



UNIVERSIDADE  
FERNANDO  
PESSOA

THE SIGNIFICANCE OF THE HYOID BONE IN ORTHODONTICS: AN IN-DEPTH  
ANALYSIS - SCOPING REVIEW

[A importância do osso híóide na ortodontia: uma análise aprofundada – revisão de  
escopo]

Dissertação de Mestrado

Mestrado Integrado em Medicina Dentária

Stefano de Franchis

Orientadora:

Doutora Vanda Maria Urzal de Carvalho

Junho 2025







THE SIGNIFICANCE OF THE HYOID BONE IN ORTHODONTICS: AN IN-DEPTH  
ANALYSIS - SCOPING REVIEW

[A importância do osso hióide na ortodontia: uma análise aprofundada – revisão de  
escopo]

Dissertação de Mestrado

Mestrado Integrado em Medicina Dentária

Stefano de Franchis

Orientadora:

Doutora Vanda Maria Urzal de Carvalho

Junho 2025



## **Acknowledgements**

I would like to express my sincere gratitude to Professor Vanda Urzal, my supervisor, for their insightful feedback, guidance and constant support for the development of this thesis.

I wish to extend my heartfelt thanks to all the professors I had the privilege of learning from during these wonderful years.

I am deeply grateful to my family for their unconditional love, for their constant support and encouragement that has always been a cornerstone of my whole academic path, the foundation of all my achievements. Your sacrifices and value have shaped my academic journey.

To my friends, both old and new, thank you for always being at my side during every step of this journey. To the ones I made during these incredible 5 years a special mention goes to Chiara, Evelina, Giuseppe, Gabriele, Ilaria, Pietro, Pietrone, Pasve, Sara, Tommaso and Valerio for being my second family, your friendship has made this experience not only bearable, but meaningful. Together we have built memories that go far beyond academic achievements.

Finally, to the city of Porto, which became part of my story and gave me a sense of belonging, that I will carry with me wherever I go.



## **Abstract**

The position of the hyoid bone has gained increasing relevance in orthodontic literature due to its anatomical and functional role in craniofacial balance. This unique structure, suspended by muscles and ligaments without direct skeletal articulation, interacts with the mandible, tongue, cervical spine, and soft palate, directly influencing functions such as swallowing, breathing, and posture. The aim of this thesis is to conduct a scoping review on the relationship between hyoid bone position and dental malocclusions, with particular focus on Angle's skeletal classes (Class I, II, and III), as well as vertical discrepancies such as open bite and deep bite. Nine studies published between 2010 and 2025 were included, employing imaging techniques like lateral cephalograms and cone-beam computed tomography, and evaluating parameters such as H-SN, H-C3, and H-MP. The results show consistent patterns between the type of malocclusion and the spatial positioning of the hyoid bone. Class II skeletal often present a posteriorly and inferiorly displaced hyoid, while Class III skeletal show anterior positioning. In open bite cases, variations in hyoid bone positioning were observed. While some studies reported a more anterior and lower position, others found a posterior and inferior displacement, suggesting methodological differences and the influence of individual skeletal and functional factors. Moreover, both orthopedic/orthodontic and surgical treatments, such as functional appliances or orthognathic surgery, were found to significantly influence hyoid bone positioning. These findings highlight the dynamic nature of the hyoid and its adaptability to craniofacial skeletal changes. It is concluded that assessing the hyoid bone position may provide valuable clinical insights in orthodontics, especially in growing patients or complex cases. Including this structure in cephalometric evaluation, may lead to more comprehensive diagnoses and more effective treatment strategies.

**Key-words:** “Hyoid Bone”, “Malocclusions”, “Orthodontics”, “Open bite”.



## Resumo

A posição do osso hióide tem vindo a ganhar crescente relevância na literatura ortodôntica, devido ao seu papel funcional e anatómico, no equilíbrio crânio-facial. Esta estrutura única, suspensa por músculos e ligamentos sem articulação óssea direta, interage com a mandíbula, a língua, a coluna cervical e o palato mole, influenciando diretamente funções como a deglutição, a respiração e a postura. O presente trabalho tem como objetivo realizar uma *scoping review* sobre a relação entre a posição do osso hióide e as más oclusões dentárias, com particular enfoque nas Classes esqueléticas de Angle (Classe I, II e III), bem como nas más oclusões verticais, como mordida aberta e profunda. Foram incluídos nove estudos publicados entre 2010 e 2025 que utilizaram técnicas de imagem como telerradiografias laterais e Cone-beam Computer Tomography, avaliando parâmetros como H-SN, H-C3 e H-MP. Os resultados evidenciam padrões consistentes entre o tipo de má oclusão e a posição do osso hióide. Pacientes com Classe II esquelética apresentam frequentemente um hióide posicionado mais posteriormente e inferiormente, enquanto indivíduos com Classe III esquelética mostram um deslocamento anterior. Em casos de mordida aberta, foram observadas variações na posição do osso hióide. Enquanto alguns estudos relataram uma posição mais anterior e inferior, outros identificaram um deslocamento posterior e inferior, sugerindo diferenças metodológicas e a influência de factores esqueléticos e funcionais individuais. Além disso, tratamentos ortopédicos/ortodônticos e cirúrgicos, como o uso de aparelhos funcionais ou cirurgias ortognáticas, demonstraram modificar significativamente a posição do osso hióide. Estas alterações indicam que o hióide é uma estrutura dinâmica que se adapta às mudanças no esqueleto craniofacial. Conclui-se que a avaliação da posição do osso hióide pode fornecer informações clínicas úteis na abordagem ortodôntica, sobretudo em casos complexos ou de crescimento. A inclusão desta estrutura na análise cefalométrica poderá contribuir para um diagnóstico mais abrangente e intervenções terapêuticas mais eficazes.

