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Application of Machine Learning in Orthodontics: A Bibliometric Analysis

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Abstract

Background: Machine learning (ML), a facet of artificial intelligence, utilizes algorithms to learn from data without explicit programming. In orthodontics, ML offers advantages like tailoring personalized treatment plans for patients. Despite its potential, there hasn't been a bibliometric analysis of ML studies in orthodontics. This study aims to fill that gap.

Types of studies reviewed: Articles on ML in orthodontics were reviewed from Web of Science Core Collection, Embase, Scopus, and PubMed. Data on journal details, country of origin, publication month, citations, keywords, and co-authorship were extracted.

Results: The search retrieved a total of 1478 articles, of which 701 were excluded. American Journal of Orthodontics and Dentofacial Orthopedics has published the most articles (3.6%), followed by the seminars in Orthodontics Journal (1.6%), and Orthodontics and Craniofacial Research Journal (1.6%). Most of the articles were from researchers from China (n = 156), the United States (n = 107), and South Korea (n = 70). The number of citations of the published articles ranged from 0 to 702, with most articles (75.54%) having at least one citation. Science Mapping analysis revealed that the most used keywords were Human(s) (n = 484), Artificial intelligence (n = 194), Female (n=169), Male (n = 161), and Cephalometry (n = 151).

Clinical implications: Clinicians should be aware of the emerging global collaborative landscape in machine learning trends, stay informed about technological advancements, and consider the potential impact of ML on patient care and treatment outcomes in their practices.

Keywords: Artificial intelligence, Machine learning, Orthodontics, Bibliometric analysis.

1. INTRODUCTION

Artificial intelligence (AI) is a general term for the use of a computer to simulate intelligent behavior with the least amount of human intervention [1]. Machine learning (ML) is a form of artificial intelligence that employs computer algorithms to learn from data without being precisely programmed [2]. Using ML has increased recently in some dental specialties, including endodontics, oral radiography, and orthodontics, because of its ability to assess patient data and provide more precise and effective decision-making [3–6].

Based on information from treatment plans, imaging data, and patient profiles, ML can help orthodontists diagnose orthodontic characteristics and predict treatment result [5]. Using ML in orthodontics has various benefits, such as creating individualized treatment plans for each patient based on their features, bone structure, and dental records [7]. As a consequence, therapy results are more consistent and efficient, giving patients improved outcomes.

Bibliometric studies in dentistry can be valuable as a practical and advantageous technique to evaluate the existing situation and to organize future studies [8]. The most cited papers or authors are found by a bibliometric analysis of scientific publications, such as journal articles and conference papers, which shows patterns and hotspots for future research. Bibliometric analyses are crucial because they can show gaps in the literature and where more research is needed to advance a subject of study [8, 9]. Therefore, due to the rapid pace of technological improvements in ML,

bibliometric studies can offer lucrative information on how the field of ML in orthodontics is currently developing.

To date, no study has performed a bibliometric analysis on studies that have been conducted on employing ML in orthodontics, despite the fact that some other bibliometric studies have been conducted in other fields of dentistry such as periodontology [10], orthodontics [11], and oral radiology [12]. In addition, a bibliometric analysis of the application of ML in orthodontics identifies research gaps and areas that need more study. In conclusion, this study aims to perform a bibliometric analysis on the application of ML in orthodontics due to a lack of prior studies and the importance of bibliometric analysis.

2. METHOD AND MATERIALS

This study's objective was to perform a bibliometric analysis of studies about the application of ML in orthodontics. This bibliometric analysis focused on the orthodontics-related articles and their authorship countries, journals, type of publication, number of citations, and year of publication to give an overall view of how ML has been employed in this field.

2.1 Data Sources and Search Strategy

Data from the Web of Science Core Collection (WoS), Embase, Scopus, and PubMed databases were accessed for this study without any language restriction until March 23, 2023. The search strategy was developed using MeSH, or medical subject heading keywords. To confirm the validity of the suggested concept, minimize the repetition of previously studied topics, and find relevant papers, two independent researchers conducted searches of these databases. In order to get the greatest number of relevant results, the final search technique was adapted to the features of each unique database. TABLE 1 contains the search strategies that have been used for each database.

