# Temporary anchorage devices in orthodontics: a bibliometric analysis of the 50 most-cited articles from 2012 to 2022

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## ABSTRACT

**Objectives:** To identify and analyze the 50 most cited articles on temporary anchorage devices (TADs) and investigate the achievement and development of scientific research about the topic through a bibliometric analysis.

**Materials and Methods:** On August 22, 2022, a computerized database search was performed to detect papers published in the scientific literature about TADs from 2012 to 2022. Metrics data were identified using the Incites Journal Citation Reports (Clarivate Analytics) data set. The Scopus database was used to obtain information on the authors' affiliations, country of origin, and h-index. Key words were automatically harvested from the selected articles to implement the visualized analysis.

**Results:** From a total of 1858 papers screened by searching the database, a list of the top 50 most cited articles was created. The total number of citations collected by the 50 most cited articles in TADs was 2380. Among the 50 most cited articles on TADs, 38 were original research papers (76.0%) and 12 were reviews (24.0%). As shown by the key word–network analysis, *Orthodontic anchorage procedure* was identified as the larger node.

**Conclusions:** Findings of this bibliometric study showed an increasing number of citations for papers on TADs, accompanied by a simultaneous rise in scientific interest in this topic in the past decade. The present work identifies the most influential articles, emphasizing the journals, the authors, and the topics addressed. (*Angle Orthod.* 2023;93:591–602.)

**KEY WORDS:** Temporary anchorage devices; Miniscrew; Skeletal anchorage; Bibliometric analysis; Network analysis

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## INTRODUCTION

Anchorage, defined as resistance to unwanted tooth movement, is the cornerstone of the orthodontic force system, and strategies for its control should be considered a significant factor in planning and achieving successful treatment.<sup>1</sup> Evolving from the work of Roberts et al.<sup>2</sup> on tissue response to orthodontic forces applied to restorative implants, orthodontic bone anchorage has attained widespread use in recent years and has had a major impact on treatment to provide intraoral anchorage, adding an entirely new scope for orthodontic practice.<sup>3–5</sup>

Orthodontic bone anchorage can be obtained through mechanically retentive devices, such as miniscrews and miniplates.<sup>6</sup> Since these temporary anchorage devices (TADs) use osseous physical engagement for stability, osseointegration is neither expected nor desired, although studies have shown that a limited and variable level (10–58%) of osseointegration could occur.<sup>6,7</sup> Therefore, the effectiveness of

miniscrews is related to primary stability, which has become a major issue to be investigated. Several factors could be related to their permanency, such as bone thickness, oral hygiene, smoking, insertion site, miniscrew design factors, type of mucosa (keratinized and nonkeratinized), and other patient-related factors.<sup>6,8</sup>

TADs have been widely used in the orthodontic field in recent years because of their capability to reduce the need for patient compliance and increase the number of treatment options to better match esthetic and occlusal treatment goals.<sup>3-5</sup>

As a result, a significant increase in research activity has been observed over the past decade, in line with the growing number of publications, on TADs.<sup>4,5</sup> The large number of publications creates difficulties for researchers in obtaining high-quality information, and bibliometric analysis is a mathematical and statistical method that assesses the interrelationships and impact of published papers within a specific scientific research area.<sup>9,10</sup>

Thus, despite the variety of research topics on TADs,<sup>3-8</sup> bibliometric and visual analysis could help to identify the hot topics in this research field and the direction of scientific development in this specific field. Therefore, the aim of this study was to perform a bibliometric analysis of the 50 most cited papers to provide a clearer scientific scenario for physicians that might improve the clinical research on this orthodontic device.

### MATERIALS AND METHODS

On August 22, 2022, an independent database search was conducted to find papers published in the scientific literature about TADs during the past 10 years (from 2012 to 2022). The following research query was developed: (("orthodontic\*" OR "orthodontic treatment" OR "orthognatic\*") AND ("TAD\*" OR "temporary anchorage device\*" OR "miniimplant\*" OR "skeletal anchorage" OR "miniscrew\*" OR "microimplant")), and the Scopus database was searched (Elsevier BV, Amsterdam, The Netherlands).

