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ORIGINAL ARTICLE

# Tooth auto-transplantation: A bibliometric analysis of the top 100 most-cited articles

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## Abstract

**Background/Aim:** Tooth auto-transplantation has recently gained high clinical acceptance. The aim of this study was to identify the top 100 most-cited articles regarding tooth auto-transplantation, to analyse multiple citations and publication metrics and to outline the historical scientific advancements in this field.

**Materials and Methods:** An advanced search of the Clarivate Analytics' Web of Science 'Core Collection' and Elsevier's Scopus databases utilising specific keywords related to tooth auto-transplantation between 1971 and 2021 was performed. The retrieved articles were ranked in descending order based on their Web of Science citation counts and further cross-matched with citation data from Scopus. The extracted data included citation counts, citation density, level of evidence, year of publication, contributing authors names and institutes, corresponding author's address, journal of publication, journal local citations index, cumulative growth index, keywords and keywords Plus. Data analysis was performed using descriptive statistics and graphical mapping.

**Results:** A total of 1290 articles were retrieved. The top 100 most-cited articles received a total of 4899 (Web of Science) and 5250 (Scopus) citations. Among these, cohort studies (29%) and case series (18%) were the most common study designs. Scandinavian countries produced major contributions in defining the top 100 most-cited articles and ranked within the top 5 countries based on the number of publications and citations per year. The greatest contributing authors were Schwartz O ($n = 12$), Andreasen JO ($n = 8$) and Paulsen HU ($n = 6$), and they were affiliated with Copenhagen, Denmark. The top contributing journals were *American Journal of Orthodontics and Dentofacial Orthopedics*, *International Journal of Oral and Maxillofacial Surgery*, *Oral Surgery Oral Medicine Oral Pathology Oral Radiology*, *European Journal of Orthodontics*, *Dental Traumatology* and *Journal of Oral and Maxillofacial Surgery*.

**Conclusion:** This bibliometric analysis revealed a large geographical scientific interest and broad development in the field of tooth auto-transplantation spanning multiple dental disciplines.

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KEYWORDS
auto-transplantation, bibliometrics, citations, tooth transplantation

## 1 | INTRODUCTION

Tooth auto-transplantation is defined as the transplantation of an erupted or unerupted tooth from one site to another (extraction site or surgically prepared socket) within the same individual.[1,2] Clinically, tooth auto-transplantation is regarded as a valuable treatment approach based on the utilisation of the patient's own tooth which is a natural biocompatible material.[3] Systematic reviews have reported high survival rates averaging between 75.3%–91%[3] and 93%–100%.[4] Recently, there has been a rise in clinical interest in tooth auto-transplantation in Dentistry.[5,6] The recent publication of a policy statement on tooth auto-transplantation by the *European Society of Endodontology* reflects the importance of this procedure in Dentistry.[6] Therefore, in-depth clinician's knowledge of clinicians regarding the clinical procedures and timing of management are of utmost importance for clinical success.[7]

The aim of a bibliometric analysis is to provide a comprehensive overview of the current status of the published literature in a particular journal, field or topic through a systematic, transparent and reproducible statistical approach.[8] This bibliometric approach utilises both a quantitative and qualitative analysis[9,10] and provides objective and reliable information on various citation and publication characteristics.[8,11] The development of sophisticated databases enabling the storage of multiple publications and citation information has driven considerable research attention towards bibliometric studies.[8] Within Dentistry, bibliometric citation analyses have been performed for specific journals such as *Dental Traumatology*,[12] *International Endodontic Journal*,[13] *Periodontology 2000*,[14] and in dental specialties such as Paediatric Dentistry[15,16] and Endodontics.[17] Topic-specific bibliometric analyses have also been performed such as COVID-19 related to dentistry,[18] early childhood caries,[19] micro-CT endodontic literature[20] and regenerative endodontics.[21,22]

Despite the clinical acceptance of tooth auto-transplantation and the apparent publication rise within the dental literature, to date, no bibliometric or scientometric studies related to tooth auto-transplantation have been reported. A bibliometric study will reveal details about the auto-transplantation concept's temporal order and evolution. Additionally, the increasing quantity or relative citations will offer information on the topic's spread in the scientific community. Therefore, the aim of this study was to analyse the top 100 most-cited articles on tooth auto-transplantation, to identify the most cited authors, institutions, countries of origin, gain insightful characteristics of influential publications, citation trends, level of evidence, collaboration research patterns, the most frequently used keywords and to outline the scientific advancements in this field over the past 5 decades (1971–2021).

## 2 | MATERIAL AND METHODS

An advanced electronic search of Clarivate Analytics' Web of Science 'Core Collection' (WoS-CC; http://www.webofknowledge.com) and Elsevier's Scopus (https://www.scopus.com) databases was performed. The search strategy involved a combination of Medical Subject Headings (MeSH) and keywords specifically related to tooth auto-transplantation - 'tooth autotransplantation', 'tooth auto-transplantation', 'tooth transplantation', 'tooth autogenous transplantation', 'tooth autotransplanted', 'premolar autotransplantation', 'premolar auto-transplantation', 'premolar transplantation', 'premolar autogenous transplantation', 'premolar autotransplanted', 'molar autotransplantation', 'molar auto-transplantation', 'molar transplantation', 'molar autogenous transplantation', 'molar autotransplanted', 'canine autotransplantation', 'canine auto-transplantation', 'canine autogenous transplantation', 'canine autotransplanted' and 'canine transplantation' in the title section. Specific terms such as 'incisors', 'supernumerary teeth' and 'mesiodens' were not included. The search was performed on 7th September 2021 and included all articles from 1971 to 2021.

The selection criteria included tooth auto-transplantation related studies such as clinical studies, cohort longitudinal studies, case series, case reports, animal studies, *in-vitro* studies, reviews and clinical guidelines in the English language only. Conference abstracts, non-research related articles (eg editorials, communication letters) and non-English literature were excluded.

The retrieved data were saved as 'Plain Text' with 'Full Record and Cited References'. Title and abstract screening was performed by two independent and calibrated investigators (A.A. & M.M.). Any discrepancies were resolved by consensus or by discussion with the third investigator (H.N.). The listed articles were ranked in descending order based on their WoS-CC citation counts, with the selection terminated at the level of the hundredth most-cited paper. The top 100 most-cited articles were further cross-matched with citation data from Elsevier's Scopus.

The following bibliometric parameters of the included articles were automatically extracted from the WoS-CC database: number of citations, citation density (mean number of citations received per year), author local citations (ALC; measurements of how many times an author included in this data set was cited by other authors in the same data set), year of publication, first and contributing authors, countries (based on the affiliation of the corresponding author), institutions (based on all authors) and journal of publication. Additionally, the journal local citation index (JLC; 'measurements of how many times a journal included in this data set was cited from the reference list of the journals in the same data set') and the cumulative growth index were calculated. The included articles were independently

classified by two calibrated investigators (A.A. & M.M.), according to the level of evidence (LoE) ranking system based on their study design[23] (Table 1). Any discrepancies were resolved by consensus or by discussion with the third investigator (H.N.).

The titles of the specific journals formerly known by previous names such as *Dental Traumatology* (formerly known as *Endodontics and Dental Traumatology* until 2001), *International Endodontic Journal* (formerly known as *Journal of the British Endodontic Society* until 1980), *International Journal of Oral and Maxillofacial Surgery* (formerly known as *International Journal of Oral Surgery* until 1986) and *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology* (formerly known as *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology* until 2012 and *Oral Surgery, Oral Medicine, Oral Pathology* until 1995), were standardised based on the most recent journal title. Additionally, due to the database system's automatic abbreviation of names of authors, universities and research centres, all data were carefully checked for any inaccuracies which resulted in certain manual edits for uniform presentation. The finalised data were imported into the R environment (R package Bibliometrix version 3.1) for relevant statistical computing and generation of relevant graphics and collaborative network mapping.[8]

## 3 | RESULTS

The advanced WoS-CC database search retrieved a total of 1290 items that were ranked in descending order based on their WoS-CC citation counts. The ranking of the top 100 most-cited articles, their citations count and citation density are listed in Table 2. The top 100 most-cited articles received a total of 4899 (WoS-CC) and 5250 (Scopus) citations and a citation range between 254–15 (WoS-CC) and 275–17 (Scopus).

