

# ORIGINAL ARTICLE

## Orijinal Araştırma

Yazışma adresi  
Correspondence address

Esra BALKANLIOĞLU  
Department of Endodontics,  
Faculty of Dentistry,  
Kahramanmaraş Sutcu Imam University,  
Kahramanmaraş, Türkiye  
esrabalkanlioglu@gmail.com

Geliş tarihi / Received : November 26, 2025  
Kabul tarihi / Accepted : December 09, 2025

Bu makalede yapılacak atıf  
Cite this article as

Balkanlioğlu E, Kamalak A.  
Twenty-five Years of Nickel–Titanium  
Instrument Research in Endodontics:  
a Bibliometric Analysis of the 150  
Most-Cited Articles

Akd Dent J 2025;4(3): 153-162

Esra BALKANLIOĞLU  
Department of Endodontics,  
Faculty of Dentistry,  
Kahramanmaraş Sutcu Imam University,  
Kahramanmaraş, Türkiye

Aliye KAMALAK  
Department of Endodontics,  
Faculty of Dentistry,  
Kahramanmaraş Sutcu Imam University,  
Kahramanmaraş, Türkiye

# Twenty-five Years of Nickel-Titanium Instrument Research in Endodontics: a Bibliometric Analysis of the 150 Most-Cited Articles

## Endodonti’de Nikel-Titanyum Enstrüman Araştırmalarının Yirmi Beş Yılı: En Çok Atıf Alan 150 Makalenin Bibliyometrik Analizi

### ABSTRACT Objectives

This study aimed to identify the 150 most-cited articles related to nickel-titanium (Ni-Ti) instruments and to evaluate the influence of authors, institutions, and countries in shaping research trends in this field.

### Material and Methods

A comprehensive search was conducted through the Web of Science Core Collection. Data extracted from each article included title, total citations, publication year, study design, country of origin, co-authorship patterns, and bibliographic coupling. VOSviewer software was applied to visualize collaboration networks and keyword relationships.

### Results

The selected articles accumulated a total of 19.790 citations, with individual citation counts ranging from 68 to 637. A significant proportion ( $n = 92$ ) achieved over 100 citations. The year 2012 yielded the highest number of highly cited publications ( $n = 13$ ). The United States, Italy, and Brazil were leading contributors to the literature. The University of Zurich and Sapienza University of Rome produced the most frequently cited works. Most studies were laboratory-based ( $n = 133$ ), with common keywords including “nickel-titanium”, “cyclic fatigue”, and “nickel-titanium instruments”.

### Conclusion

This bibliometric analysis highlights major contributions and evolving trends in Ni-Ti instrument research within endodontics. The high citation impact reflects the critical role of Ni-Ti innovations in advancing endodontic practice and sustaining strong academic interest.

### Key Words

Bibliometric analysis, Citation, Cyclic fatigue, Dental technology, Ni-Ti instruments, Root canal treatment

## ÖZ

### Amaç

Bu çalışmanın amacı, nikel-titanyum (Ni-Ti) enstrümanlarıyla ilgili en çok atıf alan 150 makaleyi belirlemek ve bu alandaki araştırma eğilimlerinin şekillenmesinde yazarlar, kurumlar ve ülkelerin etkisini değerlendirmektir.

### Gereç ve Yöntemler

Web of Science Core Collection veritabanında kapsamlı bir arama yapılmıştır. Her makaleden elde edilen veriler arasında başlık, toplam atıf sayısı, yayın yılı, çalışma tasarımı, kaynak ülke, ortak yazarlık örüntüleri ve bibliyografik eşleşme analizleri yer almıştır. İş birliği ağlarını ve anahtar kelime ilişkilerini görselleştirmek amacıyla VOSviewer yazılımı kullanılmıştır.

### Bulgular

Seçilen makaleler toplam 19.790 atıf almıştır ve bireysel atıf sayıları 68 ile 637 arasında değişmiştir. Önemli bir kısmı ( $n = 92$ ) 100'ün üzerinde atıf almıştır. En fazla atıf alan makalenin yayımlandığı yıl 2012'dir ( $n = 13$ ).

Literatüre en fazla katkı sağlayan ülkeler Amerika Birleşik Devletleri, İtalya ve Brezilya olmuştur. En çok atıf alan çalışmaları üreten kurumlar arasında Zürih Üniversitesi ve Roma Sapienza Üniversitesi öne çıkmıştır. Çalışmaların büyük çoğunluğu laboratuvar temellidir ( $n = 133$ ) ve yaygın kullanılan anahtar kelimeler arasında “*nickel-titanium*”, “*cyclic fatigue*” ve “*nickel-titanium instruments*” yer almaktadır.

### Sonuç

Bu bibliyometrik analiz, endodontide Ni-Ti enstrüman araştırmalarındaki önemli katkıları ve gelişen eğilimleri ortaya koymaktadır. Yüksek atıf etkisi, Ni-Ti yeniliklerinin endodontik uygulamayı geliştirmedeki kritik rolünü ve alana yönelik akademik ilgiyi sürdürdüğünü göstermektedir.

### Anahtar Sözcükler

Bibliyometrik analiz, Atıf, Döngüsel yorgunluk, Dental teknoloji, Nikel-Titanyum enstrüman, Kök kanal tedavisi

## INTRODUCTION

Bibliometrics represents a quantitative approach for examining scholarly literature, employing various metrics to assess scientific publications. This analytical method evaluates multiple dimensions of academic articles, including the impact factor of journals, citation patterns, research methodologies, study designs, and authorship details (1). Bibliometric analysis can elucidate information trends, identify gaps in existing literature, highlight significant journals, and identify countries with high productivity in a specific research area (2).

