



# Bibliometric Analysis of Magnetic Resonance Imaging Research in Orthodontics

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**ABSTRACT:** Magnetic resonance imaging is an imaging modality that enables high-resolution evaluation of soft tissues. The aim of this study was to evaluate the scientific production, conceptual structure, and thematic development of the literature regarding the use of magnetic resonance imaging in orthodontics through bibliometric analysis. Within the scope of the study, 305 articles indexed in the Web of Science Core Collection database between 1995 and 2025 were analyzed. The scientific production related to the subject showed an overall increasing trend despite periodic fluctuations. The term “temporomandibular joint” demonstrated strong connections with the term “magnetic resonance imaging” within the network structure. Over time, more specific research areas became prominent in the literature. In conclusion, the use of magnetic resonance imaging in orthodontics appears to be increasing and may gain broader research applications in the future.

**KEYWORDS:** Bibliometric Analysis, Magnetic Resonance Imaging, Orthodontics, Temporomandibular Joint

## I. INTRODUCTION

Orthodontics is a branch of dentistry that evaluates and treats possible disorders by examining the relationships between the teeth, jaws, and facial skeleton in order to improve breathing, chewing, and speech functions as well as to achieve facial esthetics [1]. For this purpose, it is aimed to achieve the optimal positioning of related structures such as the teeth and jaw bones [2]. For this purpose, various imaging modalities are used to identify possible abnormalities, establish treatment plans, and evaluate treatment outcomes [3].

Magnetic resonance imaging is one of these imaging modalities and generates images through changes in the positions of hydrogen atoms induced by radiofrequency energy, which are subsequently detected by specialized detectors. This imaging technique enables the acquisition of high-resolution three-dimensional images without the use of ionizing radiation. However, it also has several

disadvantages, including incompatibility with ferromagnetic metals, high cost, and susceptibility to motion artifacts. Magnetic resonance imaging is particularly useful for the evaluation of craniofacial soft tissues and various anatomical structures. In particular, it provides detailed assessment of the soft tissue components of the temporomandibular joint, upper airway, masticatory muscles, and surrounding soft tissues [2-7]. Due to these advantages and limitations, it is important to investigate the use of magnetic resonance imaging in the field of orthodontics.

Although numerous studies have investigated the use of magnetic resonance imaging in orthodontics, there is limited information in the literature regarding the conceptual structure, thematic development, trend topics, and performance analysis of this field [8-10]. Evaluating the evolution of research and the current themes in this field is challenging. Therefore, it is important to investigate the conceptual structure and research trends of the related literature. Bibliometric analysis enables the quantitative and conceptual evaluation of the literature through Performance Analysis and Science Mapping Analysis methods. These methods have the capacity to quantitatively reveal the characteristics of the field by evaluating Annual Scientific Production, Most Cited Documents Analysis, Authors' Keywords Co-occurrence Network Analysis, Trend Topics Analysis, Thematic Map Analysis, and Thematic Evolution Analysis [11-13].

The aim of the present study was to investigate the current status of the literature, research patterns in this field, and the thematic changes over time regarding the use of magnetic resonance imaging in orthodontics by performing Annual Scientific Production, Most Cited Documents Analysis, Authors' Keywords Co-occurrence Network Analysis, Trend Topics Analysis, Thematic Map Analysis, and Thematic Evolution Analysis.



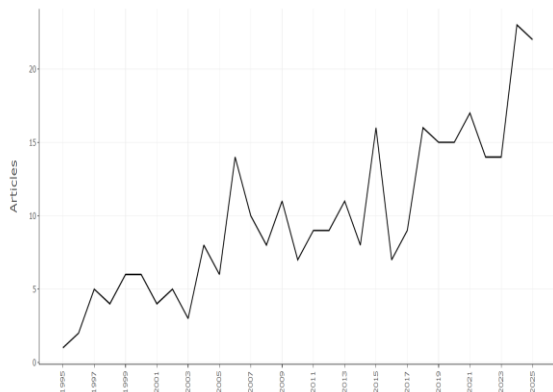
## II. MATERIALS AND METHODS

The present study was designed as a bibliometric analysis study related to the use of magnetic resonance imaging in the field of orthodontics. Since no human or animal subjects were involved in the bibliometric analysis method, ethical committee approval was not required.

