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Research Araştırma

A Bibliometric Analysis Of Digital Dentistry

Dijital Diş Hekimliğinin Bibliyometrik Analizi

ABSTRACT

Objective: In this bibliometric analysis, the research trends of the researchers, institutions, countries, and journals that contributed to the study of digital dentistry were to be analyzed.

Materials and Method: The Web of Science (WoS) database, which covers papers on digital dentistry between 2012 and 2022, served as the foundation for the literature search. Titles, abstracts, keywords, authors, connections, nations, and references are among the metadata that have been saved. Through the use of the Vosviewer software, the collected data were examined using bibliometric indicators for all interactions and collaborations.

Results: 254 studies that were published between 2012 and 2022 were identified using the bibliometric analysis through searches in the Web of Science database. Total citations for publications on digital dentistry were 2112, averaging 8.31 per article. The 25 H index was identified. These publications had an article document type at a rate of 82.66%. The Journal of Esthetic and Restorative Dentistry published the most articles on digital dentistry, while it also attracted the most citations.

Conclusion: The study on digital dentistry was expanding between 2012 and 2022. Extensive partnerships and citations between authors, institutions, and countries or regions have been observed as a result of the global expansion in digital dentistry research. In the upcoming years, it is anticipated that research on digital dentistry will continue to be popular. According to recent publications, the accuracy and precision of intraoral scanners, digital impressions, and the variations between different intraoral scanners have all become popular research topics.

Key Words: Dijital Dentistry, Bibliometric Analysis, Intraoral Scanner.

ÖZ

Amaç: Bu bibliyometrik analizde dijital diş hekimliği çalışmalarına katkıda bulunan araştırmacıların, kurumların, ülkelerin ve dergilerin araştırma eğilimleri analiz edilmeye çalışılmıştır.

Gereç ve Yöntemler: 2012-2022 yılları arasında dijital diş hekimliği ile ilgili makaleleri kapsayan Web of Science (WoS) veritabanı, literatür taramasının temelini oluşturdu. Kaydedilen meta veriler arasında başlıklar, özetler, anahtar kelimeler, yazarlar, bağlantılar, ülkeler ve referanslar yer alır. Vosviewer yazılımı kullanılarak toplanan veriler, tüm etkileşimler ve işbirlikleri için bibliyometrik göstergeler kullanılarak incelendi.

Bulgular: Web of Science veri tabanında yapılan aramalar sonucunda bibliyometrik analiz kullanılarak 2012-2022 yılları arasında yayınlanmış 254 çalışma belirlendi. Dijital diş hekimliği alanındaki yayınlara ilişkin toplam alıntı sayısı 2112 olup makale başına ortalama 8,31 idi. 25 H indeksi belirlendi. Bu yayınlar %82,66 oranında makale belge türüne sahiptir. Estetik ve Restoratif Diş Hekimliği Dergisi, dijital diş hekimliği alanında en çok makale yayınlayan ve aynı zamanda en çok alıntı alan dergi oldu.

Sonuç: Dijital diş hekimliği ile ilgili çalışmalar 2012 ile 2022 yılları arasında genişlemekteydi. Dijital diş hekimliği araştırmalarındaki küresel genişlemenin bir sonucu olarak yazarlar, kurumlar ve ülkeler veya bölgeler arasında kapsamlı ortaklıklar ve alıntılar gözlemlenmiştir. Önümüzdeki yıllarda dijital diş hekimliğine yönelik araştırmaların popüler olmaya devam edeceği öngörülüyor. Son yayınlara göre ağız içi tarayıcıların doğruluğu ve kesinliği, dijital ölçüler ve farklı ağız içi tarayıcılar arasındaki farklılıklar popüler araştırma konuları haline gelmiştir.

Anahtar Kelimeler: Dijital Diş Hekimliği, Bibliyometrik Analiz, Ağız İçi Tarayıcı.

