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"EXPLORING PUBLICATION TRENDS IN RIDGE AUGMENTATION: A BIBLIOMETRIC ANALYSIS"

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Ridge augmentation, a vital procedure in dental implantology, allows implant placement for patients with insufficient jaw bone volume. This study explored recent trends in ridge augmentation research using a bibliometric analysis of publications from 2010 to 2024, retrieved and analyzed from the PubMed database. Bibliometrics, a field employing statistical methods to analyze scholarly publications, provided insights into the current research landscape. We examined publication trends, authorship patterns, and prominent research topics. The analysis revealed a steady increase in publications, with a significant rise in recent years. Clinical Oral Implants Research and The International Journal of Periodontics & Restorative Dentistry emerged as leading publication sources. Wang HL was the most productive author, followed by Felice P, Esposito M, and Jung RE. The University of Zurich ranked first among institutions, followed by the University of Michigan and Cairo University. Dental implants were a central research topic, with growing interest in alveolar ridge augmentation techniques. This analysis provided valuable insights into current trends, including a focus on randomized controlled trials and international collaboration. Further investigation is needed to understand the decline in publications observed in 2024. By identifying leading sources, institutions, and popular topics, this study informs researchers, clinicians, and policymakers about the current state of ridge augmentation research and guides future research efforts in this crucial field

Keywords: Alveolar Ridge Augmentation, Bone-Grafting, Clinical Implant Dentistry, Dental Implantology, Osseointegration,

Introduction:

Ridge augmentation is a critical procedure in dental implantology, to combat the challenge posed by inadequate jaw bone volume and facilitate the successful placement of dental implants. The process of alveolar bone resorption after tooth loss often culminates in the formation of alveolar ridge defects, impeding the replacement of missing teeth in an optimal 3D prosthetically planned position. [1-4]

This cascade of tooth loss and bone resorption not only undermines functional integrity but also compromises aesthetic outcomes, leading to a spectrum of prosthetic complications. Consequently, ridge augmentation emerges as an indispensable therapeutic strategy to augment deficient bone volume, thereby creating a conducive environment for implant placement and subsequent prosthetic rehabilitation with the long-term success of the implant.[5-6] In recent years, the field of ridge augmentation has beheld notable advancements driven by ongoing research in refining techniques, optimizing outcomes, and expanding the purview of applicability.[7]

However, navigating the expansive landscape of ridge augmentation research necessitates a systematic approach to assimilate and evaluate the burgeoning body of scholarly literature.

By leveraging statistical methodologies, bibliometrics offers a comprehensive understanding of the evolving aspects of ridge augmentation research, shedding light on seminal contributions, identifying emerging trends, and pinpointing areas ripe for further investigation.[8-9] In this context, a bibliometric analysis represents a valuable tool for synthesizing and interpreting the valuable information embedded within scholarly publications, thereby facilitating informed decision-making and fostering advancements in clinical practice and research.[9]

This study aims to undertake a rigorous bibliometric analysis of recent developments in ridge augmentation research, providing insights into the current state and future directions of this pivotal field within dental implantology.

Methodology

This study employed a bibliometric approach to analyse trends in ridge augmentation research published between 2010 and 2024.

Data Source:

- PubMed: We utilized PubMed; a comprehensive bibliographic database maintained by the National Institutes of Health (NIH) in the United States. PubMed provides access to millions of peer-reviewed articles in biomedicine and life sciences, allowing for advanced search functionalities.

Search Strategy:

Main MeSH Term:

- Alveolar Ridge Augmentation [Mesh] (This is the most specific MeSH term for ridge augmentation) AND Additional Relevant MeSH Terms (to broaden the search): Bone Grafts, Maxillary Sinus Lift, Mandibular Reconstruction, Dental Implants
- Use Boolean operators (AND, OR, NOT) to refine your search and combine MeSH terms and keywords effectively.
- "(Alveolar Ridge Augmentation [Mesh]) AND (Bone Grafts [Mesh])" will retrieve publications that focus specifically on ridge augmentation using bone grafts.
- "(Alveolar Ridge Augmentation [Mesh]) OR Dental Implants [Mesh]" will broaden the search to publications on both ridge augmentation and dental implants. The language was restricted to English and document types were restricted to original or research articles and review articles (Figure 1 - flow diagram of research methodological design).

Data Analysis:

- The retrieved publications from PubMed were downloaded and imported into R software, a free and open-source programming language for statistical computing and graphics.

- Bibliometric packages within R, such as "bibliometrix" or "VOSviewer," were used to analyze the data. These packages offer functionalities for extracting and analyzing various aspects of the publications, including (1) Publication Dates**:** This allowed us to assess publication trends over the fourteen years (2010-2024). (2) Sources (Journals): We identified the journals publishing the highest number of articles on ridge augmentation, providing insights into core publication venues in this field. (3) Authors: Collaboration patterns were analyzed by calculating the average number of co-authors per document and identifying the prevalence of international collaborations. (4) Affiliations: The institutional affiliations of the authors were examined to determine the leading contributors to ridge augmentation research globally. (5) Document Types: The distribution of document types (e.g., research articles, case reports) within the retrieved publications was assessed. (6) Keywords and MeSH Terms: Keyword analysis using word clouds or other techniques helped identify frequently used terms and research topics within the field.

Visualization and Interpretation:
We employ bibliometric visualization methods such as co-authorship networks, maps of keyword co-occurrence, and citation networks to uncover and visually represent connections and trends within the dataset.

