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Dental occlusion and body posture in the development of temporomandibular dysfunctions – a multidisciplinary approach

Margaux Martinez

Dissertação conducente ao Grau de Mestre em

Medicina Dentária (Ciclo Integrado)

Gandra, 24 de junho de 2020

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Trabalho realizado sob a Orientação de "Mónica Cardoso" e Kátia Vilela

Declaração de Integridade

Eu, acima identificado, declaro ter atuado com absoluta integridade na elaboração deste trabalho, confirmo que em todo o trabalho conducente à sua elaboração não recorri a qualquer forma de falsificação de resultados ou à prática de plágio (ato pelo qual um indivíduo, mesmo por omissão, assume a autoria do trabalho intelectual pertencente a outrem, na sua totalidade ou em partes dele). Mais declaro que todas as frases que retirei de trabalhos anteriores pertencentes a outros autores foram referenciadas ou redigidas com novas palavras, tendo neste caso colocado a citação da fonte bibliográfica.

Declaração

Eu, Mónica Alexandra Guedes Cardoso, com a categoria profissional de Professora Auxiliar Convidada do Instituto Universitário de Ciências da Saúde, tendo assumido o papel de Orientador da Dissertação intitulada *"Dental occlusion and body posture in the development of temporomandibular dysfunctions – a multidisciplinary approach"*, do Aluno do Mestrado Integrado em Medicina Dentária, Margaux Martinez, declaro que sou de parecer favorável para que a Dissertação possa ser depositada para análise do Arguente do Júri nomeado para o efeito para Admissão a provas públicas conducentes à obtenção do Grau de Mestre.

Gandra, __ de junho de 2020

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O Orientador

AGRADECIMENTOS

Aos meus pais, por me terem apoiado e acompanhado antes e ao longo deste curso. Por me permitir realizar os meus projetos e exercer a profissão que escolhi. O seu apoio psicológico e emocional, bem como o seu amor, vieram completar o meu desejo de ter sucesso. Estou-lhes eternamente grato por tudo o que me trouxeram. Permitiram-me encontrar a força e a coragem para me superar, para evoluir e, sobretudo, para crescer.

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Posso finalmente dizer-vos que, graças a todos vós, consegui: sou um Médico Dentista!

RESUMO

O objectivo deste estudo é realizar uma revisão da literatura sobre as implicações estruturais e posturais das disfunções do sistema manducatório. Para tal, foram utilizadas bases de dados como o PubMed e o Medline para efectuar uma pesquisa bibliográfica de artigos científicos, incluindo os termos: "temporomandibular joint dysfunction" or "stomatognathic system" and "physiopathology" and "posture" and "dental occlusion" and "trigeminal nerve" and "vision".
Como resultado desta pesquisa, foram identificados 212 artigos, dos quais 15 foram considerados relevantes para esta revisão bibliográfica.
Estes artigos fornecem dados sobre oclusão dentária, postura cervical e corporal, dor, disfunção e outras síndromes temporomandibulares.
O estabelecimento de uma relação causal directa entre disfunções craniomandibulares e desvios posturais encontrados nos assuntos estudados, parece prematuro e ainda controverso entre os autores.
Parece que algumas variáveis dependentes ou independentes enviesam este estudo, incluindo o número insuficiente de artigos estudados, as diferentes variedades de metodologias utilizadas nestes estudos e o carácter único de cada indivíduo estudado.

PALAVRAS CHAVES

Disfunções da articulação temporomandibular, sistema estomatognático, postura, oclusão dentária, nervo trigémeo.

ABSTRACT

The aim of this study was to conduct a literature review on the structural and postural implications of the dysfunctions of the manducatory system. To this end, databases such as PubMed and Medline were used to perform a bibliographic search of scientific articles, including terms: "temporomandibular joint dysfunction" or "stomatognathic system" and "physiopathology" and "posture" and "dental occlusion" and "trigeminal nerve" and "vision".

As a result of this research, 212 articles were identified, of which 15 were considered relevant for this literature review.

These articles provide data on dental occlusion, cervical and body posture, pain, dysfunction, and other temporomandibular syndromes.

The establishment of a direct causal relationship between craniomandibular dysfunctions and postural deviations found in the subjects studied seems premature and still controversial among the authors.

It seems that some dependent or independent variables bias this study, including the insufficient number of articles studied, the different varieties of methodologies used in these studies and the uniqueness of everyone studied.

KEY WORDS

Temporomandibular joint dysfunction, stomatognathic system, posture, dental occlusion, trigeminal nerve.

TABLE OF CONTENTS

Abbreviations

N: Sample size

F: Female

M: Male

SG: Study group

CG: Control group

TMD: Temporomandibular Disorder (signs or symptoms)

FPTS: Functional Pathologies of the Temporomandibular System

CMD: Craniomandibular Disorder

CSD: Cervical Spine Disorder

RDC/TMD: Research Diagnostic Criteria for Temporomandibular disorders

VAS: Visual Analogue Scale

JMA: Jaw Motion Analyser

NDI: Neck Disability Index

LDF-TMDQ/JFS: Jaw Function Scale

I. Introduction

The masticatory apparatus consists of bilateral temporomandibular joints (TMJ), maxillary and mandibular dental arches, and the neuromuscular system (masticatory muscles and trigeminal nerve)[1].

The temporomandibular joint is one of the most complex joints in the body[1], as it must synchronize rotational and translational movements to open and close the mouth, as well as lateral movements. It connects the mandible to the skull via a mobile articular disc between the mandibular condyle and the fossa of the temporal bone, all protected by a joint capsule.[1-3]

Although free in space and subjected to the vertical force of gravity, the mandible remains connected to the skull through the temporomandibular joint (TMJ), ligaments and muscles, and forms a craniomandibular system. The spinal cord passing through the vertebral canal and all the muscles of the cervical region are organized along a continuous axis, thus forming an overall entity in a vertical direction. In addition to this, there are the anterior and posterior muscular insertions of the stomatognathic apparatus and the neck, forming a continuity with the rest of the body. Two parts of the cervical spine can be distinguished, an upper mobile part between C_1 and C_3 vertebrae, and a lower part between C_3 and C_7[4].

In the maximum position of intercuspation, the occlusal plane is parallel to the bipupillary plane[5], which serves us for the orientation of the head in space and the postural balance of the body, and which are facial planes of reference in the register of the vertical dimension. Decrease in vertical dimension due to loss of teeth or horizontal bone loss (pathological or physiological with age), is a condition that alters facial harmony, phonation, chewing and swallowing abilities, leads to TMJ compression, prognathism due to excessive closure, and muscular fatigue that can cause facial and neck pain.[4, 5]

The trigeminal nerve (V), is a mixed (sensory and motor roots) and double nerve, but not totally symmetrical. Its first two ophthalmic (V_1) and maxillary (V_2) branches are exclusively sensory, while the third mandibular (V_3) branch is both sensory and motor. Each of the sensory branches will innervate a specific zone of the face (targeted actions of local anesthetics). The motor fibers of the mandibular nerve innervate the mandibular muscles and the oral cavity, among others[6]. Due to its proximity, some fibers of the trigeminal ganglion are even in contact with the ear (tympanic tensor muscle)[2-3]. This proximity is also physical with the mandibular condyle located in front of the ear and its anatomical and nervous components.[1-3]

It is also a postural nerve since it carries cephalic spatial information that informs the brain about the position of the head in space and internal balance. The sensory information of the face is processed in parallel, although separate from the sensory information of the rest of the body.[1, 6]

In addition, there are bony, muscular, and nervous connections between the stomatognathic apparatus and the rest of the body, more precisely the cervical spine. Although the links between occlusion and disorders of the temporomandibular system, and those between these dysfunctions and body posture are already related[4], the causal place between temporomandibular dysfunctions and posture is still very controversial in the literature.

