 times is considered a classic. In medical fields with limited research activity, the benchmark to qualify an article as a classic is 100 citations.[11]

Considering the average number of citations in the orthodontic field, the 80 most cited papers published between 2000 and 2015 received an average number of citations of 116.2, with a peak of 274 citations.[25] Extending the timeframe from 1975 to 2011, the 100 most cited orthodontic articles collected an average number of citations of 126.54, with the most cited article received a total of 545 citations. In the present study, only 1 paper exceeds 100 citations (Kravitz et al, 2009), indicating that there is still a lack of research in the field.

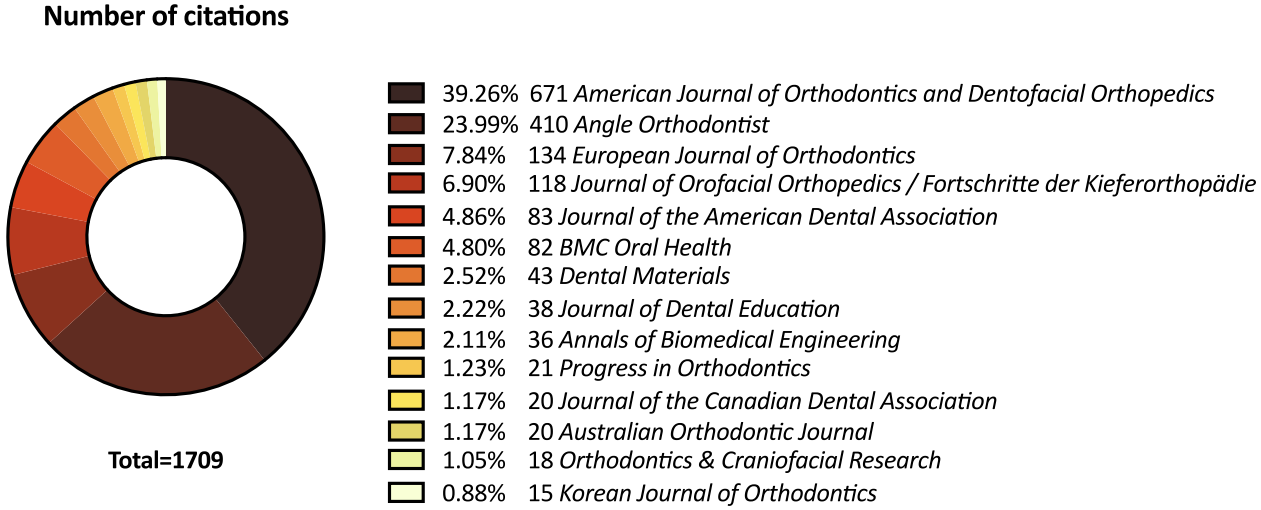

Fig 3. Distribution of the journals in which the 50 most cited articles on CAT were published.

Table III. Authors contributing to the 50 most cited articles on CAT ranked in descending order of number of total citations

Ranking position	*Author*	*Affiliation*	*Country*	*H-index*	*No. of articles*	*First author*	*Coauthor*	*Last author*	*Citations*
1	Jung BA	Universität Freiburg im Breisgau; Johannes Gutenberg Universität Mainz	Germany	11	4	0	4	0	152
2	Kravitz ND	Private Practice	United States	11	2	2	0	0	151
3	Agran B	University of Illinois	United States	2	2	0	1	1	151
4	Kusnoto B	University of Illinois	United States	19	2	0	2	0	151
5	Maganzini AL	Albert Einstein College of Medicine of Yeshiva University	United States	9	2	0	1	1	137
6	Shelton CE	Albert Einstein College of Medicine of Yeshiva University	United States	3	2	0	2	0	137
7	Deregibus A	Università degli Studi di Torino	Italy	18	3	0	2	1	135
8	Castroflorio T	Università degli Studi di Torino	Italy	18	3	0	3	0	135
9	Bollen AM	University of Washington	United States	22	3	1	1	1	125
10	King G	University of Washington	United States	31	3	0	3	0	125

Type of studies

The selected papers showed heterogeneity in analyzed topics as well as in study design. Most of the manuscripts were primary research papers (84.5%) with a predominance of clinical studies. Secondary research occurred less frequently in the present study (15.5%), despite it playing a key role in evidence-based decision-making by collecting and appraising all existing well-designed primary studies pertaining to a specific question.[37]

