

The 50 Most-Cited Articles on Polyetheretherketone (PEEK): A Bibliometric Analysis

Gülbahar Erdinç¹ 

¹Department of Prosthodontics, Faculty of Dentistry, Karabük University, Karabük, Turkey

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Correspondence

Gülbahar Erdinç, DDS
Address: Department of
Prosthodontics, Faculty of Dentistry,
Karabük University, Karabük,
Turkey
E-mail: gbaharerdinc@gmail.com



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ABSTRACT

Objectives: The aim of this study was to perform a bibliometric and visualized analysis to identify and critically assess the 50 most highly cited articles on polyetheretherketone (PEEK).

Methods: The electronic search was made to identify detailed literature sources using the Clarivate-owned Web of Science (WoS) database. The terms used in the literature search are “polyetheretherketone”, “poly ether ether ketone” and “peek”. All articles from the search results were ranked according to citation counts, and the 50 articles that received the most citations were selected. The results were summarized and processed in a spreadsheet.

Results: 380 articles were displayed due to the search, and 50 of the most cited articles were included in the present study. Schilmidin and Stawarczyk, who have 12 papers and 974 citations, were identified as the most productive and influential researchers with equal citations and publications. Dental Materials (26%) has the highest number of publications, and Germany was determined as the most productive country.

Conclusion: Considerable advancement has been made in PEEK, as demonstrated by the increase in the number of publications linked with collaboration among various authors, nations, and institutes.

Keywords: PEEK, Polyetheretherketone, Bibliometrics, Citation analysis, Web of Science

INTRODUCTION

Bibliometric analysis is a quantitative assessment method that presents data on the analysis of the number of citations received by a publication, field of study, institution, keywords, author information, country-to-country linkage, and collaborations of an article. Visual analysis to create bibliometric networks can give users an intuitive yet thorough overview of a huge amount of data [1].

The number of citations is one of the essential parts of bibliometric analysis because it points out the impact of a research publication [2]. High-cited articles will likely guide future studies and influence clinical practice [3]. Researchers can investigate updated ideas, identify popular study topics

based on bibliometric data, and collaborate with authors [4]. Authors can make inferences about the prestige and influence of journals from these analyses and benefit from these bibliometric analyses in choosing journals for future studies [1].

Polyetheretherketone (PEEK) is a linear, semi-crystalline, thermoplastic, and synthetic polymeric material used as an orthopedic biomaterial for many years [5,6]. PEEK has a lower Young's (elastic) modulus (3-4 GPa), being close to human bone, making it quite convenient for orthopedics implant application [7]. The tensile properties of PEEK are similar to those of bone, enamel, and dentin, making it a proper restorative material as far as the mechanical features are also concerned in dentistry [6-8].

PEEK has white color and superior physical properties; hence it has been appropriated for dental implant abutments, occlusal splints, and fixed and removable prostheses [6–9]. It can also be used in braces in orthodontic treatments with its aesthetic appearance [10]. Considering mechanical characteristics, chemical stability, low plaque affinity, good wear resistance, and appropriate bonding to composites and teeth, a PEEK fixed partial denture would be expected to have a reasonable survival rate [6]. The grayish appearance of metal frameworks can be eliminated due to the PEEK substructure's white color [9]. One of the significant clinical advantages of PEEK restorations is the possibility of intra-oral repair of the veneering material in chipping without restoration removal [11].

PEEK has minimal natural osteoconductive properties [12]. However, researchers show that the bioactivity of PEEK implants may improve with different methods, such as increasing its surface roughness and chemical modifications [13], coating PEEK with synthetic osteoconductive hydroxyl apatite [14] and adding bioactive particles [15]. Dental implant healing abutments and dental implants can be produced using PEEK thanks to sufficient biocompatibility [11,16].

PEEK frameworks combined with heat-cured acrylic resin denture bases and acrylic resin denture teeth may be alternatives to conventional Co-Cr frameworks [17]. PEEK has low water solubility and high chemical and thermal stability; thus, it may be a clinically appropriate choice for patients experiencing allergies to metals and more esthetic than conventionally removable partial dentures [9]. PEEK could also use as an intraradicular post in dentistry [18].

PEEK is a relatively new material, and researchers study this topic extensively. This bibliometric analysis aims to determine

and review the top-cited 50 articles in PEEK and evaluate the relative importance of journals, authors, keywords, countries, and institutions.

