



REVIEW ARTICLE

Mapping out the scientific literature on extraction and socket preservation: A Scopus based analysis (1968–2020)

Khalid Almas^a, Shakil Ahmad^b, Shafiq Ur Rehman^c, Shakil Ahmad^d, Faisal Aljofi^e, Allauddin Siddiqi^f

^a Preventive Dental Sciences Department, Division of Periodontics, Imam Abdulrahman Bin Faisal University, College of Dentistry, Dammam, Saudi Arabia

^b Central Library, Prince Sultan University, Riyadh, Saudi Arabia

^c Institute of Information Management, University of the Punjab, Quaid-e-Azam Campus, P.O. Box No. 54590. Lahore, Pakistan

^d Directorate of Library Affairs, Imam Abdulrahman Bin Faisal University, P.O. Box 1982, Dammam 31441, Kingdom of Saudi Arabia

^e Preventive Dental Sciences Department, Division of Periodontics, College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam 31441, Saudi Arabia

^f Specialist Periodontist (Private Practice), Brisbane, Queensland, Australia

Received 13 March 2022; revised 13 September 2022; accepted 21 September 2022

Available online 27 September 2022

KEYWORDS

Dental socket preservation;
Alveolar ridge preservation;
Bibliometric analysis;
Scopus research mapping;
Citation bursts;
Authorship pattern;
Research collaboration;
Research trends

Abstract Purpose: This study aimed to investigate the current state of research on tooth extraction socket preservation. The main aim of this study was to consolidate the research published on extraction socket preservation from 1968 to 2020 in Scopus indexed journals.

Methodology: The bibliometric method, a quantitative analysis investigating publishing trends and patterns, was used. Scopus database was used to retrieve the bibliographic records of published scholarly output. The analysis was performed using software and visualization tools like MS Excel, VOSviewer, Cite Space, Biblioshiny (RStudio), and BibExcel.

Results: The result showed a gradual increase in research, whereby a substantial increase was observed from 2005 to 2006. Six hundred nineteen articles were published in 173 journals with total citations of 12091. Most published articles were from the USA, Italy, Germany, and China. The authorship pattern showed an interdisciplinary and collaborative approach among researchers.

E-mail addresses: kalmas@iau.edu.sa (K. Almas), shakil@psu.edu.sa (S. Ahmad), shafiq.im@pu.edu.pk (S. Ur Rehman), shahmad@iau.edu.sa (S. Ahmad), fealjofi@iau.edu.sa (F. Aljofi)

Peer review under responsibility of King Saud University. Production and hosting by Elsevier.



Conclusion: This bibliometric analysis can guide researchers, funding agencies, industry, and institutions.

© 2022 The Authors. Production and hosting by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Contents

1. Introduction	682
1.1. Research questions	682
2. Materials and methods	683
3. Results	684
3.1. Analysis of the overall growth trend	684
3.2. The most active countries and organizations	684
3.3. Co-occurrence network of authors' keywords	685
3.4. Authorship pattern of extraction and socket preservation researchers	685
3.5. Thematic map of keywords evolution	685
4. Discussion	686
5. Limitations and future research directions	687
6. Conclusion	687
CRediT authorship contribution statement	687
Conflict of interest	687
Acknowledgments	687
Authorship declaration	687
Disclosure statement	687
References	687

1. Introduction

Tooth extraction is one of the most widely performed procedures in dentistry today. It has been historically well documented that this procedure may induce significant dimensional changes in the alveolar ridge. The dilemma clinicians face in managing tooth extractions include providing for the future placement of a dental implant or maximizing ridge dimensions for the fabrication of a fixed or removable prosthesis. If performed inadequately, the resulting deformity can be a considerable obstacle to the esthetic, phonetic, and functional results that both patients and clinicians expect at this current time (Horowitz et al., 2012).

Extraction and socket preservation are generally indicated when a tooth cannot be restored or maintained in acceptable conditions for long-term health, function, and/or esthetics. Tooth loss directly impacts the quality of life by impairing the ability to masticate, speak, and, in some instances, socialize (Gerritsen et al., 2010).

