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Critical Review

Mapping the knowledge of stomatognathic functions and orthognathic surgery

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Aim: To conduct a scientific mapping of stomatognathic system functions and orthognathic surgery (OS) with a scientometric approach. **Methods:** The articles were retrieved from the PubMed, Scopus, and Web of Science databases in April 2022. The research included studies approaching OS and stomatognathic function assessment, without time or language restrictions. The Bibliometrix package and VosViewer software analyzed and mapped the scientific knowledge of stomatognathic functions and OS. The researchers extracted and analyzed data including productive institutions, highly cited articles, journals, authors, references, and keywords. **Results:** Altogether, 223 articles were included, covering the period from 1981 to 2024. The average annual growth rate was 2.96%, with a mean of 18.4 citations. There were 942 co-authored papers, and only six were authored by a single person, resulting in an average of 4.99 co-authors per document and a 2.691% proportion of international co-authorships. Network analysis revealed three clusters, covering topics such as "speech," "cleft lip and palate," "dentofacial deformity," and "obstructive sleep apnea." Keyword co-occurrence analysis also highlighted emerging trends; terms such as "orthognathic surgery," "maxillary advancement," and "obstructive sleep apnea" gained prominence. **Conclusion:** The continuous increase in studies and diversity of journals reflects the growing relevance of the relationship between OS and stomatognathic functions. The mapping emphasizes the importance of an interdisciplinary and collaborative approach in advancing knowledge of the functional and clinical implications of OS.

Keywords: Bibliometrics. Knowledge. Orthognathic surgery. Stomatognathic system.

Introduction

Dentofacial deformities (DFD) are significant skeletal changes associated with dental malocclusion. They affect the orofacial myofunctional system according to the type of disproportion, such as deviations in chewing, swallowing, breathing, and speech; temporomandibular disorder; abnormal lip and tongue posture; and muscle asymmetry[1-8].

Orthognathic surgery (OS) is a complex intervention to correct DFDs, improve facial and dental harmony and functional occlusion, and enhance the stomatognathic system (SS) functions[9,10]. The number of orthognathic procedures has increased over the years due to advancements in technology and the growing number of qualified surgeons[11]. Despite the growing body of research on OS and SS functions, there is a lack of comprehensive scientometric analyses mapping trends in this field. This study aims to fill this gap by identifying research patterns, influential contributors, and evolving themes[12].

Various scientific fields have employed statistical analysis methods, including scientometric analyses, to evaluate and quantify the scientific landscape in terms of journals and articles[13,14]. Moreover, these analyses can predict the evolution and prospects of a specific field of study. Mapping and visualizing the production of scientific articles can facilitate the discovery of new knowledge[15-17]. For instance, document co-citation analysis helps identify relevant literature and academic communities and assess social impacts – factors that may be overlooked by conventional literature review methods[16].

This is the first scientometric analysis to date addressing SS functions and OS. It aimed to conduct a scientific mapping of the patterns and research trends related to OS and the SS functions, identifying historical and temporal trends in publications, the most relevant journals, authors, institutions, research partnerships, and the current state and future directions of scientific production.

The study aimed to achieve these objectives by answering questions such as, “What is the growth rate of articles related to OS and SS functions?”, “How are international collaboration networks organized among countries and scholars?”, “Which scientific journals and research institutions have the most publications?”, “Which articles have the greatest impact on the scientific community based on citation counts?”, and “What are the most frequently addressed research issues according to keyword analysis?”.

Material and Methods

Source of information and search strategy

Two researchers (AFMB and LOL) searched the bibliography independently in the databases of PubMed (https://pubmed.ncbi.nlm.nih.gov), Scopus (https://www.scopus.com), and Web of Science (http://apps.webofknowledge.com), encompassing publications from their inception until April 2024. The search strategy, detailed in Appendix

1, incorporated Medical Subject Headings (MeSH), synonyms, and keywords related to OS, the SS, and oral functions.

Eligibility criteria

The inclusion criteria specified that eligible studies must have performed OS and assessed SS functions such as chewing, swallowing, breathing, speech, and sucking. The study included only peer-reviewed journal articles (as they undergo rigorous evaluation and provide reliable data for scientometric analysis), indexed in the three major scientific databases: PubMed, Scopus, and Web of Science (as these platforms offer comprehensive coverage of scientific literature and are widely used in scientometric studies). The study excluded systematic reviews and/or meta-analyses, books, book chapters, abstracts, gray literature, and studies outside the scope. It removed duplicates with the Bibliometrix 4.1.3 package[18], implemented in R 3.4.1[19].

Scientometric analyses

Descriptive analyses and scientific mapping were conducted using the Bibliometrix 4.1.3 package[18], implemented in R 3.4.1.[19]. Bibliometrix is an open-source tool for bibliometric and scientometric analysis, developed by Massimo Aria and Corrado Cuccurullo[18] at the University of Naples Federico II, Italy. R, the programming language in which Bibliometrix is implemented, was created by Ross Ihaka and Robert Gentleman at the University of Auckland, New Zealand, and is maintained by the R Development Core Team[19], a global community of contributors.

The following metadata were extracted from the databases to address the research questions: the year of publication, the journal, the number of authors, each author's institution, h-index, each author's country of origin, the country where the study was conducted, and the keywords.

The extracted data included the average citations per document, the number of articles per author, the most productive authors, and the output of key authors over time. The h-index[20] and the number of citations per article were calculated to assess each author's productivity. A three-field plot was generated using a Sankey diagram to visualize the relationships among the top 10 authors, 10 keywords, and 10 journals, using Bibliometrix[18]. The descriptive metrics of the dataset were performed considering the 10 most productive authors.

Bradford's Law of Scattering stands out for identifying key journals and organizing the literature efficiently. It describes the distribution of scientific production in a specific field, indicating that a small core of journals accounts for approximately one-third of the relevant articles on the topic. As the search expands, a larger number of journals is required to encompass the next third of the literature. Finally, an even broader set of journals will be needed to constitute the final third of pertinent publications, demonstrating the progressive dispersion of knowledge[21].

The VOSviewer software (developed by the Centre for Science and Technology Studies, Leiden University, the Netherlands)[22] assessed the co-occurrence network of authors' keywords. This software, designed by Waltman (van Eck and Waltman[22], 2010), con-

structs and analyzes bibliometric networks and generates visual bibliometric maps. This analysis extracts keywords from the documents, counts keyword frequency, and identifies clusters, bursts, and connections between keywords.

Cluster analysis is a statistical method used to classify data based on the level of similarity to identify the distribution of research content related to specific topics[13,23]. This analysis considered the frequency of words in the articles' titles and abstracts to determine the titles of the clusters, naming them with the most frequent words.

Results

Search results

The database search retrieved 2,324 articles. After duplicate removal, 1,401 records remained. The initial title and abstract screening identified 983 articles as potentially eligible. Then, they underwent a full-text review, excluding 763 articles for various reasons. Ultimately, 223 articles were included in the final analysis. This process is illustrated in Figure 1 and Appendix 2.

