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The application of ultrasonography to the masticatory system: A bibliometric analysis

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Abstract

Aim: This study aimed to summarize the current knowledge on ultrasound use in the masticatory system and establish a scientific foundation for future research.

Methodology: A literature search of the Web of Science database was completed in August 2024, following preliminary scans and searches conducted before August 2, 2024, to refine the approach. A total of 205 studies were included in the meta-analysis. Bibliometric analysis and data visualization were performed using VOSviewer and the R package Bibliometrix (Biblioshiny).

Results: The first study on this topic was published in 1991. The highest number of publications and citations occurred in 2023. Turkey was the top producer of articles, whereas Japan had the greatest impact. The Universidade Estadual de Campinas published the most papers, and the Academic Center for Dentistry, Amsterdam, was the most cited institution. Stavros Kiliaridis emerged as the most prolific author, and Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology (OOOO Journal) was the most productive journal.

Conclusion: This study conducted a comprehensive bibliometric analysis and visualization of research on ultrasound use in the masticatory system using literature from the Web of Science Core Collection database covering 1991 to 2024. The current focal areas and future research avenues were identified. This research also clarified the historical foundations and prevailing trends in ultrasound application within this field, offering a nuanced perspective for scholars.

Keywords: bibliometrics, masseter muscle, masticatory system, ultrasonography

Introduction

The temporomandibular joints, teeth, supporting jaw structures, masticatory muscles (including the lips and tongue), and vascular and neurological systems that supply these tissues collectively constitute the masticatory system, which is a functional unit. Any part of the masticatory system may experience structural or functional disruptions, which may result in analogous problems in other parts of the system (1).

Ultrasonographic imaging (USG) is one of the most commonly employed diagnostic techniques in dentistry. This technique is used to assess a multitude of dental problems, including diseases of the salivary glands, cervical lymphadenopathy, soft tissue tumors, and disorders of the masticatory and neck muscles. Furthermore, it is employed as an effective diagnostic instrument in emerging domains including orthodontics, implantology, mucosal lesions, periodontal tissues, temporomandibular joint disorders, tongue tumors, maxillofacial fractures, periapical lesions, dental caries, cracks, and fractures (2). USG represents a validated approach for evaluating the masticatory system, offering valuable insights into structural alterations in the muscles. USG provides a straightforward and reliable method for examining the function and interactions of the jaw muscles within the craniomandibular system (3). USG allows for the effective real-time monitoring of normal and pathological muscle tissues, making it a convenient and noninvasive technique (4).

Bibliometric analysis is a widely employed method for the qualitative and quantitative assessment of published materials. Bibliometric analyses employ software to evaluate the contributions of different countries, institutions, journals, and academics in a specific field. Additionally, they facilitate a comprehensive examination of the knowledge structure and evolution of a given discipline, offering insights through visual representation (5). Bibliometric analysis is a commonly used method in various dental disciplines (6-8). Nevertheless, to the best of our knowledge, there is a lack of bibliometric investigations into the application of USG in the masticatory system.

The objective of this study was to conduct a bibliometric analysis of the literature on the use of ultrasonography in the masticatory system. This study aimed to comprehensively evaluate the field's leading authors, articles, journals, co-citation references, growth trends in publications, keywords, and contributions from nations, regions, and institutions.

The objective of this analysis was twofold: first, to present a comprehensive overview of the current state of knowledge regarding the application of ultrasonography in the masticatory system, and second, to establish a solid scientific foundation for further studies in this field.

Materials and Methods

A literature search of the Web of Science (WoS) database, created by the Institute for Scientific Information (ISI) and subsequently maintained by Clarivate Analytics, was conducted in August 2024. Before August 2, 2024, articles were scanned and pilot searches were conducted to refine the search strategy. During these pilot searches, the scope was expanded, and 485 studies were identified. The electronic search was performed with "all fields," which permitted the search of all searchable fields. Our search was comprehensive to avoid overlooking pertinent publications, and manual sifting was conducted to enhance accuracy. As a result of these pilot searches, the following keywords were used to determine the publications to be included in the study: "masticatory syst*" OR "muscl*" OR "masticat*" OR "masticatory musc*" OR "masticatory apparat*" OR "stomatognathic syst*" (All Fields) and "ultrasonog*" OR "usg*" OR "sonograph*" OR "diagnostic sonograph*" OR "medical ultrasoun*" OR "ultrasound scann*" OR "echo imagin*" OR "echograph*" (All Fields) and "dent*" OR "dentist*" (All Fields) were typed. A total of 485 studies were found. To filter these selected articles, the document type was selected as "article," "proceeding paper," "review," or "early access." During the screening process, the publication language was set to English, and only articles published in English were included in the study. After the filtering process, the articles were evaluated in terms of their relevance to the subject according to their titles and abstracts. In cases where suitability could not be determined, the full text of the study was opened and examined by a single author. The selected articles were saved on a marked list for further review. After these screening processes, 205 studies were selected. Bibliometric analysis and data visualization were conducted using VOSviewer (Center for Science and Technology Studies, Leiden University) and the Bibliometrix Biblioshiny R-package software (https://www.bibliometrix.org/home/index.php/layout/biblioshiny).