Evaluative bibliometric analyses are based on the assessment of scientific publication references using mathematical methods. These methods, known as citation analysis, enable the identification of citation frequencies and patterns, thus allowing the determination of how an article has influenced subsequent publications over time. In this context, a citation represents the scholarly practice of referencing similar pioneering works produced prior to one's own scientific writing. In the field of bibliometrics, citation analysis stands as one of the most prevalent techniques employed. This approach functions as a mechanism for evaluating the influence of scholarly publications by examining citation data accrued by academic works (2,3). Moreover, highly cited articles may exert greater influence on subsequent research, thereby contributing to the knowledge base in a particular field, which may lead to significant changes in clinical practice (4,5).

Rigorous bibliometric analyses can establish solid groundwork for propelling a discipline forward in innovative and significant ways. Such studies empower scholars to gain a holistic perspective, uncover research gaps, formulate novel investigative directions, and contextualize their prospective contributions within the broader academic landscape (6).

Nickel-titanium (Ni-Ti) alloys were first used in dentistry in 1971 for the production of orthodontic wires, owing to their shape memory effect and super elasticity (7). The advent of Ni-Ti alloys and their incorporation into shaping techniques heralded the commencement of a transformative period in endodontic practice. Technological advancements have led to the development of instruments that enable more anatomically precise and efficient root canal preparations. These innovations aim to reduce procedural duration while simultaneously enhancing the comfort experienced by both dental professionals and their patients.

Consequently, these continuously improved instruments, actively used in every endodontic treatment, have begun to constitute an integral part of the clinical practice (7). Although the production of stainless steel manual endodontic instruments has been standardized, there is no single standard for Ni-Ti rotary instruments (8). In recent years, various Ni-Ti file systems have been introduced, featuring modifications in design, surface treatments, and thermal processing, as well as heat treatment and reciprocating ro-

tary motion. A wide range of file systems with diverse characteristics is available in the market (9).

The rapid proliferation of new Ni-Ti systems and the exponential growth of related publications have created a vast and fragmented body of literature, making it increasingly difficult to identify the studies that have most shaped modern endodontic practice. Mapping the citation structure of this field is therefore essential to reveal key contributors, influential collaborations, and evolving research themes (7,10,11).

Although numerous studies on Ni-Ti instruments exist, no comprehensive bibliometric evaluation has yet been conducted. Such an analysis is essential for the endodontic community, as it highlights historical trends, identifies leading contributors, and directs future investigations toward underexplored or emerging areas of Ni-Ti instrument development. Previous analyses in dentistry have focused mainly on subfields such as regenerative endodontics, implantology, and orthodontics (1,12,13), and have generally been limited to the top 100 cited papers. Expanding this scope to the top 150 allows for a more representative and inclusive understanding of the scientific landscape.

By integrating traditional citation metrics with network visualization techniques (co-authorship, keyword co-occurrence, and bibliographic coupling) using VOSviewer software, the present study provides a multidimensional view of the Ni-Ti research ecosystem (6). From a clinical perspective, identifying citation patterns helps highlight innovations that have most influenced contemporary endodontic instrumentation and guides future evidence-based research directions (14,15).

Accordingly, this study offers the first comprehensive bibliometric mapping of Ni-Ti instrument research between 1990 and 2025, identifying influential articles, collaborative networks, and thematic trends that define the evolution and future trajectory of this field.

## MATERIAL and METHODS

### Ethical considerations

As this study was based exclusively on secondary bibliometric data obtained from publicly accessible databases, no ethical approval was required and no human or animal subjects were involved.

### Data collection

An advanced electronic search was conducted using the Web of Science Core Collection database via Thomson Reuters Web of Science to identify published articles on Ni-Ti instruments. The information obtained from this database was used for information analysis and the creation of scientific maps. Data were acquired on January 6, 2025. The search aimed to achieve maximum comprehensiveness by selecting the 'All Fields' option.

The exact search strategy used in the Web of Science Core Collection was as follows:

TS = ("endodontic instruments" OR "Ni-Ti instruments" OR "nickel-titanium instruments" OR "Ni-Ti rotary instruments" OR "Ni-Ti shape memory alloys" OR "nickel-titanium" OR "Ni-Ti" OR "Ni-Ti files"). English-language articles categorized under Citation Topic Meso 'Dentistry-Oral Medicine' and Citation Topic Micro 'Endodontics' were included. The Web of Science Index selections comprised Science Citation Index Expanded (SCI-Expanded) and Emerging Sources Citation Index (ESCI). A total of 2349 articles were included in the research data.

Two independent researchers conducted preliminary searches to establish the search terms for the study. Both researchers independently reviewed each article for inclusion in the list of the most-cited articles. To avoid errors, data were verified twice. Any disagreements regarding data extraction were resolved by discussion and consensus. The articles were arranged in descending order according to their citation count, with more recently published articles receiving higher rankings in instances where multiple articles had obtained an equivalent number of citations. In instances where multiple affiliations were identified for the primary author, only the initial affiliation was documented. After organizing the list in descending order according to the citation count, 15 articles were excluded because they did not focus on the area of interest.

The 150 most cited articles were selected and compiled in a database using the following parameters: article title, institution and country, journal title, publication year, author citation analysis, co-author analysis, bibliographic coupling analysis of texts, study design, number of citations received by each article since its publication date, and keywords.