The objective of this study is to deepen our knowledge and thus to understand if there is a correlation between dental occlusion and body posture in the appearance or aggravation of temporomandibular dysfunctions, in a multidisciplinary approach and a global vision of the factors involved.

II. Methods

A bibliographic research was performed using the computer databases PubMed and EbscoHost (MEDLINE complete). A total of 212 articles were found using the following combination of research terms: "Temporomandibular joint disorders" or "stomatognathic system" and "physiopatholgy" and "posture" and "dental occlusion" and "trigeminal nerve" and “vision”. Inclusion criteria involved articles published in English and Spanish, published until 2019, reporting the correlation between dental occlusion and body posture or cervical posture with temporomandibular dysfunctions.

The total number of articles was compiled for each combination of key terms and therefore the duplications were removed using the Mendeley citation manager. Preliminary assessments of the abstracts were performed to establish whether the articles met the objective of the study.

Articles were selected based on their relevance after full text reading. The following factors were recovered for this review: name of the authors, journal, year of publication, purpose, sample study, group feature and method used to assess posture, TMD or pain.

III. Results

212 articles were identified by literature search in PubMed/MEDLINE considering duplicates, which were then removed by Mendeley, as reported in Fig 1. Amongst 41 remaining articles, 35 were selected based on their title and abstract. After a thorough reading of the 35 articles, an additional 15 articles were removed from our study based on the following exclusion criteria: reviews, unrepresentative sample eligibility (children, subjects with specific professions, orthognathic surgery, or mandibular trauma) and studies involving therapeutic orthodontic treatment. At the end of the entire process of selection, 15 articles (listed in Table 1) were considered relevant for the purpose of this literature review.

The review of the articles allowed the identification of various methods of postural analysis taking into account different variables such as age, sex, temporomandibular dysfunction, vision, pain.

Before any postural analysis, the diagnosis and classification of patient's dysfunctions of the temporomandibular system (TMD, CMD, or FPTS) is necessary. One article used the Helkimo index[24], but the most frequently used protocol is the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) [7-16] It is based on patient history and clinical examination by muscle and joint palpation and mandibular movement.[9]

The RDC/TMD has two axes but the articles only took into consideration Axis I, based on orofacial pain. Subjects are then classified into 3 groups according to the presence of TMD of: I) muscular origin (myofascial pain), II) joint origin (disc displacement) and II) other common joint disorders (arthralgia/arthritis/arthrosis) respectively.[8] Each subject presents with two temporomandibular joints, so it is possible to have multiple diagnosis (muscular, articular or both TMD). For example, a subject can be allocated one muscle disorder at the most. But in addition, each joint can be assigned one diagnosis from each group (II and III). The Axis II was not considered by the authors in their studies. [7-16]

Regarding postural analysis, several methods are available like surface electromyography, kinesiography, postural platform, photographs, or radiographs analysis and posturographic devices.[4] However, not all existing techniques were encountered in the articles, and therefore not all will not be considered in this study.[4]

We first considered posturography and stabilometry[12, 16, 17], which use notions of orthostatic stability and balance. The analysis are performed using a platform that records the body's centers of strength and balance at the plantar arch. These studies also consider the sight variable and show the importance of vision in the balance and stabilization of the body. The sway area and the sway velocity belong to the parameters evaluated that seem to be influenced by the vision. It is thus noted an increase in the values of postural parameters in subjects with and without TMD, when the eyes are closed[21] or opened[16] and this is particularly significant for the sway area (increase with different mandibular position).[16, 17] The effect of visual input has also been studied in association with the electromyographic activity (studies of the function of nerves and muscles) of various muscles, and appears to have an impact, although weak, on body posture.[18] However, some studies have opposite results.[12]

In a second batch of methods, posture was studied through the analysis of photographs or radiographs (mainly in lateral view) with specific angle measurements. One of the main angles studied is the craniocervical angle [9, 10, 13, 14, 19, 20], also called craniovertebral angle[19], or High Cervical Angle (HCA)[14] depending on the article. In addition to other angles and distances measured (see Table 2), it provides information on the position of the head in relation to the spine, the flexion or extension of the head (anterior and posterior rotation), forward head position, physiological or pathological lordosis (hyperlordosis) etc. Physiologically, and according to Professor Rocabado M.[10], the craniovertebral angle must range between 96°-106°, the distances C_0-C_1[13] (OA distance[10, 14]) and C_1C_2 must be equal and not less than 8mm. The vertebral bodies must be anterior to a line running from the posterior faces of C_1 to C_7.[19]

Postural alterations are described in several articles[7, 8, 13, 16, 19, 20, 21], associated in most cases with muscular[7, 8, 13, 16] (or sometimes mixed[1]) dysfunctions as compared to less frequent joint type dysfunctions. The main postural disorders mentioned are head forward position (correlated[7, 8, 20] or not[9, 21] by TMD), exacerbation of cervical lordosis[13, 14, 20], and head rotations (antero[10, 11] or posteroflexion[15, 19]). Some articles however, report no or very limited postural alterations in TMD groups. These results did not allow the authors to conclude that there was a causal effect.[9, 10, 12, 14, 15]