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INTRODUCTION

Digital dentistry is a computer-enabled technology for designing and producing conventional dental procedures. The implementation of CAD/CAM (computer-aideddesign/computer-aidedmanufacturing) technologies in the dental field initiated in the 1980s. In addition to increasing production efficiency in laboratories, CAD/CAM systems also facilitate standardized quality control (1-3). With advancements in technology, multiple clinical and laboratory CAD/CAM systems are still being developed (4,5). In recent times, chairside single-session applications have also become available. CAD/CAM technology has become increasingly popular in clinical settings due to its time-saving benefits for both patients and physicians (2,3). In order for CAD/CAM restorations to be successful, they must be durable, functional, and prepared with the same level of expertise as traditional procedures (6-9). One of the recent advancements in CAD/CAM systems is the use of intraoral scanners for digital readings, which eliminates the disadvantages associated with traditional impression-taking methods and has become increasingly preferred in practice. By removing the drawbacks of the conventional imprint process, this technology has become a practical option. The elimination of the need for impressions and use of temporary restorations reduces the risk of cross-infection compared to conventional methods (6,7). Over time, imprint materials have improved their dimensional stability, tear resistance, and physical and chemical properties, including biocompatibility, to capture the most delicate details accurately (8). Despite the numerous advancements, the accuracy of the measurement can be influenced by various external factors such as the physician's skills and experience, environmental and storage conditions (8,9). Moreover, despite possessing beneficial features, the system is exceptionally costly. There is a lack of literature analyses on digital dentistry, although it has gained popularity due to the advancements of systems produced and developed by various companies in the dental industry. A type of analysis known as bibliometric analysis is one that may be utilized to acquire a general understanding of a subject in the academic world (16). Bibliometric research makes it possible to uncover the most prolific researchers in any field as well as the many elements of the connection between those researchers. Numerous academic disciplines utilize bibliometric tools to identify scholars, certain subjects, or influential papers in a specific field of research (12,13). The main objectives of such research are to establish temporal patterns, demonstrate citation counts, and highlight evidence-based studies.The aim of this study was to conduct a bibliometric analysis of articles on digital dentistry from the literature (11-15). Similarly, bibliometric studies allow for comparisons between countries, institutions, and schools on various topics.

MATERIAL AND METHODS

A literature review was conducted in July 2022 utilizing the Web of Science (WoS) database, initially developed by the Institute for Scientific Information (ISI) and later managed by Clarivate Analytics. To enhance and restrict the scanning process, filters were employed. By entering the text "TS=(("digital dentistry") AND (dent OR oral OR crown OR teeth OR prosthodontics))" in the section devoted to complex searches, a total of 254 results were obtained.
The study excluded articles with non-English abstracts and keywords. The obtained findings were ranked according to citation count, ranging from highest to lowest. Additionally, the information for the 20 papers with the highest citations was exported to an Excel file with a ".xls" extension. The resulting data for the 254 publications was exported as a plain text file in ".txt" format. Additionally, the information for the 20 papers with the highest citations was exported to an Excel file with a ".xls" extension. For the bibliometric analysis of the obtained data, we utilized the bibliometric analysis tool, VOSviewer, developed by the Center for Science and Technology Studies at Leiden University (17,18). We downloaded the latest version of VOSviewer 1.6.18 for free from the official website of the program, which was released on January 24, 2022 (17). The VOSviewer application was used to transfer and analyze the ".txt" and ".xls" files (18,19,20). Collaborations and citation counts were visualized through network type or overlay using VOSviewer software. A visual map was created where the size of each bubble represented the number of broadcasts, the distance between them portrayed the relationship between each element, and the coloration of each bubble had significance for other visual maps. As a result of the study, the co-authors received a network-style diagram where bubbles of the same color create clusters demonstrating their close collaborations.

Based On The Results:

A bibliometric study on digital dentistry revealed 254 articles published between 2012 and 2022 in the Web of Science database, demonstrating a consistent increase in the annual number of publications. The total number of citations for these articles was 2,112, with an average of 8.31 citations per article. The H index was calculated as 25. The majority of these publications, specifically 210, comprised articles (%

82.66). Data on specific themes, such as titles, authors, journals, publication dates, total citations, and annual averages, were collected using the database as a guide and presented in tables. The 20 publications with the highest citation counts in research on "digital dentistry" using screening goals were converted into spreadsheets (Microsoft Office 2020 Excel v16.35; Microsoft Corp) and are enumerated in Table 1. Figure 1 presents the number of publications published from 2012 to 2022 graphically.

