

Systematic Review

Trends and patterns of orthognathic surgery in Saudi Arabia: a visualized bibliometric analysis of research output

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ABSTRACT

This study conducted a bibliometric analysis of orthognathic surgery research from Saudi Arabia between 1994 and 2024 in the Web of Science database. The goal was to evaluate Saudi Arabia's influence in the field and implications worldwide. Relevant keywords were used without year restrictions to search for articles. Biblioshiny and VOS viewer were used to analyse and visualize the bibliometric data, including total citations, h-index, and number of papers. The results show that Saudi Arabia has significantly increased its orthognathic surgery research production over time, especially in 2021 and 2023. King Saud University and King Abdulaziz University emerged as the leading institutions in number of papers. The most cited work was an expert review on using artificial intelligence for orthodontic diagnosis and planning orthognathic surgeries. This represents meaningful progress in combining technology with orthognathic surgery. Alhammad, Alnofaie, and Al-Sebaei were identified as the most productive individual authors, each authoring around three papers. The bibliographic analysis highlights the need for increased cooperation between Saudi institutions to boost research outputs and advance the application of new technologies in orthognathic surgery. The study serves as a foundation for further developing orthognathic surgery research in Saudi Arabia, which remains one of the few developing nations showing promising potential for growth in this area.

Keywords: Orthognathic surgery, Bibliometric analysis, Saudi Arabia, Artificial intelligence, Orthodontics

INTRODUCTION

Orthognathic surgery (OS), a type of surgery that is specifically used for correcting the discrepancy in the alignment of jaws, is one of the most effective treatments for craniofacial anomalies and skeletal deformities, which cannot be completely corrected with orthodontic appliances only.^{1,2} It gives way to different methods and choices for people who have already attained their skeletal maturity and are no longer entitled to make growth modifications.^{2,3} It proves to be most helpful in patients with severe dentofacial problems that require some masking or surgical camouflage.^{3,4} In the context of

modern advancements in surgical, medical, and orthodontic sectors. OS is used to treat a wide range of conditions, and these conditions can vary greatly in their presentation.^{4,5} The fundamental functions of this procedure are, correction of skeletal discrepancies and enhancement of facial aesthetics, improvement of chewing function and prevention of gum diseases, correction of speech disorders, temporomandibular joint disorders (TMJ), and providing a solutions to sleep-related breathing disorders.⁶ Nowadays, for the majority of people, the appearance of their faces is one of the crucial factors defining their lives because it influences their self-esteem, recognition in society, and quality of life. It is often

regarded as a primary motivating factor for OS in numerous cases.^{6,7}

The management of these dento-facial skeletal anomalies is accomplished by multidisciplinary team of surgeons and orthodontists works together in close collaboration in addition to other participants joining them in their endeavours.⁸ The LeFort I osteotomy and bilateral sagittal split osteotomy (BSSO) are most commonly procedures in the field of OS.⁹ These techniques can be performed either independently or in conjunction with osseous genioplasty, based on the specific requirements of the patient.¹⁰

The orthognathic operation overcame staggering progress during the past century, especially the last two decades represented a breakthrough and made a revolution in this area.¹¹ Classic surgical planning for orthognathic cases has involved this orthodontic phase for decompensation of the teeth prior to the surgery. After dental correction, surgical intervention is carried out, followed by a post-surgical period to align the teeth. This requires long time of treatment, with a mean period of 36 months.¹² Several advanced approaches have been proposed to the field of OS such as surgery-first and surgery-only approaches in addition to the clear orthodontic aligners. In addition, contemporary trends in OS incorporating three-dimensional (3D) technology into the surgical planning phase such as using digital 3D skull models rather than plaster molds and facebow registrations, orthognathic surgeons can perform virtual surgery in real-time, allowing for visualization of anticipated movements, resulting in enhanced precision and less treatment duration. These developments have contributed to improved outcomes and expanded treatment options in the field of OS.¹³⁻¹⁵