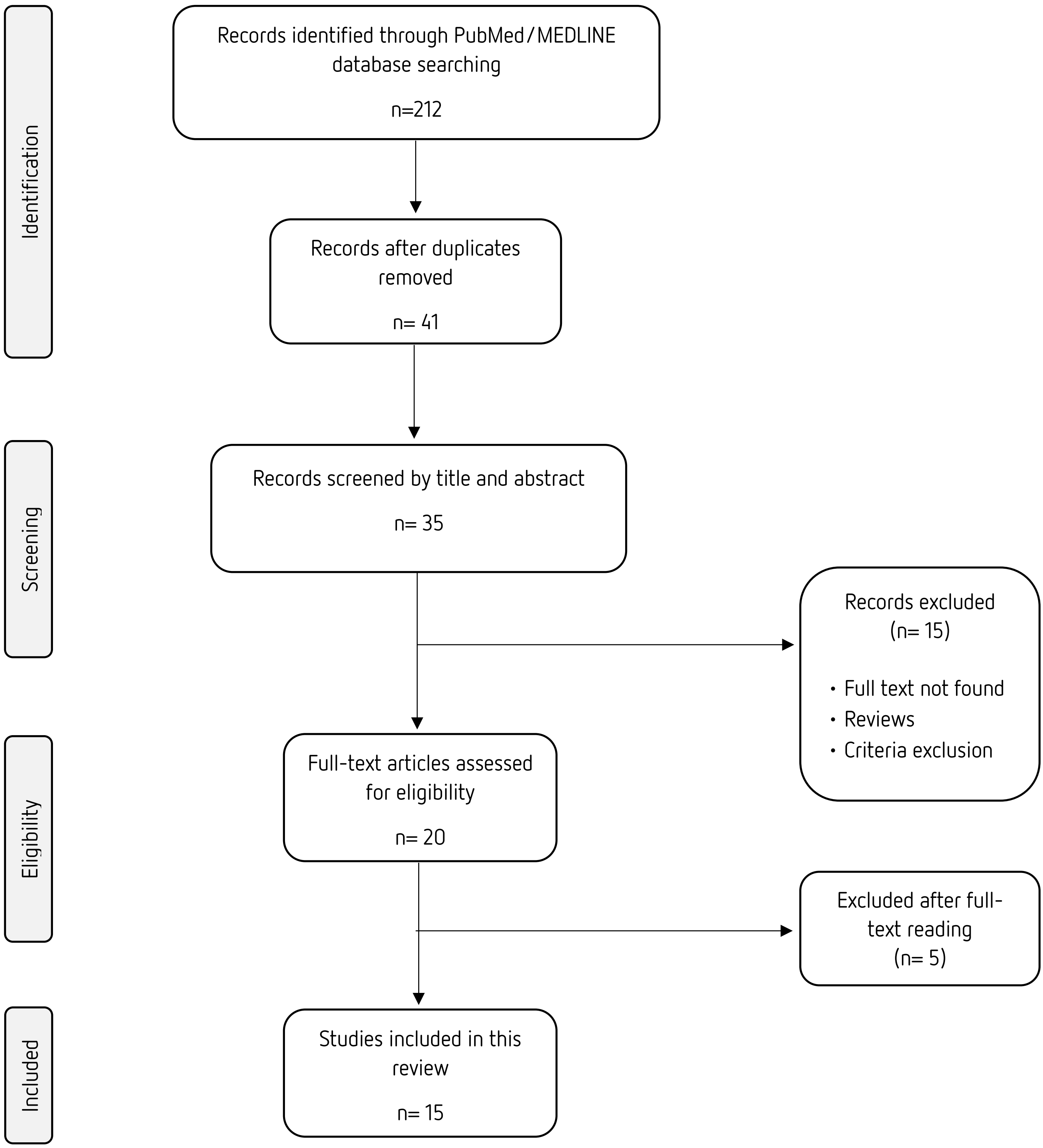

Figure 1. Flow diagram of the search strategy used in this study

Table 1. Relevant data gathered from the retrieved studies.

Author	Article/study type	Purpose	Study sample	Group feature	Method used to assess posture, TMD or pain	Main results and conclusions
Espinosa de Santillana IA et al. (2018) [7]	Cross-sectional	« To describe postural alterations according to the type of temporomandibular disorder (TMD)"	N= 30, F: 24, mean age: 27,4 M: 6, mean age: 27,4	All with TMD confirmed (origin): • Combined • Articular (joint) • Muscular	- Postural analysis in the three views (anterior, posterior, and lateral) - Expert examiner using Research Diagnostic Criteria for Temporomandibular disorders (RDC/TMD)	- 100% alterations in the lateral view - Frequent alterations (independent of the type of TMD): high shoulders, pelvic tilt, and forward head posture - Frequent alterations for articular TMD: pelvic tilt, high shoulders and lumbar hyperlordosis - Frequent alterations for muscular and combined TMD: the same as the general population "*TMD patients present postural changes, mainly forward head posture, pelvic tilt and high shoulder, with special involvement related to muscle and combined diagnosis*" [6]
Cortese S et al. (2017) [8]	Cross-sectional	"Estimate de frequency and assess postural alterations as a risk factor for temporomandibular disorders (TMD)"	N=243 Mean age: 12.6 Group A (n=133; 12,56 ± 1,69 years) Group B (n=61; 12,57 ± 1,90 years) Group C (n=49; 12,65 ± 1,82 years)	Group A: without TMD Group B: with muscle disorder Group C: with disk displacement	- Photographs (front, back and both sides) in relaxed upright position in front of a grid -Expert examiner (physiotherapist) following Kendall's postural types - Expert examiner (4 paedriatric dentists) using the protocol for Research Diagnostic Criteria for Temporomandibular disorders (RDC/TMD)	- Higher frequency of postural alteration in group B: lumbar hyperlordosis in spinal curves, forward head posture in head posture and genu valgus in lower limbs. - Most frequent: forward head position - No differences between anterior, posterior, and lateral planes "*the most frequent types of postural alterations were lumbar lordosis, forward head posture and genu valgus. [...] alterations in head posture, spinal curves and lower limbs are risk factors for muscular TMD.*" [7]
Faulin EF et al. (2015) [9]	Cross-sectional	"Examine the possible correlation between TMD and different head positions"	N=126 (dental students) F: 75 M: 51 mean age: 25	- Control group (without TMD) - Study group (with TMD): • Group I: with muscle disorder • Group II: with disk displacement • Group III: arthralgia, osteoarthritis and osteoarthrosis	- Mean value of three measurements of photographs in frontal and lateral views (craniovertebral angle in sagittal plane and interpupillary line in frontal plane) - Expert examiner (Dentist) using Research Diagnostic Criteria for Temporomandibular disorders (RDC/TMD)	- Group III TMD is superior to the other groups I and II for both sexes (>50%) - No differences in the angles in the frontal and sagittal planes with and without TMD (craniovertebral angle and interpupillary line) - Lower craniovertebral angle in men without TMD (higher head tilt among men with TMD) - No difference between sexes - For both men and women in SG and CG the head tilt was small on both sides, with slightly higher values on the right. No positive correlation between forward head posture or head tilt and a diagnosis of TMD

Câmara-Souza MB et al. (2018) [10]	Cross-sectional	"Evaluate the relationship between TMD and craniocervical posture "	N= 80 (age: 18-26) F: 54 - with TMD: 19 - without TMD: 35 M: 26 - with TMD: 9 - without TMD: 17	- Presence or absence of TMD - type of TMD: • Group II: muscle TMD • Group III: joint TMD • Mixed group	- Lateral radiographs (analysis of distance O-A, craniocervical angle and distance H-H'.) - Expert examiner using Research Diagnostic Criteria for Temporomandibular disorders (RDC/TMD)	- No difference in the diagnosis of TMD between the sexes - non-specific modifications of each parameter studied, without association with TMD (except for higher prevalence of anterior head rotation) - No significant difference between subjects with and without TMD and within the normal range - Inter-examiner bias eliminated "*no relationship can be found between craniocervical posture in the sagittal plane and the presence of temporomandibular disorder in dental student.*" [9]
Walczyńska -Dragon K et al. (2014) [11]	Randomized controlled trial	Evaluate the effect of TMD therapy on cervical spine range of motion (ROM) and reduction of spinal pain	N=60 F: 30 M: 30 Age: 18-40	Two randomized groups <u>with TMD</u>, cervical spine pain and mobility: • Treated group (using occlusal splint) • Control group	- Expert examiner using RDC/TMD - Analysis of pain using VAS and cervical Oswestry scale for cervical spine mobility - Recording mandibular position and movements using JMA device - Cervical spine motion evaluating using MCS device - <u>3 consecutive analysis</u> (avoid bias) with starting point in mandibular resting position, of: • opening and closing • lateral movements • protrusion and retrusion - <u>3 evaluations</u>: initial, 3 weeks and 3 months	After 3 months: - **RDC/TMD diagnoses**: • Control group: no significant changes (TMJ function or muscle tension) • Treated group: - 78%: No disc, asymmetry of pain problem during mandible movement. - Reduced condylar deviation in 24 subjects (4 still have an asymmetry) → better TMJ function - Decreased muscle tension and no pain on palpation (even in 22/27 subjects with intense initial muscle tension) - **Spinal pain**: • Control group: no significant changes • Treated group: reduction (only 8% at end) - **Cervical spine mobility**: • Control group: no significant changes • Treated group: enhanced mobility → especially significant for <u>flexion</u> (ante/retroflexion): 70% in the standard "*there is a significant association between TMD treatment and reduction of cervical spine pain, as far as improvement of cervical spine mobility.*" [10]