**Palavras chave:** “Osso hióide”, “Má-oclusão”, “Ortodontia”, “Mordida aberta”.



## General index

1 - Introduction.....	1
1.1 - Malocclusions .....	1
1.1.1 - Angle's Classes .....	2
1.1.2 - Open bite malocclusion.....	3
1.1.3 - Deep bite malocclusion.....	4
1.2 - Oral habits.....	5
1.2.1 - Oral Breathing .....	6
1.3 - Objective.....	6
2 - Methodology.....	7
3 - Results .....	13
4 - Discussion.....	15
4.1 - Class I malocclusion.....	15
4.2 - Class II malocclusion .....	16
4.3 - Class III malocclusion .....	16
4.4 - Open Bite malocclusion.....	17
4.5 - Treatments effects .....	18
4.6 - Methods and limitations .....	19
4.7 - Clinical implications.....	20
4.8 - General conclusions .....	20
5 - Conclusion .....	23
6 - Bibliography .....	25



## Figure Index

<b>Figura 1.</b> PRISMA Flow Diagram of study selection.....	12
--	----



## **Table index**

<b>Tabela 1.</b> Search Keys.....	10
<b>Tabela 2.</b> Relations of Hyoid bone.....	14



## **List of abbreviations and acronyms**

**C3** - The third process of the cervical vertebra.

**CBCT** - Cone-beam computer tomography.

**CSA** - Cross-sectional area.

**Div.1** – Division 1

**Div.2** – Division 2

**H** - The most anterior point of the hyoid bone.

**H-C3** - Distance between the hyoid bone and the third cervical vertebra.

**H-MP** - Distance between the hyoid bone and the mandibular plane.

**H-SN** - Distance between the hyoid bone and the Sella-Nasion plane.

**IVRO** - Intraoral vertical ramus osteotomy.

**Min-CSA** - Minimum cross-sectional area.

**MP** - Mandibular plane.

**NNS** - Non-nutritive sucking

**PNS** - Palatal plane.

**SN** - Sella-Nasion plane.

**TMJ** - Temporomandibular joint

**Vol-NA** - Nasopharyngeal airway volume



## **1 – Introduction**

The hyoid bone has a distinctive and somewhat unusual anatomy, characterized by its horseshoe shape and positioned between the mandible and the shoulder girdle. It is technically classified as a sesamoid bone, which suggests that it is freely floating. However, despite this classification, the hyoid is firmly anchored in place by a network of muscles and ligaments, making it far from truly free-floating in function (Auvenshine, R. C., & Pettit, N. J., 2020).

The hyoid bone is composed of five distinct segments: a central body, two greater cornua, and two lesser cornua. It is structurally linked to the pharynx, tongue, mandible, and cranium through an intricate system of muscles and ligaments. Additionally, it plays a crucial role as part of the oropharyngeal complex, contributing to various functions related to swallowing, speech, and airway stability (A. Sivakumar et al, 2017).

Due to its various attachments, the hyoid bone is closely integrated into a vast tendino-muscular network. Positioned strategically, it actively contributes to all functional and nutritional processes, within the oro-facial complex. Despite its small size, its numerous muscular and ligamentous connections have led many researchers to regard it as a crucial anatomical and functional fulcrum, within the stomatognathic system (Doual, A., Léger, J. L., Doual, J. M., & Hadjiat, F, 2003).

Due to its strategic location and anatomical connections, the hyoid bone serves as a key link between the jaw, tongue, cervical spine, and thorax. Any alterations in its position or function can influence, not only oral activities but also overall posture and respiratory health. In the field of orthodontics, its significance has often been overlooked when assessing malocclusions and associated dysfunctions. Only a limited number of studies have emphasized the strong correlation between hyoid bone positioning and various dento-skeletal irregularities, such as open bite, deep bite, oral respiration, and Angle's Class I, II, and III malocclusions.

### **1.1 - Malocclusions**

Malocclusion is a term used to describe an improper alignment of the teeth and an imbalance in the way the upper and lower dental arches come together. It is recognized

as a global health concern, presenting in various forms across different populations and arising from a combination of genetic and environmental influences. These contributing factors include growth patterns, muscle activity, breathing mechanics, and early tooth loss or extractions. Additionally, the natural shaping forces exerted by the muscles on the dental arches can be disrupted by detrimental oral habits, such as non-nutritive sucking (NNS), as well as persistent orofacial dysfunctions like improper tongue positioning and habitual open-mouth posture (M. Aprile, A. Verdecchia, C. Dettori and E. Spinis, 2025).

In the 1890, Angle made a classification of the different types of malocclusions which marked an unprecedented milestone for the evolution of the subject. This system was pivotal because it not only categorized the primary forms of malocclusion but also introduced one of the first precise and easily understandable definitions of what should be considered a normal type of occlusion, within a natural kind of dentition. In Angle's theory, the upper first molars played a fundamental role in determining occlusion. He stated that proper alignment occurs when the cuspid situated more mesiobuccally in the first upper molar has to fit perfectly into the groove situated in the buccal part of the corresponding lower molar, in order to ensure a stable and functional bite (W. R. Proffit, H. Fields, B. Larson and D. M. Sarver, 2019).

### **1.1.1 - Angle's Classes**

Angle has categorized malocclusion into three distinct classes providing a structured way to assess and diagnose dental misalignment. They can be described as the following:

- **Class I** - Is what can be considered a normal molar relationship, however, the occlusion is still incorrect due to other factors such as irregularities, rotations or simply misplaced teeth.
- **Class II** - In this case the lower molar is positioned further back in a more distal position that relationate it with the upper molar, with no specific mention of other irregularities in the occlusion. Class II can be further categorized into two divisions. Class II, Division 1 (Div.1) malocclusion is characterized by the forward positioning of the maxillary incisors, resulting in an increased overjet. Individuals with this type of molar relationship often have the upper lip shortened, which can make it difficult to achieve full closure of the anterior lips. Class II, Division 2 (Div.2) malocclusion is characterized by the palatal inclination of the

maxillary incisors, with an increased overbite. This condition typically features a well-sealed upper lip and a pronounced mental groove. Unlike Class II, Division 1, Division 2 is associated with a normally sized mandible (R. Ghodasra and M. Brizuela., 2023).

- **Class III:** The position of the lower molar in this case is placed further forward (in the mesial part) always in relation to the upper molar, again without a further definition of the line of occlusion. Class III malocclusion is also further categorized into three distinct types based on the alignment of the teeth. In Class III, Type 1, the dental arch exhibits an abnormal shape. The Class III, Type 2 is characterized by the lingual inclination of the mandibular teeth, while in Class III, Type 3, the maxillary teeth are positioned with a lingual tilt (R. Ghodasra and M. Brizuela., 2023).

It is important to note that Angle's classification system actually consists of four categories, if we also count the normal type of occlusion, in contraposition to the Class I, II and III type of malocclusion. With an important distinction between the normal occlusion and the type I malocclusion, that although share the same molar relationship, they have a substantial difference in the line of occlusion. In contrast to that, in both Class II and Class III malocclusions the line of occlusion is not important for the general classification and can or cannot be properly aligned (W. R. Proffit, H. Fields, B. Larson and D. M. Sarver, 2019).

### **1.1.2 - Open bite malocclusion**

An open bite refers to a vertical discrepancy in the positioning of upper and lower teeth, resulting in a gap between opposing dental surfaces. This condition can manifest across the entire dental arch or be confined to specific regions. Carevelli first introduced the concept of open bite in 1842, and it remains a distinct category within malocclusion classifications (M. A. Wajid et al., 2018).