Interpret the outcomes: We employ a comprehensive analysis of the bibliometric data to illuminate key trends shaping the research landscape in alignment with our established research objectives. This analysis prioritizes the identification of influential authors, prominent subject areas, and potential knowledge gaps that necessitate further investigation.

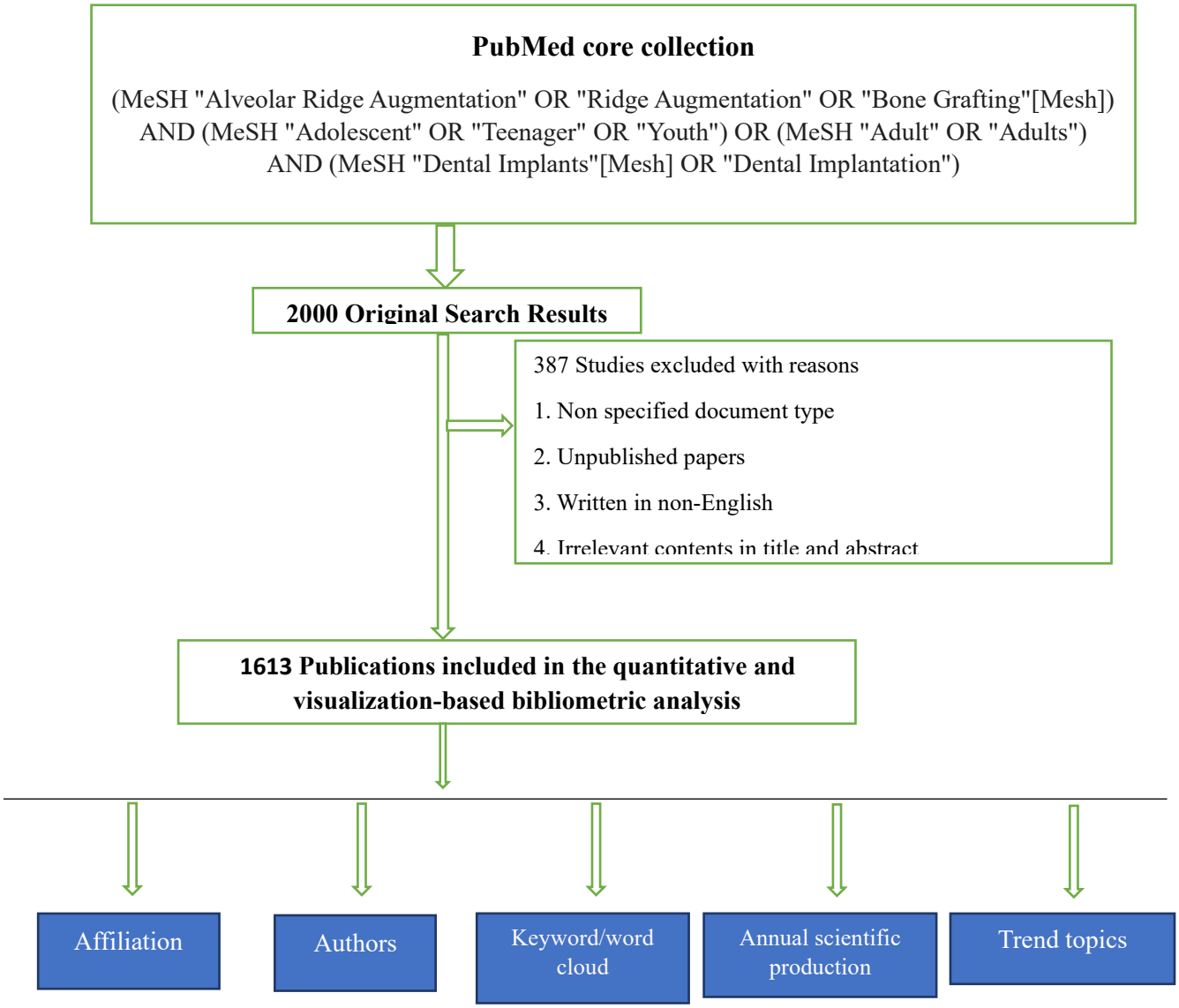

Figure 1: The methodology for this research is illustrated in a flowchart format.

Result- Figure 2 and Table 1 include Timespan, Authors, Author's Keywords (DE), References, Document Average Age, and Average citations per doc.

Figure 2- Main information about data

Source- Retrieved by R- software, based on data provided by PubMed

Table 1- "Key data overview"