Several study designs with various LoE were included within the top 100 most-cited articles (Table 3). Analysis of the included studies revealed that controlled clinical trials were of highest LoE (LoE III); however, they only represented a minority (6%) of the top 100 most-cited articles. The majority (33%) of study designs included within the top 100 most-cited articles were cohort studies, case–control studies and systematic reviews with or without a meta-analysis of cohort or case–control studies of LoE IV. At the next level (LoE V), cross-sectional studies, case series and systematic reviews with or without a meta-analysis of cross-sectional studies, case series or case reports represented 28% of the included studies. Overall, only 5 systematic reviews of various LoE ranging from IV to 0 were included. Case reports (LoE VI) and narrative literature reviews (LoE VII) represented 11% and 7% of the 100 studies, respectively. Of the articles with the lowest LoE 0, animal research, *in-vitro*/laboratory studies, systematic reviews of animal and *in-vitro*/laboratory studies constituted 9%, 5%, 1% of the 100 studies, respectively. Unfortunately, studies with a high LoE ranked as LoE I (systematic review or meta-analysis of randomised controlled clinical trials) and LoE II (randomised controlled clinical trials) were not ranked in the top 100 most-cited articles.

Further analysis of the included LoE III and IV original research (namely controlled clinical trials, cohort studies and case–control studies) highlighted a wide range of clinical indications for auto-transplantation. Clinically, tooth auto-transplantation procedures were mainly utilised for the treatment of permanent teeth such as

**TABLE 1** Classification of the level of evidence (LoE) based on the study design

| LoE | Study design |
|---|---|
| I | Systematic review with or without a meta-analysis of randomised controlled clinical trials |
| II | Randomised controlled clinical trial |
| III | Controlled clinical trial |
| IV | Cohort study |
| | Case–control study |
| | Systematic review with or without a meta-analysis of cohort or case–control studies |
| V | Cross-sectional study |
| | Case series |
| | Systematic review with or without a or meta-analysis of cross-sectional studies, case series or case reports |
| VI | Case reports |
| VII | Narrative literature review, panel and expert opinion |
| | Systematic review with or without a meta-analysis of narrative reviews, editorials, guidelines, comments and perspectives |
| 0 | Animal research |
| | *In-vitro* /laboratory studies |
| | Systematic review with or without a meta-analysis of animal, *in-vitro*/laboratory studies |

TABLE 2 Ranking of the top100 most-cited articles

| Rank | Publication | No. of citations (WoS-CC) | No. of citations (Scopus) | Citation density[a] |
|---|---|---|---|---|
| 1 | Andreasen JO, Paulsen HU, Yu Z, Bayer T, Schwartz O. A long-term study of 370 autotransplanted premolars. Part II. Tooth survival and pulp healing subsequent to transplantation. Eur J Orthod. 1990;12:14–24 | 254 | 275 | 8.19 |
| 2 | Czochrowska EM, Stenvik A, Bjercke B, Zachrisson BU. Outcome of tooth transplantation: survival and success rates 17–41 years post-treatment. Am J Orthod Dentofac Orthop. 2002;121:110–9 | 214 | 217 | 11.26 |
| 3 | Andreasen JO, Paulsen HU, Yu Z, Schwartz O. A long-term study of 370 autotransplanted premolars. Part III. Periodontal healing subsequent to transplantation. Eur J Orthod. 1990;12:25–37 | 208 | 217 | 6.70 |
| 4 | Tsukiboshi M. Autotransplantation of teeth: requirements for predictable success. Dent Traumatol. 2002;18:157–80 | 191 | 205 | 10.05 |
| 5 | Andreasen JO, Paulsen HU, Yu Z, Ahlquist R, Bayer T, Schwartz O. A long-term study of 370 autotransplanted premolars. Part I. Surgical procedures and standardized techniques for monitoring healing. Eur J Orthod. 1990;12:3–13 | 153 | 166 | 4.93 |
| 6 | Kristerson L. Auto-transplantation of human premolars - a clinical and radiographic study of 100 teeth. Int J Oral Surg. 1985;14:200–13 | 150 | 172 | 4.16 |
| 7 | Andreasen JO, Paulsen HU, Yu Z, Bayer T. A long-term study of 370 autotransplanted premolars IV. Root development subsequent to transplantation. Eur J Orthod. 1990;12:38–50 | 141 | 153 | 4.54 |
| 8 | Skoglund A, Tronstad L, Wallenius K. A microangiographic study of vascular changes in replanted and autotransplanted teeth of young dogs. Oral Surg Oral Med Oral Pathol. 1978;45:17–28 | 123 | 135 | 2.86 |
| 9 | Czochrowska EM, Stenvik A, Album B, Zachrisson BU. Autotransplantation of premolars to replace maxillary incisors: a comparison with natural incisors. Am J Orthod Dentofac Orthop. 2000;118:592–600 | 111 | 111 | 5.28 |
| 10 | Schwartz O, Bergmann P, Klausen B. Auto-transplantation of human-teeth - a life-table analysis of prognostic factors. Int J Oral Surg. 1985;14:245–58 | 109 | 123 | 3.02 |
| 11 | Slagsvold O, Bjercke B. Autotransplantation of premolars with partly formed roots: a radiographic study of root growth. Am J Orthod. 1974;66:355–66 | 108 | 109 | 2.29 |
| 12 | Lundberg T, Isaksson S. A clinical follow-up study of 278 autotransplanted teeth. Br J Oral Maxillofac Surg. 1996;34:181–5 | 101 | 109 | 4.04 |
| 13 | Paulsen HU, Andreasen JO, Schwartz O. Pulp and periodontal healing, root development and root resorption subsequent to transplantation and orthodontic rotation: a long-term study of autotransplanted premolars. Am J Orthod Dentofac Orthop. 1995;108:630–40 | 95 | 100 | 3.65 |
| 14 | Slagsvold O, Bjercke B. Applicability of autotransplantation in cases of missing upper anterior teeth. Am J Orthod. 1978;74:410–21 | 91 | 94 | 2.11 |
| 15 | Kim E, Jung JY, Cha IH, Kum KY, Lee SJ. Evaluation of the prognosis and causes of failure in 182 cases of autogenous tooth transplantation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2005;100:112–9 | 89 | 88 | 5.56 |

TABLE 2 (Continued)

| Rank | Publication | No. of citations (WoS-CC) | No. of citations (Scopus) | Citation density[a] |
|---|---|---|---|---|
| 16 | Zachrisson BU, Stenvik A, Haanæs HR. Management of missing maxillary anterior teeth with emphasis on autotransplantation. Am J Orthod Dentofac Orthop. 2004;126:284–8 | 88 | 90 | 5.17 |
| 17 | Jonsson T, Sigurdsson TJ. Autotransplantation of premolars to premolar sites. A long-term follow-up study of 40 consecutive patients. Am J Orthod Dentofac Orthop. 2004;125:668–75 | 86 | 88 | 5.05 |
| 18 | Lee SJ, Jung IY, Lee CY, Choi SY, Kum KY. Clinical application of computer-aided rapid prototyping for tooth transplantation. Dent Traumatol. 2001;17:114–9 | 81 | 90 | 4.05 |
| 19 | Kallu R, Vinckier F, Politis C, Mwalili S, Willems G. Tooth transplantations: a descriptive retrospective study. Int J Oral Maxillofac Surg. 2005;34:745–55 | 76 | 80 | 4.75 |
| 20 | Czochrowska EM, Stenvik A, Zachrisson BU. The esthetic outcome of autotransplanted premolars replacing maxillary incisors. Dent Traumatol. 2002;18:237–45 | 72 | 69 | 3.78 |
| 21 | Chung WC, Tu YK, Lin YH, Lu HK. Outcomes of autotransplanted teeth with complete root formation: a systematic review and meta-analysis. J Clin Periodontol. 2014, 2014;41:412–23 | 66 | 71 | 9.42 |
| 22 | Slagsvold O, Bjercke B. Indications for autotransplantation in cases of missing premolars. Am J Orthod. 1978;74:241–57 | 66 | 64 | 1.53 |
| 23 | Kvint S, Lindsten R, Magnusson A, Nilsson P, Bjerklin K. Autotransplantation of teeth in 215 patients: a follow-up study. Angle Orthod. 2010;80:446–51 | 64 | 58 | 5.81 |
| 24 | Mejare B, Wannfors K, Jansson L. A prospective study on transplantation of third molars with complete root formation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2004;97:231–8 | 61 | 65 | 3.58 |
| 25 | Schwartz O, Bergmann P, Klausen B. Resorption of autotransplanted human teeth: a retrospective study of 291 transplantations over a period of 25 years. Int Endod J. 1985;18:119–31 | 60 | 69 | 1.66 |
| 26 | Bauss O, Schilke R, Fenske C, Engelke W, Kiliaridis S. Autotransplantation of immature third molars: influence of different splinting methods and fixation periods. Dent Traumatol. 2002;18:322–828 | 54 | 51 | 2.84 |
| 27 | Sugai T, Yoshizawa M, Kobayashi T, Ono K, Takagi R, Kitamura N, et al. Clinical study on prognostic factors for autotransplantation of teeth with complete root formation. Int J Oral Maxillofac Surg. 2010;39:1193–203 | 51 | 50 | 4.63 |
| 28 | Watanabe Y, Mohri T, Takeyama M, Yamaki M, Okiji T, Saito C, et al. Long-term observation of autotransplanted teeth with complete root formation in orthodontic patients. Am J Orthod Dentofac Orthop. 2010;138:720–6 | 45 | 46 | 4.09 |
| 29 | Paulsen HU, Andreasen JO. Eruption of premolars subsequent to autotransplantation. A longitudinal radiographic study. Eur J Orthod. 1998;20:45–55 | 44 | 47 | 1.91 |
| 30 | Shahbazian M, Jacobs R, Wyatt J, Denys D, Lambrichts I, Vinckier F, et al. Validation of the cone beam computed tomography–based stereolithographic surgical guide aiding autotransplantation of teeth: clinical case–control study. Oral Surg Oral Med Oral Pathol Oral Radiol. 2013;115:667–75 | 42 | 45 | 5.25 |