VOSviewer is a software program that facilitates the generation of bibliometric maps of authors or journals and maps of keywords using co-citation and co-occurrence data. This software enables users to conduct detailed explorations of bibliometric maps through its comprehensive viewer functionality (9). VOSviewer version 1.6.20, released on September 31, 2023, was downloaded from the official website of the VOSviewer program. The data in the ".txt" format, exported via the creation of a marked list, was opened with Microsoft Excel (Microsoft, Inc., Redmond, WA, USA), and the dataset was edited to prevent the program from making incorrect readings due to errors in the dataset. In the author section, "duarte gaviao, maria beatriz," "gaviao, m. b. d.," and "gaviao, maria b. d." were written in three different ways, and the program saw them as three different authors. Many name errors were corrected to prevent incorrect analyses. To identify different authors, the author information in the Web of Science was

checked; if the desired information could not be found, the author information in Scopus was checked, and if it could not be found there, an Internet search was conducted. In the countries section, spelling mistakes such as "Turkey" and "Turkiye" were corrected, although they refer to the same country. In the institutions section, "univ Gothenburg" and "Gothenburg univ" refer to the same institution, but the spelling was corrected to prevent the program from mistaking them for different institutions. In the journals section, "Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics," "Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology," and "Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology" were treated as a single journal, as they are the names of the same journal in different periods. Once the aforementioned errors were rectified, the data were exported as a text file . txt format using Microsoft Excel. It was then processed using the VOSviewer program to create visualizations

One particularly noteworthy open-source tool for conducting comprehensive science-mapping analysis is the Biblioshiny R-pack. It provides a recommended methodology for conducting a bibliometric analysis. The recommended tool is readily adaptable and straightforward to upgrade and integrate with other statistical R packages because it is written in the R programming language. Consequently, it is beneficial in a constantly evolving field, such as bibliometrics (10). The data were exported in the ".bib" file format and subsequently processed by the program, resulting in the generation of visuals. The tabulation of the data was conducted using Microsoft Excel software. In the visual map, distinct nodes correspond to the authors, institutions, references, keywords, and other elements. The size of each node reflects the quantity or frequency, whereas the thickness of the connecting lines indicates the strength of the relationship. The colors of the nodes indicate different clusters or time periods. As the research did not entail clinical trials or the utilization of patient data, ethical approval was not required.

Results

Growth in publications

A total of 205 articles were identified for review concerning the application of ultrasonography (USG) to the examination of the masticatory system. The initial publication on this subject was released in 1991. The greatest number of publications and the highest number of citations were recorded in 2023 and 2022, respectively. The subject has attracted considerable interest in recent years, as evidenced by the fact that over half of the articles published in this field were published from 2016 onwards. Moreover, 15 additional manuscripts were published by August 2024, and 19 articles were published in 2023. This indicates that the number of publications in 2024 will likely exceed that in 2023 (Fig. 1).

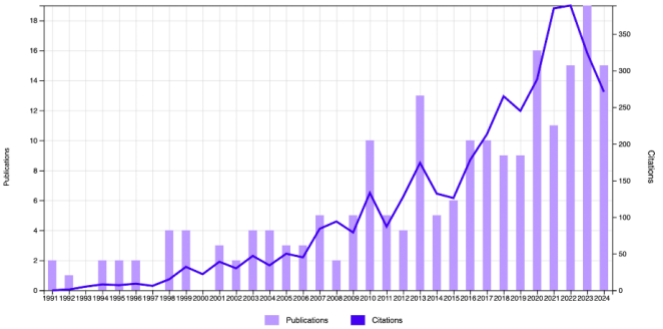

Figure 1. Global publication growth trends between 1991 and 2024. The number of publications per year is represented by each bar. The citations for this trend are shown by the line

Countries/regions and institutions

A total of 39 countries or regions published at least one article on the application of ultrasonography to the masticatory system between 1991 and 2024. Turkey published the greatest number of articles on the subject, with 39 articles, followed by India and Japan, which published 32 articles. Regarding the number of citations, Japan had the greatest impact, with 783 citations, followed by the Netherlands and Brazil, with 655 and 545 citations, respectively. Figure 2 presents a collaboration map of countries/regions on this subject, accompanied by a list of the five most prolific and cited countries on this topic. In the country/region collaboration map, each node in the network represents a country or region, with the size of the node corresponding to the number of publications in that country/region. The lines connecting the nodes represent inter-country collaboration. In terms of institutional affiliations, there were notable examples of robust collaborative relationships, including those with the following academic institutions: Universidade Estadual de Campinas, Universidade Federal de Lavras, and Universidade Federal de Sergipe (Fig. 3A). Each node in the visualization map of the collaborative network of institutions represents an institute. The number of publications is represented by the scale of each node. The collaboration between institutions is represented by the lines connecting the nodes. A stronger collaborative link is indicated by a thicker line connecting the nodes. Universidade Estadual de Campinas published the greatest number of papers, with a total of 14, followed by Yonsei University and the Aichi Gakuin University, which published 13 and 12 papers, respectively. In terms of citation figures, the Academic Center for Dentistry Amsterdam, University of Gothenburg, and Universidade Estadual de Campinas were the most highly cited universities, with 549, 515, and 349 citations, respectively. The five institutions with the highest number of publications and greatest influence are shown in Figures 3B and 3C.

