

TOP 100 PUBLICATIONS IN ORTHODONTICS AND ORTHOGNATHIC SURGERY: RANKED BY ANNUAL CITATION RATES

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ABSTRACT

Background and Aim: The aim of this study is to identify the 100 articles in orthodontics and orthognathic surgery based on the annual citation rate, to reveal the scientific impact of these articles, and to identify the key research areas and trends shaping the literature.

Materials and Methods: Articles and reviews were searched in the Scopus database using the keywords "orthodon*" and "orthognat*" resulting in 217,121 publications. The publications were ranked based on their annual citation rates, identifying the top 100 most influential articles. Data visualization was conducted using VOSviewer and the Bibliometrix Biblioshiny R-package, while Microsoft Excel was utilized for data tabulation.

Results: The articles with the highest annual citation rate span the period from 1982 to 2024. The highest annual citation rate is 45.33, with a total citation count of 272. The journals that have published the most articles are the American Journal of Orthodontics and Dentofacial Orthopedics and The Angle Orthodontist. The United States of America (USA) is the most contributing country, while Saveetha University is the most contributing institution. The most contributing author was Franchi L. Thematic areas prominently featured clear aligners, artificial intelligence, and digital dentistry.

Conclusions: The annual citation rate offers a contemporary perspective on the scientific impact of articles, indicating that modern treatment approaches and digital technologies are emerging trends in the literature. The findings indicate that an approach based on the annual citation rate provides a more balanced and up-to-date evaluation of scientific impact.

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INTRODUCTION

Over the past two decades, substantial advancements have been achieved in orthodontics, particularly through integrating digital dentistry and artificial intelligence technologies.¹ Among these developments, noteworthy are the rapid rise in popularity of orthodontic treatments using clear aligners,² the implementation of digital scanning and three-dimensional modeling systems enabling more precise and personalized treatment planning,^{3,4} and the effective management of the treatment process through artificial intelligence, allowing for more reliable predictions of potential treatment outcomes. Digital dentistry, particularly in aligner treatments, has facilitated a more comfortable, aesthetic, and accelerated treatment process for patients by enabling the production of patient-specific aligners using 3D printing technology.⁵ Additionally, AI-supported software enables more precise planning of tooth movements, resulting in more predictable treatment outcomes.⁶⁻⁸ Keeping up with current developments in orthodontics is crucial for enhancing the quality of clinical practice and meeting patients' increasing expectations by effectively adapting to rapidly advancing technologies. However, the ever-increasing number of published articles presents a significant challenge for both researchers and clinicians in identifying studies of the highest quality and greatest clinical effectiveness.⁹ Therefore, systematically evaluating the existing literature and providing comprehensive insights to readers through bibliometric analyses are becoming increasingly important.¹⁰⁻¹² Bibliometric analyses assess the citation performance, impact, and contributions of scientific publications within a specific field, facilitating the identification of exemplary studies and thematic trends. Analyzing high-impact publications is particularly crucial for understanding advancements in orthodontics and orthognathic surgery, as well as for identifying studies that significantly influence the direction of future research.¹³ A common approach in existing literature is to evaluate the 100 most impactful articles in orthodontics based on their total citation counts.¹⁴⁻¹⁶ Nevertheless, it is expected that older publications will accumulate a higher number of citations. To address this issue, creating a top 100 list based on the annual citation rate offers a more reliable and balanced analysis.

This study represents the first investigation to identify the most significant articles in the fields of orthodontics and orthognathic surgery based on annual citation rates, aiming

to address a notable gap in knowledge within these areas. Previous bibliometric studies in orthodontics have typically employed ranking systems based solely on the total number of citations each article has received.^{9,15,16,17} Evaluating an article's impact based solely on total citation count can be misleading. High-quality and original articles published more recently may be overlooked with this approach,¹⁸ as studies generally accumulate more citations the longer they remain in the literature.¹⁹ Research indicates that articles often achieve their highest scientific impact between 10 and 20 years after publication.^{15,20} Therefore, the future impact of recently published articles is frequently underestimated. The average annual citation rate is a valuable metric that more accurately reflects the scientific potential of newer articles, which have not yet accumulated a high total citation count.^{20,21}

This study aims to evaluate the most impactful publications in the fields of orthodontics and orthognathic surgery literature, ranked according to annual citation rate, by employing bibliometric analysis. The data obtained will provide insights into how research in orthodontics and orthognathic surgery has evolved and identify which topics have attracted greater attention within the scientific community.

MATERIALS AND METHODS

On August 30, 2024, a search was conducted in the Scopus database using the query: (ALL ("orthodon*") OR ALL ("orthognat*")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re")) AND (EXCLUDE (PUBYEAR, 2025)), which included articles and reviews, while excluding publications from the year 2025. The search encompassed all fields, resulting in a total of 217,121 exported publications. Subsequently, an Excel formula was developed to calculate the annual citation rate [Total number of citations of the article / (2024 – publication year of the article + 1)]. Publications were then ranked based on this calculated annual citation rate.

To identify relevant articles, two researchers independently reviewed the publications ranked according to their annual citation rates. Initially, articles were evaluated based on their titles and abstracts. In cases of uncertainty, the full texts were examined to determine relevance to the study topic. The lists compiled by both researchers were subsequently compared by a third researcher. Any discrepancies were discussed and resolved through an online meeting involving all three researchers, resulting in the final selection of

the top 100 articles. Following this selection, the two researchers conducted an additional online meeting to classify the articles according to topic areas and study types.

For the bibliometric analysis and visualization of data obtained in this study, VOSviewer (Center for Science and Technology Studies, Leiden University) and the Biblioshiny R-package software programs were utilized. These software packages offer advanced visualization tools, enabling detailed examination and interpretation of bibliometric maps.²²

VOSviewer version 1.6.20 was downloaded from the official VOSviewer website. To prevent incorrect processing of the exported .csv dataset by the software, the data were initially opened and edited in Microsoft Excel (Microsoft, Inc., Redmond, Washington). These edits involved correcting various inaccuracies, including author names, journal titles, and country names.

The Biblioshiny R-package is a unique open-source tool designed for conducting comprehensive science mapping analyses. It supports a recommended workflow for performing bibliometric analyses and is programmed in the R language, making it flexible, easily upgradable, and compatible with other statistical R packages.²³ These features make it particularly valuable in a continuously evolving field such as bibliometrics. For analysis with Biblioshiny, data were exported in “.bib” format, processed within the software, and subsequently visualized. Microsoft Excel was used for data tabulation. Ethical approval was not required, as the research did not involve clinical studies or patient data.

RESULTS

A comprehensive search of the Scopus database, using keywords related to orthodontics and orthognathic surgery, yielded a total of 217,121 articles. These articles were ranked according to their annual citation rates, and the top 100 most-cited articles were selected (Table 1). The selected articles span the period from 1982 to 2024. The article with the highest annual citation rate received 45.33 citations per year, accumulating a total of 272 citations.

Among the countries contributing most significantly, the USA ranked first with 32 articles and 10,726 citations, followed by Italy with 14 articles and 3,674 citations, and India with 12 articles and 2,352 citations (Table 2). Saveetha University was the leading contributing institution with 7 articles and 1,419 citations, followed by the University

of Michigan with 6 articles and 2,118 citations, and the University of Florence with 4 articles and 1,732 citations (Table 3).

