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Relación entre posición de las vértebras cervicales y la maloclusión clase II. Revisión de la literatura

Relationship between cervical vertebrae position and class II malocclusion. a literature review

[1] Yamanua Gabriela Leon Ochoa https://orcid.org/0009-0006-9541-5189
Dentistry student, Catholic University of Cuenca, Cuenca, Ecuador.
leonyamanua@gmail.com
[2] Maria Isabel Cabrera Padron https://orcid.org/0000-0002-4086-6082
Professor of dentistry, Catholic University of Cuenca, Cuenca, Ecuador.
mcabrerap@ucacue.edu.ec
[3] Evelyn Mireya Guiracocha Viñanzaca https://orcid.org/0009-0001-7485-1364
Dentistry student, Catholic University of Cuenca, Cuenca, Ecuador.
evelynmguiracocha1419@gmail.com

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Palabras claves:
Vértebras cervicales, Maloclusión, clase II, asociación, postura.

Resumen

En la práctica clínica ortodóncica, el análisis detenido de las estructuras craneofaciales es imperativo para evaluar la armonía y equilibrio anatómico en los pacientes, la columna vertebral desempeña un papel crucial en la anatomía y funcionalidad del sistema estomatognático. **Objetivo.** Analizar la información disponible en diferentes bases de datos digitales, con el fin de establecer la relación entre la postura cráneo-cervical y la maloclusión clase II. **Materiales y métodos.** Se realizó una exhaustiva revisión de la literatura científica utilizando bases de datos como PubMed, Scielo, Google Scholar, Taylor&Francis, Redalyc, Scopus, mediante la utilización de palabras clave obtenidas del Medical Subject Heading (MeSH), así como en Descriptores en Ciencias de la Salud (DeCs). Se consideraron estudios analizaron la relación entre la posición de las vértebras cervicales, la postura craneal y la maloclusión en clase esquelética II, se aplicaron criterios de inclusión y exclusión para seleccionar estudios relevantes para evaluar la relación entre las mediciones craneocervicales y los tipos de maloclusión. **Justificación.** La evaluación craneocervical ha emergido como un área de interés crucial en la ortodoncia, y comprender su relación con la maloclusión es fundamental para una evaluación integral y un tratamiento ortodóncico preciso. Esta revisión pretende sintetizar y analizar la evidencia existente para subrayar la importancia de considerar la postura craneocervical en el diagnóstico y tratamiento de la maloclusión. **Resultados:** El equilibrio postural cráneo-facial se produce cuando la cabeza por medio de la articulación occipito-atloidea se mantiene en equilibrio, la columna cervical, los maxilares, la musculatura, el hioides y todas las estructuras en relación con esta mantienen un equilibrio de fuerzas. **Área de estudio general:** Odontología. **Área de estudio específica:** Ortodoncia. **Tipo de artículo:** revisión bibliográfica.

Keywords:
Cervical vertebrae, Malocclusion, Class II, association, posture

Abstract

In orthodontic clinical practice, careful analysis of craniofacial structures is essential to assess the harmony and anatomical balance in patients. The spinal column plays a crucial role in the anatomy and functionality of the stomatognathic system.

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Objective: To analyze the information in digital databases to establish the relationship between craniocervical posture and Class II Malocclusion. Materials and Methods: A comprehensive literature review was conducted using databases such as PubMed, SciELO Google Scholar, Taylor & Francis, Redalyc, and Scopus by using keywords obtained from Medical Subject Heading (MeSH) and Health Sciences Descriptors (DeCs). Studies analyzing the relationship between cervical vertebral position, cranial posture, and Class II Malocclusion were considered, and inclusion and exclusion criteria were applied to select the most relevant studies. Rationale: Craniocervical evaluation is crucial in orthodontics. This review analyzes its relationship with malocclusion, highlighting its importance for accurate diagnosis and treatment through synthesizing and analyzing existing evidence. Results: Cranio-maxillofacial postural balance occurs when the head is maintained in equilibrium through the atlanto-occipital joint. The cervical spine, maxillae, musculature, hyoid bone, and all related structures maintain a balance of forces.