Table 1. 20 most cited articles in digital dentistry research

Title	Authors	Source Title	Document Type	Publication Year	Total Citations	Average per Year
Application of Intra-Oral Dental Scanners in the Digital Workflow of Implantology	van der Meer, Wicher J.; Andriessen, Frank S.; Wismeijer, Daniel; Ren, Yijin	Plos One	article	2012	170	15.45
3D printed versus conventionally cured provisional crown and bridge dental materials	Tahayeri, Anthony; Morgan, MaryCatherine; Fugolin, Ana P.; Bompolaki, Despoina; Athirasala, Avathamsa; Pfeifer, Carmem S.; Ferracane, Jack L.; Bertassoni, Luiz E.	Dental Materials	article	2018	140	28
Patients' preferences when comparing analogue implant impressions using a polyether impression material versus digital impressions (Intraoral Scan) of dental implants	Wismeijer, Daniel; Mans, Ronny; van Genuchten, Michiel; Reijers, Hajo A.	Clinical Oral Implants Research	article	2014	98	10.89
digital vs. conventional full-arch implant impressions: a comparative study	Amin, Sarah; Weber, Hans Peter; Finkelman, Matthew; El Rafie, Khaled; Kudara, Yukio; Papaspyridakos, Panos	Clinical Oral Implants Research	article	2017	91	15.17
Accuracy of 9 intraoral scanners for complete-arch image acquisition: A qualitative and quantitative evaluation	Kim, Ryan Jin-Young; Park, Ji-Man; Shim, June-Sung	Journal Of Prosthetic Dentistry	article	2018	60	12
Digitally Oriented Materials: Focus on Lithium DisilicateCeramics	Zarone, Fernando; Ferrari, Marco; Mangano, Francesco Guido; Leone, Renato; Sorrentino, Roberto	Internatıonal Journal Of Dentistry	review	2016	59	8.43
Accuracy and practicality of intraoral scanner in dentistry: A literature review	Kihara, Hidemichi; Hatakeyama, Wataru; Komine, Futoshi; Takafuji, Kyoko; Takahashi, Toshiyuki; Yokota, Jun; Oriso, Kenta; Kondo, Hisatomo	Journal Of Prosthodontic Research	review	2020	57	19

ToothNet: Automatic Tooth Instance Segmentation and Identification from Cone Beam CT Images	Cui, Zhiming; Li, Changjian; Wang, Wenping	2019 Ieee/Cvf Conference On Computer Vision And Pattern Recognition (Cvpr 2019)	Proceedings Paper	2019	51	12.75
Color Aspect of Monolithic Zirconia Restorations: A Review of the Literature	Tabatabaian, Farhad	Journal Of Prosthodontics-Implant Esthetıc And Reconstructive Dentistry	review	2019	47	11.75
Understanding dental CAD/CAM for restorations - accuracy from a mechanical engineering viewpoint	Tapie, L.; Lebon, N.; Mawussi, B.; Fron-Chabouis, H.; Duret, F.; Attal, JP.	International Journal Of Computerized Dentistry	article	2015	43	5.38
Digital Undergraduate Education in Dentistry: A Systematic Review	Zitzmann, Nicola U.; Mattisson, Leah; Ohla, Harald; Joda, Tim	Internatıonal Journal Of Environmental Research And Public Health	review	2020	42	14
Accuracy of digital technologies for the scanning of facial, skeletal, and intraoral tissues: A systematic review	Bohner, Lauren; Gamba, Diego Diaz; Hanisch, Marcel; Marcio, Bruno Silva; Tortamano Neto, Pedro; Lagana, Dalva Cruz; Sesma, Newton	Journal Of Prosthetic Dentistry	review	2019	42	10.5
Digital dentistry: The new state of the art - Is it disruptive or destructive?	Rekow, E. Dianne	Dental Materials	Article; Proceedings Paper	2020	40	13.33
Effect of scan pattern on complete-arch scans with 4 digital scanners	Latham, Jason; Ludlow, Mark; Mennito, Anthony; Kelly, Abigail; Evans, Zachary; Renne, Walter	Journal Of Prosthetic Dentistry	article	2020	38	12.67
Understanding dental CAD/CAM for restorations - the digital workflow from a mechanical engineering viewpoint	Tapie, L.; Lebon, N.; Mawussi, B.; Chabouis, H. Fron; Duret, F.; Attal, JP	International Journal Of Computerızed Dentıstry	article	2015	37	4.63
Examination of the Position Accuracy of Implant Abutments Reproduced by Intra-Oral Optical Impression	Ajioka, Hitoshi; Kihara, Hidemichi; Odaira, Chikayuki; Kobayashi, Takuya; Kondo, Hisatomo	Plos One	article	2016	33	4.71