### Data visualization and analysis

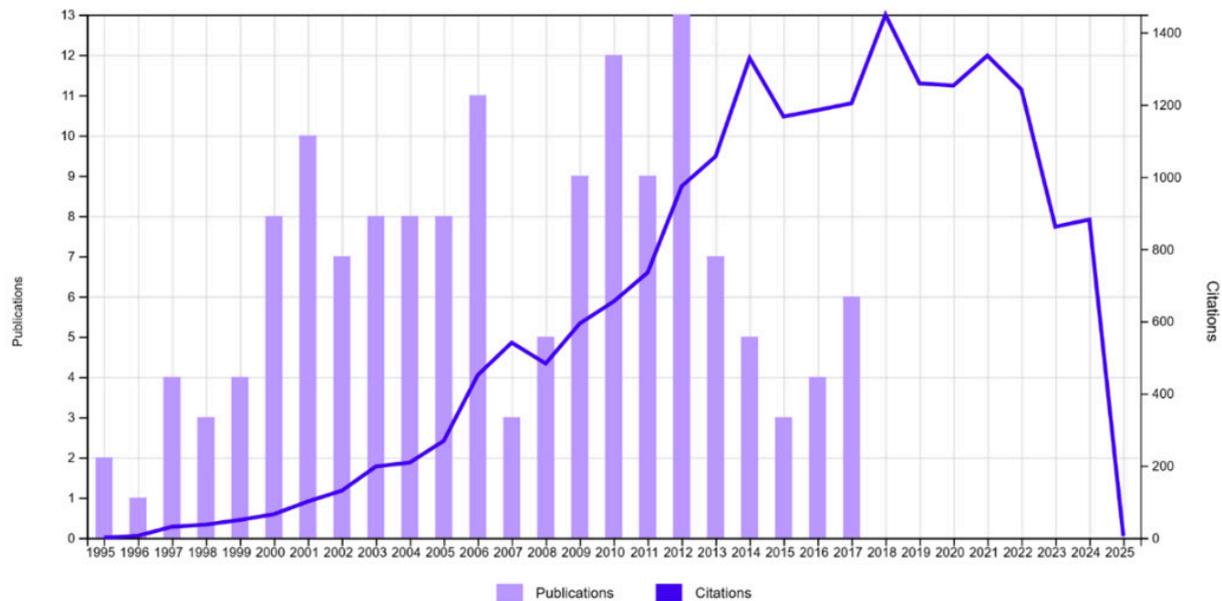
The software program VOS viewer version 1.6.20 was used for the visualization of similarities. VOS viewer analyzed the data in the form of maps, generating clusters based on bibliographic coupling analysis of documents, citation counts, co-authors, countries, keywords, and texts. A visual analysis was conducted for the number of publications and presented in the form of a cluster, with the relationship to other elements indicated by the distance between clusters.

## RESULTS

The 150 most cited publications on Ni-Ti instruments received 18,855 citations excluding self-citations and 19,790 citations in total. The average number of citations per article was 131.93. The relationship between the number of citations and publication years is illustrated in Figure 1.

The most frequently cited articles were listed in Table 1 in descending order of citation count, along with their average number of citations per year. The most frequently cited article on Ni-Ti instruments received 637 citations. In the list of most cited articles, 92 papers garnered 100 or more citations, thus qualifying as citation classics.

**Figure 1.** Relationship between citation counts and years of publications.



**Table 1.** Title, publication year, authors, average and total citation count of the 150 most cited articles.

Rank	Article Title-Publication Title-Year	Average Citations Per Year	Total Citations
1	Cyclic fatigue testing of nickel-titanium endodontic instruments. Pruett JP, Clement DJ and Carnes DL. <i>J Endod.</i> 1997;23(2):77-95	21.97	637
2	Defects in rotary nickel-titanium files after clinical use. Sattapan B, Nervo GJ, Messer HH et al. <i>J Endod.</i> 2000; 26(3):161-165	20.54	534
3	Effects of four Ni-Ti preparation techniques on root canal geometry assessed by micro computed tomography. Peters OA, Schönenberger K and Laib A. <i>Int Endod J.</i> 2001; 34(3):221-230	18.64	466
4	Canal preparation using only one Ni-Ti rotary instrument: Preliminary observations. Yared G. <i>Int Endod J.</i> 2008; 41(4): 339–344.	18	324
5	A comparison of root-canal preparations using Ni-Ti hand, Ni-Ti engine-driven, and K-Flex endodontic instruments. Glosson C.R., Haller R.H., DelRio C.E., et al. <i>J Endod.</i> 1995; 21(3): 146–151.	10.39	322
6	Reduction of intracanal bacteria using nickel-titanium rotary instrumentation and various medications. Shuping, GB; Orstavik, D; Trope, M et al. <i>J Endod.</i> 2000; 26 (12) ,751-755	11,31	294
7	Comparison of nickel-titanium and stainless-steel hand-file instrumentation using computed tomography. Gambill J.M., Alder M., and delRio C.E. <i>J Endod.</i> 1996; 22(7): 369–375.	9.03	271
8	Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of extracted teeth: Reciproc and WaveOne versus Mtwo and ProTaper. Bürklein S., Hinschitzka K., Schäfer E. Et al. <i>Int Endod J.</i> 2012; 45(5): 449–461.	18.14	254
9	Changes in root canal geometry after preparation assessed by high-resolution computed tomography. Peters O.A., Laib A., Barbakow F., et al. <i>J Endod.</i> 2001; 27(1): 1–6.	10.16	254
10	ProTaper rotary root canal preparation: effects of canal anatomy on final shape analysed by micro CT. Peters O.A., Peters C.I., Barbakow F., et al. <i>Int Endod J.</i> 2003; 36(2): 86–92.	10.26	236
11	Fatigue resistance of engine-driven rotary nickel-titanium instruments produced by new manufacturing methods. Gambarini G., Grande N.M., Testarelli L., et al. <i>J Endod.</i> 2008; 34(8): 1003–1005.	12,78	230
12	Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. Bürklein S., Schäfer E. <i>J Endod.</i> 2012; 38(6): 850–852.	15,64	219
13	Dynamic and cyclic fatigue of engine-driven rotary nickel-titanium endodontic instruments. Haikel Y., Serfaty R., Allemann C., et al. <i>J Endod.</i> 1999; 25(6): 434–440.	7.74	209
14	Factors influencing defects of rotary nickel-titanium endodontic instruments after clinical use. Parashos P., Gordon I., Messer H.H. <i>J Endod.</i> 2004; 30(10): 722–725.	9.18	202
15	Cyclic fatigue resistance and three-dimensional analysis of instruments from two nickel-titanium rotary systems. Grande N.M., Plotino G., Somma F., et al. <i>Int Endod J.</i> 2006; 39(10): 755–763.	9.3	186