MATERIALS AND METHODS

Ethical standards were adhered to in this study. Ethical approval was not required because the study used bibliometric data from the Web of Science (WoS) database. The electronic search was made to identify detailed literature sources using the WoS database on 9 June 2023. The electronic search was limited to the topic field, which included the title, abstract, and keywords. The results were filtered as the category of the documents as dentistry oral surgery medicine. Research published in any language other than English and review articles were excluded. The terms used in the literature search are “polyetheretherketone”, “polyether ether ketone” and “peek”. All articles from the search results were ranked according to citation counts. Fifty articles that received the most citations were selected from 380 results, and their full text was obtained. One researcher evaluated the data extracted from WoS for inclusion and exclusion criteria three times to avoid bias. Prejudice was eliminated by evaluations made at other times, and objective results were obtained. The following bibliometric parameters of each article were recorded: article title, first author, citation count, year of publication, country, institution of publication, and study design.

The records obtained WoS were exported as a complete record in Tab Delimited File format. The cited references were processed using a bibliometric software program (VOSviewer v1.6.14.; Center for Science and Technology Studies, Leiden University). The results were summarized and processed in a spreadsheet. Data obtained by the WoS functions of “citation report” and “analyze results” were collected. VOSviewer software was used for the graphical mapping of the bibliometric material.

RESULT

Three hundred eighty articles were displayed due to the search, and 50 of the most cited articles were included in the present study. Table 1 shows the title, first author, publication year, journals, and citation of the PEEK-related first ten articles based on the WoS database. It was observed that the most cited article was the study by Schmidlin et al. [19]. Among the 50 most cited papers in the research, the article with the lowest number of citations is the articles of Schwitalla et al. [20] and Çulhaoğlu et al. [21], with 37 citations.

Main Points;

- PEEK is a popular material that can be used in many areas in dentistry.
- It is the first bibliometric analysis study associated with PEEK.
- Within the search criteria, 380 articles were reached and 5 of them were evaluated.
- There are many aspects of PEEK that still need to be evaluated and it is a material open to research.

Table 1. The top 10 cited manuscripts according to citations

First Author	Article Title	Times Cited, All Databases	Journal ISO Abbreviation	Year
Schmidlin, PR	Effect of different surface pre-treatments and luting materials on shear bond strength to peek	156	Dent. Mater.	2010
Vandewegh, S	Accuracy of digital impressions of multiple dental implants: an in vitro study	136	Clin. Oral Implant. Res.	2017
Hahnel, S	Biofilm formation on the surface of modern implant abutment materials	138	Clin. Oral Implant. Res.	2015
Zoidis, P	The use of a modified poly-ether-ether-ketone (peek) as an alternative framework material for removable dental prostheses. A clinical report	131	J. Prosthodont.	2016
Kern, M	Influence of surface conditioning on bonding to polyetheretherketon (peek)	129	Dent. Mater.	2012
Stawarczyk, B	Peek surface treatment effects on tensile bond strength to veneering resins	113	J. Prosthet. Dent.	2014
Tannous, F	Retentive forces and fatigue resistance of thermoplastic resin clasps	123	Dent. Mater.	2012
Fuhrmann, G	Resin bonding to three types of polyaryletherketones (paeks)-durability and influence of surface conditioning	110	Dent. Mater.	2014
Koch, FP	Osseointegration of one-piece zirconia implants compared with a titanium implant of identical design: a histomorphometric study in the dog	102	Clin. Oral Implant. Res.	2010
Zhou, L	The effect of different surface treatments on the bond strength of peek composite materials	100	Dent. Mater.	2014

Figure 1 demonstrates the trend of scientific articles published related to PEEK by year of publication. According to the search made in the database after the necessary filters were selected, the oldest publication among the 50 most cited publications was from 2008 [22]. The number of articles, the journals in which they were published, and the citation relationships are shown in Figure 2. Dental Materials (26%) has the highest number of publications. It is followed by the Journal of Prosthetic Dentistry (18%), Journal of Craniomaxillofacial Surgery (12%), Journal of Prosthodontics Implant-Esthetic and Reconstructive Dentistry (8%), and Clinical Oral Implants Research (8%).