Interestingly, these findings are in contrast with the dominant position occupied by secondary research in the hierarchy of evidence, the overall propensity of authors to cite articles conducted with great scientific rigor,[39,40] and the increasing number of systematic reviews and meta-analyses in dentistry.[41,42]

Some possible explanations can be surmised. There is a relatively small number of well-designed primary studies, as for instance, randomized controlled trials (RCTs), because conducting and monitoring an RCT is a challenging task, expensive[43] and time-consuming[43,44] and academic interest in CAT is relatively recent. In addition, when the usual treatment is assumed to be effective, randomization of patients into groups to be compared may even be considered unethical because it would mean exposing participants to potentially ineffective or harmful treatment.[45] Nevertheless, in an era focused on evidence-based medicine, studies accurately conducted and reported are what clinicians and patients deserve. The limited number of well-designed clinical trials on CAT could explain the high number of citations they collected.

It is reported that disproportionately more secondary research is conducted than primary research: synthesizing evidence from multiple sources requires fewer resources,[43] shorter time-frames, no procedures on human patients, and no ethical clearance.[42] If primary studies, though well-designed, are insufficient, the systematic reviews, meta-analysis, and clinical practice guidelines will also potentially include primary studies that are both biased and performed without high methodological standards. For these reasons, only 22% of the

Table IV. Affiliations of authors contributing to the 50 most cited articles on CAT ranked in descending order of number of total citations percentage (authors' level fractionally counted)

Ranking position	*Institution*	*Manuscript in the top 50 (%)*	*Citations (%)*
1	No affiliation	13.4	15.1
2	Albert Einstein College of Medicine of Yeshiva University	4.0	7.9
3	University of Illinois	3.1	6.9
4	Università degli Studi di Torino	4.6	6.6
5	University of Washington	4.5	5.5
6	Universität Göttingen	6.0	4.9
7	Johannes Gutenberg Universität Mainz	4.7	4.1
8	University of Alberta	2.3	3.5
9	Universität Bonn	2.4	3.4
10	University of the Pacific	2.7	2.7