The studies on this topic should be analyzed to evaluate their impact on applied research in clinical implant dentistry. One method for assessing the effects in applied science can be through bibliometric analysis or mapping out the scientific literature. Bibliometrics is a statistical analysis of written publications (Mayr & Scharnhorst, 2015).

Although much attention has been paid to socket or alveolar ridge preservation, few papers have attempted to gather systematic global data and conduct large-scale reviews of scientific studies. Bibliometric analysis has been performed of

various sub-specialties of dentistry, including pediatric dentistry Poletto and Faraco Junior (2010), prosthodontics Thornton et al. (2012), oral and maxillofacial surgery Tahim et al. (2016), implantology Tarazona et al. (2017), orthodontics Prevezanos et al. (2018), endodontics Adnan and Ullah (2018), periodontology Shaikh et al. (2019) and of dental materials (Khan et al., 2020).

However, the authors could not find any bibliographic analysis on extraction, socket, or alveolar ridge preservation (ARP). In this respect, we attempted to use bibliometric methods to quantitatively explore global research trends in extraction and socket preservation research. Therefore, our objectives were to reveal underlying patterns in scientific outputs, characteristics of international collaboration, and author distribution on socket preservation research. The research questions of this study were:

1.1. Research questions

- i. What publishing and citation trends followed in extraction and socket preservation research during 1968–2020?
- ii. To investigate the most productive and highly cited countries, organizations, and authors in extraction and socket preservation research.
- iii. What are the authorship and collaborative research patterns of extraction and socket preservation researchers?
- iv. To investigate the most frequently used keywords and themes in extraction and socket preservation research.

2. Materials and methods

This study applied the bibliometric research analysis and science mapping method to achieve the research objectives. The present study adopted a similar bibliometric mapping approach utilized in recent studies in the field of dental health (Chen et al., 2020; Khan et al., 2020).

A database in a bibliometric study is a foremost important task. Scopus was selected as a data source considering its comprehensive coverage of scientific knowledge. The database claims to be the largest citation and abstract database of scientific literature. It has been widely used in bibliometric studies. A comprehensive four-phased data retrieval and filtration strategy was adopted to retrieve the bibliographic records from the database, as explained in Fig. 1.