Introduction

In the field of Orthodontics, careful analysis of the craniofacial structures is imperative to assess the anatomical harmony and balance in patients.1 The Natural Head Position (NHP) emerges as a key physiological parameter, related to the natural posture of the body and the disposition of the cervical spine. This concept, based on the direction of vision when the individual looks straight ahead, plays an essential role in the orthodontic clinical examination, contributing to an accurate diagnosis.2

The vertebral column, composed of thirty-three vertebrae, plays a crucial role in the anatomy and functionality of the human body; of these, the seven cervical vertebrae are especially relevant for the support of the craniofacial structures and therefore influence the maxillomandibular position. The cervical region, although almost constant in the number of vertebrae, presents distinctive characteristics, such as the smaller and wider size of the vertebral bodies, as well as the presence of transverse and articular processes with specific directions. The C1 vertebra, called the atlas, and the C2 vertebra, the axis, stand out for their anatomical peculiarities, being essential for the support of the skull and

the atlantooccipital joint,1 since their muscle-tendon structure enables an adequate position of the head and therefore of the temporomandibular joint (TMJ). In this context, the outstanding importance falls on the capacity of these vertebrae to facilitate the precise positioning of the head and the function of the TMJ. The distance between the first vertebra and the occipital bone, as well as the position of the head and neck, are linked to different aspects such as the shape of the head and face, the basal structure of the skull, the space in the upper airways, dental alignment and temporomandibular disorders.3

In this context, dental malocclusion, according to Wylie's definition (1941), It is the alternative maxillo-mandibular relationship resulting in disproportionate parts, andThis imbalance can affect one or more elements of the oral system, such as teeth, bones, muscles, temporomandibular joint and nerves. It is important to note that the term malocclusion cannot be considered as an absolute criterion of what is normal or abnormal. Instead, it occurs in different degrees of affectation, influenced by the presence of a variety of risk factors and how they interact with individual characteristics.4

In contrast, malocclusion, according to Angle (1899), refers to the lack of harmony between the masticatory surfaces of the upper and lower teeth when closing the jaw. The etiology of this condition is multifaceted and diverse, as it involves a variety of risk factors, such as those that may be of external or internal origin, exerting their influence at a general or local level, the severity of the malocclusion will be conditioned by the susceptibility of the individual and the duration of exposure to such factors. These represent a quantifiable probability with predictive value and their identification can be beneficial for prevention at an individual or community level.4

From this perspective, the relationship between the cervical vertebrae and malocclusion has been the subject of growing interest in dentistry and orthodontics. Research has shown the significant influence that alterations in the spine have on the position of the jaw and the temporomandibular joint, which directly impacts dental alignment. This deeper understanding has led to a more comprehensive approach to orthodontic and dental treatments, seeking to address not only dental aspects, but also those linked to the posture and alignment of the cervical spine to obtain more complete and lasting results in oral health.3 The cervical spine, which supports the structure of the head, plays a fundamental role in the position and development of the jaws. From a biomechanical perspective, alterations in the alignment of the cervical vertebrae can influence dental position and the relationship between the upper jaw and the mandible. This phenomenon is especially relevant within the framework of Angle class II malocclusion, characterized by an advanced position of the upper jaw in relation to the mandible.3,4 The relationship between cranial posture, facial structures and breathing has been the subject of study, pointing out specific patterns associated with the natural position of the head.4

In this sense, the Cranio-Mandibular-Cervical Biomechanical relationship is presented as an "Indivisible Functional Unit". The analysis proposed by Dr. Rocabado (1984)5, evaluates various aspects, from the angular inclination between the skull and the cervical spine to the resting position of the tongue and the airways, highlighting the need for an accurate diagnosis based on objective methods of radiographic evaluation. This deep understanding of the anatomical and biomechanical interrelations is essential to address not only class II malocclusion, but also to promote oral health and craniofacial function in a comprehensive manner.6

Methodology

This bibliographic review is descriptive and documentary in nature, intended to collect data on the relationship between the position of the cervical vertebrae and class II malocclusion, which was carried out through an exhaustive electronic search on various digital platforms, such as Pubmed, Scopus, Scielo, Google Academic, Taylor & Francis and Redalyc, including information in English and Spanish.

Given the subject's approach, the search strategy was based on the use of keywords obtained from the Medical Subject Heading (MeSH), as well as terms from the Health Sciences Descriptors (DeCs). Specific controlled and indexed descriptors were used for each database involved in this scoping review, combining them using the Boolean operator AND, as detailed in Table 1.

Table 1.*Search strategy*

Search strategy.	Keywords or database collection descriptors
PUBMED	((Cervical Vertebrae) AND (Malocclusion))
REDALYC	(class II malocclusion AND cervical posture)
SCOPUS	(malocclusion, AND class AND III, AND posture, AND cervical)
SKY	(malocclusion AND class II AND cervical posture)
TAYLOR & FRANCIS	[All: malocclusion] AND [All: class] AND [All: II] AND [All: cervical] AND [All: posture]
GOOGLE ACADEMIC	((association) and (malocclusion) and (class II) and (cervical posture))

The inclusion and exclusion criteria of the literature review article on the relationship between the position of the cervical vertebrae and class II malocclusion were chosen according to the focus and objective of the study.

Inclusion criteria:

1. Thematic relevance: Articles that specifically address the relationship between the position of the cervical vertebrae and class II malocclusion.