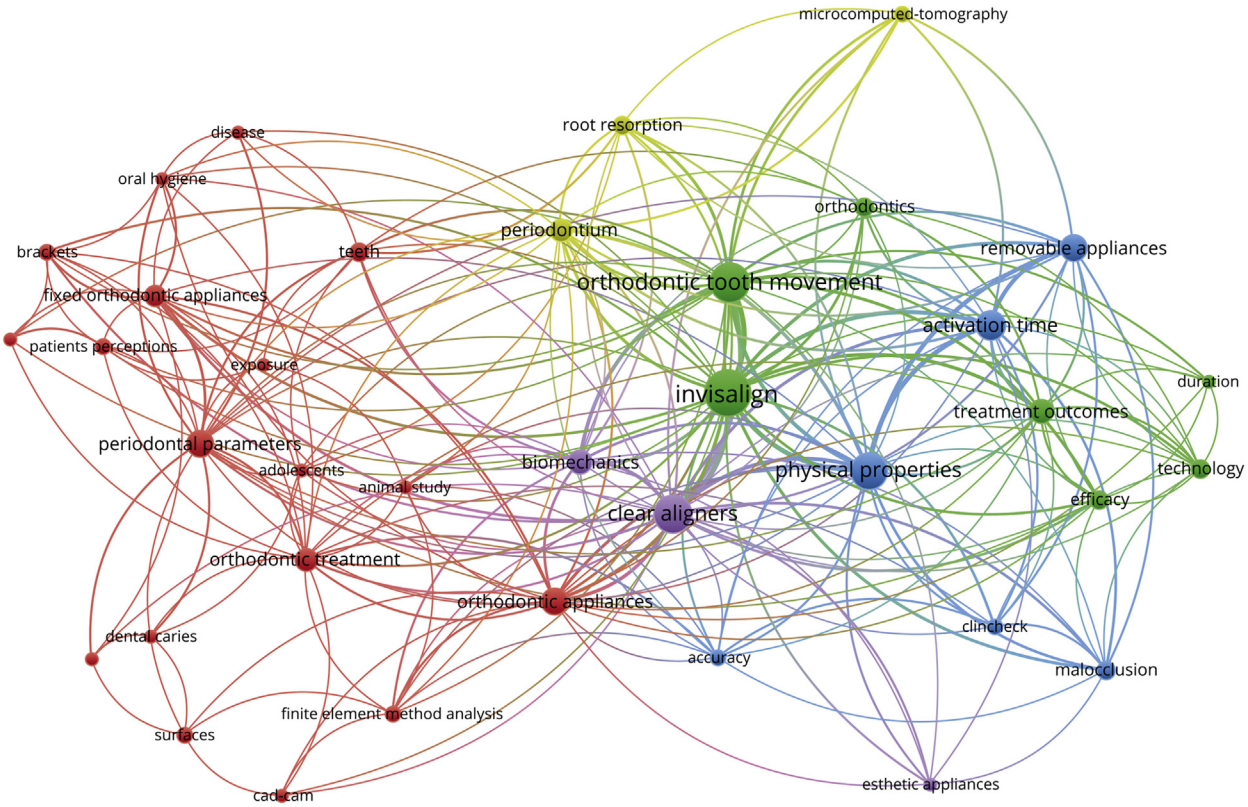

Fig 4. Network analysis of keywords co-occurrence. The size of the nodes represents the frequency of the keywords, with larger nodes indicating higher frequency. The thickness and the length of the edges indicate the closeness of the interactions between 2 nodes. The colors of the nodes of the keywords indicate the cluster to which keywords belong.

reviews, on average, reported adequate evidence for supporting clinical decisions in dentistry.[46]

Nevertheless, "absence of evidence is not evidence of absence."[47] Because research activities have intensified in recent years, substantial improvement of the quality of existing evidence is expected.

Journals

According to the results, 30% of the ranked articles were published in just 2 journals (*American Journal of Orthodontics and Dentofacial Orthopedics* and *Angle Orthodontics*), collecting more than half of the total citations (1081 of 1724). These outcomes demonstrate that a significant number of studies were concentrated in a limited core of journals, according to Bradford's law.[48-50]

Authors tend to submit their works to the most prestigious journals,[51] attracted by the enhanced visibility of the searched results and the higher probability of being cited. The most common measure of journal prestige is the JIF, defined as the frequency with which the *average article* in a journal has been cited in the previous 2 years.[52] Despite the wide recognition, the JIF is flawed because of considerable limitations. The most important is the time-constrained nature of the JIF is arguably suboptimal because many important papers achieve their maximal scientific impact outside this timeframe.[53] The 5-JIF has been introduced to counterbalance this limitation,[54] extending the timeframe from 2 to 5 years.

The research field also influences the JIF: scientific productivity may vary according to the area of application. Furthermore, the number of authors, articles, and therefore citations, related to a research field[55] (popularity), the average number of references per article[56] (citation habits), and the timeframe between publication and citations peak[53] (citation dynamics) change from specialty to specialty.

Multidisciplinary journals usually tend to have a higher JIF than discipline-specific journals because of their broader readership and, consequently, a more significant number of citations.[52] Accordingly, all the

ranked journals with a JIF greater than 2.0 are nonorthodontic. Nevertheless, the greater number of citations is sourced from journals specialized in orthodontics with a lower JIF but a broader readership and recognition within a specific research community.

The abuse of self-citations is another element that may substantially affect the JIF. The self-citation rate in the presented list was limited (11%), similar to the average reported in dentistry[57] and under the median self-citation rate of 12.7% emerging from a recent study.[58] This bias can be overcome by considering self-citation-free indices[59]: The SJR[60] and the EF[61] exclude self-citations and calculate, through algorithms, both the number of citations received by the journal and the value of the sources of the citations.[54] Both indicators also offer an extended timeframe (3 years for SJR; 5 years for EF). For these reasons, the use of these indicators should be encouraged in the academic world.

Authors, institutions, and countries

Metadata from all documents were used to reveal the most productive authors and the most impactful sources. The relevant number of authors (195) contributing to the top 50 papers listed suggested an average of more than 3 authors per article. Because there are a number of authors per document, it is difficult to determine the individual contribution and, consequently, the role of each author.[62] Traditionally, in multiauthored papers, the first position is occupied by the major contributor, whereas the last position is reserved for the supervisor.[63] The corresponding author, in most articles, is situated in one of these positions.[62] The most impactful authors in CAT rarely occupied a relevant position in the byline. Kravitz ND is the only contributor who appeared twice as the first author in the ranking of the most productive authors.

