CESPU
INSTITUTO UNIVERSITÁRIO
DE CIÊNCIAS DA SAÚDE

Correlation between occlusion and posture

Maëva Rasolofo

Dissertação conducente ao Grau de Mestre em
Medicina Dentária (Ciclo Integrado)

Gandra, 28 de maio de 2020

CESPU
INSTITUTO UNIVERSITÁRIO
DE CIÊNCIAS DA SAÚDE

Maëva Rasolofo

Dissertação conducente ao Grau de Mestre em
Medicina Dentária (Ciclo Integrado)

Correlation between occlusion and posture

Trabalho realizado sob a Orientação de "José Alberto Gonçalves Rocha Coelho"

CESPU
INSTITUTO UNIVERSITÁRIO
DE CIÊNCIAS DA SAÚDE

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.

CESPU
INSTITUTO UNIVERSITÁRIO
DE CIÊNCIAS DA SAÚDE

DECLARAÇÃO DO ORIENTADOR

Eu, **"José Alberto Gonçalves Rocha Coelho"**, com a categoria profissional de **Assistente convidado** do Instituto Universitário de Ciências da Saúde, tendo assumido o papel de Orientador da dissertação intitulada ***"Correlation between occlusion and posture"***, do Aluno do Mestrado Integrado em Medicina Dentária, **"Maëva Rasolofo"**, 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, ___ / ___ / ______

O Orientador

____

ACKNOWLEDGMENTS

To my beloved mother for all the sacrifices she made for me to succeed.

To my best friend chiropractor who gave me the idea of this interesting topic to pursue.

To my orienteer who contributed in the successful writing of this work.

To my oral rehabilitation teacher, for her help and advices she gave me in the clinic.

To all my friends and my clinic partner whom I have met over the years and have allowed me to learn and grow in both my professional and personal life.

RESUMO

Hoje em dia, as pessoas estão muito preocupadas com o aspeto estético dos dentes sem pensar à importância do aspeto funcional da boca e do sistema estomatognático. Uma boa oclusão dentária desempenha um papel fundamental na mastigação, na fala e na deglutição. Se houver um desequilíbrio na oclusão, vários sintomas como dores agudas ou crónicas, podem ocorrer na cabeça e pescoço.

O objetivo deste trabalho consiste numa revisão sistemática integrativa para ver se existe uma correlação entre a oclusão e postura, e se for o caso, quais os níveis de alterações existentes na coluna vertebral em função do tipo de oclusão.

Realizou-se uma pesquisa bibliográfica na Pubmed com duas combinações de palavras chave: " malocclusion " AND " posture " OR " dental occlusion " AND " posture ". Dos 261 artigos encontrados, 28 relevantes foram selecionados. 68% dos artigos estabeleceram uma correlação positiva, 25% uma corelação negativa e 7% uma correlação parcial.

A maioria dos autores observaram uma extensão da cabeça para os indivíduos de classe II esquelética e uma flexão da cabeça para os de classe III esquelética, acompanhado de uma assimetria do corpo leve a moderada, seguindo o tipo de oclusão. Alguns tratamentos como RPE, Invisalign® ou cirurgia ortodôntica, também permitiram de corrigir a oclusão e, portanto, a postura.

O corpo é um sistema dinâmico onde a visão e o grau de severidade da maloclusão podem modificar a relação oclusão/postura e criar alterações compensatórias na postura e equilíbrio corporal.

PALAVRAS-CHAVE

Maloclusão; postura; oclusão dentária; ATM; DTM

CESPU
INSTITUTO UNIVERSITÁRIO
DE CIÊNCIAS DA SAÚDE

ABSTRACT

Nowadays, people are very concerned about the aesthetic aspect of the teeth without thinking about the importance of the functional aspect of the mouth and the stomatognathic system. A good dental occlusion plays a fundamental role in chewing, speaking and swallowing. If there is an imbalance in this occlusion, several symptoms such as acute or chronic pain can occur in the head and neck.

The goal is to make a systematic integrative review to see if there is a correlation between occlusion and posture, and if so, up to which level do alterations in the spine occur depending on the type of occlusion.

A bibliographic search was carried out on Pubmed with two key word combinations: "malocclusion" AND "posture" OR "dental occlusion" AND "posture". From the 261 articles found, 28 relevant ones were selected. 68% of the articles found a positive correlation, 25% were for a negative correlation and 7% for a partial correlation.

Most of the authors observed an extension of the head for skeletal class II individuals and a flexion of the head for skeletal class III individuals, accompanied by a slight to moderate body asymmetry following the type of occlusion. Some treatments such as RPE, Invisalign® or orthodontic surgery also allowed correction of the occlusion and, therefore, posture.

The body is a dynamic system where vision and the degree of malocclusion severity can modify the occlusion/posture relationship and create compensatory changes in posture and body balance.

KEYWORDS

Malocclusion; posture; dental occlusion; TMJ; TMD

CESPU
INSTITUTO UNIVERSITÁRIO
DE CIÊNCIAS DA SAÚDE

TABLE OF CONTENTS

ABREVIATIONS

BO	blocked occlusion
CCA	craniocervical angle
CCJ	craniocervical junction
CR	cotton rolls
CVCM	cervical vertebral column morphology
DOB	dentoalveolar open bite
ICP	intercuspal position
LWD	lateral weight distribution
MSB	mouth slow balance
NHP	natural head posture
NUCCA	National Upper Cervical Chiropractic Association
RPE	rapid palatal expansion
SAPO	Postural Assessment Software
SOB	skeletal open bite
TMD	temporomandibular disorders
TMJ	temporomandibular joint
VTC	voluntary tooth clenching

1. INTRODUCTION

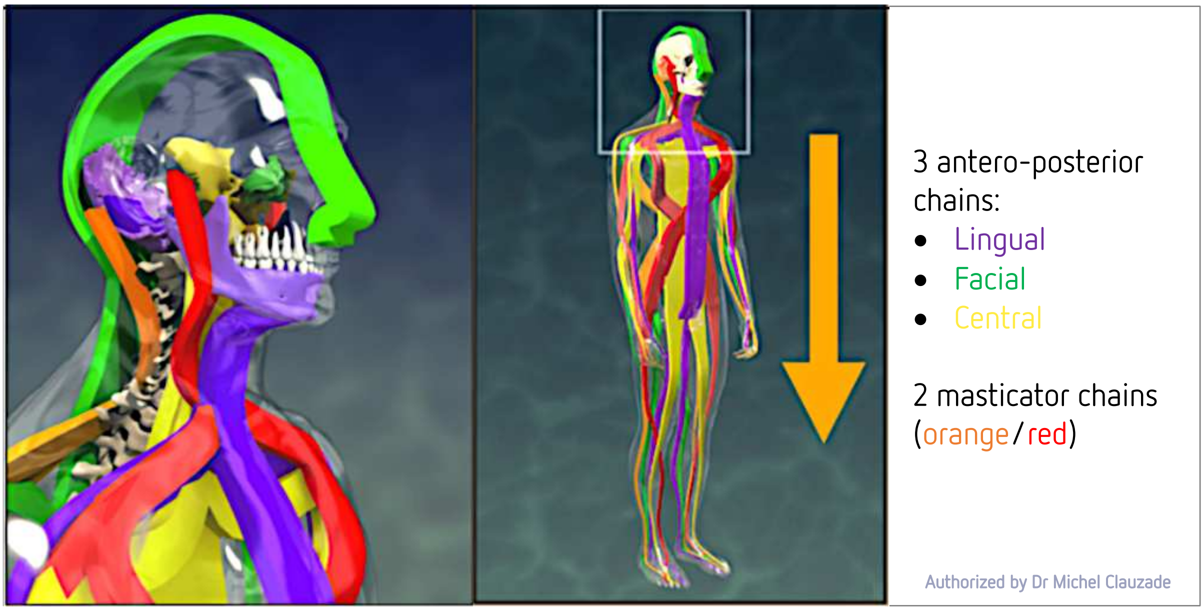
1.1. General anatomy description of body posture

The human body is governed by the bipedality and verticality concepts where the spherical cranial shape appears as an optimal criterion. Body posture can be resumed to a head balanced in space in relation to the visual axis. The eye provides the reference frame necessary for the execution of the movement. The visual plane, that corresponds to the Frankfurt plane, is thus important in occlusion.[1] Some authors[2,3] have demonstrated that vision can exercise an important influence on the postural system, in particular in air force and civilian pilots where visual function allows for better postural control.[2]

From the head start 5 musculoaponeurotic postural chains which ensure the stability of the standing man **(Fig. 1):**