The most productive author was Franchi L. with 4 articles and 1,732 citations, followed by McNamara Jr. J. A. with 3 articles and 1,573 citations (Table 4). Figure 1 illustrates the distribution of the top 100 articles, ranked by annual citation rate, across the studied period.

The analysis of authors' keywords revealed that the most frequently occurring terms were orthodontics, systematic review, artificial intelligence, deep learning, clear aligners, machine learning, orthognathic surgery, periodontal ligament, cervical vertebrae, and bone remodeling. The results of the frequency analysis of authors' keywords are presented in Figure 2. Figure 3 illustrates the distribution of trending authors' keywords over the years, while Figure 4 depicts the network structure of these keywords. Additionally, Figure 5 demonstrates the geographical distribution of contributing countries.

The most common thematic areas were aligners (19 articles), artificial intelligence (11 articles), and digital dentistry (9 articles) (Table 5). The most frequently encountered study types included systematic reviews (23 articles), narrative literature reviews (18 articles), and prospective studies (14 articles) (Table 6). The journals publishing the highest number of articles were the American Journal of Orthodontics and Dentofacial Orthopedics and the Angle Orthodontist (Table 7).

DISCUSSION

The average annual citation rate is an essential metric, accurately reflecting the scientific potential of newer articles that have not yet accumulated high total citation counts.^{20,21} This study addresses a notable gap in the field by presenting a ranking based on annual citation rates, providing an objective assessment of how effectively studies maintain or increase their scientific influence over time.

Three major databases—Google Scholar, Scopus, and Web of Science (WoS)—are commonly utilized for bibliometric analyses. Among these, Scopus is the most widely employed database due to its reliable information collection and advanced analytical tools.²⁴ The utilization of the Scopus database in our study ensured reliable data collection and provided a robust foundation for the analysis. Its extensive journal coverage and detailed bibliometric analysis capabilities enabled accurate identification of the

Tablo 1. Top 100 most cited articles ranked by annual citation rate

No	Title	Authors	Year of Publications	Total Citations	Citations Per Year	Thematic Field	Type of Study	Source Title	Correspond Author's Country
1	Evaluation of Three-Dimensional Changes in Pharyngeal Airway Following Isolated Left Orbit Osteotomy for the Correction of Vertical Maxillary Excess: A Prospective Study	Vijayakumar Jain S.; Muthusekhar M.R.; Baig M.F.; Senthilnathan P.; Loganathan S.; Abdul Wahab P.U.; Madhulakshmi M.; Vohra Y.	2019	272	45.33	Airway space	Prospective study	Journal of Maxillofacial and Oral Surgery	India
2	Efficacy of clear aligners in controlling orthodontic tooth movement: A systematic review	Rossini G.; Parrini S.; Castorfflorio T.; Deregibus A.; Debernardi C.L.	2015	443	44.3	Aligners	Systematic review	Angle Orthodontist	Italy
3	How sample size influences research outcomes	Faber J.; Fonseca L.M.	2014	476	43.27	Importance of sample size	Narrative literature review	Dental Press Journal of Orthodontics	Brazil
4	Development and validation of a formula for objective assessment of cervical vertebral bone age	Chandrasekar R.; Chandrasekhar S.; Sundari K.K.S.; Ravi P.	2020	213	42.6	Cervical vertebral maturation	Methodological study	Progress in Orthodontics	India
5	The Cervical Vertebral Maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics	Baccetti T.; Franchi L.; McNamara Jr. J.A.	2005	813	40.65	Cervical vertebral maturation	Methodological study	Seminars in Orthodontics	Italy
6	Cone-beam computerized tomography (CBCT) imaging of the oral and maxillofacial region: A systematic review of the literature	De Vos W.; Casselman J.; Swennen G.R.J.	2009	616	38.5	Cone-beam computed tomography	Systematic review	International Journal of Oral and Maxillofacial Surgery	Belgium
7	Has Invisalign improved? A prospective follow-up study on the efficacy of tooth movement with Invisalign	Haouili N.; Kravitz N.D.; Vaid N.R.; Ferguson D.J.; Makki L.	2020	191	38.2	Aligners	Prospective study	American Journal of Orthodontics and Dentofacial Orthopedics	USA
8	Advances in orthodontic clear aligner materials	Bichu Y.M.; Alwafi A.; Liu X.; Andrews J.; Ludwig B.; Bichu A.Y.; Zou B.	2023	74	37	Aligners	Narrative literature review	Bioactive Materials	Canada

9	Orthodontic tooth movement: The biology and clinical implications	Li Y.; Jacox L.A.; Little S.H.; Ko C.-C.	2018	238	34	Tooth movement	Narrative literature review	Kaohsiung Journal of Medical Sciences	USA
10	A 2003 update of bone physiology and Wolff's law for clinicians	Frost H.M.	2004	709	33.76	Alveolar bone	Narrative literature review	Angle Orthodontist	USA
11	Effectiveness of clear aligner therapy for orthodontic treatment: A systematic review	Robertson L.; Kaur H.; Fagundes N.C.F.; Romanyk D.; Major P.; Flores-Mir C.	2020	157	31.4	Aligners	Systematic review	Orthodontics and Craniofacial Research	Canada
12	Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage	Miyawaki S.; Koyama I.; Inoue M.; Mishima K.; Sugahara T.; Takano-Yamamoto T.	2003	666	30.27	Anchorage	Retrospective study	American Journal of Orthodontics and Dentofacial Orthopedics	Japan
13	The analysis of errors in orthodontic measurements	Houston W.J.B.	1983	1269	30.21	Error in cephalometric measurement	Narrative literature review	American Journal of Orthodontics and Dentofacial Orthopedics	United Kingdom
14	Precision and trueness of dental models manufactured with different 3-dimensional printing techniques	Kim S.Y.; Shin Y.S.; Jung H.D.; Hwang C.J.; Baik H.S.; Cha J.Y.	2018	211	30.14	Digital dentistry	Experimental study	American Journal of Orthodontics and Dentofacial Orthopedics	South Korea
15	Global distribution of malocclusion traits: A systematic review	Alhammadi M.S.; Halboub E.; Fayed M.S.; Labib A.; El-Saadi C.	2018	208	29.71	Prevalence of malocclusion	Systematic review	Dental Press Journal of Orthodontics	Saudi Arabia
16	Precision of intraoral digital dental impressions with iTero and extraoral digitization with the iTero and a model scanner	Flügge T.V.; Schlager S.; Nelson K.; Nahles S.; Metzger M.C.	2013	347	28.92	Digital models	Prospective study	American Journal of Orthodontics and Dentofacial Orthopedics	Germany
17	Root resorption associated with orthodontic tooth movement: A systematic review	Weltman B.; Vig K.W.L.; Fields H.W.; Shanker S.; Kaizar E.E.	2010	432	28.8	Root resorption	Systematic review	American Journal of Orthodontics and Dentofacial Orthopedics	USA
18	Worldwide prevalence of malocclusion in the different stages of dentition: A systematic review and meta-analysis	Lombardo G.; Vena F.; Negri P.; Pagano S.; Barilotti C.; Paglia L.; Colombo S.; Orso M.; Cianetti S.	2020	142	28.4	Prevalence of malocclusion	Systematic review	European Journal of Paediatric Dentistry	Italy