Figure 3 shows the relationship between coauthorship and the number of documents by year. Schilmidin and Stawarczyk, who have 12 papers and 974 citations, were identified as the most productive and influential researchers with equal citations and publications. As can be seen from Figure 4, when the affiliations of the authors are evaluated, the institution that produced the most articles was the University of Zurich.

Figure 5 shows the distribution of articles by country, and in this

analysis, Germany is observed to be the most efficient country in producing PEEK-related publications. Figure 6 shows a mapping of the keywords used in the research included in this study. The most commonly used keywords were peek, shear bond strength, cad/cam, cranioplasty, digital impression polyetheretherketone, bond strength, and sem. When the articles included in the present study are evaluated according to study design, the results are shown in Figure 7: in vitro study (66%), case report (28%), finite element analysis (FEA) (4%) and animal study (2%).

The research topics of the articles are mainly on the bond strength of chemicals or surface treatments of PEEK. Similarly, many studies examine the physicomechanical and biological properties of PEEK, such as roughness, hardness, water absorption, fracture strength, wear resistance, bioactivity, antibacterial activity, and cytotoxicity. In addition, when the case reports are examined, using PEEK as a patient-specific implant in craniofacial defects or reconstructive surgeries comes to the fore. In addition, there are articles in which PEEK's endocrown, implant abutment, framework, clips on implants bar and clasp are produced, and their properties are investigated.