### Citation of authors

The author with the highest number of citations for their articles was Ove Peters with 2127 citations, followed by Harrold H. Messer with 1028 citations, Platino Gianluca with 957 citations, and Schönerberger K with 846 citations. Among the analyzed publications, 110 articles involved contributions from one to 5 authors, while the remaining

40 articles featured collaborations of 6 to 10 authors. The author citation analysis was visually represented employing VOS viewer software. In this visualization, the dimensions of nodes correspond to the publication output of individual authors, while the interconnecting lines depict the intensity of collaborative relationships among researchers (Fig. 2).

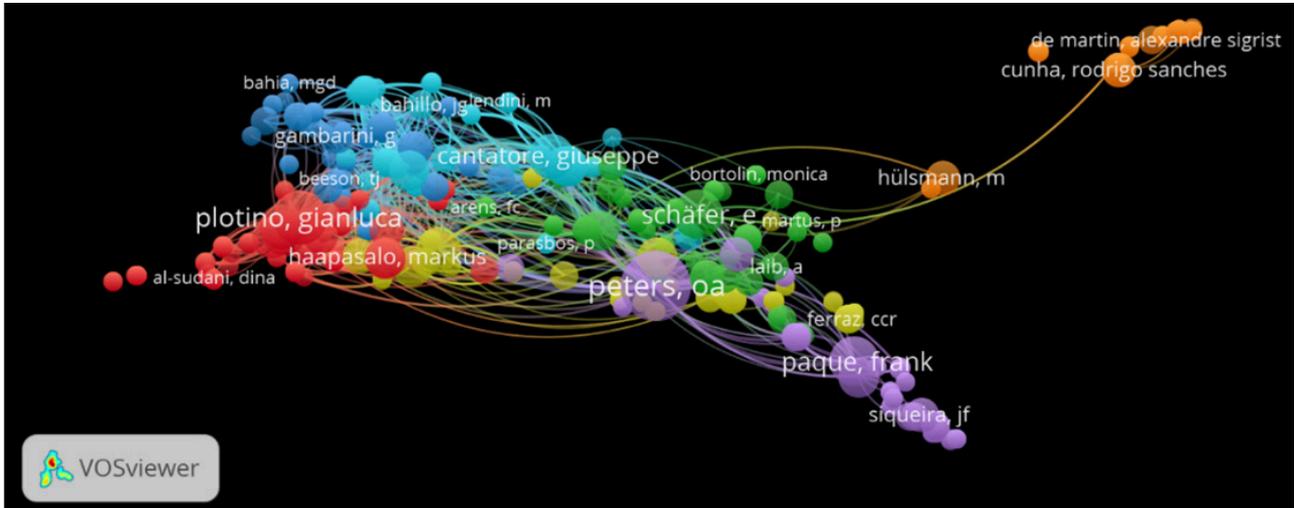


Figure 2. Citation of authors.

Upon examination of authors who have published at least five articles regarding Ni-Ti instruments and their publication counts, Ove Peters emerged as the most prolific author with 12 articles. Grande Nicola Maria, Plotino Gianluca,

and Gambarini Gianluca followed with 10 publications each. Authors with a minimum of 5 publications and their respective publication counts were presented (Tab. 2).

Table 2. Authors with a minimum of five publications and their publication counts.

Author Name	Number of Publications	Author Name	Number of Publications
Peters, Ove	12	Berutti, Elio	6
Grande, Nicola Maria	10	Shen, Ya	6
Plotino, Gianluca	10	Cantatore, Giuseppe	6
Gambarini, Gianluca	10	Siqueira, José F	5
Schaefer, Edgar	9	Testarelli, Luca	5
Paque, Frank	7	Pasqualini, Damiano	5
Kim, Hyeon Cheol	6	Cheung, Gary Shun Pan	5



Figure 3. Co-Author analysis collaboration network.

### Co-authorship of authors

A minimum publication count of one was selected for each author, and using this data, a collaboration network was developed for co-authors contributing to the article (Fig. 3).