Two reviewers independently screened the papers according to titles, abstracts, and full text to determine study eligibility. In case of disagreement, consensus was achieved through a third reviewer.

Using the Incites Journal Citation Reports (Clarivate Analytics), the following journal-based bibliometric parameters were collected: 2021 Journal Impact Factor (JIF); quartile of the Category "Dentistry, Oral Surgery & Medicine," according to Web of Science Core Collection (when it was available); Eigenfactor Score; Normalized Eigenfactor; article influence score; 5-Year Journal Impact Factor (5-JIF); Immediacy Index.

Key words were automatically retrieved from the data set based on bibliographic data and used to create a cooccurrence network. Key words were counted using full counting, meaning that each cooccurrence link received the same weight. To eliminate repetition, two authors carefully reviewed and amended all of the terms to construct a bespoke thesaurus. VOSviewer (Centre for Science and Technology Studies, Leiden University, Leiden, The Netherlands) was used to map key words. The nodes represented the key words, the edges represented the key word association, and the distance between nodes generally reflected relationships among the nodes.

## RESULTS

From the research query, 1858 papers were identified. After applying a limitation filter to find papers from 2012 to 2022, 1274 papers were obtained, which are listed from the most cited to the least cited paper in Table 1,<sup>11–60</sup> with the total number of citations collected being 2380. Thirty-eight were original research papers (76.0%), and 12 were reviews (24.0%). Ten of the reviews were systematic reviews (20.0%), of which 6 were with meta-analyses (12.0%). Among the original articles, 14 were prospective studies (28%), 8 were finite element analysis studies (16%), 5 were retrospective studies (10%), 4 were case reports (8%), 2 were in vitro studies (4%), 2 were randomized clinical trials (RCTs) (4%), and 3 were animal studies (6%). Figure 1 displays further details. The papers on TADs were published in 16 different scientific journals, and 9 (56.25%) were in the category "Dentistry, Oral Surgery & Medicine," as depicted by Table 2.

## DISCUSSION

This was the first bibliometric analysis of the 50 most cited articles on TADs. According to other comparable publications, the size of 50 articles was selected to have a sample size large enough to extract significant information and to graph with significant trendline data. The last 10 years were selected to increase clinical interest in looking at articles with newer protocols, with recognition of the rapid and recent evolution of this technique.<sup>61,62</sup>

The popularity of TADs has grown in recent years, supported by clinicians and researchers, confirming TADs as valuable tools. Despite the importance of reviews in supporting evidence about a specific topic, only 20% of the articles listed in the present work belong to that category. Secondary studies represent the apex of the research hierarchy, and