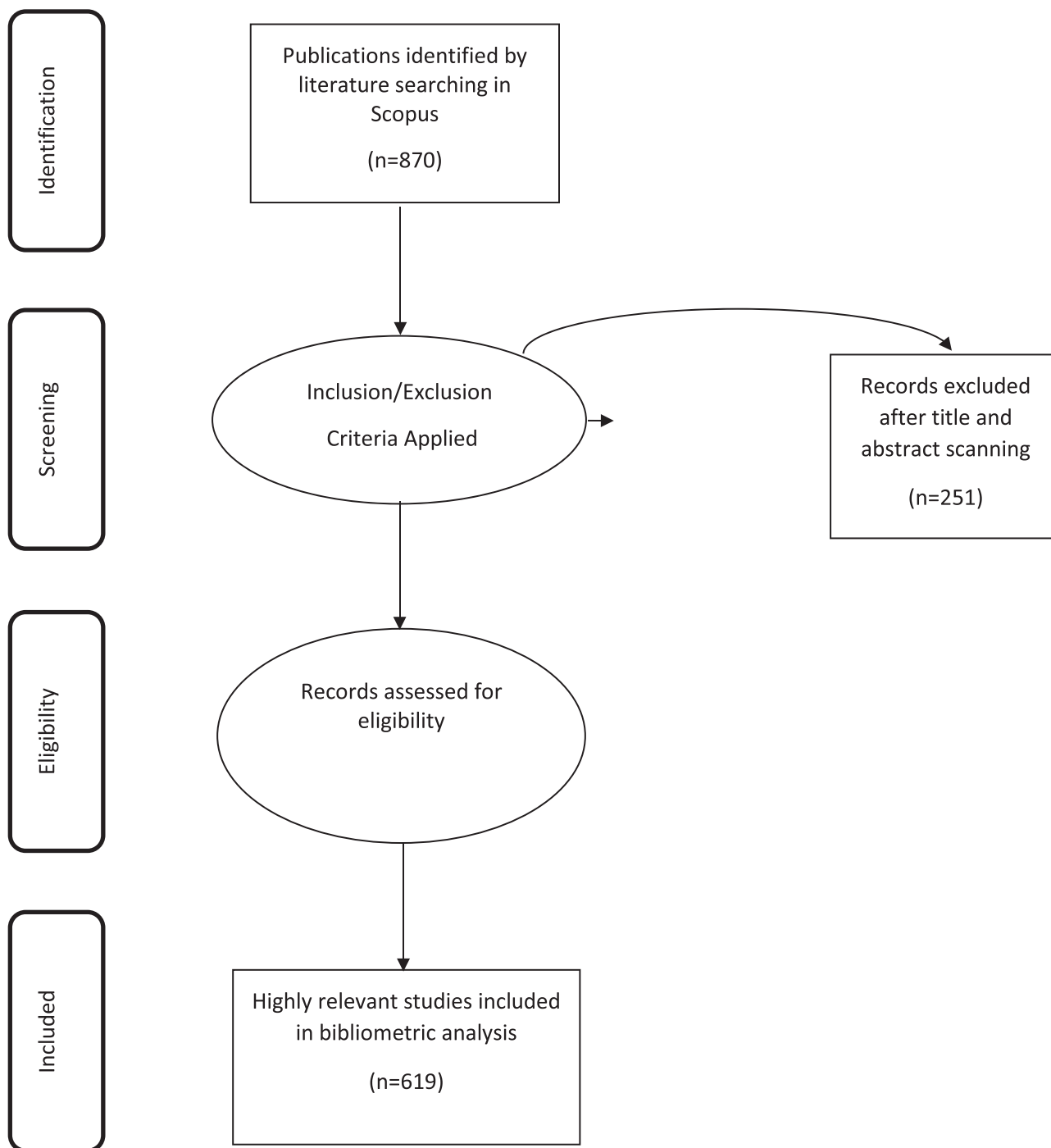


Fig. 1 Four-phase flow diagram of data extraction and filtration process of dental socket publications.

Data of selected papers were exported in plain text format for analysis and processing in visualization tools. The software and data visualization tools used were MS Excel, VOSviewer Van Eck and Waltman (2010), Cite Space Chen (2010), Biblioshiny (RStudio) Aria and Cuccurullo (2017), and BibExcel (Persson et al., 2009).

3. Results

3.1. Analysis of the overall growth trend

Fig. 2 shows that the first publication on the topic appeared in 1968. Publications and citations of the 20th century are grouped into three different periods covering the last 32 years of the 20th century. The highest number of publications (n = 29) and citations (n = 1766) were produced during the previous century in the last ten years, from 1991 to 2000. A consistent increase was observed in publications and citations on dental socket prevention except for a slight descending vari-

ation during 2005 and 2006. The year 2019 witnessed the highest number of publications (n = 70), while the highest number of citations were received in 2012. A downward trend of citations was observed during the last few years of the study period, which may be attributed to these publications' citation life cycle.

3.2. The most active countries and organizations

The United States of America was the most active country among the top ten prolific countries producing dental socket research, as depicted in Table 1. Italy follows the United States with 97 publications and 2264 citations. The lowest producer in the top 10 influential countries, Spain, had the highest citation impact of 39.13 on its publications. Peking University School and Hospital of Stomatology was the most active institution with 23 dental socket publications, followed by the University of Michigan and the University of Zurich with 20 publications each.