The Kingdom of Saudi Arabia is the largest country in the Arabian Peninsula.¹⁶ Saudi Arabia's population is approximately 34.81 million.¹⁷ In a short period of time, it has developed from an agricultural society into a regional and global economic power with modern infrastructure.¹⁶ Petroleum is an integral part of the Saudi economy; Saudi Arabia is the world's largest producer and exporter of oil.¹⁶ Bibliometric analysis is a popular and rigorous method for exploring and analysing large volumes of scientific data. Generally, it is used to measure academic productivity by analysing the available scientific literature.¹⁸ There are a variety of reasons why scholars use bibliometric analysis, such as uncovering emerging trends in publication performance, collaboration patterns, and research constituents, and studying the intellectual structure of a particular field.¹⁹

The field of OS continues to evolve, requiring further research and advancements to improve surgical techniques, optimize patient selection algorithms, and broaden its application to a wider range of patients. Saudi Arabia has made significant advances in OS research and treatment, however there is a lack of comprehensive analysis of the Saudi research regarding the field of OS from a bibliometric point of view. Furthermore, it is crucial to recognize the scope and extent of Saudi research in OS, this will provide a foundation for future studies and the

improvement of healthcare services. To the best of our knowledge, no previous bibliometric analysis has investigated the current trends and patterns of orthognathic surgeries in Saudi Arabia. This study aims to investigate the current trends and patterns of OS in Saudi Arabia providing an outlook on contribution, advanced, and impact of Saudi Arabia in this field.

METHODS

Web of Science database was chosen for this bibliometric analysis. Ethical approval was not required. Using keywords and search terms in the WoS database was part of the search strategy. The following were the search terms and keywords: TS= ("Orthognathic surgery" OR "Orthognathic correction" OR "Orthognathic operation" OR "Le Fort I Osteotomy" OR "Bilateral Sagittal Split Osteotomies" OR "Vertical ramus osteotomy" OR "Maxillofacial deformities" OR "Dentofacial deformity" OR "Genioplasty" OR "Jaw Reconstruction" OR "Jaw discrepancy" OR "Jaw surgery" OR "Maxillofacial Surgery" OR "Bimaxillary surgery" OR "Osteotomy" OR "Mandibular osteotomy" OR "Maxillary osteotomy" OR "Cephalometric analysis" OR "skeletal malocclusion" OR "skeletal asymmetry) and TS= ("Saudi Arabia" OR "KSA" OR "Kingdom of Saudi Arabia" OR "Saudi"). The search was conducted on 10 April 2024. No limited to a specific year of publication, and the first article that met the inclusion criteria was published in October 1996, while the last was published in April 2024. The inclusion criteria were articles written in English or Arabic that specifically focused on OS in Saudi Arabia, while the exclusion criteria were book chapters, editorials, and articles that did not focus on OS in Saudi Arabia. The search yielded a total of 76 articles that met the inclusion criteria and were used in the analysis. Five articles have been removed because the articles not related to OS. These articles were subsequently arranged by the number of citations they received in the WoS core collection (WoS-CC) database, which was done in descending order. Upon a comprehensive screening procedure carried out by two reviewers, conflicts were resolved by agreement and discussion.

Biblioshiny and VOS viewer were used in the analysis to visualize the data. The R foundation for statistical computing's tool Biblioshiny was accessed using R-studio software. The WoS database was accessed, and data was sorted, analyzed, and papers that were considered unnecessary were eliminated using Microsoft excel. Using significant bibliometric indices, such as the total citation count, h-index, and publication count, a thorough analysis was conducted.

RESULTS

Most global cited documents

A comprehensive search was done to find the most influential publications related to OS that included authors or institutions from Saudi Arabia. The search focused on publications receiving the highest total number of citations

globally. After analyzing citations, the publication determined to have received more citations than others was a 2021 article authored by Khanagar Sb. The article was titled "Scope and performance of artificial intelligence technology in orthodontic diagnosis, treatment planning,

and clinical decision-making - a systematic review" and was published in the Journal of Dental Sciences. A further examination was then conducted to identify the top 10 most cited articles in total. These results are displayed in summary form without direct details.

Table 1: Top 10 articles on orthognathic surgery based on number of citations received.