- 3 anteroposterior chains: lingual, facial and central (antero-posterior balance)
    - The mandible acting as a regulator
- 2 tonic-phasic lateral chains called masticators (introversion/extraversion functions) [1]

Fig. 1: 5 Musculoaponeurotic postural chains

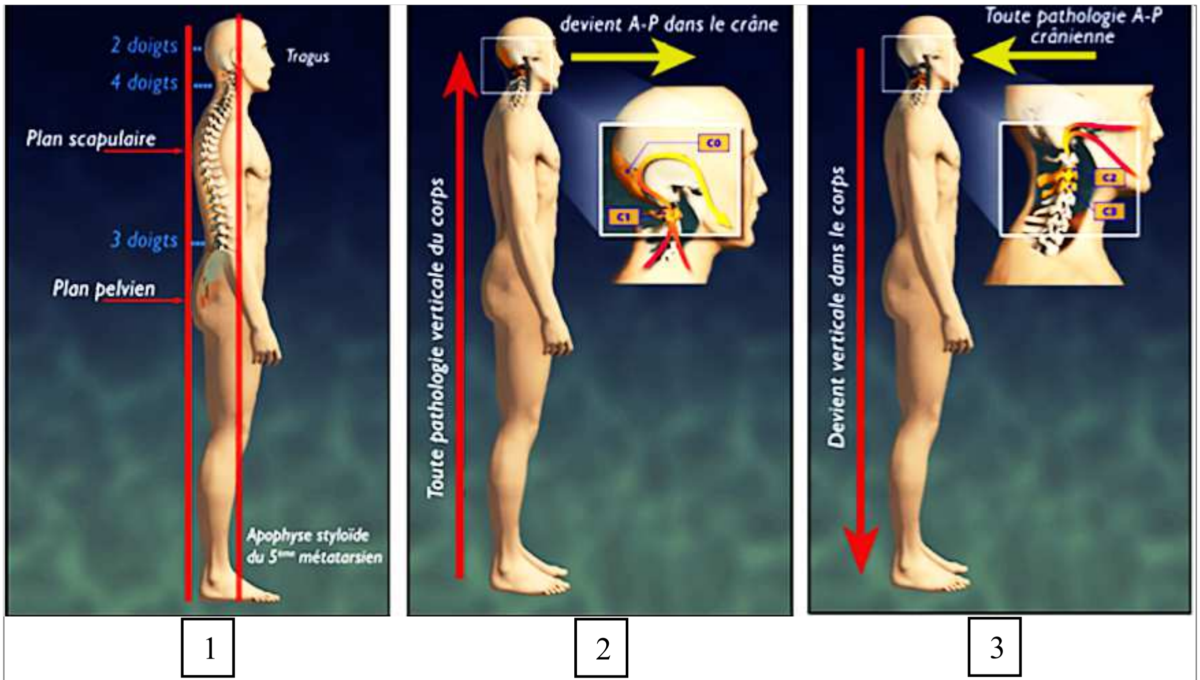


1.2. Relationship between occlusion and postural system

1.2.1. Central postural system

The anteroposterior postural organization is subject to an orthopedic law of compensation: any anteroposterior cranial pathology or dysmorphosis induces a vertical postural compensation in the body; any vertical postural pathology in the body will find anteroposterior compensation in the skull **(Fig. 2).** The mandible thus plays the role of anteroposterior postural compensator by regulating the anterior and posterior postural chains (lingual and facial). The skeletal Class I individual, which predisposes to optimal verticality, represents the ideal model to reach. [1]

<u>Fig. 2</u>: Orthopedic laws of postural organization

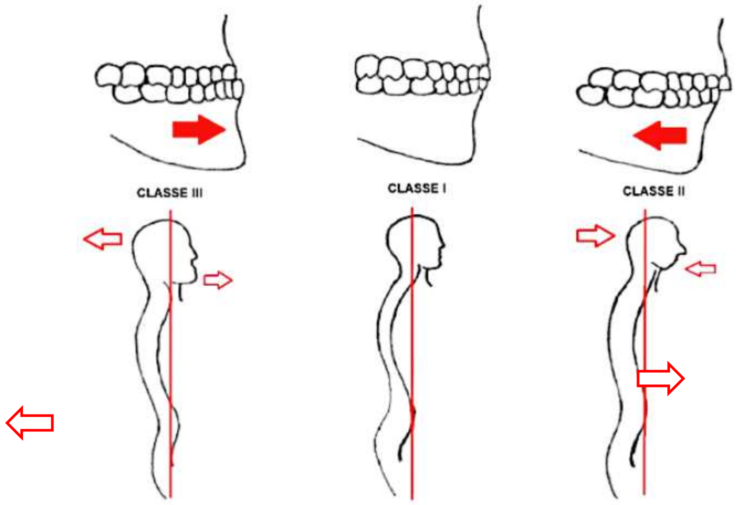


1) Line tragus-styloid process of the 5th metatarsal
2) Any vertical postural pathology in the body will find anteroposterior compensation in the skull
3) Any anteroposterior cranial pathology or dymorphosis finds a vertical postural compensation in the body

Authorized by Dr Michel Clauzade

Skeletal class II or III individuals are compensatory biotypes and have compensatory anterior or posterior postures **(Fig. 3)** [4]. Moreover, the permanent vertical force of gravity can constitute, during aging, a later decompensatory mechanism, especially for Class II. [1]

Fig. 3: Skeletal class II and III individuals: compensatory biotypes (anterior and posterior)



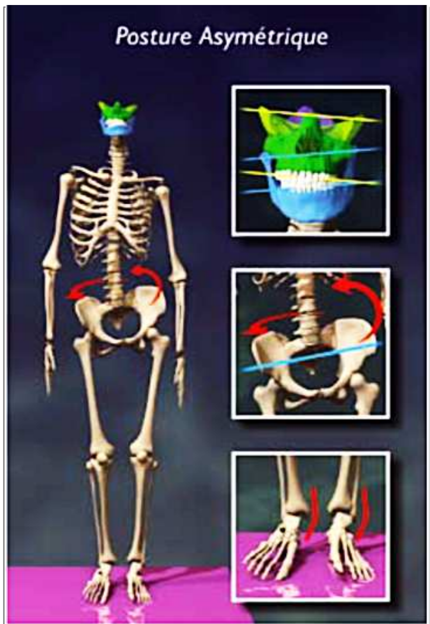
Skeletal Class II: Retrognathic people naturally have a recessed lower jaw. Even slight, this shift is enough to make the upper body plunge forward, with a head extension in relation to the cervical spine.

Skeletal Class III: Prognathic people have a lower jaw projected forward, this shift causes the upper body to plunge backwards with a head flexion in relation to the cervical spine.

Authorized image

Transversally, the human system doesn't have a compensation system. Any dysmorphosis or transverse dysfunction, as a mandibular latero-deviation, results in a postural asymmetry and thus a decompensation. **(Fig. 4).** [1]

Fig. 4: Transversal decompensation



Authorized by Dr Michel Clauzade

1.2.2. Peripherical postural system

The peripheral postural system includes sensory parameters such as eyes, inner ears, feet and skin. When one element of this system is dysfunctional, a lesional postural pattern appears, characterized by a contralateral symptomatology of the lesional TMJ. In an occlusal and postural involvement, the central occlusal pathology has to be treated first, as eyes and feet adapt to the mandible. Once the system is free of occlusal disturbances, the defective sensor will be treated. For a dentist, modifying the cranio-mandibular relationship of the patient, by choosing a therapeutic joint position, will allow to find a new postural balance. The highly neurological trigeminal dental occlusion complexity can sometimes explain the difficulty or impossibility of some treatments. [(1)]

2. AIM

The two main purposes of this review are first to understand the degree of correlation between occlusion and posture, and second, if such a correlation exists, determine until which level there are alterations in the spine following the different types of occlusion.

3. METHOD

A research was performed on PUBMED (via National Library of Medicine) using the following two combinations of search words: " malocclusion " AND " posture " OR " dental occlusion " AND " posture ". From a total of 261 identified articles with the two different combinations, a preliminary selection was made by reading the title and abstract of each article found. The inclusion and exclusion criteria had to be respected for an article to be chosen.