The data for this study were obtained from the advanced search section of the Web of Science Core Collection (WoSCC) database using the following search query: ((MRI OR “magnetic resonance imaging” OR MRG) AND (orthodontics OR orthodontic OR ortodonti)). Scientific publications produced between 1995 and 2025 were included in this study, while conference proceedings, editorial letters, case reports, and publications unrelated to the use of magnetic resonance imaging in orthodontics were excluded in order to ensure the reliability of the dataset.

## III. RESULTS

A total of 305 articles indexed in the WoSCC database were included in this study. Evaluation of the Annual Scientific Production demonstrated a relatively low level of scientific publication output in the early years, followed by an increase with periodic fluctuations in subsequent years (Figure 1).



**Figure 1.** Annual scientific production in orthodontic magnetic resonance imaging research.

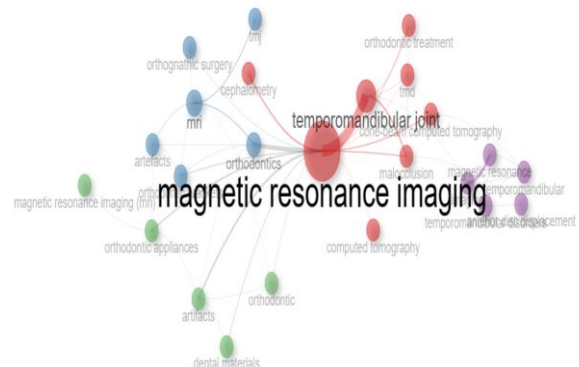
Evaluation of the Most Global Cited Documents Analysis revealed that the study by Ruf and Pancherz [14] received the highest number of citations with 161 citations, followed by the study of Ikeda and Kawamura [15] with 119 citations. In addition, the third most cited study was another publication by Ruf and Pancherz [16] which received 105 citations.

Evaluation of the Authors’ Keywords Co-occurrence Network Analysis demonstrated that the term “magnetic resonance imaging” was located at

The analyses in this study were performed using the bibliometrix package (version 5.3.0) through R (version 4.6.0), RStudio, and Biblioshiny. Within the scope of Performance Analysis, Annual Scientific Production and Most Cited Documents Analysis were applied. Within the scope of Science Mapping Analysis, Authors’ Keywords Co-occurrence Network Analysis, Trend Topics Analysis, Thematic Map Analysis, and Thematic Evolution Analysis were performed.

While examining the conceptual structure of the literature, network-based clustering approaches were applied. In the generated networks, node sizes represented keyword frequency, edge thickness represented co-occurrence strength, and colors represented different thematic clusters. In the thematic map analysis, niche themes, emerging/declining themes, basic themes, and motor themes were evaluated.

the center of the network with a high connection density. In addition, the terms “temporomandibular joint,” “dental materials,” “malocclusion,” “cone-beam computed tomography,” “cephalometry,” “orthognathic surgery,” “orthodontic appliances,” and “temporomandibular disorders” formed different focal points within the network. A particularly strong connection was observed between the terms “magnetic resonance imaging” and “temporomandibular joint” (Figure 2).

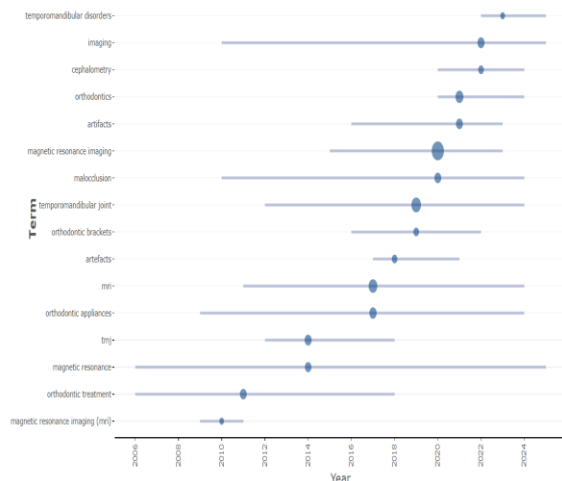


**Figure 2.** Co-occurrence Network of Authors’ Keywords in Orthodontic Magnetic Resonance Imaging Research

Evaluation of the Trend Topics Analysis showed that the terms “magnetic resonance imaging (MRI)” and “orthodontic treatment” were prominent in the early period of the literature. In the following years, the terms “TMJ,” “orthodontic appliances,” “MRI,” “artefacts,” “orthodontic brackets,”