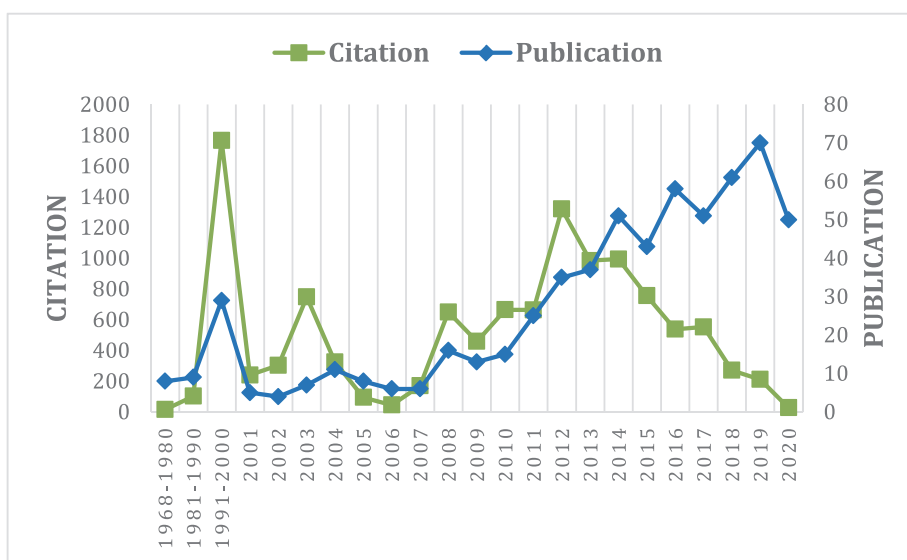


Fig. 2 Evolution of dental socket publications and citations over the study period.

Table 1 Top ten influential countries and organizations producing dental socket research.

Highly Productive Country				Highly Productive Organization			
Country	TP	TC	Citation Impact	Country	TP	TC	Citation Impact
United States	201	5038	25.06	Peking University School and Hospital of Stomatology	23	26	1.13
Italy	97	2264	23.34	University of Michigan	20	335	16.75
Germany	60	802	13.37	University of Zurich	20	487	24.35
China	39	216	5.54	Harvard School of Dental Medicine	19	393	20.68
Brazil	34	678	19.94	New York University College of Dentistry	19	318	16.74
Switzerland	33	944	28.61	University of Pisa	18	404	22.44
South Korea	31	233	7.52	University of Louisville	16	544	34.00
India	30	198	6.60	Tel Aviv University	13	620	47.69
Israel	25	769	30.76	University of Sao Paulo	13	507	39.00
Spain	23	900	39.13	University of Minnesota	13	204	15.69

3.3. Co-occurrence network of authors' keywords

Keywords provided by authors in their dental socket research reflected the contents and viewpoints of their research. The co-occurrence network of these authors.

Keywords with a minimum of 10 occurrences was analyzed. The spheres or circles with bigger sizes represent the most commonly used keywords based on link strengths and occurrences. The strength of the link between the nodes indicates the number of research publications having the displayed keywords. These keywords form four different clusters represented by different colors in Fig. 3.

3.4. Authorship pattern of extraction and socket preservation researchers

The scientific literature regarding the dental socket is predominantly collaborative, as only 10% ($n = 65$) of publications

were prepared with single authorship. Six authors' collaboration is the most common authorship trend, followed by studies designed with five authors as depicted in Fig. 4. Data indicated that collaborative studies attracted better attention from fellow researchers and were more often cited. On average, studies with single authorship received about 13 citations per publication, while co-authored publications received 22 citations per publication.

3.5. Thematic map of keywords evolution

Fig. 5 depicts the thematic evolution of keywords developed across time in separate periods from 1968 to 2019. The results indicate that the research focus on dental socket preservation has evolved over the years. Grafts, extraction socket, and alveolar ridge augmentation were the popular keywords in the research published during the 20th century. The keywords used