Inclusion criteria:

- Terms "Dental occlusion" or "Occlusion" or "Malocclusion" AND "Posture" or "Body posture"
- Terms "TMD" or "TMJ" included in the keywords of the articles and linked with occlusion or dental occlusion
- Only the articles published in the last 10 years

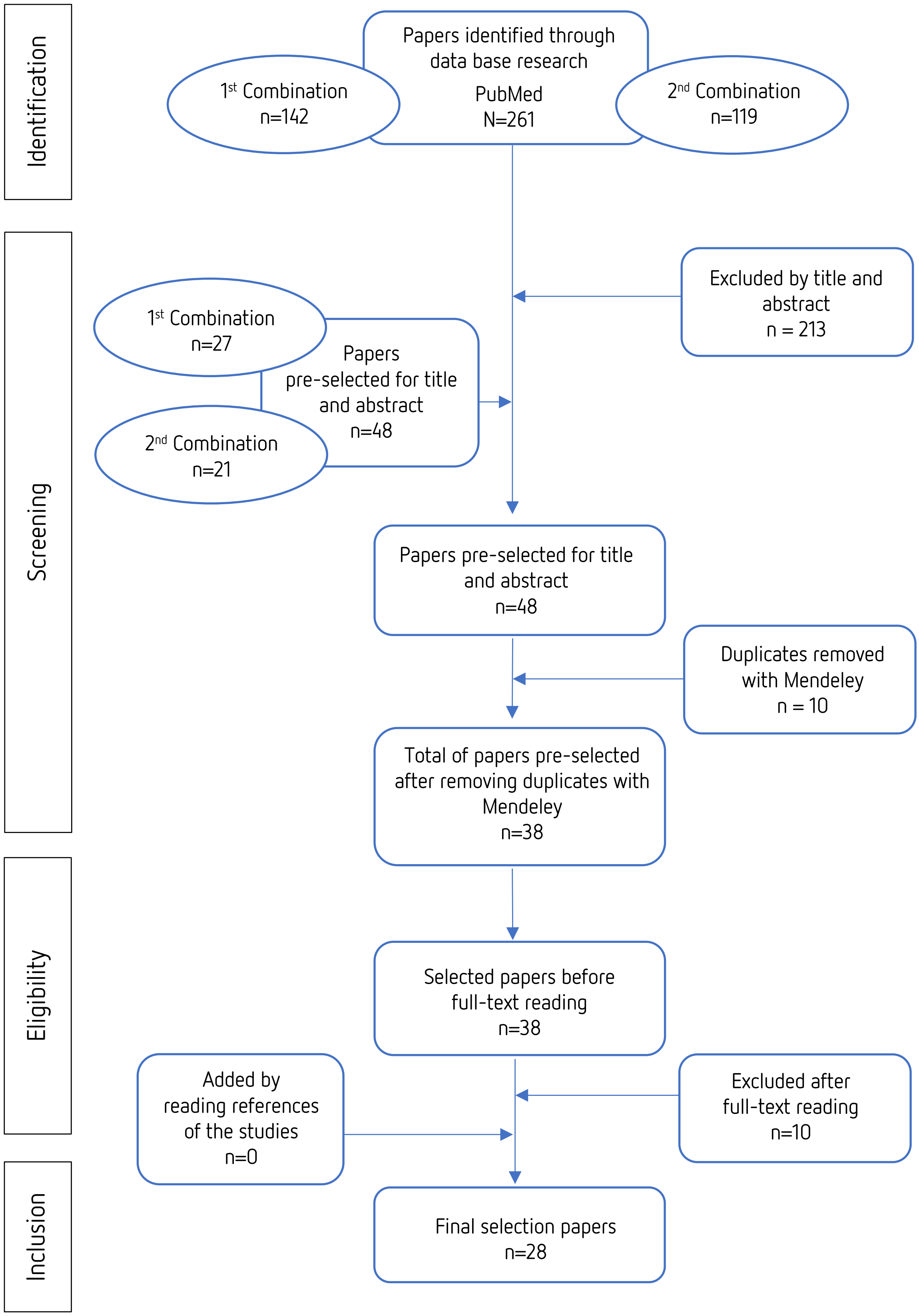
Exclusion criteria:

- Correlation with tongue position
- Correlation with airways
- Correlation with hyoid bone without link with the dental occlusion
- TMD not linked with the dental occlusion

With this method, 48 articles (27 selected from the first combination and 21 from the second) were selected over a total of 261. 213 articles were excluded because the inclusion or exclusion criteria were not met. The total number of articles was compiled for each combination of key terms and therefore 10 duplicates were removed using the Mendeley citation manager, resulting in a total of 38 articles. Selected articles were then individually read and evaluated concerning the purpose of this study. The following factors were recovered for this review: keywords, authors' names, journal, year of publication, and purpose. By fully reading each article, a selection of new articles through references within the examined studies was also performed but no relevant articles were found by this manual method. 10 articles were excluded after full-text reading: 3 were reviews of literature and7 did not provide comprehensive data considering the purpose of the study. A total of 28 articles was finally chosen to be evaluated in this integrative systematic review, as shown below in **Fig. 5.**

A book [(1)] talking about occlusion linked with body posture, and a figure [(4)] illustrating the posture linked with different skeletal classes were added as an integrative part of the introduction.

Fig. 5. Flow diagram of the search strategy used in this study.



1st Combination: "Malocclusion" AND "Posture"
2nd Combination: "Dental occlusion" AND "Posture"

4. RESULTS

A first classification was made following the design of the articles and the corresponding levels of evidence according to their methodological procedures, as shown below in **Table 1.**

Table 1: Study designs of the 28 articles included in the review, with the corresponding levels of evidence according to their methodological procedures.

Level	Study design	Number of articles found
1	**Experimental study**	**7**
1A	Randomized controlled trial	4
1B	Non-randomized controlled trial	3
2	**Observational study**	**19**
2A	Prospective cohort study	3
2B	Case-control	8
2C	Cross-sectional study (analytic / transversal)	8
3	**Observational study of individual data**	**2**
3A	Case report	2
		Total=28

Among the 28 articles included in this review, summarized in **Table 2**, 19 articles (67,86%) found a positive correlation between occlusion and posture, 2 (7,14%) articles found a partial correlation and 7 (25%) articles did not find a clinically relevant correlation between occlusion and posture.

By classifying according to the type of analyzing method, 12 articles used cephalometry to verify the correlation between occlusion and posture, 8 others used the force platform, 2 used the stabilo-baropodemetric platform, 3 used rasterstereography, 1 used the MatScan system, 1 used the PostureScreen mobile app, 1 used the SonoSens Monitor, 1 used SAPO, 1 used the Dyno Concept 2 machine, 2 used the stereophotogrammetry and 3 used the T-Scan system. Some studies used more than one analyzing method.

The main findings are explained as follows:

4.1. POSITIVE CORRELATION

4.1.1. Cervical curvature

- Cervical curvature variations in patients with infraocclusion and weak positive relationship between the cervical curvature and the vertical dimension of occlusion. (5)
- Deviation in the CVCM significantly associated with head extension.
    - Deviations of CVCM significantly associated with retrognathia of the jaws, and large cranial base angle. (6)
- Link between the alterations of a subject's CCJ alignment and distribution of occlusal forces into a maximum bite **(ascendant mechanism).** (7)

4.1.2. Splint

- Resolving malocclusion: Better occlusal load distribution after insertion of a splint, better postural balance. (8)

4.1.3. Vision

- Important influence of vision on body posture
    - Influence of the mandibular position on body posture
    - The sway area is the most sensitive parameter of the force platform to evaluate the effect of occlusion on body posture. (2,3)

4.1.4. Orthodontic devices

- Functional orthopedic device (MSB Class III) allowed the restauration of the correct intermaxillary relationship, conditioning a good posture
    - Valgus flat foot correction and significative reduction on the podalic support discrepancy between feet. (9)
- By using a RPE, correlation between dental occlusion and body posture was shown
    - Especially in the dynamic posture, where modifications at the mandibular level affected the whole body. (10)

- Use of Invisalign® appliance
    - Existence of a postural effect
    - Positive correlation between body posture, spine position and occlusal contacts after 6 months of treatment. [11]
- Partial correlation: the body posture changes, during a Twin-block treatment, were an expression of the physiological growth and not a response to occlusion improvement. [12]

4.1.5. Occlusion and posture

- Correlation between malocclusion and spinal posture. [13,14]
- After the correction of skeletal class III patients by an orthodontic surgery: Adjustments of the NHP (head extension). [15,16]
    - Posterior displacement of the head, trunk, knees and ankle valgus [16]
- Skeletal II subjects tended to exhibit more extended head. [17,19]
- Skeletal III subjects often exhibit flexed head. [17]
- Skeletal Class II subjects presented a more posterior rotation of the ramus in relation to the cranium and a more extended head than skeletal Class III. [18]
- The condition of VTC determines:
    - A load reduction
    - an increase in surface of both feet
    - opposite effect occurs with cotton rolls. [20]