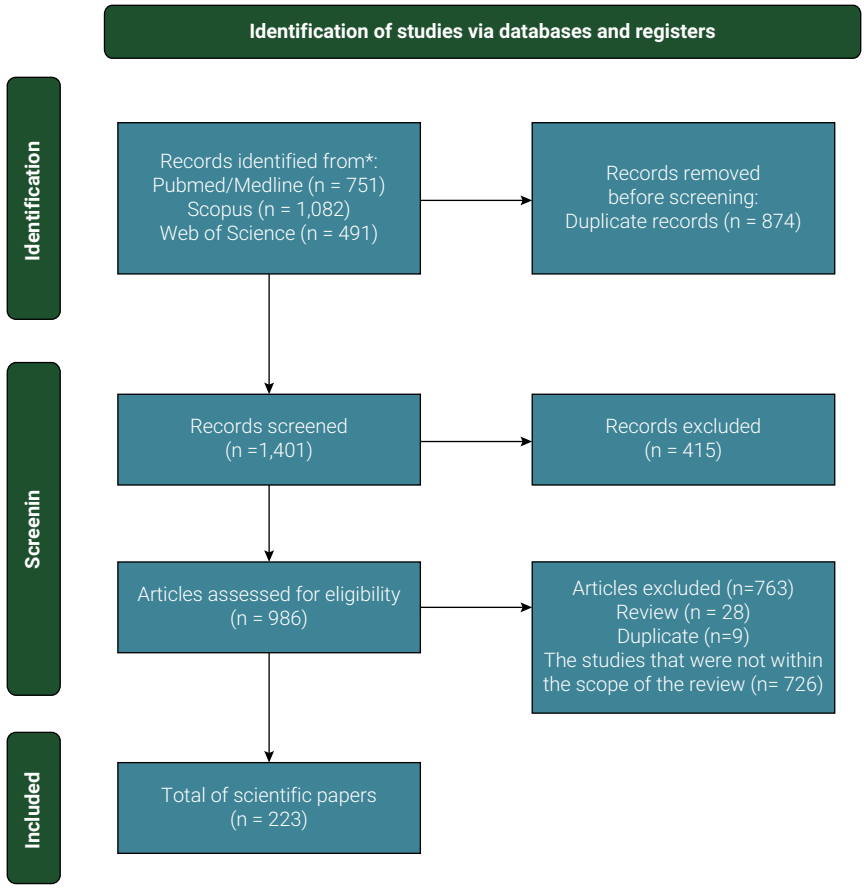

Figure 1. Flow chart of scientometric analysis.

Temporal trends in publication and authorship

The scientometric analysis of the sample ranging from 1981 to 2024 provides a comprehensive overview of the scientific output in question. Over this period, 93 scientific journals published articles on this topic. The average 2.96% annual growth rate indicates a gradual increase in document production over this period. They published an annual average of 11 scientific articles, with an average of 18.4 citations per document, indicating substantial recognition and influence within the academic community. Their 389 keywords provide insight into the issues addressed in these studies. However, 65 scientific articles in the survey, corresponding to 29%, did not include keywords.

Furthermore, collaboration among multiple authors is commonly practiced, with 942 papers produced in co-authorship, while only six were written by a single author. The average number of co-authors per document was approximately 4.99, highlighting the importance of teamwork in producing scientific knowledge. Moreover, the proportion of international co-authorships was 2.691% of the total, demonstrating that scientific research in recent years has been global and collaborative.

Figure 2 presents an overview of the 10 most prolific authors on the topic, specifically from 1990 to 2019. The author productivity graph over time shows the relationship between the period when authors published papers, the number of individual publications, and the number of citations for each author's publication. The authors' productivity varies over the years. However, some authors (e.g., Kobayashi T, Marukawa K, and Lee J) maintain consistent output over time, while others peak in specific years (e.g., Choi J, Throckmorton G, Alaluusua S, Leikola J, Pereira V, Sell D, and Sinn D).

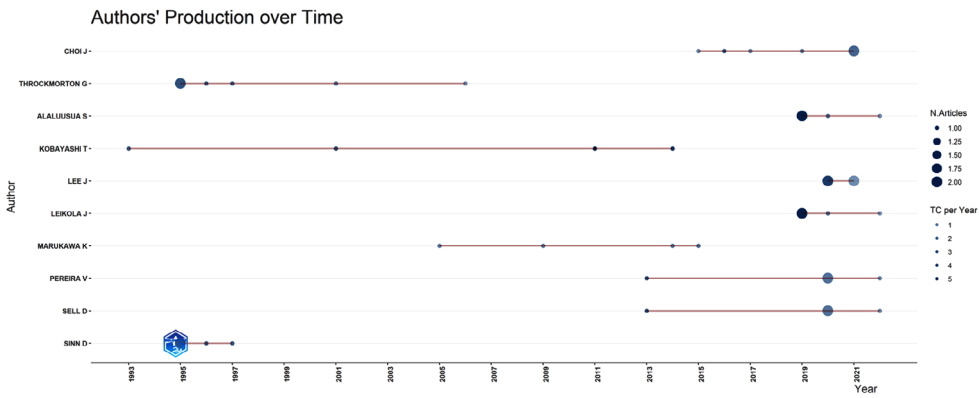

Figure 2. Overview of the authors' scientific knowledge based on database publications. Distribution of the proportion of articles by the 10 most productive authors. The line represents the chronological production of the author, the size of the circle is proportional to the number of articles. The color intensity is proportional to the number of citations (Total Citations - TC) in the corresponding year.

Choi J and Throckmorton G stand out (n = 6) among the 10 most productive authors based on the number of publications, followed by other authors (n = 4) (Figure 3A). These highly productive authors are respectively affiliated with the Department of Oral

and Maxillofacial Surgery at the University of Pennsylvania Hospital and the Department of Cellular Biology at the University of Texas. The two most prominent and influential authors, measured here by their h-index (within the subset of articles related to OS and SS functions), are Lee J (h-index = 21), from the Department of Oral and Maxillofacial Surgery at the School of Dentistry, Seoul National University; Marukawa K (h-index = 19), from the Department of Oral and Maxillofacial Surgery at the University of Yamanashi; and Sell D (h-index = 15), from the Centre for Outcomes and Experience Research in Children's Health, Illness, and Disability (ORCHID), London (Figure 3B).

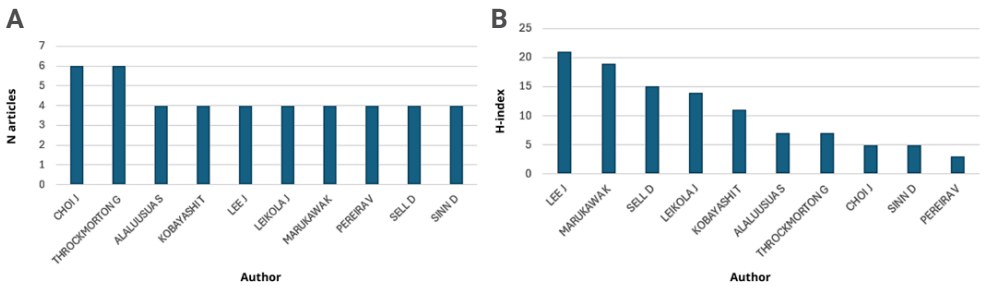

Figure 3. Overview of the authors' scientific knowledge based on database publications. Distribution of the proportion of articles by the 10 most productive authors. The line represents the chronological production of the author, the size of the circle is proportional to the number of articles. The color intensity is proportional to the number of citations (Total Citations - TC) in the corresponding year.