### Publication years-titles

The 150 most cited articles produced using Ni-Ti instruments were published in four journals. All of these journals are categorized as Sci-Expanded. The highest number of

**Table 3.** Number of publications by year for the 150 most cited articles

Year	Number of Publications	Year	Number of Publications	Year	Number of Publications
1998	3	2005	8	2012	13
1999	4	2006	11	2013	7
2000	8	2007	3	2014	5
2001	10	2008	5	2015	3
2002	7	2009	9	2016	4
2003	8	2010	12	2017	6
2004	8	2011	9		

most cited articles was published in 2012 ( $n = 13$ ). This was followed by articles published in 2010 ( $n = 12$ ), 2006 ( $n = 11$ ), and 2001 ( $n = 10$ ), respectively. The years 2015, 2007, and 1998 had the least number of publications (Tab. 3).

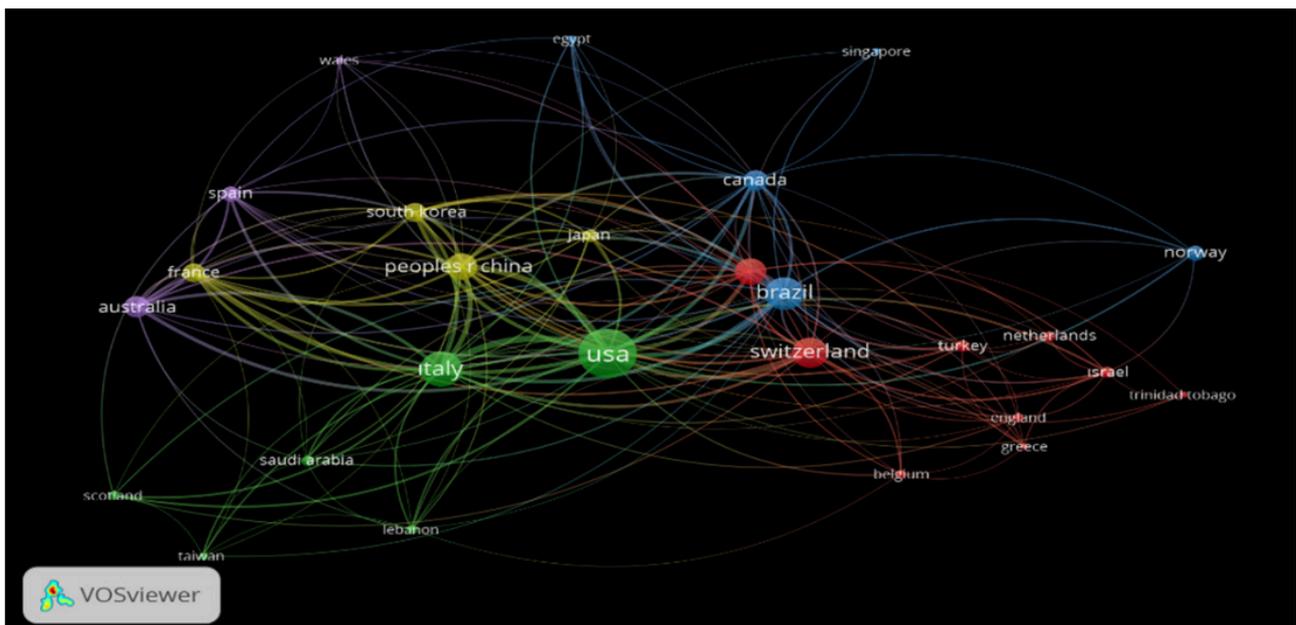
### Country and institution citation analysis

The 150 most cited articles were produced by 27 countries. Upon examination of the countries contributing to publications, the United States of America (USA) ( $n = 39$ ), Italy ( $n = 25$ ), and Brazil ( $n = 25$ ) emerged as the primary contributors. A collaboration network was constructed for the citation analyses of countries. In the figure, node size represents the number of citations received by each country, while connecting lines represent the strength of collaborations between countries and authors (Fig. 4).

Universities that produced at least five or more publications related to the subject are depicted in Table 4. The institutions with the highest number of publications were the University of Zurich ( $n = 12$ ), Sapienza University of Rome ( $n = 11$ ), University of Münster ( $n = 9$ ), and University of the Pacific ( $n = 9$ ).

### Keywords analysis

The top 10 most frequently occurring keywords from the 150 most cited studies are nickel-titanium ( $n = 34$ ), cyclic fatigue ( $n = 21$ ), nickel-titanium instruments ( $n = 11$ ), root canal preparation ( $n = 11$ ), m-wire ( $n = 9$ ), ProTaper ( $n = 9$ ), rotary instruments ( $n = 8$ ), reciprocating motion ( $n = 8$ ), self-adjusting file ( $n = 7$ ), and canal transportation ( $n = 6$ ).