4.1.6. Fusion of cervical vertebrae

- Partial correlation: Children and adolescents with anterior open bite showed deviations in CVCM but no significant differences were found between SOB group and DOB group.
    - Head more extended in relation to the cervical vertebral column in SOB group (C2-C3 fusion; block fusion C2-C3-C4; more partial cleft of atlas) than DOB group (more C2-C3 fusion; partial cleft). [21]
- Class III skeletal malocclusion associated with fusion of cervical vertebrae and deviation of the cervical column. [22]

4.1.7. Legs and feet

- Leg length discrepancy affected body posture and dental occlusion **(ascendant mechanism)**. [23]

4.2. NEGATIVE CORRELATION

- No relationship found between skeletal Class II and cervical spine. [24]
- By simulating malocclusion with a splint, there was no significant influence on posture. [25]
- The composite occlusal interference didn't significantly influence body posture during a 14-day follow-up period. [26]
- No conclusions on a direct impact of dental occlusions, with different mandible positions, on spinal and body posture parameters. [27]
- No clinical impact of the association between symmetrical and asymmetrical BO in the premolar region and changes in the 3 spine regions during standing and walking. [28]
- The results do not support the existence of clinically relevant correlations between malocclusions and body posture. [29]
- No significant influence of dental parameters on plantar pressure distribution and postural control was found during BO. [30]

Table 2: Relevant data gathered from the retrieved studies.

Author (Year) design	Subject group	Goal	Method of outcome assessment	Results	Conclusion
(2) Baldini A et al. (2013) **Observational study** (Cross-sectional study)	40 male patients (aged 18-49) divided in 2 groups: • 20 air force pilots • 20 civilian pilots	Evaluate the influence of dental occlusion and vision on their body posture.	Oral examination and a force platform test to evaluate the subjects' postural system efficiency. Test with 3 positions: • mandibular rest position • mandibular centric occlusion position • mandibular position using CR. Once with both eyes open and once with both eyes closed.	Air force pilots presented more bruxism, Angle I molar relationship Civilian pilots presented more Angle II molar relationship. Angle III molar relationship found in both groups. Sway area and Sway velocity parameters influenced by vision (eyes closed). Sway area parameter influenced by the mandibular position: more changes with eyes opened than closed. No statistically significant differences were found between both groups.	Vision has an important influence on the postural system of air force and civilian pilots: better postural control was observed. The mandibular position has an impact on the postural system reflected by modifications of the sway area postural parameter. Vision reduces both the sway area and velocity parameters, and thus, improve the balance of the entire body. The mandibular position influences the sway area statistical significantly, but not the sway velocity.
(3) Baldini A et al. (2013) **Experimental Study**	44 healthy volunteers: 30 males 14 females (17-35 years)	Evaluate if force platforms are able to detect eventual postural modifications	6 postural stabilometric exams (different mandibular and visual conditions) 4 parameters considered:	The ocular afference significantly influenced the sway area and sway velocity parameters. Weak influence of the mandibular position.	Vision influences body posture. Weak correlation observed between mandibular position and body posture in healthy subjects.

(Non-randomized controlled trial in simple blind)		resulting from dental occlusion.	• sway area • sway velocity • X axis displacement of the center of the foot pressure • Y axis displacement of the center of the foot pressure.		Sway area is the most sensitive parameter for evaluating the effect of occlusion on body posture.
(5) Ando E et al. (2014) **Observational study** (case-control study)	32 patients with infraocclusion (29-82 years) 28 controls (29-84 years)	Observe the variations of cervical curvature in patients with infraocclusion, and to compare this with the controls.	6 points of inquiry: • Cervical vertebra height • Neck alignment • Ratio of lower facial height • Vertical dimension of occlusion • Cervical angle • Occlusal angle Measurements on the same lateral cephalogram, with NHP of the patient.	Over 90% of the patients with infraocclusion: straight or kyphosis. 36% of the control subjects: Lordosis.	Weak positive correlation between the vertical dimension of occlusion and the cervical curvature in all subjects. Control group: • positive correlation between age and cervical curvature • negative correlation between age and cervical angle and occlusal angle. Patients with infraocclusion: • age only correlated with the ratio of lower facial height

			Classification Cervical curvature was divided into 4 groups: • Hyperlordosis • Lordosis • Straight • Kyphosis		• higher prevalence of non-lordosis than the control group.
(6) Arntsen T et al. (2011) **Observational study** (case-control study)	213 children (7-15 years) with a horizontal maxillary overjet of more than 6 mm 2 groups: • SOB (43 girls, 56 boys) • DOB (58 girls, 56 boys).	Evaluation of cervical column morphology in relation to craniofacial morphology and head posture.	Profile radiographs were used to make visual assessments of the cervical column and measurements of craniofacial morphology and head posture.	28% of SOB group has deviations in the CVCM 17% for the DOB group Fusion anomalies associated with a large sagittal jaw relationship, retrognathia of the jaws, large inclination of the jaws, and extended head posture. Partial cleft was associated with a large cranial base angle.	Were found associations between CVCM, craniofacial morphology, and head posture.
(7) Westersund CD et al. (2017) **Observational study** (case-control study)	11 adult volunteers: • with regular supportive care in the chiropractic clinic • demonstrated CCJ misalignment the day of or	By using a dental force plate (T-Scan®), understand if a CCJ adjustment can induce measurable occlusion changes.	Before–after intervention assessment included posture evaluation and dental occlusion with T-Scan®.	Changes in posture and occlusion observed after the NUCCA adjustment.	Link is shown between the alterations of a subject's CCJ alignment and the generation of occlusal forces in a maximum bite. Possible change in biomechanics of the bite linked to head and neck postural parameters.

	the day before the study				
(8) Baldini A (2010) **Observational Study of individual data** (Case Report)	55-years-old female patient with: • Regular spontaneous pain due to mastication in the right region of the masseter • Muscular tension inducing cephalea in the right frontal region 2 or 3 times a week	Diagnose and treat dysfunctional patients, who needed to stabilize or balance occlusion using a splint.	Static postural analysis with scoliometer and podoscope Evaluation of the skeletal and dental relations. By using Instrumental analysis: • Computerized occlusal analysis system (KeyT-Scan) to do 3D and 2D occlusion images • Force platform	Occlusal loads: 60% on the right (overloading in the posterior section) 40% on the left After 4 months of wearing the splint: • Significantly less pain in the masseter • Stop of the cervical pain • Frequency reduction of the bouts of cephalea Same clinical and instrumental improvements at 6, 9, and 12 months.	A clinical and instrumental approach permits to diagnose and treat patients with postural and occlusal problems. The instrumental analysis can only support and not replace the essential clinical analysis.
(9) Bardellini E et al. (2019) **Observational Study of individual data** (Case Report)	5½-year-old patient with Angle Class III malocclusion and anterior cross bite in deciduous dentition.	Evaluate the treatment of Class III malocclusion, through a new elastic functional orthopedic device	By using a stabilo-baropodometric platform analysis, evaluation of frontal and lateral postural plumb line to record the podalic support discrepancy between	Restoration of the correct intermaxillary relationship. Correction of the valgus flat foot Reduction of the podalic support discrepancy between feet	A global approach of the patient permits successful malocclusion and postural alterations.

		Verify an improvement of the podalic support.	feet, in static and dynamic phases.		
(10) Mason M et al. (2018) **Observational study** (case-control study)	41 patients (6-12 years) 3 groups: • 10 control subjects (Cs) • 16 patients with unilateral posterior crossbite (CbMono) • 15 patients with maxillary transverse discrepancy and no crossbite (Nocb)	Evaluate the effects of RPE on posture and gait analysis in subjects with maxillary transverse discrepancies.	Gait analysis and posturographic examination to evaluate balance alterations before (T0) and after (T4) RPE application, by using a six-cameras stereo-photogrammetric system synchronized with 2 force plates. Romberg test was performed on a force plate. Statokinesiogram and joint kinematics were evaluated.	Differences across the 3 population in T0: 95% power frequency in medio-lateral and antero-posterior direction, median frequency in medio-lateral direction, mean power frequency in medio-lateral direction. Differences registered in the three-dimensional joints kinematics variables: between Cs and Cbmono in T0 and T4 between Cbmono and Nocb in T4.	Correlation between dental occlusion and body posture by using the RPE, observed in the dynamic posture where alterations at the mandibular level affect the entire body.
(11) Parrini S et al. (2018) **Observational study**	15 patients: 9 females, 6 males (mean age: 21.8 years)	Evaluate possible correlations between orthodontic treatment and posture.	Comparation (at baseline, after 1, 3 and 6 months) of Rasterstereographic values between 15 untreated patients and	After 6 months of treatment with aligners, correlations between kyphosis angle, upper toracic Inclination, pelvic Inclination and body posture.	The use of aligners could influence body posture (upper spine and lower spine sections).