Trends in scientific journals

Scientific output has changed over the decades, as illustrated in Figure 4. There was a gradual increase in the number of articles from 1981 to 2024, with notable peaks in 2015 (14 articles) and 2023 (20 articles), highlighting periods of heightened academic activity. However, the databases had no indexed articles from 1982, 1983, 1987, and 1999.

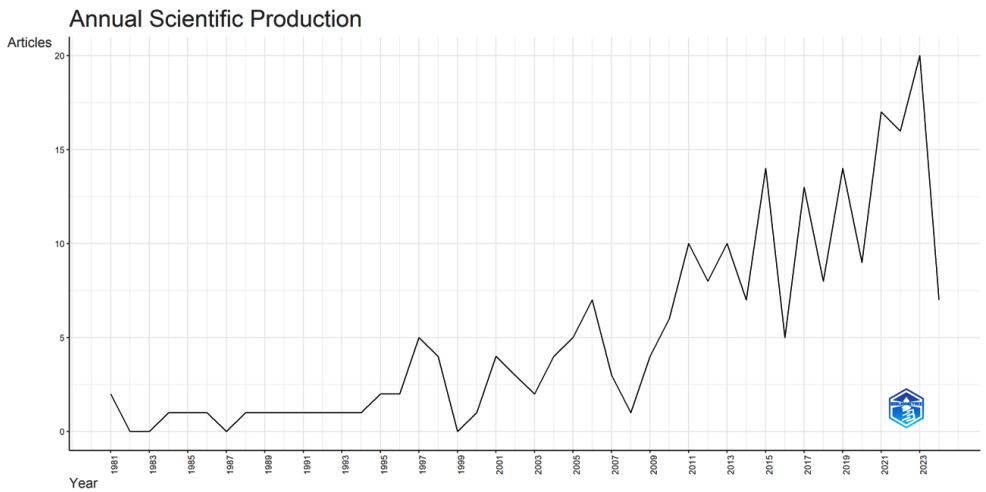

Figure 4. Number of publications per year on the relationship between orthognathic surgery and the functions of the stomatognathic system in databases from 1981 to 2024.

The journals with the highest publication counts, their impact factors, and Bradford's group are shown in Table 1. Among the top 10 sources with the most publications on the topic, the Journal of Cranio-Maxillofacial Surgery has the highest impact factor at 3.1, followed by the American Journal of Orthodontics and Dentofacial Orthopedics, with an impact factor of 3.0, and the Journal of Oral Rehabilitation, with a score of 2.9.

Table 1. Scientific journals with the highest number of publications on the topic, their respective publication counts, impact factors, and classification according to Bradford's law.

Journal	Number of Article	Impact factor 2022	Bradford's law of scattering
Journal of Oral and Maxillofacial Surgery	32	1.9	Zone 1
International Journal of Oral and Maxillofacial Surgery	24	2.4	Zone 1
Journal of Craniofacial Surgery	15	0.9	Zone 1
Journal of Cranio-Maxillofacial Surgery	14	3.1	Zone 1
American Journal of Orthodontics and Dentofacial Orthopedics	10	3.0	Zone 2
British Journal of Oral and Maxillofacial Surgery	9	1.8	Zone 2
Cleft Palate-Craniofacial Journal	5	1.1	Zone 2
Journal of Oral Rehabilitation	5	2.9	Zone 2
American Journal of Orthodontics	3	3.0	Zone 2
Annals of Maxillofacial Surgery	3	2.4	Zone 2

The organization of scientific knowledge of OS and SS functions was revealed using authors, keywords, and scientific journals (Figure 5). The three-field plot showed that scientific production is concentrated on more frequent topics in dentistry, such as OS, mandibular prognathism, cleft palate, and DFDs, with authors affiliated with departments in this broad field, such as the department of oral and maxillofacial surgery and orthodontics at their universities. Moreover, the most frequent keyword was "orthognathic surgery," the name of the surgical technique evaluated and performed by oral and maxillofacial surgeons.

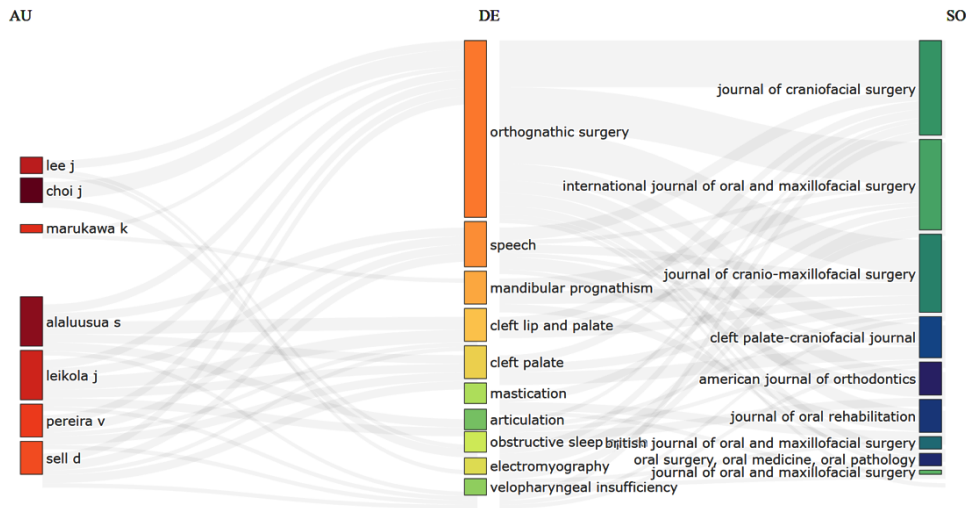

Figure 5. Three-field plot showing the relationship between the seven main authors (AU), Journals (SO), and Keywords (DE).

The keyword "orthognathic surgery" was associated with obstructive sleep apnea, speech, and chewing, which are affected by this surgical technique. It was also linked to motivating factors that led to this practice, such as mandibular prognathism, cleft palate, DFD, and cleft lip and palate.

Trends in citations of scientific articles

The 10 most relevant articles, considering the number of citations, are presented in Table 2. The article with the highest total citation count is by Vijayakumar Jain et al.[24] (2019), totaling 270 citations, followed by Rustemeyer and Gregersen[25] (2012) with 129 citations, and in third place, the study by Abramson et al.[26] (2011) with 118 citations.

Table 2. Most relevant articles considering the number of citations.

Author, Journal	DOI	Total Citations	TC per Year	Normalized TC
Vijayakumar Jain et al.[24] J Maxillofac Oral Surg. 2019	10.1007/s12663-018-1113-4	270	45,00	9,84
Rustemeyer and Gregersen[25]. J Cranio-Maxillofac Surg. 2012	10.1016/j.jcms.2011.07.009	129	9,92	4,55
Abramson et al.[26] J Oral Maxillofac Surg. 2011	10.1016/j.joms.2010.11.037	118	8,43	3,06
Kawakami et al.[27] J Cranio-Maxillofac Surg. 2005	10.1016/j.jcms.2004.10.005	111	5,55	2,88
Janulewicz et al.[28] J Oral Maxillofac Surg. 2004	10.1016/j.joms.2003.08.014	86	4,10	2,26
Hasebe et al.[29] Int J Oral Maxillofac Surg. 2011	10.1016/j.ijom.2011.01.011	81	5,79	2,10

Continue

Continuation				
Proffit et al.[30] J Oral Maxillofac Surg. 1989	10.1016/0278-2391(89)90277-2	81	2,25	1,00
Pahkala and Kellokoski[31]. Am J Orthod Dentofacial Orthop. 2007	10.1016/j.ajodo.2005.09.033	78	4,33	1,47
Iwase et al.[32] Int J Oral Maxillofac Surg. 2006	10.1016/j.ijom.2006.08.014	63	3,32	2,35
Kim and Oh[33] J Oral Maxillofac Surg. 1997	10.1016/S0278-2391(97)90224-X	63	2,25	1,80

TC = Total citations

Structure and partnerships in the scientific field

Figure 6 shows the visualization map overlapping the most frequent keywords (five or more occurrences) in this area and the collaboration networks.