MAIN INFORMATION ABOUT DATA	
Timespan	2010:2024
Sources (Journals, Books, etc)	245
Documents	1613
Annual Growth Rate %	-6.16
Document Average Age	6.94
Average citations per doc	0
References	0
DOCUMENT CONTENTS	
Keywords Plus (ID)	2074
Author's Keywords (DE)	2074
AUTHORS	
Authors	4993
Authors of single-authored docs	79
AUTHORS COLLABORATION	
Single-authored docs	98
Co-Authors per Doc	4.63
International co-authorships %	16.06
DOCUMENT TYPES	
case reports	157
case reports; clinical trial; journal article; multicenter study; research support, non-U.S. gov't	1
case reports; comparative study; journal article	3
case reports; comparative study; journal article; research support, non-U.S. gov't	1
case reports; comparative study; journal article; review	1
case reports; English abstract; journal article	8
case reports; evaluation study; journal article	1
case reports; interview; journal article	1
case reports; journal article	386
case reports; journal article; research support, non-U.S. gov't	21
case reports; journal article; research support, non-U.S. gov't; review	1
case reports; journal article; review	19
case reports; journal article; systematic review	1
case reports; research support, non-U.S. gov't	2
clinical study; comparative study; journal article	1
clinical study; journal article	9
clinical study; journal article; research support, non-U.S. gov't	1
clinical trial protocol; journal article	1
clinical trial, phase II; journal article; multicenter study; randomized controlled trial; research support, non U.S. gov't	1
clinical trial, phase II; journal article; randomized controlled trial	1
clinical trial; comparative study; journal article	5
clinical trial; comparative study; journal article; multicenter study	3
clinical trial; comparative study; journal article; randomized controlled trial	1
clinical trial; comparative study; journal article; research support, non-U.S. gov't	3
clinical trial; English abstract; journal article; research support, non-U.S. gov't	1
clinical trial; journal article	32
clinical trial; journal article; multicenter study	4
clinical trial; journal article; multicenter study; research support, non-U.S. gov't	1
clinical trial; journal article; randomized controlled trial	1
clinical trial; journal article; randomized controlled trial; research support, non-U.S. gov't	1
clinical trial; journal article; research support, non-U.S. gov't	11

The Timespan column shows the range of years the article covers (2010-2024). The Authors column includes the number of single-authored authors (4993), the number of international co-authors (16.6), and the co-authors per document (4.63).

The Author's Keywords (DE) column likely refers to the keywords used by the author(s) in German (DE). There are 2074 listed here. The References column shows the number of references included in the article (0). The Document Average Age shows the average age of the documents used in the article (6.94 years). Finally, the Average citations per doc column shows the average number of times the documents used in the article have been cited by other scholarly works (0).

Figure 3- Graph 1 shows the annual scientific production, measured by the number of articles published each year from 2010 to 2024.

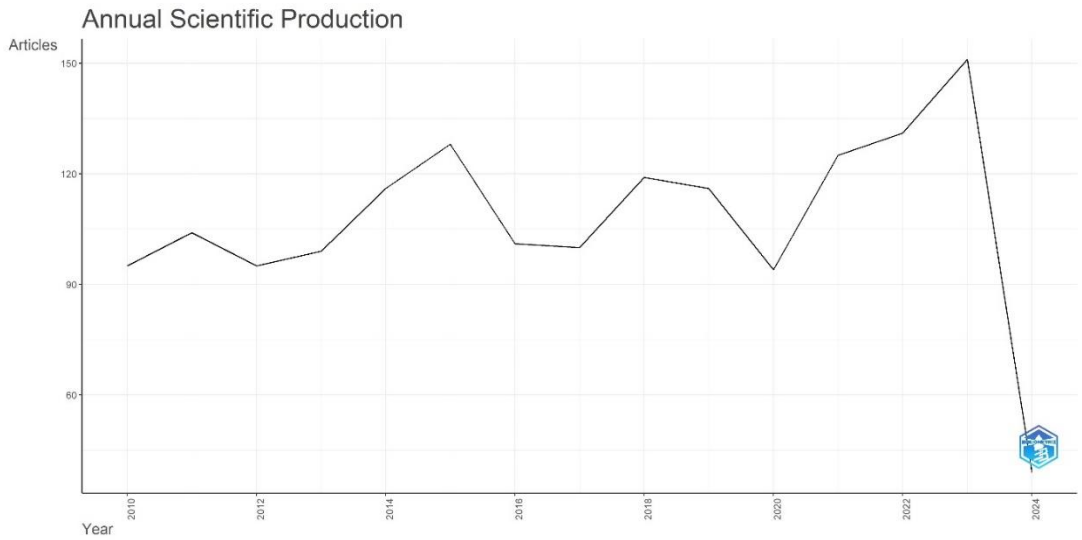

Figure 3 shows (graph 1) – annual scientific production

Source- Retrieved by R- software, based on data provided by PubMed

Publication trends depicted in the graph reveal a steady increase in research activity over time. The number of publications exhibits a notable rise from 95 in 2010 to a peak of 151 articles in 2023. This trajectory suggests an expanding interest and development within this field of research. While yearly fluctuations are evident, as demonstrated by the decrease from 128 articles in 2015 to 101 in 2016 followed by a period of relative stability, the overall trend remains upward. Particularly noteworthy is the significant surge observed in recent years, with the number of publications rising from 94 in 2020 to 151 in 2023. This marked increase potentially reflects heightened research efforts, increased funding availability, or a growing appreciation for the research topic's significance. It is important to acknowledge that the sharp decline to 39 articles in 2024 can likely be attributed to the fact that data for the current year is incomplete, and all publications for 2024 may not yet be captured.

Figure 4 demonstrates the distribution of publications on alveolar ridge augmentation. This analysis reveals a varied landscape of contributing sources