Prospective cohort study (Longitudinal study)	Control Group: 15 patients (8 females, 7 males) mean age: 23.67 years.		15 patients treated with aligners. Rasterstereographic parameters: • kyphotic angle • lordotic angle • upper thoracic inclination • pelvic inclination		
(12) Smailienė D et al. (2017) **Observational study** **Prospective cohort study** (Longitudinal study)	23 children: 13 boys, 10 girls (10–15 years) 14 patients for control group	Analyze the effect of orthodontic treatment with Twin-block appliance on body posture.	Orthopedic (back shape analysis) and orthodontic (cephalometric radiograph analysis) analysis: • before the treatment with Twin- block appliance • 10-14 months after the beginning of treatment.	Statistically significant decrease in kyphotic, lordotic, craniocervical angles, upper thoracic, pelvic, and trunk inclinations. Statistically significant changes of the orthopedic measurements were observed during the treatment period. No statistically significant changes of the orthopedic measurements were observed between study and control group.	Despite the results we can say that the body posture changes were an expression of a physiological growth instead of a response to an occlusion treatment.

(13) Castellano M et al. (2016) **Observational study** (case-control study)	61 patients: 37 males 24 females (mean age 12.23 +/- 1.74 years) 1) control group: 15 skeletal class I 2) 37 skeletal class II: 17 skeletal symmetric class II 20 skeletal asymmetric class II 3) 9 skeletal class III 8 skeletal asymmetric class III	Evaluate the possible influence of a malocclusion on a patient's posture.	Clinical and X-ray evaluation of patients with symmetric malocclusion or malocclusion, with mild to moderate non-syndromic craniofacial asymmetry. Evaluation of differences in postural pattern by using rasterstereography.	37 subjects showed a skeletal class II malocclusion. 9 subjects presented a skeletal class III malocclusion. 15 subjects had a class I skeletal malocclusion. 16 subjects in the symmetric malocclusion group. 32 subjects in the malocclusion with asymmetry group. 13 in the control group. No significant differences were found in posture between different groups of overjet, but only between males and females in the rasterstereographic parameters lordotic angle and pelvic tilt.	Orthodontic patients show mild to moderate asymmetry associated with malocclusion. Craniofacial asymmetry could also indicate a more general asymmetry present in another part of the body.
(14) Iacob SM et al. (2018) **Observational study** (Cross-sectional study)	29 students (25 females, 4 males) of the Dental Faculty, (22-35 years)	Determine if PostureScreen® Mobile app can evaluate the correlation between malocclusion and posture.	By using PostureScreen® Mobile app (photographic method) to analyze: Deviations of 13 parameters Static and dynamic dental occlusion examinations	Significant differences regarding head deviation angle during the frontal examination by comparing the Angle Class 1 group with another group with Angle Class 2 and 3.	Direct correlation is found between the different Angle classes of dental occlusion and posture. Statistically significant differences were found regarding head deviation angle between the Angle Class 1

			Postural exam		group vs. the Angle Class 2 and 3 group. PostureScreen® Mobile app can be useful in the early diagnosis of dental occlusion pathology.
(15) Cho D et al. (2015) **Observational study** (case-control study)	20 skeletal Class III patients (mean age, 21.6 years) Control group: 20 skeletal Class I patients (mean age, 22.2 years)	Evaluate the change NHP after orthognathic surgery in skeletal Class III patients.	Analyze of cephalometric radiographs and lateral facial photographs at T1 (pretreatment) and T2 (posttreatment). The Class III patients did a mandibular setback surgery The control group received a conventional orthodontic treatment.	T1: Class III group showed head flexion compared to Class I. T2: Class III group showed head extension, but no significantly different from Class I group.	Most of the Class I patients who underwent a conventional orthodontic treatment showed minimal or no change in NHP. Some Class III patients who did a mandibular setback surgery showed a change in their NHP (head extension).
(16) Kulczynski FZ et al. (2018) **Experimental Study**	31 skeletal class III patient (14 men, 17 women), adults <60 years, who underwent orthodontic	Evaluate body posture before and after bimaxillary orthognathic surgery by photogrammetry in	By photogrammetry using SAPO® (Postural Assessment Software) based on anterior, posterior, and lateral view images taken:	No significant difference between groups for age, gender, and GAP. After intervention: Normalization of the right leg/hindfoot angle with an initial valgus deformity	Correction of class III dentofacial deformities by bimaxillary orthognathic surgery Systemic postural adjustments, with posterior displacement of

(Non-randomized controlled trial)	preparation for surgery. Control group: 15 who did not undergo orthognathic surgery Study group: 16 who did orthognathic surgery	skeletal class III patients.	• 1 month before • 4 months after bimaxillary orthognathic surgery (or 4 months after the initial assessment, for the control group).	Posterior displacement of the head and trunk	the head and trunk and knee and ankle valgus observed
(17) Liu Y et al. (2016) **Observational study** (Cross-sectional study)	90 children (11-14 years) classified into 3 groups: skeletal class I, II, and III relationships according to ANB angle • Group 1: Skeletal class I • Group 2: Skeletal class II • Group 3: Skeletal class III	Investigate the relationships of sagittal skeletal discrepancy, NHP, and craniocervical posture in young Chinese children with average vertical facial pattern.	By using Cephalometric radiographs in patients in NHP, were measured and compared sagittal and vertical craniofacial morphology, head posture, and craniocervical posture.	The skeletal class II group showed larger craniovertical angles and craniocervical angles than the skeletal class III group Not all the measurements showed significant differences. The angle NSL/RL (nasion-sella line and the tangent to the posterior border of the mandibular ramus) is larger in the skeletal class II group than the skeletal class III group	Significant differences exist in NHP and craniocervical posture among skeletal class I, II, and III Subjects with skeletal class II has a more extended head. Skeletal class III showed a head flexion.

(18) Sandoval C et al. (2019) **Observational study** (Cross-sectional study)	65 lateral radiographs chosen over 700 according to Delaire's categorization: • 34 Class II malocclusion • 31 Class III malocclusion. (Adults subjects)	Determine the relationships between craniocervical posture and skeletal classes II and III malocclusion.	Evaluation of craniocervical posture using the variables of Solow and Rocabado to see if an association between cranio-cervical posture and skeletal Class exists.	Skeletal Class II: • More posterior rotation of the ramus in relation to the cranium • More extended head than skeletal Class III. Significant correlations in Class II individuals between: • Rotation of mandibular ramus and cervical lordosis • Rotation of mandibular ramus and craniocervical posture.	Correlations observed in skeletal Class II, but not in skeletal Class III.
(19) Vukicevic V et al. (2016) **Observational study** (Cross-sectional study)	90 subjects (8-14 years): 30 for each skeletal class I, II and III (based on angle ANB values, indicator of sagittal jaws relations).	In people with different sagittal skeletal jaw relationship, analyzing the relationship between: • Head posture • Sagittal position parameters • Length of the jaws	Lateral cephalograms analysis by the computer program "Onyx Ceph", following: • Craniocervical angle • Angle of maxillary prognathism • Angle of mandibular prognathism • The difference angles of maxillary and mandibular prognathism • Length of maxilla • Length of mandible	Class I and II patients: positive correlation of the angle of maxillary prognathism with CCA Class III patients: negative correlation of the angle of maxillary prognathism with CCA Class I and III patients: positive correlation of the angle of mandibular prognathism with the CCA In Class II patients: negative correlation of the angle of mandibular prognathism with the CCA	Class II malocclusion can increase the extension of the head in relation to the cervical spine.

				statistically significant positive correlation between the CCA and length of the maxilla significant negative correlation between the CCA and length of the mandible	
(20) Cuccia AM et al. (2011) **Observational study** (case-control study)	168 subjects: • control group: 32 males, 52 females (18 -36 years) • TMD group: 28 males, 56 females (19-42 years)	Identify the effects of TMD on plantar pressure and surface compared to a healthy control group during gait. Verify if different jaws relationships may modify the plantar arch in the same sample.	Compare the postural parameters of the two groups, by using a baropodometric platform: • Mean load pressure on the plantar surface • Total surface of feet • Forefoot vs rearfoot loading • Forefoot vs rearfoot surface • Percentage of body weight on each limb Following 3 dental occlusion conditions: • Mandibular rest position (REST)	TMD group: all posturographic parameters in both lower limbs showed a significant difference between REST vs CR and between VTC vs CR, except for the percentage of body weight on each limb; mean load pressure on the plantar arch in VTC, forefoot and total surfaces of feet in CR were significantly higher in both limbs. Control group: significant difference between REST vs VTC, REST vs CR and VTC vs CR in the mean load pressure on the plantar arch, forefoot surface, rearfoot surface and total surface of feet.	Between the TMD group and control group, differences observed in the plantar arch. In each group: The condition of VTC permits a load reduction and an increase in surface area on both feet The CR allows an increase in load and a reduction in surface area on both feet A change in the load distribution between forefoot and backfoot by using CR can influence body posture.