The authors' keywords totaled 389. The most frequent ones were "orthognathic surgery" (85 occurrences), "maxillary advancement" (23 occurrences), and "obstructive sleep apnea" (18 occurrences).

Three clusters were identified for the topic. In cluster 1, represented in purple, nine keywords, such as "speech" and "cleft lip and palate," are the most frequent. They are often associated with speech disorders and craniofacial interventions. Cluster 2, in yellow, consists of eight keywords related to various themes, with "dentofacial deformity" being the most frequent, linked to treatment approaches for patients with DFDs. Four keywords in cluster 3, represented in green, focus primarily on obstructive sleep apnea. This theme is typically related to risk factors, diagnosis, and treatments for this condition, including the relationship between obstructive sleep apnea and craniofacial characteristics and surgical and nonsurgical interventions to improve this condition (Appendix 3).

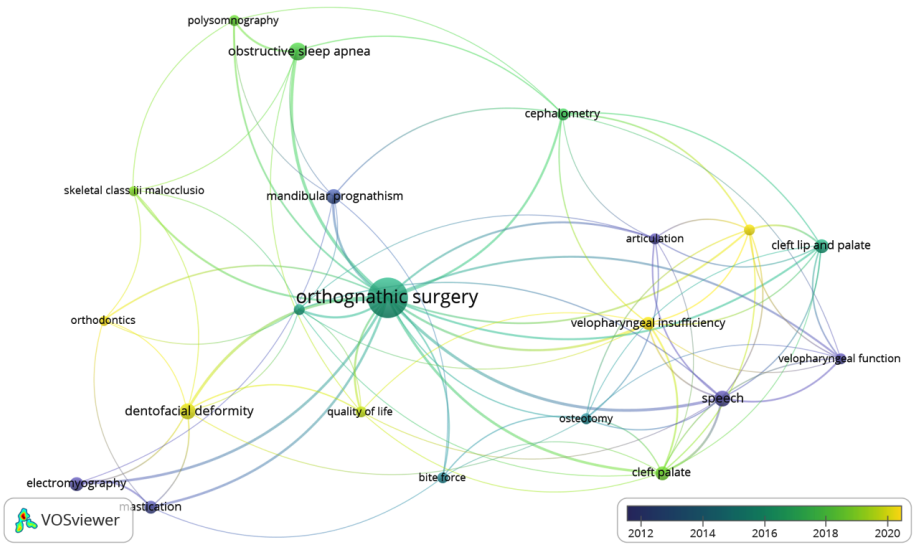

Figure 6. Co-occurrence network, where each node represents a keyword, and the thickness between the nodes represents the strength of the relationship between the keywords, determined by how frequently they appeared together in publications. Cluster 1 (Purple), Cluster 2 (Yellow), Cluster 3 (Green).

Scientific production and collaboration between countries

Figure 7 presents each country's relative importance in scientific production and how often they are cited in SS functions and OS research. Japan is the most cited country, with 594 citations, suggesting that it has a significant influence on scientific and academic production. The United States of America (USA) is the second most cited country, with 426 citations, while India ranks third, with 316 citations.

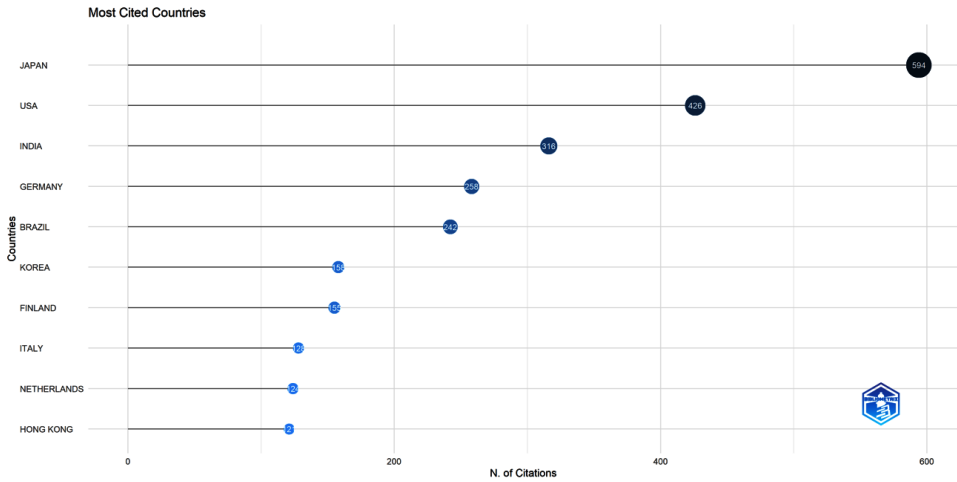

Figure 7. The most cited countries within the research context on SS and CO are shown.

Figure 8 compares the production of scientific articles over time among six countries: Brazil, China, India, Japan, South Korea, and the USA. Trends in production can be identified for each country, as well as a comparison of their performance over the years. Brazil had a relatively stable output of articles until 2008 when it began to increase. China experienced a steady rise in article production, with accelerated growth starting in 2018. India also grew consistently in article production, with a more pronounced increase beginning in 2016. Japan saw gradual growth in article production until 2012 when output stabilized. South Korea experienced steady growth in article production until 2013 when it stabilized and then increased again in 2016. The USA grew steadily in article production until 2013, after which it stabilized and then rose again in 2018. The overall trend of the graph indicates an increase in article production across all six countries, with China and India standing out.

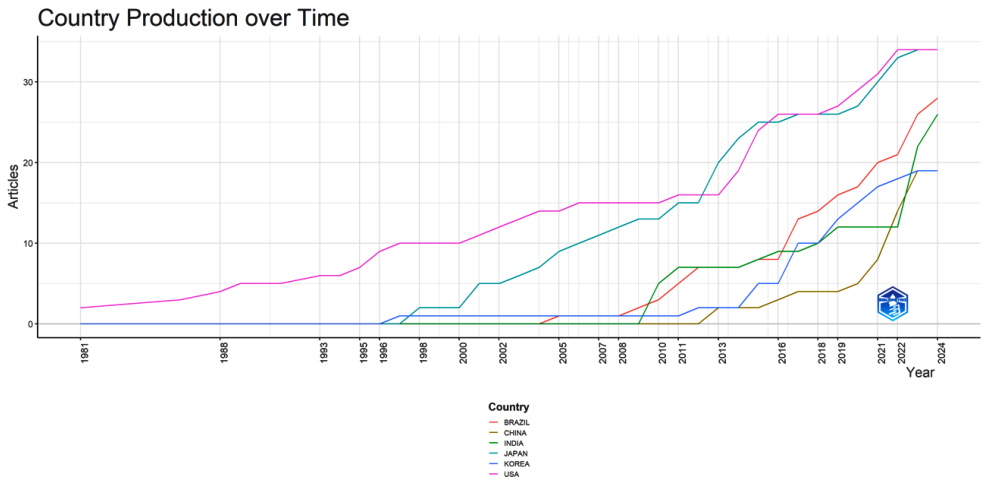

Figure 8. The temporal evolution of scientific production on orthognathic surgery related to the functions of the stomatognathic system from the six most productive countries per year is presented.