Table 1.	The 50 Most Cite	d Articles Regarding	Temporary Anchor	age Devices (TADs) <sup>a</sup>
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Ranking Position	Title	Authors	Journal	Total Citations	Year of Publication	Study Design
1	Failure rates and associated risk factors of orthodontic miniscrew implants: A meta-	Papageorgiou Spyridon Zogakis Ioannis Papadopoulos Moschos	American Journal of Orthodontics and Dentofacial	182	2012	Systematic review and meta- analysis
2	analysis <sup>17</sup> Comparison of intrusion effects on maxillary incisors among mini implant anchorage, J-hook beadnear and utility arch <sup>12</sup>	Jain Ravindra Kumar Kumar Sridhar Prem Manjula	Journal of Clinical and Diagnostic Research	107	2014	Prospective study
3	Microimplant-assisted rapid palatal expansion appliance to orthopedically correct transverse maxillary deficiency in an adult <sup>13</sup>	Carlson Chuck Sung Jay McComb Ryan MacHado André Wilson Moon Won	American Journal of Orthodontics and Dentofacial Orthopedics	92	2016	Case report
4	Nonsurgical miniscrew-assisted rapid maxillary expansion results in acceptable stability in young adults <sup>14</sup>	Choi Sunghwan Shi Kyung-keun Cha Jung Yul Park Youngchel Lee Kee-joon	Angle Orthodontist	78	2016	Retrospective study
5	Non-surgical treatment of transverse deficiency in adults using microimplant-assisted rapid palatal expansion (MARPE) <sup>15</sup>	Brunetto Daniel Paludo Eduardo Franzzotti Sant'Anna MacHado André Wilson Moon Won	Dental Press Journal of Orthodontics	77	2017	Case report
6	Primary failure rate for 1680 extra-alveolar mandibular buccal shelf mini-screws placed in movable mucosa or attached gingiva <sup>16</sup>	Chang Chris Liu Sean Shih Yao Roberts Wilbur Eugene	Angle Orthodontist	63	2015	Retrospective study
7	Orthodontic miniscrew failure rate and root proximity, insertion angle, bone contact length, and bone density <sup>17</sup>	Watanabe Hisako Deguchi Touru Hasegawa Masakazu Ito Mau Kim Sung-jin Takano-Yamamoto Tenuko	Orthodontics and Craniofacial Research	62	2013	Prospective study
8	Effectiveness of orthodontic miniscrew implants in anchorage reinforcement during en-masse retraction: A systematic review and meta- analysis <sup>18</sup>	Antoszewska-Smith Joanna Sarul Michał Łyczek Jan Konopka Tomasz Kawala Beata	American Journal of Orthodontics and Dentofacial Orthopedics	59	2017	Systematic review and meta- analysis
9	Stress distribution and displacement by different bone- borne palatal expanders with micro-implants: A three- dimensional finite-element analysis <sup>19</sup>	Lee Hye-kyung Bayome Mohamed Ahn Chee Soo Kim Seong-Hun Kim Ki Beom Mo Sung-Seo Kook Yoon-Ah	European Journal of Orthodontics	57	2014	Finite element analysis study
10	Palatal bone thickness compared with cone-beam computed tomography in adolescents and adults for mini-implant placement <sup>20</sup>	Ryu Jun-ha Park Jae-hyun Vu Thi Thu Trang Bayome Mohamed Kim Yoonji Kook Yoon-Ah	American Journal of Orthodontics and Dentofacial Orthopedics	56	2012	Retrospective study
11	Outcomes and stability in patients with anterior open bite and long anterior face height treated with temporary anchorage devices and a maxillary intrusion solint <sup>21</sup>	Scheffler Nicole Proffit William Phillips Ceib	American Journal of Orthodontics and Dentofacial Orthopedics	53	2014	Prospective study