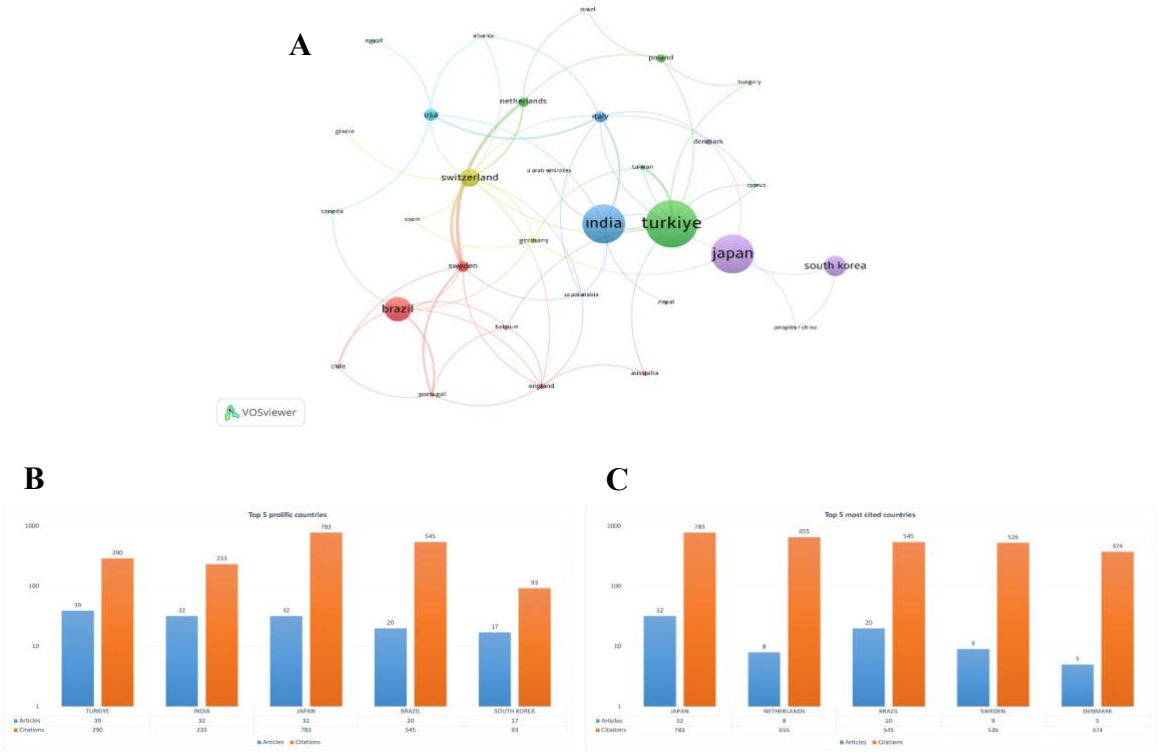

Figure 2. The collaboration map of countries and regions on this subject **(A)**, The most prolific five countries and regions in terms of publication numbers **(B)**, The most prolific five countries and regions according to citation numbers **(C)**.

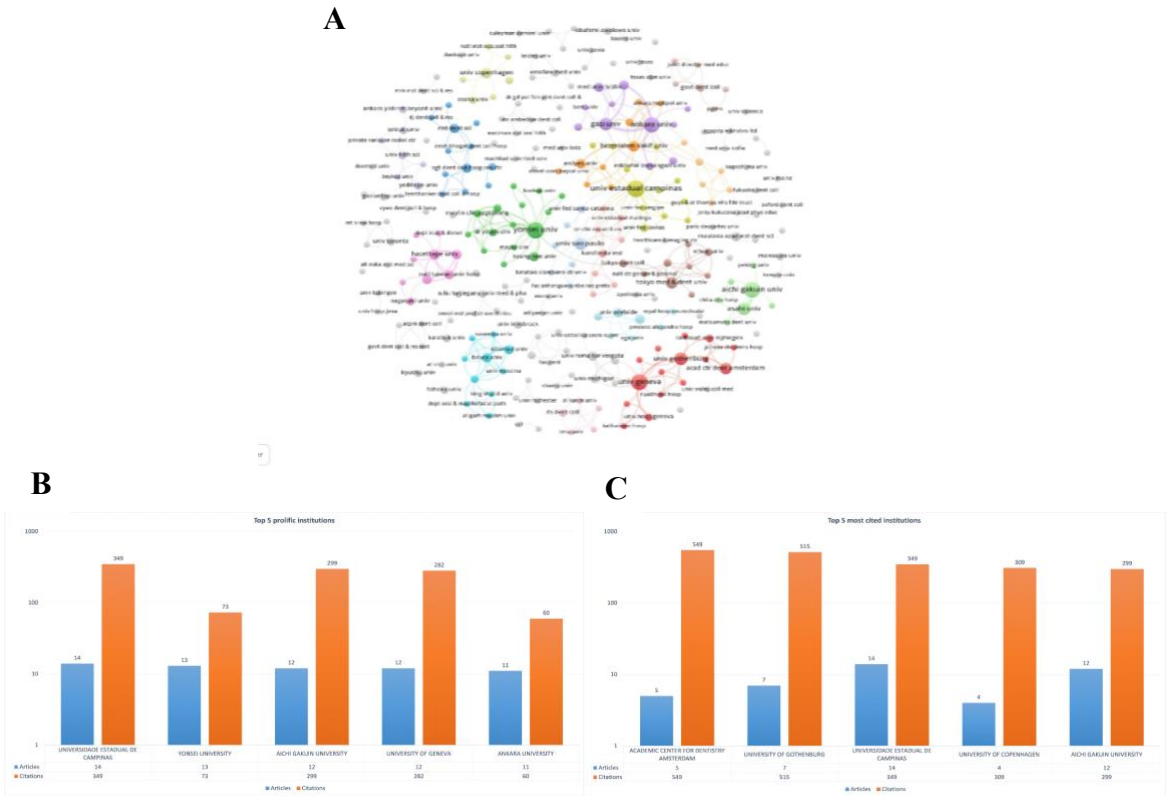

Figure 3. The collaboration network of institutions **(A)**, The most prolific five institutions on this topic **(B)**, The most cited five institutions on this topic **(C)**.

Authors

Author profiles extracted from the publications were analyzed to identify the most influential scholars in the field of ultrasonography application to the masticatory system. A total of 792 authors contributed to this topic. A collaboration map of the authors revealed that Arijii, Y., and Arijii, E. were the most frequently engaged in joint projects on this topic (Fig. 4A). Each node represents one author. The number of publications is represented by the scale of the node. The collaboration of the authors is represented by the lines connecting the nodes. In terms of productivity, Kiliaridis, S. (n = 15) was the most prolific author, followed by Arijii, Y. (n = 14) and Arijii, E. (n = 13). With regard to the attention paid to their work by other authors, the most significant impact has been made by Kiliaridis, S., Raadsheer, MC., and Prahl-Andersen, B., who were cited 600, 559, and 511 times, respectively. The most productive and frequently cited authors are presented in Figure 4, along with the authors' collaboration networks.