Figure 9 presents the countries with the most published articles, considering the affiliation of the corresponding authors. Japan ranks first, with 24 published articles, followed by Brazil with 20 articles, the USA with 17 articles, South Korea with 15 articles, and China with 11 articles – of which two include contributions from authors affiliated with institutions in other countries. Likewise, one of the 11 articles published in India counts on contributions from authors from other institutions. Italy has nine published articles, while Finland, Germany, and Turkey have seven published articles each. One author in Turkey is affiliated with institutions from other countries.

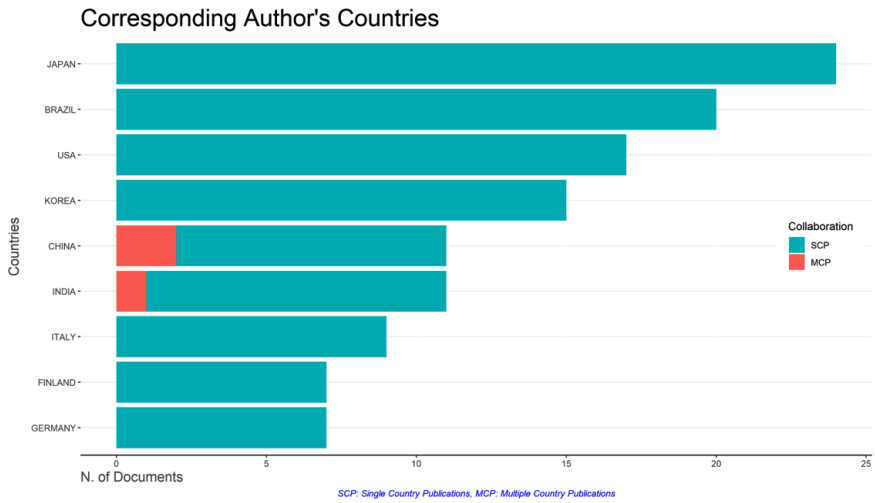

Figure 9. Correspondence between authors from countries with the highest number of published articles on the topic. SCP: Single Country Publication, MCP: Multiple Countries Publication.

Discussion

The scientometric study provided important insights into the scientific field and identified trends and patterns by developing a scientific mapping of the literature on OS related to SS functions. The analysis of data from the PubMed, Scopus, and Web of Science databases found that the number of OS and SS publications has gradually increased annually. The increase in the number of publications and journals in which the articles are published expands the area where the literature is distributed. Hence, the scientific mapping developed in this study highlights the importance of collaboration and its impact on the dissemination and advancement of scientific knowledge.

Furthermore, the temporal variation reflects the dynamics of scientific research in the field and highlights potential contextual influences. OS studies tend to include new aspects due to the evolution and changes in methods, techniques, and correlations[34]. Thus, the growing interest in OS and its interrelations will continue to rise.

The countries' contributions to the literature indicate that Japan, Brazil, the USA, South Korea, and China are the top five countries in the number of publications in the field. In this context, a bibliometric study identified the USA as leading with 37 articles on OS, followed by the United Kingdom and Germany with nine each, the Netherlands with six, Japan with five, Taiwan, Hong Kong, Denmark, Canada, and Belgium with four articles each, and South Korea, Italy, and Spain with two[34]. On the other hand, the study by Wong et al.[35] (2023) identified South Korea as the country with the most publications and citations, followed by China and Germany, focusing on the use of artificial intelligence in OS.

This scenario reflects significant changes in the geographic distribution of OS research. While the USA maintains its historical leadership in publications, Asian countries like South Korea and China rose significantly, which may be associated with technological development, particularly regarding the use of artificial intelligence in interventions. The substantial participation of European countries, such as Germany and the United Kingdom, also indicates a growing interest in advancements in this area[4]. Therefore, the current scenario suggests diversified scientific contributions, with greater involvement from countries that previously played secondary roles in the literature on OS.

On the other hand, only China, India, and Turkey collaborated with institutions, universities, or research centers from other countries, revealing a trend of limited scientific cooperation. The impact of global collaboration on knowledge dissemination is highly positive. Different research centers have varying technological densities; by interacting, authors contribute to a faster and more integrated advancement of the field, helping standardize surgical techniques, improve clinical practices, and diversify scientific approaches[36].

International collaboration networks are essential. However, there is limited progress, generally associated with authors sharing a common third collaborator[37]. China, India, and Turkey are the main protagonists in this collaborative scenario, while the participation of other nations in OS and SS studies is nonexistent. This suggests the need to allocate resources to invest in research and research groups with collaborators from other universities and institutions.

These data highlight the importance of collaboration in scientific production. The average of approximately 4.99 co-authors per study on this topic demonstrates that scientific research is characterized by collective and collaborative work. OS patients are involved by establishing multidisciplinary teams to achieve the best prognosis for them[38]. Thus, collaborative scientific production helps establish evidence-based practices. The development of a collaborative network suggests an understanding of the impact of OS on orofacial functions and the trends and patterns in the field, through the technical analysis of the study teams. However, potential biases in citation patterns should be acknowledged. For instance, foundational theoretical papers may receive more citations than impactful clinical studies, which could skew the perceived relevance of certain research areas. Addressing these biases is critical to ensuring a balanced representation of both theoretical and clinical contributions in the field.

Another noteworthy factor is that the scientific journals that have most contributed with publications on OS and the SS functions are predominantly from dentistry. This is an interesting point, as the SS functions are also a subject of study for other professionals, such as speech-language-hearing pathologists[39]. These data indicate that the dissemination of research in this area is largely concentrated in certain journals focused on facial surgery and orthopedics with an emphasis on dentistry. However, the study conducted by Grillo[34] (2021) shows that, although there is a greater number of publications in the Journal of Oral and Maxillofacial Surgery, there are also journals related to orthodontics, radiology, biomedicine, plastic surgery, and otorhinolaryngology. OS is a complex procedure, requiring that professionals have a broad range of knowledge in related fields, not just oral and maxillofacial surgery.

This can be explained by the fact that understanding the impact of orthognathic surgery is a priority in dentistry to enable minimally invasive approaches and improve postoperative outcomes. However, other fields do not yet seem to be aligned with these emerging clinical needs. This review highlights a visible gap in translating knowledge into clinical practice, reinforcing the need for greater dialogue between researchers, clinical professionals, and the multidisciplinary team.