Authors	Total citations	TC per year	Year	Title	Journal
Khanagar et al²¹	56	14.00	2021	Scope and performance of artificial intelligence technology in orthodontic diagnosis, treatment planning, and clinical decision-making – a systematic review	Journal of Dental Sciences
Abdullah et al²²	25	2.50	2015	Changes in quality of life after orthognathic surgery in Saudi patients	The Saudi Dental Journal
Al-Sebaei et al²³	23	2.30	2015	The validity of three neo-classical facial canons in young adults originating from the Arabian peninsula	Head and Face Medicine
Alam et al²⁴	21	3.00	2018	3d cbct morphometric assessment of mental foramen in Arabic population and global comparison: imperative for invasive and non-invasive procedures in mandible	Acta Odontologica Scandinavica
Albarakati et al²⁵	10	0.67	2010	Orthognathic surgical norms for a sample of Saudi adults: hard tissue measurements	The Saudi Dental Journal
Albalawi et al²⁶	6	2.00	2022	Trends and application of artificial intelligence technology in orthodontic diagnosis and treatment planning—a review	Applied Sciences
Assari et al²⁷	2	0.67	2022	Effect of religious beliefs on bone graft selection for oral and maxillofacial surgery in Saudi Arabia	Journal of Stomatology, Oral and Maxillofacial Surgery
Suganna et al²⁸	2	0.67	2022	Knowledge on applications of 3d design and printing in dentistry among dental practitioners in Saudi Arabia: a questionnaire-based survey	Cureus Medical Journal
Alatel et al²⁹	2	0.15	2012	Soft tissue genioplasty new modality of chin surgery utilizing mentalis muscle only	Saudi Medical Journal
Siddika et al³⁰	1	0.25	2021	Cephalometric for orthognathic surgery (cogs) analysis for Saudi population	Pesquisa Brasileira Em Odontopediatria E Clínica Integrada

TC=Total citations

Authors with the most articles

A comprehensive evaluation of author productivity was conducted using the Biblioshiny software, resulting in noteworthy outcomes that are visually into represented in Figure 1. The analysis unveiled that Alhammad, Alnofaie and Al-Sebaei all had the highest publication count with approximately three articles for each author, positioning them as the most prolific authors in the field of orthognathic surgeries. Following closely were the remaining authors, who contributed around two articles in the field of OS.

These findings highlight the substantial research output and impact of these authors in the realm of orthognathic surgeries research.

Institutions with the most relevant articles

A bibliometric analysis was conducted to examine the research literature on OS. The study identified the top 10 institutions contributing to this field. King Saud University and King Abdulaziz University emerged as the top two leading institutions; King Saud University published 38 research articles on the top while King Abdulaziz published 27 research articles. Following closely was the university of King Saud bin Abdulaziz Health Science University, which produced around 21 relevant articles. Riyadh Elm University also made contributions, authoring roughly 7 articles on OS as shown in Figure 2.

In terms of collaboration, King Saud University, King Abdulaziz University and King Saud bin Abdulaziz Health Science University stood out as the primary collaborative

institutions in Saudi Arabia for OS, as depicted in the network visualization as shown in Figure 3. These three universities not only demonstrated significant collaboration with each other but also exhibited a high research output by publishing the most articles in this field. While other institutions in Saudi Arabia were involved in

OS research, their level of engagement appeared comparatively lower. The network diagram emphasizes the pivotal role of King Saud University, King Abdulaziz University and King Saud Bin Abdulaziz Health Science University in leading research initiatives and scholarly contributions related to OS within Saudi Arabia.

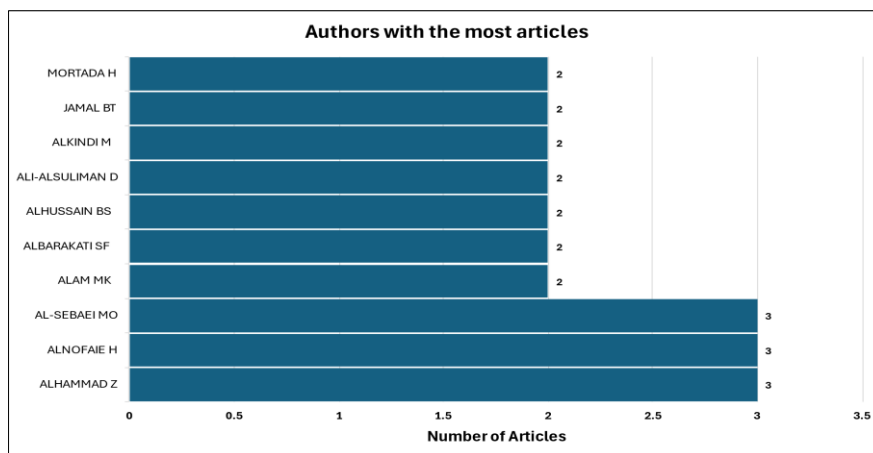


Figure 1: Authors with the highest number of publications on orthognathic surgeries articles related to Saudi Arabia.