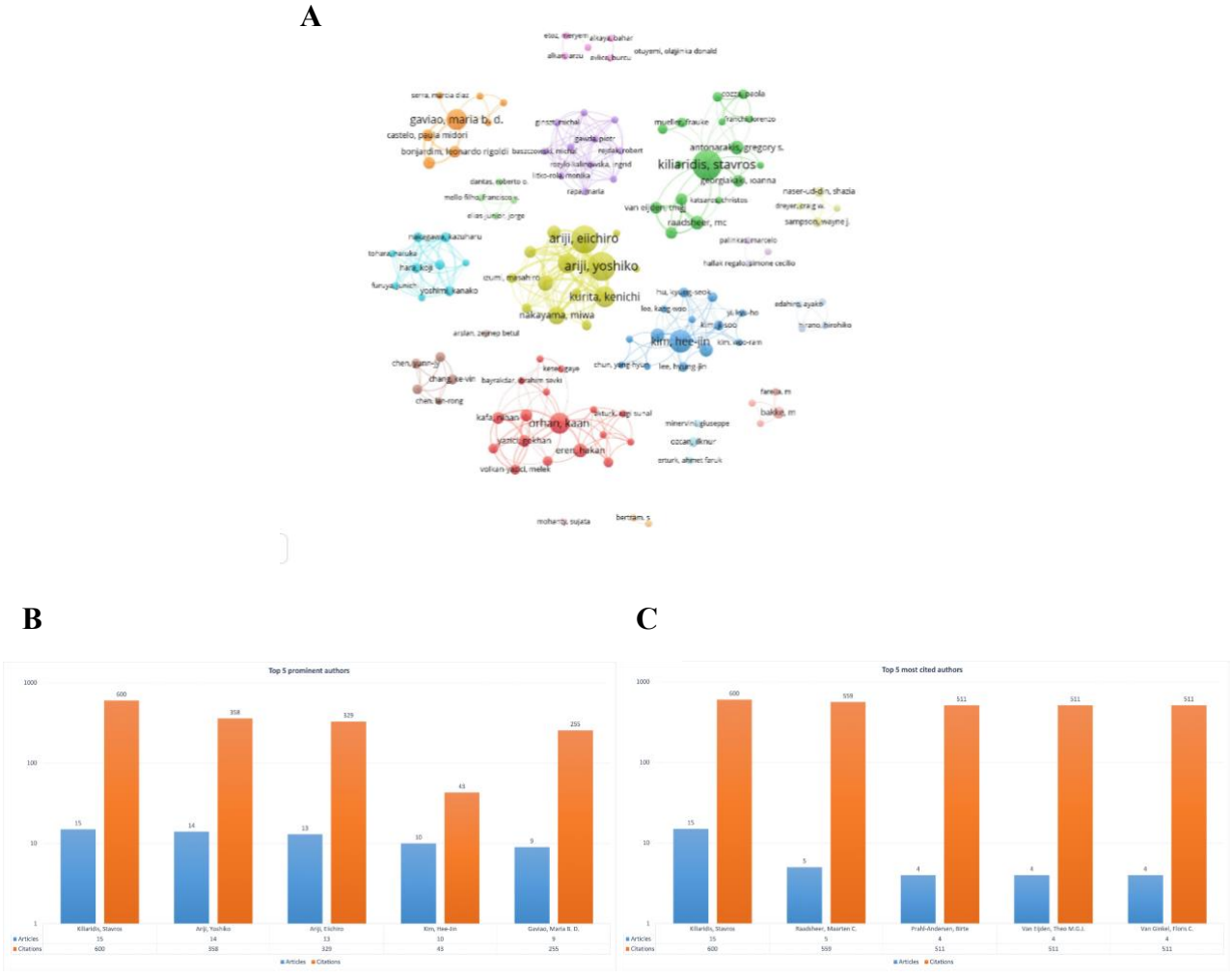

Figure 4. The collaboration map of the authors (A), the most productive five authors (B), and the most cited five authors (C).

Articles

The most highly cited articles provide a comprehensive overview of the evolution and current state of a research field, offering guidance to new researchers and informing the direction of ongoing studies. In this context, Table 1 presents a list of the ten most-cited articles.

Journals

Figure 5 presents the five most prolific journals, along with the number of publications and citations for each. The three most prolific journals were Oral Surgery, Oral Medicine, Oral Pathology, and Oral Radiology (OOOO Journal), with 14 publications. The European Journal of Orthodontics and Oral Radiology were the second and

third most productive journals, with 11 publications each. With regard to the number of citations, the most influential journals were the European Journal of Orthodontics, the Archives of Oral Biology, and the OOOO Journal, with 503, 447, and 354 citations, respectively.

Co-citation references

In the context of bibliometric analysis, a co-citation reference network can be defined as a network comprising nodes representing documents and edges reflecting the co-citation relationships between these documents. The term "co-citation" is used to describe the phenomenon of two documents being cited together by one or more subsequent documents. The application of co-citation analysis is beneficial for elucidating the structure and evolution of scientific fields, identifying seminal works, and discovering relationships between disparate areas of research. For illustrative purposes, a co-citation reference network map of references cited at least 20 times is provided in (Fig. 6).

Keywords

The authors' keywords, classified according to the number of years they have been used, are presented in Figure 7A. The most frequently occurring keywords were ultrasonography, masseter muscle, ultrasound, bruxism, and masticatory muscles (Fig. 7B). Figure 7C presents a word cloud of the keywords.