In addition to recording the total number of citations of each author, the number of articles authored, and their position in the author list, we investigated the relationship between a researcher's expertise and productivity.

The h-index is the bibliometric indicator examined: it quantifies the research performance of individual scientists, incorporating both quantity and visibility of publications.[64] The uneven distribution of h-index between authors of the top 50 papers listed indicates contributions from researchers with different academic experience.

The most cited articles were authored almost exclusively from the United States and Western Europe. A similar trend has been observed in citation analysis in other dental fields[18-21,23,26] and other medical specialties. This trend may be explained by accumulative geographic advantage, as citations originate more frequently from institutions located in the same country as where the author was based.[65] In addition, the United States can rely on a broad scientific community and generous science funding policies.[66] Indeed, the first and the second institutions with the most numbers of citations are located in the United States, in the state of New York (Albert Einstein College of Medicine of Yeshiva University) and Illinois (University of Illinois), respectively. In Europe, the University of Turin (Italy) is noteworthy for the number of citations.

Although the findings evidenced a collaboration between institutions, according to the increase of cross-institutional collaborations on coauthored papers documented in the literature,[67,68] the highest number of citations is associated with authors without affiliation.[69]

Author-level fractional counting was used for affiliation assessment: assigning coauthored publications fractionally to each coauthor will result in properly field-normalized results. The use of full counting could have resulted in bias by assigning the number of citations or number of manuscripts in coauthored publications multiple times (once for each coauthor).[32]

Keywords

A network analysis of keyword cooccurrences is a tool for mapping the research domain in a specific field by examining the links between keywords.[70] Keywords are a set of terms enabling correct indexing in computerized databases, maximizing the sourcing of scientific literature.[71]

According to the keyword cooccurrences map, the bigger and centrally located nodes were filled by terms such as *Invisalign*, *Clear Aligners,* and *Orthodontic Tooth Movement*.

The keyword *Invisalign* had a significant weight in the keyword map probably because it represents the brand name of the most used clear aligners system, gaining the first-mover advantage. Invisalign is still the dominant player in terms of brand recognition, research and development, manufacturing, training, and sales regarding clear aligner therapies. Several companies are currently manufacturing aligners, with the number increasing every year.[72]

Orthodontic tooth movement was the keyword reported in several studies investigating the predictability of specific outcomes (eg, distalization,[73] intrusion, extrusion, rotation). The efficacy of clear aligners has been a subject of ongoing debate since their introduction.[9,74-76]

Given the tendency for CAT to evolve rapidly,[1] it is conceivable that the current predictability of treatment

outcomes could be higher than that which the literature has reported.

The occurrence of the term *physical properties* was significant, indicating the increasing interest in testing materials and exploring innovative solutions.[77] Orthodontic aligner performance is strongly influenced by the mechanical properties of the thermoformed material, such as by the intraoral environment.[78] All the polymers currently used showed a significant stress decay over time,[79] suggesting the need for a material able to yield greater initial stress values or slower stress decay over time.

Under the word *Biomechanics*, all the articles concerning the interaction between clear aligners and the tooth-periodontium complex were collected. The biological mechanism behind CAT does not differ from that of traditional appliances.[80] Intermittent forces applied with aligners respect the periodontium physiology and seem capable of inducing greater concentrations of orthodontic tooth movement biological markers.[80]

Periodontal parameters were also extensively investigated in CAT literature. It was largely demonstrated that the use of removable appliances could mitigate the adverse effects of orthodontic treatment on periodontal health, allowing patients easier oral hygiene procedures.[3] The keyword was significantly linked to terms related to fixed appliances, indicating the comparison of the impact of the 2 treatment options on the periodontium.

Limitations

Although the present study was designed to minimize all the potential shortcomings, it is crucial to highlight the existing limitations. Plausible omissions in articles included in the current work could be considered: comprehensive research was not performed, consulting 1 citation database only.