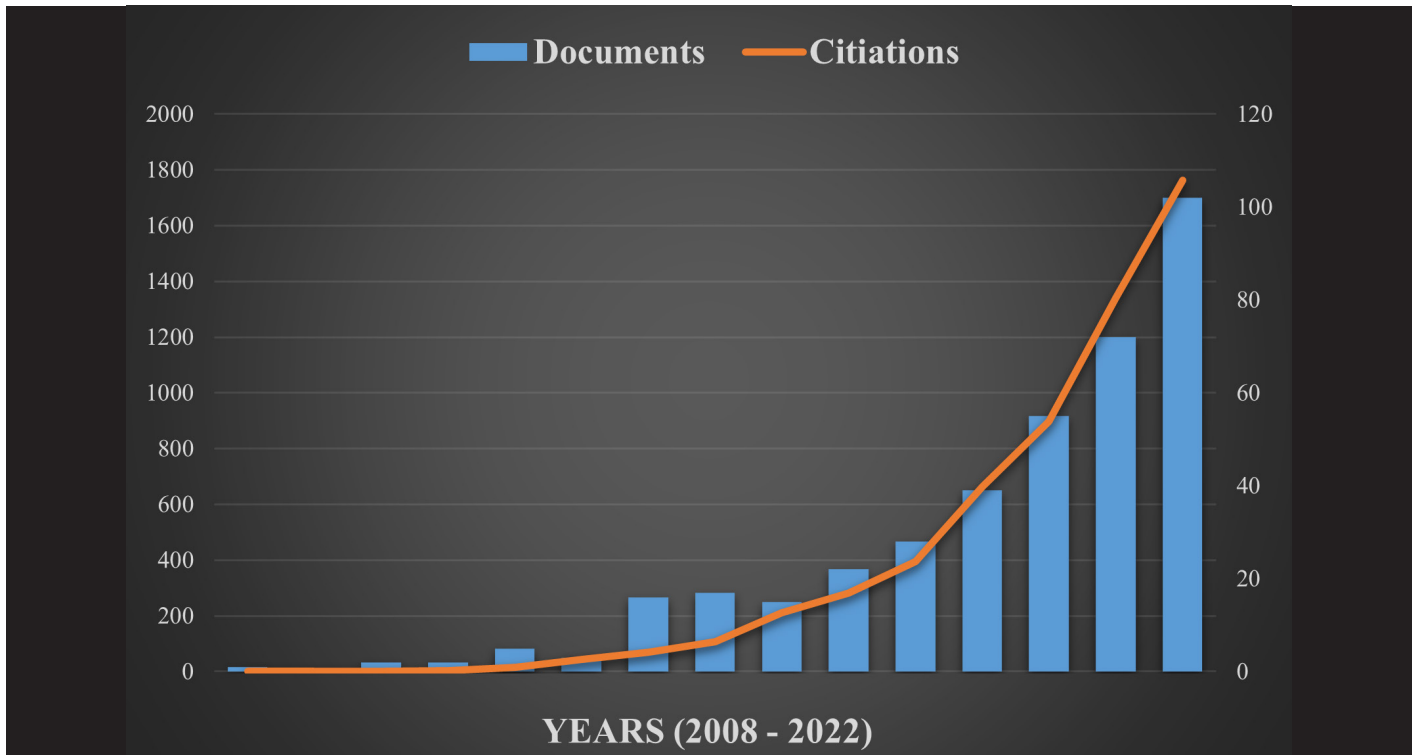


Figure 1. Distribution of articles and citations by years

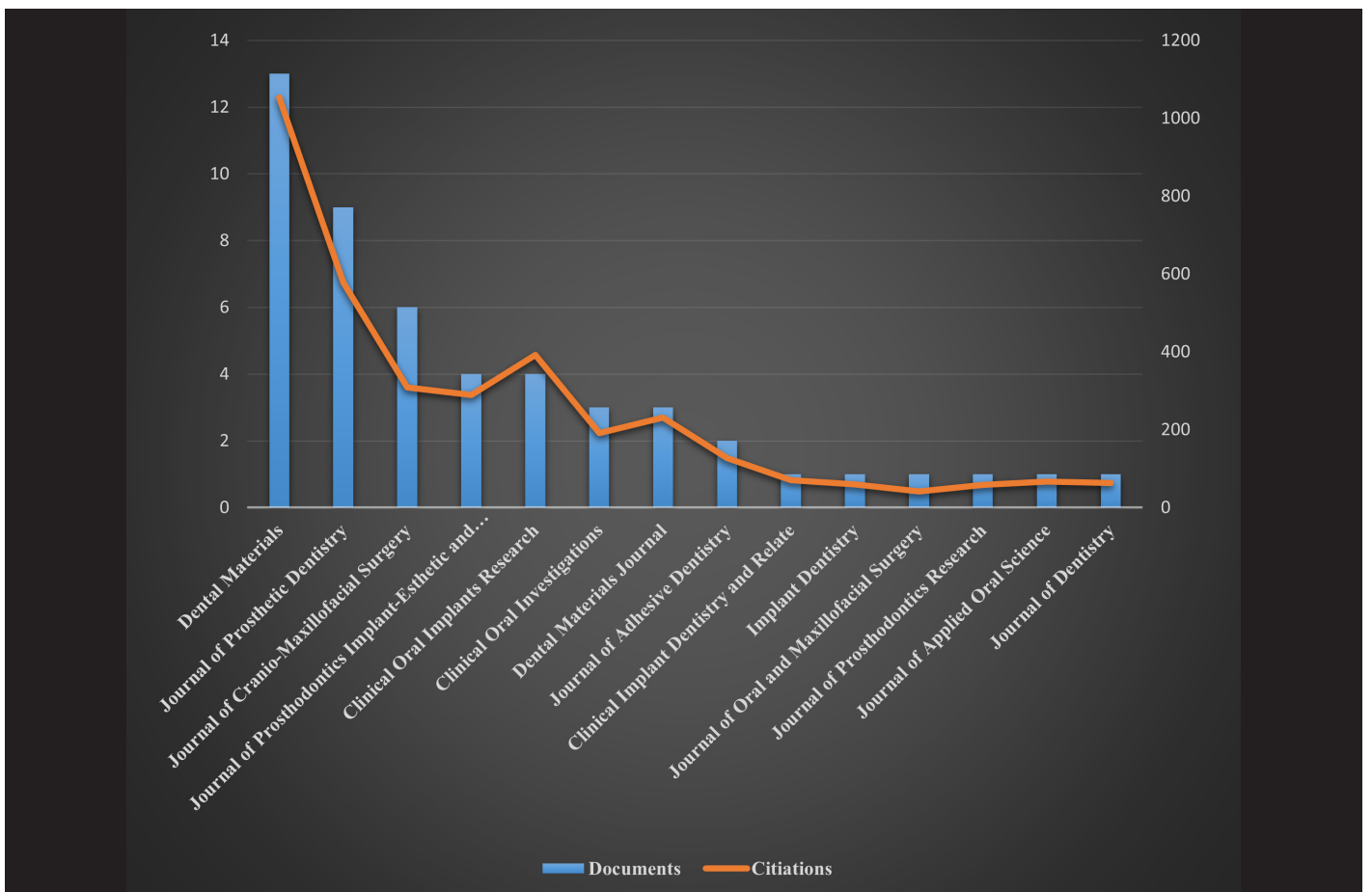