Table 1. Most cited 10 articles

Title	Author	Sources	Publication Year	Total Citations	Average Per Year	Type of Study
Contribution of Jaw Muscle Size and Craniofacial Morphology to Human Bite Force Magnitude	Raadsheer MC, Van Eijden TMGJ, Van Ginkel FC, Prahl-Andersen B.	Journal of Dental Research	1999	227	8.73	Article
Ultrasound Image of Human Masseter Muscle Related to Bite Force, Electromyography, Facial Morphology, and Occlusal Factors	Bakke, M, Tuxen A, Vilmann P, Jensen BR, Vilmann A, Toft M.	Scandinavian Journal of Dental Research	1992	167	5.06	Article
Masseter Muscle Thickness Measured by Ultrasonography and Its Relation to Facial Morphology	Kiliaridis S, Kalebo P.	Journal of Dental Research	1991	162	4.76	Article
Masseter Muscle Thickness in Growing Individuals and Its Relation to Facial Morphology	Raadsheer MC, Kiliaridis S, Van Eijden TMGJ, Van Ginkel FC, Prahl-Andersen, B	Archives of Oral Biology	1996	132	4.55	Article
Masseter Muscle Thickness, Chewing Efficiency and Bite Force in Edentulous Patients with Fixed and Removable Implant-Supported Prostheses: A Cross-Sectional Multicenter Study	Müller F, Hernandez M, Grütter L, Aracil-Kessler L, Weingart D, Schimmel M.	Clinical Oral Implants Research	2012	112	8.62	Article
Masseter Muscle Volume Measured Using Ultrasonography and Its Relationship with Facial Morphology	Benington PCM, Gardener JE, Hunt NP.	European Journal of Orthodontics	1999	102	3.92	Article
A Comparison of Human Masseter Muscle Thickness Measured by Ultrasonography and Magnetic-Resonance-Imaging	Raadsheer MC, Van Eijden TMGJ, Van Spronsen PH, Van Ginkel FC, Kiliaridis S, Prahl-Andersen B.	Archives of Oral Biology	1994	100	3.23	Article
Comparative Data on Facial Morphology and Muscle Thickness Using Ultrasonography	Satiroglu F, Arun T, Isik F.	European Journal of Orthodontics	2005	87	4.35	Article
Recent Advances of Ultrasound Imaging in Dentistry - A Review of The Literature	Marotti J, Heger S, Tinschert J, Tortamano P, Chuembou, F, Radermacher K, Wolfart S.	Oral Surgery Oral Medicine Oral Pathology Oral Radiology	2013	86	7.17	Review
Ultrasound Measurements of Superficial and Deep Masticatory Muscles in Various Postures: Reliability and Influencers	Chang PH, Chen YJ, Chang KV, Wu WT, Özçakar L.	Scientific Reports	2020	68	13.6	Article

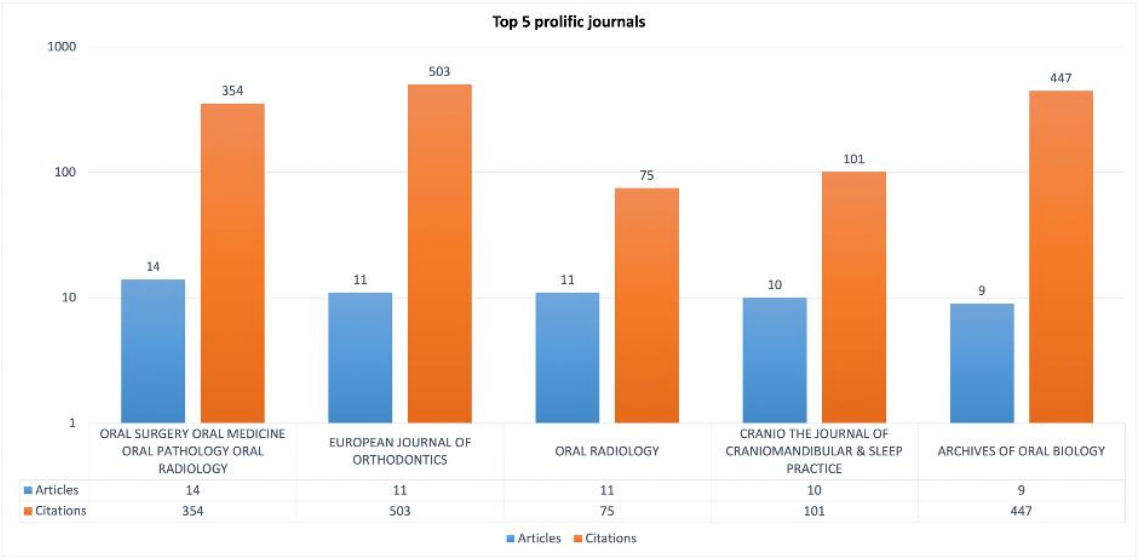

Figure 5. The five most prolific journals.