Table <sup>•</sup>	1.	Continued
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Ranking Position	Title	Authors	Journal	Total Citations	Year of Publication	Study Design
12	Distalization pattern of the maxillary arch depending on the number of orthodontic miniscrews <sup>22</sup>	Bechtold Till Kim Jinwook Choi Tae-hyun Park Youngchel	Angle Orthodontist	52	2013	Prospective study
13	Does cortical thickness influence the primary stability of miniscrews? A systematic review and meta-analysis <sup>23</sup>	Marquezan Mariana Mattos Claudia Trindade Eduardo Franzzotti Sant'Anna De Souza Margareth Maria Gomes Lucianne Conle Maia	Angle Orthodontist	51	2014	Systematic review and meta- analysis
14	Treatment effects of the Forsus fatigue resistant device used with miniscrew anchorage <sup>24</sup>	Aslan Belma Işık Küçükkaraca Ebru Türköz Çağri Dincer Müfide	Angle Orthodontist	50	2014	Prospective study
15	Application of a new viscoelastic finite element method model and analysis of miniscrew- supported hybrid hyrax treatment <sup>25</sup>	Ludwig Björn Baumgaertel Sebastian Zorkun Berna Bonitz Lars Glasl Bettina A Wilmes Benedict Lisson Jörg Alexander	American Journal of Orthodontics and Dentofacial Orthopedics	50	2013	Finite element analysis study
16	In vivo determination of aluminum, cobalt, chromium, copper, nickel, titanium and vanadium in oral mucosa cells from orthodontic patients with mini-implants by Inductively coupled plasma-mass spectrometry (ICP-MS) <sup>26</sup>	Martín-Cameán Ana Jos Ángeles Puerto María Calleja Ana Iglesias-Linares Alejandro Solano-Reina Enrique Cameán Ana María	<i>Journal of Trace Elements in Medicine and Biology</i>	48	2015	Prospective study
17	Determinants for success rates of temporary anchorage devices in orthodontics: A meta- analysis ( $n > 50$ ) <sup>27</sup>	Dalessandri Domenico Salgarello Stefano Dalessandri Michela Maiorana Carlo Santoro Franco	European Journal of Orthodontics	48	2014	Systematic review and meta- analysis
18	Risks and complications of miniscrew anchorage in clinical orthodontics <sup>28</sup>	Kuroda Shingo Tanaka E	Japanese Dental Science Review	47	2014	Review
19	Finite element analysis of miniscrew implants used for orthodontic anchorage <sup>29</sup>	Liu Techun Chang Chih-Han Wong Tung-Yiu Liu Jia-Kuang	American Journal of Orthodontics and Dentofacial Orthopedics	47	2012	Finite element analysis study
20	Bone anchor systems for orthodontic application: A systematic review <sup>30</sup>	Tsui Wai Kin Chua Hannah Daile Cheung Lim Kwong	International Journal of Oral and Maxillofacial Surgery	46	2012	Systematic review
21	Evaluation of optimal length and insertion torque for miniscrews <sup>31</sup>	Suzuki Makoto Deguchi Touru Watanabe Hisako Seiryu Masahiro Iikubo Masahiro Sasano Takashi Fujiyama Koji Takano-Yamamoto Teruko	American Journal of Orthodontics and Dentofacial Orthopedics	42	2013	Prospective study
22	Three-dimensional finite element analysis of strength, stability, and stress distribution in orthodontic anchorage: A conical, self-drilling miniscrew implant system <sup>32</sup>	Singh Shivani Mogra Subraya Shetty Vorvady Surendra Shetty Siddarth Philip Pramod	American Journal of Orthodontics and Dentofacial Orthopedics	42	2012	Finite element analysis study