Figure 2. Distribution of articles and citations by journals

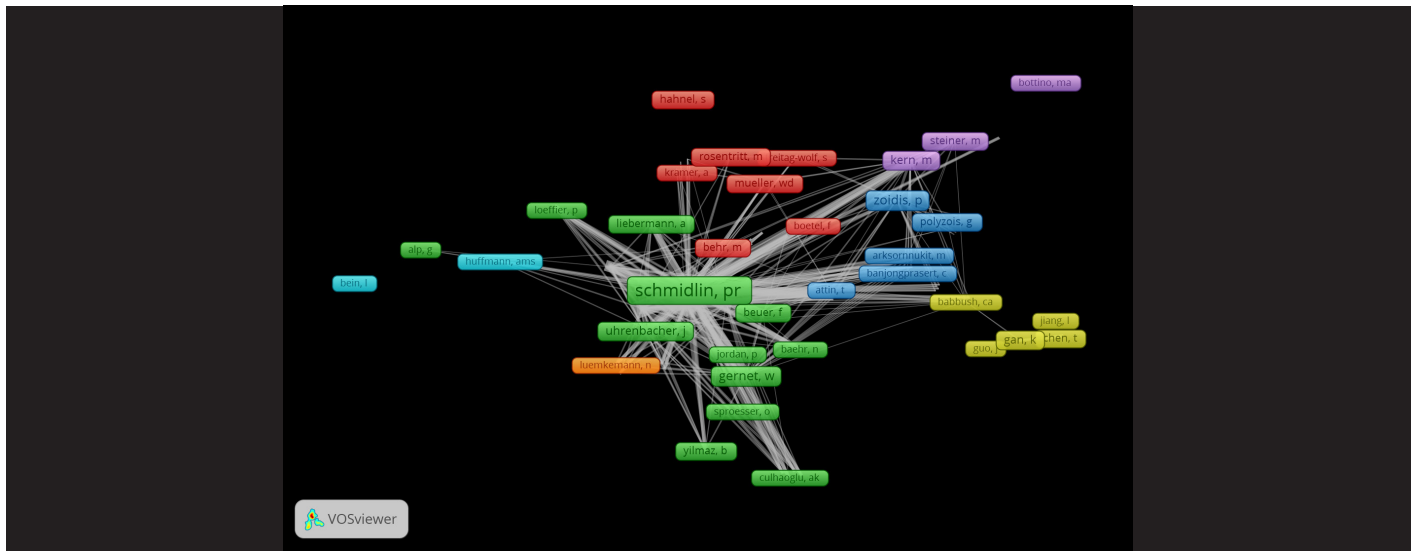


Figure 3. Collaboration networks among authors