**Figure 4.** Citation analysis and collaboration network of countries.

**Table 4.** Institutions with five or more publications among the 150 most-cited articles.

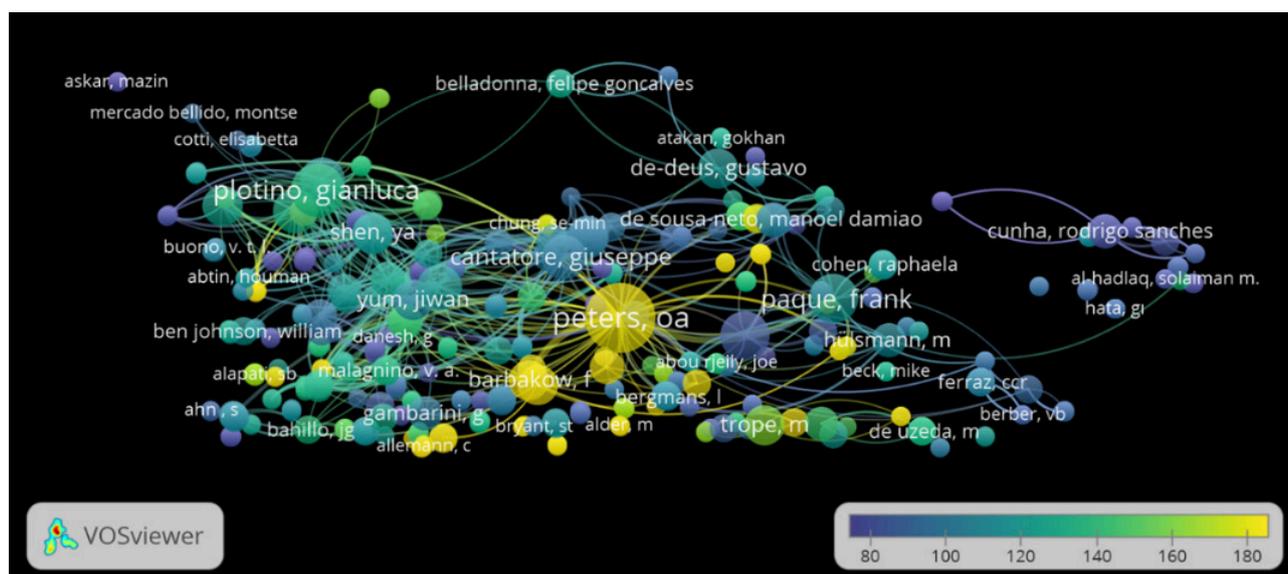
University Name	Number of Publications	University Name	Number of Publications
University of Zurich	12	Pusan National University	6
Sapienza University Rome	11	University of Verona	6
University of Munster	9	Catholic University of the Sacred Heart	5
University of the Pacific	9	University of Melbourne	5
University of Hong Kong	7	University of Texas System	5
A O U Citta Della Salute e della Scienza	6	University of Turin	5

### Bibliographic coupling of documents

The documents that were identified as having cited one or more common sources in the reference lists of the 150 most cited articles were designated as bibliographically coupled documents. A visualization was generated wherein the node size represents the authors' citation counts, and the lines indicate the authors who produced the coupled documents (Fig. 5).

### Analysis of study design

The 150 most cited articles were examined, and the study design of these articles were determined. Of the publications, 133 were *in vitro* studies, 11 were clinical studies, two were methodology studies, two were randomized clinical trials, one was a retrospective cohort study, and one was a case-control study.

**Figure 5.** Visualization of authors' bibliographic coupling analysis.

## DISCUSSION

This bibliometric analysis represents the first of its kind to evaluate the 150 most cited articles and their fundamental characteristics in the field of Ni-Ti instruments, which led to a significant advancement in endodontics, by including all articles from 1990 to 2025 in the research area.

A comprehensive literature review was conducted in the database for all time periods to identify articles in the field of Ni-Ti instruments, thereby preventing any potential loss of data from any publication year. In bibliometric studies, the top 100 articles are generally examined when evaluating article citation numbers (1,4,16). Upon examining the artic-

les in the field of Ni-Ti instruments, we determined that the citation numbers were considerably high and included 150 articles in our study.

Scientific articles featured in the list of most frequently cited papers in their respective fields provide significant data, and the citation count reflects the quality of the article (12,13). Typically, a research paper with 100 or more citations is considered a '*classic*' in its field (17). In our study, the most cited article received 637 citations. The second and third most cited articles garnered 534 and 466 citations, respectively. Of the 150 articles, 92 can be classified as '*classic*' papers based on their citation counts. Furthermore, exami-

ning the remaining 58 articles reveals that the article ranked last in terms of citations still received 79 citations.

When determining the country of origin for the most cited articles, the institutions affiliated with the first authors were evaluated, and the United States of America ranks first with 39 articles and 5745 citations. Italy, with 25 articles and 2996 citations, and Brazil, with 25 articles and 2689 citations, hold significant positions. This result aligns with other bibliometric studies conducted in the field of dentistry (1,13). As demonstrated in other scientific measurement analyses, the United States of America is the leading country in most research areas within the medical field (18). The presence of a comprehensive scientific community and larger research budgets have likely contributed to the significant contribution made by the United States (19). This demonstrates its preeminence in several areas: substantial research and development funding allocated by both government entities and private organizations, a higher concentration of highly educated professionals, increased researcher mobility, and the presence of multiple state-of-the-art research facilities. As a result, this has positioned the United States as the preeminent nation in terms of scientific and technological innovation (20). The University of Zurich ( $n = 12$ ) has made the largest contribution among the institutions affiliated with first authors in the top 150 most cited articles. This is followed by Sapienza University Rome ( $n = 11$ ). Among the institutions located in the United States, no single one stands out; instead, many different universities and researchers have contributed to this field. This highlights the quality of universities nationwide and the propensity for producing high-quality publications.