(Continues)

TABLE 2 (Continued)

| Rank | Publication | No. of citations (WoS-CC) | No. of citations (Scopus) | Citation density[a] |
|---|---|---|---|---|
| 31 | Shahbazian M, Jacobs R, Wyatt J, Willems G, Pattijn V, Dhoore E, et al. Accuracy and surgical feasibility of a CBCT-based stereolithographic surgical guide aiding autotransplantation of teeth: in vitro validation. J Oral Rehabil. 2010;37:854–9 | 42 | 44 | 3.81 |
| 32 | Bae JH, Choi YH, Cho BH, Kim YK, Kim SG. Autotransplantation of teeth with complete root formation: a case series. J Endod. 2010;36:1422–6 | 42 | 49 | 3.81 |
| 33 | Schwartz O. Cryopreservation as long-term storage of teeth for transplantation or replantation. Int J Oral Maxillofac Surg. 1986;15:30–2 | 41 | 44 | 1.17 |
| 34 | Stenvik A, Zachrisson BU. Orthodontic closure and transplantation in the treatment of missing anterior teeth - an overview. Endod Dent Traumatol. 1993;9:45–52 | 40 | 40 | 1.42 |
| 35 | Altonen M, Haavikko K, Malmström M. Evaluation of autotransplantations of completely developed maxillary canines. Int J Oral Surg. 1978;7:434–41 | 39 | 39 | 0.90 |
| 36 | Almpani K, Papageorgiou SN, Papadopoulos MA. Autotransplantation of teeth in humans: a systematic review and meta-analysis. Clin Oral Investig. 2015;19:1157–79 | 38 | 44 | 6.33 |
| 37 | Laureys W, Beele H, Cornelissen R, Dermaut L. Revascularization after cryopreservation and autotransplantation of immature and mature apicoectomized teeth. Am J Orthod Dentofac Orthop. 2001;119:346–52 | 37 | 37 | 1.85 |
| 38 | Cross D, el-Angbawi A, McLaughlin P, Keightley A, Brocklebank L, Whitters J, et al. Developments in autotransplantation of teeth. Surgeon. 2013;11:49–55 | 36 | 38 | 4.5 |
| 39 | Josefsson E, Brattstrom V, Tegsjo U, Valerius-Olsson H. Treatment of lower second premolar agenesis by autotransplantation: four-year evaluation of eighty patients. Acta Odontol Scand. 1999;57:111–5 | 36 | 47 | 1.63 |
| 40 | Kugelberg R, Tegsjo U, Malmgren O. Autotransplantation of 45 teeth to the upper incisor region in adolescents. Swed Dent J. 1994;18:165–72 | 35 | 42 | 1.29 |
| 41 | Fang Y, Choi YJ, Lee SJ, Roh BD, Park SH, Kim E. Prognostic factors for clinical outcomes in autotransplantation of teeth with complete root formation: survival analysis for up to 12 years. J Endod. 2016;42:198–205 | 34 | 35 | 6.8 |
| 42 | Plakwicz P, Wojtowicz A, Czochrowska EM. Survival and success rates of autotransplanted premolars: a prospective study of the protocol for developing teeth. Am J Orthod Dentofac Orthop. 2013;144:229–37 | 34 | 32 | 4.25 |
| 43 | Bauss O, Schilke R, Fenske C, Engelke W, Kiliaridis S. Autotransplantation of immature third molars: influence of different splinting methods and fixation periods. Dent Traumatol. 2002;18:322–8 | 34 | 51 | 1.78 |
| 44 | Akiyama Y, Fukuda H, Hashimoto K. A clinical and radiographic study of 25 autotransplanted third molars. J Oral Rehabil. 1998;25:640–4 | 34 | 39 | 1.47 |
| 45 | Machado LA, do Nascimento RR, DMTP F, Mattos CT, Vilella OV. Long-term prognosis of tooth autotransplantation: a systematic review and meta-analysis. Int J Oral Maxillofac Surg. 2016;45:610–7 | 34 | 37 | 6.8 |

TABLE 2 (Continued)

| Rank | Publication | No. of citations (WoS-CC) | No. of citations (Scopus) | Citation density[a] |
|---|---|---|---|---|
| 46 | Ahlberg K, Bystedt H, Eliasson S, Odenrick L. Long-term evaluation of autotransplanted maxillary canines with completed root formation. Acta Odontol Scand. 1983;41:23–31 | 32 | 40 | 0.84 |
| 47 | Northway WM, Konigsberg S. Autogenic tooth transplantation - state of the art. Am J Orthod Dentofac Orthop. 1980;77:146–62 | 32 | 37 | 0.78 |
| 48 | Schwartz O, Rank CP. Autotransplantation of cryopreserved tooth in connection with orthodontic treatment. Am J Orthod Dentofac Orthop. 1986;90:67–72 | 31 | 30 | 0.88 |
| 49 | Ploder O, Partik B, Rand T, Fock N, Voracek M, Undt G, et al. Reperfusion of autotransplanted teeth—comparison of clinical measurements by means of dental magnetic resonance imaging. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2001;92:335–40 | 30 | 33 | 1.5 |
| 50 | Bauss O, Engelke W, Fenske C, Schilke R, Schwestka-Polly R. Autotransplantation of immature third molars into edentulous and atrophied jaw sections. Int J Oral Maxillofac Surg. 2004;33:558–63 | 29 | 29 | 1.70 |
| 51 | Hasselgren G, Larsson A, Rundquist L. Pulpal status after autogenous transplantation of fully developed maxillary canines. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1977;44:106–12 | 29 | 35 | 0.65 |
| 52 | Reich PP. Autogenous transplantation of maxillary and mandibular molars. J Oral Maxillofac Surg. 2008;66:2314–7 | 28 | 37 | 2.15 |
| 53 | Skoglund A. Pulpal changes in replanted and autotransplanted apicoectomized mature teeth of dogs. Int J Oral Surg. 1981;10:111–21 | 28 | 32 | 0.7 |
| 54 | Tanaka T, Deguchi T, Kageyama T, Kanomi R, Inoue M, Foong KWC. Autotransplantation of 28 premolar donor teeth in 24 orthodontic patients. Angle Orthod. 2008;78:12–9 | 27 | 31 | 2.07 |
| 55 | Lagerström L, Kristerson L. Influence of orthodontic treatment on root development of autotransplanted premolars. Am J Orthod. 1986;89:146–50 | 27 | 32 | 0.77 |
| 56 | Skoglund A, Hasselgren G, Tronstad L. Oxidoreductase activity in the pulp of replanted and autotransplanted teeth in young dogs. Oral Surg Oral Med Oral Pathol. 1981;52:205–9 | 27 | 33 | 0.67 |
| 57 | Rohof ECM, Kerdijk W, Jansma J, Livas C, Ren Y. Autotransplantation of teeth with incomplete root formation: a systematic review and meta-analysis. Clin Oral Investig. 2018;22:1613–24 | 26 | 30 | 8.66 |
| 58 | Verweij JP, Jongkees FA, Anssari Moin D, Wismeijer D, van Merkesteyn JPR. Autotransplantation of teeth using computer-aided rapid prototyping of a three-dimensional replica of the donor tooth: a systematic literature review. Int J Oral Maxillofac Surg. 2017;46:1466–74 | 26 | 29 | 6.5 |
| 59 | Mendoza-Mendoza A, Solano-Reina E, Iglesias-Linares A, Garcia-Godoy F, Abalos C. Retrospective long-term evaluation of autotransplantation of premolars to the central incisor region. Int Endod J. 2012;45:88–97 | 25 | 23 | 2.77 |
| 60 | Keightley AJ, Cross DL, McKerlie RA, Brocklebank L. Autotransplantation of an immature premolar, with the aid of cone beam CT and computer-aided prototyping: a case report. Dent Traumatol. 2010;26:195–9 | 27 | 28 | 2.45 |