19	Artificial intelligence in orthodontics: Evaluation of a fully automated cephalometric analysis using a customized convolutional neural network	Kunz F.; Stellzig-Eisenhauer A.; Zeman F.; Boldt J.	2020	137	27.4	Artificial intelligence	Prospective study	Journal of Orofacial Orthopedics	Germany
20	Biomechanical and biological responses of periodontium in orthodontic tooth movement: up-date in a new decade	Li Y.; Zhan Q.; Bao M.; Yi J.; Li Y.	2021	109	27.25	Tooth movement	Narrative literature review	International Journal of Oral Science	China
21	Accuracy of a computer-aided surgical simulation protocol for orthognathic surgery: A prospective multicenter study	Hsu S.S.P.; Gateno J.; Bell R.B.; Hirsch D.L.; Markiewicz M.R.; Teichgraber J.F.; Zhou X.; Xia J.J.	2013	317	26.42	Digital dentistry	Prospective study	Journal of Oral and Maxillofacial Surgery	USA
22	Automated identification of cephalometric landmarks: Part 2- Might it be better than human?	Hwang H.W.; Park J.H.; Moon J.H.; Yu Y.; Kim H.; Her S.B.; Srinivasan G.; Aljanabi M.N.A.; Donatelli R.E.; Lee S.-J.	2020	132	26.4	Artificial intelligence	Methodological study	Angle Orthodontist	South Korea
23	Influence of the three-dimensional printing technique and printing layer thickness on model accuracy	Zhang Z.C.; Li P.L.; Chu F.T.; Shen G.	2019	157	26.17	Digital dentistry	Experimental study	Journal of Orofacial Orthopedics	China
24	Clear aligners in orthodontic treatment	Weir T.	2017	209	26.13	Aligners	Narrative literature review	Australian Dental Journal	Australia
25	Cellular, molecular, and tissue-level reactions to orthodontic force.	Krishnan V.; Davidovitch Z.	2006	495	26.05	Tooth movement	Narrative literature review	American Journal of Orthodontics and Dentofacial Orthopedics	India
26	Can ChatGPT be used in oral and maxillofacial surgery?	Balel Y.	2023	52	26	Artificial intelligence	Prospective study	Journal of Stomatology, Oral and Maxillofacial Surgery	Türkiye
27	Clinical effectiveness of Invisalign® orthodontic treatment: a systematic review	Papadimitriou A.; Mousoulea S.; Gkantidis N.; Kloukos D.	2018	181	25.86	Aligners	Systematic review	Progress in Orthodontics	Switzerland
28	Direct 3D printing of clear orthodontic aligners: Current state and future possibilities	Tartaglia G.M.; Mapelli A.; Maspero C.; Santaniello T.; Serafin M.; Farronato M.; Caprioglio A.	2021	102	25.5	Aligners	Narrative literature review	Materials	Italy

29	Mechanisms of tooth eruption and orthodontic tooth movement	Wise G.E.; King G.J.	2008	428	25.18	Tooth movement	Narrative literature review	Journal of Dental Research	USA
30	CBCCT in orthodontics: Assessment of treatment outcomes and indications for its use	Kapila S.D.; Nervina J.M.	2015	248	24.8	Cone-beam computed tomography	Narrative literature review	Dentomaxillofacial Radiology	USA
31	How well does Invisalign work? A prospective clinical study evaluating the efficacy of tooth movement with Invisalign	Kravitz N.D.; Kusnoto B.; BeGole E.; Obrez A.; Agran B.	2009	396	24.75	Aligners	Prospective study	American Journal of Orthodontics and Dentofacial Orthopedics	USA
32	Orthodontic management of a dilacerated central incisor and partially impacted canine with unilateral extraction - A case report	Felicita A.S.	2017	193	24.13	Impacted tooth	Case report	Saudi Dental Journal	India
33	Comparison of pterygomaxillary dysjunction with tuberosity separation in isolated Le Fort I osteotomies: a prospective, multi-centre, triple-blind, randomized controlled trial	Christabel A.; Anantanarayanan P.; Subash P.; Soh C.L.; Ramanathan M.; Muthusekhar M.R.; Narayanan V.	2016	216	24	Surgical technique	Clinical trial	International Journal of Oral and Maxillofacial Surgery	India
34	Factors affecting the clinical success of screw implants used as orthodontic anchorage	Park H.-S.; Jeong S.-H.; Kwon O.-W.	2006	450	23.68	Anchorage	Longitudinal study	American Journal of Orthodontics and Dentofacial Orthopedics	South Korea
35	Mini-implant for orthodontic anchorage.	Kanomi R.	1997	661	23.61	Anchorage	Case report	Journal of Clinical Orthodontics : JCO	Japan
36	A comparison of treatment effectiveness between clear aligner and fixed appliance therapies	Ke Y.; Zhu Y.; Zhu M.	2019	141	23.5	Aligners	Systematic review	BMC Oral Health	China
37	Automated identification of cephalometric landmarks: Part 1—Comparisons between the latest deep-learning methods YOLOV3 and SSD	Park J.H.; Hwang H.W.; Moon J.H.; Yu Y.; Kim H.; Her S.-B.; Srinivasan G.; Aljanabi M.N.A.; Donatelli R.E.; Lee S.J.	2019	139	23.17	Artificial intelligence	Prospective study	Angle Orthodontist	South Korea

38	The impact of malocclusion on the quality of life among children and adolescents: A systematic review of quantitative studies	Dimberg L.; Arnrup K.; Bondemark L.	2015	230	23	Prevalence of malocclusion	Systematic review	European Journal of Orthodontics	Sweden
39	Automated Skeletal Classification with Lateral Cephalometry Based on Artificial Intelligence	Yu H.J.; Cho S.R.; Kim M.J.; Kim W.H.; Kim J.W.; Choi J.	2020	115	23	Artificial intelligence	Prospective study	Journal of Dental Research	South Korea
40	Obstructive sleep apnea and orthodontics: An American Association of Orthodontists White Paper	Behrents R.G.; Shelgikar A.V.; Conley R.S.; Flores-Mir C.; Hans M.; Levine M.; McNamara J.A.; Palomo J.M.; Pliska B.; Stockstill J.W.; Wise J.; Murphy S.; Nagel N.J.; Hittner J.	2019	137	22.83	Obstructive sleep apnea	Expert consensus document	American Journal of Orthodontics and Dentofacial Orthopedics	USA
41	An Improved Version of the Cervical Vertebral Maturation (CVM) Method for the Assessment of Mandibular Growth	Baccetti T.; Franchi L.; McNamara Jr. J.A.	2002	523	22.74	Cervical vertebral maturation	Longitudinal study	Angle Orthodontist	Italy
42	Treatment outcome and efficacy of an aligner technique - regarding incisor torque, premolar derotation and molar distalization	Simon M.; Keilig L.; Schwarze J.; Jung B.A.; Bourauel C.	2014	250	22.73	Aligners	Prospective study	BMC Oral Health	Germany
43	The cervical vertebral maturation method: A user's guide	McNamara J.A.; Franchi L.	2018	158	22.57	Cervical vertebral maturation	Narrative literature review	Angle Orthodontist	USA
44	Clinical trials with crystal growth conditioning as an alternative to acid-etch enamel pretreatment	Årtun J.; Bergland S.	1984	925	22.56	Enamel conditioning	Experimental study	American Journal of Orthodontics and Dentofacial Orthopedics	Norway
45	Accuracy of 3-dimensionally printed full-arch dental models: A systematic review	Etemad-Shahidi Y.; Qallandar O.B.; Evenden J.; Alifui-Segbaya F.; Ahmed K.E.	2020	112	22.4	Digital dentistry	Systematic review	Journal of Clinical Medicine	Australia
46	Wolff's Law and bone's structural adaptations to mechanical usage: an overview for clinicians.	Frost H.M.	1994	694	22.39	Alveolar bone	Longitudinal study	Angle Orthodontist	USA