The occurrence of different forms of open bite depends from various factors, including skeletal growth patterns, dental development issues, and soft tissue influences. Jaw growth disparities, where maxillary and mandibular development diverge instead of aligning, contribute to skeletal open bites. Dental factors may arise from habits such as digit sucking or improper tongue positioning, which interfere with normal tooth eruption

or alignment. Soft tissue dynamics, particularly atypical resting tongue posture, can significantly impact tooth positioning and eruption patterns (F. Laranjo and T. Pinho, 2014).

Among the malocclusions most frequently observed in clinical practice, open bite stands out as one of the most common and also one of the hardest to manage. When its origin is multifactorial, this condition not only leads to aesthetic alterations but also impacts speech by interfering with the articulation of certain phonemes. Additionally, it can result in unfavourable psychological effects, further complicating its treatment and management (M. A. Wajid et al.,2018).

Open bite can be divided into anterior and posterior types, with the anterior open bite being the most common form. In this situation, the upper front teeth do not properly come into contact with the lower front teeth, leaving a noticeable gap between them. This condition is frequently caused by self-induced habits in children, such as prolonged thumb or finger sucking, excessive use of pacifiers beyond the recommended age (N. Patel, 2025).

Addressing open bite malocclusions is a routine practice for dental professionals and orthodontic specialists. Early detection and intervention during childhood significantly improves the probability of correcting an open bite without resorting to surgical procedures. However, for mature patients, surgical intervention becomes a more probable approach to resolve the condition effectively (J. Salim, G. Nalchajian, 2024).

### **1.1.3 - Deep bite malocclusion**

Graber defines deep bite as a condition characterized by an excessive vertical overlap between the maxillary and mandibular incisors when the mandible is positioned in habitual or centric occlusion. This condition is a significant orthodontic concern due to its potential impact on both function and aesthetics occlusions. The vertical measurement in a deep bite exceeds normal limits, often leading to complications such as trauma to the palatal tissues, periodontal issues, or temporomandibular joint (TMJ) dysfunction. Graber's definition emphasizes the importance of evaluating the vertical relationship of the incisors, as a critical diagnostic criterion for identifying and addressing this malocclusion (Dr A. Bhardawaj, Dr. S. Patel and Dr. K. Mishra, 2019).

Similar to an open bite, a deep bite can be present across different types of malocclusions, including Class I, II, and III. The severity of a deep bite is most often associated with skeletal hypodivergence, and a defining trait of Class II, Div.2 malocclusion. This condition is characterized by distinct skeletal and dentoalveolar features, including a shortened lower anterior facial height, a flatter mandibular plane angle, a sharper gonial angle, and nearly parallel alignment of the upper and lower occlusal planes. Additionally, the mandibular arch exhibits a noticeably deepened curve of Spee, further contributing to the overall malocclusion pattern (H. Fattahi et al, 2014).

When comparing Class II, Div.2 malocclusion to the Syndrome of the Long Face, the development and hereditary factors appear to play a primary role in the aetiology of deep bites. Unlike open bites, however deep bites have not been strongly associated with pathological conditions or external environmental influences (J. G. Ghafari, A. T. Macari and R. V. Haddad, 2013).

This issue can be addressed through the use of specialized orthodontic devices, commonly referred to as functional appliances. These appliances work by repositioning the upper front teeth forward and influencing the growth patterns of either the upper jaw, lower jaw, or both. Most functional appliances are designed to be removable, offering flexibility during treatment. Additionally, this method typically avoids the need for extracting permanent teeth, making it a less invasive approach. However, to achieve optimal results, supplementary treatment with fixed braces is often recommended to refine tooth alignment and ensure long-term stability (D. T. Millett et Al., 2018).

## **1.2 - Oral habits**

In the field of orthodontics, oral habits refer to repetitive actions involving the mouth that can have a considerable effect on the development and alignment of both dental and skeletal structures. Though many of these behaviours are common during early childhood, its persistence beyond some stages of growth may result in a range of dental and skeletal complications. It is crucial for orthodontists to understand the characteristics, frequency, and consequences of these habits, in order to apply appropriate preventive and corrective treatments (C. Grippaudo et al., 2016).

Continued involvement in habits like non-nutritive sucking (such as thumb or finger sucking) can disrupt the normal development of the teeth and jaws, potentially causing

orthodontic issues that last into adulthood. Approaches to managing these habits often include using rewards, reminder techniques, and the application of orthodontic appliances (M. Silva and D. Manton., 2014).

Sucking habits begin to negatively affect oral health when they continue past infancy. These habits, along with others, are linked to both immediate and long-term dental and orthodontic issues. They are significant contributors to malocclusion in young children and can disrupt the development of proper occlusion. The extent of their impact is influenced by factors such as the frequency, intensity, and duration of the habit (K. A. Kolawole et al., 2019).

Studies have shown a clear link between habits, like thumb sucking, tongue thrusting, and mouth breathing, and several types of malocclusions, such as anterior open bite, protrusion of the teeth, crowding and posterior crossbite. Recognizing these connections is essential for creating focused treatment strategies, to reduce the negative impacts of these habits (H. S. Katib et al., 2024).

### **1.2.1 - Oral Breathing**

Mouth breathing, a condition impacting people across age groups, especially young ones, is more than just a learned behaviour. It's a complicated multidimensional issue that intersects with various aspects of skull and facial growth, as well as overall functional wellbeing (D. Feștilă et al, 2025). Mouth breathing describes the act of taking in and releasing air through the mouth rather than the nose. This habit can lead to a variety of effects that impact multiple areas of the body, including the oral cavity, craniofacial development, and both the upper and lower airways. The practice of mouth breathing often has significant repercussions on the development of the facial skeleton and the alignment of teeth, primarily due to the alteration of normal lateral, buccal, and lingual muscular forces.

### **1.3 - Objective**

This research project has multiple aims. First, to examine completely the structure, function, and mechanical properties of the hyoid, emphasizing its significance in the oral and facial system. Second, it seeks to investigate the connections between the hyoid bone

and major orthodontic misalignments, specifically focusing on open bite, deep bite, and mouth breathing. Lastly, this work intends to establish a foundation, both theoretical and practical, for recognizing the hyoid as a crucial component in orthodontic evaluation and intervention, stressing the need for a comprehensive approach that incorporates postural and functional considerations.

This investigation seeks to address a knowledge gap regarding the hyoid's role in orthodontics by surveying existing research and examining functional and postural relationships. The goal is to promote greater recognition of this structure's importance, potentially enhancing both orthodontic treatment outcomes and overall patient wellness.