2. Type of study: Inclusion of systematic reviews, meta-analysis and original studies that provide a comprehensive synthesis or analysis of the aforementioned relationship.

3. Language: English and Spanish.

Exclusion criteria:

1. Thematic irrelevance.

2. Data duplication.

3. Conflict of interest.

4. Clinical trials in syndromic patients.

Ethical Aspects:

This study, being a bibliographic review article, does not entail any risk, since its approach is based on the collection and analysis of already existing information. Since it does not require the participation of subjects or direct experimentation, it is considered documentary in nature.

Results

In this bibliographic review article, a database record was established: 49 articles from Pubmed, 32 from Scopus, Scielo, 1,460 from Google Academic, 74 from Taylor & Francis and 32,591 from Redalyc. Resulting in a total of 34,211 articles as shown in the graph, of which 16 articles were used to prepare the results of this study.

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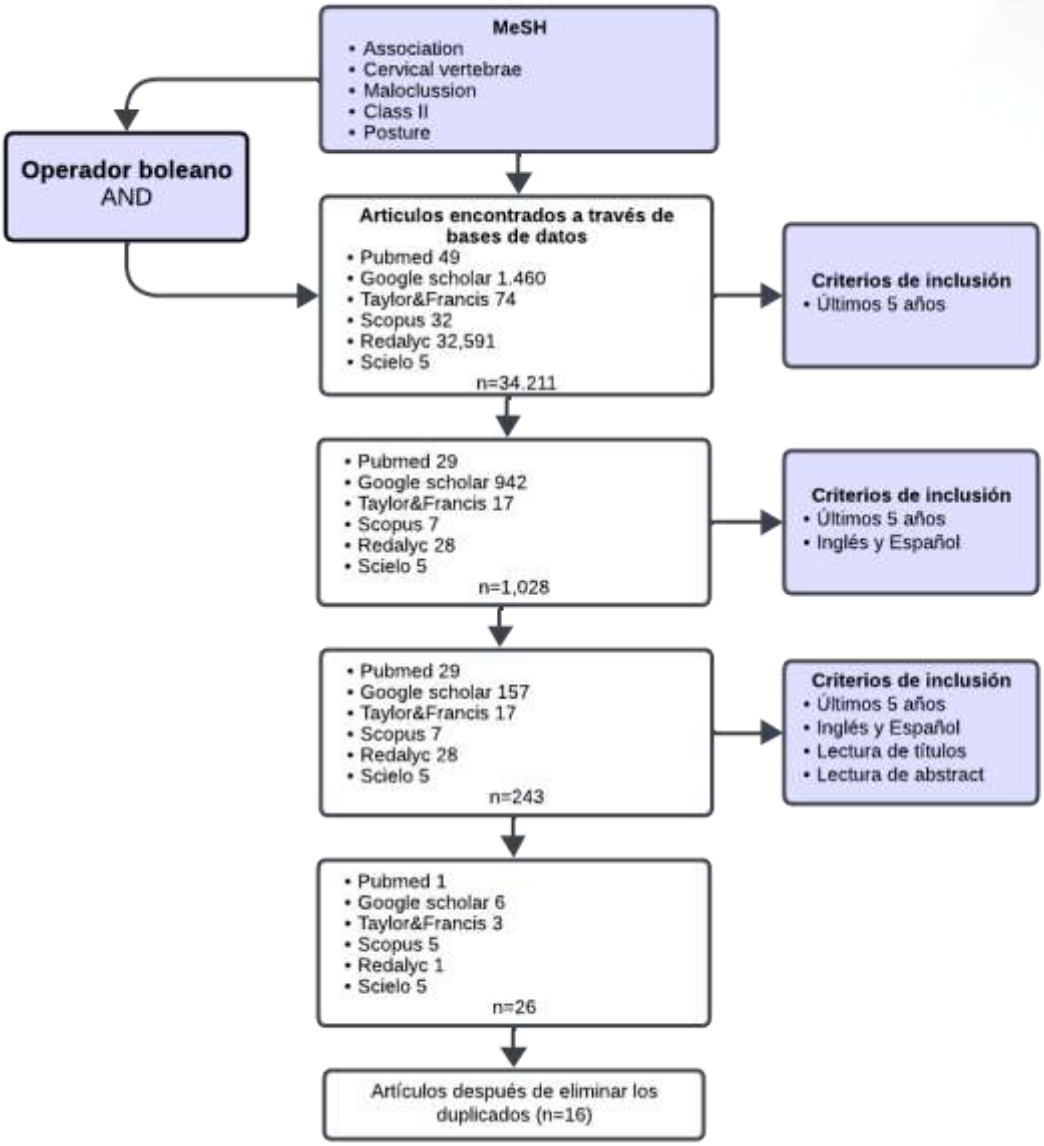

Figure 1.*Item Selection Flowchart*

A first search was performed, obtaining 34,211 articles, of which 1,028 were obtained by applying the declared temporality; after including inclusion criteria for English and Spanish, a result of 243 articles was obtained. After verifying all the registered articles, 217 articles that did not meet the selection criteria were excluded. By eliminating duplicates, 16 articles were found to be suitable for this literature review. In this review, it was considered that clinical trials represent 44%, systematic literature review articles 25%, and bibliographic review articles 31%.