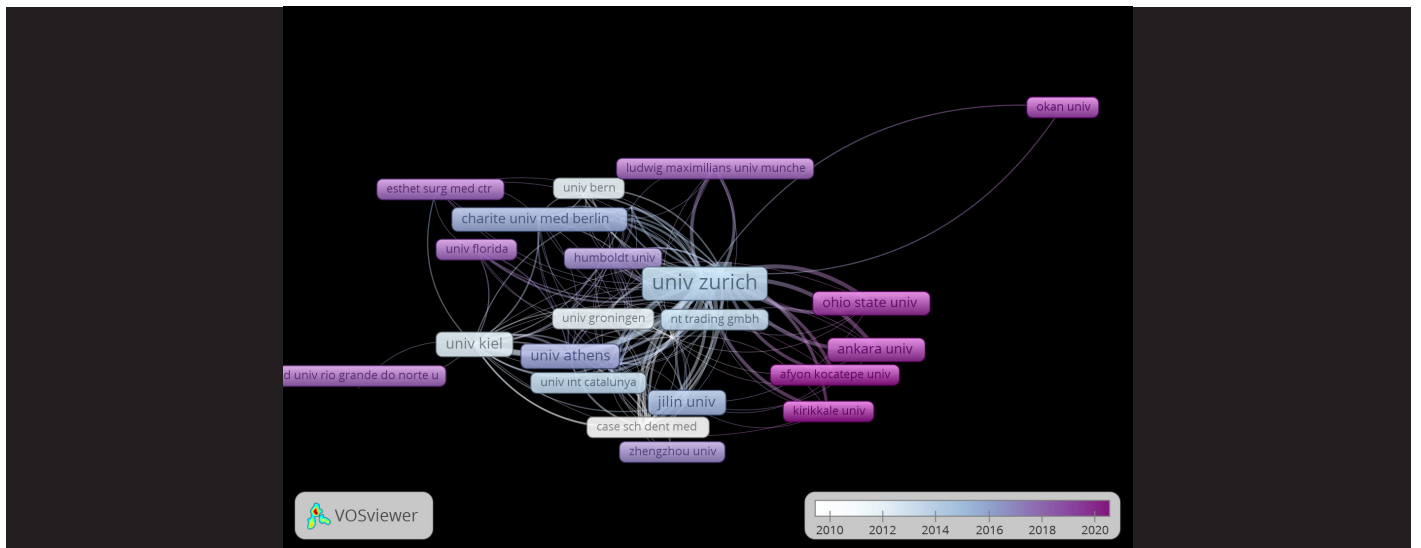


Figure 4. Affiliation of researchers by years and the number of articles they have published