## 2 – Methodology

The scoping review methodology was chosen as it seeks to systematically map the existing research within a particular field and identify gaps in the current evidence. Scoping reviews are often employed for “reconnaissance” purposes, helping in the clarification of operational definitions and the boundaries of concept, within a very specific topic or area of study. They are especially valuable when the literature on a subject has not yet been thoroughly reviewed (Peters, Godfrey, McInerney et al., 2015).

The most important characteristic of the chosen approach is based on the fact that the focus is not assessing the quality of the method of the chosen study, that were included or analysing their best scientific evidence. Its main objective is instead offering a vast overview of the existing body of scientific literature, that refers to that precise topic (Peters, Godfrey, Khalil et al., 2015).

With the methodology of this scoping review, the framework outlined by Arksey and O’Malley (2005), and further refined by Levac, Colquhoun, and O’Brien (2010), that consists of six different stages, were followed (Arksey and O’Malley, 2005; Levac, Colquhoun, and O’Brien, 2010).

**Stage 1** - Consist in the formulation of a research question after an initial exploration of the available literature. It was identified two research questions that has been answer:

- What is the correlation between the hyoid bone position and the different types of malocclusions?
- What is the role of the hyoid bone, and how can it be used in orthodontics?

**Stage 2** - It is used to identify the studies that are relevant, the sources of information and the research strategy:

It was conducted an extensive research using three different research engines: PubMed ([www.ncbi.nlm.nih.gov/pubmed](http://www.ncbi.nlm.nih.gov/pubmed)), Wiley ([www.onlinelibrary.wiley.com](http://www.onlinelibrary.wiley.com)) and Cochrane Library ([www.cochranelibrary.com](http://www.cochranelibrary.com)). With this search strategy the intention was to find studies exploring the relationship between “orthodontics” and “hyoid bone position.” It included articles published in the last twenty-five years up until February 2025, in English, Portugues and Italian. The search keywords used in each database are listed in Table 1.

**Tabela 1.** *Search Keys.*

<b>Databases</b>	<b>Search Keys</b>	<b>Number of Articles</b>
<b>PubMed</b>	(Hyoid Bone) AND (Orthodontics) AND (Malocclusions OR Open Bite OR Deep Bite OR Oral Respiration OR Class I OR Class II OR Class III)	33
<b>Cochrane Library</b>	(Hyoid Bone) AND (Orthodontics) AND (Malocclusions OR Open Bite OR Deep Bite OR Oral Respiration OR Class I OR Class II OR Class III)	27
<b>Wiley</b>	(Hyoid Bone) AND (Orthodontics) AND (Malocclusions OR Open Bite OR Deep Bite OR Oral Respiration OR Class I OR Class II OR Class III)	7

**Eligibility criteria:**

The focus of this study is the hyoid bone but its role it's not only important in orthodontics. Therefore, were included only the papers that satisfied all of this inclusion criteria:

- **Type of population:** Paediatric and adult patients with malocclusions or normal occlusion.
- **Type of studies:** Observational studies, clinical study, randomised controlled trials and evaluation studies.
- **Diagnostic techniques:** The use of imaging such as lateral radiographs, Cone-beam computer tomography (CBCT) or 3D analysis.

**Exclusion criteria:**

Since the subject of this study is very restrictive, the exclusion criteria had to permit a large number of studies:

- **Population:** Patients with systemic or syndromic conditions that affect the structure

and function of the craniofacial complex.

- **Studies:** Conference abstracts, and articles in grey literature.
- **Diagnostic techniques:** Studies not using imaging techniques to analyse the position of the hyoid bone.

The filters are studies published in English, Portuguese and Italian published between the year 2000 and 2025.

After retrieving studies from the three previously mentioned databases, duplicate articles were removed. Once the inclusion and exclusion criteria, were established, the following procedure was surveyed: all titles and abstracts were reviewed, applying the exclusion criteria. Then, the full content of the selected articles was assessed, and the inclusion criteria were applied.

**Stage 3** - The screening of the articles was performed on two different levels: the first one being selecting articles based on the title and the abstract and a second based on a full-text review.

**Stage 4** - Collecting the data:

The chosen articles were independently examined, and the following information was extracted: publication details (which included the title, the authors, and published year), research aims, study design, and principal outcomes.

**Stage 5** - Collating, summarizing, and reporting the results.

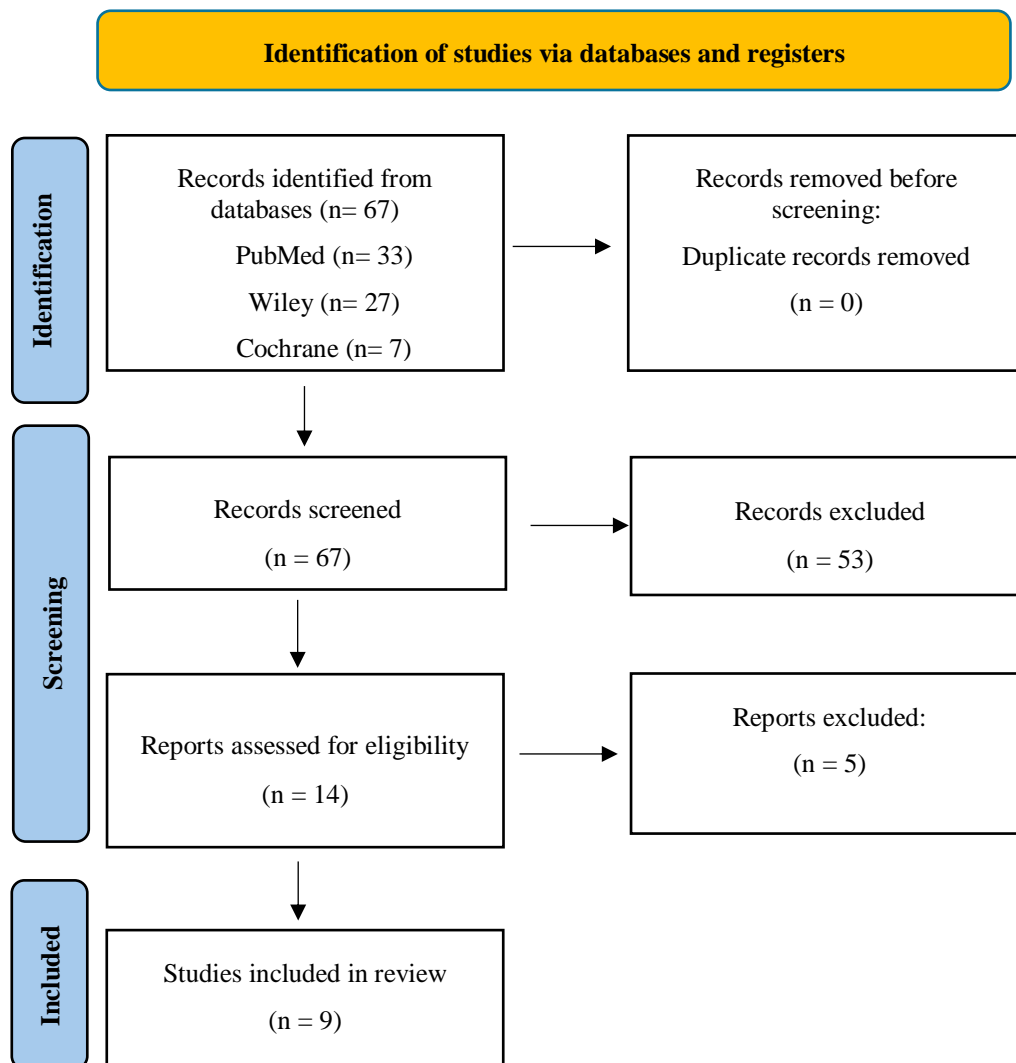
**Stage 6** - Optional consultation. This scoping review did not include the optional consultation phase. As a result, insights from external experts or stakeholders were not incorporated, which could influence the interpretation and applicability of the results.