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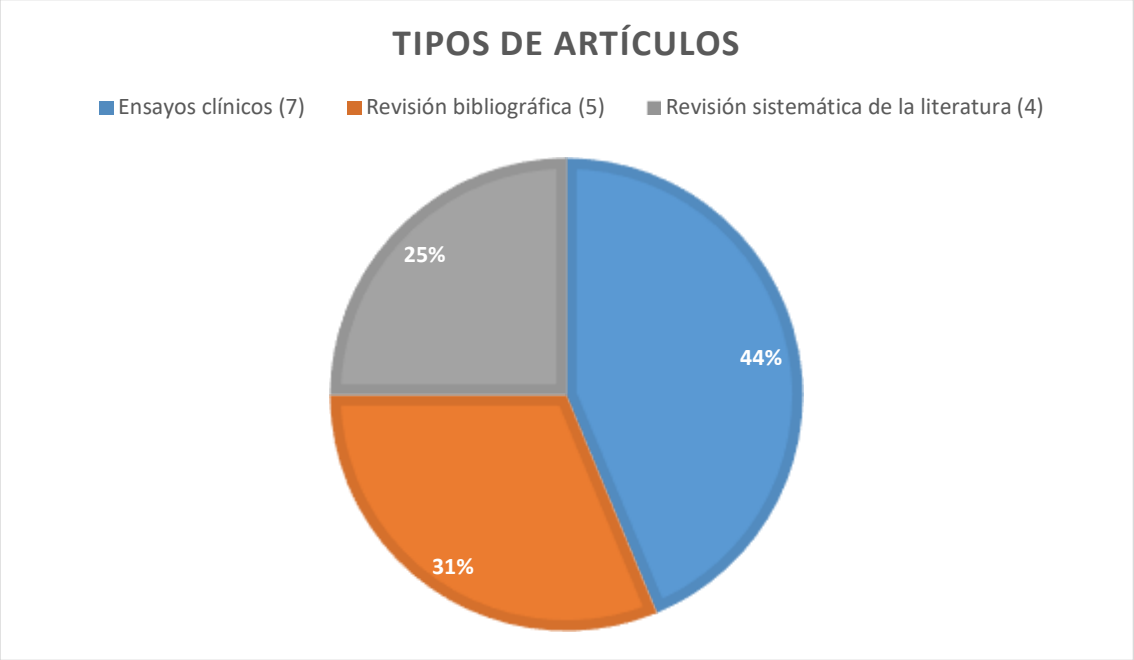

Figure 2.*Percentage of study types of the selected articles*

In the literature search process to support the research, a total of 16 bibliographic sources were collected. These are distributed in various categories, including 7 clinical trials2,3,6,9,10,11,16, 5 bibliographic reviews7,8,12,14,17 and 4 systematic reviews13,15,18,19. This diverse set of sources will provide a solid basis for addressing the different aspects of the research and will enrich the analysis through a variety of perspectives and approaches.

From the evaluation of the collected data, it is possible to say that the dynamics of the craniocervical system constitutes an essential part of the upper quadrant of the body, composed of the head, neck and shoulder girdle. Class II malocclusion is associated with changes in the cervical position, bringing the head and shoulders forward; this biomechanical connection between the skull, mandible and cervical spine highlights the importance of a comprehensive approach in orthodontic diagnosis and treatment.4 It is made up of bony structures, such as the skull and cervical vertebrae, which are interconnected by joints such as the atlantooccipital, atlantoaxial and vertebral joints. In addition, it includes muscular, ligamentous, and nervous connections sharing aponeurosis and blood supply.6

The interaction of this system focuses on maintaining the stability of the skull on the spine, achieving this when the eyes are in a horizontal position. In this alignment, both the auriculonasal plane and the occlusal plane are horizontal, crossing the upper part of the external auditory canal and the anterior nasal protuberance. During the biomechanics of the craniocervical interaction, a system of levers is formed:

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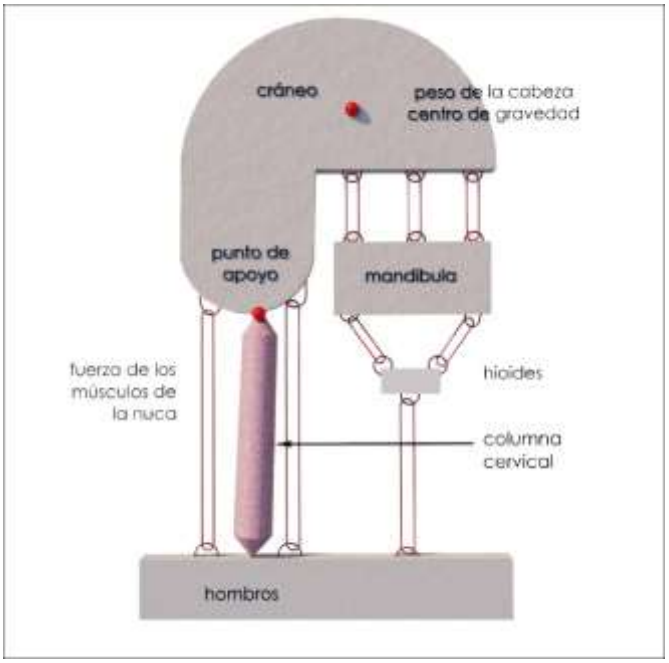

Figure 3.*Biomechanics of the head and neck*

- A support point on the occipital condyles.
- The force counteracted by the weight of the head, which is exerted on its center of gravity near the sella turcica.
- The energy generated by the force of the suboccipital muscles, which must continually compensate for the weight of the head to prevent it from leaning forward.

The forward position of the head's centre of gravity explains why the posterior neck muscles exert a greater force compared to the flexor muscles. The extensor muscles, such as the suboccipitals, must work against gravity, while the flexor muscles, including the supra- and infrahyoids, receive greater force.

assistance of this.8The physiological adaptation of the spine is influenced by the muscles that are inserted into the different vertebrae.7

The rectus femoris minor and major muscles cause flexion at the junction between the atlas and the axis6. On the other hand, the anterior neck muscles, both the suprahyoid and infrahyoid, which have a longer lever arm, act as powerful flexors of both the head and the cervical spine. These muscles find support in the hyoid bone, whose muscular contraction action, combined with the ligaments and fascia that connect to it, establishes a connection between the head and neck. This structure serves as an anchor point for the the muscles and ligaments that attach at the base of the skull, the mandible, the scapula, and the upper mediastinum.[7.8]

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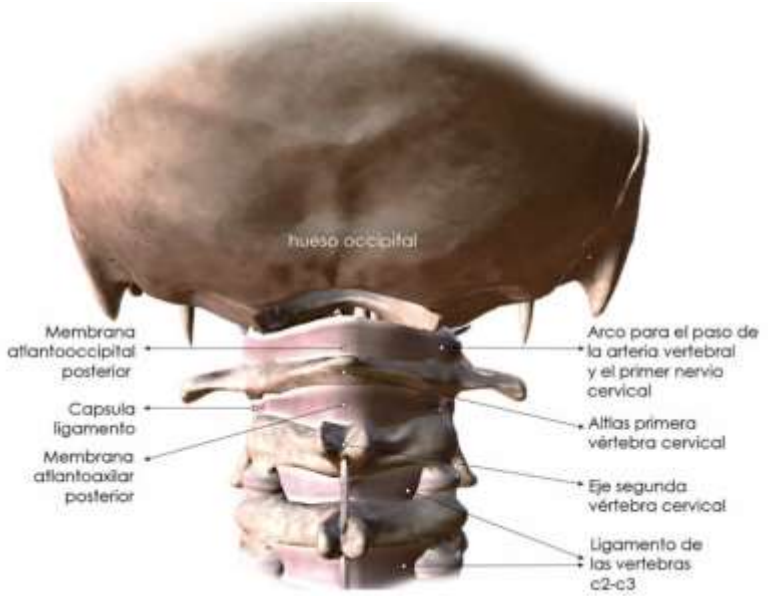