The longitudinal analysis of scientific productivity, combined with the identification of prominent authors and institutions, provides an in-depth view of the evolution and dynamics of the field of study. The variation in scientific output among researchers indicates the different stages of academic maturity[40]. Early-career researchers often have lower productivity or thematic diversification in their publications as they establish their research lines. In contrast, consolidated researchers tend to increase their productivity, influenced by greater access to resources and the need to maintain or progress in their academic trajectories[40] – a pattern exemplified by Choi J and Throckmorton G.

These authors are affiliated with recognized institutions – the Department of Oral and Maxillofacial Surgery at the University of Pennsylvania Hospital and the Department of Cellular Biology at the University of Texas. This highlights the importance of being connected to institutions with adequate infrastructure and support for high-quality research.

The h-indexes of Lee J (h = 21) and Marukawa K (h = 19) indicate not only the number of publications but also the relevance and impact of their research in the field. The number of article citations is also an important metric regarding the state of OS and SS studies. The total number of citations of the 10 most cited articles ranged from 63[32,33] to 270[24]. The h-index holds significant value as it reflects both the quantity and quality of scientific contributions. A researcher with a high h-index has not only produced numerous publications but also has their work widely recognized and cited by other researchers. This indicates that their contributions are impactful and relevant within their area of expertise[41].

Keywords are essential for the precise identification of a paper's topic, linking the content with search mechanisms. By using controlled vocabulary, keywords facilitate efficient indexing, which in turn enhances the retrieval of information in bibliographic searches[42]. The keywords included two different areas – dentistry and speech-language-hearing pathology. However, there is a notable relationship between orofacial myofunctional changes and the intervention to restore the SS functions, as evidenced by the keywords that connect the two fields: "orthognathic surgery," "obstructive sleep apnea," "speech," "cleft lip and palate," and "dentofacial deformity."

In the analysis of keyword co-occurrence, larger nodes typically represent a higher degree of relevance for a specific keyword within the dataset. The proximity between the nodes reflects the strength of the association between two keywords – i.e., shorter distances indicate stronger relationships between the terms[43]. Furthermore, the thickness of the lines connecting the nodes suggests the frequency with which these keywords occur together – thicker lines indicate more frequent co-occurrences[43].

A wide variety of keywords can be found, encompassing advanced diagnostic and assessment methods (e.g., "electromyography, polysomnography, cephalometry"), structural and skeletal changes (e.g., "cleft palate, cleft lip and palate, velopharyngeal insufficiency, Class III malocclusion, dentofacial deformity, mandibular prognathism"), and functional areas and influences (e.g., "orthodontics, quality of life, speech, bite force, obstructive sleep apnea"). These generic keywords represent the most researched areas in the literature on OS and SS functions. The maxilla and mandible are facial bones that serve as the foundation for the dental arches. Therefore, changes in these structures can affect occlusal relationships and functions, which may result in malocclusions or functional changes[44]. Furthermore, obstructive sleep apnea is expected in cases of severe mandibular retroposition, due to the structural and biomechanical changes in breathing[44].

This study's scientific mapping provides general data on the connection between OS and SS functions. However, despite the trend of increasing speech-language-hearing and dentistry publications in recent decades, there are still relatively few studies in these areas. Future research should focus on bridging these gaps by fostering interdisciplinary collaboration and addressing underrepresented topics, such as the long-term clinical outcomes of OS interventions and the integration of emerging technologies into practice.

Limitations

Although 389 keywords have been identified, providing a comprehensive view of the topics addressed, 65 studies (29%) did not present keywords, which may compromise the consistency of the analysis. Keywords are critical for identifying thematic patterns and relationships between topics in scientometric studies. When a significant portion of the dataset is missing keywords, this can lead to an incomplete or biased representation of the research landscape, as the analysis may overlook relevant topics or overemphasize others.

Furthermore, the current study carefully and cautiously interpreted the co-occurrence results, recognizing that the absence of keywords in some articles may bias the overall findings. Moreover, the number of citations reflects only the popularity and influence of a study, but not necessarily the quality of the research.

Future research directions

This study highlights several avenues for further exploration in orthognathic surgery research. First, the role of artificial intelligence and machine learning in predicting trends and analyzing large datasets could be explored to enhance the understanding of emerging topics and their impact on the field. Second, a more in-depth analysis of cutting-edge themes, such as 3D printing and digital workflows, in citation patterns and keyword co-occurrence networks is warranted to assess their growing influence. Finally, future studies could investigate whether interdisciplinary collaboration between dentistry, surgery, and speech-language-hearing pathology is increasing by analyzing keyword trends and co-authorship networks. These research directions would offer valuable insights into the evolving landscape of OS research and its integration with related disciplines.

In conclusion, the scientific mapping highlights an increasing and gradual growth rate of articles on OS and the SS functions. International collaboration networks among countries and scholars are limited, although there has been an uptick in productivity in recent years. Most often, authors belong to research groups within the same country, with few studies developed by individual authors.

The Journal of Oral and Maxillofacial Surgery stands out with the most publications in the field. The study by Vijayakumar Jain et al.[24] (2019) is the most impactful article. Among the keywords, OS and SS functions bridge the fields of dentistry and speech-language-hearing pathology and are associated with "orthognathic surgery," "obstructive sleep apnea," "speech," "cleft lip and palate," and "dentofacial deformity."

Studies on OS and SS functions continue to expand, highlighting the need for increased research on the impact of OS on SS functions.

Declaration of Conflicting Interests

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Ethical Statement

This Scientometric study only analyzed data obtained from Scopus, Web of Science, and PubMed. The process of using data did not involve ethical problems. Therefore, this study did not require the approval of the ethics committee.

Informed consent/Patient consent

Is not applicable and not needed.

Author Contribution

Allya Francisca Marques Borges: contributed to data curation, software, and original draft preparation. **Lidiane Oliveira Leão:** contributed to data curation, software, and original draft preparation. **Rayane Délcia da Silva** contributed to the review and editing of the manuscript. **Sofia Helyeth Ramirez Cardenas:** contributed to data curation, software, and original draft preparation. **Cristiano Miranda de Araujo** contributed to conceptualization. **Renata Veiga Andersen Cavalcanti** contributed to supervision and validation. **Karinna Veríssimo Meira Taveira** contributed to data curation, software supervision, conceptualization, and validation. All authors approved the final version of the work and are accountable for all aspects of the work.

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Appendix 1. Database search strategy.