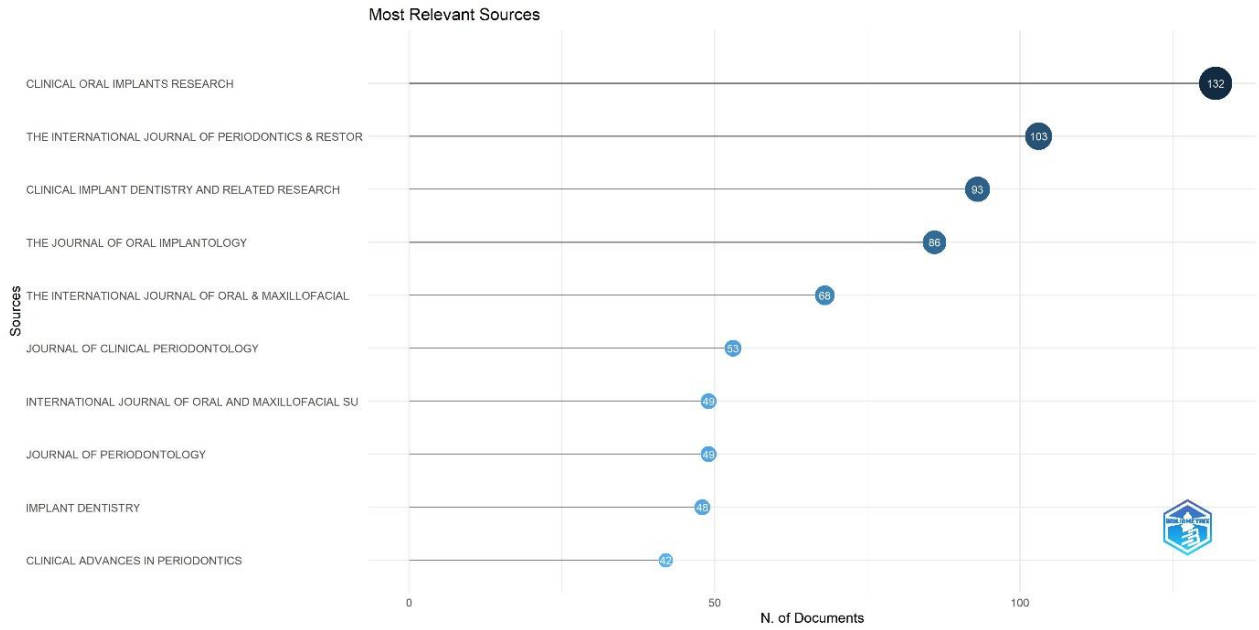

Figure 4- (graph 2) shows the most relevant sources
Source- Retrieved by R- software, based on data provided by PubMed

Table 2 - most relevant sources

Sources (Journal names)	ARTICLE
Clinical Oral Implants Research	132
The International Journal of Periodontics & Restorative Dentistry	103
Clinical Implant Dentistry and Related Research	93
The Journal of Oral Implantology	86
The International Journal of Oral & Maxillofacial Implants	68
Journal of Clinical Periodontology	53
International Journal of Oral and Maxillofacial Surgery	49
Journal of Periodontology	49
Implant Dentistry	48
Clinical Advances in Periodontics	42

Considering the data presented in Figure 4(graph 2) and Table 2, we observe a varied landscape of journals publishing research on ridge augmentation. Clinical Oral Implants Research stands out as the top source, contributing a significant 132 publications within the studied timeframe. This high volume suggests its importance as a leading platform for disseminating research in this field. The focus on highly cited articles or a substantial capacity for publishing ridge augmentation research could be contributing factors. The International Journal of Periodontics & Restorative Dentistry follows closely with 103 publications, further underlining its relevance to the subject matter. Titles like Clinical Implant Dentistry and Related Research (93) and The Journal of Oral Implantology (86) demonstrate a clear specialization in the clinical aspects of ridge augmentation. Conversely, journals such as the International Journal of Oral & Maxillofacial Implants (68) and International Journal of Oral and Maxillofacial Surgery (49) appear to emphasize the surgical facets of these procedures. Publication counts for journals like Journal of Clinical Periodontology (53), Journal of Periodontology (49), Implant Dentistry (48), and Clinical Advances in Periodontology (42) are comparatively lower. This might indicate a more focused research area or niche within ridge augmentation, or potentially lower publication or citation rates compared to the leading journals.

Figure 5 presents a core source distribution based on Bradford's Law, revealing the most productive sources for publications on ridge augmentation.

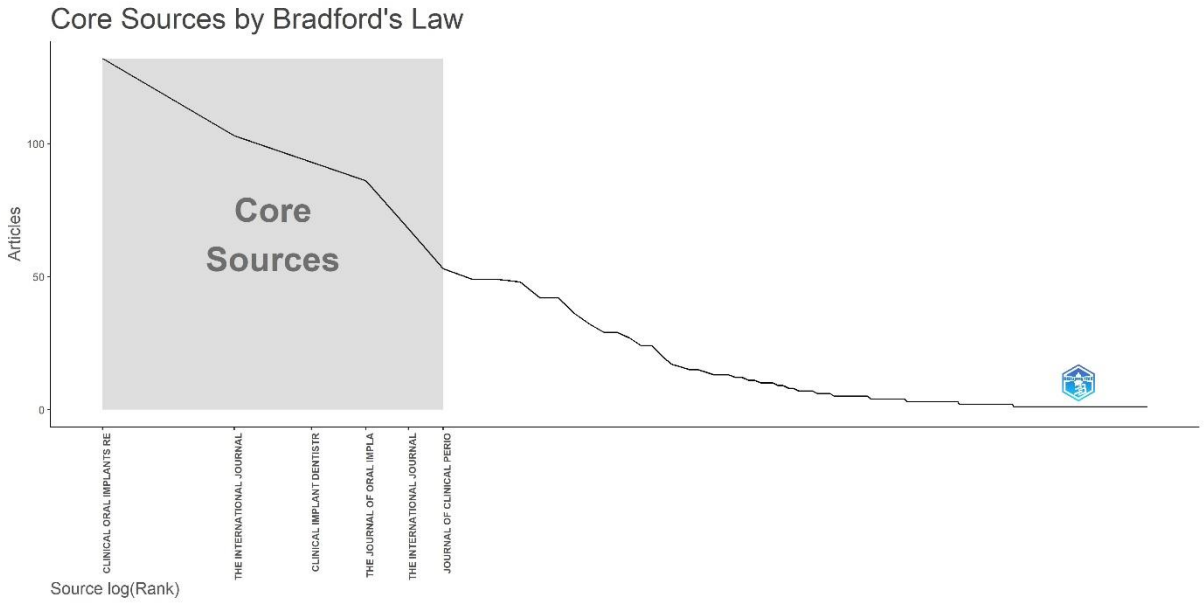

Figure 5 shows (graph 3) sources by Bradford's law
Source- Retrieved by R- software, based on data provided by PubMed