The most widely used citation-tracking databases include Web of Science, Scopus, and Google Scholar.[81] No bibliometric database indexes every type of publication, and comprehensive coverage of research publications is not possible. The number of citations may fluctuate across databases. The use of each database directly impacts the bibliometric measures indexing different content and considering only citations within their collections.[82]

Not considering other databases and the gray literature could potentially restrict the comprehensiveness of our search results.[81] Furthermore, Web of Science does not automatically exclude self-citations. However, the self-citation rate of 11% identified in the present paper should not jeopardize the results. The average self-citation rate in dental journals has been proven to be near 10%,[57] consistent with the data of the present study.

There are shortcomings in the study. Future research suggestions that address these limitations could be proposed. A wider search through more than 1 database and gray literature would be desirable. A statistical test to determine the potential correlation between the analyzed variables could also be attractive and useful.

CONCLUSIONS

Taken together, the evidence gathered from the present bibliometric and visualized analysis suggest the following:

1. The total number of articles in aligner orthodontics is rapidly increasing; the total number of citations among the 50 most cited papers about CAT is small despite the growing interest of the scientific community.
2. Advances in CAT depend on well-designed secondary researches or RCTs; a significant portion of the 50 most cited articles on CAT is represented by studies of lower position in evidence hierarchy.
3. Two leading journals published 30% of the most influential articles on CAT and collected more than half of the total number of citations.
4. Most of the papers are coauthored; individual researchers not belonging to an institution collected a noteworthy quantity of citations; not belonging to an institution could increase the risk of not-independent studies; academic involvement in the field should be encouraged.
5. The main topics, according to keyword mapping, are the predictability of diverse tooth movements, physical properties of materials, biomechanics, and the influence of CAT on periodontal health. For all those topics, well-designed studies are still lacking.

There is considerable room for the improvement and further development of CAT. Conclusions generated by this bibliometric analysis may be employed to guide further research in several areas of CAT. Because research activities have expanded over recent years, substantial advances can be expected soon, in addition to a significant improvement in research quality.

AUTHOR CREDIT STATEMENT

Conceived and designed the study: A.B; acquisition, analysis or interpretation: A.B, V.G, and T.C; drafting the work: A.B and V.G; data collection: V.G and F.G.S; wrote the article: A.B and F.G.S; critical revision of the article: A.D; final approval of the article: A.D and T.C.

ACKNOWLEDGMENTS

We thank Michela Biafora and June Winterflood for the English editing.

SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ajodo.2020.11.029.