#### THE 50 MOST-CITED ARTICLES ON TADs

Table 1. Continued

Ranking Position	Title	Authors	Journal	Total Citations	Year of Publication	Study Design
23	Miniscrews failure rate in orthodontics: Systematic review and meta- anglygic <sup>33</sup>	Alharbi Fahad Almuzian Mohammed Bearn David Russell	European Journal of Orthodontics	41	2018	Systematic review and meta- analysis
24	Nonsurgical correction of a Class III malocclusion in an adult by miniscrew-assisted mandibular dentition distalization <sup>34</sup>	Jing Yan Han Xianglong Guo Yongwen Li Jingyu Bai Ding	American Journal of Orthodontics and Dentofacial Orthopedics	41	2013	Case report
25	Miniscrew design and bone characteristics: An experimental study of primary stability <sup>35</sup>	Migliorati Marco Benedicenti Stefano Signori Alessio Drago Sara Barberis Fabrizio Tournier Henry Silvestrini-Biavati Armando	American Journal of Orthodontics and Dentofacial Orthopedics	41	2012	Animal study
26	Bone and cortical bone thickness of mandibular buccal shelf for mini-screw insertion in adults <sup>36</sup>	Nucera Riccardo Lo Giudice Antonino Bellocchio Angela Mirea Spinuzza Paola Caprioglio Alberto Perillo Letizia Matarese Giovanni	Angle Orthodontist	40	2017	Retrospective study
27	Three-dimensional soft-tissue and hard-tissue changes in the treatment of bimaxillary protrusion <sup>37</sup>	Solem Richard Christian Marasco Richard Guiterrez-Pulido Luis Nielsen Ib Leth Kim Seong-Hun Nelson Gerald	American Journal of Orthodontics and Dentofacial Orthopedics	40	2013	Prospective study
28	Finite element analysis of the effect of force directions on tooth movement in extraction space closure with miniscrew sliding mechanics <sup>38</sup>	Kojima Yukio Kawamura Jun Fukui Hisao	American Journal of Orthodontics and Dentofacial Orthopedics	40	2012	Finite element analysis study
29	Evaluation of miniscrew- supported rapid maxillary expansion in adolescents: A prospective randomized clinical trial <sup>39</sup>	Celenk-Koca Tugce Erdinç Aslihan Ertan Hazar Serpil Harris Lacey English Jeryl Akyalçin Sercan	Angle Orthodontist	38	2018	Randomized controlled trial
30	Evaluation of alveolar cortical bone thickness and density for orthodontic mini-implant placement <sup>40</sup>	Cassetta Michele Sofan Aisha Ali Abdullah Altieri Federica Barbato Ersilia	Journal of Clinical and Experimental Dentistry	38	2013	Retrospective study
31	Analysis of stress in bone and microimplants during en-masse retraction of maxillary and mandibular anterior teeth with different insertion angulations: A 3-dimensional finite element analysis study <sup>41</sup>	Jasmine M Issa Fathima Arif Yezdani Arif Tajir Faisal Venu R Murali	American Journal of Orthodontics and Dentofacial Orthopedics	37	2012	Finite element analysis study
32	Role of anatomical sites and correlated risk factors on the survival of orthodontic miniscrew implants: A systematic review and meta- analysis <sup>42</sup>	Mohammed Hisham Wafaie Khaled Rizk Mumen Almuzian Mohammed Sosly Rami Beam David Russell	Progress in Orthodontics	36	2018	Systematic review and meta- analysis

Table 1. Continued
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	Continued					
Ranking Position	Title	Authors	Journal	Total Citations	Year of Publication	Study Design
33	Miniscrew-assisted rapid palatal expander (MARPE): The quest for pure orthopedic movement <sup>43</sup>	Suzuki Hideo Moon Won Previdente Luiz Henrique Suzuki Selly Sayuri Garcez Aguinaldo Silva Consolaro Alberto	Dental Press Journal of Orthodontics	36	2016	Review
34	Clinical factors correlated with the success rate of miniscrews in orthodontic treatment <sup>44</sup>	Topouzelis Nikolaos Tsaousoglou Phoebus	International Journal of Oral Science	35	2012	Prospective study
35	Gummy smile and facial profile correction using miniscrew anchorage <sup>45</sup>	Kaku Masato Kojima Shunichi Sumi Hiromi Koseki Hiroyuki Abedini Sara Motokawa Masahide FujFujita Tadashi Ohtani Junji Kawata Toshitsugu Tanne Kazuo	Angle Orthodontist	35	2012	Case report
36	Measurement of strain distribution in cortical bone around miniscrew implants used for orthodontic anchorage using digital speckle pattern interferometry <sup>46</sup>	Kumar Manoj Agarwal Rupali Bhutani Ravi Shakher Chandra	Optical Engineering	34	2016	In vitro study
37	Comparison of tooth displacement between buccal mini-implants and palatal plate anchorage for molar distalization: A finite element study <sup>47</sup>	Yu II-Jun Kook Yoon-Ah Sung Sang-Jin Lee Kee-Joon Chun Youn-Sic Mo Sung-Seo	European Journal of Orthodontics	33	2014	Finite element study
38	Systematic review of mini-implant displacement under orthodontic loading <sup>48</sup>	Nienkemper Manuel Handschel Jörg Drescher Dieter	International Journal of Oral Science	33	2014	Systematic review
39	Measurement of mini-implant stability using resonance frequency analysis <sup>49</sup>	Nienkemper Manuel Wilmes Benedict Panayotidis Agamemnon Pauls Alexander Harry Golubovic Vladimir Schwarz Frank Drescher Dieter	Angle Orthodontist	33	2013	Animal study
40	Light emitting diode mediated photobiomodulation therapy improves orthodontic tooth movement and miniscrew stability: A randomized controlled clinical trial <sup>50</sup>	Ekizer Abdullah Türker Gökhan Uysal Tancan Güray Enis Taşdemir Zekeriya	Lasers in Surgery and Medicine	32	2016	Randomized controlled trial
41	Comparison of two implant- supported molar distalization systems <sup>51</sup>	Şar Çağla Kaya Burçak Özsoy Onur Polat Arman-Ozcirpici Ayca	Angle Orthodontist	32	2013	Prospective study
42	Real-time cell analysis of the cytotoxicity of orthodontic mini- implants on human gingival fibroblasts and mouse osteoblasts <sup>52</sup>	Malkoç Sıddık lk Öztürk Fırat Öreki Bayram Bozkurt Buket S Hakkı Sema Sezgin	American Journal of Orthodontics and Dentofacial Orthopedics	32	2012	In vitro study
43	Effect of molar intrusion with temporary anchorage devices in patients with anterior open bite: A systematic review <sup>53</sup>	Alsafadi Ahmad Šaleem Alabdullah Mohannad Saltaji Humam Abdo Anas Youssef Mohamed	Progress in Orthodontics	31	2016	Systematic review