Table 3 Sources by Bradford's law

Sources	RANK	FREQUENCY	CumFrequency	ZONE
Clinical oral implants research	1	132	132	Zone1
The International Journal of Periodontics & Restorative Dentistry	2	103	235	Zone1
Clinical implant dentistry and related research	3	93	328	Zone1
The Journal of Oral Implantology	4	86	414	Zone1
The International Journal of Oral & Maxillofacial Implants	5	68	482	Zone1
Journal of Clinical Periodontology	6	53	535	Zone1
International journal of oral and maxillofacial surgery	7	49	584	Zone2
Journal of Periodontology	8	49	633	Zone2
Implant Dentistry	9	48	681	Zone2
Clinical advances in Periodontics	10	42	723	Zone2

Graph 3 and Table 3 -Bradford's Law to rank and categorize key dental research journals based on their publication frequency or citation count. It classifies them into two zones, indicating their relative importance and influence within the field. Zone 1 includes top-ranked journals like "Clinical Oral Implants Research" and five others, which are the most frequently cited and contribute significantly to the field, with a cumulative frequency of up to 535. Zone 2 consists of journals ranked 7 to 10, like "International Journal of Oral and Maxillofacial Surgery," which are less frequently cited, but still important, contributing to a cumulative frequency of up to 723. This classification helps identify core journals that are essential for researchers and practitioners in dental research, guiding effective resource allocation and targeted literature review strategies.

The distribution of authorship productivity in ridge augmentation research is further visualized in a graph (**Figure 6**).

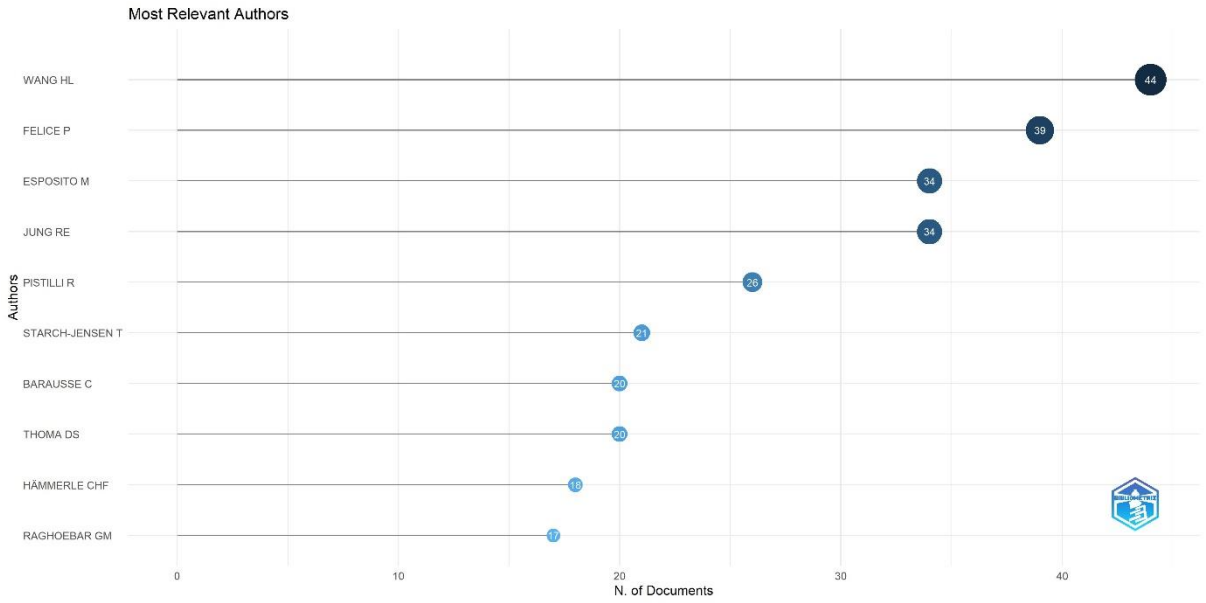

Figure -6 (graph 4) most relevant authors

Source- Retrieved by R- software, based on data provided by PubMed

This graph highlights the most prolific authors in the field. Wang HL tops the list with 44 articles, followed by Felice P with 39, and Esposito M and Jung RE both with 34, indicating their significant influence and active contribution to the field. Other notable contributors include Pistilli R with 26 articles and Starch-Jensen T with 21. these authors are major voices in research of ridge augmentation.

Figure 7 depicts a line graph illustrating author production in the field of alveolar ridge augmentation over time.