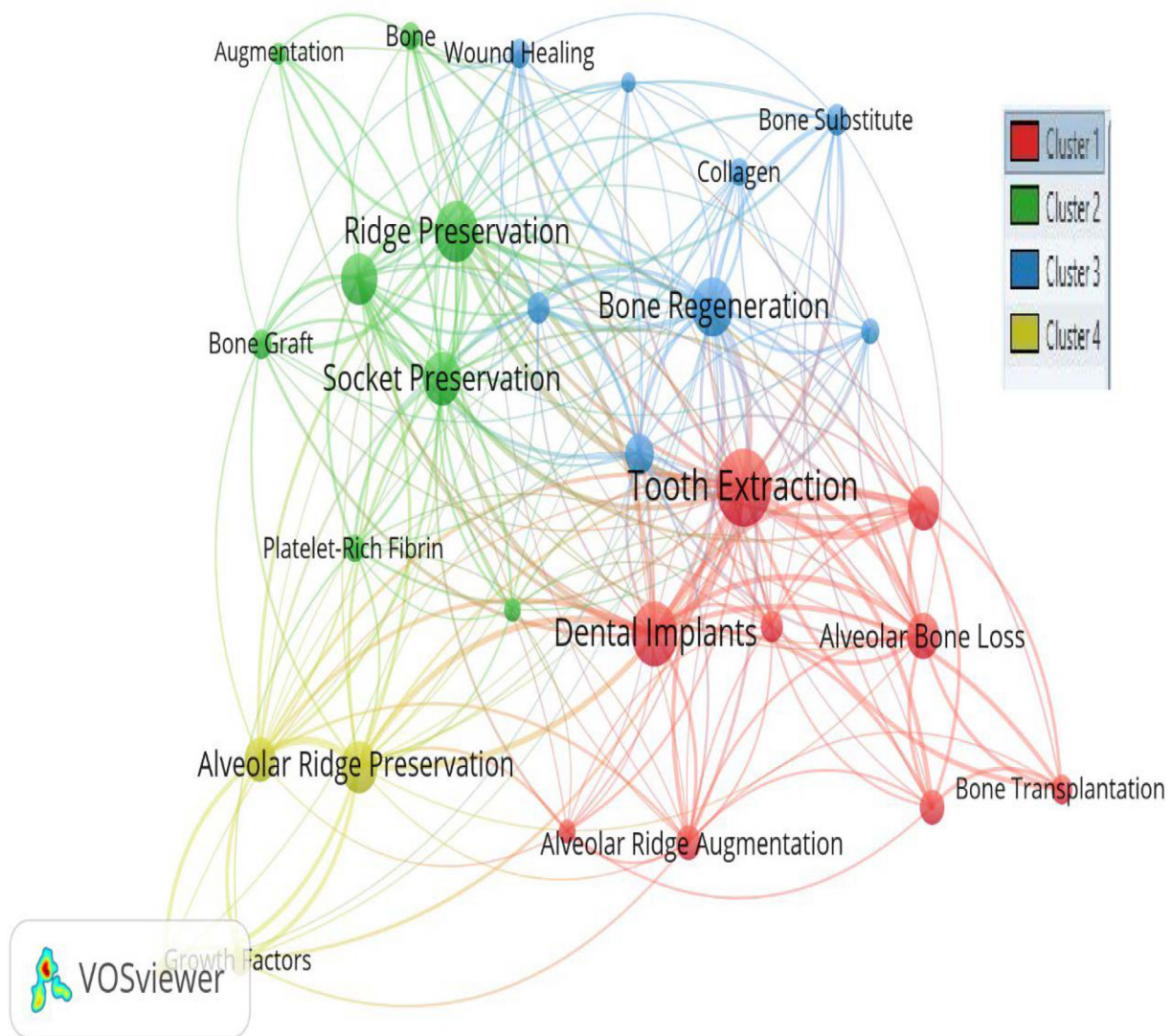


Fig. 3 Co-occurrence network of author keywords (minimum number of occurrences: 10).