Rocha T et al. (2017) [12]	Case-control study	Compare the postural characteristics of pain-free subjects, with one group having TMD (disc displacement) and the other having no TMD.	N=42 Age: 18-40 - Disc displacement group: 21 • F: 17 • M: 4 • mean age: 22,2 ± 3,9 - Control group: 21 • F: 15 • M: 6 • mean age: 21,2 ± 3,7	2 pain-free groups: With TMD: disc displacement group (unilateral) Without TMD: normal disc position	- Expert examiner using RDC/TMD protocol - Posturographic evaluation: • Body segments: ➢ Ant/posterior views: check for elevated segment of bilateral structures ➢ Lateral view: ant/posteriorisation of the head, and cervical flexion/extension • Postural balance reactions through the center of gravity during jaw movements using a balance platform	- **Body posture segments**: No significant difference between the two groups - **Postural balance reactions to mandibular movements**: No significant difference between groups "*No significant differences in body posture between subjects with and without unilateral disc displacement in the temporomandibular joint. […] well-preserved postural balance in the presence of TMJ internal derangement*" [11]
Saddu SC et al. (2015) [13]	Comparative study	Compare the head and craniocervical postures in subjects with and without TMD, by analyzing photographs and radiographs	N= 68 Age: 18-50 With TMD: 34 - I: 17 - II: 17 Without TMD: 34	Study group: with TMD • Group I: muscle disorders • Group II: disc displacement Control group: without TMD	- Expert examiner using RDC/TMD protocol - Lateral photographs with "true vertical axis" drawn as a reference: • head posture angle (Tragus-C7-horizontal) - Lateral head and neck radiographs: • craniocervical angle • cervical curvature angle • suboccipital space • atlas-axis distance	- **Head posture angle**: No significant difference between study and control groups - **Craniocervical angle**: No significant difference between study and control groups - **Cervical curvature angle**: significant difference in group I - **Suboccipital angle**: No significant difference between study and control groups **- Atlas-axis distance**: significant difference in group II "*the muscular component plays a more significant role in the production of TMD rather than the articular component*" [12]

de Farias Neto JP et al. (2010) [14]	Case-control study	Compare the craniocervical angles and distances between TMD and free TMD subjects	N= 23 - Control group: 11 Mean age: 20 F: 7 M: 4 - Study group: 12 Mean age: 22.5 F: 7 M: 5	Control group: without TMD Study group: with TMD • Ia - myofascial pain without limited opening • Ib - myofascial pain with limited opening • IIa - displaced disc with reduction • IIIa - arthralgia • IIIb - osteoarthritis	- Expert examiner using RDC/TMD protocol - Lateral head and neck radiographs (three angles and two distances) • high cervical angle (HCA) • low cervical angle (LCA) • atlas plane angle (APA) • anterior translation distance • occipital-atlas distance (O-A)	- **High cervical angle (HCA):** No significant difference between study and control groups - **Low cervical angle (LCA):** No significant difference between study and control groups - **Atlas plane angle (APA):** mean values SG < CG - **Anterior translation distance**: mean values SG > CG **Occipital-atlas distance (O-A)**: No significant difference between study and control groups "*the symptomatic TMD patients presented a flexion of the first cervical vertebra associated with an anteriorization of the cervical spine (hyperlordosis). […] it is not possible to affirm whether it was the TMD that caused the alterations in the measurements*" [13]
Armijo-Olivo S et al. (2011) [15]	Case-control study	Determine whether there is a difference in the postural posture of the head and neck between patients with TMD and healthy patients by analyzing commonly used angles	N=154 <u>Only females</u> Control group: 50 Age: 18-50 Study group: 104 Age: 18-50 - I: 55 - II: 49	Study group: with TMD • Group I: muscle disorders • Group II: mixed (muscular and articular disorders) Control group: without TMD	- Expert examiner using RDC/TMD protocol - Neck Disability Index (NDI) and Jaw Function Scale (LDF-TMDQ/JFS) completed - Pain intensity reporting on a VAS score - Lateral head and neck photographs (four angles analyzed): • eye-tragus-horizontal angle • tragus-C7-horizontal angle • pogonion-tragus-C7 angle • tragus-C7-shoulder angle	- **Eye-tragus-horizontal angle**: statistical difference between study group I and control group. Higher mean values in group I compared to the healthy group. Also weakly associated with jaw disability (JFS) - **Tragus-C7-horizontal angle**: No significant difference between study and control groups - **Pogonion-tragus-C7 angle**: statistically significant but weakly associated with jaw disability and pain intensity. - **Tragus-C7-shoulder angle**: No significant difference between study and control groups Postural variables had no effect on jaw disability or pain intensity. No individual angle was significantly correlated with neck disability, jaw disability and pain intensity. More extended position of the head (craniocervical region) in the TMD myogenous group, but very small difference with healthy group, and was judged not significant.

Nota A et al. (2017) [16]	Comparative study	Analyze differences in postural stability between subjects with and without myogenous TMD	N= 44 Control group: 19 F: 15 M: 4 Age: 27.26 ± 3.85 Study group: 25 F: 19 M: 6 Age: 31.75 ± 6.68	Study group: with TMD muscle disorders (myogenous) Control group: without TMD	- Expert examiner using RDC/TMD protocol - Posturo-stabilometric force platform exam analyzing sway area and sway velocity of the COP - Each parameter evaluated under different conditions: • mandibular rest position (REST) • maximum intercuspation (MAX INT) • mandibular position with cotton rolls (ROLLS) (all with eyes opened or closed)	- Sway area and sway velocity higher in TMD group - **Sway area**: statistically significantly higher in TMD group in: REST, MAX INT (both with eyes opened) and MAX INT (with eyes closed) - **Sway velocity**: statistically significantly higher in TMD group in: REST, MAX INT (both with eyes opened) "*Significant difference in body postural stability between subjects with myogenous TMD and healthy controls. Sway area and sway velocity postural parameters are increased in these subjects*." [15]
Baldini A et al. (2013) [17]	Evaluation study	Assess whether there is a correlation between dental occlusion and posture in healthy subjects using a force plate	N= 44 F: 14 M: 30 Age: 17-35 (mean age: 23.75 ± 4.10)	Subjects without TMD	- Posturographic and stabilometric analysis using a force platform and assessment of: • sway area • sway velocity • COP X • COP Y - Each parameter evaluated under different conditions: • mandibular rest position • mandibular position of centric occlusion • mandibular position with cotton rolls (all with eyes opened or closed) - Single-blind study (the subjects do not know the purpose of this study)	- Higher values of postural parameters with eyes closed - **Sway area**: • mean values with eyes closed • Lowest areas recorded in mandibular resting position • 39% increase with eyes closed - **Sway velocity**: • mean values with eyes closed • 29% increase with eyes closed → Sway area and sway velocity influenced by vision → Sway area (only) influenced by mandibular position "*Vision was shown to influence body posture, and a weak correlation was observed between mandibular position and body posture in healthy subjects. However, the force platform is most likely not able to clearly detect this relationship. Gnathologists must use caution when using force platform analysis to modify a therapeutic plan. The sway area seems to be the most sensitive parameter for evaluating the effect of occlusion on body posture*." [20]