			• Voluntary teeth clenching (VTC) • Cotton rolls placed between upper and lower dental arches without clenching (CR)		
(21) Kim P et al. (2014) **Observational study** (Cross-sectional study)	111 patients (6-18 years) with an anterior open bite of more than 0 mm divided in: • SOB group: 19 girls, 19 boys • DOB group: 43 girls, 30 boys	Compare the CVCM and head posture between SOB group and DOB group. Analyze the CVCM and head posture in relation to the craniofacial morphology in both groups combined.	By analyzing the profile radiographs in both SOB and DOB groups, where were made visual assessment of the cervical column and measurements of craniofacial morphology and head posture.	No significant difference observed: 23.7% of the SOB group presented deviations in the CVCM 19.2% of the DOB group presented deviations in the CVCM Head posture significantly more extended in the SOB group compared with the DOB group. Head posture associated with craniofacial morphology: extended posture associated with a large cranial base angle, large vertical craniofacial dimensions, and retrognathia of the jaws.	No significant differences in the CVCM' deviations were found between the SOB and DOB groups. Significant differences were found in head posture between the groups, that might indicate a respiratory etiologic component in anterior open bite.

(22) Meibodi SE et al. (2011) **Observational study** (case-control study)	30 skeletal class III malocclusion (17-30 years) 46 controls (17-30 years)	Compare CVCM in skeletal class III malocclusion patients and adults with normal occlusion.	By evaluating the lateral cephalograms: Cervical vertebrae anomalies (fusion anomalies and posterior arch deficiency) were analyzed.	Study group: 73.3% had fusion of the body of the cervical vertebrae (between C2-C3, C3-C¬4 or C4-C¬5) cervical column deviations occurred significantly more often Control group: 32.6% showed fusion (between C2 and C3)	Class III skeletal malocclusion may be associated with fusion of cervical vertebrae and deviation of the cervical column.
(23) Maeda N et al. (2011) **Experimental Study** (Randomized controlled trial In single blind)	30 asymptomatic subjects:15 males, 15 females (19-33 years)	To quantitatively evaluate the effects of experimental leg length discrepancies on body posture and dental occlusion.	30 asymptomatic subjects randomly assigned to group 1 or group B. Experimental leg length discrepancies were provided by using 10 types of insoles with heights ranging from 1 to 10 mm at 1 mm intervals, placed under both feet. The MatScan system was used to measure changes in body posture (center of foot pressure) in 3 postural positions:	<u>Right foot</u>: With a heel lift of 6 mm or more: LWD shifted to the right side When a heel lift of 8 mm or more: occlusal force shifted to the right side <u>Left foot</u>: When a heel lift of 4 mm or more: LWD shifted to the left side When a heel lift of 7 mm or more: occlusal force shifted to the left side	Leg length discrepancy affected body posture and dental occlusion. Altering body posture by changing the length of the left or right leg shifts, the LWD and occlusal force distribution to the side that has a heel lift.

			• natural standing posture (control) • control with a heel lift under the right foot • control with a heel lift under the left foot. The T-Scan II system was used to analyze the results of changes in dental occlusion (center of occlusal force) in the 3 postural positions.		
(24) Di Giacomo P et al. (2018) **Observational study** (Cross-sectional study)	59 subjects with skeletal Class II were divided into: Group A: patients with TMD (24 females, 2 males), mean age: 44.69 years	Evaluate changes in the craniocervical structure skeletal Class II subjects with and without TMD.	By using cephalometric analysis, were measured: • ANB as a parameter of Class II • C0-C1 distance • C1-C2 distance • craniocervical angle, for the	In most of patients the distances C0-C1 and C1-C2 resulted in the normal range. Craniocervical angle was altered in 33 patients. Group A: statistically significant reduction of the craniocervical angle and the increase of the ANB value.	Alteration of craniocervical angle in groups A and B, with backward rotation of the head. The presence of TMD resulted of changes in neck posture, which explained the different result between the two groups about the ANB and craniocervical angle relationship.

	Group B: patients without TMD (14 females, 19 males) mean age: 24.33 years.		cervical spine analysis.		Neck posture could be the result of a compensatory mechanism in response to TMD.
(25) Leroux E et al. (2018) **Experimental Study** (Randomized controlled cross-over trial)	7 members of the "Pôle France Aviron" (15-17 years)	Evaluate the influence of dental occlusion on body posture and the competitive performance of young elite rowers.	By using dental occlusion disturbance devices to simulate dental malocclusions, was evaluated the influence of malocclusion on the body balance, paravertebral muscle contraction symmetry, and muscular power of young elite rowers. A force platform and a Dyno Concept 2 machine were used as measuring instruments. Stabilometric tests Posturographic tests Aerobic tests	Body balance parameters were not significantly influenced by the artificial occlusal disturbance. Interposition of an occlusal silicone splint: • significantly increased the presence of asymmetric muscular contractions • Induced a significant decrease in their muscular power	Negative impacts of an occlusal disturbance on muscular contractions and power but no significant influence on posture.

(26) Marini I et al. (2013) **Observational study** **Prospective cohort study** (Longitudinal study)	12 subjects (22 +/- 1.3 years)	Investigate the effects of an experimental occlusal interference on body posture.	Use of a force platform and an optoelectronic stereophotogrammetric analysis. An occlusal interference of a 0- to 2-mm-thick glass composite was made to disturb the intercuspal position. Measurements of: • Frontal and sagittal kinematic parameters • Dynamic gait measurement • Superficial electromyographic (SEMG) activity of head and neck muscles In 4 different exteroceptive conditions.: • 10 days before the application of the occlusal interference	No significantly changes with an occlusal interference over static and dynamic parameters of body posture in the 4 different exteroceptive conditions. Minimal influence only on the frontal kinematic parameters related to mandibular position. Increase of the activity of masticatory muscles.	The experimental occlusal interference did not significantly influence the body posture in a 14 days period.

			• Immediately before the application • the day after the application • 7 and 14 days after		
(27) Marz K et al. (2017) **Experimental Study** (Randomized controlled trial)	44 volunteers: 23 females: mean age 24.2 years 21 males: mean age 24.7 years.	Evaluate the correlation between dental occlusion and body posture.	By using a Rasterstereography, 44 body scans. 7 mandible positions Were evaluated for each mandible position and compared with scans performed with habitual intercuspation: • Trunk inclination • Trunk imbalance • Pelvic tilt • Pelvic torsion • Fleche cervical • Fleche lumbar • Kyphotic angle • Lordotic angle	Body posture deviations were found for: the fleche cervical, fleche lumbar and the kyphotic angle.	No conclusions on a direct impact of dental occlusions (different mandible positions) on spinal and body posture parameters. The detected posture changes could be due to individual neuromuscular compensation.

			• Surface rotation • Lateral deviation		
(28) Ohlendorf D et al. (2014) **Observational study** (Cross-sectional study)	23 healthy subjects (18 women, 5 men) without discomfort in the temporomandibular system or body movement. (25.2 +/- 2.2 years)	Examine if a symmetric or asymmetric dental occlusion block, by using 4 mm thick silicon panels, can significantly change the spine position (cervical, thoracic, or lumbar region) during standing and walking.	Quantification by an ultrasonic distance measurement system (sonoSens Monitor) of the upper spine position. Placement of a 4 mm thick silicon panel between the left/right premolars or the front teeth.	Significant differences between the habitual dental position and the BO conditions during standing position and walking in all body plans except in the right lumbar region during walking. Significant differences observed between the standing and walking trials in the frontal, sagittal, and transverse planes, especially the lumbar region.	Symmetrical and asymmetrical occlusion blocks in the premolar region can be associated with changes in all 3 spine regions during standing and walking. Highly similar reaction in all spine positions, following the silicon panel location. Between standing and walking, the main differences were in the lumbar spine. Relationship between the chewing and the movement system. No direct clinical impact of the study design.