#### THE 50 MOST-CITED ARTICLES ON TADS

#### Table 1. Continued

Ranking Position	Title	Authors	Journal	Total Citations	Year of Publication	Study Design
44	Effectiveness of maxillary protraction using a hybrid hyrax-facemask combination: A controlled clinical study <sup>54</sup>	Nienkemper Manuel Wilmes Benedict Franchi Lorenzo Drescher Dieter	Angle Orthodontist	31	2015	Prospective study
45	Comparison of stainless steel and titanium alloy orthodontic miniscrew implants: A mechanical and histologic analysis <sup>55</sup>	Brown Ryan N Sexton Brent E Gabriel Chu Tien-Min Katona Thomas R Stewart Kelton T Kyung Hee-Moon Liu Sean Shih-Yao	American Journal of Orthodontics and Dentofacial Orthopedics	31	2014	Animal study
46	Implants for orthodontic anchorage: Success rates and reasons of failures <sup>56</sup>	Rodriguez Juan Suarez Fernando Chan Hsun-Liang Padial-Molina Miguel Wang Hom-Lay	Implant Dentistry	31	2014	Systematic review
47	The ideal insertion angle after immediate loading in Jeil, Storm, and Thunder miniscrews: A 3D-FEM study <sup>57</sup>	Cozzani Mauro Nucci Ludovica Lupini Daniela Dolatshahizand Hedieh Fazeli Delaram Barzkar Esmaeil Naeini Ehsan Jamilian Abdolreza	International Orthodontics	30	2020	Finite element study
48	Use of shape correspondence analysis to quantify skeletal changes associated with bone- anchored Class III correction <sup>58</sup>	Nguyen Tung Cevidanes Lucia Paniagua Beatriz Zhu Hongtu Koerich Leonardo De Clerck Hugo	Angle Orthodontist	30	2014	Prospective study
49	Accuracy of miniscrew surgical guides assessed from cone- beam computed tomography and digital models <sup>59</sup>	Bae Mi-Ju Kim Ji-Young Park Jong-Tae Cha Jung-Yul Kim Hee-Jin Yu Hyung-Seog Hwang Chung-Ju	American Journal of Orthodontics and Dentofacial Orthopedics	30	2013	Prospective study
50	Root proximity and cortical bone thickness effects on the success rate of orthodontic micro-implants using cone beam computed tomography <sup>60</sup>	Min Kyung-Inna Kim Sang-Cheola Kang Kyung-Hwaa Cho Jin-Hyounga Lee Eon-Hwaa Chang Na-Younga Chae Jong-Moon	Angle Orthodontist	30	2012	Prospective study