The initial analysis of the electronic databases yielded a total of 67 articles. After verifying the absence of any possible duplicates, the titles and abstracts of still 67 articles were reviewed. In the final selection, after the exclusion of 53 articles considered not related to topic of the study, 14 potentially relevant articles were identified. The full texts of these articles were obtained and thoroughly evaluated. After applying the inclusion criteria, only 9 articles were included. The gathering, analysis, and display of findings were carried out following the protocol of PRISMA-ScR (Tricco et al., 2018).

Adhering to the method proposed by Levac et al. (2010) the thematic evaluation comprised three primary stages: (1) scrutinizing the information, (2) showcasing the discoveries, and (3) elucidating the implications of the outcomes (Levac, Colquhoun, and O'Brien, 2010).

The overview is shown in Table 2.

**Figure 1.** PRISMA Flow Diagram of study selection.



### **3 – Results**

A total of nine studies were included in this scoping review, published between 2010 and 2025. Among them, the majority utilized CBCT as the primary imaging technique, while a smaller number employed traditional lateral cephalometric radiographs.

The included studies analysed different types of malocclusions, notably Angle's Class I, Class II, Class III, and open bite conditions. Several studies also included healthy control groups with normocclusion, allowing direct comparisons. The evaluated parameters primarily involved the position of the hyoid bone relative to skeletal landmarks, specifically measurements such as H-SN, H-C3, and H-MP.

In general, individuals with Class II malocclusion demonstrated a tendency for the hyoid bone to be positioned more posteriorly and inferiorly compared to individuals with normal occlusion. On the other hand, Class III malocclusion patients showed a more anterior positioning of the hyoid bone. Open bite patients showed variable hyoid bone positioning when compared to healthy controls. While some studies described an anterior displacement, others reported a posterior and inferior positioning, highlighting inconsistencies likely due to methodological differences and individual anatomical variation..

Surgical interventions, such as bimaxillary surgery and intraoral vertical ramus osteotomy (IVRO), were associated with posterior and inferior shifts of the hyoid bone following treatment. Orthodontic appliances, particularly functional devices like Twin Block appliances, were associated with an anterior repositioning of the hyoid bone post-treatment.

The findings across studies underline a consistent relationship between the type of malocclusion and the spatial positioning of the hyoid bone. A detailed summary of the characteristics and main findings of the included studies is presented in Table 2.

**Tabela 2.** *Relations of Hyoid bone.*

Parameter	Kitahara (2010)	Zheng (2014)	Li (2014)	Laranjo (2014)	Urzal (2014)	Li (2014)	Dalmau (2015)	Iwasaki (2019)	Xu (2025)
<b>Individuals (n)</b>	76	60	60	80	191	29	60	60	36
<b>Ages</b>	19–30	14-18	10–14	14–21	6-55	18-35	12–35	7–13	16–30
<b>Control group (n)</b>	Yes	No	Yes	Yes	Yes	No	No	No	No
<b>Class I (n)</b>	–	20	–	–	–	–	20	20	–
<b>Class II (n)</b>	–	20	30	–	–	–	20	20	–
<b>Class III (n)</b>	46	20	–	–	–	29	20	20	36
<b>Open bite (n)</b>	–	–	–	40	62	–	–	–	–
<b>Appliances</b>	IVRO	–	Twin	–	–	Bimaxilla	–	–	Orthognathic
<b>Surgery</b>	Surgery	–	Block	–	–	ry Surgery	–	–	S.
<b>Cephalogram</b>	Yes	No	No	Yes	Yes	No	No	No	No
<b>CBCT</b>	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
<b>H-SN (mm)</b>	(pre/post,14.1 17.4)	/107.2 / –	– / –	– / –	64.7 / 68.2	– / –	– / –	– / –	– / –
<b>H-C3 (mm)</b>	(pre/post,37.5 34.2)	/ – / –	– / –	39.51 / 43.03	29.4 / 27.6	– / –	– / –	– / –	– / –
<b>H-MP (mm)</b>	(pre/post,18.2 22.7)	/ 20.1 / –	19.4 / 17.0	19.01 / 21.93	18.02 / 19.06	22.3 / 26.1	– / –	– / –	– / –
<b>Post-treatment values</b>	Yes	No	Yes	No	No	Yes	No	No	Yes
<b>Results (Hyoid shift)</b>	Post-inf displacement	Retruded in Anterior in class III	Anterior after treatment	More anterior in OB	Post-inf displacement	Post-inf displacement	Retruded in CII, Anterior in class III	Lower in kids	Posterior shift

## **4 – Discussion**

The aim of this scoping review was to evaluate how the spatial position of the hyoid bone changes in different types of malocclusions, in order to determine whether consistent patterns exist, and to understand its potential clinical implications.

The hyoid bone is a unique and functionally significant anatomical structure. Unlike other bones, it does not articulate directly with any other skeletal component, but is suspended in place by muscles and ligaments. It serves as a structural anchor for the tongue, mandible, pharynx, and cervical spine. Given these connections, it is considered a potential marker for alterations in craniofacial morphology and posture. Investigating its position, in relation to malocclusions, may offer insights into compensatory adaptations of the orofacial system.