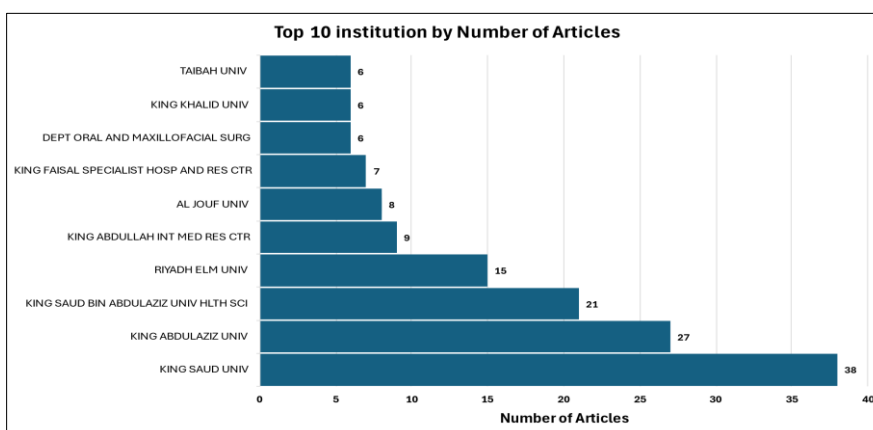


Figure 2: Top 10 academic and research institutions with the most Saudi publications on OS.

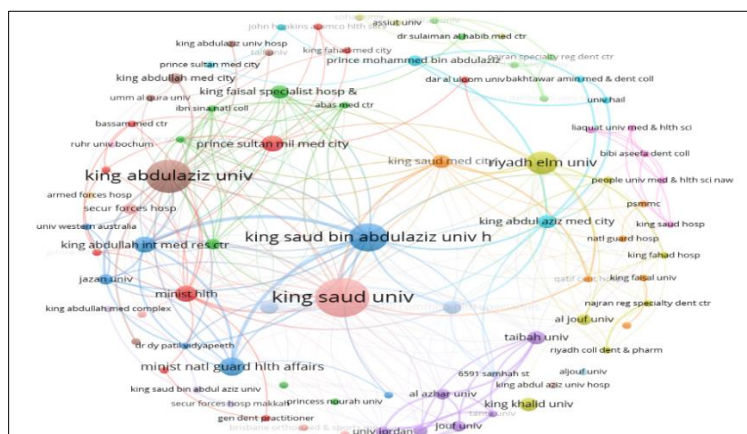


Figure 3: Collaboration network of institutions that have collaborated on orthognathic surgery research in Saudi Arabia.

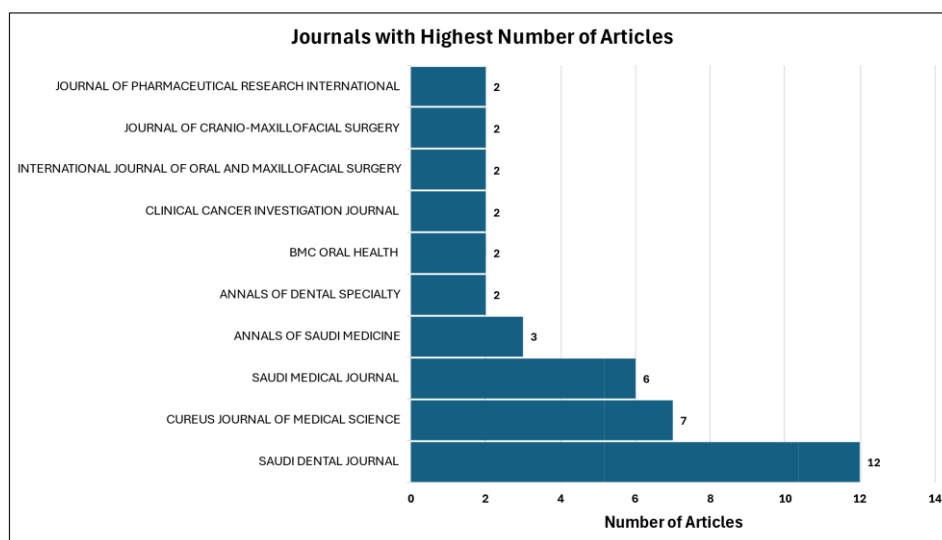


Figure 4: Journals with highest number of Saudi publications on orthognathic surgery.