Database	Search (April 24th 2024)
PubMed/ Medline	#1. "Dentofacial Deformities"[Mesh] OR "Dentofacial Deformities" OR "Dentofacial Deformity" OR "Dentofacial Abnormalities" OR "Dentofacial Abnormality" OR "Orthognathic Surgery"[Mesh] OR "Orthognathic Surgery" OR "Orthognathic Surgeries" OR "Maxillofacial Orthognathic Surgery" OR "Orthognathic Surgical Procedures" OR "Orthognathic Surgical Procedures"[Mesh] OR "Orthognathic Surgical Procedures" OR "Orthognathic Surgical Procedure" OR "Maxillo-Mandibular Surgery" OR "Maxillo Mandibular Surgery" OR "Maxillofacial Orthognathic Surgery" OR "Maxillofacial Orthognathic Surgeries" OR "surgical-orthodontic" OR "Orthognatic" OR "orthodontic-surgical" OR "orthodontic-surgery" #2. "Stomatognathic System"[MeSH] OR "Masticatory System" OR "Masticatory Systems" OR stomatognathic OR "Mastication"[MesH] OR Chewing OR "Sucking Behavior" OR "Sucking Behaviors"[MeSH] OR sucking OR "Deglutition"[MeSH] OR deglutitions OR Swallowing OR swallowings OR "Speech"[MeSH] OR "Respiration"[MeSH] OR Breathing OR voice OR voices OR Phonations #3. #1 AND #2
Scopus	(TITLE-ABS-KEY ("Dentofacial Deformities" OR "Dentofacial Deformity" OR "Dentofacial Abnormalities" OR "Dentofacial Abnormality" OR "Orthognathic Surgery" OR "Orthognathic Surgeries" OR "Maxillofacial Orthognathic Surgery" OR "Orthognathic Surgical Procedures" OR "Orthognathic Surgical Procedure" OR "Maxillo-Mandibular Surgery" OR "Maxillo Mandibular Surgery" OR "Maxillofacial Orthognathic Surgery" OR "Maxillofacial Orthognathic Surgeries" OR "surgical-orthodontic" OR "Orthognatic" OR "orthodontic-surgical" OR "orthodontic-surgery") AND TITLE-ABS- KEY ("Stomatognathic System" OR "Masticatory System" OR "Masticatory Systems" OR stomatognathic OR mastication OR Chewing OR "Sucking Behavior" OR "Sucking Behaviors" OR sucking OR Deglutition OR deglutitions OR Swallowing OR swallowings OR Speech OR Respiration OR Breathing OR voice OR voices OR Phonations))
Web of Science	TÓPICO: ("Dentofacial Deformities" OR "Dentofacial Deformity" OR "Dentofacial Abnormalities" OR "Dentofacial Abnormality" OR "Orthognathic Surgery" OR "Orthognathic Surgeries" OR "Maxillofacial Orthognathic Surgery" OR "Orthognathic Surgical Procedures" OR "Orthognathic Surgical Procedure" OR "Maxillo-Mandibular Surgery" OR "Maxillo Mandibular Surgery" OR "Maxillofacial Orthognathic Surgery" OR "Maxillofacial Orthognathic Surgeries" OR "surgical-orthodontic" OR "Orthognatic" OR "orthodontic-surgical" OR "orthodontic-surgery") AND TÓPICO:("Stomatognathic System" OR "Masticatory System" OR "Masticatory Systems" OR stomatognathic OR mastication OR Chewing OR "Sucking Behavior" OR "Sucking Behaviors" OR sucking OR Deglutition OR deglutitions OR Swallowing OR swallowings OR Speech OR Respiration OR Breathing OR voice OR voices OR Phonations)

Appendix 2. Eligible articles for the scientometric review.

N	AUTHORS	TITLE	REFERENCE	JOURNAL - CODE	YEAR
1	Abrahamsson C, Henrikson T, Bondemark L, Ekberg E.	Masticatory function in patients with dentofacial deformities before and after orthognathic treatment-a prospective, longitudinal, and controlled study.	Eur J Orthod. 2015 Feb;37(1):67-72. doi: 10.1093/ejo/cju011.	European Journal of Orthodontics	2015
2	Abramson Z, Susarla SM, Lawler M, Bouchard C, Troulis M, Kaban LB.	Three-dimensional computed tomographic airway analysis of patients with obstructive sleep apnea treated by maxillomandibular advancement.	J Oral Maxillofac Surg. 2011 Mar;69(3):677-86. doi: 10.1016/j.joms.2010.11.037.	Journal of Oral and Maxillofacial Surgery	2011
3	Ahn J, Kim G, Kim YH, Hong J.	Acoustic analysis of vowel sounds before and after orthognathic surgery.	J Craniomaxillofac Surg. 2015 Jan;43(1):11-6. doi: 10.1016/j.jcms.2014.10.002.	Journal of Cranio-Maxillo-Facial Surgery	2015
4	Alaluusua S, Harjunpää R, Turunen L, Geneid A, Leikola J, Heliövaara A.	The effect of maxillary advancement on articulation of alveolar consonants in cleft patients.	J Craniomaxillofac Surg. 2020 May;48(5):472-476. doi: 10.1016/j.jcms.2020.02.002.	Journal of Cranio-Maxillo-Facial Surgery	2020
5	Alaluusua S, Turunen L, Saarikko A, Geneid A, Leikola J, Heliövaara A.	The effects of Le Fort I osteotomy on velopharyngeal function in cleft patients.	J Craniomaxillofac Surg. 2019 Feb;47(2):239-244. doi: 10.1016/j.jcms.2018.11.016.	Journal of Cranio-Maxillo-Facial Surgery	2019
6	Alam MK, Elbeshbeishy R, Abutayyem HM, Sghaireen MG.	Assessment of patient satisfaction and functional outcomes in orthognathic surgery.	J Pharm Bioallied Sci. 2024 Feb;16(Suppl 1):S561-S563. doi: 10.4103/jpbs.jpbs_864_23.	Journal of Pharmacy & Bioallied Sciences	2024
7	Al-Asfour A, Waheedi M, Koshy S.	Survey of patient experiences of orthognathic surgery: health-related quality of life and satisfaction.	Int J Oral Maxillofac Surg. 2018 Jun;47(6):726-731. doi: 10.1016/j.ijom.2017.12.010.	International Journal of Oral and Maxillofacial Surgery	2018
8	Ambrožič MK, Hočevar Boltežar I, Ihan Hren N.	Changes of some functional speech disorders after surgical correction of skeletal anterior open bite.	Int J Rehabil Res. 2015 Sep;38(3):246-52. doi: 10.1097/MRR.0000000000000123.	International Journal of Rehabilitation Research	2015
9	Aoyagi M, Oshima M, Oishi M, Kita S, Fujita K, Imai H, et al.	Computational fluid dynamic analysis of the nasal respiratory function before and after postero-superior repositioning of the maxilla.	PLoS One. 2022 Apr 28;17(4):e0267677. doi: 10.1371/journal.pone.0267677.	PLoS One	2022
10	Ballon A, Laudemann K, Sader R, Landes CA.	Patients' preoperative expectations and postoperative satisfaction of dysgnathic patients operated on with resorbable osteosyntheses.	J Craniofac Surg. 2011 Mar;22(2):730-4. doi: 10.1097/SCS.0b013e318207b700.	Journal of Craniofacial Surgery	2011