### **4.1 - Class I malocclusion**

While much of the literature on craniofacial morphology and upper airway dimensions focuses on extreme skeletal discrepancies such as Class II and III malocclusions, Class I patients also exhibit distinct anatomical characteristics that merit consideration. In the study by Zheng et al. (2014), Class I subjects demonstrated significantly larger nasopharyngeal airway volumes (Vol-NA) compared to Class II individuals, though similar to Class III, suggesting a more favourable airway configuration. Notably, the most constricted cross-sectional area (Min-CSA) was also significantly wider in Class I subjects than in Class II, potentially indicating a reduced risk of pharyngeal collapse during respiration. Dalmau et al. (2015), using CBCT-based analysis, found that Class I individuals presented more homogeneous airway dimensions across the upper, middle, and lower pharyngeal levels compared to Class III subjects. Specifically, Class I patients showed no significant anteroposterior or transversal constriction at the lower airway level, near the hyoid bone, indicating a relatively stable spatial relationship between craniofacial structures and the hyoid region. This suggests that in Class I patients, the hyoid bone may have a less variable relationship with the mandible and tongue posture, contributing to a more stable oropharyngeal configuration.

Overall, these findings imply that in Class I malocclusion, although not severely disharmonic from a skeletal standpoint, the airway and hyoid-related anatomy still reflects a well-balanced system that supports efficient respiratory function. This balance may serve as a reference when evaluating deviations observed in other malocclusion types, particularly in the context of orthodontic treatment planning and functional assessments.

#### **4.2 - Class II malocclusion**

In the studies included in this scoping review, individuals with Class II malocclusion consistently demonstrated a retruded and inferiorly positioned hyoid bone when compared to those with Class I or Normal occlusion. This pattern was evident in several investigations utilizing different imaging modalities, including CBCT and lateral cephalograms. The posterior displacement of the hyoid bone in Class II patients may be interpreted as a functional adaptation to the retruded position of the mandible. Since the hyoid bone maintains close muscular and ligamentous connections with the mandible, a posterior mandibular position likely exerts a mechanical influence on the spatial orientation of the hyoid.

Studies by Zheng et al. (2014) and Li et al. (2014) both identified that, prior to orthodontic intervention, Class II patients showed significantly shorter H-SN distances, and increased inferior displacement compared to control groups. Moreover, in the longitudinal evaluation conducted by Li et al., application of a functional appliance (Twin Block) resulted in an anterior repositioning of the hyoid bone, further supporting the hypothesis that its position dynamically responds to mandibular changes. Iwasaki et al. (2019) also observed that in paediatric populations, the hyoid bone in Class II subjects was located lower relative to Class I individuals, reinforcing the notion that skeletal discrepancies during growth phases influence hyoid positioning.

#### **4.3 - Class III malocclusion**

In contrast to Class II malocclusion, individuals with Class III skeletal patterns typically exhibited an anterior positioning of the hyoid bone. This finding was consistently reported across several of the studies included in this review.

A more anterior location of the hyoid in Class III patients is likely due to the mandibular prognathism that characterizes this malocclusion. The forward growth or protrusion of the mandible could lead to traction forces exerted on the suprahyoid and infrahyoid musculature, resulting in an anterior displacement of the hyoid bone itself.

Kitahara et al. (2010), who studied Class III patients undergoing IVRO, observed that prior to surgery, the hyoid bone was located more anteriorly compared to norms controls. Following surgical repositioning of the mandible, the hyoid shifted posteriorly and inferiorly, highlighting its capacity to adapt to skeletal changes.

Similarly, Xu et al. (2025) reported that patients with Class III malocclusion demonstrated significant changes in airway volume and hyoid bone position after orthognathic surgery, although not all differences reached statistical significance when compared to control groups.

These observations suggest that the hyoid bone does not maintain a fixed anatomical location but responds to underlying skeletal frameworks, particularly to anterior-posterior discrepancies of the mandible.

#### **4.4 - Open Bite malocclusion**

Open bite malocclusion, although less frequently addressed compared to Class II and III patterns, presents unique characteristics in terms of hyoid bone positioning. In the studies reviewed, particularly in the work by Laranjo et al. (2014), patients with anterior open bite exhibited a tendency for the hyoid bone to be positioned more anteriorly when compared to control groups with normal occlusion.

This anterior displacement may be related to alterations in tongue posture typically observed in open bite cases. Given the close anatomical and functional relationship between the tongue and the hyoid bone, a more anterior or lowered tongue posture, given primarily by muscular compensation and absence of incisal contact, could transmit mechanical forces leading to anterior positioning of the hyoid. In this context, altered function of the suprahyoid and infrahyoid muscles may influence the vertical and anteroposterior alignment of the hyoid bone, especially in growing patients.

Furthermore, modified swallowing patterns and decreased oropharyngeal muscle tone—both frequently reported in individuals with open bite—could contribute to long-term

adaptations in the spatial positioning of the hyoid bone. These compensations may, in turn, exacerbate the functional imbalance already present in these malocclusions.

In support of these findings, Urzal et al. (2014) conducted a comparative analysis of hyoid bone positioning across open bite, deep bite, and normocclusion subjects. However, contrary to what is observed in Laranjo et al., their results revealed that individuals with open bite consistently presented with a more inferior and posterior placement of the hyoid bone when assessed relative to cranial base landmarks. This suggests that, rather than advancing, the hyoid bone tends to descend and retract in response to an altered vertical skeletal pattern, potentially reflecting a compensatory mechanism to maintain airway patency or due to soft tissue imbalances associated with hyperdivergent growth patterns.

Such apparently contradictory findings between Laranjo et al. and Urzal et al. may come from differences in methodology, reference systems, and sample characteristics. While Laranjo et al. used cephalometric analysis with a focus on anteroposterior measurements relative to dentoalveolar landmarks, Urzal et al. based their evaluations on cranial base landmarks in a comparative framework involving multiple occlusal patterns. This could partially explain why one study found anterior positioning, whereas the other reported posterior displacement. Such discrepancies highlight the importance of standardizing reference points in future studies to enable consistent interpretation of hyoid position in open bite cases.

Such observations underscore the clinical significance of evaluating hyoid bone position in patients with vertical dysplasia. They also emphasize the importance of integrating functional assessments, such as swallowing, respiration, and tongue posture, into the diagnostic process. Nevertheless, due to the relatively small number of studies specifically targeting open bite malocclusion and its impact on hyoid dynamics, additional research is essential to establish stronger evidence and to determine whether these morphological variations can inform individualized orthodontic treatment planning and prognosis.

#### **4.5 - Treatments effects**

Several studies included in this review assessed the effects of orthodontic and surgical treatments on the spatial position of the hyoid bone. These interventions confirmed that

the hyoid bone is a dynamic structure capable of positional adaptation in response to changes in skeletal and dental relationships.

Surgical treatments, particularly bimaxillary surgery and IVRO, were associated with a posterior and inferior displacement of the hyoid bone after the operation. Kitahara et al. (2010) reported significant posterior repositioning of the hyoid following IVRO in Class III patients. Similarly, Li et al. (2014) observed a posterior and inferior shift of the hyoid bone after bimaxillary surgery, suggesting that skeletal setback procedures impact not only mandibular positioning, but also the connected muscular structures.