47	Accuracy and reproducibility of dental replica models reconstructed by different rapid prototyping techniques	Hazeveld A.; Huddleston Slater J.J.R.; Ren Y.	2014	245	22.27	Digital dentistry	Comparative study	American Journal of Orthodontics and Dentofacial Orthopedics	Netherlands
48	The development of an index of orthodontic treatment priority	Brook P.H.; Shaw W.C.	1989	798	22.17	Orthodontic treatment priority	Methodological study	European Journal of Orthodontics	United Kingdom
49	Orthodontic extrusion of Ellis Class VIII fracture of maxillary lateral incisor - The sling shot method	Felicita A.S.	2018	155	22.14	Orthodontic treatment duration	Case report	Saudi Dental Journal	India
50	Scope and performance of artificial intelligence technology in orthodontic diagnosis, treatment planning, and clinical decision-making - A systematic review	Khanagar S.B.; Al-Ehaideb A.; Vishwanathaiah S.; Maganur P.C.; Patil S.; Naik S.; Baeshen H.A.; Sarode S.S.	2021	87	21.75	Artificial intelligence	Systematic review	Journal of Dental Sciences	Saudi Arabia
51	Biomechanics of clear aligners: hidden truths & first principles	Upadhyay M.; Arqub S.A.	2022	65	21.67	Aligners	Narrative literature review	Journal of the World Federation of Orthodontists	USA
52	Prevalence of white spot lesions during orthodontic treatment with fixed appliances	Tufekci E.; Dixon J.S.; Gunsolley J.C.; Lindauer S.J.	2011	300	21.43	White spot lesions	Prospective study	Angle Orthodontist	USA
53	Role of osteopontin in bone remodeling and orthodontic tooth movement: a review	Singh A.; Gill G.; Kaur H.; Amhmed M.; Jakhu H.	2018	150	21.43	Tooth movement	Narrative literature review	Progress in Orthodontics	Canada
54	The tissue, cellular, and molecular regulation of orthodontic tooth movement: 100 Years after Carl Sandstedt	Meikle M.C.	2006	397	20.89	Tooth movement	Narrative literature review	European Journal of Orthodontics	New Zealand
55	Clinical recommendations regarding use of cone beam computed tomography in orthodontic treatment. Position statement by the American Academy of Oral and Maxillofacial Radiology	Scarfe W.C.	2013	249	20.75	Cone-beam computed tomography	Retrospective study	Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology	USA
56	Efficiency, effectiveness and treatment stability of clear aligners: A systematic review and meta-analysis	Zheng M.; Liu R.; Ni Z.; Yu Z.	2017	165	20.63	Aligners	Expert consensus document	Orthodontics and Craniofacial Research	China

57	The efficacy of mesenchymal stem cells to regenerate and repair dental structures	Shi S.; Miura M.; Seo B.M.; Robey P.G.; Bartold PM.; Gronthos S.	2005	412	20.6	Periodontal ligament	Experimental study	Orthodontics and Craniofacial Research	Australia
58	Prevalence of malocclusion and orthodontic treatment need in the United States: estimates from the NHANES III survey.	Proffit W.R.; Fields Jr. H.W.; Moray L.J.	1998	555	20.56	Prevalence of malocclusion	Cross-sectional study	The International Journal of Adult Orthodontics and Orthognathic Surgery	USA
59	Clinical effectiveness of clear aligner treatment compared to fixed appliance treatment: an overview of systematic reviews	Yassir Y.A.; Nabbat S.A.; McIntyre G.T.; Bearn D.R.	2022	61	20.33	Aligners	Systematic review	Clinical Oral Investigations	Iraq
60	Angular photogrammetric analysis of the soft-tissue facial profile of Indian adults	Pandian K.; Krishnan S.; Kumar S.	2018	141	20.14	Craniofacial morphology	Cross-sectional study	Indian Journal of Dental Research	India
61	Effect of micro-osteoperforations on the rate of tooth movement	Alikhani M.; Raptis M.; Zoldan B.; Sangsuwon C.; Lee Y.B.; Aliyami B.; Corpodian C.; Barrera L.M.; Alansari S.; Khoo E.; Teixeira C.	2013	241	20.08	Tooth movement	Case series	American Journal of Orthodontics and Dentofacial Orthopedics	USA
62	A Prospective Study of the Risk Factors Associated with Failure of Mini-implants Used for Orthodontic Anchorage	Cheng S.J.; Tseng I.Y.; Lee J.J.; Kok S.-H.	2004	421	20.05	Anchorage	Prospective study	International Journal of Oral and Maxillofacial Implants	Taiwan
63	Mechanical and geometric properties of thermoformed and 3D printed clear dental aligners	Jindal P.; Juneja M.; Siena F.L.; Bajaj D.; Breedon P.	2019	120	20	Aligners	Experimental study	American Journal of Orthodontics and Dentofacial Orthopedics	United Kingdom
64	Three-Dimensional Treatment Planning of Orthognathic Surgery in the Era of Virtual Imaging	Swennen G.R.J.; Mollemans W.; Schutyser F.	2009	318	19.88	Digital dentistry	Methodological study	Journal of Oral and Maxillofacial Surgery	Belgium
65	Treatment outcome with orthodontic aligners and fixed appliances: A systematic review with meta-analyses	Papageorgiou S.N.; Koletsi D.; Iliadi A.; Peltomaki T.; Eliades T.	2020	99	19.8	Aligners	Systematic review	European Journal of Orthodontics	Switzerland
66	Deep learning for cephalometric landmark detection: systematic review and meta-analysis	Schwendicke F.; Chaurasia A.; Arsiwala L.; Lee J.H.; Elhennawy K.; Jost-Brinkmann P.G.; Demarco F.; Krois J.	2021	79	19.75	Artificial intelligence	Systematic review	Clinical Oral Investigations	Germany