Miralles R et al. (2016) [18]	Case-control study	Determine the input visual effect on electromyographic (EMG) activity of the sternocleidomastoid and masseter muscles in different positions	N = 40 Study group: 22 F: 15 M: 7 Age: 18-61 (mean age: 29,23) Control group: 18 F:12 M:6 Age: 19-35 (mean age: 24,61)	Study group: subjects with myogenic craniomandibular dysfunction (CMD) Control group: healthy subjects	- EMG activity recorded in different positions of the body: • At rest • During swallowing of saliva • Maximal voluntary clenching Initial EMG recording: with eyes open Final EMG recording: with eyes close	- At rest: decrease of EMG activity with closed eyes in both groups in sternocleidomastoid (lateral decubitus position) and in masseter (supine position) - During swallowing of saliva: decrease of EMG activity with closed eyes in sternocleidomastoid (lateral decubitus position) in healthy group subjects - During maximal voluntary clenching: no significant differences upon variation in the visual input The significant change in EMG activity (mainly at rest) suggests that the visual input effect is weak
Joy T.E. et al. (2019) [19]	Cross-sectional	Determine the craniocervical posture in patient with and without TMD	N=120 Group I: 30, age: 20-30 Group II: 90, age: 20-50 - A: 30 - B: 30 C: 30	Group I: asymptomatic Group II: symptomatic* • A: mild (TMD) • B: moderate (TMD with masticatory muscle tenderness without radiating pain to shoulders) • C: severe (TMD with masticatory muscle tenderness and radiating pain to shoulders and sleep disturbances)	- Postural analysis of lateral radiographic views in normal head position (craniovertebral angle, Cobbs angle, Individual vertebral angle, odontoid plane angle, linear measurements, and individual intervertebral spaces) -Expert examiner	- Higher incidence of TMD for F>M - Craniovertebral and odontoid plane angles higher in group II - Higher Cobbs angle in group IIB, but not in group IIC - Individual vertebral angles increased in groups IIA and C except for C5 which were increased in groups IIB and C - C1-C7 and opisthion-C7 lengths were decreased - Opisthion to intersection of Craniovertebral angle demonstrated a gradual increase in groups IIB and C - Increases in C2-C4 spaces in group II - Decreases in C5-C7 spaces in group II The craniovertebral, odontoid plane angle, and individual vertebral angle parameters were corroborated by the linear measurements in this study. "*Significant postural changes in the skull in relation to the cervical vertebrae [...] (dorsiflexion) as a compensatory effort of the stomatognathic system*" [22]

Munhoz WC et al. (2014) [20]	Regression study	Proved to partially predict the presence and magnitude of body posture deviations by drawing on subjects' characteristics and specific FPTS symptoms	N = 50 Study group: 30 M: 3 F: 27 Age: 22.9 ± 7 Control group: 20 M: 4 F: 16 Age: 23 ± 1.4	Study group: with FPTS** • Mild: 15 • Moderate: 9 • Severe: 6 Control group: without FPTS	- Analyze of some independent variables (age, sex, malocclusion and FPTS symptoms) and selected posture alterations ➢ Malocclusion: Helkimo occlusal index (Oi) ➢ FPTS symptoms: • Helkimo; dysfunction (Di) and anamnestic (Ai) indices • History of craniofacial pain and FPTS ➢ Body posture deviations: • photographs (full body posture evaluation) in frontal, lateral and dorsal views • analysis of muscle chains (respiratory, antero-internal hip and shoulder chain) completed by lateral cervical spine radiography analysis	- Highest correlation found between Di and the degree of cervical spine curvature: relationship between the degrees of FPTS severity and of increasing cervical spine lordosis - Other correlations with the degree of cervical spine lordosis: age, number of masticatory muscle pain regions, pain intensity at masticatory muscles, number of masticatory muscle and TMJ pain regions, pain intensity at masticatory muscles and TMJ and TMJ functional index Correlation between age, sex, malocclusion, and symptoms of FPTS with specific posture alterations at the cervical spine, shoulders, lumbar lordosis and to the number of posture alterations in the antero-internal hip muscle chain. Some posture alterations appear to be correlated with certain independent variables, suggesting that some FPTS, or malocclusion, age, or sex, may be more strongly correlated than others with specific posture patterns.

Visscher C. M. et al. (2002)[21]	Comparative study	• Determine differences in head posture between well-defined CMD pain patients with or without a painful cervical spine disorder and healthy controls • Determine differences in head posture between myogenous and arthrogenous CMD pain patients and controls	N = 250 F: 179 M: 71 Age: 34 ± 13,3 • With CMD pain group: 112 • Without CMD group: 77 • Equivocal CMD: 57 (Missing values: 4)	Study groups (unambiguous): 138 • Non-patient group (Non-CMD and non-CSD): 47 • With CMD group: 112 • With CSD group: 87 • With both CMD and CSD group: 65 Head posture analysis group: Group with painful CMD: 112 • Myogenous: 82 • Arthrogenous: 14 • Mixed: 15 • Not classified: 1 Control group: without CMD or CSD	- Oral history of pain in head and neck - Tests performed by a blind examiner to differentiate between people with and without pain complaints CMD or CSD: • Verbal score for pain responses provoked by the different tests • VAS scores for pain responses to the palpation tests and to the dynamic/static tests - Lateral photographs and a lateral radiograph of the head and the cervical spine (blind head posture analysis) • Radiograph: angle between horizontal plane and "cervical posture line" (CPL) • Photographs: angle between horizontal plane and line between tragus of the ear and tip of the 7th cervical spinous process	Head posture: • Significant correlation between head posture measured on radiograph and on photographs (head posture factor in common) • No difference between the 4 study groups for both radiographic and photographic methods • Photographs: association between increasing age and anteroposition of the head • No significant interactions between age and head posture • No difference between subgroups of CMD patients and non-CMD patients No correlation between head forward position (anteroposition) and CMD (even in the presence of CSD or in CMD subgroups) "*The results of this study do not support the suggestion that painful CMD, with or without a painful CSD, are related to abnormal head posture.*"[26]

Table 2. Table of the different angles and distances reported by the articles studied

	Craniovertebral angle (postero-inferior angle) Rocabado* Craniocervical angle / High cervical angle (HCA)	Cobbs angle	Individual vertebral angle	Odontoid plane angle	Linear measurements
Definition/ Function	Measures the position of the head in relation to the spine. **McGregor plane (MGP)**: line from posterior nasal spine to the basi-occiput **Odontoid plane (OP):** line that extends from apex to the anterior inferior angle of the odontoid process	Measures the degree of curvature of the spine.	Assess changes in the vertebral stacks.	Evaluate the dimensional relation of the skull to the vertebrae	Cross-check the results obtained from the angle parameters of the head in relation to the cervical spine
Description	Intersection between McGregor's plane and odontoid plane. 101 degrees +/- 5 degrees (96-106 degrees) • >106°: head flexion (anterior rotation) • 96°>: head extension (posterior rotation) – loss of physiological lordosis	Angle between two lines, drawn perpendicular to the upper endplate of the uppermost vertebra (C2) involved and the lower endplate of the lowest vertebra (C7) involved in the curvature.	Angle between a tangent line from the opisthion to the posterior surface of the spinous process of C7 and from the superior surfaces of the body of the cervical vertebra C3 to C7	Angle between a tangent line from the menton to opisthion and a line tangent to the posterior surfaces of the vertebral bodies of cervical vertebrae 1 to 7	• Opisthion- intersecting point of the craniovertebral angle distance • Opisthion-tip of the spinous process of C7 distance • Body of C1-lower border of C7