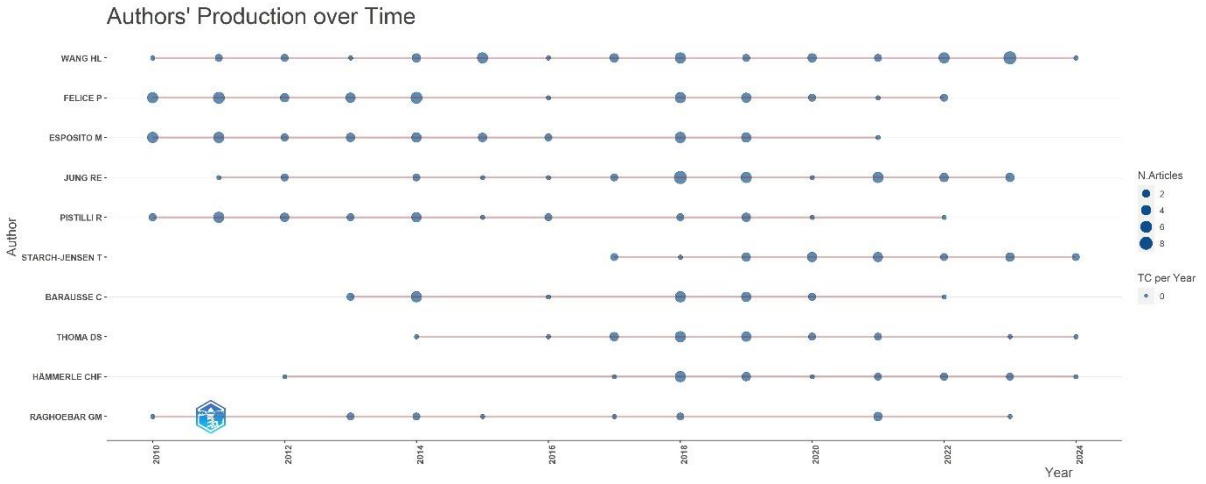

Figure 7 (graph 3) Authors production over a year

Source- Retrieved by R- software, based on data provided by PubMed

The line graph 3 is titled "Authors' Production over Time". The x-axis shows the year, ranging from 2010 to 2024. The y-axis shows the number of articles (N.Articles) published by each author.

Each line in the graph represents an individual author. The steeper the slope of a line, the more productive the author was during that time period. For instance, the line for author Wang HL appears to be the steepest, which suggests that this author published a relatively high number of articles compared to the other authors in the dataset, and their publication rate seems to have increased over time.

Contrarily, the trendline for author Thoma DS appears notably flat, indicating a relatively lower volume of articles published over the specified time frame concerning alveolar ridge augmentation. This suggests a consistent publication rate over time, with minimal fluctuations in output.
Figure 8 highlights the leading academic and research institutions in terms of publication output in a ridge augmentation.

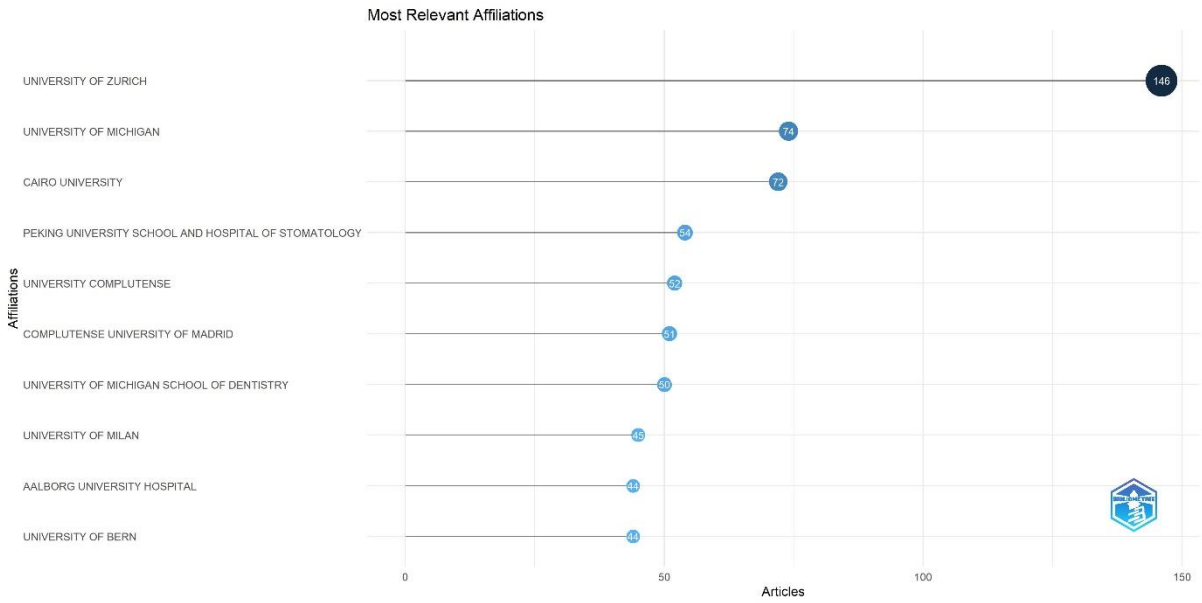

Figure 8 (graph–4) most relevant affiliation

Source- Retrieved by R- software, based on data provided by PubMed

Several institutions have emerged as leading forces in advancing our understanding of alveolar ridge augmentation. The University of Zurich is at the forefront with 146 articles, indicating its dominant role in the research community. The University of Michigan collectively ranks second with 124 articles from its main campus and School of Dentistry. Cairo University follows closely with 72 publications, demonstrating significant contributions from Africa.

Peking University School of Stomatology represents Asia with 54 articles. Notably, the Complutense University of Madrid, when its different campuses are combined, has contributed a total of 103 articles, making it a major European contributor. Other notable European institutions include the University of Milan, Aalborg University Hospital, and the University of Bern, each contributing around 44 to 45 articles.