Figure 2.*Cervicoccipital structures (posterior view)*

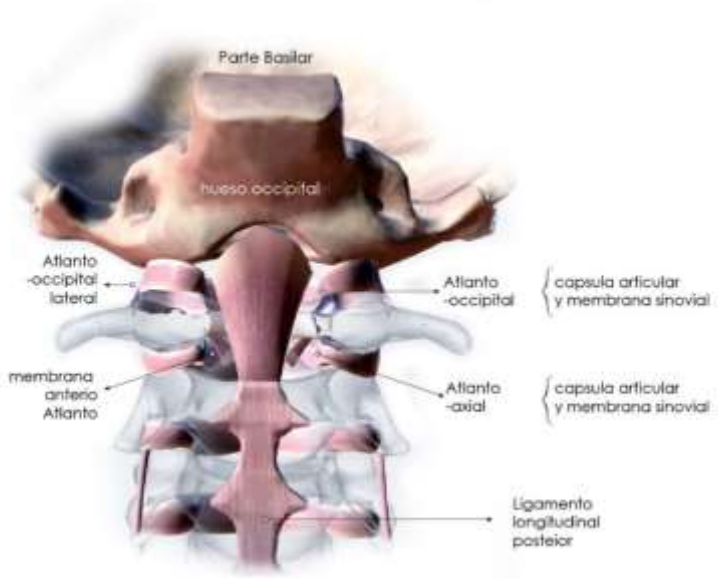

Figure 3.*Cervicoccipital structures (Anterior view)*

Rocabado has investigated the biomechanical connection between the skull, airway and hyoid region using a radiographic assessment approach that is currently in use. This analysis approach considers several parameters, including the angle relationship between the skull and the cervical spine, as well as the distance from the base of the occipital bone to the posterior arch of the atlas.7

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The relevant information obtained on the correlation between the position of the cervical vertebrae and class II malocclusion is summarized in the following tables.

Table 1. Relationship between skeletal class and vertebral position

Author and Year	Qualification	Result
Rocio Serrano Herrera Oscar Norambuena Lama Andrés Celis Sercen Christian Vergara Nunez 20212	Comparative study of the natural head position between skeletal classes using facial photogrammetry.	The true horizontal was used as a reference plane with the plane formed by the tragus point (t) and the exocanthus (ex), the measurement of the angle formed was taken, thus determining the PNC and resulting in patients with a Class II skeletal structure showing a PNC more inclined clockwise compared to Class I patients, according to the data of the analyzed sample.
Luisa Cardenas. Fernando Morales. Roberto Justus. Ricardo Ondarza. 20193	Comparative study of the craniocervical position of the head and its relationship with class II and III skeletal patterns	A statistically significant discrepancy was observed between patients with Class II and III malocclusions when considering their relationship with the craniocervical angle. A statistically significant disparity was observed between patients with Class II and III malocclusions when relating to the C0-C1-C2 distance. A statistically relevant divergence was evident between patients with Class II and III malocclusions when considering their relationship with the lower airway.
Iris Ocampo Fonseca Maria de la Paz Consuelo Aguilar Francisco Manuel Sanchez 20136	Changes in the position of the skeletal structures of the craniocervical complex after orthognathic surgery	Changes in the position of the bony structures of the craniocervical complex are observed in patients undergoing combined orthognathic surgery. A reduction in the angle formed by the McGregor planes and the odontoid plane is recorded, suggesting a posterior rotation of the skull, possibly in response to the reduction of the pharyngeal spaces. In addition, a significant decrease in the distance between the base of the skull and the atlas is found in women, indicating a tendency towards posterior rotation of the skull. This could trigger suboccipital compression and, as a result, headache.
Swami Gonzalez Maiyelin Llanes Nurys Batista Lucia Pedroso Maykel Perez 20197	Relationship between dental occlusion and craniocervical posture in children with class II and III malocclusions	As the discrepancy in the molar-canine relationship increases, the craniovertebral angle and suboccipital space increase. This suggests an anterior tilt of the head in Class II and a posterior tilt in Class III.

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Table 1. Relationship between skeletal class and vertebral position (continued)

Author and Year	Qualification	Result
Camilo Sandoval Alejandro Diaz German Manriquez 20218	Relationship between craniocervical posture and skeletal class: A statistical multivariate approach for studying Class II and Class III malocclusions.	Class II malocclusion showed a more pronounced backward tilt of the mandible compared to the skull, and also a more extended position of the head compared to Class III malocclusion. In addition, significant relationships were found between the inclination of the mandible and the natural curvature of the neck (cervical lordosis), Also, the relationship between the inclination of the jaw and the position of the head and neck.
Mishell Muñoz 20209	Craniocervical relationship in skeletal class II and class III using Cone Beam tomography	In CT scans of skeletal class II patients, the average craniocervical angle was found to be 94°, which means that, as far as the norm is concerned, the values varied between 78° and 99°. When measuring the occipitoatloid space in CT scans of patients with Class II skeletal structure, the distance was 3.9 mm, which tells us that it is also within the norm and its values fluctuated between -4.6 mm and 9.8 mm.
Camilo Sandoval Alejandro Diaz German Manriquez 202111	Assessing cervical spine and craniofacial morphology in Class II and Class III malocclusions: A geometric morphometric approach. Cranio	Skeletal Class II individuals showed a shorter mandibular body, posterior rotation of the mandibular ramus, maxillary protrusion, and anterior rotation of the skull base. Additionally, a forward tilt of the cervical spine and a straighter upper/mid cervical spine were observed in Class II individuals, relative to Class III individuals. In contrast to Class III, skeletal Class II individuals showed a lower height of the third and fourth vertebral bodies. Skeletal Class II individuals showed a maxillary protrusion, mandibular retrusion, shorter mandibular body, posterior ramus rotation, and anterior rotation of the skull base, a smaller and more forward cervical spine, a smaller cervical vertebral body, and a lower centroid size.
Rene Gonzalez Cristina Adriazola 202012	Postural alterations as an etiology of dentomaxillary anomalies: Scoping Review	The most prominent correlation between craniocervical position and dentomaxillary irregularities is mainly observed in the sagittal plane, especially in head extension in cases of skeletal Class II malocclusion. Regarding the connection between body posture and dentomaxillary anomalies, this is more notable in the transverse plane, especially in situations of scoliosis and crossbite. Body posture was assessed by clinical examination, while cervical irregularities were assessed by cephalometry.