	Individual intervertebral spaces	**Occiput-Atlas distance (O-A) / Suboccipital space (C_0-C_1)**	**Atlas-axis distance (C_1-C_2)**	**H-H' distance**	**Cervical curvature angle (C_3-C_6)**
Definition/ Function	measure intervertebral spaces from C1-C7 Verify the craniovertebral, odontoid plane angle, and individual vertebral angle parameters	Measures anterior/posterior rotation of the head Physiologically: C_0-C_1 = C_1-C_2	Measures anterior/posterior rotation of the head	position of the hyoid bone (low or high)	Measure the degree of low cervical spine lordosis
Description	Measured from the end points of the inferior plate to those of the superior plate of the cervical vertebrae	From base of the occiput to the posterior arch of the atlas. Normal value: 4-9 mm <4mm: posterior rotation of the head >9mm: anterior rotation of the head	Perpendicular distance from the most enfero-posterior point of the posterior arch of the atlas to the most supero-posterior point of the spinous process of axis Normal value: 4-9 mm <4mm: posterior rotation of the head >9mm: anterior rotation of the head	**Hyoid triangle**: union of the most antero-inferior point of C3, the most antero-superior point of the hyoid bone (H), and the most postero-inferior point of the mantonian symphysis (RGn) **Line H'**: union of C3-RGn The vertical hyoid position is below the H' line	angle between the extended line from the posterior margin of the third and sixth cervical vertebral body

	Low cervical angle (LCA)	Atlas plane angle (APA)	Anterior translation distance	Eye-Tragus-Horizontal angle (photographs)	Tragus-C7-Horizontal angle (photographs)
Definition/ Function	Relationship between the high and low cervical spine	Plane of the atlas vertebra (C_1) **Atlas Plane Line**: drawn through the center of the anterior tubercle and center of the thinnest portion of the posterior arch.	Determine value for anterior transport of the head (in millimeters)		Head posture angle
Description	Angle between McGregor plane and line tangent to the vertebral bodies of C3 (highest point of the posterior surface) and C4 (lowest point of the posterior surface) Increase: cervical lordosis and extension of HCL on LCA	Angle between line parallel to the horizontal and atlas plane line. Increase: head extension (increase of HCA) Reduction: head flexion	Distance between the postero-superior edge of the body of C2 and vertical line perpendicular to the inferior edge of C7	Angle formed by a line connecting the midpoint of the lateral corner of the eye with the Tragus of the ear (the cartilaginous protrusion in front of the ear hole) and a horizontal line	Angle formed between the true horizontal and a line drawn from the midpoint of the Tragus of the ear to the skin overlying the tip of the spinous process of C7

	Pogonion-Tragus-C7 angle (photographs)	**Tragus-C7-Shoulder angle** (photographs)	**Odontoid-C_3C_4**	**Interpupillary line**	
Definition/ Function			Assesses the degree of high cervical spine lordosis	Measures head tilt in frontal plane	
Description	Angle formed by a line connecting the pogonion (most forward-projecting point on the anterior surface of the chin) with the midpoint of the Tragus of the ear and a line connecting the skin overlying the tip of the spinous process of C7 with the midpoint of the Tragus of the ear	Angle formed by the intersection between the upper middle point of the shoulder with the skin overlying the tip of the spinous process of C7 and the line connecting the Tragus of the ear with the skin overlying the tip of the spinous process of C7	Angle formed by the intersection between Odontoid plane and the C_3C_4 line		

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IV. Discussion

i. Stomatognathic system, occlusion, and temporomandibular disorders

As described above, the temporomandibular system is composed of two complex joints moving in synergy[1, 22] and involved in a plethora of functions such as phonation, chewing and swallowing[1]. These functions result from a balance between the activity of masticatory muscles and dental occlusion.

The dental occlusion is the contact between maxillary and mandibular teeth, which have different functions[22]. The incisors cut food, but also serve as guides and reference points for biting[1]. The posterior teeth grind the food bolus and participate in shimming the mandible. They are subjected to strong and variable pressures (with an increase during stress and bruxism for example)[23] which can also cause tension, mainly in the masseter and temporal muscles[2-3]. Teeth are therefore of primary importance for the temporomandibular system[1].

Indeed, the loss of teeth, especially posterior teeth, can lead to chewing problems, loss of vertical dimension[24] and thus a facial disharmony and of the entire manducatory system and cause temporomandibular dysfunction (TMD). Similarly, it is known that a natural supra-occlusion or one due to an inadequate restoration[25] or poorly adapted prosthesis, leads to deviations of the mandible, abnormal closing[26], or a detrimental adaptation of the mandible during movements.

These cranio-mandibular dysfunctions (CMD) is a multifactorial disorder. Occlusion is considering the main risk factor[26], but also exist psychological, emotional (anxiety or depression), and parafunctional implications (bruxism, atypical swallowing). [22, 27] This musculoskeletal condition is affects 5% to 12% of the population.[28]

FPTS are mainly characterized by myofascial pain [4, 22, 27, 29], but not only. In some articles craniomandibular pain severity is also quantified, with or without dysfunction of the temporomandibular system. [11, 15, 21] However, only one study was involved a therapeutic treatment and showed a reduction in pain following treatment with occlusal splint [11]. The others showed no correlation between pain intensity and posture or craniomandibular dysfunction.

The quantification of such pain is part of the diagnosis of TMD, reported in the RDC/TMD and Helkimo index. In his article, Munhoz W.C. et al (2019)[29] compares these two protocols. The

RDC/TMD, unlike the Helkimo index, classifies FPTS according to their origin (muscular, articular or both), and introduces an important psychological-affective variable (Axis II) that takes into account the quality of life of subjects and other etiologies of these pains and dysfunctions. Although the psycho-affective axis is not mentioned in the articles reported in the results, the RDC/TMD appears to be a more precise and adapted protocol in terms of classification and not a consequent study of these temporomandibular dysfunctions.[29] The fact that not all authors follow the same protocol in order to distinguish between subjects with and without TMD brings into question the relevance of the subsequent results.

In some reviewed studies, no significant difference was found in the incidence of TMD between females and males except for Joy T.E. et al.[19] and Garg A.K. et al[30], who report a higher incidence in females. which states that the prevalence of Myofascial Pain Dysfunction Syndrome (MPDS) has a prevalence of 85% in the population, and more commonly in women. Another study by Armijo-Olivo S. et al[15] included only women. It may be useful to study this variable in a more focused context to see whether intrinsic male or female factors such as malocclusion, age, and sex, might be involved in the correlation found in the other Munhoz WC et al.[20] study.

ii. Relationship between stomatognathic system, occlusion, and body posture

Posture is the position of the body in space. As described by Carini et al,[31] posture is described by three key concepts: orientation in space, gravity, and balance.

The concept of orthoposturodontics was introduced in 1994 by Mr Clauzade. It deals with the "occluso-postural" link[5]. Although widely documented, it is still controversial in the scientific literature. Indeed, even though there is an anatomical link between articular and neuromuscular components, their physiopathological relationship remains insufficiently documented.

In a first approach, it seems appropriate to differentiate between physiological (natural lordosis and kyphosis of the column, or head forward and age-related lordosis[4, 25]) and pathological (scoliosis, increased lordosis) postural changes. Physiologically, the Cobbs angle of the normal cervical spine sagittal alignment is variable, but typically maintained at 20-35°.[32]

Some frequent pathologies such as forward head position[7, 8, 20], hyperlodosis[13, 14, 20], and head flexion/extension[10, 11, 15, 19] were highlighted in the results.