2.2 Study Selection and Data Extraction

The EndNote software (Clarivate Plc, London, UK) was used to import and delete duplicates from comprehensive metadata that had been exported from the searched databases. Two independent researchers chose the studies that would be included in this analysis by reviewing the complete texts, titles, and abstracts of every article found in the electronic literature search. A high level of inter-examiner agreement (k=0.92) was subsequently reached by repeating the process. The outcomes were compared after both reviewers had finished selecting all pertinent publications. A third reviewer was invited to independently assess the paper for inclusion if there was a disagreement. Finally, unrelated articles to the study were omitted from the analysis.

Two different reviewers extracted the existing bibliographic information for all of the chosen articles, including the affiliations and countries of the authors, the year and type of publication, the title of the document, the names of the journals, the number of citations, and keywords. Consensus and discussion with a third reviewer were used to resolve any disagreements between the earlier two

Table 1: Specific search strategy for each database.

Database	Keyword	Result
Pubmed	(”Machine Learning”[Mesh] OR ”Deep Learning”[Mesh] OR ”Supervised Machine Learning”[Mesh] OR ”Unsupervised Machine Learning”[Mesh] OR ”Neural Networks, Computer”[Mesh] OR ”Artificial Intelligence”[Mesh]) AND (”Orthodontics”[Mesh] OR ”lateral cephalometric” OR ”cephalometric” OR Orthodontist OR ”Orthodontists”[Mesh] OR ”Dentofacial Orthopedist” OR ”tooth movement”)	187
Embase	(’machine learning’/exp OR ’machine learning’ OR ’deep learning’/exp OR ’deep learning’ OR ’supervised machine learning’/exp OR ’supervised machine learning’ OR ’unsupervised machine learning’/exp OR ’unsupervised machine learning’ OR ’artificial neural network’/exp OR ’artificial neural network’ OR ’artificial intelligence’) AND (’orthodontics’/exp OR ’orthodontics’ OR ’lateral cephalometric’ OR ’cephalometry’/exp OR ’cephalometry’ OR ’orthodontist’/exp OR ’orthodontist’ OR ’orthodontic tooth movement’/exp OR ’orthodontic tooth movement’)	523
Scopus	(TITLE-ABS-KEY (”Machine Learning”) OR TITLE-ABS-KEY (”Deep Learning”) OR TITLE-ABS-KEY (”Supervised Machine Learning”) OR TITLE-ABS-KEY (”Unsupervised Machine Learning”) OR TITLE-ABS-KEY (”Neural Network”) OR TITLE-ABS-KEY (”Artificial Intelligence”)) AND (TITLE-ABS-KEY (orthodontics) OR TITLE-ABS-KEY (”lateral cephalometric”) OR TITLE-ABS-KEY (”cephalometric”) OR TITLE-ABS-KEY (orthodontist) OR TITLE-ABS-KEY (”Dentofacial Orthopedist”) OR TITLE-ABS-KEY (”tooth movement”))	414
Scopus Secondary	(TITLE-ABS-KEY (”Machine Learning”) OR TITLE-ABS-KEY (”Deep Learning”) OR TITLE-ABS-KEY (”Supervised Machine Learning”) OR TITLE-ABS-KEY (”Unsupervised Machine Learning”) OR TITLE-ABS-KEY (”Neural Network”) OR TITLE-ABS-KEY (”Artificial Intelligence”)) AND (TITLE-ABS-KEY (orthodontics) OR TITLE-ABS-KEY (”lateral cephalometric”) OR TITLE-ABS-KEY (”cephalometric”) OR TITLE-ABS-KEY (orthodontist) OR TITLE-ABS-KEY (”Dentofacial Orthopedist”) OR TITLE-ABS-KEY (”tooth movement”))	56
Web of sciences	(TS=(”Machine Learning” OR ”Deep Learning” OR ”Supervised Machine Learning” OR ”Unsupervised Machine Learning” OR ”Neural Networks” OR ”Artificial Intelligence”)) AND TS=(”Orthodontics” OR ”lateral cephalometric” OR ”cephalometric” OR Orthodontist OR ”Orthodontists” OR ”Dentofacial Orthopedist” OR ”tooth movement”)	298

reviewers. Papers from Taiwan were excluded from the China category, and articles from England, Scotland, and Wales were classified as being from the UK. Google Scholar was used retrieving the number of citations for each paper.