This data highlights these institutions as central hubs for research and expertise in alveolar ridge augmentation, solidifying their pivotal roles globally within their respective fields

Figure 9 presents a word cloud to visualize the co-occurrence of keywords within the identified publications from the PubMed database.

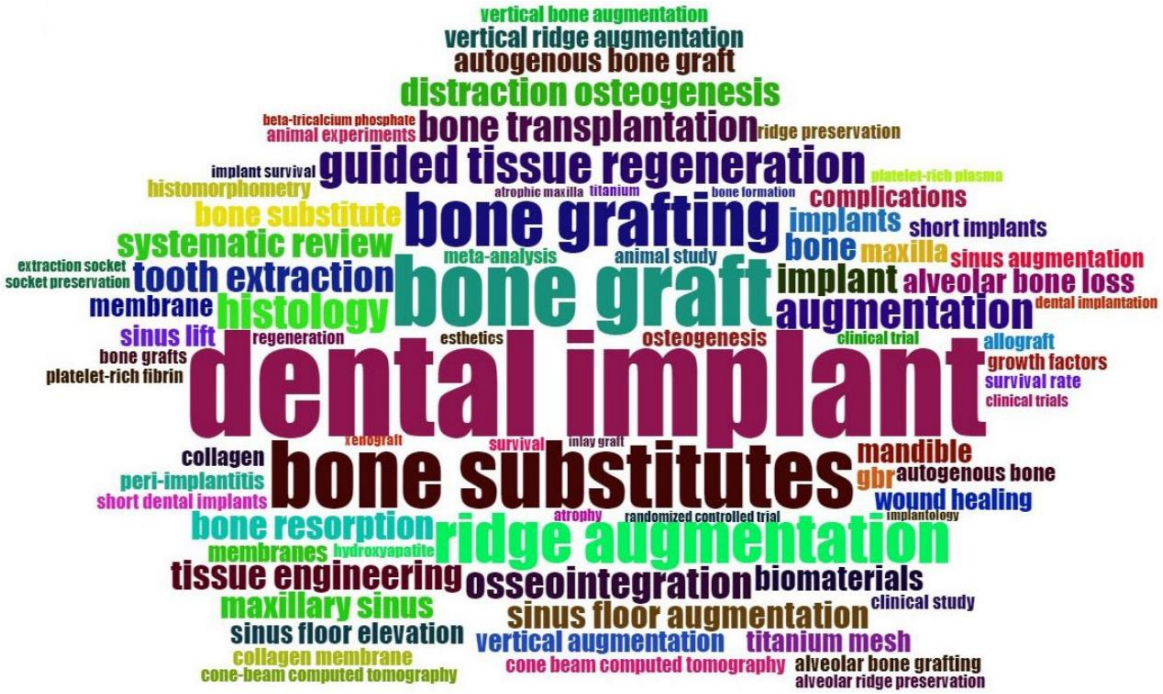

Figure -9- Word cloud of keyword
Source- Retrieved by R- software, based on data provided by PubMed

Figure 9 presents a word cloud visualization, highlighting the key procedures involved in establishing a strong foundation within the jaw bone. This foundation is critical for the successful placement and long-term viability of dental implants. Terms such as "alveolar ridge augmentation," "bone grafting," and "sinus lift" signify interventions focused on reinforcing bone mass prior to implant placement. These procedures play a vital role in addressing bone loss resulting from tooth extraction or other contributing factors, thereby ensuring a resilient base for implantation and optimizing overall success rates.
Figure 10 depicts the trending topics identified within the PubMed database