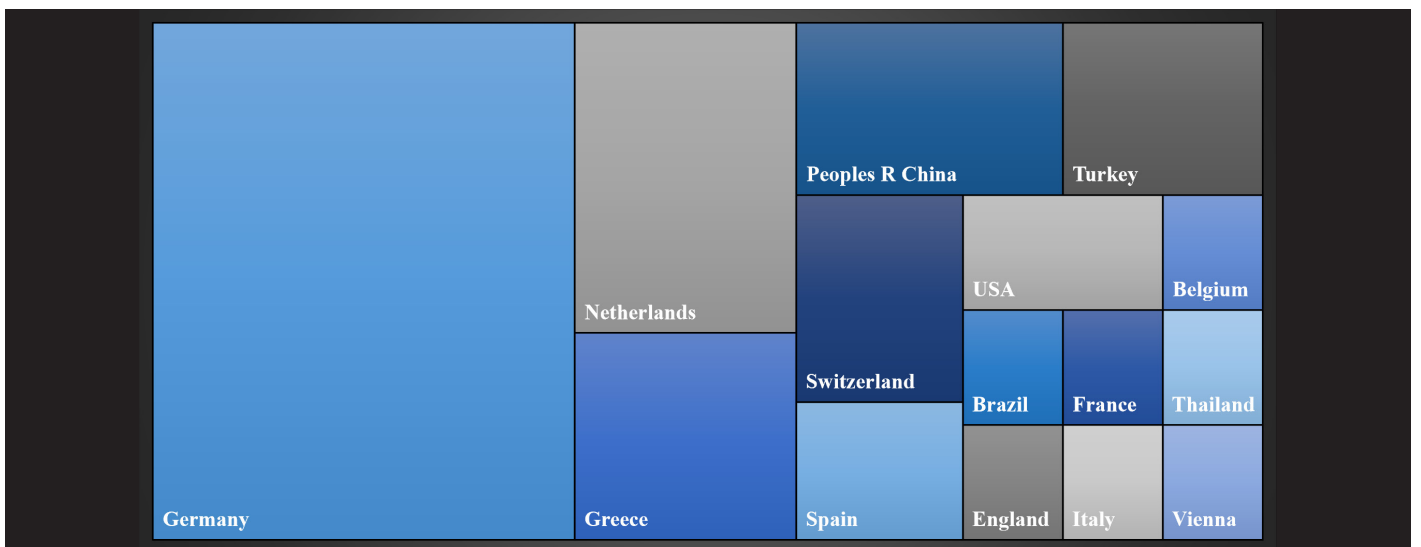


Figure 5. Distribution of published articles by country

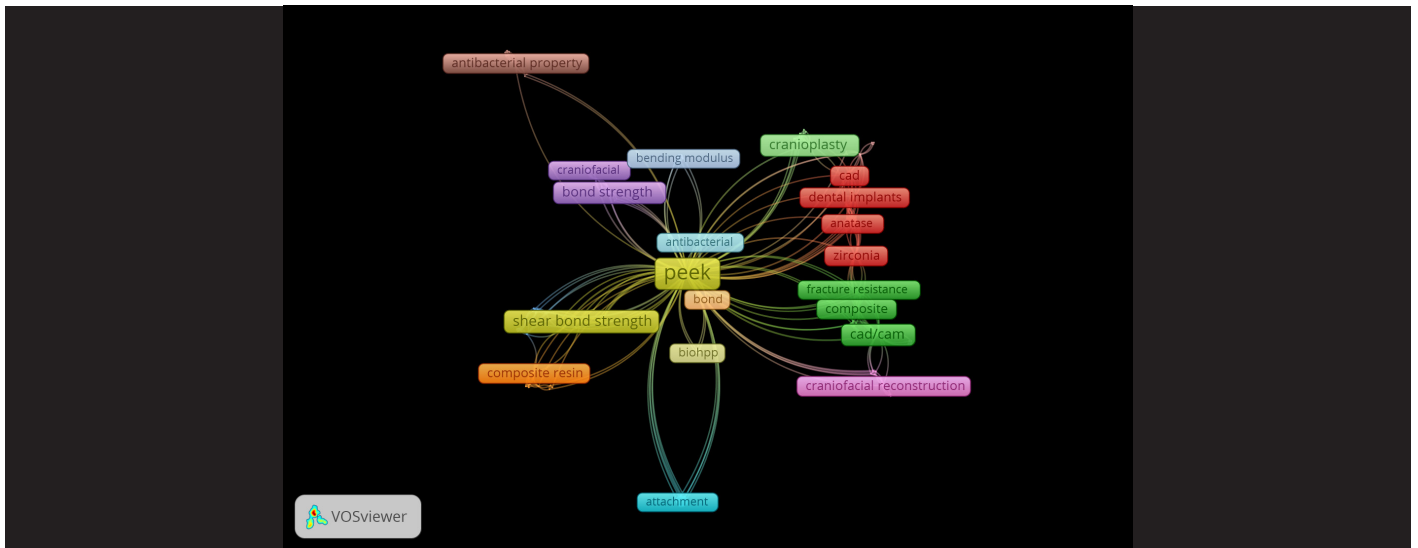


Figure 6. Commonly used keywords in articles

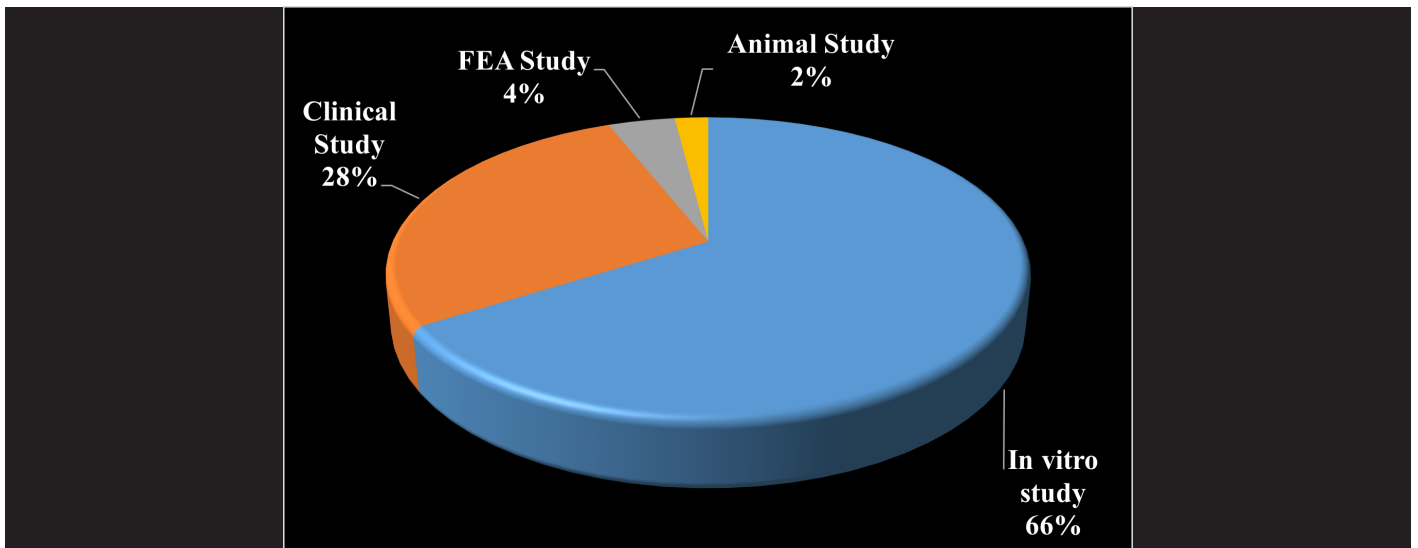


Figure 7. Distribution of published articles by study design type

DISCUSSION

This study aimed to determine and analyze the main features of the top 50 most cited articles published about PEEK. The results from the literature search showed that the number of articles on PEEK and citation count has been increasing from the past to the present. This indicates that research on this subject will become increasingly popular in the coming years.