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Table 1. Relationship between skeletal class and vertebral position (continued)

Author and Year	Qualification	Result
Karen Luna RamírezGloria Julieth 202014	Relationship between malocclusion, condyle shape and body posture in children through a literature review, year 2020.	It was observed that all studies that examined the relationship between dental malocclusion and body position found a significant association when one of them was altered, suggesting a connection between the two.
Houli Peng Weihan Liu Lanxin Yang Wenjie Zhong Yuanyuan Yin Xiang Gao Jinlin Song 202215	Does head and cervical posture correlate to malocclusion? A systematic review and meta-analysis	Neck and head position may be associated with Class II and III malocclusion; however, the evidence currently available is not strong enough to support this claim.
Camilo Sandoval Alejandro Diaz German Manriquez 201916	Relationship between craniocervical posture and skeletal class: A statistical multivariate approach for studying Class II and Class III malocclusions	Class II malocclusion exhibited a more pronounced posterior rotation of the mandibular ramus compared to the skull and a more posterior head tilt than Class III malocclusion. In addition, significant relationships were identified in Class II malocclusion subjects between mandibular inclination and cervical curvature, as well as between mandibular inclination and craniocervical posture.
C Alvarez Solano LA Gonzalez Camacho SP Castano Duke T Cortes Velosa JA Vanoy Martin L. Chambrone 202017	To evaluate whether there is a relationship between occlusion and body posture as delineated by a stabilometric platform: A systematic review	They identified a connection between dental malocclusion and body posture, based on the observation of the displacement of the centroid of individuals, and observed a posture inclined forward in those with Class II malocclusion, while in Class III cases the posture tended to lean backwards.
Tatiana Cortes Jenny Vanoy Martin 202118	Relationship between dental occlusion and body posture: a systematic review	All of the studies examined showed changes in body position as a result of adjustments in jaw position. It is suggested that myocentric position is related to an improvement in body posture.
Sebastian Erazo 202119	Association between craniocervical posture and temporomandibular disorders: a review of the literature	In this recent literature review study, it is concluded that the relationship between temporomandibular dysfunction (TMD) and craniocervical posture, as well as various head and neck disorders, remains a controversial topic among researchers. Although the stomatognathic system is recognized as an interconnected craniocervicomandibular system, the results still show a lack of clarity on whether the pathological alteration begins in the cervical spine or in the temporomandibular joint (TMJ).

The results related cervical position and Class II malocclusion using imaging analysis, showing a number of distinctive features at both the craniofacial and cervical levels

compared to Class III patients. These findings may be important for understanding the etiology and clinical features associated with each type of malocclusion and may be relevant for orthodontic and orthopedic treatment planning in patients with these types of malocclusion.

Table 2.*Craniocervical posture in children with malocclusion I, II, III*

Author and Year	Qualification	Result: Measurements
Lucia Bernal Harold Marin Claudia Herrera Carolina Montoya Yudy Herrera 201710	Craniocervical posture in children with class I, II and III skeletal relationships	More patients were found in class I malocclusion, being more prevalent in girls. In contrast, class II predominated more in boys. Class III was the least prevalent malocclusion, being equal between boys and girls. Significant differences were found in several postural variables between boys and girls. Postural variables that showed significant differences between genders include lordosis, CCA (cervical cranial angle), inferior space.
Bohorquez Rios, John HenryRodriguez Varon, Tania 202113	Craniocervical postural alteration associated with dental malocclusion, systematic review of the literature in the Scielo database, Google Scholar and PubMed	The most commonly identified type of malocclusion in the study was Class II. This malocclusion was associated with the presence of a rectified cervical spine and cervical kyphosis (abnormal forward curvature of the cervical spine).

A higher number of patients were found to have class I malocclusion, which was more prevalent in girls. In contrast, class II was more prevalent in boys. Class III was the least prevalent malocclusion, being equal between boys and girls. The presence of cervical kyphosis was associated with class II malocclusion. Significant differences were found in postural variables between genders, including lordosis and cervical cranial angle. The most common dental malocclusion was Class II, associated with a rectified cervical spine and cervical kyphosis.