REFERENCES

1. Weir T. Clear aligners in orthodontic treatment. Aust Dent J 2017;62(Suppl 1):58-62.
2. Cardoso PC, Espinosa DG, Mecenas P, Flores-Mir C, Normando D. Pain level between clear aligners and fixed appliances: a systematic review. Prog Orthod 2020;21:3.
3. Rossini G, Parrini S, Castroflorio T, Deregibus A, Debernardi CL. Periodontal health during clear aligners treatment: a systematic review. Eur J Orthod 2015;37:539-43.
4. Jiang Q, Li J, Mei L, Du J, Levrini L, Abbate GM, et al. Periodontal health during orthodontic treatment with clear aligners and fixed appliances: a meta-analysis. J Am Dent Assoc 2018;149:712-20.e12.
5. Alansari RA, Faydhi DA, Ashour BS, Alsaggaf DH, Shuman MT, Ghoneim SH, et al. Adult perceptions of different orthodontic appliances. Patient Prefer Adherence 2019;13:2119-28.
6. Robertson L, Kaur H, Fagundes NCF, Romanyk D, Major P, Flores Mir C. Effectiveness of clear aligner therapy for orthodontic treatment: a systematic review. Orthod Craniofac Res 2020;23:133-42.
7. Papadimitriou A, Mousoulea S, Gkantidis N, Kloukos D. Clinical effectiveness of Invisalign® orthodontic treatment: a systematic review. Prog Orthod 2018;19:37.
8. Rossini G, Parrini S, Deregibus A, Castroflorio T. Controlling orthodontic tooth movement with clear aligners. J Aligner Orthod 2017;1:7-20.
9. Papageorgiou SN, Koletsi D, Iliadi A, Peltomaki T, Eliades T. Treatment outcome with orthodontic aligners and fixed appliances: a systematic review with meta-analyses. Eur J Orthod 2020;42:331-43.
10. Moed HF. Citation Analysis in Research Evaluation. Dordrecht, The Netherlands: Springer Science & Business Media; 2006.
11. Garfield E. What is a citation classic. Clin Chem 2013;147-57.
12. Ding Y, Rousseau R, Wolfram D. Measuring Scholarly Impact. Berlin, Germany: Springer; 2016.
13. Moed HF. From journal impact factor to SJR, Eigenfactor, SNIP, CiteScore and usage factor, Applied Evaluative Informetrics. Cham, Switzerland: Springer; 2017. p. 229-44.
14. Garfield E, Sher IH. New factors in the evaluation of scientific literature through citation indexing. Amer Doc 1963;14:195-201.
15. Kodonas K, Fardi A, Gogos C, Economides N. Top 50 cited articles on dental stem cell research. Restor Dent Endod 2020;45:e17.
16. Patil SS, Sarode SC, Sarode GS, Gadbail AR, Gondivkar S, Kontham UR, et al. A bibliometric analysis of the 100 most cited articles on early childhood caries. Int J Paediatr Dent 2020;30:527-35.
17. Gogos C, Kodonas K, Fardi A, Economides N. Top 100 cited systematic reviews and meta-analyses in dentistry. Acta Odontol Scand 2020;78:87-97.
18. Praveen G, Chaithanya R, Alla RK, Shammas M, Abdurahiman VT, Anitha A. The 100 most cited articles in prosthodontic journals: a bibliometric analysis of articles published between 1951 and 2019. J Prosthet Dent 2020;123:724-30.
19. Alarcón MA, Esparza D, Montoya C, Monje A, Faggion CM Jr. The 300 most-cited articles in implant dentistry. Int J Oral Maxillofac Implants 2017;32:e1-8.
20. Fardi A, Kodonas K, Gogos C, Economides N. Top-cited articles in endodontic journals. J Endod 2011;37:1183-90.