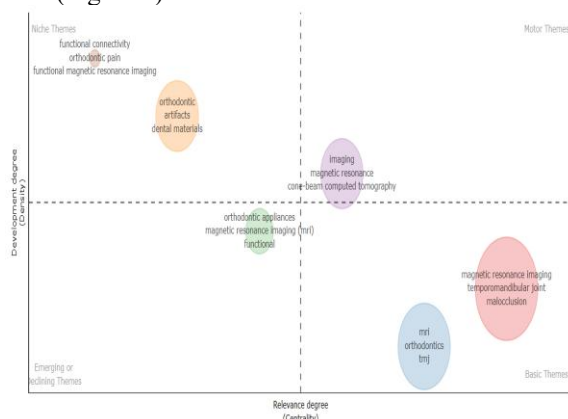


“temporomandibular joint,” “malocclusion,” and “magnetic resonance imaging” became more prominent. In recent years, the terms “cephalometry” and “temporomandibular disorders” were identified as popular research topics (Figure 3).



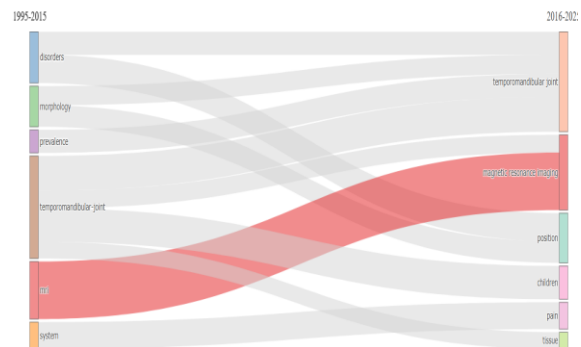
**Figure 3.** Trend Topics Analysis of Authors' Keywords in Orthodontic Magnetic Resonance Imaging Research.

Evaluation of the Thematic Map Analysis demonstrated that the terms “magnetic resonance imaging,” “temporomandibular joint,” and “malocclusion” were located within the basic themes region. The term “cone-beam computed tomography” was identified within the motor themes, while the terms “artifacts,” “dental materials,” “functional connectivity,” “orthodontic pain,” and “functional magnetic resonance imaging” were located within the niche themes. In addition, the terms “orthodontic appliances” and “functional” were found within the emerging/declining themes area (Figure 4).



**Figure 4.** Thematic Map of Authors' Keywords in Orthodontic Magnetic Resonance Imaging Research.

Evaluation of the Thematic Evolution Analysis revealed that the themes “disorders,” “morphology,” “prevalence,” “temporomandibular joint,” “MRI,” and “system” were dominant before 2016. In the period after 2016, the terms “temporomandibular joint,” “magnetic resonance imaging,” “position,” “children,” “pain,” and “tissue” became more prominent (Figure 5).



**Figure 5.** Thematic Evolution of Authors' Keywords in Orthodontic Magnetic Resonance Imaging Research.

#### IV. DISCUSSION

Magnetic resonance imaging is an imaging modality that provides high-resolution visualization of soft tissues. With this method, soft tissue pathologies, muscles, salivary glands, and particularly the soft tissue components of the temporomandibular joint can be clearly evaluated. In addition to being used in various branches of dentistry, magnetic resonance imaging is also a valuable method in orthodontics, and one of its greatest advantages is the lower exposure to radiation [8, 17, 18].

Although numerous studies have investigated magnetic resonance imaging in orthodontics, there is limited information in the literature regarding the conceptual structure, annual scientific production, and thematic evolution of this imaging modality. Therefore, the use of bibliometric analysis methods is necessary to evaluate the current status of the field and to predict potential future developments and changes [19-21].

Evaluation of the Annual Scientific Production related to the present topic demonstrated an increasing trend in scientific production over the years. Although fluctuations were observed throughout the study period, the highest level of scientific production in recent years indicates the growing popularity of the use of magnetic resonance imaging in the field of orthodontics. This increase may be associated with improvements in the image quality produced by magnetic resonance imaging techniques over time and the growing awareness



regarding lower radiation exposure in imaging methods [10, 22, 23].