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11	Behbehani F, Al-Aryan H, Al-Attar A, Al-Hamad N.	Perceived effectiveness and side effects of intermaxillary fixation for diet control.	Int J Oral Maxillofac Surg. 2006 Jul;35(7):618-23. doi: 10.1016/j.ijom.2006.01.010.	International Journal of Oral and Maxillofacial Surgery	2006
12	Bergonzani M, Anghinoni ML, Pedrazzi G, Maglitto F, Varazzani A, Sesenna E, et al.	Nebulized hyaluronic acid improves nasal symptoms after orthognathic surgery: a randomized clinical trial.	Oral Maxillofac Surg. 2023 Dec;27(4):617-623. doi: 10.1007/s10006-022-01093-8.	Oral and Maxillofacial Surgery	2023
13	Bhandari SK, Issar Y, Rana RPS, Datana S.	Evaluating the quality of life among patients undergoing orthognathic surgery using a customized questionnaire a prospective study.	Apos Trends Orthod. 2023;13(2):100-5. doi: 10.25259/APOS_230_2022.	APOS Trends in Orthodontics	2023
14	Bhat M, Shetty S, Shetty P, Khan FA, Husain A, Ragher M.	Evaluation of patient and parent satisfaction after orthodontic treatment/orthognathic surgery for cleft lip and palate deformity.	J Pharm Bioallied Sci. 2019 May;11(Suppl 2):S184-S187. doi: 10.4103/JPBS.JPBS_289_18.	Journal of Pharmacy & Bioallied Sciences	2019
15	Bhatt K, Roychoudhury A, Bhutia O, Trikha A, Seith A, Pandey RM.	Equivalence randomized controlled trial of bioresorbable versus titanium miniplates in treatment of mandibular fracture: a pilot study.	J Oral Maxillofac Surg. 2010 Aug;68(8):1842-8. doi: 10.1016/j.joms.2009.09.005.	Journal of Oral and Maxillofacial Surgery	2010
16	Bianchi B, Ferri A, Brevi B, Di Blasio A, Copelli C, Di Blasio C, et al.	Orthognathic surgery for the complete rehabilitation of Moebius patients: principles, timing and our experience.	J Craniomaxillofac Surg. 2013 Jan;41(1):e1-4. doi: 10.1016/j.jcms.2012.07.002.	Journal of Cranio-Maxillo-Facial Surgery	2013
17	Biradar JM, Kumar M, Srinath N, Kadam HR, Tamboli AN, Shinde SU.	Assessment of posterior pharyngeal airway changes after orthognathic surgery using barium sulfate.	Cureus. 2023 Aug 2;15(8):e42836. doi: 10.7759/cureus.42836.	Cureus	2023
18	Bogusiak K, Kowalczyk T, Arkuszewski P.	Satisfaction with life in patients with skeletal Class III malocclusion after orthognathic surgery.	Dent Med Probl. 2016;53:236-46.	Dental and Medical Problems	2016
19	Bourdiol P, Soulier-Peigue D, Lachaze P, Nicolas E, Woda A, Hennequin M.	Only severe malocclusion correlates with mastication deficiency.	Arch Oral Biol. 2017 Mar;75:14-20. doi: 10.1016/j.archoralbio.2016.12.002.	Archives of Oral Biology	2017
20	Bowers J, Tobey EA, Shaye R.	An acoustic-speech study of patients who received orthognathic surgery.	Am J Orthod. 1985 Nov;88(5):373-9. doi: 10.1016/0002-9416(85)90064-8.	American Journal of Orthodontics	1985
21	Branco R, Korb L, Marques R, Rosa R, Berretin-Feli G.	Breathing pattern orthognathic surgery and head posture in dentofacial deformity.	Fisioter Mov. 2022;35:e35105. doi: 10.1590/fm.2022.35105.	Fisioterapia em Movimento	2022

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22	Bruguiere F, Sciote JJ, Roland-Billecart T, Raoul G, Machuron F, Ferri J, et al.	Pre-operative parafunctional or dysfunctional oral habits are associated with the temporomandibular disorders after orthognathic surgery: an observational cohort study.	J Oral Rehabil. 2019 Apr;46(4):321-329. doi: 10.1111/joor.12749.	Journal of Oral Rehabilitation	2019
23	Brusati R, Meazzini MC, Rezzonico A, Biglioli F, Garattini G, Battista VMA, et al.	Evaluation of a sample of patients with unilateral cleft lip and palate treated with a two-stage protocol.	J Craniofac Surg. 2018 Nov;29(8):2058-2064. doi: 10.1097/SCS.0000000000004789.	Journal of Craniofacial Surgery	2018
24	Bueno PM, Kiemle Trindade PA, Medeiros LH, Silva MM, Scomparin L, et al.	Bite force assessment before and after orthognathic surgery in individuals with repaired cleft lip and palate.	J Oral Biol Craniofac Res. 2021 Apr-Jun;11(2):138-142. doi: 10.1016/j.jobcr.2020.12.005.	Journal of Oral Biology and Craniofacial Research	2021
25	Cacho A, Tordera C, Colmenero C.	Use of Transcutaneous Electrical Nerve Stimulation (TENS) for the recovery of oral function after orthognathic surgery.	J Clin Med. 2022 Jun 7;11(12):3268. doi: 10.3390/jcm11123268.	Journal of Clinical Medicine	2022
26	Cacucci L, Ricci B, Moretti M, Gasparini G, Pelo S, Grippaudo C.	Surgical orthodontic treatment of a patient affected by type 1 myotonic dystrophy (Steinert Syndrome).	Case Rep Dent. 2017;2017:7957961. doi: 10.1155/2017/7957961.	Case Reports in Dentistry	2017
27	Cano-Rosás M, Vicente-Jiménez J, Diosdado-Cano JM, Suárez-Quintanilla D, González-Sarmiento R, Curto D, et al.	Oral rehabilitation as part of a multidisciplinary treatment in a case study of pigmentary incontinence.	Children (Basel). 2023 Sep 4;10(9):1505. doi: 10.3390/children10091505.	Children (Basel)	2023
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Appendix 3. Authors' keyword network. The keyword network includes terms cited by the authors at least five times in the analyzed studies.

id	Key words	y	x	Cluster	weight <Links>	weight <Total link strength>	weight <Occurrences>	score <average publication year>
21	ARTICULATION	0,586	0,1902	1	8	17	7	2010
35	BITE FORCE	0,0063	-0,4619	1	5	8	7	2014
42	CEPHALOMETRY	0,3324	0,5321	3	9	20	8	2017
55	CLEFT LIP AND PALATE	1,0418	0,1721	1	9	22	11	2016
57	CLEFT PALATE	0,6049	-0,4485	1	11	29	11	2018
79	DENTOFACIAL DEFORMITY	-0,6929	-0,279	2	8	19	13	2019
84	ELECTROMYOGRAPHY	-0,9974	-0,4783	2	4	15	11	2011
157	MALOCCLUSION	-0,387	-0,004	2	10	16	7	2015
165	MANDIBULAR PROGNATHISM	-0,2931	0,3072	3	7	14	12	2012
170	MASTICATION	-0,7935	-0,5426	2	5	15	9	2012
178	MAXILLARY ADVANCEMENT	0,8453	0,2149	1	9	23	7	2019
214	OBSTRUCTIVE SLEEP APNEA	-0,3922	0,7025	3	6	21	18	2017
237	ORTHODONTICS	-0,921	-0,0334	2	5	7	6	2020
240	ORTHOGNATHIC SURGERY	-0,1453	0,03	2	20	119	86	2015
244	OSTEOTOMY	0,3991	-0,3028	1	9	15	7	2014
267	POLYSOMNOGRAPHY	-0,5643	0,786	3	5	12	7	2018
284	QUALITY OF LIFE	-0,218	-0,2818	2	7	12	7	2019
318	SKELETAL CLASS III MALOCCLUSION	-0,8404	0,3231	2	6	10	6	2018
329	SPEECH	0,7684	-0,2463	1	10	35	13	2011
377	VELOPHARYNGEAL FUNCTION	1,0943	0,1386	1	8	19	7	2008
378	VELOPHARYNGEAL INSUFFICIENCY	0,5665	-0,0409	1	9	22	9	2020