2.3 Data Analysis and Visualization

The IBM SPSS statistics 26 SPSS (IBM, NY, USA) was used to do a descriptive analysis of bibliographic data. The search results were also imported into VOSviewer in RIS format (Leiden University's Center for Science and Technology Studies, Leiden, Netherlands; http://www.vosviewer.com) and with the minimum number of keyword occurrences set at 15 and the co-authorship number set at 5, network visualization was performed.

3. RESULTS

A flow diagram is used to display the search results (FIGURE 1). 233 articles were omitted based on the exclusion criteria after the 468 duplicated articles were removed. Therefore, 777 papers about the use of ML in orthodontics that were published up through March 23, 2023, were included in the study. In terms of document types, there were 188 undefined article types, 43 review papers, 75 conference papers, 13 editorial articles, and 458 original articles.

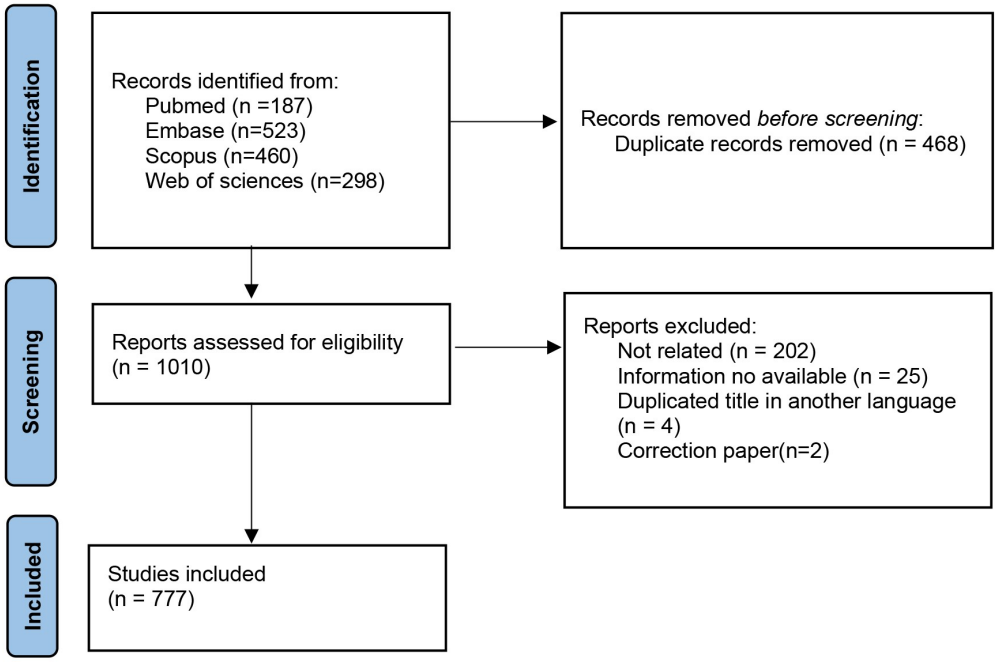

Figure 1: Flow diagram of the articles analyzed in the study

3.1 Countries

The authors of the analyzed publications were from 56 various countries. FIGURE 2 shows the contribution of each country to the distribution of ML in articles about orthodontics. More than half of the papers (n = 412; 53.1%) were written by authors from five countries. China and the United States accounted for 33.8% of articles (n = 263) followed by South Korea (n = 70, 9%), India (n = 42, 5.4%), and Germany (n = 37, 4.8%). FIGURE 3 shows the five major countries and their number of articles from 2020 to 2023.