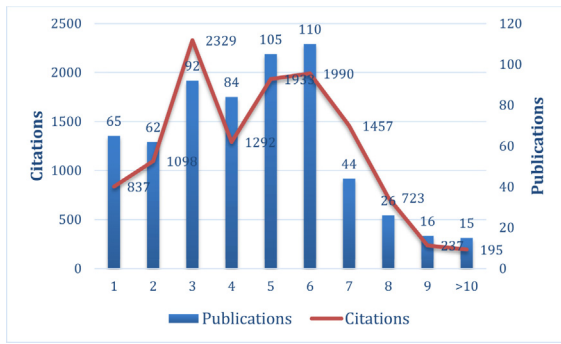


Fig. 4 Authorship pattern of dental socket preservation researchers.

from 1968 to 2000 were less prevalent in the research produced in the subsequent years. Bone regeneration, tooth extraction, socket preservation, and dental implants were frequently used from 2001 to 2010.

4. Discussion

The United States of America was the most active country producing extraction and socket preservation research. The country produced the highest number of research publications and attracted the highest number of citations. This could be attributed to the abundance of active research groups and the availability of research funds. Italy follows the United States in the number of publications and citations.

The scientific literature in extraction and socket preservation is predominantly collaborative. Six author collaboration is the most common authorship trend, followed by studies designed with five authors. About one-third of extraction and socket preservation publications have this pattern of 5 or 6 authors. On average, a study with single authorship received 13 citations per publication, while co-authored publications received 22 citations per article.

The findings in this study showed that the keywords determined the trend of publications in this area. Grafts, extraction socket, and alveolar ridge augmentation were the popular keywords in the research published during the 20th century. The