67	Accuracy of clear aligners: A retrospective study of patients who needed refinement	Charalampakis O.; Iliadi A.; Ueno H.; Oliver D.R.; Kim K.B.	2018	135	19,29	Aligners	Retrospective study	American Journal of Orthodontics and Dentofacial Orthopedics	USA
68	Accuracy of virtual planning in orthognathic surgery: a systematic review	Alkhayer A.; Piffkó J.; Lippold C.; Segatto E.	2020	96	19,2	Digital dentistry	Systematic review	Head and Face Medicine	Germany
69	A systematic review of the accuracy and efficiency of dental movements with invisalign®	Galan-Lopez L.; Barcia-Gonzalez J.; Plasencia E.	2019	115	19,17	Aligners	Systematic review	Korean Journal of Orthodontics	Spain
70	"Safe zones": A guide for miniscrew positioning in the maxillary and mandibular arch	Poggio P.M.; Incorvati C.; Velo S.; Carano A.	2006	363	19,11	Anchorage	Retrospective study	Angle Orthodontist	Italy
71	Isolation and characterization of multipotent human periodontal ligament stem cells	Gay I.C.; Chen S.; MacDougall M.	2007	343	19,06	Periodontal ligament	Methodological study	Orthodontics and Craniofacial Research	USA
72	Midpalatal suture maturation: Classification method for individual assessment before rapid maxillary expansion	Angelieri F.; Cevidanes L.H.S.; Franchi L.; Gonçalves J.R.; Benavides E.; McNamara Jr. J.A.	2013	228	19	Rapid maxillary expansion	Retrospective study	American Journal of Orthodontics and Dentofacial Orthopedics	Brazil
73	Quality of life assessment in patients with dentofacial deformity undergoing orthognathic surgery - A systematic review	Soh C.L.; Narayanan V.	2013	228	19	Orthognathic surgery	Systematic review	International Journal of Oral and Maxillofacial Surgery	India
74	3D printing in orthognathic surgery – A literature review	Lin H.H.; Lonic D.; Lo L.J.	2018	133	19	Digital dentistry	Literature review	Journal of the Formosan Medical Association	Germany
75	Applications of artificial intelligence and machine learning in orthodontics: a scoping review	Bichu Y.M.; Hansa I.; Bichu A.Y.; Premjani P.; Flores-Mir C.; Vaid N.R.	2021	76	19	Artificial intelligence	Scoping review	Progress in Orthodontics	South Africa
76	Is inflammation a friend or foe for orthodontic treatment?: Inflammation in orthodontically induced inflammatory root resorption and accelerating tooth movement	Yamaguchi M.; Fukasawa S.	2021	76	19	Root resorption	Narrative literature review	International Journal of Molecular Sciences	Japan

77	Impacted Central Incisors in the Upper Jaw in an Adolescent Patient: Orthodontic- Surgical Treatment—A Case Report	Malcangi G.; Inchingolo A.D.; Patano A.; Coloccia G.; Ceci S.; Garibaldi M.; Inchingolo V.; Piras F.; Cardarelli F.; Settanni V.; Rapone B.; Corriero A.; Mancini A.; Corsalini M.; Nucci L.; Bordea I.R.; Lorusso F.; Scarano A.; Giovanniello D.; Dipalma G.; Posa V.M.; Di Venere D.; Inchingolo F.	2022	57	19	19	Impacted tooth	Case report	Applied Sciences (Switzerland)	Italy
78	Study on the role of nano antibacterial materials in orthodontics (a review)	Budi H.S.; Jameel M.F.; Widiyaji G.; Alasady M.S.; Mahmudiono T.; Mustafa Y.F.; Fardeeva I.; Kuznetsova M.	2024	19	19	19	Antibacterial materials in orthodontics	Systematic literature review	Brazilian Journal of Biology	Iraq
79	Orthodontic measurements on digital study models compared with plaster models: A systematic review	Fleming P.S.; Marinho V.; Johal A.	2011	265	18,93	18,93	Digital models	Systematic review	Orthodontics and Craniofacial Research	United Kingdom
80	Clinical use of miniscrew implants as orthodontic anchorage: Success rates and postoperative discomfort	Kuroda S.; Sugawara Y.; Deguchi T.; Kyung H.M.; Takano-Yamamoto T.	2007	339	18,83	18,83	Anchorage	Retrospective study	American Journal of Orthodontics and Dentofacial Orthopedics	Japan
81	Association of orthodontic force system and root resorption: A systematic review	Roscoe M.G.; Meira J.B.C.; Cattaneo P.M.	2015	187	18,7	18,7	Root resorption	Systematic review	American Journal of Orthodontics and Dentofacial Orthopedics	Denmark
82	Tooth-borne vs bone-borne rapid maxillary expanders in late adolescence	Lin L.; Ahn H.W.; Kim S.J.; Moon S.C.; Kim S.H.; Nelson G.	2015	187	18,7	18,7	Rapid maxillary expansion	Clinical trial	Angle Orthodontist	South Korea
83	3D planning in orthognathic surgery: CAD/CAM surgical splints and prediction of the soft and hard tissues results - Our experience in 16 cases	Aboul-Hosn Centenero S.; Hernández-Alfaro F.	2012	243	18,7	18,7	Digital dentistry	Clinical trial	Journal of Cranio-Maxillofacial Surgery	Spain
84	Elastodontic Therapy of Hyperdivergent Class II Patients Using AMCOP® Devices: A Retrospective Study	Inchingolo A.D.; Ceci S.; Patano A.; Inchingolo A.M.; Montenegro V.; Di Pede C.; Malcangi G.; Marinelli G.; Coloccia G.; Garibaldi M.; Kruti Z.; Palmieri G.; De Leonardis N.; Rapone B.; Mancini A.; Semjonova A.; Nucci L.; Bordea I.R.; Scarano A.; Lorusso F.; Ferrara E.; Farronato M.; Tartaglia G.M.; Di Venere D.; Cardarelli F.; Inchingolo F.; Dipalma G.	2022	56	18,67	18,67	Class II malocclusion	Retrospective study	Applied Sciences (Switzerland)	Romania

85	Rapid orthodontics with alveolar reshaping: Two case reports of decrowding	Wilcko W.M.	2001	444	18,5	Alveolar bone	Case series	International Journal of Periodontics and Restorative Dentistry	USA
86	Rapid maxillary expansion for pediatric obstructive sleep apnea: A systematic review and meta-analysis	Camacho M.; Chang E.T.; Song S.A.; Abdullatif J.; Zaghi S.; Pirelli P.; Certal V.; Guilleminault C.	2017	148	18,5	Rapid maxillary expansion	Systematic review	Laryngoscope	USA
87	Incidence of white spot formation after bonding and banding	Gorelick L.; Geiger A.M.; Gwinnett A.J.	1982	795	18,49	White spot lesions	Retrospective study	American Journal of Orthodontics and Dentofacial Orthopedics	USA
88	Retention procedures for stabilising tooth position after treatment with orthodontic braces	Littlewood S.J.; Millett D.T.; Doubleday B.; Bearn D.R.; Worthington H.V.	2016	166	18,44	Orthodontic bonding techniques	Systematic review	Cochrane Database of Systematic Reviews	United Kingdom
89	Failure rates and associated risk factors of orthodontic miniscrew implants: A meta-analysis	Papageorgiou S.N.; Zogakis I.P.; Papadopoulos M.A.	2012	239	18,39	Anchorage	Systematic review	American Journal of Orthodontics and Dentofacial Orthopedics	Greece
90	Miniscrews as orthodontic anchorage: a preliminary report.	Costa A.; Raffaini M.; Melsen B.	1998	495	18,33	Anchorage	Narrative literature review	The International Journal of Adult Orthodontics and Orthognathic Surgery	Italy
91	Multiclass CBCT Image Segmentation for Orthodontics with Deep Learning	Wang H.; Minnema J.; Batenburg K.J.; Forouzanfar T.; Hu F.J.; Wu G.	2021	73	18,25	Artificial intelligence	Prospective study	Journal of Dental Research	Netherlands
92	Comparison of pain perception, anxiety, and impacts on oral health-related quality of life between patients receiving clear aligners and fixed appliances during the initial stage of orthodontic treatment	Gao M.; Yan X.; Zhao R.; Shan Y.; Chen Y.; Jian F.; Long H.; Lai W.	2021	73	18,25	Aligners	Prospective study	European Journal of Orthodontics	China
93	Biomimetic Effect of Nano-Hydroxyapatite in Demineralized Enamel before Orthodontic Bonding of Brackets and Attachments: Visual, Adhesion Strength, and Hardness in in Vitro Tests	Scribante A.; Dermenaki Farahani M.R.; Marino G.; Matera C.; Rodriguez Y Baena R.; Lanteri V.; Butera A.	2020	91	18,2	Orthodontic bonding techniques	Laboratory study	BioMed Research International	Italy