(Continues)

TABLE 2 (Continued)

| Rank | Publication | No. of citations (WoS-CC) | No. of citations (Scopus) | Citation density[a] |
|---|---|---|---|---|
| 61 | Denys D, Shahbazian M, Jacobs R, Laenen A, Wyatt J, Vinckier F, et al. Importance of root development in autotransplantations: a retrospective study of 137 teeth with a follow-up period varying from 1 week to 14 years. Eur J Orthod. 2013;35:680–8 | 25 | 22 | 3.12 |
| 62 | Patel S, Fanshawe T, Bister D, Cobourne MT. Survival and success of maxillary canine autotransplantation: a retrospective investigation. Eur J Orthod. 2011;33:298–304 | 25 | 24 | 2.5 |
| 63 | Claus I, Laureys W, Cornelissen R, Dermaut LR. Histologic analysis of pulpal revascularization of autotransplanted immature teeth after removal of the original pulp tissue. Am J Orthod Dentofac Orthop. 2004;125:93–9 | 25 | 30 | 1.47 |
| 64 | Kristerson L, Johansson LÅ, Kisch J, Stadler LE. Autotransplantation of third molars as treatment in advanced periodontal disease. J Clin Periodontol. 1991;18:521–8 | 25 | 28 | 0.83 |
| 65 | Hillerup S, Dahl E, Schwartz O, Hjortinghansen E. Tooth transplantation to bone-graft in cleft alveolus. Cleft Palate J. 1987;24:137–41 | 25 | 25 | 0.73 |
| 66 | Skoglund A. Vascular changes in replanted and autotransplanted apicoectomized mature teeth of dogs. Int J Oral Surg. 1981;10:100–10 | 25 | 31 | 0.62 |
| 67 | Moss J. The indications for the transplantation of maxillary canines in the light of 100 cases. Br J Oral Surg. 1975;12:268–74 | 25 | 25 | 0.54 |
| 68 | Strbac GD, Schnappauf A, Giannis K, Bertl MH, Moritz A, Ulm C. Guided autotransplantation of teeth: a novel method using virtually planned 3-dimensional templates. J Endod. 2016;42:1844–50 | 24 | 24 | 4.8 |
| 69 | Park JH, Tai K, Hayashi D. Tooth autotransplantation as a treatment option: a review. J Clin Pediatr Dent. 2011;35:129–35 | 24 | 33 | 2.4 |
| 70 | Marcusson KAM, Lilja-Karlander EK. Autotransplantation of premolars and molars in patients with tooth aplasia. J Dent. 1996;24:355–8 | 24 | 24 | 0.96 |
| 71 | Atala-Acevedo C, Abarca J, Martínez-Zapata MJ, Díaz J, Olate S, Zaror C. Success rate of autotransplantation of teeth with an open apex: systematic review and meta-analysis. J Oral Maxillofac Surg. 2017;75:35–50 | 23 | 24 | 5.75 |
| 72 | Frenken J, Baart JA, Jovanovic A. Autotransplantation of premolars - a retrospective study. Int J Oral Maxillofac Surg. 1998;27:181–5 | 23 | 24 | 1 |
| 73 | Filippi A, Pohl Y, Tekin U. Transplantation of displaced and dilacerated anterior teeth. Endod Dent Traumatol. 1998;14:93–8 | 23 | 26 | 1 |
| 74 | Mensink G, van Merkesteyn R. Autotransplantation of premolars. Br Dent J. 2010;208:109–11 | 22 | 18 | 2 |
| 75 | Kitagawa Y, Sano K, Nakamura M, Ogasawara T. Use of third molar transplantation for closure of the oroantral communication after tooth extraction: a report of 2 cases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003;95:409–15 | 22 | 27 | 1.22 |
| 76 | Jang JH, Lee SJ, Kim E. Autotransplantation of immature third molars using a computer-aided rapid prototyping model: a report of 4 cases. J Endod. 2013;39:1461–6 | 21 | 22 | 2.62 |

TABLE 2 (Continued)

| Rank | Publication | No. of citations (WoS-CC) | No. of citations (Scopus) | Citation density[a] |
|---|---|---|---|---|
| 77 | Aoyama S, Yoshizawa M, Niimi K, Sugai T, Kitamura N, Saito C. Prognostic factors for autotransplantation of teeth with complete root formation. Oral Surg Oral Med Oral Pathol Oral Radiol. 2012;114:S216–S28 | 21 | 23 | 2.33 |
| 78 | Temmerman L, De Pauw GA, Beele H, Dermaut LR. Tooth transplantation and cryopreservation: state of the art. Am J Orthod Dentofac Orthop. 2006;129:691–5 | 21 | 22 | 1.4 |
| 79 | Schwartz O, Andreasen J. Allo-and autotransplantation of mature teeth in monkeys: a sequential time-related histoquantitative study of periodontal and pulpal healing. Dent Traumatol. 2002;18:246–61 | 21 | 25 | 1.10 |
| 80 | Schwartz O, Andreasen J. Allotransplantation and autotransplantation of mature teeth in monkeys: the influence of endodontic treatment. J Oral Maxillofac Surg. 1988;46:672–81 | 21 | 24 | 0.63 |
| 81 | Akkocaoglu M, Kasaboglu O. Success rate of autotransplanted teeth without stabilisation by splints: a long-term clinical and radiological follow-up. Br J Oral Maxillofac Surg. 2005;43:31–5 | 20 | 20 | 1.25 |
| 82 | Berglund L, Kurol J, Kvint S. Orthodontic pre-treatment prior to autotransplantation of palatally impacted maxillary canines: case reports on a new approach. Eur J Orthod. 1996;18:449–56 | 20 | 23 | 0.8 |
| 83 | Hernandez SL, Cuestascarnero R. Autogenic tooth transplantation - a report of 10 cases. J Oral Maxillofac Surg. 1988;46:1051–5 | 20 | 25 | 0.60 |
| 84 | Nethander G, Andersson JE, Hirsch JM. Autogenous free tooth transplantation in man by a 2-stage operation technique - a longitudinal intra-individual radiographic assessment. Int J Oral Maxillofac Surg. 1988;17:330–6 | 20 | 27 | 0.60 |
| 85 | Verweij JP, Moin DA, Mensink G, Nijkamp P, Wismeijer D, van Merkesteyn JPR. Autotransplantation of premolars with a 3-dimensional printed titanium replica of the donor tooth functioning as a surgical guide: proof of concept. J Oral Maxillofac Surg. 2016;74:1114–9 | 19 | 21 | 3.8 |
| 86 | Moin DA, Derksen W, Verweij JP, van Merkesteyn R, Wismeijer D. A novel approach for computer-assisted template-guided autotransplantation of teeth with custom 3d designed/printed surgical tooling. An ex vivo proof of concept. J Oral Maxillofac Surg. 2016;74:895–902 | 19 | 21 | 3.8 |
| 87 | Kokai S, Kanno Z, Koike S, Uesugi S, Takahashi Y, Ono T, et al. Retrospective study of 100 autotransplanted teeth with complete root formation and subsequent orthodontic treatment. Am J Orthod Dentofac Orthop. 2015;148:982–9 | 19 | 19 | 3.16 |
| 88 | Azaz B, Zilberman Y, Hackak T. Clinical and roentgenographic evaluation of thirty-seven autotransplanted impacted maxillary canines. Oral Surg Oral Med Oral Pathol. 1978;45:8–16 | 19 | 17 | 0.44 |
| 89 | Borring-Møller G, Frandsen A. Autologous tooth transplantation to replace molars lost in patients with juvenile periodontitis. J Clin Periodontol. 1978;5:152–8 | 19 | 19 | 0.44 |
| 90 | Honda M, Uehara H, Uehara T, Honda K, Kawashima S, Honda K, et al. Use of a replica graft tooth for evaluation before autotransplantation of a tooth. A CAD/CAM model produced using dental-cone-beam computed tomography. Int J Oral Maxillofac Surg. 2010;39:1016–9 | 18 | 20 | 1.63 |

(Continues)