Journals with the most relevant articles

The findings obtained from a comprehensive analysis of the data are presented in Figure 4, highlighting the journals that have published the highest number of articles related to OS by Saudi authors or institutions. Saudi Dental Journal emerged as the leading journal in this field, with approximately 12 articles specifically focusing on OS research. The Cureus Journal of Medical Science closely followed, contributing around seven articles on the same subject. Ranking third, the Saudi Medical Journal provided 6 articles dedicated to the study of OS as shown in Figure 4.

Yearly scientific contribution

An extensive and thorough analysis of publication data from 1994 to 2024 reveals a significant increase in scholarly contributions related to OS over this period. Figure 5 clearly depicts the progression of research output over the years, indicating that the growth rate has not been consistent. For instance, there were no articles published between 1997-2001, 2004-2006 and 2008-2009 in addition to 2016. However, there was a significant surge in 2019 with five articles. The number of articles increased to six in 2020 but experienced a substantial increase in 2021 and 2023, with the highest number of articles published during the considered timeframe, reaching approximately 18 scholarly pieces. This remarkable peak in publications in 2021 and 2022 underscores the increasing knowledge base and the intensification of research efforts towards advancing the understanding of OS in recent years. These quantifiable trends observed in the systematic evaluation of literature highlight the growing interest and focus on this field. The provided chart in Figure 5 shows the number of scientific articles published in Saudi Arabia on the topic of OS from 1994 to 2024.



Figure 5: Yearly scientific contribution and trends in publications on orthognathic surgery in Saudi research.

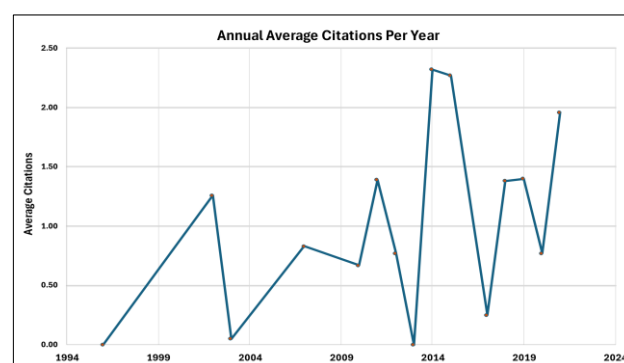


Figure 6: Average citation trends over time for publications on orthognathic surgery from Saudi Arabia.

Citations per year

A thorough examination of the publications and citation data related to OS research reveals an interesting trend in the average annual citations received. It becomes clearly

evident that from 1996 till 2002, the average citations per year embarked on a notable trajectory of steady increase. Reaching 1.25 citation per year however after. Subsequently, from 2002 to 20011, a ranging average annual citations can be observed, with sudden increase up to 2.25 citations by 2014 as visually depicted in Figure 6. This rising interest and acknowledgement of contributions to the literature until 2014 till 2023 followed by a modest downtrend suggests OS was gaining significant momentum and recognition within the orthodontics and maxillofacial surgery community during that earlier period, with numerous studies building upon and referring to the work of others. While interest and citations remain elevated even in recent times compared to the start of the analysis timeframe, the field may have reached a plateau in terms of the highest degree of annual inquiry, discussion, and dissemination of novel findings during the

2014 peak period portrayed in the graph. Figure 6 presents the average number of citations received per year for publications related to OS that were authored/co-authored by Saudi researchers.

Citation and keyword

The most frequently cited articles from journals regarding OS in Saudi publications are display in Figure 7. The most prominent journal by number of articles is the Journal of Oral and Maxillofacial Surgery with a total of 76 cited articles. Followed by the Journal of Dental Education, the American Journal of Orthodontics and Dentofacial Orthopedics, and the International Journal of Oral and Maxillofacial Surgery with around 41, 40 and 39 articles cited respectively.