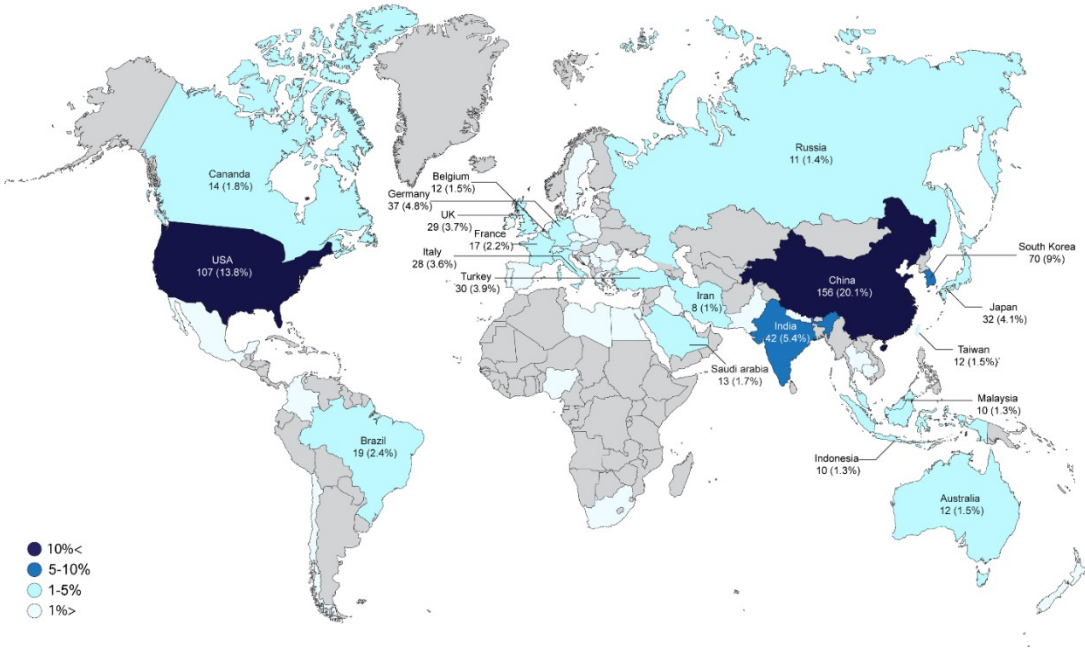

Figure 2: the contribution of each country within the distribution of machine learning in orthodontics related articles.

3.2 Year of Publication

The articles have been published since 1970 and the 2022 had the highest number of published articles with 224 papers. In addition, 66.7 % of the articles have been published from 2020 to 2023 (n=519) with 54.5 % of these articles being published from 2022-2023. More details are shown in FIGURE 4.

3.3 Journals

American Journal of Orthodontics and Dentofacial Orthopedics has published 28 articles (3.6%), followed by the Seminars in Orthodontics Journal with 13 articles (1.6%), Orthodontics and Cran-