TABLE 2 (Continued)

| Rank | Publication | No. of citations (WoS-CC) | No. of citations (Scopus) | Citation density[a] |
|---|---|---|---|---|
| 91 | Gault PC, Warocquier-Clerout R. Tooth auto-transplantation with double periodontal ligament stimulation to replace periodontally compromised teeth. J Periodontol. 2002;73:575–83 | 18 | 19 | 0.94 |
| 92 | Yoshino K, Kariya N, Namura D, Noji I, Mitsuhashi K, Kimura H, et al. A retrospective survey of autotransplantation of teeth in dental clinics. J Oral Rehabil. 2012;39:37–43 | 17 | 21 | 1.88 |
| 93 | Yan QM, Li B, Long X. Immediate autotransplantation of mandibular third molar in china. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;110:436–40 | 17 | 21 | 1.54 |
| 94 | Arikan F, Nizam N, Sonmez S. 5-year longitudinal study of survival rate and periodontal parameter changes at sites of maxillary canine autotransplantation. J Periodontol. 2008;79:595–602 | 17 | 16 | 1.30 |
| 95 | Hamamoto N, Hamamoto Y, Kobayashi T. Tooth autotransplantation into the bone-grafted alveolar cleft: report of two cases with histologic findings. J Oral Maxillofac Surg. 1998;56:1451–6 | 17 | 20 | 0.73 |
| 96 | Schendel KU, Schwartz O, Andreasen JO, Hoffmeister B. Reinnervation of autotransplanted teeth. A histological investigation in monkeys. Int J Oral Maxillofac Surg. 1990;19:247–9 | 17 | 18 | 0.54 |
| 97 | Robinson P. An electrophysiological study of the reinnervation of reimplanted and autotransplanted teeth in the cat. Arch Oral Biol. 1983;28:1139–47 | 17 | 18 | 0.44 |
| 98 | Cardona JLM, Caldera MM, Vera J. Autotransplantation of a premolar: a long-term follow-up report of a clinical case. J Endod. 2012;38:1149–52 | 16 | 13 | 1.77 |
| 99 | Schatz JP, Joho JP. Long-term clinical and radiologic evaluation of autotransplanted teeth. Int J Oral Maxillofac Surg. 1992;21:271–5 | 16 | 20 | 0.55 |
| 100 | Nethander G, Skoglund A, Kahnberg KE. Experimental autogenous tooth transplantation in the dog: a comparison between one-and two-stage surgical techniques. Acta Odontol Scand. 2003;61:223–9 | 15 | 17 | 0.83 |

[a]Citation density (average citations per annum) based on Web of Science 'Core Collection' citation counts; WoS-CC, Web of Science 'Core Collection'.

aplasia, impaction, traumatic loss of anterior teeth, root fracture and tooth loss due to non-restorable caries and/or periodontal infection. Specifically, in terms of donor tooth type, premolars were the main source of transplanted donor teeth. Third molars were also frequently used as a donor tooth for the replacement of missing teeth due to aplasia of premolars or early loss of molars.

The top 100 most-cited articles were published over a wide time span between 1974[24] and 2018[25] (Figure 1). The data revealed that throughout the decades, the auto-transplantation literature has shown a steady increase in terms of the number of articles. Approximately one-third of top 100 most-cited articles were published between 2010 and 2018. Specifically, in the year 2010, they accounted for the highest number of publications ($n = 10$) in a single year.

A total of 300 authors contributed to the top 100 most-cited articles. Contributing authors with more than 3 articles and their local citations are presented in Figure 2. The highest contributions of articles and author local citations (ALC) were made by 3 individuals, namely Schwartz O ($n = 12$, ALC = 178), Andreasen JO ($n = 8$, ALC = 151) and Paulsen HU ($n = 6$, ALC = 146). Furthermore, collaboration and co-citation analyses were performed to identify relevant co-authorships and collaboration networks among authors, and this is interactively given in supplementary online resource 1 and 2, respectively. Both above analyses were automatically generated based on the imported data using system-specific 'Louvain Clustering Algorithm'.

According to an analysis of the corresponding author's addresses, 26 countries contributed to the top 100 most-cited articles. Graphical mapping illustrating the countries of the top 100 most-cited articles based on the corresponding author's affiliation, the total number of citations and average citations per year are shown in Figure 3A–C, respectively. Overall, Scandinavian countries (Denmark, Sweden and Norway) were highly present in all maps of Figure 3. Based on the corresponding author's affiliation (Figure 3A), the top 5 countries in

**TABLE 3** Level of evidence (LoE) based on study design covered by the top 100 most-cited articles

| LoE | Study design | No. of articles |
|---|---|---|
| I | Systematic review with or without a meta-analysis of randomised controlled clinical trials | 0 |
| II | Randomised controlled clinical trial | 0 |
| III | Controlled clinical trial | 6 |
| IV | Cohort study | 29 |
| | Case–control study | 2 |
| | Systematic review with or without a meta-analysis of cohort or case–control studies | 2 |
| V | Cross-sectional study | 7 |
| | Case series | 18 |
| | Systematic review with or without a or meta-analysis of cross-sectional studies, case series or case reports | 3 |
| VI | Case reports | 11 |
| VII | Narrative literature review, panel and expert opinion | 7 |
| | Systematic review with or without a meta-analysis of narrative reviews, editorials, guidelines, comments and perspectives | 0 |
| 0 | Animal research | 9 |
| | *In-vitro* /laboratory studies | 5 |
| | Systematic review with or without a meta-analysis of animal, *in-vitro*/laboratory studies | 1 |

descending order were Denmark ($n$ = 17), Sweden ($n$ = 14), Japan ($n$ = 11), Norway ($n$ = 8), Belgium ($n$ = 7). A similar pattern in terms of total citations (Figure 3B) included Denmark (1222), Sweden (810), Norway (790), Japan (462) and Belgium (268). The average article citations per year (Figure 3 C) had a slightly different pattern, which in descending order was Norway (98.8), Denmark (87.3), Iceland (86), South Korea (53.4), Sweden (47.6), Japan (42) and China (41.5). In addition, Canada and Brazil (both 32) had a higher average article citations intensity compared with their presence in Figure 3A,B.

Analysis of the contributing institutions of all listed authors revealed a total of 98 institutes/research centres (Figure 4). The greatest contribution to the top 100 most-cited articles was made by Niigata University ($n$ = 23), the University of Oslo ($n$ = 22) and Yonsei University ($n$ = 18). Detailed collaborative networks of both countries and institutes are interactively given in supplementary online resource 3 and 4, respectively.

The top 100 most-cited articles were analysed based on the journal of publication and the journal local citations (JLC) index as detailed in Figure 5. Overall 23 journals contributed to the top 100 most-cited articles, with the top 6 contributing journals being the *American Journal of Orthodontics and Dentofacial Orthopedics* ($n$ = 17, JLC = 1130), *International Journal of Oral and Maxillofacial Surgery* ($n$ = 16, JLC = 700), *Oral Surgery Oral Medicine Oral Pathology Oral Radiology* ($n$ = 11, JLC = 480), *European Journal of Orthodontics* ($n$ = 8, JLC = 870), *Dental Traumatology* ($n$ = 8, JLC = 509) and *Journal of Oral and Maxillofacial Surgery* ($n$ = 8, JLC = 181). The cumulative growth index of the top 6 contributing journals had a gradual increase over time with the *American Journal of Orthodontics and Dentofacial Orthopedics and the International Journal of Oral and Maxillofacial Surgery* maintaining the lead (Figure 6).

The top 100 most-cited articles contained several author keywords (provided by the original authors) and keywords Plus (index terms automatically generated by Clarivate Analytics from the titles of the cited articles). The top 10 most frequently occurring author keywords and keywords Plus are presented in Figure 7A,B, respectively. Auto-transplantation specific keywords were actively present in various versions of the word 'auto-transplantation' and are listed in Table 4. Speciality-specific keywords (such as orthodontics and oral surgery) and general non-specific keywords (such as long term, premolars, healing subsequent, replantation, and teeth) were also frequently listed. Map and cluster analysis of the extracted author keywords and keywords Plus can be interactively viewed in supplementary online resource 5 and 6, respectively.