(29) Perinetti G et al. (2010) **Experimental Study** (Non-randomized controlled trial)	122 subjects: 86 males, 36 females (10.8-16.3 years) from a local sport center.	Investigate if malocclusal traits are correlated with body posture alterations.	A dental occlusion assessment included phase of dentition, molar class, overjet, overbite, anterior and posterior crossbite, scissorbite, mandibular crowding and dental midline deviation. By using a vertical force platform, body posture was recorded through static posturography. Under two conditions: 1) mandibular rest position 2) dental intercuspidal position Posturographic parameters included the projected sway area and velocity and the antero-posterior and right-left load differences.	High variability of all of the posturographic parameters and very similar between the two recording conditions. Weakly significant correlations observed for overbite and dentition phase.	No clinically relevant correlations between malocclusions and body posture.

(30) Scharnweber B et al. (2017) **Experimental Study** (Randomized controlled trial)	87 male subjects (18-35 years)	Evaluate correlations between dental parameters, postural control and plantar pressure distribution.	Analysis of dental casts of the subjects By using a force platform, postural control and plantar pressure distribution were taken. All tests performed were randomized and repeated 3 times each for ICP and BO.	ICP, compared to BO, increases body sway in the frontal and sagittal planes. In all other 29, correlations were independent of the occlusion position. For both of the ICP or BO cases, Angle-class, midline-displacement, crossbite, or orthodontic therapy were found to have no influence on postural control or plantar pressure. Contact time of the left foot decreased while detecting the plantar pressure distribution in each position.	Reduction in body sway was observed during BO. No significant influence of dental parameters on plantar pressure distribution was found. No correlation between malocclusions and sagittal sway or plantar pressure distribution. No impact in permanent dental parameters over plantar pressure distribution, only in BO.

5. DISCUSSION

5.1. Correlation between occlusion and posture

This review was undertaken with two main purposes, of which the first is to understand the degree of correlation between occlusion and posture. From a long time ago, this question has been in the center of a huge debate and various conclusions came out of it during the last 10 years. The analysis was performed in diverse population types: 1 article included both adults and seniors (>60 years), 10 articles included only children (<18 years) and 17 articles included only adults (from 18 to 60 years).

Among the 28 relevant articles selected and reviewed according to the inclusion and exclusion criteria previously cited, 19 articles (67,86%) found a positive correlation between occlusion and posture, 2 (7,14%) articles found a partial correlation and 7 (25%) articles did not find a clinically relevant correlation between occlusion and posture.

Both Kim P et al. and Smailienė D et al. found a partial correlation. (21,12) After a Twin-block treatment, changes were observed in body posture as straightening of the back profile. The physiological growth might be an explanation for those changes rather than a response to the treatment. (12)

By analyzing profile radiographs, a more extended head in the SOB group was highlighted than the DOB one. However, no associations were found between CVCM and craniofacial dimensions. A respiratory etiologic component could play a role in the anterior open bite. (21)

In the 7 articles which expressed a negative correlation between occlusion and posture, Di Giacomo P et al. found no significant relationship between skeletal Class II patients with or without TMD and cervical spine posture. The changes observed in cervical spine could be linked to the position of the mandible or due to a compensatory mechanism in response to TMD. (24)

According to Leroux E et al. and Marini I et al., the creation of an occlusion disturbance, with a splint or composite, didn't modify body balance parameters significantly. (25,26)

Marz K et al. found no direct impact of dental occlusions with different mandible positions on spinal and body posture parameters. Even when differences were detected, a neuromuscular compensation could be the cause. [27]

Ohlendorf D et al. found changes in all three spine regions during standing and walking by symmetrical and asymmetrical occlusion blocks in the premolar region, but there is no clinical impact of a transversal study. [28]

Perinetti G et al. mention an insignificant correlation between malocclusion and body posture. The presence of small anteroposterior and transversal load imbalances observed could come from the neck posture in response to the malocclusion. [29]

Scharnweber B et al. emphasize an insignificant influence of dental parameters on plantar pressure distribution during blocking occlusion. Postural control and plantar pressure distribution were considered independent factors. [30]

Finally, only 9 articles out of 28 found a partial or a negative correlation between occlusion and posture because most did not find a significant relationship based on their results. When results were found, they were not considered significant to induce an anatomical or functional change in the body. A neuromuscular compensation might be another explanation for negative results. In the second part, by analyzing the 19 articles which found a positive correlation, we sought to understand up to level alterations occurred in the spine and what is the influence on the whole body.

5.2 . Up to which level do alterations in the spine occur?

According to some authors [13,20,23,7], 3 different hypotheses or mechanisms can regulate the relationship between occlusion and posture:

1) Ascendant: an upward postural alteration can influence cranio-mandibular position, forcing the mandible to assume an incorrect position.

2) Descendant: a craniomandibular alteration can affect the position of the column, pelvis, and foot, resulting in compensation mechanisms and postural alterations.

3) Combined: the simultaneous presence of both mechanisms.

To understand our second aim which is to know up to which level there is an impact in the spine, the 19 articles that found a positive relationship were classified according to the type of mechanism explained above and the affected area in the body: the cervical vertebrae column and head posture, the spine and consequent body balance in standing position and walking, and relationship with the legs, knees and feet.

5.2.1. Impact on the cervical vertebrae column level and head posture

Most of the articles revolve around the first or second mechanism. In a dentist's point of view, it is more relevant to focus on the descendent mechanism where a craniomandibular alteration can affect the position of the column, pelvis and foot and not the posture affecting the occlusion. It is also very important to understand what type of compensation mechanisms and postural alterations the human body can undertake to reply physiologically to this disturbance, in order to propose a better treatment for the patient.

Regarding the impact on the cervical vertebrae column level and head posture, 7 authors used the descendent theory, where the occlusion is affecting the posture. Ando E et al. explained that there was a significant positive correlation between the vertical dimension of occlusion and the cervical curvature. The cranio-mandibular condition can modify the spine morphology and muscle activity in cervical region. [5]

Arntsen T et al. showed that deviations of CVCM were significantly associated with retrognathia and large inclination of the jaws, a large cranial base angle, and head extension in relation to the cervical vertebral column in class II malocclusion patients. [6]

Cho D et al., concluded that most of the Class I patients who received conventional orthodontic treatment showed a minimal or inexistent change in their NHP compared to Class III patients who had undergone mandibular setback surgery and shown a change in their NHP, with a head extension. [15]

Some authors [17,18,19] demonstrated that Skeletal II subjects tended to exhibit more extended head[17,19], Skeletal Class II presented a more posterior rotation of the ramus in relation to the cranium and a more extended head than skeletal Class III [18] and Skeletal Class III subjects often exhibit flexed head [17] and may be associated with fusion of cervical vertebrae and deviation of the cervical column. [22] According to those findings, the type of skeletal class, and thus the occlusion, has an impact on the head posture.

Only one article used the ascendant mechanism. Changes in posture and occlusion can be observed after the NUCCA chiropractic adjustment. A link is shown between the alterations of a subject's CCJ alignment and the occlusal forces generation in a maximum bite. [7]

5.2.2. Implications on the spine and body balance (standing position and walking)

Concerning only the descendent theory and regarding the standing position, Castellano M et al. found that orthodontic patients showed mild to moderate asymmetry associated with malocclusion. A craniofacial asymmetry may also induce a more general asymmetry in the body and thus, confirm the relationship between malocclusion and spinal posture. [13]
Iacob SM et al. confirms that there is a direct correlation between the different Angle classes of dental occlusion and posture. [14]
Baldini A. reported a better occlusal load distribution and better postural balance after using a splint to treat a dysfunctional patient and stabilize or balance the occlusion. [8]
As we saw in the introduction, vision has also an important influence on the postural system, which is in accordance with the findings of the studies. An influence of the mandibular position on body posture has also been found. [2,3]
Regarding the walking position, the use of an RPE permits to see the correlation between dental occlusion and body posture, which is mainly revealed in the dynamic posture where modifications at the mandibular level affect the whole body. [10]
Correlations between kyphosis angle, upper thoracic inclination and pelvic inclination and body posture were found after 6 months of aligners treatment. Changes were found in upper and lower spine sections. [11]

5.2.3. Relationship with legs, knees and feet

Explaining the descendent theory, a functional orthopedic device (MSB Class III) allowed the restauration of the correct intermaxillary relationship, conditioning a good posture, a correction of valgus flat foot and reduction on the podalic support discrepancy between feet.[9]

Another study indicates that the condition of VTC can induce a load reduction and an increase in surface on both feet. The opposite effect occurs with CR. A change in the load distribution between forefoot and backfoot with the use of CR can suggest that the creation of a temporary voluntary malocclusion could influence posture. [20]

A correction of skeletal class III malocclusion by an orthodontic surgery allowed a backward head posture, a reduction of tension on the suprahyoid muscles, a correction of cervical hyperlordosis and a posterior displacement of the trunk, knees and ankle valgus of the patients. Posture realignment was observed. [16]

Following the ascendant theory, Maeda N et al. found that leg length discrepancy could affect body posture and dental occlusion. By changing the length of the left or right leg shifts, body posture was altered, and the weight distribution and occlusal force distribution go to the side that has a heel lift. [23]

6. CONCLUSIONS

The relationship between dental occlusion and posture has been in the center of a huge debate for years. Most of the articles concluded there is a correlation between occlusion and posture. Alterations were observed in body posture following the type of malocclusion (skeletal class II and III) or the type of treatment used to solve these malocclusions.