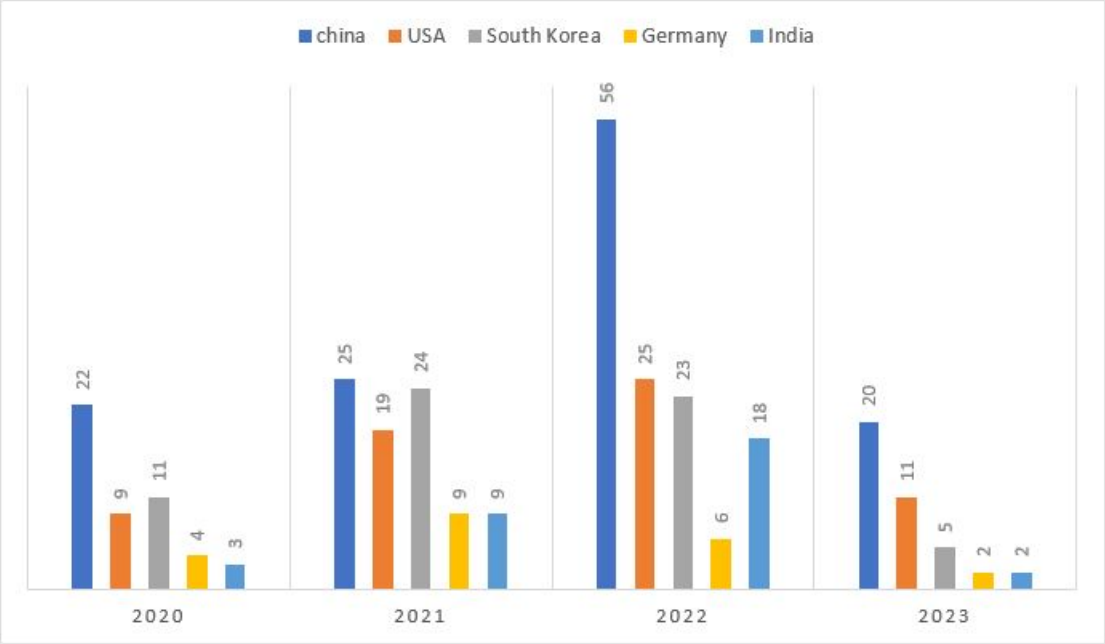

Figure 3: 5 major countries and their number of articles from 2020 to 2023.

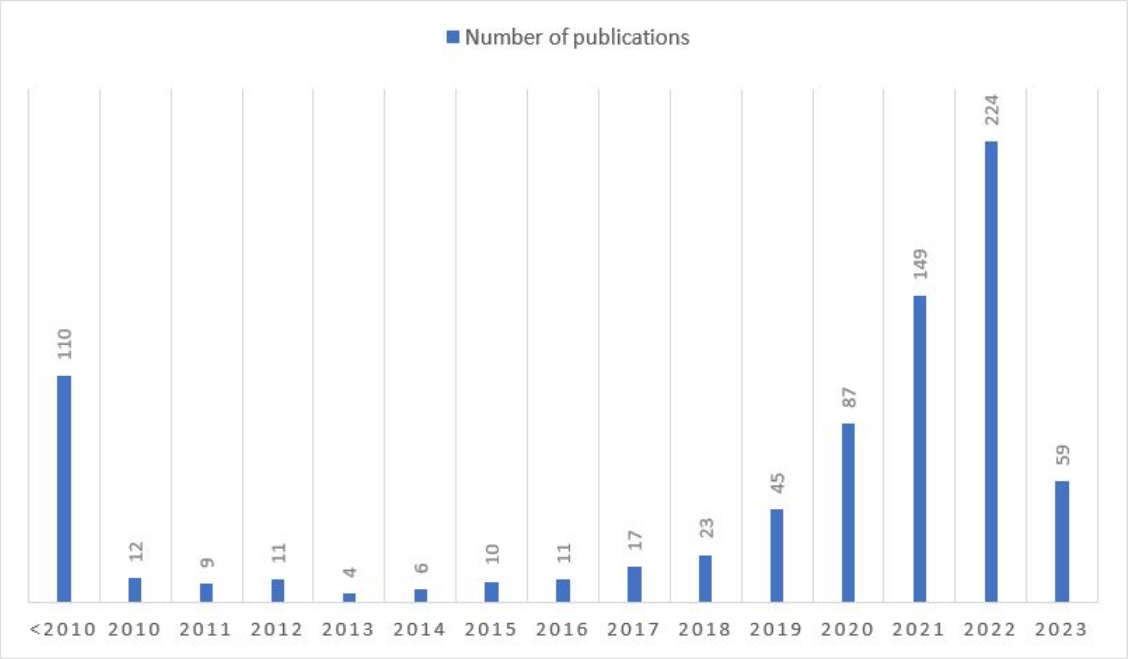

Figure 4: Number of publications based on the year of publication.

iofacial Research Journal with 13 articles (1.6%), the Journal of Clinical Medicine Journal with 11 articles (1.4%) and the Scientific reports journal and Diagnostic journal with 10 articles each (1.3%).

3.4 Citations

The studied articles were cited 14960 times, ranging from 0 to 702 citations per paper. There were 19.25 citations on average per paper and 587 publications had one or more citations. A methodology for evaluation of boundary detection algorithms on medical images, the most cited article, was published in the IEEE Transactions on Medical Imaging [13]. Further information is mentioned in FIGURE 5.