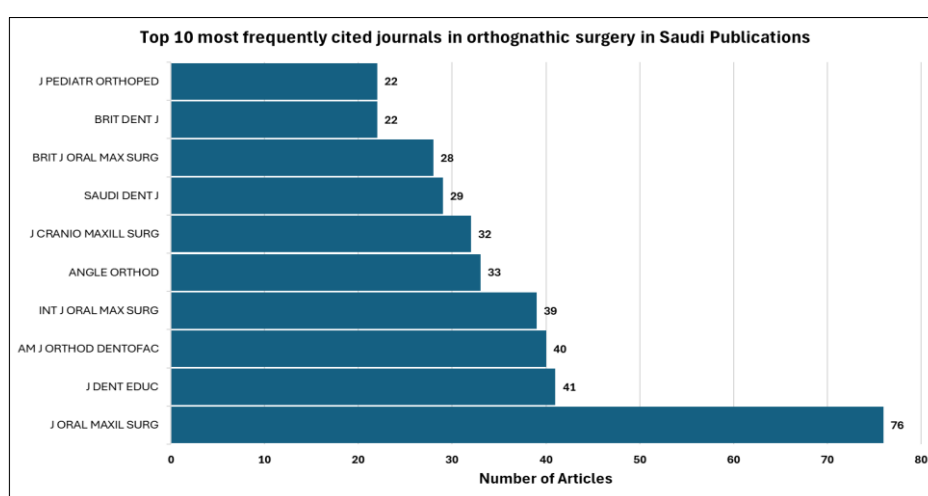


Figure 7: Co-citation network of the most frequently cited journals in orthognathic surgery in Saudi publications ranked by number of articles.

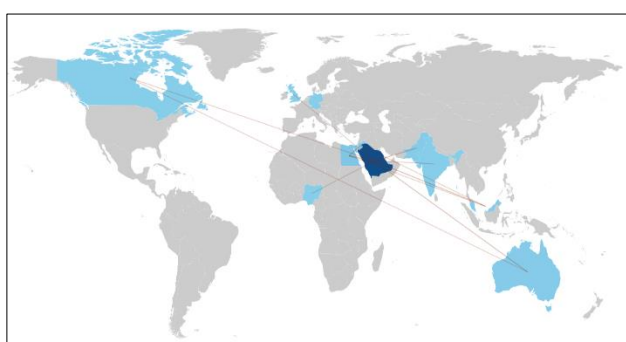


Figure 8: World map with countries colored based on research collaboration with Saudi Arabia in orthognathic surgery research.

Collaboration with countries

When examining the research contributions originating from Saudi Arabia, it was observed that collaborative affiliations existed with various countries such as the

United States of America, Saudi Arabia, Egypt, India, and others, as shown in Figure 8. These collaborative partnerships highlight the global nature of research in OS, promoting the exchange of knowledge and expertise among researchers from different countries. Notably, the United States, Egypt, and India have emerged as prominent collaborators with Saudi Arabia in this field. These international collaborations demonstrate the active involvement of scholars from these countries in advancing knowledge and finding practical solutions in OS. If researchers from different countries work together, they will adjust their perception of the field by researching and exchanging their knowledge and experience to come up with the ideal intervention and solutions to their patients' problems.

Lighter blues denote a very limited extent of cooperation with Saudi Arabia. On the contrary, the darker the shades of blue, the more collaboration exists within countries. The chart illustration shows which international partners Saudi Arabia is most actively cooperating with for an OS carried out in joint research.

DISCUSSION

Web of Science database was chosen for this bibliometric analysis due to its thorough coverage and reliable indexing of scientific articles. It has gradually become the dominant bibliographic data source typically utilized for journal selection, research evaluation, bibliometric analyses, and other tasks. Compared to other databases, the Web of Science database includes records dating back to 1945 and features a wide range of reputable, peer-reviewed scientific journals from various regions worldwide. By contrast, the Scopus database limits citations to those created after 1996, which may restrict the evaluation of the most frequently referenced works to a relatively short period of time. Furthermore, Google Scholar also contains books, theses, and dissertations that lack peer review and may possess questionable scientific validity.²⁰

The bibliometric analysis in this study provides valuable insights into the research landscape of OS in Saudi Arabia. The findings reveal several noteworthy trends and patterns that contribute to our understanding of the field's development and progression within the Saudi context.