Discussion

The literature review conducted to analyze the connection between craniocervical posture and type II dental malocclusion revealed a number of significant findings. First, Gonzales, et al7 found that the natural position of the head is linked to a neutral molar position, suggesting that Class II malocclusion can trigger a postural misalignment leading to head hyperextension. This postural imbalance can generate muscular tensions in the cervical region, which in turn can affect the position of the mandible and the temporomandibular joint.7

Furthermore, it has been observed that Class III malocclusions can increase the function of the prevertebral muscles causing a verticalization of the cervical spine, which over time can cause excessive curvature in the cervical region, manifested as cervical kyphosis and a double curvature in the cervical vertebrae, with cranial displacement by hyperextending dorsally.7 In relation to the above, Fonseca et al.6 assure that this could cause compression in the suboccipital region and, as a result, cause headache in the occipital region.[6]

The study by González, et al. (2020)4 addresses the risk factors for malocclusion, suggesting that certain characteristics of the occlusion may be altered due to the presence of factors such as mouth breathing, atypical swallowing, and tongue interposition, among others. These factors may be associated with alterations in the position of the cervical vertebrae, supporting the connection between Class II malocclusion and craniocervical position.4

Bernal, et al (2017).10 have reported a reduction in cervical lordosis in patients with class II malocclusion, using methods to measure lordotic curvature similar to the one used in your study. This suggests a possible association between the position of the cervical vertebrae and class II malocclusion, which is relevant to understanding the influence of cervical posture on craniofacial morphology in this population.10

In relation to the above, Sandoval et al. (2021)8 found that Class II individuals had a more posterior rotation of the mandibular process than Class III individuals. This supports previous studies showing that Class II individuals have a retrusive effect related to a more posterior rotation of the mandibular process.8

While Fonseca, et al.6 In their study determined that with combined orthognathic surgery changes in cervical posture are also achieved.6

Conclusions

- The available evidence in the literature supports the existence of a connection between the position of the cervical vertebrae and Class II malocclusion. These findings have important implications for clinical practice, as they indicate that orthodontists and oral health professionals should consider the craniocervical posture when evaluating and treating type II dental malocclusions.
- PNC analysis revealed a more pronounced clockwise inclination in skeletal Class II patients. In addition, a greater distance in the relationship between the molars and canines was found to be related to a forward tilt of the head in Class II.
- In terms of prevalence, class II malocclusion was more prevalent in boys. Regarding the modifications observed in the cervical region and craniofacial shape, skeletal class II individuals exhibited characteristics such as a shorter

mandibular body, maxillary protrusion, anterior rotation of the skull base, and a straighter cervical spine.

- A relevant correlation was observed between Class II malocclusion and cervical position, where alterations in the spine can influence dental arrangement and the connection between the maxilla and the mandible. The crucial influence of the cervical vertebrae, especially C1 and C2, on the position of the mandible and the temporomandibular joint is highlighted, which directly impacts dental alignment and the presence of malocclusions.
- PNC is presented as an essential physiological factor associated with the organic position of the body and the alignment of the cervical spine, which contributes significantly to accurate diagnosis in orthodontics. This highlights the importance of a comprehensive approach that not only addresses dental aspects, but also those related to posture and alignment of the cervical spine to obtain more complete and lasting results in oral health.
- The study highlights the importance of performing a detailed analysis of craniofacial structures in orthodontic clinical practice to assess harmony and balance in patients. Furthermore, it shows a biomechanical connection between the skull, mandible and cervical spine, underlining the need to understand the anatomical and biomechanical interrelations for effective treatment of malocclusions.

Conflict of interest

The authors of this literature review, Yamanua León, Evelyn Guiracocha, and Isabel Cabrera, declare that they have no conflict of interest that could influence the objectivity or impartiality of this work. They have no financial or personal relationships with organizations or entities that could have an interest in the results presented in this article. In addition, they have not received funding or support from any company or institution that may have an interest in the subject matter discussed in this work.

Authors' contribution statement

Author 1: It has contributed with a thorough review of the relevant scientific literature, contextualizing and adequately justifying the study. The most recent advances in the field have been taken into account, which has allowed establishing a solid theoretical framework.

Author 2: Participation in the interpretation of data and in the development of conclusions.

Author 3: Review and correction of the manuscript, figures and tables, ensuring precision and clarity in the presentation of the results.

In summary, the contribution of Evelyn Guiracocha and Isabel Cabrera in this scientific article has been fundamental for the development and successful completion of the study. The efforts have allowed us to advance knowledge of the subject and provide new perspectives for future research in this field.

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