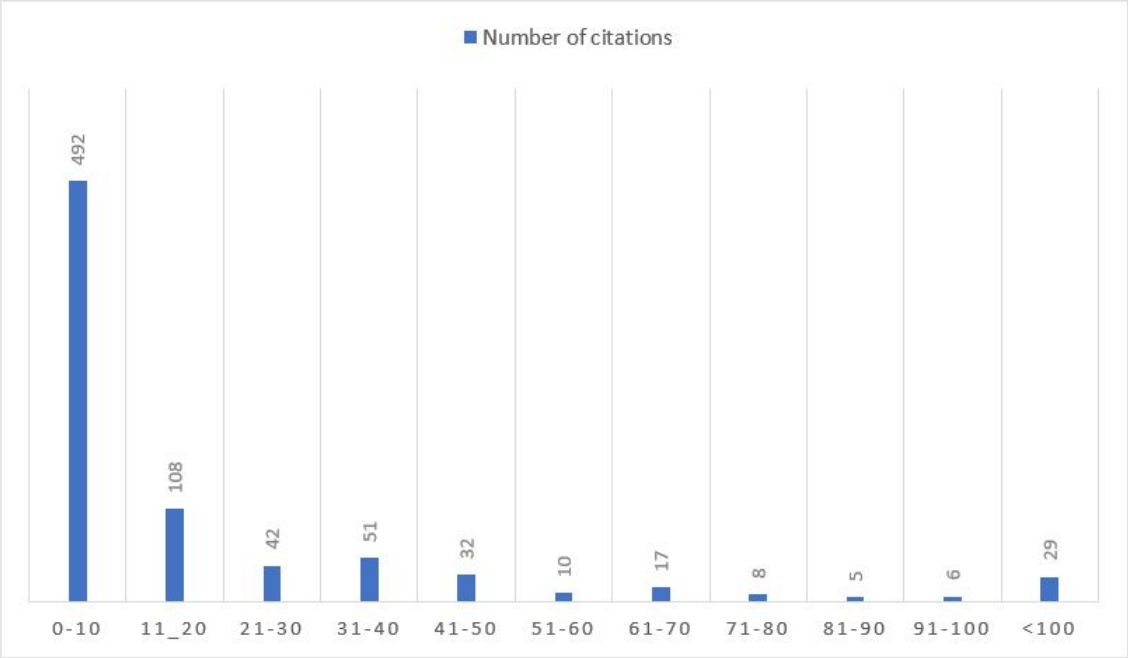

Figure 5: Number of citations

3.5 Keywords and Authors

For science mapping analysis, all 777 were included. A total of 84 keywords met the minimum co-occurrence. The most frequently used keywords were Human(s) (n = 484), Artificial intelligence (n = 194), Female (n=169), Male (n = 161), Cephalometry (n=151), Adult (n = 141), Deep learning (n = 127), Orthodontics (n = 120), Controlled study (n = 119), and Machine learning (n = 105). In addition, network analysis revealed the density and categorization of these keywords in five clusters (FIGURE 6). Sixty-four authors met the co-authorship threshold and among them Xu T (n=17), Zhang Y (n=16), Lui Y (n=13), Guo Y (n=11), and Li H (n=11) participated in the higher number of articles. FIGURE 7 demonstrated the co-authorship network between forty-nine of the authors who had collaboration.