The bibliometric analysis of OS in Saudi Arabia revealed several key findings. The most globally cited article related to OS in Saudi Arabia was a 2021 article by Khanagar et al, which received 56 total citations.²¹ The top 10 most globally cited articles on OS in Saudi Arabia are listed in Table 1, with a total of 229 citations. These articles cover a range of topics, including the validity of facial canons in young adults from the Arabian Peninsula, 3D CBCT morphometric assessment of mental foramen in the Arabic population, and changes in quality of life after OS in Saudi patients. The analysis of authors with the most articles revealed that Alhammad, Alnofaie, and Al-Sebaei were the most prolific authors, with approximately three articles each. This finding highlights the significant research output and impact of these authors in the realm of orthognathic surgeries. The analysis of institutions with the most relevant articles revealed that King Saud University and King Abdulaziz University were the top two leading institutions in terms of research output, with 38 and 27 articles, respectively. These institutions are followed by the University of King Saud bin Abdulaziz Health Science University, which produced 21 relevant articles. The collaboration network analysis showed that King Saud University, King Abdulaziz University, and King Saud Bin Abdulaziz Health Science University were the primary collaborative institutions in Saudi Arabia for OS research. The analysis of journals with the most relevant articles revealed that the Saudi Dental Journal was the leading journal in this field, with approximately 12 articles specifically focusing on OS research. The Cureus Journal of Medical Science and the Saudi Medical Journal closely followed, contributing around seven and six articles, respectively. The number of research papers in the field of OS has been increasing consistently over the years, with a significant increase in publications in recent years. The number of citations for these papers has also been

increasing, with a peak in 2014. The Journal of Oral and Maxillofacial Surgery is the most prominent journal in this field, with a high number of cited articles. The collaboration network analysis showed that the United States, Egypt, and India were the top collaborative countries with Saudi Arabia in OS research. These collaborations demonstrate the active involvement of scholars from these countries in advancing knowledge and finding practical solutions in OS.

Several bibliometric analysis studies have been conducted in Saudi Arabia, covering various fields such as physiotherapy, library and information science, medicine and others.³¹⁻³⁵ These studies, along with the one on OS in Saudi Arabia, demonstrate the increasing interest in bibliometric analysis in the country, as well as the growth in research productivity and visibility in various fields. The findings from these studies can be used to inform policy and decision-making in research and development in Saudi Arabia, as well as to identify areas for improvement and potential collaboration opportunities. In addition to the findings of the bibliometric analysis of OS research in Saudi Arabia, the study by Hamadallah et al also identified a significant increase in the number of publications in the field of cleft lip and palate research in the country.³⁴ The study reported a 12.2% annual growth rate in the number of publications from 2011 to 2019, which is a similar trend to the one observed in OS research in Saudi Arabia. Saudi Arabia has experienced significant population growth in recent years, with the population increasing from 25.5 million in 2006 to 34.8 million in 2019.¹⁷ This growth has led to an increased demand for healthcare services, including OS and cleft lip and palate treatment, and a corresponding need for research in these areas. The Saudi Arabian government has also recognized the importance of healthcare research and development and has taken steps to promote and support research in the field. The Saudi Health Council, established in 2007, is responsible for setting the overall health research strategy in the country and for coordinating and overseeing health research activities. The council has identified several priority areas for research, including oral health and craniofacial anomalies.³⁶ The bibliometric analysis of OS research in Saudi Arabia revealed a significant increase in the number of publications in the field, similar to the trend observed in other research in Saudi Arabia.³¹⁻³⁵ The growth in the number of publications in both areas can be attributed to the overall growth in the country's population, as well as the increasing emphasis on healthcare research and development. The findings of this bibliometric analysis provide a comprehensive overview of the current trends and patterns of OS research in Saudi Arabia. The results of this analysis can be used to inform future research and policy decisions in the field of OS.

CONCLUSION

This bibliometric analysis for the trends and patterns of OS was done in WOS to analyse the scholarly output between 1994 to 2024. This investigation shows various aspects of

research activities and the advancement in the treatment of orthognathic surgeries. It indicated that there are limited number of articles was written in Saudi Arabia at this period due to limited Institution that have the capability of doing such cases. This can show the importance of collaboration between the institution in said Arabia to help in increasing the research output.

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