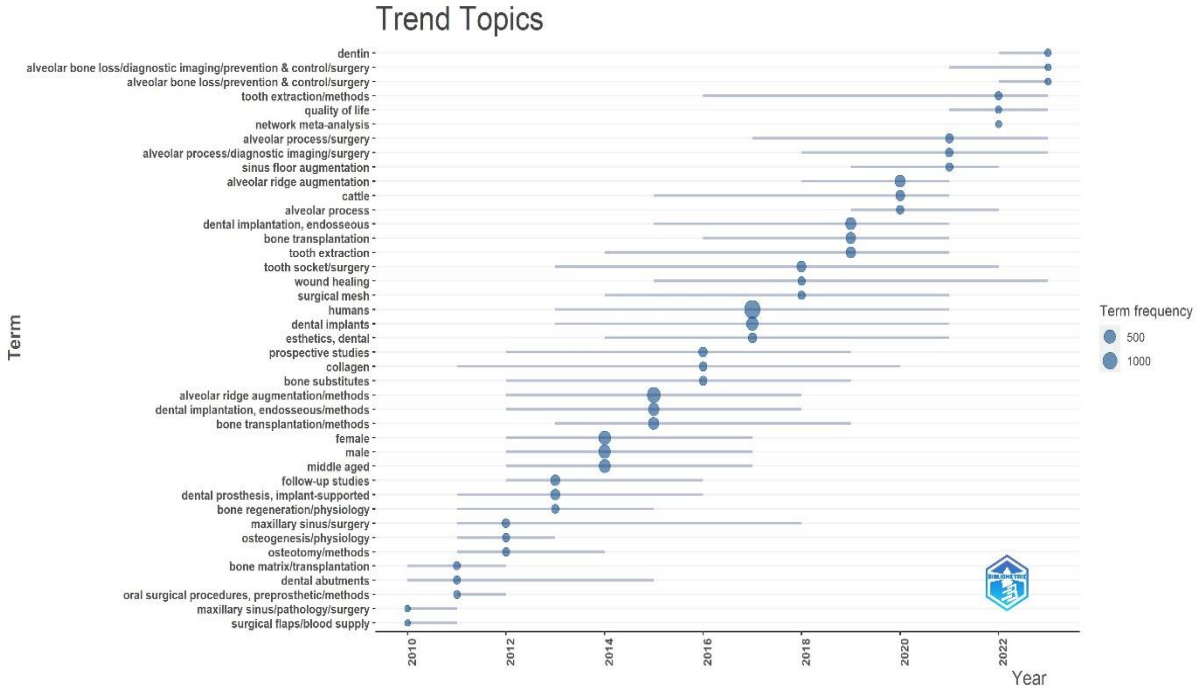

Figure – 10 (graph 5) trend topics
Source- Retrieved by R- software, based on data provided by PubMed

The graph indicates an upward trend in research on multi-objective optimization in manufacturing. Key research topics consistently include "dental implants" and related areas like "endosseous dental implantation," "bone substitutes," and "prospective studies." Recent years show a growing focus on "alveolar ridge augmentation" and "sinus floor augmentation," suggesting these are emerging areas of interest.

Discussion

The objective of this study is to conduct a bibliometric analysis of literature about alveolar ridge augmentation, to evaluate the insight aiming to offer insights into the scientific output and growth within this specialized area. Utilizing bibliometric analysis facilitates the understanding of trends and nexus within scholarly literature. Also, bibliometric analysis aids in setting the priorities for future research pathways.[10-11]

This bibliometric analysis delved into the recent trends of ridge augmentation research, offering valuable insights into the current landscape and future directions of this field. The analysis unveiled an expanding realm of research focused on refining implant placement methods, notably through approaches such as alveolar ridge augmentation. Alveolar ridge augmentation is frequently performed to establish sufficient bone volume necessary for dental implants or other restorative dental procedures.[12-13] Recent literature related to ridge augmentation has revolved around augmentation material properties, advancement in surgical technique, and their long-term success.[14-16] Various information related biocompatibility of augmentation materials, their influence on implant stability, and complication rates are key factors for surgeons in their decision-making process.[17-18]

Moreover, discussions have centered around changes and advancements in surgical techniques, especially the increase in implementation of minimally invasive approaches and digital technologies.[19-20] The analysis findings demonstrate the evolution of publication counts in alveolar ridge augmentation research over time and highlight the topics receiving increased attention. Moreover, they identify leading countries, institutions, and authors in this field, offering comprehension into the development of global collaborations and research networks in alveolar ridge augmentation.

We investigated trends in ridge augmentation research from 2010 to 2024 using a bibliometric analysis. PubMed searches with MeSH terms and keywords identified relevant publications. Publication dates, journals, authors, affiliations, document types, and keywords were analyzed using R software, revealing valuable insights. This approach sheds light on the evolving landscape of ridge augmentation research, informing dental implantology practices. The findings from our study unveil several significant trends in ridge augmentation research. Firstly, the analysis of annual scientific production indicates a consistent increase over time, with recent years experiencing notable growth. This suggests heightened research activity and emphasizes the growing relevance of ridge augmentation in the field of dental implantology. Secondly, core publication venues such as Clinical Oral Implants Research, The International Journal of Periodontics & Restorative Dentistry, and Clinical Implant Dentistry and Related Research emerge as prominent contributors, highlighting their substantial impact on the literature in this area. Thirdly, Bradford's Law categorizes key dental research journals based on their publication frequency or citation count, thus identifying essential journals crucial for researchers and practitioners engaged in dental research.

Furthermore, our examination sheds light on prominent authors like Wang HL, Felice P, Esposito M, and Jung RE, who are shaping ridge augmentation research with their significant publication output and impact. Similarly, leading academic and research institutions such as the University of Zurich, the University of Michigan, and Cairo University play pivotal roles in advancing research and expertise in ridge augmentation.

Implications:

The findings presented here provide valuable insights for researchers, clinicians, and policymakers. Researchers can identify leading journals, collaborate with prominent authors, and explore emerging

research trends to shape future investigations. Clinicians can stay updated on the latest advancements in ridge augmentation techniques, potentially leading to improved patient care. Policymakers can utilize this data to allocate resources and support research efforts in this crucial field of dental implantology.

Limitations:
The study primarily examined English-language publications, potentially limiting the inclusion of international research. Furthermore, the analysis of keywords and MeSH terms offers a broad insight into research topics, possibly overlooking nuanced aspects within the field. Additionally, the sharp decrease observed in 2024 may be attributed to incomplete data, as the year has not concluded yet.

Future Directions:
Building upon this foundation, researchers can delve deeper into specific ridge augmentation techniques, evaluating their long-term success, potential complications, and cost-effectiveness to inform treatment planning and assess clinical impact on patient outcomes like satisfaction and quality of life, ultimately refining methods for successful and predictable implant placement in jawbone reconstruction.

Conclusion
This bibliometric analysis provided a comprehensive overview of recent trends in ridge augmentation research. The analysis revealed a flourishing field with an upward trajectory in research activity, particularly focused on optimizing implant placement through innovative techniques.
Dental implants remained a central theme, alongside a growing interest in alveolar ridge augmentation. The identification of leading publication sources, prominent authors, and collaborating institutions sheds light on the key contributors shaping this field. The findings offer valuable insights for researchers, clinicians, and policymakers to navigate the evolving landscape of ridge augmentation research and contribute to its continued advancement.

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