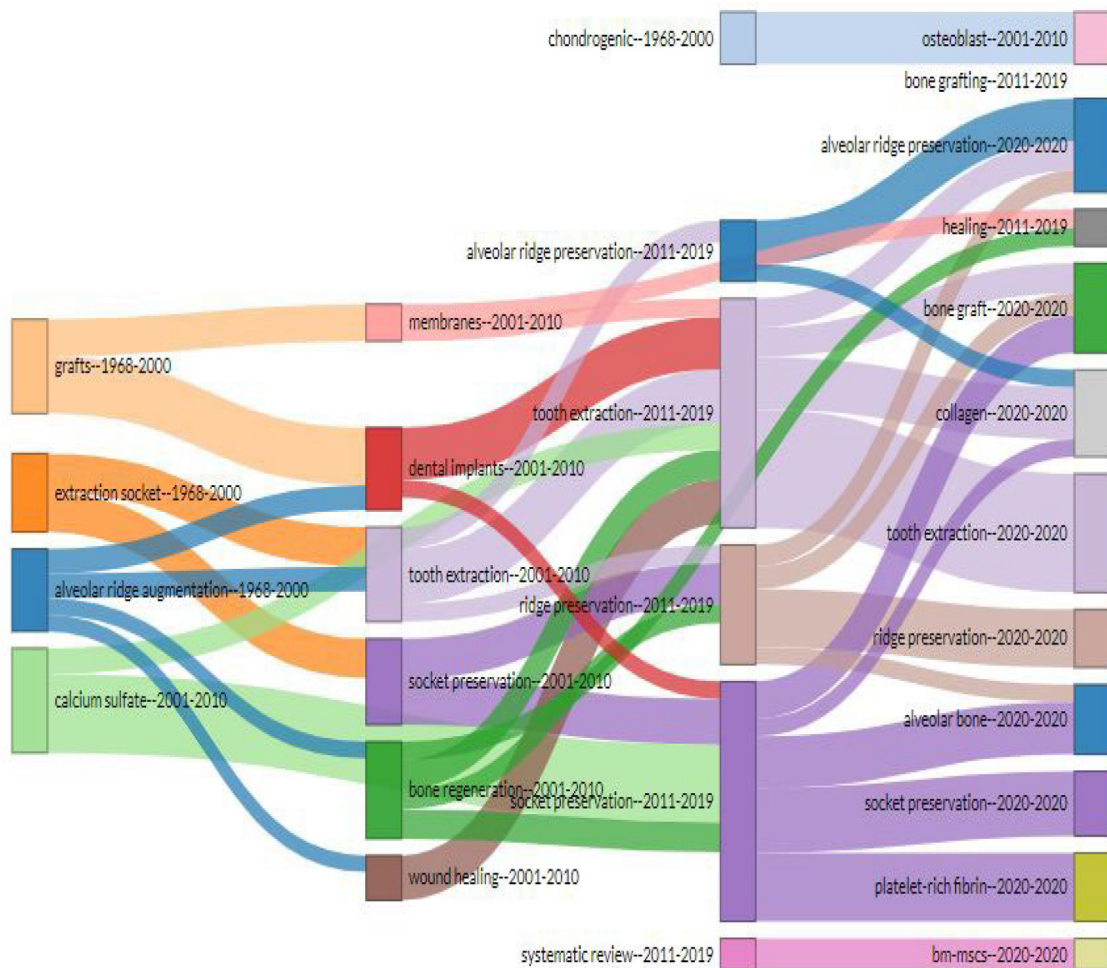


Fig. 5 Thematic evolution of keywords.

data indicate a thematic gap in dental socket research as no keyword was repeated in all the periods.

The present structural analysis emphasizes that high-quality work in learning the biology of alveolar socket healing and the ridge resorption's physiological mechanisms mark the basis for developing novel techniques and materials in alveolar ridge preservation. This progress has been brought about by the collaborative efforts of research groups from the USA and Europe. These groups chose to publish their work in critical periodontal and implant journals.

5. Limitations and future research directions

The year 2020 does not represent the complete year as the data was retrieved up to October 15, 2020. Although Scopus claims to be the largest abstract and citation database of scientific literature, the data not covered in Scopus due to its coverage and indexing policies may have been missed. Other indexing and citation databases like Web of Science, PubMed, and Google Scholar are not covered. Future research should map the literature on the surgical technique and the socket grafting materials to facilitate institutions in this domain.

6. Conclusion

The overall purpose of this study was to provide a comprehensive bibliographic review of the research published on extraction socket preservation. The research on alveolar ridge preservation/socket preservation (ARP/SP) has significantly developed over time. The analysis enables the reader to visualize the addressed topic concerning many different aspects by identifying the source of evidence. This knowledge will play an essential role in decision-making when dealing with extraction sockets that are potential sites for future dental implants.

Only 10% of the publications were with single authorship, and six authors' collaboration was the most common authorship trend. The USA was the top collaborating country with Italy, Germany, and China. The Journal of periodontology published the highest number of highly cited papers. Bone regeneration, tooth extraction, socket preservation, and dental implants were common during the second period (2001–2010), and socket preservation & tooth extraction were relevant during the third period (2011–2019). Among the field-related keywords, osteolysis followed by oral surgery had a burst strength of 22.66 and 20.62, respectively.

It is envisaged that this quantitative bibliometric study will provide direction for researchers for future research about gaps in predictable healing, ridge preservation, and favorable outcomes of extraction socket preservation.

CRediT authorship contribution statement

Khalid Almas: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing. **Shakil Ahmad:** Data curation, Funding acquisition, Project administration, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing. **Shafiq Ur Rehman:** Conceptualization, Formal analysis, Funding acquisition, Methodology,

Resources, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing. **Shakil Ahmad:** Funding acquisition, Investigation, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - review & editing. **Faisal Aljofi:** Data curation, Formal analysis, Investigation, Validation, Writing - original draft, Writing - review & editing. **Allauddin Siddiqi:** Data curation, Formal analysis, Investigation, Validation, Writing - original draft, Writing - review & editing.

Conflict of interest

There is no conflict of interest in this manuscript.

Acknowledgments

The authors would like to acknowledge Prince Sultan University's support for paying the Article Processing Charges (APC) of this publication.

Authorship declaration

All authors have contributed significantly, and all authors are in agreement with the present manuscript.

Disclosure statement

The authors declare no potential conflicts of interest with respect to the authorship and/or publication of this article.