21. Faggion CM Jr, Málaga L, Monje A, Trescher AL, Listl S, Alarcón MA. The 300 most cited articles published in periodontology. Clin Oral Investig 2017;21:2021-8.
22. Pena-Cristóbal M, Diniz-Freitas M, Monteiro L, Diz Dios P, Warnakulasuriya S. The 100 most cited articles on oral cancer. J Oral Pathol Med 2018;47:333-44.
23. Hui J, Han Z, Geng G, Yan W, Shao P. The 100 top-cited articles in orthodontics from 1975 to 2011. Angle Orthod 2013;83:491-9.
24. Adobes Martin M, Lipani E, Alvarado Lorenzo A, Aiuto R, Garcovich D. Trending topics in orthodontics research during the last three decades: a longitudinal bibliometric study on the top-cited articles. Orthod Craniofac Res 2020;23:462-70.
25. Prevezanos P, Tsolakis AI, Christou P. Highly cited orthodontic articles from 2000 to 2015. Am J Orthod Dentofacial Orthop 2018;153:61-9.
26. Tarazona B, Lucas-Dominguez R, Paredes-Gallardo V, Alonso-Arroyo A, Vidal-Infer A. The 100 most-cited articles in orthodontics: a bibliometric study. Angle Orthod 2018;88:785-96.
27. Tarazona-Alvarez B, Lucas-Dominguez R, Paredes-Gallardo V, Alonso-Arroyo A, Vidal-Infer A. A bibliometric analysis of scientific production in the field of lingual orthodontics. Head Face Med 2019;15:23.
28. Hulley SB. Designing Clinical Research. Philadelphia: Lippincott Williams & Wilkins; 2007.
29. AlRyalat SAS, Malkawi LW, Momani SM. Comparing bibliometric analysis using PubMed, Scopus, and Web of Science databases. J Vis Exp 2019;152:e58494.
30. McHugh ML. Interrater reliability: the kappa statistic. Biochem Med (Zagreb) 2012;22:276-82.
31. Röhrig B, Du Prel JB, Wachtlin D, Blettner M. Types of study in medical research: part 3 of a series on evaluation of scientific publications. Dtsch Arztebl Int 2009;106:262-8.
32. Waltman L, van Eck NJ. Field-normalized citation impact indicators and the choice of an appropriate counting method. J Inform 2015;9:872-94.
33. Van Eck NJ, Waltman L. Visualizing bibliometric networks. In: Ding Y, Rousseau R, Wolfram D, editors. Measuring Scholarly Impact. Cham, Switzerland: Springer; 2014. p. 285-320.
34. Ojima K, Kau CH. A perspective in accelerated orthodontics with aligner treatment. Semin Orthod 2017;23:76-82.
35. Ahmad P, Vincent Abbott P, Khursheed Alam M, Ahmed Asif J. A bibliometric analysis of the top 50 most cited articles published in the Dental Traumatology. Dent Traumatol 2020;36:89-99.
36. Ahmad P, Elgamal HAM. Citation classics in the Journal of Endodontics and a comparative bibliometric analysis with the most downloaded articles in 2017 and 2018. J Endod 2020;46:1042-51.
37. Marx W, Schier H, Wanitschek M. Citation analysis using online databases: feasibilities and shortcomings. Scientometrics 2001;52:59-82.
38. Seglen PO. Citation rates and journal impact factors are not suitable for evaluation of research. Acta Orthop Scand 1998;69:224-9.
39. Montori VM, Wilczynski NL, Morgan D, Haynes RB, Hedges Team. Systematic reviews: a cross-sectional study of location and citation counts. BMC Med 2003;1:2.