94	Automatic classification and segmentation of teeth on 3D dental model using hierarchical deep learning networks	Tian S.; Dai N.; Zhang B.; Yuan F.; Yu Q.; Cheng X.	2019	109	18,17	Artificial intelligence	Cross-sectional study	IEEE Access	China
95	Prevalence of white spot lesion formation during orthodontic treatment	Julien K.C.; Buschang P.H.; Campbell P.M.	2013	217	18,08	White spot lesions	Retrospective study	Angle Orthodontist	USA
96	Predictability of orthodontic tooth movement with aligners: effect of treatment design	Castroflorio T.; Sedran A.; Parrini S.; Garino F.; Reverdito M.; Capuzzo R.; Mutinelli S.; Grybauskas S.; Vaitiekūnas M.; Deregiibus A.	2023	36	18	Aligners	Longitudinal study	Progress in Orthodontics	Italy
97	Perceptions of dental professionals and laypersons to altered dental esthetics: Asymmetric and symmetric situations	Kokich V.O.; Kokich V.G.; Kiyak H.A.	2006	341	17,95	Aesthetic	Cross-sectional study	American Journal of Orthodontics and Dentofacial Orthopedics	USA
98	Microimplant-assisted rapid palatal expansion appliance to orthopedically correct transverse maxillary deficiency in an adult	Carlson C.; Sung J.; McComb R.W.; MacHado A.W.; Moon W.	2016	158	17,56	Rapid maxillary expansion	Case report	American Journal of Orthodontics and Dentofacial Orthopedics	USA
99	Web-based fully automated cephalometric analysis by deep learning	Kim H.; Shim E.; Park J.; Kim Y.J.; Lee U.; Kim Y.	2020	87	17,4	Artificial intelligence	Methodological study	Computer Methods and Programs in Biomedicine	South Korea
100	The hierarchy of stability and predictability in orthognathic surgery with rigid fixation: An update and extension	Proffit W.R.; Turvey T.A.; Phillips C.	2007	312	17,33	Orthognathic surgery	Retrospective study	Head and Face Medicine	USA

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Table 2. The most contributing countries with more than two publications

Country or Region	Number of Articles	Number of Citations
USA	32	10726
Italy	14	3674
India	12	2352
South Korea	9	1746
Germany	8	1366
China	8	908
United Kingdom	6	2687
Japan	5	1951
Brazil	5	1138
Canada	5	597
Saudi Arabia	5	645
Canada	5	597
Australia	4	809
Greece	4	657
Belgium	3	1120
Taiwan	3	871
United Arab Emirates	3	345

Table 3. Institutions contributing the most with more than two publications

Source title	Number of Articles	Number of Citations
Saveetha University	7	1419
University of Michigan	6	2118
University of Florence	4	1732
Seoul National University	4	550
University of North Carolina	3	1111
Yonsei University	3	415
University of Alberta	3	372

Table 4. Authors contributing the most with more than two publications

Authors	Number of Articles	Number of Citations
Franchi L.	4	1732
McNamara Jr. J.A.	3	1573
Flores-Mir C.	3	372
Kim H.	3	362

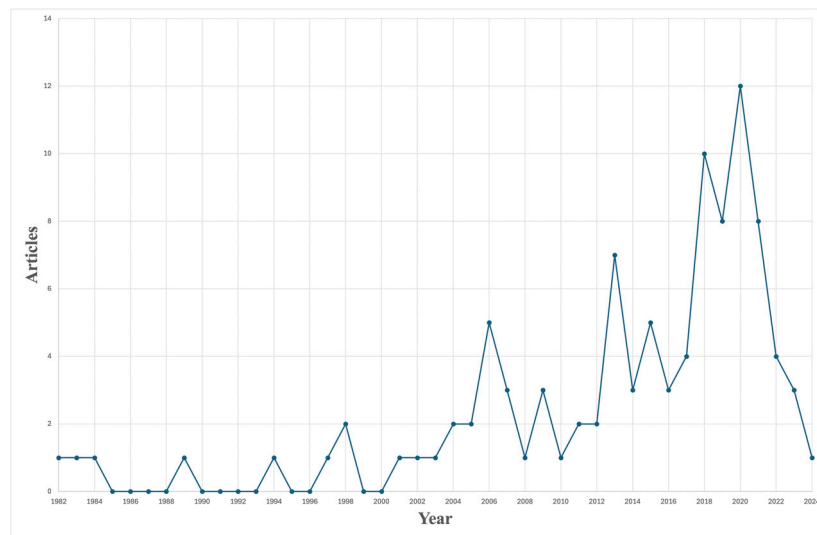


Figure 1. Distribution of the top 100 articles ranked by annual citation rate by year