References

- Adnan, S., Ullah, R., 2018. Top-cited Articles in Regenerative Endodontics: A Bibliometric Analysis. *J. Endod.* 44 (11), 1650–1664. <https://doi.org/10.1016/j.joen.2018.07.015>.
- Aria, M., Cuccurullo, C., 2017. bibliometrix: An R-tool for comprehensive science mapping analysis. *J. Informetr.* 11 (4), 959–975.
- Chen, C. (2010). CiteSpace: Visualizing patterns and trends in scientific literature. Retrieved January, 27, 2010.
- Chen, Y., Yeung, A.W., Pow, E.H., Tsoi, J.K., 2020. Current status and research trends of lithium disilicate in dentistry: A bibliometric analysis. *J. Prosthetic Dent.*
- Gerritsen, A.E., Allen, P.F., Witter, D.J., Bronkhorst, E.M., Creugers, N.H., 2010. Tooth loss and oral health-related quality of life: a systematic review and meta-analysis. *Health Qual Life Outcomes* 8 (1), 126. <https://doi.org/10.1186/1477-7525-8-126>.
- Horowitz, R., Holtzclaw, D., Rosen, P.S., 2012. A review on alveolar ridge preservation following tooth extraction. *J. Evid. Based Dent. Pract.* 12 (3 Suppl), 149–160. [https://doi.org/10.1016/S1532-3382\(12\)70029-5](https://doi.org/10.1016/S1532-3382(12)70029-5).
- Khan, A.S., Ur Rehman, S., AlMaimouni, Y.K., Ahmad, S., Khan, M., Ashiq, M., 2020. Bibliometric Analysis of Literature Published on Antibacterial Dental Adhesive from 1996–2020. *Polymers (Basel)* 12 (12), 1–29. <https://doi.org/10.3390/polym12122848>.
- Mayr, P., Scharnhorst, A., 2015. Scientometrics and information retrieval: weak-links revitalized. *Scientometrics* 102 (3), 2193–2199. <https://doi.org/10.1007/s11192-014-1484-3>.
- Persson, O., Danell, R., Schneider, J.W., 2009. How to use Bibexcel for various types of bibliometric analysis. Celebrating scholarly communication studies: A Festschrift for Olle Persson at his 60th Birthday, 5, 9–24.

- Poletto, V.C., Faraco Junior, I.M., 2010. Bibliometric study of articles published in a Brazilian journal of pediatric dentistry. *Braz. Oral Res.* 24 (1), 83–88. <https://doi.org/10.1590/s1806-8324201000100014>.
- Prevezanos, P., Tsolakis, A.I., Christou, P., 2018. Highly cited orthodontic articles from 2000 to 2015. *Am. J. Orthod. Dentofacial Orthop.* 153 (1), 61–69. <https://doi.org/10.1016/j.ajodo.2017.06.015>.
- Shaikh, M.S., Ullah, R., Lone, M.A., Matabdin, H., Khan, F., Zafar, M.S., 2019. Periodontal regeneration: a bibliometric analysis of the most influential studies. *Regen. Med.* 14 (12), 1121–1136. <https://doi.org/10.2217/rme-2019-0019>.
- Tahim, A., Bansal, H., Goodson, A.M., Payne, K.F., Sabharwal, S., 2016. Open Access Publishing: A Study of Current Practice in Oral and Maxillofacial Surgery Research. *J. Maxillofac. Oral Surg.* 15 (4), 517–520. <https://doi.org/10.1007/s12663-016-0898-2>.
- Tarazona, B., Vidal-Infer, A., Alonso-Arroyo, A., 2017. Bibliometric analysis of the scientific production in implantology (2009–2013). *Clin. Oral Implants Res.* 28 (7), 864–870. <https://doi.org/10.1111/clr.12891>.
- Thornton, K., Lee, D.J., Yuan, J.C., Knoernschild, K.L., Campbell, S. D., Sukotjo, C., 2012. An analysis of prosthodontic research productivity: geographic, economic, and collaborative perspective. *J. Prosthodont.* 21 (1), 73–78. <https://doi.org/10.1111/j.1532-849X.2011.00776.x>.
- Van Eck, N., Waltman, L., 2010. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* 84 (2), 523–538.