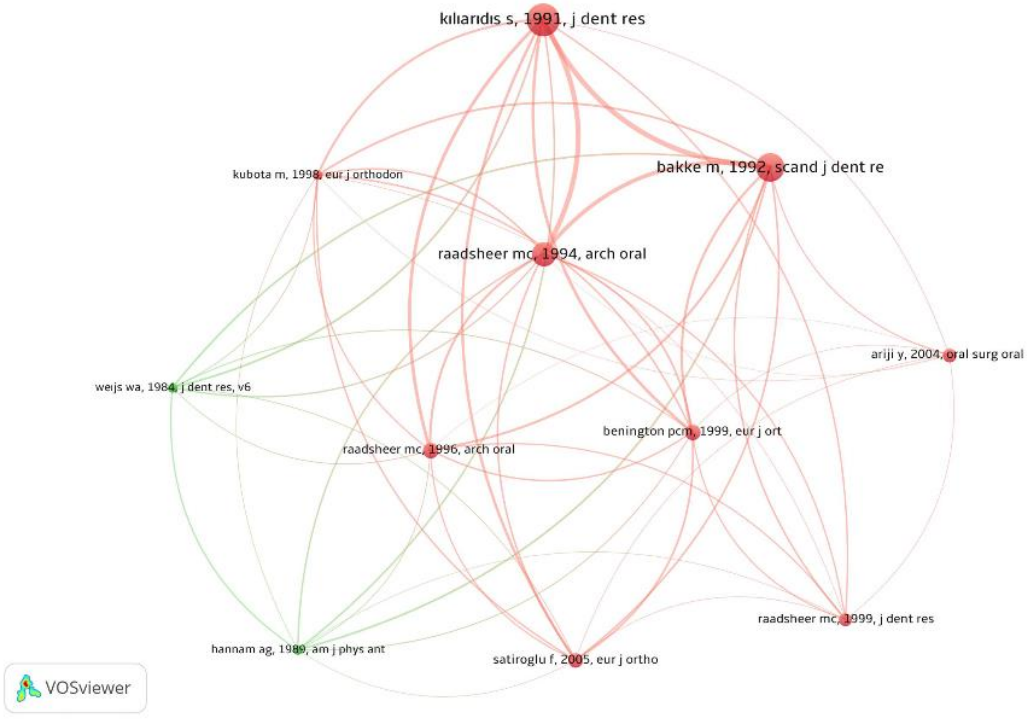

Figure 6. The co-citation reference network map of references cited at least 20 times.

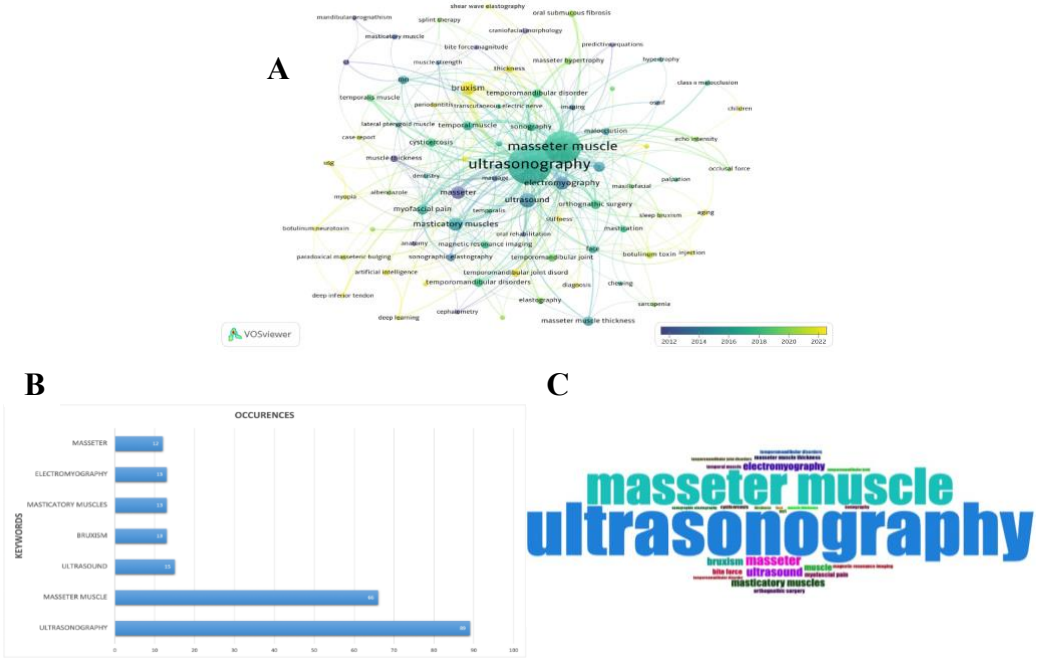

Figure 7. The VOSviewer cluster visualization of authors' keywords by year **(A)**, the most occuring authors' keywords on this field **(B)**, and word cloud of the authors' keywords **(C)**.

Discussion

Our findings indicated that between 1991 and 2024, 205 articles on the application of ultrasonography to the masticatory system were published by 792 authors across 39 countries and 306 affiliations. Of the 3,945 citations, 205 articles were cited 3,030 times without self-citations. The average number of citations per article was 19.24. In a bibliometric analysis conducted by Pirri et al. on the ultrasonographic examination of the musculoskeletal system, they stated that there has been a notable rise in interest in USG examination over the past decade, with a marked growth in the number of publications occurring after 2010 (11). However, a review of the literature revealed that nearly half of the articles on this topic were published in 2016 or later. The discrepancy in prevalence can be attributed to the fact that ultrasonography is employed in dentistry to a lesser extent than in medicine and that the utilization of this modality has gained popularity in the dental field in recent years. On the other hand, this review is in accordance with the growing interest in the use of ultrasonography over the past decade. This can be attributed to the growing prevalence of USG imaging among physicians of various specialties. In other words, as usage increases, so does the awareness of the potential for efficiency and effectiveness.

Considering the number of publications, Türkiye was the world leader in this discipline. Approximately one in four manuscripts published in Turkey on this subject was authored by Kaan Orhan from Ankara University's Faculty of Dentistry (39). Additionally, Orhan K. serves as the president of the Oral Diagnosis and Maxillofacial Radiology Society in Turkey. His contributions to the field may have inspired and influenced other researchers conducting related studies. In the most cited research in this field, Orhan et al. evaluated the impact of occlusal splint type (hard, soft, or semi-soft) on patients with bruxism using ultrasonography and electromyography (EMG). Their findings indicated that a reduction in EMG activity was observed with all three splint types, with the greatest decrease occurring in the hard occlusal splint group. To accurately assess muscle activity in patients with bruxism, it was recommended that ultrasonographic measurements of muscle length and thickness be employed in conjunction with EMG (12). Notwithstanding the aforementioned, Japan has had the most significant impact on this subject area in terms of citations (783). Japan has made a significant contribution to the development of this field, with 32 articles published. It can be observed that approximately half of the total number of publications were produced by Yoshiko Ariji and Eiichiro Ariji. These researchers were the source of 358 of the 783 citations from Japan. Furthermore, the most prolific collaborative output was created by them, from Aichi Gakuin University, Japan, that co-published 13 publications and had the largest network of collaborations. The study focused on the ultrasonographic profiles of the masseter muscle in female patients suffering from temporomandibular disorder (TMD) with myofascial pain, and compared them with those of healthy controls. The findings highlighted distinct ultrasonographic features in patients with TMD,