The present study indicates that Dental Materials and Journals Prosthetic Dentistry are the two journals with the highest contribution. This situation shows that these journals are distinguished with high citation rates for publishing their PEEK research. The researchers care about journal impact factors and the suitability of these journals to the subject while choosing

the appropriate journal for their academic research. Journals with higher impact factor values are given the status of being more critical or carrying more prestige in their respective fields. When similar bibliometric analysis studies in the field of dentistry are examined, especially in material research, journals such as Dental Materials, Journal of Dental Research, Journal of Dentistry, the Journal of Prosthetic Dentistry, Clinical Oral Investigations and Materials come to the fore [3,23–25].

While calculating the number of citations in this study, the Web of Science database was used as a reference, considering the existing literature studies [26,27]. The citation count for many articles is higher in Google Scholar than in WoS, which indicates that there may be changes in the citation count due to differences

in databases due to changes in the journals indexed. Ahmad et al. also reported that citation numbers fluctuate when different databases are queried, and a more specific evaluation may not be possible because Google Scholar also includes conference papers, technical reports, and theses. There is no option to sort search results according to the number of citations in Google Scholar [2].

When we evaluate the countries where the first authors originated in this study, Germany and Switzerland are at the forefront. Looking at similar bibliometric analysis studies, the USA, China, and the UK are among the countries the first authors belong to [2,3,28–30]. Countries with high citation rates are generally more economically stable. Countries with shortfalls in research facilities and socioeconomically less developed countries have contributed relatively little to this research area [3,31].

Previous bibliometric analysis studies showed that the rate of in vitro studies was higher than that of other study designs [28,30,32]. The present research results are similar to their results, and it has been determined that there are proportionally more articles with in vitro study design. This situation can be explained by the ethical problems, complications, and the risk of harming the patient, especially in using new materials in clinical studies. On the other hand, more clinical studies are needed to analyze dental materials better.

Keywords are a significant part of a research paper. While searching the literature, using keywords helps to find more relevant results. They act as “codes” to source the required scientific studies. Therefore, choosing and including keywords that can readily search and identify relevant references is imperative when researching articles. The aim of determining the most frequently used keywords was to lead researchers to search for published articles pertinent to PEEK using search engines [4].

In some articles, the search term was used as “polyetheretherketone” “polyether ether ketone” or “peek”, considering that there might be a difference in spelling and to access more articles. Same way, a recent bibliometric study on regenerative endodontics used the different terms “Revitalization,” “Revascularization,” “Regeneration,” and “Dental pulp” in order not to restrict the study results [28].

Only the Web of Science database was used in the present

bibliometric analysis, which is one of the limitations of this study because no bibliometric database indexes every type of publication, and some articles may have been omitted. There are also bibliometric analysis studies in the literature using other databases such as Scopus, Medline, or PubMed. In this study, Web of Science, a reliable data source, preferred to go on a single basis [28,33,34]. The average self-citation rate in dental journals is nearly 10% [35]. Web of Science does not automatically exclude self-citations, and so this situation may be thought to be another limitation. Other limitations of this study are the inclusion of articles, books, or conference proceedings written in other languages.

CONCLUSION

The results from this present study highlight the increase and distribution of scientific production of PEEK materials from the past to now. This citation analysis gives a perspective on the progress of research in the field of PEEK and allows identification of the most significant and pertinent research areas. The predominance of in vitro studies in this research field reinforces the need for clinical studies, to extrapolate the reported features of PEEK into the clinical setting.

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Ethics Committee: Ethical standards were adhered to in this study. Ethical approval was not required because the study used bibliometric data from the Web of Science (WoS) database. The electronic search was made to identify detailed literature sources using the WoS database on 9 June 2023.

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