Ni-Ti instruments have garnered significant attention since their introduction in the field of endodontics, resulting in numerous studies and theses (21). Articles with earlier publication dates may have higher citation counts compared to more recent publications, as they have been accessible to researchers in databases for a longer duration. Conversely, a recently published article may surpass an older one in citation count (4). In our study, an examination of the publication years revealed that the highest number of articles ( $n = 13$ ) were published in 2012. When considering the publication years of the most cited articles, a generally balanced distribution was observed; however, only three articles from each of the years 2015, 2007, and 1998 were included in the list of most cited articles. Nevertheless, it will be possible to evaluate how the citation counts of these articles will change over time or to assess the status of the results evaluated in this article as time progresses. There may be a tendency among researchers to adhere to a particular pattern, which could create a 'snowball effect' in citations due to authors gravitating towards highly cited publications rather than reassessing their relevance and quality (22). While foundational, this phenomenon may obscure newer, potentially transformative research that has not yet had sufficient time to accumulate comparable citation counts. This suggests a potential area for future bibliomet-

ric studies to incorporate alternative metrics that account for recency or emerging impact. In our study, a total of 13 publications from 2015 ( $n = 3$ ), 2016 ( $n = 4$ ), and 2017 ( $n = 6$ ) were able to enter the list of the 150 most cited articles, with no publications after 2017 appearing on the list of most cited articles. This may be a result of authors' tendency to adhere to established patterns or to gravitate towards more frequently cited articles.

Of the 150 most cited articles in the field of Ni-Ti instruments, 133 comprise *in vitro* studies. Although *in vitro* studies play a fundamental role in developing new materials and protocols, their predominance among the most-cited articles -133 compared to only 11 clinical studies and two randomized clinical trials- reveals a critical gap in the literature. Because *in vitro* results cannot be directly translated into clinical practice (19), there is a clear need for more well-designed clinical and translational research to validate these findings and strengthen the evidence base for Ni-Ti instrument use. Although the results of *in vitro* studies cannot be directly translated to clinical practice, *in vitro* models allow for well-controlled environments when developing scientific fields, rendering them crucial for testing new protocols, materials, and instruments (14). There are over 200 brands of Ni-Ti instrument systems available in the market, with the number increasing continuously (9).

When evaluating researchers, research productivity is a significant criterion for assessment, as productive researchers tend to have higher citation counts (10). In our study, Ove Peters emerged as both the most cited and the most productive author. Conversely, while Messer Harold H. ranked second in the citation ranking with 1028 citations, he had 4 articles in the list of most cited papers.

Upon examination of the co-author analysis, it was observed that Platino Guanlica demonstrated the highest level of collaboration with other authors. This researcher has seven publications and collaborations with 22 authors. De-deus Gustavo has 4 publications with collaborations involving 20 authors. Gambarini Gianluca has 5 publications and a collaborative network with 14 different authors. Tasterelli Luca has four publications with collaborations involving 14 authors, while Grande Nicola M. has 5 publications with collaborations involving 13 different authors. The collaborative nature of these 3 authors' work can be discerned through an examination of the co-authorship analysis network visualization.

Keywords constitute a crucial component of academic articles. The utilization of keywords during literature review facilitates researchers in obtaining relevant results (23). Consequently, researchers should select and include easily searchable keywords when determining them for publications (24). In our study, the keyword analysis revealed that the most frequently used keyword was "nickel-titanium". This outcome was anticipated. It was followed by the keywords "cyclic fatigue" and "nickel-titanium instruments".

The presence of "*cyclic fatigue*" as the second most frequent keyword provides insight into the content of the most cited articles. The keyword analysis highlighted recurring themes such as cyclic fatigue, reciprocating motion, and heat-treated Ni-Ti alloys, pointing to both enduring and emerging research areas.

Bibliographic coupling is predicated on the premise that two publications sharing common references are likely to exhibit similarity in content (25). This approach facilitates the visualization of recent contributions that have not yet accrued substantial impact, thereby reflecting the most current scientific output in the field. This analysis generates thematic clusters derived from publications with shared bibliographic citations, thus offering a more up-to-date depiction of the research landscape (6). This analysis employs spheres whose dimensions correspond to the authors' aggregate citation counts. The spatial relationships between these spheres, along with the varying thicknesses of their interconnecting lines, reflect the extent of similarity among articles, as determined by the quantity of references they share. Upon examining the bibliographic coupling analysis of the texts in our study, researchers with over 180 citations, such as Peter Ove, Schönerberger K, Barbakow F, and Laib A, were found to have a high rate of citing common publications in their work.

Several limitations are encountered when conducting research using the WOS Core Collection. One such limitation is the inability to include sources that have not been disseminated internationally through the Scopus and PubMed databases in analyses performed on listed studies.

Article metadata provided through databases can be used as a method of accessing content. Visualization tools employing these data demonstrate collaborations and periods of research productivity. Generally, VOS viewer is an excellent tool for information specialists to map and visualize where author and keyword networks are situated within a field of study (11). Another limitation is that the program may interpret authors using different publication names as separate individuals, potentially dividing the data and causing issues in visualization. It is recommended that researchers carefully examine the results and visuals to avoid errors when obtaining data using this program.

Another important limitation relates to potential database-related bias. Because this study relied exclusively on the Web of Science Core Collection, articles indexed solely in other major databases such as Scopus or PubMed may not have been captured. Differences in indexing policies, journal coverage, and citation tracking across platforms can influence citation counts, the visibility of specific authors or countries, and the overall representation of the scientific landscape. Therefore, the trends and rankings reported in this bibliometric analysis should be interpreted with the understanding that database selection inherently shapes the scope and output of such evaluations.