which may be indicative of muscle edema (13). The study garnered 57 citations. In other studies conducted by the aforementioned researchers, the normal findings of arteries in and around the masseter muscle were elucidated, as were the pathological changes observed with the use of color Doppler sonography. Moreover, an investigation was conducted to ascertain whether there was an association between muscle hardness, as measured using a hardness meter in healthy individuals, and the masseter muscle elasticity index (MEI) ratio, as assessed by sonographic elastography. The characteristics of masseter muscle hardness in patients with myofascial pain and temporomandibular disorder (TMD) were also investigated and elucidated. It was posited that color Doppler sonography represents a valuable technique for the description of arteries in and around the masseter muscle. Moreover, it has the potential to be employed in the depiction of pathological changes. Furthermore, the researchers proposed that sonographic elastography could be employed to quantify muscle hardness, potentially offering a valuable tool for visualizing the characteristics of muscles experiencing pain (14,15).

The University of Campinas in Brazil was a highly regarded institution among numerous international research organizations, largely because of the contributions of Maria Beatriz Duarte Gaviao. She was the author of nine of the 14 articles published by the university, and her work was cited 255 times out of a total of 349 citations. The study evaluated the maximum bite force, the number of occlusal contacts, and the masseter and anterior portion of the temporalis muscles' ultrasonographic thickness in children with normal occlusion and unilateral crossbite. The study focused on children in the primary and early mixed dentition stages of dental development. The objective of this study was to assess the characteristics of structural and functional malocclusions (16). In a further study, Pereira et al. demonstrated that in adolescents exhibiting symptoms of temporomandibular dysfunction, muscle thickness affects the proportions of the face and the force exerted during mastication (17). Of the 792 authors included in the study, Stavros Kiliaridis from the University of Geneva, Switzerland, was the most prolific and influential, publishing 15 articles that were cited 600 times. He received 162 citations, representing approximately a quarter of the total, for his 1991 study on masseter muscle thickness measured by ultrasound and its correlation with facial morphology. In collaboration with his colleague Kalebo P., he investigated the efficacy of ultrasonography in measuring the thickness of the masseter muscle. The findings indicated that this technique is a reliable and sensitive method for examining the thickness of the masseter muscle. Additionally, a significant inter-individual variance in muscle thickness was observed, along with a correlation between women's masseters and facial shape (18).

For the most cited articles, we found that earlier publication dates may have been associated with higher citation counts. This is because six of the ten most cited articles were published before 2000. Researchers have primarily examined the dimensions and volume of the masseter muscle and its connection to facial structure (18–22). The only significant correlation identified was between the masseter muscle thickness and magnitude of the bite force generated by the jaw muscles. Furthermore, the masseter muscle was found to contribute more to the variation in bite force magnitude than craniofacial factors. Raadsheer et al. investigated the relationship between the magnitude of bite force, jaw muscles, and craniofacial morphology. This study received 227 citations and was the most-cited article (19). Chang et al. conducted an investigation with the objective of identifying potential measurement confounders and developing a reliable ultrasonography (USG) methodology for imaging the superficial and deep masticatory muscles. They found that the reliability of USG in assessing superficial and deep masticatory muscle thickness was acceptable (23). However, this study was published recently, and it managed to gain attention with high citations and became one of the ten most cited studies, in contrast to the others.

In a total of 205 articles, the leading publication source in the field was Oral Surgery, Oral Medicine, Oral Pathology, and Oral Radiology, with the highest number of articles (n=14). Nevertheless, the European Journal of Orthodontics and the Archives of Oral Biology published fewer articles than the Journal of Oral Surgery, Oral Medicine, Oral Pathology, and Oral Radiology. However, they achieved a greater number of citations than the aforementioned journal, with 503 and 447 citations, respectively. A total of 55 articles were identified in the five most productive journals, 33 of which were published in 2013 or earlier. Following 2013, the Oral Radiology and Cranio-the Journal of Craniomandibular & Sleep Practice Journals published a total of 18 articles. In other words, these publishers were the most prolific in terms of publication numbers since 2013. However, they received fewer citations than the other publishers in this category. This may be attributed to the fact that a greater number of citations are often identified in works that were published at an earlier date. It is also important to note that citation counts can be influenced by a number of additional factors, including the specific research topic, the context of the publication, the identity of the authors, and the institutions with which they are affiliated.

A co-citation reference network map of references cited at least 20 times was employed, as illustrated in Figure 6. The most frequently cited references, with 69, 60, and 51 citations, respectively, were those of Kiliaridis et al., who measured masseter muscle thickness using ultrasonography and examined its relationship with facial morphology (18). Bakke et al.'s study, which employed ultrasonography to image human muscle in connection to facial morphology, electromyography, bite force, and occlusal variables, was another often cited source (20). Furthermore, Raadsheer et al. conducted a comparative analysis of the thickness of the human masseter muscle using both magnetic resonance imaging (MRI) and ultrasonography

(24). In conclusion, these scholars' contributions and their publications have constituted a fundamental basis for the advancement of this field of study.

Keyword analysis enables the formation of knowledge networks and illustrates the prevalence of contemporary topics. The findings of this study indicate that between 1991 and 2008, research within this field predominantly focused on the masseter muscle, its hypertrophy, and the impact of this on the morphology of both the facial and craniofacial regions, as well as on the magnitude of bite force.