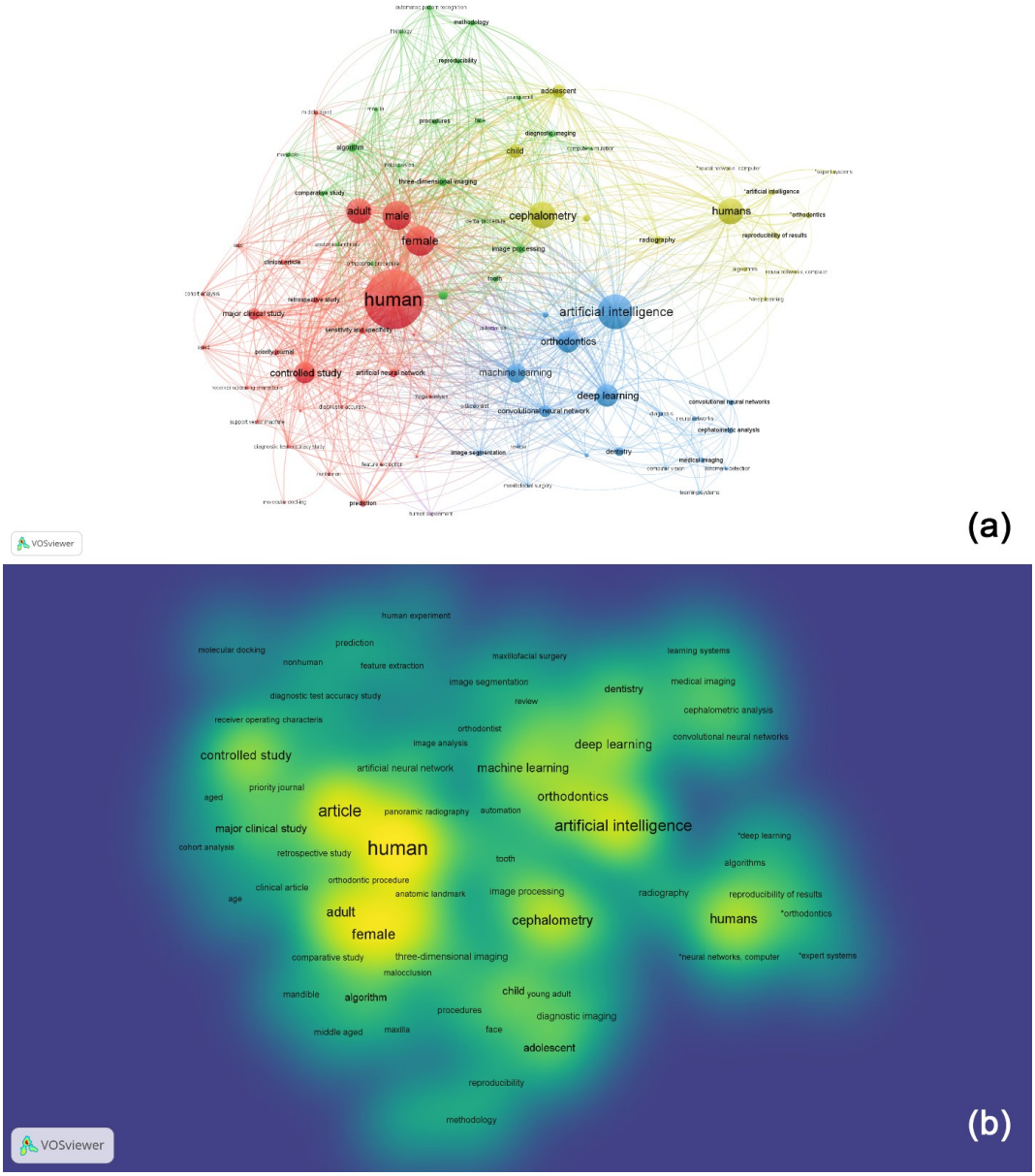

Figure 6: A) Network visualization of the keywords showing 84 nodes and 5 clusters. B) Keywords density.

4. DISCUSSION

Seven hundred seventy-seven articles published from 1970 to 2023 in the field of using ML in orthodontics were analyzed. The findings of this study showed that the number of published machine learning-related publications in orthodontics increased from 1970 to 2022, especially from