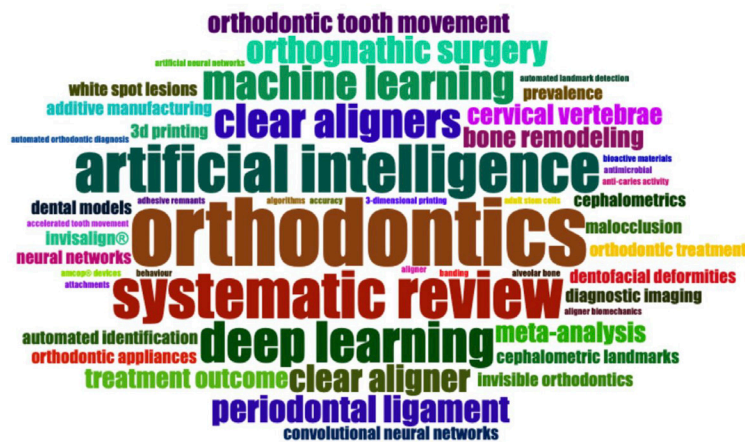


Figure 2. Frequency analysis of author's keywords

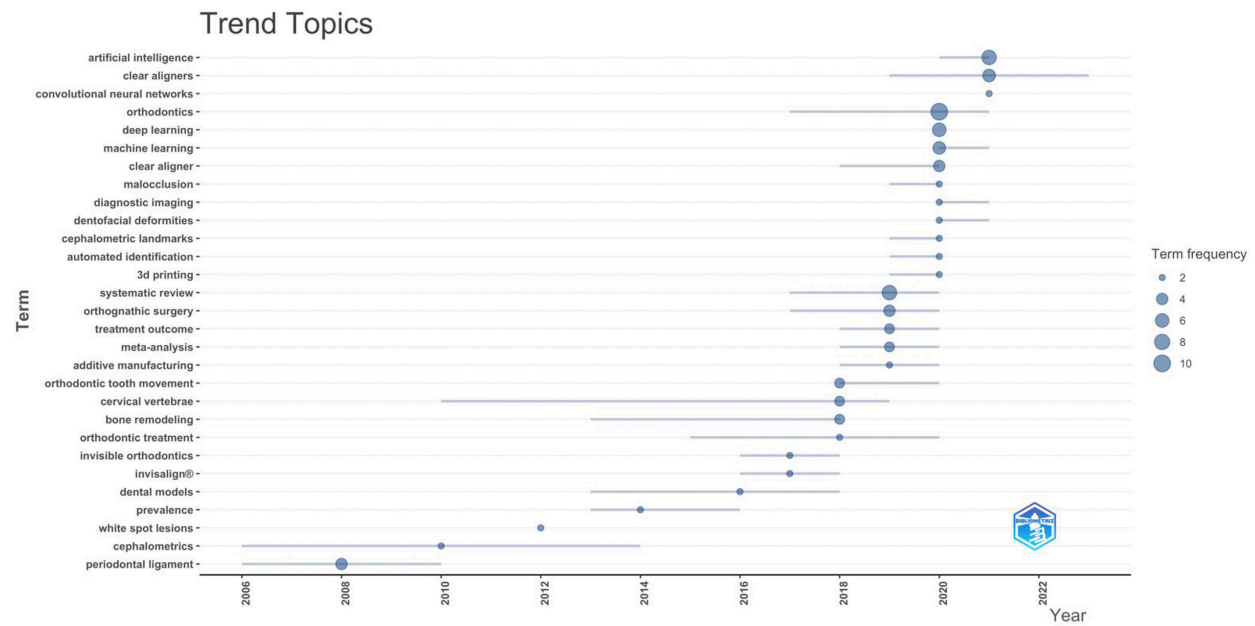


Figure 3. Annual distribution of trending authors' keywords

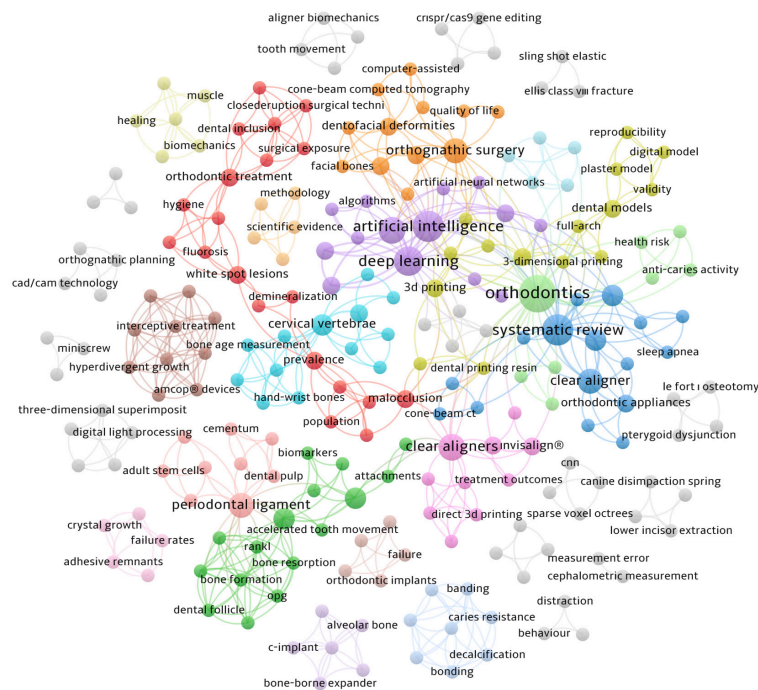


Figure 4. Network structure of author's keywords

most influential articles in orthodontics and orthognathic surgery based on their annual citation rates.

Web of Science and Scopus have traditionally been the two most commonly used databases for bibliometric analyses.²⁵ These databases have been extensively compared through

direct coverage comparisons^{26,27} as well as citation-based comparative studies.²⁸ Numerous comparative analyses have demonstrated that while Scopus offers broader journal coverage, Web of Science is more selective regarding the journals' indexes. Specifically, approximately 99.11%

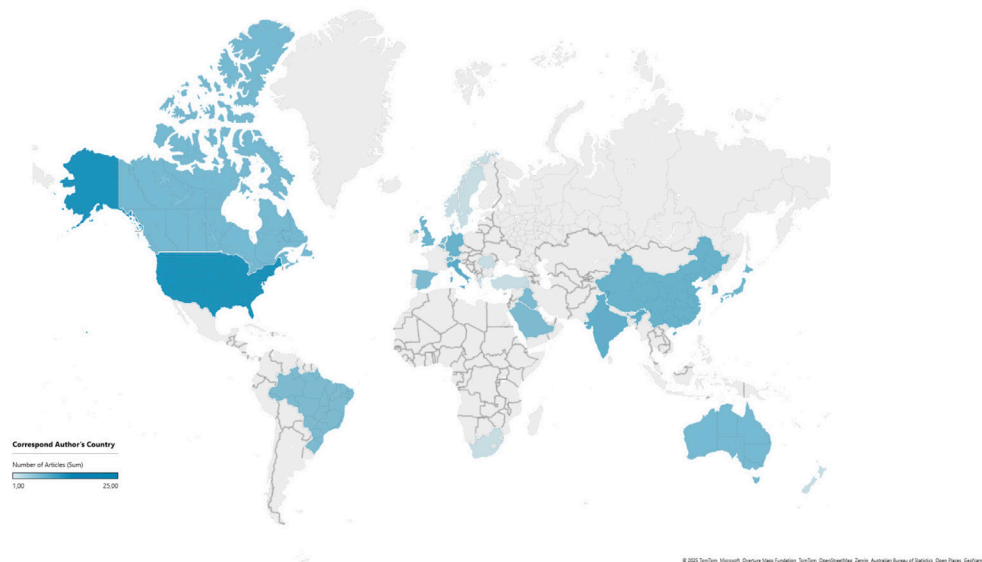


Figure 5. Geographical distribution of contributing countries.

of journals indexed in Web of Science are also included in Scopus, whereas only 33.93% of Scopus-indexed journals appear in Web of Science.²⁵ Given that our study focuses specifically on identifying the top 100 influential publications, the Scopus database was preferred due to its broader coverage.

Upon examination of the articles ranked by annual citation rate, it was determined that the selected articles were published between 1982 and 2024, with the highest density of publications observed in 2020 (12 articles). The article with the highest annual citation rate (45.33 citations per year) was published in 2019.²⁹ The majority of the top 100 articles appeared in recent years, notably in 2018 (10 articles), 2019 (8 articles), 2020 (12 articles), and 2021 (8 articles). While bibliometric studies utilizing total citation counts typically concentrate article distributions between 2000 and 2010,^{16,30} our study highlights newer and more contemporary research by employing the average annual citation rate as the ranking criterion.

The publication with the highest total citation count and the publication with the highest annual citation rate²⁹ were found to be different. The article with the highest total citation count was older, whereas the highest annual citation rate belonged to a more recent publication from 2019. From another perspective, although the publication with the highest annual citation rate²⁹ accumulated a total of 272 citations, the publication with the lowest annual citation rate³¹ within the top 100 had a higher total

citation count (312 citations). This finding highlights that relying solely on total citation counts can be misleading, underscoring the significance of annual citation rate as an essential metric. Therefore, evaluating studies based on the annual citation rate provides a valuable complementary approach, allowing recent but impactful publications to achieve appropriate recognition.

The American Journal of Orthodontics and Dentofacial Orthopedics (AJODO) and The Angle Orthodontist are the two journals that have contributed most significantly to this study, establishing themselves as leaders in orthodontic scientific research. The rigorous research published in these journals has consistently positioned them at the forefront of the field, with their articles frequently cited, thereby reinforcing their impact within the scientific community. Our analysis further supports previous bibliometric studies indicating that high-impact publications tend to be concentrated in a limited number of journals.^{16,32} In addition, the AJODO and The Angle Orthodontist particularly stand out as prominent platforms for influential research. This evaluation, based on annual citation rates, further emphasizes the central role these journals play in shaping research trends and scholarly discourse (Table 7).