<sup>a</sup> The articles are ordered by number of citations.

consequently, they should be the best source for understanding a topic.<sup>63</sup> Studies at the bottom of the evidence hierarchy (case reports, animal studies, in vitro studies, finite element analysis) can be found in the list, probably because the topic is relatively young and more time is required to improve the quality of the literature supporting it. Only 3 were RCTs, although this study design could provide the highest quality evidence, probably due to the cost and time required to carry out these types of scientific work.<sup>63</sup>

#### **Number of Citations**

The rate of citations per year has increased during the past decade. This trend in the total number of articles regarding the topic is depicted by Figure 2. It might be relevant to note that the use of citations per year as an indicator might reduce the bias caused by the time frame needed to collect citations related to older articles, considering that time could influence the ranking of article citations. Consequentially, dominant items on the list may be old studies, whereas high-



Figure 1. Study design of the 50 most cited papers on temporary anchorage devices.

quality, meaningful, and original papers published in recent years could be undervalued. In addition, the use of citations per year as an indicator may indicate that many high-quality articles were published during the decade 2012–2022 and that the quality of these papers has been increasing over the years. On the other hand, the phenomenon of obliteration by incorporation<sup>9,10,61,62</sup> should be taken into consideration, which implies that historical scientific research is rarely cited, as the information provided becomes an integral part of clinical medical activity, and researchers may no longer feel the need to cite those studies.

#### Journals

The 50 most cited articles were published in 17 different journals, indicating heterogeneity in the source of scientific information regarding the topic. It is relevant to notice that 2 journals (*American Journal of Orthodontics and Dentofacial Orthopedics* and *The* 

Angle Orthodontist) collected the majority of the citations (n = 1478, 62.10% of the total amount of citations). This was in line with Bradford's law, according to which, despite the large number of journals, most of the citations were collected by a few of them.9,10,61,62 This could have been due to many factors. First, multidisciplinary journals, such as medical and engineering journals, have often been awarded with higher journal metrics. Second, journals with a higher JIF often have a rate of publications extremely low and with very strict selection. In addition, some journals are renowned by clinicians and have a larger audience despite their measured scientific impact. Last, some of the journals are open access and promote distribution of published articles and their citations. Despite the higher publication fees often requested by open access journals, researchers are motivated to send their work to these journals due to the larger audience and wider dissemination of articles.

Table 2. Journals That Published the 50 Most Cited Articles About Temporary Anchorage Devices (TADs)<sup>a</sup>

		2020	Quartile of the							
		Journal	Category "Dentistry,			Article	5-Year			
		Impact	Oral Surgery	Eigenfactor	Normalized	Influence	Impact	Immediacy	Number of	
	Journal	Factor	& Medicine"	Score	Eigenfactor	Score	Factor	Index	Manuscripts	Citations
1	American Journal of	2.711	Q3	0.00631	1.35013	0.742	3.345	0.579	17	915
	Orthodontics and									
	Dentofacial Orthopedics									
2	Angle Orthodontist	2.684	Q3	0.00402	0.85966	0.749	3.212	0.683	13	563
3	European Journal of	3.131	Q2	0.00315	0.67349	0.799	3.166	1.000	4	179
4	Dental Press Journal of	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	113
	Orthodontics									
5	Journal of Clinical and	N/A	N/A	0.01121	2.39624	0.174	N/A	N/A	1	107
	Diagnostic Research									
6	International Journal of	24.897	Q1	0.00411	0.88024	2.627	13.721	0.952	2	68
	Oral Science									
7	Progress in Orthodontics	3.247	Q2	0.00177	0.37987	0.866	3.782	0.220	2	67
8	Orthodontics & Craniofacial	2.563	Q3	0.00172	0.36768	0.590	2.599	0.626	1	62
	Research									
9	Journal of Trace Elements in Medicine and Biology	3.995	N/A	0.00469	1.00240	0.567	4.001	0.863	1	48
10	Japanese Dental Science Review	6.468	Q1	0.00096	0.20590	1.079	5.862	0.594	1	47
11	International Journal of	2.986	Q2	0.00795	1.69965	0.729	3.02	0.721	1	46
	Oral and Maxillofacial									
	Surgery									
12	Journal of Clinical and	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	38
	Experimental Dentistry									
13	Optical Engineering	1.352	N/A	0.00643	1.37554	0.215	1.197	0.276	1	34
14	Lasers in Surgery and	4.025	N/A	0.00403	0.84511	0.767	3.881	1.241	1	32
	Medicine									
15	Implant Dentistry	3.000	Q2	0.00195	0.41703	N/A	N/A	N/A	1	31
16	International Orthodontics	N/A	N/A	0.00067	0.14437	0.223	N/A	N/A	1	30