Artificial Neural Networks as a powerful numerical tool to classify specific features of a tooth based on 3D scan data	Raith, Stefan; Vogel, Eric Per; Anees, Naeema; Keul, Christine; Gueth, Jan-Frederik; Edelhoff, Daniel; Fischer, Horst	Computers In Bıology And Medıcıne	article	2017	32	5.33
Evaluation of the effect scan pattern has on the trueness and precision of six intraoral digital impression systems	Mennito, Anthony S.; Evans, Zachary P.; Lauer, Abigail W.; Patel, Ravi B.; Ludlow, Mark E.; Renne, Walter G.	Journal Of Esthetic And Restorative Dentistry	article	2018	30	6
Current state of the art in the use of augmented reality in dentistry: a systematic review of the literature	Farronato, Marco; Maspero, Cinzia; Lanteri, Valentina; Fama, Andrea; Ferrati, Francesco; Pettenuzzo, Alessandro; Farronato, David	BMC Oral Health	review	2019	29	7.25
Materials in digital dentistry-A review	Sulaiman, Taiseer A.	Journal Of Esthetic And Restorative Dentistry	review	2020	28	9.33

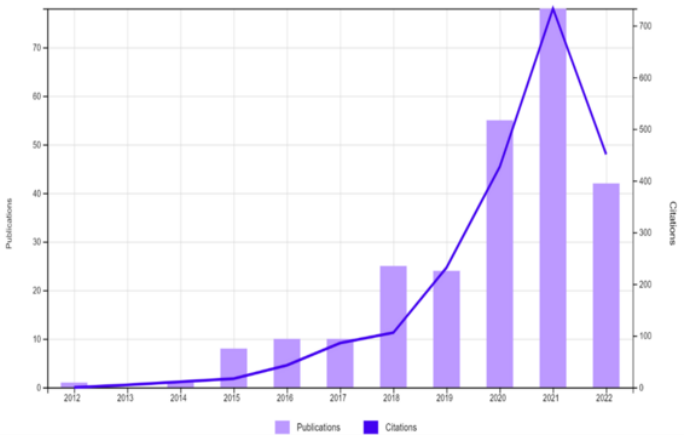

Figure 1. Graph showing the number of articles and citations from WOS by years of digital dentistry research.

Bibliometric analyses generated network structures distributed by authors in Fig. 2, institutions in Fig. 3, countries in Fig. 4, keywords in Fig. 5, and journals in Fig. 6.

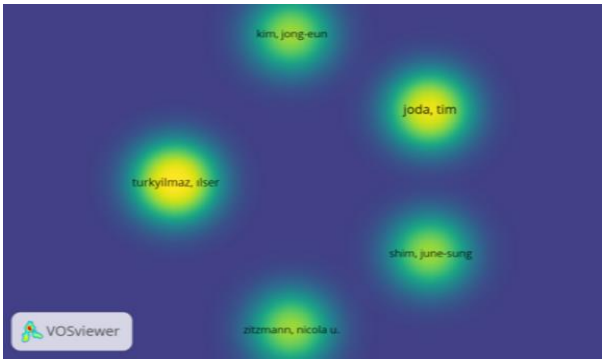

Figure 2. VOSviewer collaboration network map showing the relationship between authors from WOS by years of digital dentistry research.

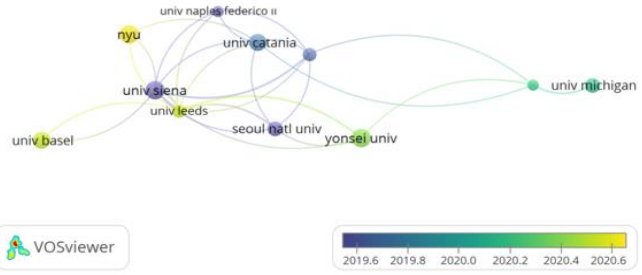

Figure 3. VOSviewer collaboration network map showing the relationship between institutions.

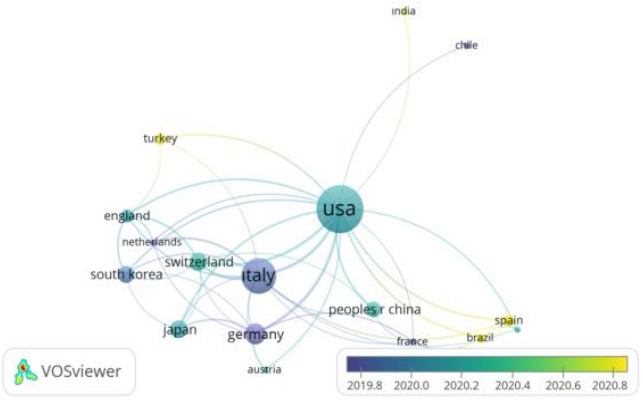

Figure 4. VOSviewer collaboration network map showing the relationship between countries.