## 4 | DISCUSSION

In Medicine, various bibliometric analyses have been published about particular topics - for example, shoulder arthroscopy[26] and laser-assisted *in situ* keratomileusis surgery.[27] Additionally within Dentistry, bibliometric studies concerning regenerative endodontics,[21,22] squamous cell carcinoma[28] and vital pulp therapy[29] have been performed. Tooth auto-transplantation is a recognised viable and successful treatment approach in the management of teeth with specific indications, mainly related to poor prognosis and/or missing teeth.[2,3] To the best of the authors' knowledge, no bibliometric research has been done on auto-transplantation of teeth. Therefore, the aim of this bibliometric study was to identify the top 100 most-cited articles related to tooth auto-transplantation, to analyse metrics and to outline the scientific advancements in this field over the past 5 decades (1971–2021). The sample size of the top 100 most-cited articles correlates to the methodology used in previous bibliometric studies in the Medicine and Dentistry.[11,17,30,31]

In this study, the WoS-CC database was adopted as a benchmark for citation counts, in line with previous bibliometric studies.[15,22] Furthermore, the WoS database is considered one of the most renowned citation databases that harnesses a collection of several cross-searchable databases measuring scientific article citations over an extensive time span.[17,32] Further comparisons with the Scopus citation counts were also performed, which is similar to previous studies.[17,33] The Scopus database is largely considered a primary competitor to the WoS database for article citation analysis. Results in this work revealed slight fluctuations in citation count between both databases. However, citation counts based on the Google Scholar database were not performed in this study. Although Google Scholar is considered as a free powerful scholarly source,

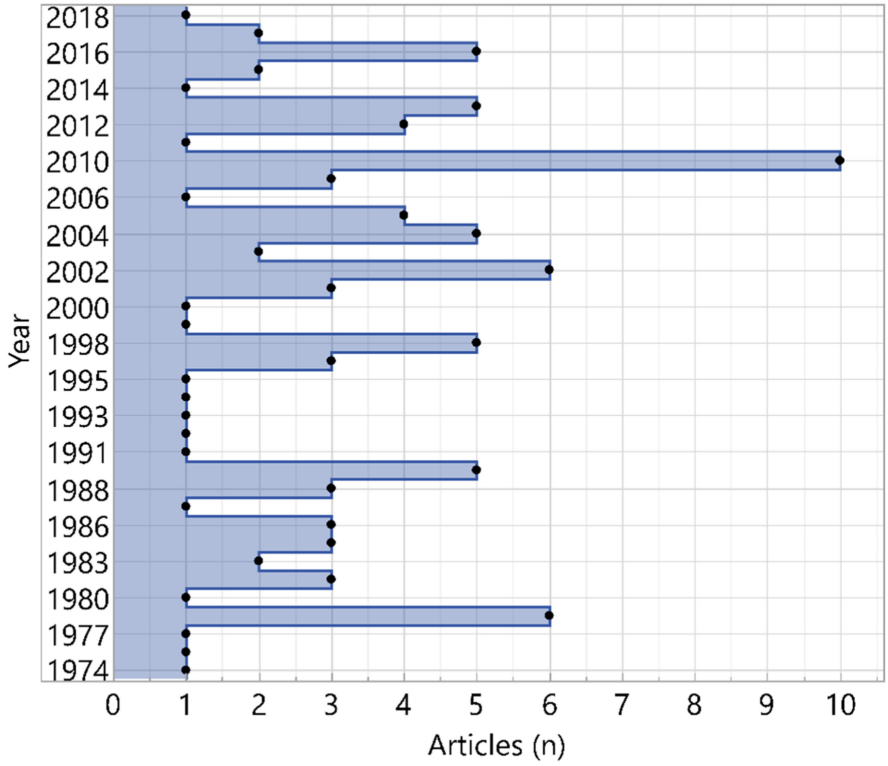


FIGURE 1 Numbers of publications in the top 100 most-cited articles by year of publication

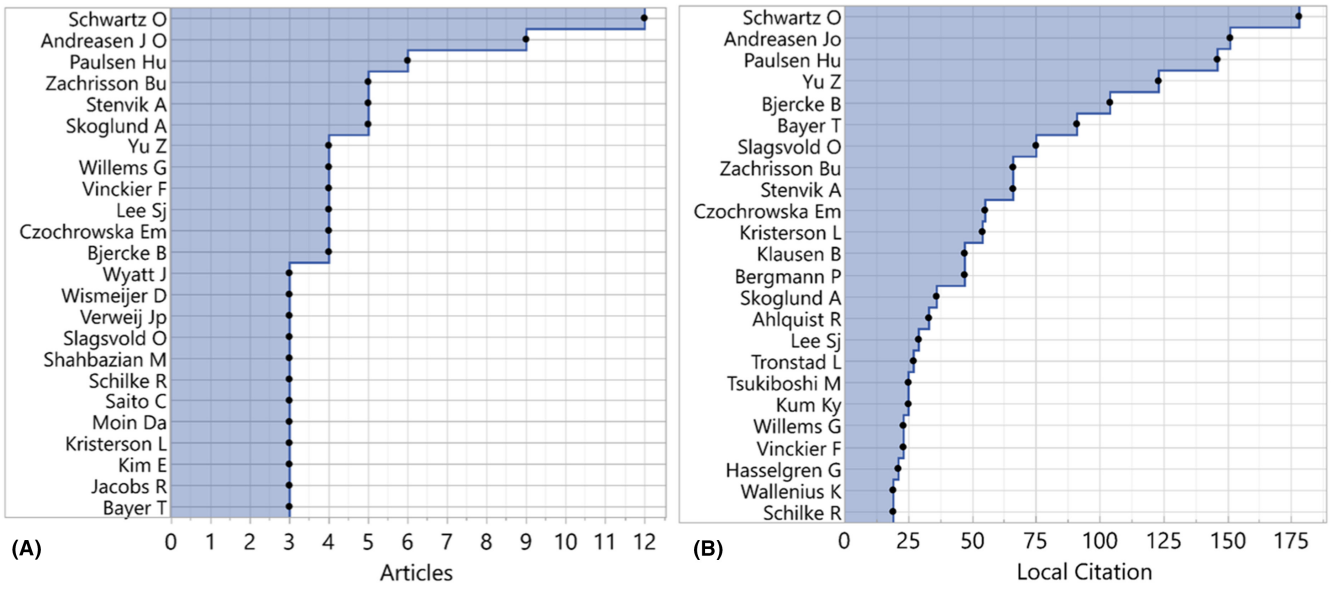


FIGURE 2 Highest contributing authors based on (A) Number of articles (the list included authors with a minimum of 3 articles), (B) Author local citations (measurements of how many times an author included in this data set was cited by other authors in the same data set)

inherent database limitations mainly in terms of indexing quality, citations and metrics have been reported.[34]

Historically, Eugene Garfield defined a classic citation article is one that is highly cited as defined by the Science Citation Index.[35,36] In general, an article cited more than 400 times is considered as a classic. However, this can vary between different disciplines and in smaller fields 100 citations can be justified.[35,36] Within the dental field, the term 'classic articles' has been previously considered to include articles that exceed the threshold of 100 citations and usually represent a significant reference point in the development of a given area.[11,17] In the present study, 12 articles published between 1974 and 2002 reached this milestone as 'classic articles' based on the analysis using the Clarivate Analytics WoS-CC database. These 'classic articles' include 10 primary clinical research articles,[24,37–45]