<sup>a</sup> The journals are ordered by number of citations. N/A indicates not applicable.

Indeed, as reported by Hua et al.,<sup>64</sup> open access papers should accelerate research, improve education, and benefit all researchers and practitioners, particularly those in low-income countries and resource-poor institutions.

#### **Key Word Network Analysis**

A key word map was built using the terms from the 50 most referenced articles about TADs (Figure 3). Key



Figure 2. Number of citations per year received by the 50 most cited papers on temporary anchorage devices.

words are used to express the research field of hotspots; in addition, directions can be reflected in key word co-occurrence. The key word map showed *Orthodontic anchorage procedure* as the larger node, because this term has been the most used among articles, collecting 39 occurrences and 758 total link strengths. The clinical protocols for using TADs are undoubtedly one of the most relevant matters of focus by clinicians, considering the relatively recent introduction of skeletal anchorage in daily clinical practice.

One of the most recurrent words was *palatal expansion*. Indeed, seven papers among the 50 most cited articles on TADs discussed miniscrew-supported rapid maxillary expansion, and one paper was on maxillary protraction using a hybrid hyrax-facemask combination. Scientific literature showed that bone-borne expanders increased the skeletal separation of the midpalatal suture, with a more parallel sutural opening and reduced buccal tipping of the maxillary first molars.<sup>15,39</sup> In addition, the use of bone-borne palatal expanders has enabled midpalatal suture disjunction, even in the latter stages of suture



Figure 3. Key word network analysis of the 50 most cited papers on temporary anchorage devices.

maturation, reducing undesired dental effects related to these procedures in adolescents and adults.<sup>15,39</sup>

Looking at the co-occurrence maps, another recurrent word was *palate*, which is often selected as an extra-alveolar site for TAD insertion because of excellent bone quality and less possibility of root damage to the adjacent teeth. Considering the keratinized soft tissue and sufficient cortical bone, TAD placement in the paramedian palatal area has been recommended. However, it was reported that there was thinner bone in the early mixed dentition, compared with the late mixed and permanent dentition groups.<sup>20</sup>

### Limitations

This study was not free from limitations. First, even if the number of total citations is an important indicator of the quality and attractiveness of an article, a certain amount of time is needed for a paper to accumulate citations. Therefore, using only the number of citations is not sufficient to determine the value of a paper. Indeed, high-quality but more recent articles may not have been identified. Second, there may have been a bias related to the presence of self-citations and the potential preference of some authors to cite articles from a specific journal. Third, the articles were identified only from Scopus. Last, the total citations of an article could have been affected by the journal level, and an article published in a journal with a high impact factor may have been more likely to receive more citations.

## CONCLUSIONS

- Taken together, findings of this bibliometric study showed an increasing number of citations for papers on TADs, highlighting an increasing interest in scientific research in the past decade on this topic in orthodontics.
- Among the 50 most cited articles on TADs, 10 were systematic reviews, of which 6 had meta-analyses.
- Starting from the analysis of the most cited articles on TADs in this field, researchers might improve the clinical research on this orthodontic device.

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