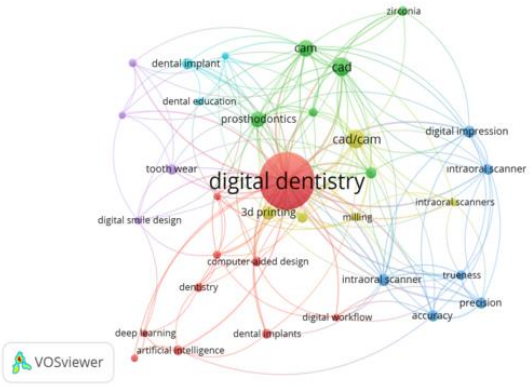

Figure 5. VOSviewer collaboration network map showing affinity between keywords.

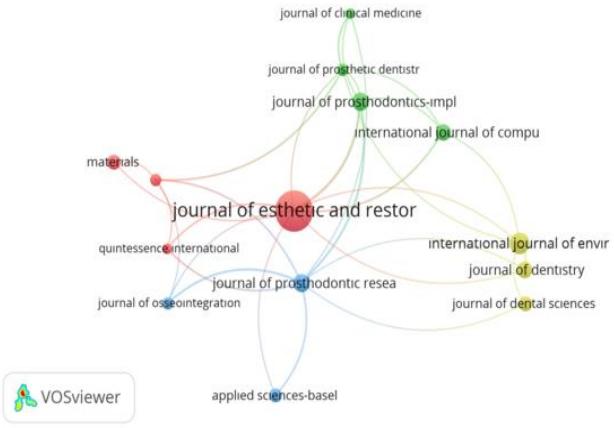

Figure 6. VOSviewer collaboration network map showing proximity between journals.

Table 2 provides data on the top ten most prolific authors in Digital Dentistry, indicating that Joda T. was the most prolific. Research in digital dentistry receives support from various countries and institutions. Tables 3 and 4 display the number of articles and citations for each country and institution. The United States has the highest number of articles, followed by Italy and Germany. The Journal of Esthetic and Restorative Dentistry has the most articles and citations in digital dentistry. Ferrari M., Joda T., and Zitzmann NU are the three most cited authors. While multiple organizations are leading the way in digital dentistry, the University of Siena, New York University, and Yonsei University have made the most significant contributions. The most frequently used keywords were cad, cam, and CAD/CAM, despite our primary search term being digital dentistry (Fig. 5). After the final screening process, we arranged all the findings in order of most-cited publications to those with the fewest citations.

The bibliometric analysis publications' data was exported and saved as plain text documents in the .txt format. Additionally, the data from the top 20 papers with the most citations was exported as Excel files in the .xls format.

Author	Citiations	Documents	Average Per Articale
Ferrari M	133	7	19
Joda T	123	10	12.3
Zitzmann NU	90	6	15
Kondo H	93	4	23.25
Shim JS	69	5	13.8
Lee JH	35	5	7
Han JS	28	4	7
Kim JE	9	5	1.8
Turkyilmaz I	3	7	0.43
Wilkins GN	3	5	0.6

Table 2. The 10 most cited authors.

DISCUSSION

In dentistry, like any other discipline, there exists a shift from traditional to digital methods. The digital dataset, comprising radiographs, photographs, intraoral scans, and patient records, has led to a revolution in clinical operations, creating a platform for improving interaction between patients, clinicians, and interlaboratory teams. Additionally, data is available in both the forensic and epidemiological sectors (10). It is currently crucial for patients to become more informed about prosthetic restoration, take more interest in its aesthetics, reduce the treatment duration for both themselves and physicians, and minimize the number of appointments necessary.

Organizations	Documents	Citiations	Aveage Per Article
New York University	10	6	0.6
University of Siena	9	139	15.44
Yonsei University	9	71	7.89
University of Basel	8	89	11.13
University of Catania	8	80	10
Yonsei University Health System	8	71	8.88
Seoul National University SNU	7	94	13.43
University of Michigan	7	34	4.86
Medical University of South Carolina	6	123	20.5
University of Hamburg		28	4.67

Table 3. 10 most contributing institutions.