Some changes were found in the spine, depending on the degree of severity of malocclusion, and compensatory alterations were observed in body posture and body balance. A skeletal class II malocclusion tends to be associated with an extension of the head in relation to the cervical vertebral column and a deviation of cervical vertebral column morphology. A skeletal class III malocclusion can be associated with a more flexed head, a cervical hyperlordosis and trunk, knees and ankle valgus deformities.

Specific occlusal treatments such as RPE, occlusal splint, functional orthopedic device (MSB Class III), Invisalign®, as well as orthognathic surgery, could also modify the occlusion in different levels by changing and correcting the body posture. The follow-up of the patients, using occlusal devices, is important to determine if the changes observed would be permanent or temporary.

Inducing a temporary malocclusion with occlusal disturbance devices also confirmed the existence of a correlation between occlusion and posture.

However, these finding have to be taken very carefully following the evidence of the study design. In the future, more studies could confirm this positive relationship by taking a larger sample of subjects, being more rigorous in the inclusion and exclusion criteria, and using one efficient machine to measure the degree of correlation between occlusion and posture. The combined mechanism should not be overlooked by dentists and chiropractors so as to be able to propose a better and more complete treatment for the patient, without neglecting the origin of symptoms.

REFERENCES

1. Clauzade M. Orthoposturodontie. Actualités Odonto-Stomatologiques 2007;240:387-405
2. Baldini A, Nota A, Cravino G et al. Influence of vision and dental occlusion on body posture in pilots. Aviation Space and Environmental Medicine 2013;84(8):823-827
3. Baldini A, Nota A, Tripodi D et al. Evaluation of the correlation between dental occlusion and posture using a force platform. Clinics 2013;68(1):45-49
4. Hourset M et al. Kinésithérapie, la Revue. 2019 Oct;19(214):3-11
5. Ando E, Shigeta Y, Hirabayashi R et al. Cervical curvature variations in patients with infraocclusion. Journal of Oral Rehabilitation 2014;41(8):601-607
6. Arntsen T, Sonnesen L. Cervical vertebral column morphology related to craniofacial morphology and head posture in preorthodontic children with Class II malocclusion and horizontal maxillary overjet. American Journal of Orthodontics and Dentofacial Orthopedics 2011;140(1)
7. Westersund CD, Scholten J, Turner RJ. Relationship between craniocervical orientation and center of force of occlusion in adults. Cranio - Journal of Craniomandibular Practice 2017; 35(5):283-289
8. Baldini A. Clinical and instrumental treatment of a patient with dysfunction of the stomatognathic system: a case report. Annali di stomatologia 2010;1(2):2-5

9. Bardellini E, Gulino M, Fontana S et al. Long-term evaluation of the efficacy on the podalic support and postural control of a new elastic functional orthopaedic device for the correction of Class III malocclusion. European journal of paediatric dentistry 2019;20(3):199-203
10. Mason M, Spolaor F, Guiotto A et al. Gait and posture analysis in patients with maxillary transverse discrepancy, before and after RPE. Int Orthod. 2018 Mar;16(1):158-173
11. Parrini S, Comba B, Rossini G et al. Postural changes in orthodontic patients treated with clear aligners: A rasterstereographic study. Journal of Electromyography and Kinesiology 2018;38:44-48
12. Smailiené D, Intiené A, Dobradziejuté I et al. Effect of treatment with twin-block appliances on body posture in class ii malocclusion subjects: A prospective clinical study. Medical Science Monitor 2017;23:343-352
13. Castellano M, Lilli C, Barbato E et al. Craniofacial asymmetry in non-syndromic orthodontic subjects: clinical and postural evaluation. Cranio - Journal of Craniomandibular Practice 2016;34(3):144-154
14. Iacob SM, Chisnoiu AM, Lascu LM et al. Is PostureScreen(R) Mobile app an accurate tool for dentists to evaluate the correlation between malocclusion and posture? Cranio - Journal of Craniomandibular Practice 2018;1-7
15. Cho D, Choi D, Jang I et al. Changes in natural head position after orthognathic surgery in skeletal Class III patients. American Journal of Orthodontics and Dentofacial Orthopedics 2015;147(6):747-754
16. Kulczynski FZ, de Oliveira Andriola F, Deon PH et al. Postural assessment in class III patients before and after orthognathic surgery. Oral Maxillofac Surg. 2018 Jun;22(2):143-150
17. Liu Y, Sun X, Chen Y et al. Relationships of sagittal skeletal discrepancy, natural head position, and craniocervical posture in young Chinese children. Cranio - Journal of Craniomandibular Practice 2016;34(3):155-162
18. Sandoval C, Diaz A, Manriquez G. Relationship between craniocervical posture and skeletal class: A statistical multivariate approach for studying Class II and Class III malocclusions. Cranio - Journal of Craniomandibular Practice 2019;1-8
19. Vukićević V, Petrović D. Relationship Between Head Posture and Parameters of Sagittal Position and Length of Jaws. Medicinski pregled 2016;69(9-10):288-293

20. Cuccia AM. Interrelationships between dental occlusion and plantar arch. Journal of Bodywork and Movement Therapies 2011;15(2):242-250
21. Kim P, Sarauw MT, Sonnesen L. Cervical vertebral column morphology and head posture in preorthodontic patients with anterior open bite. American Journal of Orthodontics and Dentofacial Orthopedics 2014;145(3):359-366
22. Meibodi SE, Parhiz H, Motamedi MHK et al. Cervical vertebrae anomalies in patients with class III skeletal malocclusion. Journal of Craniovertebral Junction and Spine 2011;2:14
23. Maeda N, Sakaguchi K, Mehta NR et al. Effects of experimental leg length discrepancies on body posture and dental occlusion. Cranio - Journal of Craniomandibular Practice 2011;29(3):194-203
24. Di Giacomo P, Ferrara V, Accivile E et al. Relationship between cervical spine and skeletal Class II in subjects with and without temporomandibular disorders. Pain Research and Management 2018;2018
25. Leroux E, Leroux S, Maton F et al. Influence of dental occlusion on the athletic performance of young elite rowers: a pilot study. Clinics. 2018;73:453
26. Marini I, Gatto MR, Bartolucci ML et al. Effects of experimental occlusal interference on body posture: An optoelectronic stereophotogrammetric analysis. Journal of Oral Rehabilitation 2013;40(7):509-518
27. Marz K, Adler W, Matta R et al. Can different occlusal positions instantaneously impact spine and body posture? : A pilot study using rasterstereography for a three-dimensional evaluation. Journal of Orofacial Orthopedics 2017;78(3):221-232
28. Ohlendorf D, Seebach K, Hoerzer S et al. The effects of a temporarily manipulated dental occlusion on the position of the spine: a comparison during standing and walking. Spine J. 2014 Oct 1;14(10):2384-2391
29. Perinetti G, Contardo L, Biasati AS et al. Dental malocclusion and body posture in young subjects: a multiple regression study. Clinics 2010;65(7):689-695
30. Scharnweber B, Adjami F, Schuster G et al. Influence of dental occlusion on postural control and plantar pressure distribution. Cranio - Journal of Craniomandibular Practice 2017;35(6):358-366

CESPU
INSTITUTO UNIVERSITÁRIO
DE CIÊNCIAS DA SAÚDE

ANNEXS

Annex 1: Authorization written by Dr Michel Clauzade for using images from his book

Dr CLAUZADE Michel
1, rue de l'Ange
66000 PERPIGNAN
Tél : 06/07/01/40/15
michel.clauzade@wanadoo.fr

Perpignan le 30 Mai 2020

Je soussigné, docteur Michel CLAUZADE, autorise Mademoiselle Maëva RASOLOFO à utiliser pour la rédaction de sa thèse de doctorat des illustrations et des références tirées de mes livres Orthoposturodontie 1 et 2, ainsi que de mon livre « le capteur mandibulo-spinal ».
Cependant, je demande qu'une mention bibliographique y soit jointe.

Très cordialement

Dr Michel CLAUZADE