Every head position induces the adjustment of the mandible (which can lead to a displacement of the articular disc) downward and backward exacerbated by gravity, lengthening the muscles as well as compressing the nerves and vessels at the back of the neck. Among the muscles of the head and neck, the sternocleidomastoid muscle plays a role in the position of the head [22] and its movement. A bilateral contraction produces an extension of the head and increases cervical lordosis [24]. Each new position of the mandible requires adaptation [25] and overactivity of the masticatory muscles such as the masseter and the temporal muscle whose contraction is counterbalanced by the vertical force of gravity on the mandibule. The anterior imbalance creates a weight that could have an influence on the body's sway area, stability, and center of gravity. [22, 24, 26] Two studies report an influence of mandibular positions on the sway area or sway velocity when a subject open or closes the eyes [16, 17]. In the first study, Baldini A. et al [17] as mentioned in the Marchili N. et al review [33], studied patients without TMD. They reported an increase of 39% in sway area and 29% in sway velocity when the eyes were closed. The mandibular position had an effect on the sway area that could be increased by 0.7 to 2.5% depending on the position. In the second study, Nota A. et al [16] comparing two groups with and without TMD, reported an increase in sway area/velocity in the group with TMD, depending on the different mandibular positions (at rest, in maximal intercuspation and mandibular position with cotton rolls) but only associated with the open eyes situation. In the two abovementioned studies, the mandibular position with cotton rolls had no influence [16, 17]. Conversely, no influence of mandibular movements on postural balance was shown by Rocha T. et al [12] although not investigating the influence of the vision. Perinetti et al. [34] reviewing the literature investigating mandibular positions and body balance, could not fully conclude to a correlation regarding the variable results.

In support to a link between vision, body balance and mandibular position Cuccia A. et al [24] introduces the notion of neuroanatomy influence. As cited by the author regarding the craniomandibular system: "*All of these anatomical connections suggest that portions of the trigeminal system strongly influence the coordination of posture and sight. It seems likely that sensory information from SS proprioceptive receptors is processed in tandem with information from the vestibular and oculomotor systems. Changes in trigeminal stimulations can cause an imbalance in the vestibular and oculomotor systems.*" (Cuccia A., Caradonna C. 2009) [24]

For each particular position of the head, there is an adaptation of the sight [24]. The role of the proprioceptive sensation of the periodontal ligament on postural balance has also been investigated [22, 24] and could have an influence on the body balance. As described above, the trigeminal nerve has three main branches, ophthalmic, maxillary, and mandibular [1]. From its sensitive part, the mandibular nerve carries the proprioceptive information of the oral cavity by the teeth and periodontal ligament (pressure, tactile, temperature, etc.).[5, 31] Linking this information, it can be hypothesized that trigeminal proprioception influences mastication. Poor dental prehension in the oral cavity can lead to abnormal activity of the mandible during maximum closing movements and intercuspidation (e.g. during anaesthesia) [24]. In view of this, the loss of occlusion caused by the loss of teeth and desmodontal support would lead to the same decrease in proprioception.[22] The hypothesis of Cuccia A. et al.[24] about a link between the oculomotor and trigeminal systems was relayed in the publication of Marchili et al.[33] The study by Carini F. et al.[31] supports this hypothesis by explaining the effects of vestibular and visual-oculomotor systems on posture. There is a functional relationship between trigeminal and oculomotor systems [31]. Indeed, to function correctly, the eye has sensitive innervations coming from the optic nerve (II), and trigeminal (ophthalmic branch V1), and motor from the abducens (VI) and oculomotor (III) nerves.[1]

These publications [22, 24, 31, 33] suggest that mandibular movements and/or the gaze could have an impact on body balance and postural control although their effect is still debated. Additional investigations would thus be required to determine their respective influence.

In a more objective context, several authors have used photographs or radiographs of study subjects to measure angles and postural changes (cf. Results). However, not all have used the same anatomical references to measure similar angles and postural alterations.

Among the many angles studied, the main ones cited in the results determine the position of the head in relation to the cervical spine (head forward posture, anterior or posterior rotation and flexion/extension of the head) [7, 8, 10, 15, 19, 21]. Head extension (posterior rotation) is associated with an increase in craniocervical angle [9, 10, 13, 14, 19, 20] tragus-C7-horizontal angle [13, 15, 20, 21], eye-tragus-horizontal angle [15, 20, 26], and a reduction in O-A distance [10, 13, 14, 20]. This backward displaced head weight results in an adaptation of the curvature of the cervical spine with an increased lordosis [14, 20] shown by the O-A distance, the odontoid plane angle as well as the Cobbs angle [19]. The eye-tragus-horizontal angle was statistically significant in the Armijo-Olivo S. et al[15] study. The fact that the sample was exclusively female, lead us to question the influence of the gender factor in such results, and to consider the need for future comparative study between men and women.

Lower cervical flexion seems to compensate for this upper cervical extension, which leads to hyperlordosis of the cervical spine[4, 22, 24-26]. This condition appears to be found in Class II malocclusions. The reverse is found in subjects with class III malocclusions with posterior rotation of the head, shortening of the neck muscles and lengthening of the sternocleidomastoid muscle [24, 25]. All these alterations have an impact on the distribution of the weight of the head on the cervical spine and therefore the rest of the body [22].

It a relatively unanimous that dysfunctions of muscular origin are the most clinically relevant [7, 8, 16, 20, 25, 26]. "there is evidence and low risk of bias that patients with myogenous TMD have craniocervical postural misalignment" (Chaves TC et al., 2014) [26]. However, in the study by Espinosa de Santillana I.A. et al [7], the forward head position was considered a frequent alteration, but independent of the type of TMD.

Muscle activity is measurable using electromyography [4, 18, 22, 24, 25]. The authors of these articles studied the activity of the masseter and/or sternocleidomastoid muscles, involved in mastication. They showed that subjects with TMD had abnormal muscle activity as well as a transmission of muscular tension between these two muscles[4, 18, 22, 24, 26]. The Miralles R. et al [18] study reports a decrease of EMG activity in the subjects with closed eyes, in both control and TMD groups with the mandible at rest, and in the healthy group during swallowing. A correlation between the jaw and neck muscles seems to stand out but will require further research before a direct causal link can be stated. The study conducted by Cuccia A. et al [24], which discusses the link between dental occlusion, oculomotor system and visual stabilization was also reported in a journal treating specifically the occlusion/ophthalmology link by Marchili N. et al. [33] They concluded that "nervous system and functional pathways strictly connect vision and dental occlusion" [33]. In addition, Monaco et al. cited in the Marchili N. et al. [33] study demonstrated a connection between malocclusions, TMD and visual defects (particularly ocular convergence defects).

V. Conclusion

Despite extensive research on the subject, a complete understanding of the links between the dysfunctions of the temporomandibular system, and the the overall posture of the body or the cervical spine, is not obvious and still debated, suggesting the need for additional innovative investigations. In our study, new factors of possible significant importance have been considered such as the trigeminal system, the influence of the periodontal ligament, fascias and the vision.

It appears that anatomical links between all ligaments involved, and neuromuscular structures must be methodically studied to understand their multiple interactions.

In future studies, improved diagnostic tools and methods seem to be fundamental as well as the choice of sampling, unbiased clinical and biological examination and longitudinal studies.

The diversity of causal interacting factors suggests the need for multidisciplinary approaches in the understanding and management of these dysfunctions by orthopaedists, psychologists, physiotherapists, dentists, ophthalmologists, and otolaryngologists.

REFERENCES:

1. Kamina. Anatomie Clinique Tome 2: tête, cou, dos (3th Ed). Maloine. 2006 jul; section II chap 6, 7, 8, section VII chap 26, 27.