Articles published between the aforementioned dates were of particular significance with regard to orthodontics and orthognathic surgery. This is because a significant number of researchers sought to determine whether there was a correlation between masseter muscle thickness, volume, and size and craniofacial morphology (18,20–22,25,26). The emerging keywords from 1991 to 2008 included "electromyography," "cysticercosis," and "alveolar process." Electromyography (EMG) is a commonly used technique for assessing alterations in masticatory muscle activity. The reliability of EMG data is enhanced by the fact that many of the craniofacial muscles are superficial (27). Given its noninvasive and nonionizing nature, high-resolution ultrasound plays an instrumental role in establishing a diagnosis in patients presenting with muscular cysticercosis (28). The objective of the investigation conducted by Jonasson et al. was to ascertain whether there is a correlation between masseter thickness and the mass of the mandibular alveolar bone and the thickness of the alveolar process (29). Between 2009 and 2019, we observed a notable expansion in the scope of this topic, which was increasingly employed across a diverse range of disciplines in dentistry. During the study period, new terms were coined, including 'myofascial pain', 'sonographic elastography', 'temporomandibular disorder', 'botulinum toxin', and 'oral submucous fibrosis'. A study was conducted on patients suffering from temporomandibular disorders to investigate the efficacy, suitability and safety of masseter and temporal muscle massage using an oral rehabilitation robot. Sonograms were employed to evaluate alterations in the thickness of the masseter muscle (30). Ultrasonic probes are employed in real-time tissue elastography, an imaging method that determines the physical characteristics of the tissue.

The distribution of tissue elasticity can be computed based on the strain and stress found in the tissue under examination (31). In a separate study, sonographic elastography was used to assess the rigidity of the masseter muscle (15). Botulinum toxin (BoNT) is a neurotoxin produced by the bacterium Clostridium botulinum. It inhibits the release of the neurotransmitter acetylcholine at neuromuscular junctions, resulting in a brief state of chemodenervation.

This substance is commonly used to treat masseter muscle hypertrophy. Park et al. demonstrated that botulinum toxin injection resulted in a change only in muscle thickness and had no impact on subcutaneous thickness from the skin surface to the masseter muscle (32). Histopathology is the gold standard for diagnosing oral submucous fibrosis (OSF); however, it may worsen the illness and leave scars. Ultrasonography (USG) has been used as a substitute method for measuring the cross-sectional area of the head and neck muscles in individuals diagnosed with OSF (33).

According to our findings, 76 articles, almost a third of the full manuscripts, were published in 2020 and later. New keywords were observed, including "artificial intelligence," "deep learning," "shear wave elastography." "Artificial intelligence" (AI) is defined as the utilization of computers or other devices to undertake tasks that would otherwise be completed by humans (34). The application of AI has facilitated considerable advances in the field of medical imaging, including ultrasound, in recent years (35). "Deep learning" represents one of the most recent developments among models created for artificial intelligence-based image analysis. Deep learning is employed to generate patterns for decision-making, emulating the manner in which the human brain processes information (36). With the help of networks that can learn from data, deep learning may be able to produce early radiological reports, suggest differential diagnoses, and automatically detect abnormalities.

The multilayer structure of multilayer perceptions is referred to as the "deep" aspect of deep learning. A hierarchy of features, which is a sophisticated composition of low-level input features, can be expressed by stacking many layers. Recently, deep learning techniques have been employed for the analysis of medical images and have yielded promising outcomes across a range of applications, such as image segmentation and registration on USG (34, 36). A recently coined term is shear wave elastography (SWE), which is a real-time diagnostic imaging method that provides quantitative tissue elasticity information in meters per second (m/s) or kilopascals (kPa). The fundamental principle of SWE is the measurement of the velocity of shear waves generated when local tissues are stimulated by acoustic impulses transmitted from the probes, resulting in tissue displacement. From the velocity of the wave, two elastic parameters can be inferred: shear modulus and Young's modulus. The use of shear wave elastography (SWE) to examine the masticatory muscles has recently been published in the scientific literature (37–39).

The evolution of keywords has facilitated the identification of prospective trends in the utilization of ultrasound guidance (USG) in relation to the masticatory system. One of the initial advancements is the growing prominence of artificial intelligence (AI) integrated with USG technology for the stomatognathic system. This can be achieved by several methods, including the segmentation of healthy members of the system, diagnosis of unhealthy conditions such as cysticercosis and temporomandibular disorder, comparison of AI-related parameters on different devices, including USG, and facilitation of decision-making for the treatment of diseases related to muscles and the temporomandibular joint. Moreover, as practitioners become more proficient

in the utilization of ultrasound guidance (USG), the deployment of diverse ultrasound machines, including the M-Turbo, in conjunction with sophisticated diagnostic imaging techniques such as shear wave elastography, will become increasingly prevalent.

Limitations

The bibliometric analysis in this study had some limitations and flaws. The publications were sourced exclusively from the WoSCC database, which may have resulted in the exclusion of influential manuscripts listed in other databases, including Scopus and PubMed. Moreover, this study was limited to English-language publications. Nevertheless, only four non-English publications were excluded, and these articles had a minimal impact on the main findings. Moreover, while the authors' profiles were analyzed to explore international collaboration, it was not possible to determine the specific level of contribution from each author, which may have resulted in an overestimation of collaboration. Nevertheless, our bibliometric analysis has elucidated the current situation, prospective development trends, and focal points of the utilization of USG in masticatory system research and may thus furnish researchers in this field with insight and ideas.

Conclusion

This study conducted an extensive bibliometric analysis and visualization of research related to the use of ultrasound in the masticatory system. We conducted the analysis by retrieving relevant literature from the WoSCC database covering the period from 1991 to 2024. Türkiye, India, and Japan were identified as the leading contributors in this field. The Universidade Estadual de Campinas in Brazil has been the most prominent institution in terms of publication output and global collaboration. Stavros Kiliaridis has emerged as the most prolific author in this area. The OOOO Journal is at the core of the publication of research on ultrasound use in the stomatognathic system. Furthermore, we investigated prospective avenues for future research and identified the current focal points of the field through analysis. In light of the aforementioned considerations, our investigation sought to elucidate the historical underpinnings and prevailing trends in the utilization of USG in this particular field, thereby offering a nuanced perspective for scholars.

Disclosures

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