## CONCLUSION

This bibliometric analysis provides a comprehensive overview of the evolution, influential contributors, and major research trends related to Ni-Ti instruments in endodontics. By mapping citation patterns and identifying leading authors, institutions, and themes, the study highlights the pivotal role of Ni-Ti instrument research in advancing endodontic science. The consistently high citation counts of the analyzed articles underscore their significant scientific influence and enduring relevance within the field. Importantly, these findings also indicate future research priorities—particularly the need to translate *in vitro* discoveries into robust clinical evidence—to ensure that technological innovations in Ni-Ti instruments continue to enhance patient care and evidence-based clinical practice.

### Ethics approval

Ethics approval is not required for the development of this study, as all information is publicly available.

### Conflicts of Interests

No potential conflict of interest relevant to this article was reported.

### Funding

The authors did not receive support from any organization for the submitted work.

### Data availability statement

All study-related data is included in the publication or provided as supplementary information.

### Acknowledgments

None.

1. Adnan S, Ullah R. Top-cited articles in regenerative endodontics: a bibliometric analysis. *J Endod.* 2018; 44: 1650-64.
2. Celeste RK, Broadbent JM, Moyses SJ. Half-century of Dental Public Health research: bibliometric analysis of world scientific trends. *Commun Dent Oral Epidemiol.* 2016; 44: 557-63.
3. Bornmann L, Mutz R, Neuhaus C, *et al.* Citation counts for research evaluation: standards of good practice for analyzing bibliometric data and presenting and interpreting results. *Ethics Sci Environ Polit.* 2008; 8: 93-102.
4. Feijoo JF, Limeres J, Fernández-Varela M, *et al.* The 100 most cited articles in dentistry. *Clin Oral Investig.* 2014; 18: 699-706.
5. Molléri JS, Petersen K, Mendes E. Towards understanding the relation between citations and research quality in software engineering studies. *Scientometrics.* 2018; 117: 1453-78.
6. Donthu N, Kumar S, Mukherjee D, *et al.* How to conduct a bibliometric analysis: an overview and guidelines. *J Bus Res.* 2021; 133: 285-96.
7. Gavini G, Santos Md, Caldeira CL, *et al.* Nickel-titanium instruments in endodontics: a concise review of the state of the art. *Brazil Oral Res.* 2018; 32: E67.
8. Dablanca-Blanco A-B, Castelo-Baz P, Miguéns-Vila R, *et al.* Endodontic rotary files, what should an endodontist know? *Medicina.* 2022; 58: 719.
9. Grande N, Castagnola R, Minciocchi I, *et al.* A review of the latest developments in rotary NiTi technology and root canal preparation. *Aust Dent J.* 2023; 68: S24-38.
10. Abramo G, Cicero T, D'Angelo CA. Are the authors of highly cited articles also the most productive ones? *J Inform.* 2014; 8: 89-97.
11. McAllister JT, Lennertz L, Atencio Mojica Z. Mapping a discipline: a guide to using VOSviewer for bibliometric and visual analysis. *Sci & Technol Librar.* 2022; 41: 319-48.
12. Fardi A, Kodonas K, Lillis T, *et al.* Top-cited articles in implant dentistry. *Int J Maxillofac Implants.* 2017; 32:555-64.
13. Tarazona B, Lucas-Dominguez R, Paredes-Gallardo V, *et al.* The 100 most-cited articles in orthodontics: a bibliometric study. *Angl Orthod.* 2018; 88: 785-96.
14. Nagendrababu V, Murray PE, Ordinola-Zapata R, *et al.* PRILE 2021 guidelines for reporting laboratory studies in endodontology: a consensus-based development. *Int Endod J.* 2021; 54: 1482-90.
15. Arias A, Peters OA. Present status and future directions: canal shaping. *Int Endod J.* 2022; 55: 637-55.
16. dos Reis-Prado AH, Maia CA, Nunes GP, *et al.* Top 100 most-cited scientific articles in regenerative endodontics 2019–2023: a bibliometric analysis. *Int Endod J.* 2024; 57: 1434-52.
17. Andersen J, Belmont J, Cho CT. Journal impact factor in the era of expanding literature. *J Microbiol Immunol Infect.* 2006; 39: 436-43.
18. Brüggmann D, Kayser L, Jaque J, *et al.* Human papilloma virus: Global research architecture assessed by density-equalizing mapping. *Oncotarget.* 2018; 9: 21965.
19. Shadgan B, Roig M, HajGhanbari B, *et al.* Top-cited articles in rehabilitation. *Arch Phy Med Rehabil.* 2010; 91: 806-15.
20. Philipson L. Medical research activities, funding, and creativity in Europe: comparison with research in the United States. *JAMA.* 2005; 294: 1394-8.
21. Balkanlıoğlu E. Publication rates of endodontics specialization theses defended between 2015 and 2022: a bibliometric analysis. *Turk Endod J.* 2024; 9: 165-72.
22. Lareau CR, Deren ME, Fantry A, *et al.* Does autogenous bone graft work? A logistic regression analysis of data from 159 papers in the foot and ankle literature. *Foot Ankle Surg.* 2015; 21: 150-9.
23. Natarajan K, Stein D, Jain S, *et al.* An analysis of clinical queries in an electronic health record search utility. *Int J Med Inform.* 2010; 79: 515-22.
24. Asghari S, Navimipour NJ. Nature inspired meta-heuristic algorithms for solving the service composition problem in the cloud environments. *Int J Commun Syst.* 2018; 31: E3708.
25. Rojas-Lamorena AJ, Del Barrio-García S, Alcántara-Pilar JM. A review of three decades of academic research on brand equity: a bibliometric approach using co-word analysis and bibliographic coupling. *J Bus Res.* 2022; 139: 1067-83.