On the other hand, functional orthodontic appliances, such as the Twin Block device evaluated by Li et al. (2014 - Twin Block study), induced an anterior repositioning of the hyoid bone in Class II patients. This forward movement reflected the mandibular advancement achieved through orthopaedic intervention and emphasized the ability of the hyoid to react to mandibular positional changes.

#### **4.6 - Methods and limitations**

Interpretation of the findings from this scoping review must be approached with caution due to several methodological limitations present in the included studies. First, considerable heterogeneity was observed regarding imaging techniques. While some studies utilized CBCT to evaluate three-dimensional changes in hyoid bone positioning, others relied on two-dimensional lateral cephalometric radiographs. CBCT offers higher spatial accuracy and volumetric data, whereas cephalometry is more prone to projection errors and superimpositions, potentially influencing the comparability of results. Secondly, the definitions and measurement methods of the skeletal landmarks varied across studies. Although parameters such as H-SN, H-C3, and H-MP were frequently assessed, discrepancies in landmark identification, head posture control, and measurement protocols could introduce biases.

Another notable limitation is the diversity in the study populations. Differences in age ranges, growth status (adolescent vs. adult patients), and sample sizes were evident. Some studies, particularly those focusing on open bite or paediatric populations, involved relatively small cohorts, reducing statistical power and generalizability.

Furthermore, most investigations employed a cross-sectional design, offering only a static depiction rather than longitudinal data. Only a few studies evaluated pre- and post-treatment changes, and long-term adaptations of the hyoid bone remain largely unexplored.

Finally, publication bias and the exclusion of articles in languages that differs from the ones chosen in the inclusion criteria, could have limited the comprehensiveness of the review.

#### **4.7 - Clinical implications**

The evidence collected in this review emphasizes the potential clinical relevance of the hyoid bone position in patients with malocclusion. Given its anatomical and functional links with the mandible, tongue, pharynx, and cervical structures, the hyoid bone may serve as an indicator of craniofacial balance or disharmony. Changes in its position seem to reflect underlying skeletal discrepancies, particularly mandibular retrusion in Class II malocclusion and mandibular protrusion in Class III cases.

Clinically, assessing the position of the hyoid bone could provide additional diagnostic information, complementing conventional cephalometric analyses. For instance, a significantly retruded or lowered hyoid bone might suggest the presence of posterior mandibular positioning, increased airway collapsibility risk, or altered orofacial muscle tone. Moreover, understanding hyoid dynamics may aid in planning orthodontic or surgical interventions, especially those that aim to sagittal skeletal corrections. Monitoring changes in hyoid bone positioning before and after treatment, could also offer insight into the functional stability and adaptation of the stomatognathic system.

In paediatric populations, early recognition of abnormal hyoid positioning might support preventive strategies aimed at guiding normal craniofacial growth and minimizing the risk of future malocclusion or respiratory dysfunction.

#### **4.8 - General conclusions**

Individuals with Class II malocclusion showed a consistent pattern of posterior and inferior displacement of the hyoid bone, typically due to mandibular retrusion. On the contrary, Class III malocclusion was often associated with a more anterior position of the

hyoid, likely reflecting the forward mandibular development. In open bite cases, some studies hypothesized an anterior shift of the hyoid bone due to tongue posture adaptations, however, quantitative analyses found a posterior and inferior displacement, challenging this assumption.

Beyond classification-based observations, the review highlighted the influence of treatment modalities on hyoid bone positioning. Surgical procedures such as bimaxillary surgery and IVRO led to significant posterior displacement of the hyoid bone, whereas functional orthopedic devices like the Twin Block tended to advance it anteriorly. These post-treatment shifts reinforce the idea that hyoid bone movement is closely linked to mandibular changes and myofunctional balance.

Despite methodological variability across the included studies, particularly regarding imaging techniques (CBCT vs. lateral cephalometry), sample size, and reference planes, the majority of the findings support the hypothesis that the hyoid bone position can serve as a clinical indicator of skeletal and functional disharmony.



## **5 – Conclusion**

Based on the evaluation of nine relevant studies, this review confirms that the hyoid bone is not a static skeletal element, but rather a highly adaptive and functionally responsive structure influenced by mandibular posture, airway dimensions, and surrounding muscular dynamics. The hyoid bone appears to play a significant role in craniofacial dynamics and it can be influenced by malocclusions and their treatments, making it a potentially useful diagnostic and prognostic tool in orthodontic evaluation.

Future research using standardized imaging methods and larger sample sizes will be essential to establish normative values and confirm its clinical utility.

Moreover, longitudinal studies are needed to assess long-term post-treatment stability of hyoid positioning and its effect on airway function and musculoskeletal adaptation.



## 6 - Bibliography

- Aprile, M., Verdecchia, A., Dettori, C., & Spinass, E. (2025). Malocclusion and its relationship with sound speech disorders in deciduous and mixed dentition: A scoping review. *Dentistry Journal*, *13*(1), 27. <https://doi.org/10.3390/dj13010027>
- Auvenshine, R. C., & Pettit, N. J. (2020). The hyoid bone: An overview. *Cranio: The Journal of Craniomandibular Practice*, *38*(1), 6–14. <https://doi.org/10.1080/08869634.2018.1487501>
- Bhardawaj, A., Patel, S., & Mishra, K. (2019). Deep bite and its treatment modalities with fixed orthodontics: A review. *International Journal of Current Research*, *11*(6), 4901–4907. <https://doi.org/10.24941/ijcr.35723.06.2019>
- ChingCho, H., Liu, H., Lin, C., Liu, Z., Zhai, Y., Guo, S., & Xu, R. (2025). Comparison of upper airway volume and hyoid position after camouflage orthodontic or orthodontic-orthognathic treatment in patients with skeletal class III malocclusion with normal-angle vertical pattern. *West China Journal of Stomatology*, *43*(1), 53–62. <https://doi.org/10.7518/hxkq.2025.2024184>
- Dalmau, E., Zamora, N., Tarazona, B., Gandia, J. L., & Paredes, V. (2015). A comparative study of the pharyngeal airway space, measured with cone beam computed tomography, between patients with different craniofacial morphologies. *Journal of Cranio-Maxillo-Facial Surgery*, *43*(8), 1438–1446. <https://doi.org/10.1016/j.jcms.2015.06.016>
- Doual, A., Léger, J.-L., Doual, J.-M., & Hadjiat, F. (2003). L'os hyoïde et la dimension verticale. *L'Orthodontie Française*, *74*(3), 333–363. <https://doi.org/10.1051/orthodfr/200374333>
- Fattahi, H., Pakshir, H., Afzali Baghdadabadi, N., & Shahian Jahromi, S. (2014). Skeletal and dentoalveolar features in patients with deep overbite malocclusion. *Journal of dentistry (Tehran, Iran)*, *11*(6), 629–638.
- Feștilă, D., Ciobotaru, C. D., Suci, T., Olteanu, C., & Ghergie, M. C. (2025). Oral breathing effects on malocclusions and mandibular posture: Complex consequences on dentofacial development in pediatric orthodontics. *Children*, *12*.
- Ghafari, J. G., Macari, A. T., & Haddad, R. V. (2013). Deep bite: Treatment options and challenges. *Seminars in Orthodontics*, *19*(4), 253–266. <https://doi.org/10.1053/j.sodo.2013.07.005>
- Ghomasra, R., & Brizuela, M. (2023). Orthodontics, malocclusion. *StatPearls*.
- Grippaudo, C., Paolantonio, E. G., Antonini, G., Saulle, R., La Torre, G., & Deli, R. (2016). Association between oral habits, mouth breathing and malocclusion. Associazione fra abitudini viziate, respirazione orale e malocclusione. *Acta otorhinolaryngologica Italica : organo ufficiale della Societa italiana di otorinolaringologia e chirurgia cervico-facciale*, *36*(5), 386–394. <https://doi.org/10.14639/0392-100X-770>
- Iwasaki, T., Saitoh, I., Takemoto, Y., Inada, E., Kanomi, R., Hayasaki, H., & Yamasaki, Y. (2018). Relationships among tongue volume, hyoid position, airway volume,