2. Ramírez LM, Ballesteros LE, Sandoval GP. Tensor tympani muscle: strange chewing muscle. Med Oral Patol Oral Cir Bucal. 2007 Mar 1;12(2):E96-100.

3. E. Ferendiuk, K. Zajdel et M. Pihut.*Incidence of Otolaryngological Symptoms in Patients with Temporomandibular Joint Dysfunctions*. BioMed Research International. 2014 jun; 2014:1–5.

4. Khan MT, Verma SK, Maheshwari S, Zahid SN, Chaudhary PK. Neuromuscular dentistry: Occlusal diseases and posture. J Oral Biol Craniofac Res. Sep-Dec 2013;3(3):146-50.

5. Clauzade M. Orthoposturodontie. AOS. 2007; 240:387-405.

6. Snell, Richard S. Clinical Neuroanatomy (7th Ed). Wolters Kluwer: Lippincott Williams & Wilkins; 2010: Chap 3.

7. Espinosa de Santillana IA, García-Juárez A, Rebollo-Vázquez J, Ustarán-Aquino AK. Frequent postural alterations in patients with different types of temporomandibular disorders. Rev. Salud Publica 2018; 20(3): 384-389.

8. Cortese S, Mondello A, Galarza R, Biondi A. Postural alterations as a risk factor for temporomandibular disorders. Acta Odontol. Latinoam. 2017; 30(2): 57-61.

9. Faulin EF, Guedes CG, Feltrin PP, Joffiley CM. Association between temporomandibular disorders and abnormal head postures. Braz Oral Res. 2015; vol 29(1): 1-6.

10. Câmara-Souza MB, Figueredo OMC, Maia PRL, Dantas IS, Barbosa GAS. Cervical posture analysis in dental students and its correlation with temporomandibular disorder. The Journal of Craniomandibular & Sleep practice. 2018; 36(2): 85-90.

11. Walczyńska-Dragon K, Baron S, Nitecka-Buchta A, Tkacz E. Correlation between TMD and cervical spine pain and mobility: is the whole body balance TMJ related ? Biomed Res Int. 2014 jun; doi: 10.1155/2014/582414. Epub 2014 Jun 19

12. Rocha T, Castro MA, Guarda-Nardini L, Manfredini D. Subjects with temporomandibular joint disc displacement do not feature any peculiar changes in body posture. J Oral Rehabil. 2017 Feb; 44(2):81-88

13. Saddu SC, Dyasanoor S, Valappila NJ, Ravi BV. The Evaluation of Head and Craniocervical Posture among Patients with and without Temporomandibular Joint Disorders- A Comparative Study. J Clin Diagn Res. 2015 Aug; vol 9(8): ZC55-ZC58

14. de Farias Neto JP, de Santana JM, de Santana-Filho VJ, Quintans-Junior LJ, de Lima Ferreira AP, et al. Radiographic measurement of the cervical spine in patients with temporomandibular dysfunction. Arch Oral Biol. 2010 Sep; 55(9):670-8.

15. Armijo-Olivo S, Rappoport K, Fuentes J, Gadotti IC, Major PW, Warren S, Thie NM, Magee DJ. Head and cervical posture in patients with temporomandibular disorders. J Orofac Pain. 2011; 25(3):199-209.

16. Nota A, Tecco S, Ehsani S, Padulo J, Baldini A. Postural stability in subjects with temporomandibular disorders and healthy controls: A comparative assessment. J Electromyogr Kinesiol. 2017 Dec; 37:21-24.

17. Baldini A, Nota A, Tripodi D, Longoni S, Cozza P. Evaluation of the correlation between dental occlusion and posture using a force platform. Clinics. 2013; 68(1): 45-49.

18. Miralles R, Valenzuela S, Ramirez P, Santander H, Palazzi C, Ormeño G, Zúñiga C. Visual input effect on EMG activity of sternocleidomastoid and masseter muscles in healthy subjects and in patients with myogenic cranio-cervical-mandibular dysfunction. Cranio. 1998 Jul;16(3):168-84.

19. Joy TE, Tanuja S, Pillai RR, Dhas Manchil PR, Raveendranathan R. Assessment of craniocervical posture in TMJ disorders using lateral radiographic view: A cross-sectional study. Cranio. 2019 Sep ; 13:1-7.

20. Munhoz WC, Hsing WT. Interrelations between orthostatic postural deviations and subjects' age, sex, malocclusion, and specific signs and symptoms of functional pathologies of the temporomandibular system: a preliminary correlation and regression study. Cranio. 2014 Jul; 32(3):175-86.

21. Visscher C. M., De Boer W., Lobbezoo F., Habets L. L. M. H., Naeije M. Is there a relationship between head posture and craniomandibular pain? J Oral Rehabil. 2002 29;1030–1036.

22. Moon HJ, Lee YK. The relationship between dental occlusion/temporomandibular joint status and general body health: part 1. Dental occlusion and TMJ status exert an influence on general body health. J Altern Complement Med. 2011 Nov;17(11):995-1000.

23. Slavicek R. Relationship between occlusion and temporomandibular disorders: implications for the gnathologist. Am J Orthod Dentofacial Orthop. 2011 Jan;139(1):10, 12, 14.

24. Cuccia A, Caradonna C. The relationship between the stomatognathic system and body posture. Clinics (Sao Paulo). 2009;64(1):61-6.

25. Manfredini D, Castroflorio T, Perinetti G, Guarda-Nardini L. Dental occlusion, body posture and temporomandibular disorders: where we are now and where we are heading for. J Oral Rehabil. 2012 Jun;39(6):463-71.

26. Chaves TC, Turci AM, Pinheiro CF, Sousa LM, Grossi DB. Static body postural misalignment in individuals with temporomandibular disorders: a systematic review. Braz J Phys Ther. Nov-Dec 2014;18(6):481-501.

27. Rocha CP, Croci CS, Caria PH. Is there relationship between temporomandibular disorders and head and cervical posture? A systematic review. J Oral Rehabil. 2013 Nov;40(11):875-81.

28. Schiffman E., Ohrbach R., Truelove E., Look J., Anderson G. et al. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for Clinical and Research Applications: Recommendations of the International RDC/TMD Consortium Network* and Orofacial Pain Special Interest Group. J Orofac Pain. 2014 Winter; 28(1): 6–27.

29. Munhoz WC, Hsing WT. The inconclusiveness of research on functional pathologies of the temporomandibular system and body posture: Paths followed, paths ahead: A critical review. Cranio. 2019 Apr ; 29 :1-12.

30. Garg A. K. , Jain S., Gupta S., Gupta V. Myofascial Pain Dysfunction Syndrome: An Overview. AJCDHT. 2013; 5(6): 12-14.

31. Carini F., Mazzola M., Fici C., Palmeri S., Messina M., Damiani P., Tomasello G. Posture and posturology, anatomical and physiological profiles: overview and current state of art. Acta Biomed 2017; 88(1): 11-16.

32. Katsuura Y., Lemons A.,Lorenz E., Swafford R., Osborn J.,Cason G. Radiographic Analysis of Cervical and Spinal Alignment in Multilevel ACDF with Lordotic Interbody Device. Int J Spine Surg. 2017; 11(2):13.

33. Marchili N., Ortu E., Pietropaoli D., Cattaneo R., Monaco A. Dental occlusion and Ophtalmology: A littérature review. Open Dent J. 2016; 10: 460-468.

34. Perinetti G., Primozic J., Manfredini D., Di Lenarda R., Contardo L. The diagnostic potential of body-sway recording in orthodontics: a systematic review. Eur J Orthodont. 2012 nov; 35(5): 696-705.