The United States ranks first among contributing countries, with 32 articles accumulating a total of 10,726 citations. The leading role of the United States in orthodontics and orthognathic surgery literature is evident both in terms of the number of publications and citations received,

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Table 5. Thematic fields of the top 100 most cited articles ranked by annual citation rate

Thematic Field	Number of Articles
Aligners	19
Artificial intelligence	11
Digital dentistry	9
Anchorage	8
Tooth movement	7
Cervical vertebral maturation	4
Prevalence of malocclusion	4
Rapid maxillary expansion	4
Cone-beam computed tomography	3
Alveolar bone	3
Root resorption	3
White spot lesions	3
Digital models	2
Impacted tooth	2
Periodontal ligament	2
Orthognathic surgery	2
Orthodontic bonding techniques	2
Airway space	1
Importance of sample size	1
Error in cephalometric measurement	1
Class II malocclusion	1
Surgical technique	1
Obstructive sleep apnea	1
Enamel conditioning	1
Orthodontic treatment priority	1
Orthodontic treatment duration	1
Craniofacial morphology	1
Antibacterial materials in orthodontics	1
Aesthetic	1

Table 6. Study types of the top 100 most cited articles ranked by annual citation rate

Type of Study	Number of Articles
Systematic review	23
Narrative literature review	18
Prospective study	14
Retrospective study	10
Methodological study	7
Experimental study	5
Case report	5
Longitudinal study	4
Cross-sectional study	4
Clinical trial	3
Case series	2
Expert consensus document	2
Scoping review	1
Laboratory study	1
Comparative study	1

aligning closely with findings from previous bibliometric studies.^{15,32,33} The dominance of the U.S. in orthodontics and orthognathic surgery is consistent with earlier research in this field. Additionally, the analysis based on annual citation rates has shown that the United States has conducted the highest number of studies focusing on aligners, whereas South Korea has emerged as a leader in research related to artificial intelligence.

Among the contributing institutions, Saveetha University emerges prominently as the leading institution, contributing 7 articles that have collectively received 1,419 citations. The notable contribution of Saveetha University underscores its significant role in orthodontic and orthognathic surgery research.³⁴ The recent prominence of institutions like Saveetha University highlights changing global academic dynamics and increasing regional diversity within the orthodontic and orthognathic surgery literature. The contributing institutions identified in this study span Europe, Asia, and North America, underscoring the importance of

global academic collaboration and the growing influence of research centers across different geographical regions.

Among authors, Franchi L. stands out as the top contributor, with 4 articles and 1,732 citations, making him the most impactful author. Previous research has identified Franchi L. as one of the most prolific and frequently cited authors, particularly in the fields of rapid maxillary expansion (RME) and maxillary protraction.^{35,36} The known effectiveness of maxillary protraction and RME in individuals with higher growth potential, coupled with the direct influence of treatment timing on outcomes,³⁷ may explain the high citation rate of Franchi's studies observed in our analysis. Furthermore, among the contributing authors, McNamara Jr.J.A. was notable for achieving a high citation count (1,573 citations) despite publishing fewer articles, reinforcing that scientific impact depends not only on publication quantity but also on the quality and originality of the research. The identified contributing authors thus include both established and highly influential researchers whose work

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Table 7. The most contributing journals with more than two publications

Source	Documents	Citations	Total Link Strength
American Journal of Orthodontics and Dentofacial Orthopedics	22	8569	43
Angle Orthodontist	11	3879	27
European Journal of Orthodontics	5	1606	12
Orthodontics and Craniofacial Research	5	1346	18
Progress in Orthodontics	5	658	15
International Journal of Oral and Maxillofacial Surgery	3	1063	4
Journal of Dental Research	3	617	3
Applied Sciences (Switzerland)	2	116	0
BMC Oral Health	2	394	14
Clinical Oral Investigations	2	142	12
Dental Press Journal of Orthodontics	2	689	2
Head and Face Medicine	2	417	4
Journal of Oral and Maxillofacial Surgery	2	637	3
Journal of Orofacial Orthopedics	2	297	5
Saudi Dental Journal	2	348	0
The International Journal of Adult Orthodontics	2	1052	4

significantly shapes the orthodontic literature.

In our study, articles were ranked based on their annual citation rates, highlighting prominent thematic areas such as clear aligners, artificial intelligence, and digital dentistry. These results underscore the rapidly growing importance of digital technologies in orthodontic and orthognathic surgery literature, as well as their increasingly widespread adoption in clinical practice in recent years.³⁸⁻⁴⁰ Aligners emerged as the most studied topic, represented by 19 articles, followed by artificial intelligence with 11 articles, and digital dentistry with 9 articles.

In recent years, there has been a notable increase in research activity related to clear aligner treatments, corresponding with a growing volume of publications on this topic.³⁹ In previous bibliometric studies evaluating the top 100 articles based on total citation count, only one publication on clear aligners and two publications on digital dentistry were included.¹⁶ This discrepancy occurs because

older studies typically accumulate more citations over time, overshadowing more recent and influential research. In contrast, our analysis based on annual citation rates placed aligners and digital dentistry prominently among the top positions, thereby highlighting contemporary and emerging topics that might otherwise be overlooked.

The most frequently encountered study types were systematic reviews (23 articles) and narrative literature reviews (18 articles), indicating that comprehensive reviews and studies systematically summarizing existing literature attract significant attention within the orthodontic and orthognathic surgery literature.

When examining studies based on total citation counts,¹⁶ differences in thematic areas were observed. One notable distinction is that rankings based on total citation counts often highlight more established orthodontic topics, such as anchorage and root resorption, because these subjects have been studied extensively over longer periods and thus

accumulate more citations. In contrast, rankings based on annual citation rates place greater emphasis on innovative and technological areas, such as aligners, artificial intelligence, and digital dentistry. This suggests that these contemporary topics have rapidly attracted attention and achieved high citation rates within shorter periods. While evaluations based on total citation counts generally highlight classical, well-established areas, our study, utilizing annual citation rates, better reflects current trends in orthodontics literature and emphasizes the increasing importance of innovative treatment methods. Although a large number of articles were considered using the Scopus database, one of the potential limitations of our study is the possibility of omitting certain relevant publications indexed in other databases, such as Web of Science (WoS), Dimensions, PubMed, Google Scholar, and the Cochrane Library.

CONCLUSIONS

This study represents the first bibliometric analysis to identify the most influential articles in orthodontics and orthognathic surgery based on annual citation rates. Unlike traditional approaches that rely solely on total citation counts, utilizing the annual citation rate provides a more dynamic and contemporary assessment of an article's scientific impact over time. The findings reveal that modern treatment methodologies, digital technologies, artificial intelligence, and clear aligners are rapidly emerging trends in the current literature. Additionally, the prominent roles played by American journals and institutions underscore the geographic concentration of scientific contributions, particularly from the USA. These results offer valuable insights into the growing significance of innovative approaches in orthodontics and orthognathic surgery literature, highlighting potential directions for future research. By employing the annual citation rate, our study provides a more balanced and timely evaluation compared to traditional methods, allowing recent, influential studies to receive appropriate recognition and visibility in the field.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

ETHICS STATEMENT

Ethical approval was not required, as the research did not involve clinical studies or patient data.

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