and maxillofacial morphology in growing children. *Orthodontics & Craniofacial Research*, 21(2), 97–103. <https://doi.org/10.1111/ocr.12221>

- Katib, H. S., Aljashash, A. A., Albishri, A. F., Alfaifi, A. H., Alduhyaman, S. F., Alotaibi, M. M., Otayf, T. S., Bashikh, R. A., Almadani, J. A., Thabet, A. M., & Alaman, K. A. (2024). Influence of oral habits on pediatric malocclusion: Etiology and preventive approaches. *Cureus*, 16(11), e72995. <https://doi.org/10.7759/cureus.72995>
- Kolawole, K. A., Folayan, M. O., Agbaje, H. O., Oyedele, T. A., Onyejaka, N. K., & Oziegbe, E. O. (2019). Oral habits and malocclusion in children resident in Ile-Ife, Nigeria. *European Archives of Paediatric Dentistry*, 20(3), 257–265. <https://doi.org/10.1007/s40368-018-0391-3>
- Kulshrestha, R. (2018). Open bite malocclusion: An overview. *Journal of Oral Health and Craniofacial Science*, 3(1), 11–20. <https://doi.org/10.29328/journal.johcs.1001022>
- Laranjo, F., & Pinho, T. (2014). Cephalometric study of the upper airways and dentoalveolar height in open bite patients. *International Orthodontics*, 12(4), 467–482. <https://doi.org/10.1016/j.ortho.2014.10.005>
- Levac, D., Colquhoun, H., & O'Brien, K. K. (2010). Scoping studies: Advancing the methodology. *Implementation Science*, 5, 69. <https://doi.org/10.1186/1748-5908-5-69>
- Li, L., Liu, H., Cheng, H., Han, Y., Wang, C., Chen, Y., Song, J., & Liu, D. (2014). CBCT evaluation of the upper airway morphological changes in growing patients of class II division 1 malocclusion with mandibular retrusion using Twin Block appliance: A comparative research. *PLOS ONE*, 9(4), e94378. <https://doi.org/10.1371/journal.pone.0094378>
- Li, Y. M., Liu, J. L., Zhao, J. L., Dai, J., Wang, L., & Chen, J. W. (2014). Morphological changes in the pharyngeal airway of female skeletal class III patients following bimaxillary surgery: A cone beam computed tomography evaluation. *International Journal of Oral and Maxillofacial Surgery*, 43(7), 862–867. <https://doi.org/10.1016/j.ijom.2014.03.009>
- Millett, D. T., Cunningham, S. J., O'Brien, K. D., Benson, P. E., & de Oliveira, C. M. (2018). Orthodontic treatment for deep bite and retroclined upper front teeth in children. *The Cochrane Database of Systematic Reviews*, 2(2), CD005972. <https://doi.org/10.1002/14651858.CD005972.pub4>
- Peters, M. D., Godfrey, C. M., Khalil, H., McInerney, P., Parker, D., & Soares, C. B. (2015). Guidance for conducting systematic scoping reviews. *International Journal of Evidence-Based Healthcare*, 13(3), 141–146. <https://doi.org/10.1097/XEB.0000000000000050>
- Proffit, W. R., Fields, H., Larson, B., & Sarver, D. M. (2019). *Contemporary Orthodontics (6th ed.)*.
- Silva, M., & Manton, D. (2014). Oral habits—Part 1: The dental effects and management of nutritive and non-nutritive sucking. *Journal of Dentistry for Children (Chicago, Ill.)*, 81(3), 133–139.

- Sivakumar, A., Azharuddin, M., Sivakumar, I., Sharan, J., Raju, D. V. S. K., & Krishna, V. (2017). Assessment of hyoid bone position among different skeletal patterns. *Orthodontic Waves*, 76(3), 221–225. <https://doi.org/10.1016/j.odw.2017.09.003>
- Ulusoy, C., Canigur Bavbek, N., Tuncer, B. B., Tuncer, C., Turkoz, C., & Gencturk, Z. (2014). Evaluation of airway dimensions and changes in hyoid bone position following class II functional therapy with activator. *Acta Odontologica Scandinavica*, 72(8), 917–925. <https://doi.org/10.3109/00016357.2014.923109>
- Urzal, V., Braga, A. C., & Ferreira, A. P. (2014). Hyoid bone position and vertical skeletal pattern – Open bite/deep bite. *Oral Health and Dental Management*, 13(2), 341–347. <https://www.researchgate.net/publication/263705008>
- Xiang, M., Hu, B., Liu, Y., Sun, J., & Song, J. (2017). Changes in airway dimensions following functional appliances in growing patients with skeletal class II malocclusion: A systematic review and meta-analysis. *International Journal of Pediatric Otorhinolaryngology*, 97, 170–180. <https://doi.org/10.1016/j.ijporl.2017.04.009>
- Zheng, Z., Xu, Q., Chen, W., & Liu, H. (2013). Three-dimensional evaluation of upper airway in patients with different anteroposterior skeletal patterns. *Orthodontics & Craniofacial Research*, 16(3), 187–195. <https://doi.org/10.1111/ocr.12029>