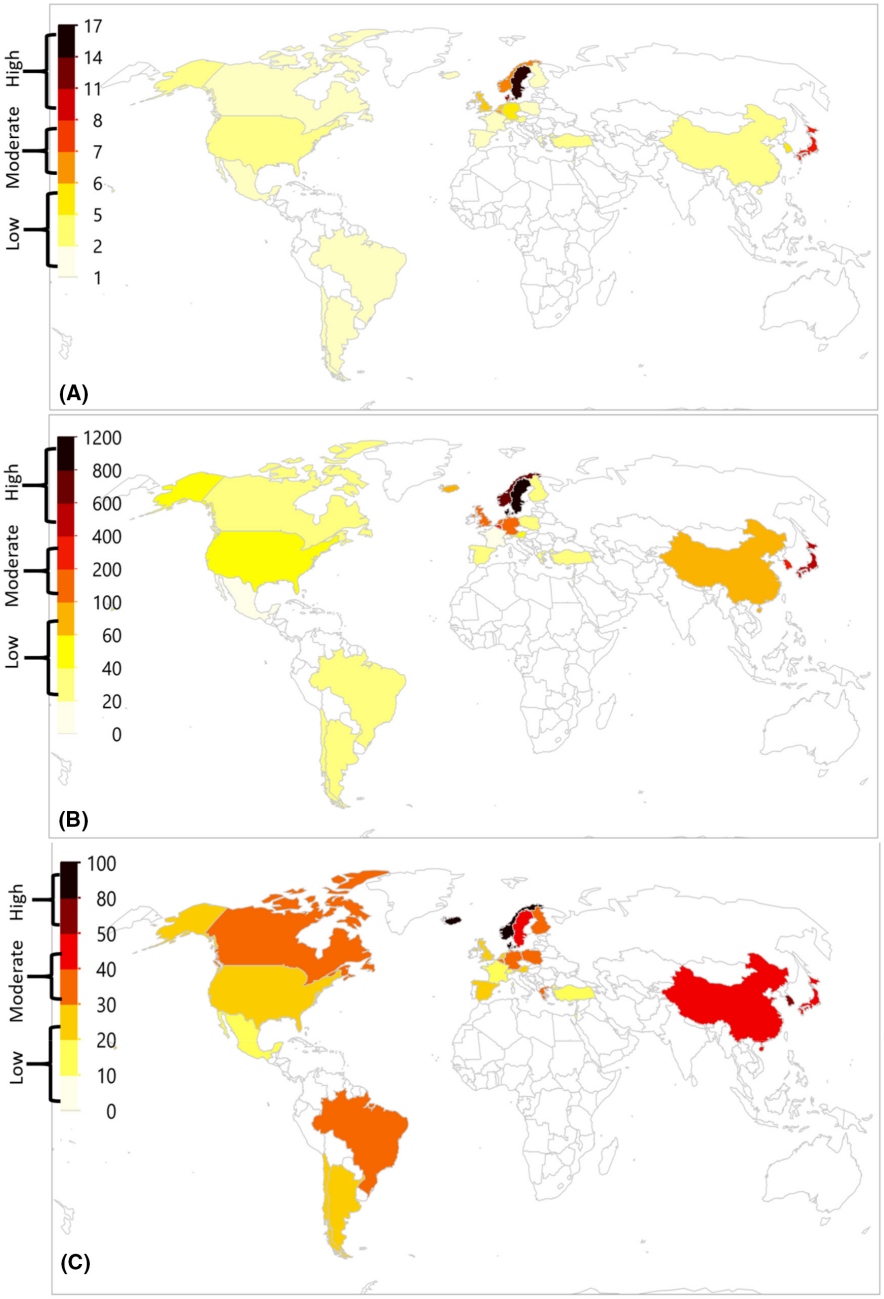


**FIGURE 3** World map illustrating the contribution of each country to the top 100 most-cited articles based on (A) Country of the corresponding author, (B) Total citation counts, (C) Average citations per year

one animal study[46] and one review article.[47] Nine of these were published more than 20 years ago with only three published in or after the year 2000.

An influence of the publication year on the citation counts in the present bibliometric study was apparent. Indeed, the year of publication is known to largely contribute to the number of citations a given article receives.[17] In line with the above, a bibliometric study by Adan et al., concluded that time duration, which increased exposure to the scientific community, was a main factor contributing to an increase in citation counts.[22] However, to further look into these results, the citation density (average citation received per year since publication) was also calculated and an altered order of articles in comparison to total citations was apparent as seen in Table 2. Furthermore, variations can be seen in Figure 3A–C which impacted the contribution by countries in terms of the corresponding author affiliation, total citations and average article citations per year. This could be attributed to the difference in the average article citation equation which takes into consideration the year of publication. This further highlights complex interlaced factors such as the topic of the article, popularity, specific study design, relevance to clinical and research advancements, all of which are variations from the main topic which could play a role in the number of citations a given article receives.

Furthermore, specific study designs such as cross-sectional, non-systematic reviews and validation studies are reported to be more frequently highly cited than other designs as they provide pivotal background information.[33] Hence, direct comparisons of citation counts of various study designs such as original research and review articles cannot be equally done.[48] In this study, the included

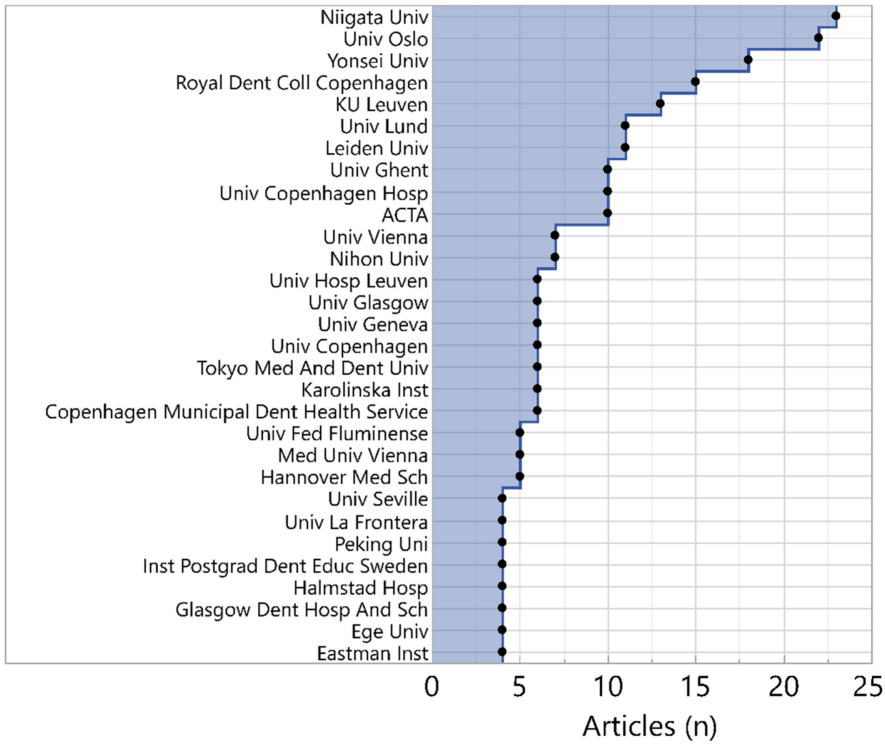


**FIGURE 4** Contributing institutes of the top 100 most-cited articles based on the corresponding author's address

studies were classified based on their study design using an 8-point LoE ranking system as has been previously used.[18] Cohort studies, case series and case reports were the most common included study designs within the top 100 most-cited articles. Unfortunately, high-quality studies such as auto-transplantation randomised clinical trials were not included in the top 100 most-cited articles, and they are scarcely available within the literature. This might be explained by the nature of the clinical technique, in which planned controlled clinical studies are difficult to perform, plus the difficulty of enrolling a sufficient sample size and the cost of conducting such a study.

The top 100 most-cited articles highlighted multiple clinical indications for tooth auto-transplantation – such as, congenital tooth absence, replacement of avulsed anterior teeth and non-restorable first or second molars.

The results highlighted that Scandinavian countries (mainly Denmark, Norway and Sweden) were the major contributors in the top 100 most-cited articles and were ranked within the top 5 countries based on the number of publications and citations per year. This could be explained by the affiliations of the top 3 contributing authors, namely Schwartz O, Andreasen JO and Paulsen HU from Copenhagen, Denmark. In this context, the above-mentioned authors must be acknowledged for their valuable contributions to the field of tooth auto-transplantation over the past five decades. Interestingly, in this study, the United States of America provided only a moderate contribution to the top 100 most-cited articles, which differs from other dental bibliometric studies in which the United States of America was the highest ranked country.[16,33] Additionally, South America (Brazil, Chile and Mexico) also contributed, albeit with a lower number of articles. Within Asia, Japan, South Korea, China and Turkey had a moderate number of contributions in the top 100 most-cited articles. Other countries within Asia, such as India and the Gulf Cooperation Council countries, and Africa were not included within the top listed papers. This highlights research deficiencies in these countries, and hence the need for local and global research funding agencies in collaboration with scientific researchers to provide funding and to fill the gaps in the evidence-based dental literature in these specific countries.

Interestingly, the results of this study also highlighted that tooth auto-transplantation articles were published across a wide variety of 23 dental journals. This could be explained by the wide acceptance of auto-transplantation in several dental specialities such as Endodontics, Oral Surgery, Orthodontics, Paediatric Dentistry and Periodontics for the treatment of various clinical conditions such as ectopic tooth position, congenital tooth absence and tooth loss as a result of dental trauma, periodontal disease and dental caries. Remarkably, the majority of the 'classic articles' were associated with the top six journals that published most papers on tooth auto-transplantation. Overall, the *American Journal of Orthodontics and Dentofacial Orthopedics*, one of the oldest running dental journals, in its 107th year in 2022 and considered to be the leading orthodontic resource, maintained the lead in terms of the number of included studies, journal local citations index and cumulative growth. Consequently, the word orthodontics has been highlighted as a commonly reported keyword.