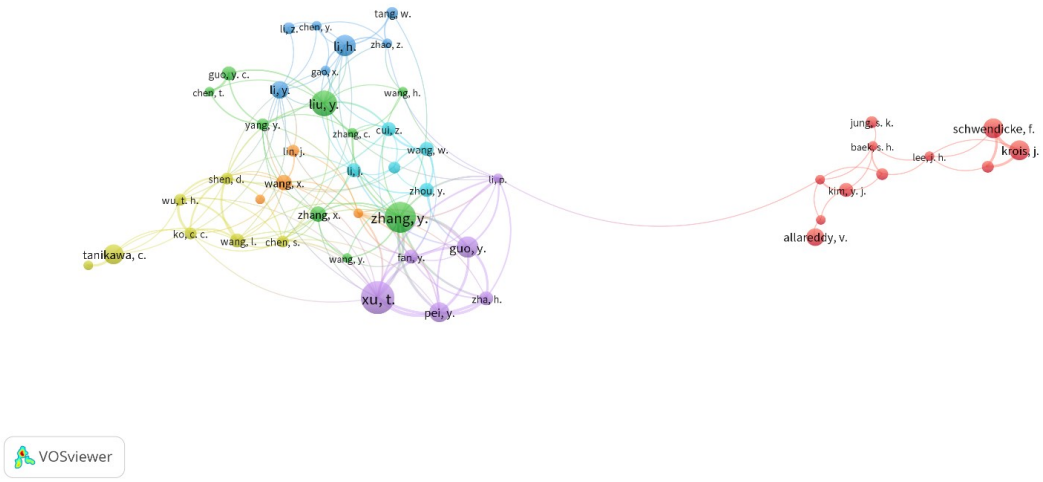

Figure 7: Network visualization of the co-authorship among 49 authors.

2016. Moreover, this study demonstrated that a major portion of published articles has been cited at least one time and about half of the articles have been conducted in China, the USA, South Korea, and India. In addition, the articles mainly focused on Human(s), Artificial intelligence, Female, Male, Cephalometry, Adult, Deep learning, Orthodontics, Controlled study, and Machine learning keywords.

The number of published articles each year has rapidly increased after 2016 because the papers conducted after 2016 constitute 77.73% of the total publications. This can be due to the improvement of processing powers of computing devices in the last few years which opened up more possibilities for ML to be used for disease prediction, diagnosis, and treatment in orthodontics. Like the present study, the number of ML and artificial intelligence-related articles has increased in the past few years in other fields such as oral radiology [14], social sciences[15], pancreatic cancer[16], and health care [17].

Research on the use of ML in orthodontics has drawn researchers from around the globe, but high-income countries dominate the field. China, the USA, and South Korea contributed about 43% of the studies in the field. Due to being high-income countries, these three countries can invest a vast amount of money in machine learning-related studies. Moreover, the electrical technology industry has advanced in the USA, China, and South Korea which provides the needed hardware and processors. On the other hand, some developed countries have not published a vast number of articles such as the UK. UK has launched federal AI healthcare policies that include guidance on the development and regulation of AI technology in healthcare which can affect performing studies about using ML in orthodontics [18]. In comparison, the number of publications in low-income countries remains low due to several factors, including funding, prioritization, research capacity, and infrastructure [19]. Similar to this study, Wang et al [16], Akay et al.[20], and Jimma [17],

studies demonstrated that USA and China have published the highest number of articles about using ML and AI in fields of economy, pancreatic cancer, and health care.

The outcomes of this study showed that the most of studies were original articles (58.94%). In addition, the West et al. study in 2019 and the Salli et al. study in 2023 demonstrated that the most common type of publication about using ML in radiology and oral radiology were original articles [14, 21], In the West et al. study, 53.7% of articles were original followed by proceedings papers (38.0%) and meeting abstracts (6.8%) [21]. Moreover, according to the results of the Salli et al. study, 76.6% of publications were original studies and were followed by review articles (10.5%) [14]. Unlike these two studies, the results of the present study showed that the second most common type of publication was conference papers (9.6%).

The present study considered articles' keywords and showed 84 keywords appeared at least 15 times. The technology keywords that appeared most frequently were Artificial intelligence, Machine Learning, and Deep learning. Moreover, some of the keywords that appeared were general terms such as Human, Female, Male, and Adult. The most frequent orthodontic-related keyword was Cephalometry which is due to the importance of cephalometry analysis in orthodontic treatments and the uses of ML for detecting landmarks and performing analysis on cephalometry radiographs [5]. Because there is no other bibliometric analysis about using ML in orthodontics it is not possible to compare the current study's keywords with other studies.

One of the limitations of this study was not including the gray literature such as books. Moreover, the google scholar database was not analyzed in this study. Further studies can increase the range of included databases and gray literature to achieve a more accurate outcome.

5. CONCLUSION

This bibliometric study showed that 777 papers about the use of ML in orthodontics were published until March 23, 2023, and 58.94% of them were original articles. The number of publications increased each year and China and the USA have published the most articles. The articles were cited 19.25 on average and 587 publications had one or more citations. Finally, the American Journal of Orthodontics and Dentofacial Orthopedics has published ML in orthodontics-related articles more than other journals.

6. FUNDING

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