40. Patsopoulos NA, Analatos AA, Ioannidis JP. Relative citation impact of various study designs in the health sciences. JAMA 2005;293:2362-6.
41. Bassani R, Pereira GKR, Page MJ, Tricco AC, Moher D, Sarkis-Onofre R. Systematic reviews in dentistry: current status, epidemiological and reporting characteristics. J Dent 2019;82:71-84.
42. Papageorgiou SN, Eliades T. Evidence-based orthodontics: too many systematic reviews, too few trials. J Orthod 2019;46(1 Suppl):9-12.
43. Glasziou P, Djulbegovic B, Burls A. Are systematic reviews more cost-effective than randomised trials? Lancet 2006;367:2057-8.
44. Zuccati G, Clauser C, Giorgetti R. Randomized clinical trials in orthodontics: reality, dream, or nightmare? Am J Orthod Dentofacial Orthop 2009;136:634-7.
45. Koletsi D, Fleming PS, Seehra J, Bagos PG, Pandis N. Are sample sizes clear and justified in RCTs published in dental journals? PLoS One 2014;9:e85949.
46. Faggion CM Jr. Is the evidence supporting dental procedures strong? A survey of Cochrane systematic reviews in oral health. J Evid Based Dent Pract 2012;12:131-4.e14.
47. Altman DG, Bland JM. Absence of evidence is not evidence of absence. BMJ 1995;311:485.
48. Brookes BC. Bradford's law and the bibliography of science. Nature 1969;224:953-6.
49. Ioannidis JP. Concentration of the most-cited papers in the scientific literature: analysis of journal ecosystems. PLoS One 2006;1:e5.
50. Bradford SC. Sources of information on specific subjects. Engineering 1934;137:85-6.
51. Callaham M, Wears RL, Weber E. Journal prestige, publication bias, and other characteristics associated with citation of published studies in peer-reviewed journals. JAMA 2002;287:2847-50.
52. Durieux V, Gevenois PA. Bibliometric indicators: quality measurements of scientific publication. Radiology 2010;255:342-51.
53. Kurmis AP. Understanding the limitations of the journal impact factor. J Bone Joint Surg Am 2003;85:2449-54.
54. Garner RM, Hirsch JA, Albuquerque FC, Fargen KM. Bibliometric indices: defining academic productivity and citation rates of researchers, departments and journals. J Neurointerv Surg 2018;10:102-6.
55. Rousseau R. Journal evaluation: technical and practical issues. Library Trends 2002;50:418-39.
56. Seglen PO. Why the impact factor of journals should not be used for evaluating research. BMJ 1997;314:498-502.
57. Livas C, Delli K. Journal self-citation rates and impact factors in dentistry, oral surgery, and medicine: a 3-year bibliometric analysis. J Evid Based Dent Pract 2018;18:269-74.
58. Ioannidis JPA, Baas J, Klavans R, Boyack KW. A standardized citation metrics author database annotated for scientific field. PLoS Biol 2019;17:e3000384.
59. Mavrogenis AF, Ruggieri P, Papagelopoulos PJ. Self-citation in publishing. Berlin, Germany: Springer; 2010.
60. González-Pereira B, Guerrero-Bote VP, Moya-Anegón F. A new approach to the metric of journals' scientific prestige: the SJR indicator. J Inform 2010;4:379-91.
61. Bergstrom C. Eigenfactor: measuring the value and prestige of scholarly journals. Coll Res Libr News 2007;68:314-6.
62. Mattsson P, Sundberg CJ, Laget P. Is correspondence reflected in the author position? A bibliometric study of the relation between corresponding author and byline position. Scientometrics 2011;87:99-105.
63. Tscharntke T, Hochberg ME, Rand TA, Resh VH, Krauss J. Author sequence and credit for contributions in multiauthored publications. PLoS Biol 2007;5:e18.
64. Bornmann L, Daniel HD. What do we know about the h index? J Am Soc Inf Sci Technol 2007;58:1381-5.
65. Pasterkamp G, Rotmans J, de Kleijn D, Borst C. Citation frequency: a biased measure of research impact significantly influenced by the geographical origin of research articles. Scientometrics 2007;70:153-65.
66. Wang X, Liu D, Ding K, Wang X. Science funding and research output: a study on 10 countries. Scientometrics 2012;91:591-9.
67. Wuchty S, Jones BF, Uzzi B. The increasing dominance of teams in production of knowledge. Science 2007;316:1036-9.
68. Hottenrott H, Lawson C. A first look at multiple institutional affiliations: a study of authors in Germany, Japan and the UK. Scientometrics 2017;111:285-95.
69. ElSabry E. Unaffiliated researchers: a preliminary study. Challenges 2017;8:20.
70. Waltman L, Van Eck NJ, Noyons ECM. A unified approach to mapping and clustering of bibliometric networks. J Inform 2010;4:629-35.
71. Natarajan K, Stein D, Jain S, Elhadad N. An analysis of clinical queries in an electronic health record search utility. Int J Med Inform 2010;79:515-22.
72. Gierie WV. Clear aligner therapy: an overview. J Clin Orthod 2018;52:665-74.
73. Ravera S, Castroflorio T, Garino F, Daher S, Cugliari G, Deregibus A. Maxillary molar distalization with aligners in adult patients: a multicenter retrospective study. Prog Orthod 2016;17:12.
74. Rossini G, Parrini S, Castroflorio T, Deregibus A, Debernardi CL. Efficacy of clear aligners in controlling orthodontic tooth movement: a systematic review. Angle Orthod 2015;85:881-9.
75. Galan-Lopez L, Barcia-Gonzalez J, Plasencia E. A systematic review of the accuracy and efficiency of dental movements with Invisalign®. Korean J Orthod 2019;49:140-9.
76. Zheng M, Liu R, Ni Z, Yu Z. Efficiency, effectiveness and treatment stability of clear aligners: a systematic review and meta-analysis. Orthod Craniofac Res 2017;20:127-33.
77. Bruni A, Serra FG, Deregibus A, Castroflorio T. Shape-memory polymers in dentistry: systematic review and patent landscape report. Materials (Basel) 2019;12:2216.
78. Tamburrino F, D'Antò V, Bucci R, Alessandri-Bonetti G, Barone S, Razionale AV. Mechanical properties of thermoplastic polymers for aligner manufacturing: in vitro study. Dent J (Basel) 2020;8:47.
79. Lombardo L, Martines E, Mazzanti V, Arreghini A, Mollica F, Siciliani G. Stress relaxation properties of four orthodontic aligner materials: a 24-hour in vitro study. Angle Orthod 2017;87:11-8.
80. Castroflorio T, Gamerro EF, Caviglia GP, Deregibus A. Biochemical markers of bone metabolism during early orthodontic tooth movement with aligners. Angle Orthod 2017;87:74-81.
81. Bakkalbasi N, Bauer K, Glover J, Wang L. Three options for citation tracking: Google Scholar, Scopus and Web of Science. Biomed Digit Libr 2006;3:7.
82. Martín-Martín A, Orduna-Malea E, Thelwall M, López-Cózar ED. Google Scholar, Web of Science, and Scopus: a systematic comparison of citations in 252 subject categories. J Inform 2018;12:1160-77.