In recent years, the use of digital technology has led to a surge in research studies, which are thought to have numerous benefits. Our study was inspired by the lack of a bibliometric analysis of digital dentistry research in current literature. Through a search of the Web of Science database, it was discovered that the initial digital dentistry study was conducted in 2012. Since 2018, there has been a steady increase in the number of articles published on digital dentistry, with a total of 254 publications up through July 2022. Notably, the year with the highest number of publications was 2021, with 78 publications, illustrating the recent growth in this field. It should be noted that the study's data search was conducted in July 2022 and therefore the number of publications in 2022 may appear lower compared to previous years. Based on the graph's linear upward trend, it is expected that the number of publications will be similar to that of previous years by the end of 2022 (Fig. 1). Laboratory investigations and clinical reviews were among the top 20 publications referenced in digital dentistry. The subjects covered include the accuracy and precision of intraoral scanners, the integration of conventional and digital applications, and the therapeutic usability of modern ceramics such as lithium disilicate. The top three contributors were Ferrari M, Joda T, and Zitzmann NU.

Country	Documents	Citiations	Average Per Articale
USA	67	652	9.73
Italy	47	305	6.49
Germany	26	205	7.88
Japan	19	162	8.53
Switzerland	19	234	12.32
South Korea	18	121	6.72
Peoples R China	16	100	6.25
England	14	65	4.64
Spain	12	17	1.42
Turkey	10	13	1.3

Table 4. 10 most contributing countries or regions.

Keyword	Occurens	Total Link Strength
Digital Dentistry	188	265
Cad	26	75
Pine	20	66
Cad/Cam	26	52
Prosthodontics	19	52
Intraoral Scanner	12	34
Accuracy	11th	34
Dental Materials	11th	33
Precicion	10	30
Digital Impression	15	28

Table 5. 10 most key words total link strength.

There is often a correlation between the quantity of publications produced by authors and the level of citation received by their articles (Table 1). Despite the low number of articles from authors like Konda H and Shim JS, their articles have a high impact rate, reflected in the large number of citations (Table 1). The United

States, Italy, and Germany are the top three most productive countries, followed by Japan and Switzerland (Table 2). This assessment reveals that the three countries with the highest output are also the most frequently cited, showing a nearly proportional relationship between the number of articles and citations. Specifically, the United States, Italy, and Switzerland are the most referenced countries per article. Among those nations, the United States and Italy stand out as the most productive and influential. It is believed that the abundance of research-based institutions in the United States and Italy is responsible for their leading positions in productivity and efficiency. Table 3 displays the top-performing institutions, with New York University, University of Siena, and Yonsei University ranking as the three most productive universities. Italy and the United States are the two countries that make up the majority of the 10 most productive institutions. Additionally, these two countries rank first and second, respectively, in the publication order of the countries. Studies conducted in this context suggest that this trend is growing. Based on the number of articles, the University of Siena, Medical University of South Carolina, and Seoul National University are the three most influential universities. Based on the findings, it can be concluded that the rate of effect and research conducted at institutions did not increase linearly (Table 3). Between 2010 and 2019, the number of papers published in the Journal of Prosthetic Dentistry increased to 10,638. This growth can be attributed to advancements in treatment approaches in the field of prosthetic therapy, technological expansion, and the emergence of the digital age. Additionally, an electronic referral system was implemented that enables applications from all parts of the globe, which is another potential contributing factor (21). In digital dentistry, 3D printing technologies like stereolithography (SLA), digital light projection (DLP), material jetting (MJ), and material extrusion (ME) are commonly utilized for fabricating various products such as Invisalign orthodontic aligners, surgical aligners, and fully digital dentures. Material choices consist of glass ceramic, cobalt chrome, PMMA, polymers, titanium, zirconium, wax, and more. Employing the chairside approach in fixed prosthetic applications results in time savings for both practitioners and patients. (10) Tahayeri A et al. found that 3D-printed temporary Crown-bridge acrylics have a comparable elastic modulus with conventional temporary crown-bridge acrylics, and that 3D-printed temporary restorations are suitable for intra-oral use. Digital dentistry offers advantages over the conventional method, including increased production precision by reducing human error and shorter appointment times (22).

CONCLUSION

Following are the conclusions that were drawn from a bibliometric analysis of published research on digital dentistry:

1. The replacement of traditional workflow by digital workflow has led to an increase in world-wide research on digital dentistry. As a result, this topic has become more popular, and the number of citations is growing.
2. The accuracy and precision of intraoral scanners and digital impressions have become popular research topics in recent years, as evidenced by recent publications. The Trios 3 has proven to outperform traditional impression scanners and other intraoral scanners.

It is expected that digital dentistry will continue to be a prominent area of research in the future.

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