Various synonyms of the term auto-transplantation such as auto-transplantation, transplantation and tooth transplantation were extracted as the main reported author keywords and/or keywords Plus within the included studies. Based upon unique database algorithms, keywords Plus are words/phrases that commonly appear in the titles of an article's references, but do not appear in the title of the article itself and aim to

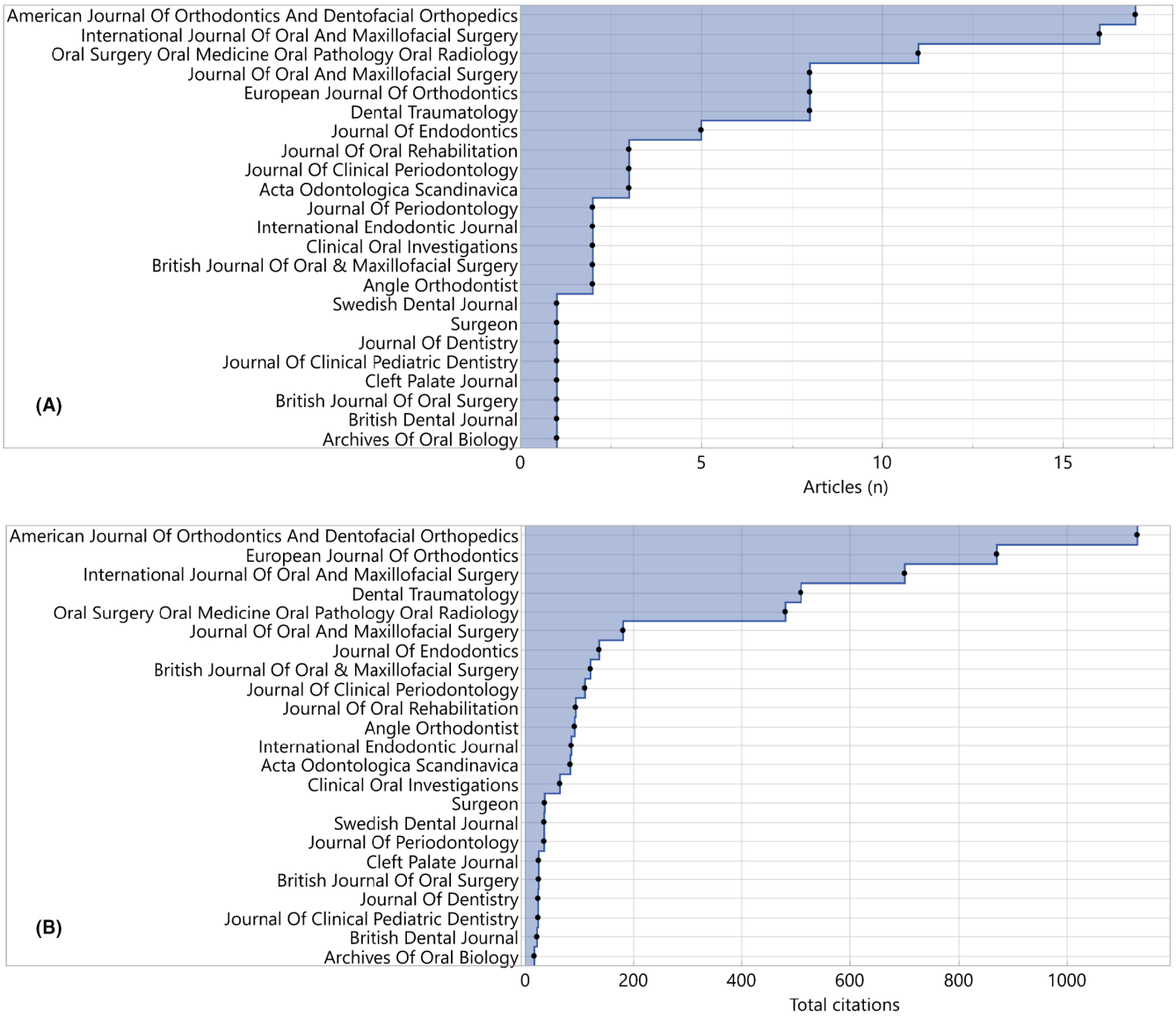


**FIGURE 5** Contributing journals of the top 100 most-cited articles based on (A) Journal source, (B) Journal local citations index (measurements of how many times a journal included in this data set was cited from the reference list of the journals in the same data set)

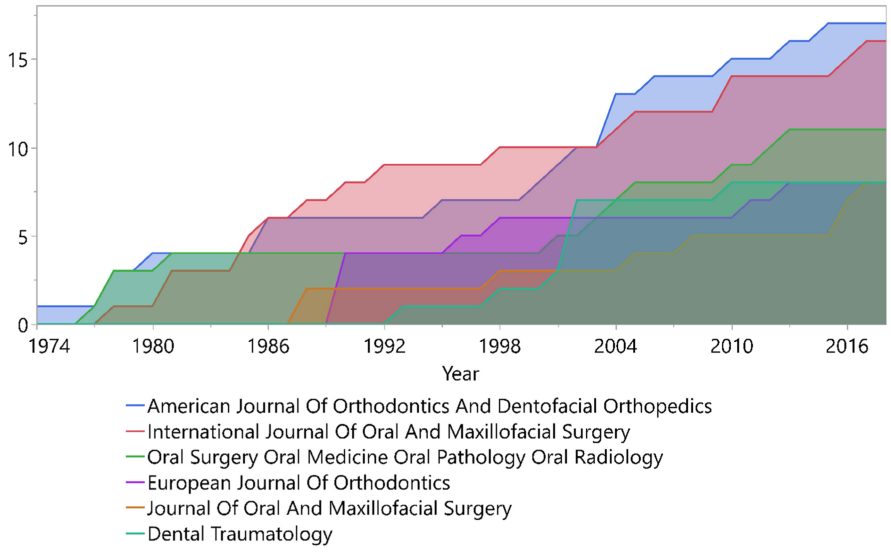


**FIGURE 6** The cumulative growth of the top 6 contributing journals


FIGURE 7 TreeMap of the unique keywords present in the top 100 most-cited articles based on (A) Author keywords, (B) Keywords Plus

enhance the power of cited-reference searching.[49] Therefore, for ease of identification, searching and reporting, the authors strongly recommend the use of the term 'auto-transplantation' which is the term mostly generated through keyword Plus. Further implementation of this throughout manuscripts should be implemented by journal editors/reviewers.

The present bibliometric analysis provides important insights in the field of tooth auto-transplantation. The aim was to further assist readers, journal editors and reviewers to better understand the relevance of tooth auto-transplantation in the wider context of dentistry. Additionally, the clinical usage, study designs and most influential authors should assist policymakers, funding agencies, clinicians and researchers in evidence-based decision-making and further expand research opportunities in less developed countries.

Some limitations of the current study are acknowledged. First, irrespective of the individual study design and LoE, recent published articles are most likely to be disadvantaged in terms of citation counts largely due to the time effect. Secondly, the search strategy relied on the relevant search terms being included in the article title. This search strategy was adopted to restrict multiple irrelevant articles if a wider option had been implemented. Additionally, the language was restricted to English which could have excluded articles in the non-English language literature. However, the main strength of this study

**TABLE 4** Topic-specific most frequently used keywords of the top 100 most-cited articles

| Topic specific keywords | Author keyword frequency | Keywords Plus frequency |
|---|---|---|
| Autotransplantation | 18 | 3 |
| Tooth transplantation | 9 | 18 |
| Auto-transplantation | – | 26 |
| Tooth autotransplantation | 3 | – |
| Transplantation | 3 | 14 |
| Replantation | – | 18 |
| Autogenous transplantation | – | 2 |
| 370 Autotransplanted premolars | – | 4 |
| Autotransplantation | – | 3 |
| Aiding autotransplantation | – | 2 |
| Autogenous transplantation | – | 2 |
| Autotransplantation of premolars | 1 | – |
| Autotransplantation of teeth | 1 | – |
| Autotransplantation of tooth | 1 | – |
| Autotransplants | 1 | – |
| Donor tooth | 2 | – |
| Donor premolar | 1 | – |

lies with the data extracted from the two main databases, namely WoS-CC and Scopus. Both WoS-CC and Scopus are journal indexing databases of the peer-reviewed literature, and they are widely utilised for measuring research impact and relevant metrics. Furthermore, the included studies were based on a robust inclusion and exclusion criteria which was assessed by two independent and calibrated assessors.

## 5 | CONCLUSIONS

This bibliometric analysis revealed useful information regarding tooth auto-transplantation current trends and the recognition of scientific advancements over a 50-year time span. A large geographical interest and broad development in the field of tooth auto-transplantation spanning multiple dental disciplines were evident. Examples of clinical usage of tooth auto-transplantation included, but were not limited to, agenesis, dental trauma and non-restorable teeth. The majority of the top 100 most-cited articles were of a cohort study and case series design, and they were published mainly by authors from the Scandinavian countries.

### CONFLICT OF INTEREST

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

### AUTHOR CONTRIBUTIONS

Ahmed Abdou: Conceptualization, Methodology, Software, Investigation, Formal analysis, Data Curation, Visualization, Writing – Original Draft. Manal Matoug-Elwerfelli: Conceptualization, Methodology, Software, Investigation, Formal analysis, Data Curation, Visualization, Writing – Original Draft. Venkateshbabu Nagendrababu: Conceptualization, Methodology, Writing – Review & Editing. Hani Nazzal: Conceptualization, Methodology, Writing – Review & Editing. Monty Duggal: Conceptualization, Methodology, Writing – Review & Editing. All authors give the final approval.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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