Evaluation of the Most Global Cited Documents Analysis revealed that the three most cited publications were related to the temporomandibular joint. This finding indicates that magnetic resonance imaging plays a highly important role in the evaluation of the temporomandibular joint within the field of orthodontics [14-16, 24]. In particular, the fact that two studies by Ruf and Pancherz received the highest citation counts indicates that these authors are pioneering researchers in this field [14, 16].

Evaluation of the Authors' Keywords Co-occurrence Network Analysis demonstrated that the strong connections between the term "magnetic resonance imaging," located at the center of the network, and the term "temporomandibular joint" suggest that magnetic resonance imaging is most frequently used for temporomandibular joint evaluation in the field of orthodontics. This may be related to the ability of magnetic resonance imaging to successfully visualize the soft tissue components of the temporomandibular joint [25, 26]. In addition, the association of the term "magnetic resonance imaging" with the terms "malocclusion," "cephalometry," "orthognathic surgery," and "orthodontic appliances" indicates that this imaging modality is used in treatment planning, evaluation of treatment outcomes, and surgical procedures [10, 27-29]. The presence of the terms "cone-beam computed tomography" and "dental materials" within the network structure may indicate the combined use of different imaging modalities and the presence of studies related to dental materials in magnetic resonance imaging. Artifacts caused by dental materials in magnetic resonance imaging may have contributed to the association between the terms "magnetic resonance imaging" and "dental materials" [9, 30, 31].

Evaluation of the Trend Topics Analysis demonstrated a noticeable change in research trends over time. In the early period, the prominence of the terms "magnetic resonance imaging (MRI)" and "orthodontic treatment" indicates that the clinical applications and areas of use of this imaging modality in orthodontics were being extensively investigated [10]. In the following years, the prominence of the terms "temporomandibular joint," "orthodontic appliances," "artefacts," and "orthodontic brackets" suggests an increase in studies focusing on temporomandibular joint evaluation using magnetic resonance imaging and

on the effects of artifacts caused by orthodontic appliances on MRI image quality [24, 32-34]. Finally, the recent prominence of the terms "cephalometry" and "temporomandibular disorders" indicates that cephalometric analysis, orthodontic treatment planning, and the evaluation of temporomandibular joint disorders have become current research topics in the literature [27, 35, 36].

Evaluation of the Thematic Map Analysis demonstrated that the presence of the terms "magnetic resonance imaging," "temporomandibular joint," and "malocclusion" within the basic themes cluster indicates that these topics represent the main research focuses in the field. The presence of the term "cone-beam computed tomography" within the motor themes suggests that cone-beam computed tomography shares a greater number of common research areas with magnetic resonance imaging. This may be explained by the widespread use of cone-beam computed tomography in dentistry due to its relatively low radiation dose, lower cost, and high hard tissue resolution among three-dimensional imaging modalities [5, 31, 37]. The presence of the terms "artefacts," "dental materials," "functional connectivity," "orthodontic pain," and "functional magnetic resonance imaging" within the niche themes indicates that these topics represent more specific research areas. The term "orthodontic appliances" was located within the emerging/declining themes, suggesting that this research area may gain greater importance in the future [19, 20, 34].

Evaluation of the Thematic Evolution Analysis demonstrated that the prominence of the terms "disorders," "morphology," "prevalence," "temporomandibular-joint," "MRI," and "system" before 2016 reflected a focus on more general research topics. In recent years, the prominence of the terms "position," "children," and "pain" indicates an increased focus on joint disc position, pain-related research, and studies involving pediatric patients, suggesting that the research topics have become more specific over time.

The limitations of this study include the use of only English-language search terms and the exclusion of scientific publications indexed in databases other than WoSCC. However, the widespread use of English in the scientific literature and the high indexing quality of the WoSCC database increase the reliability of the present study.



## V. CONCLUSION

As a result of this study, it was understood that In conclusion, the use of magnetic resonance imaging in the field of orthodontics has gradually increased, and the research topics have evolved into more specific areas over time. The related field is expected to gain broader research applications in the future. Future studies are recommended to include different languages and multiple databases.

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