CORRELATIONS BETWEEN DENTAL MALOCCLUSIONS, OCULAR MOTILITY, AND CONVERGENCE DISORDERS: A CROSS-SECTIONAL STUDY IN GROWING SUBJECTS

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SUMMARY

Objective. The purpose of the study was to analyze the association between dento-skeletal malocclusions, ocular motility, and convergence disorders in growing subjects.

Materials and methods. 84 subjects (49 males, 35 females) with a mean age of 7.3±1.7 years were enrolled in a screening procedure for celiac disease at the Department of Gastroenterology of the University of Rome "Tor Vergata". Each child underwent an orthodontic, orthoptic, and ophtalmological examination. Pearson's Chi-Square test with Yates' correction and Fisher's exact test were conducted to assess the association between orthoptic defects and malocclusions ($p<0.05$).

Results. Ocular motility disorders were present in 44.9% of males and in 57.1% of females, while convergence defects were present in 10.2% of males and in 2.9% of females. Ocular motility disorders were more frequent in subjects with Angle Class III malocclusion (66.7%) than in subjects with Angle Class II (59.1%) and Class I (45.8%) malocclusion. Convergence defects were equally frequent in Angle Class I and Class II malocclusion (5.1%), while none subject presenting with Angle Class III malocclusion exhibited convergence defects. A statistically significant correlations was found between ocular motility disorders and unilateral cross-bite with midline deviation.

Conclusion. Ocular motility defects had a significant greater prevalence in subjects presenting with unilateral cross-bite and midline deviation. The importance of role of orthodontic diagnosis among interdisciplinary treatment in growing children should be recognized.

Key words: dental malocclusions, ocular motility defects, ocular convergence disorders.

Introduction

Anatomical systems are organized through a network of structural and functional relationships among their elements. This network of relationships generates the set of rules orienting and constraining the morphogenetic processes (1). Continuous afferent impulses from the eyes, labyrinths, muscles, and joints inform the individual about the position of the body (2). In particular, a strong relationship exists between the oculomotor and the trigeminal system. The oculomotor system comes from the occipital somites together with the tongue muscles and the suboccipital muscles. These structures are functionally bound and cooperate to manage head and neck position (3).

Head retraction or protrusion or chin elevation and chin depression may be noted in certain ocular significance. The findings indicate that vision plays an important and directly specific role in the control of postural reactions (4). Also occlusion affects posture through its influence on vision. Sharifi-Milani et al. (5) showed the relationship between dental occlusion and visual fo-

cusing on 30 subjects chosen from a sport club. The study consisted of examining the effects on posture and on visual convergence in subjects, who were divided into two groups: an experimental group who had worm mandibular orthopedic appliances in order to modify the masticatory behavior and a control group who had not worm any oral device. The alteration of dental occlusion after wearing occlusal splint induced some fluctuations in visual focusing, while the removal of oral devices caused a return to the pretreatment occlusal relationship and of initial focusing. This data suggest that human equilibrium is based on essential elements such as eyes, feet, spinal and sensorial receptors. Monaco et al. (6) investigated the link between mandibular deviation and the general muscle structure, particularly the muscles responsible for ocular motility. The occurrence of ocular convergence defects was assessed in 60 subjects with functional mandibular latero-deviation and in 60 healthy subjects in pediatric age. The Authors reported that ocular convergence defects occurred with a higher frequency in growing subjects with functional mandibular deviation. More recently, the same authors pointed out in children a significant association between myopia and Class II malocclusion (7), between hyperopia/strabismus and Class I malocclusion (8), and between astigmatismus and cross-bite (9).
To our knowledge, studies that relate dento-skeletal malocclusions to orthoptic defects (the alterations of the ocular convergence and motility) are scarce in literature. Therefore, the aim of the present study was to analyze the association between dental and ocular disorders in growing subjects.

Material and methods

The study was conducted at the University of Rome "Tor Vergata" on 101 consecutive Caucasian subjects (57 males; 44 females) with a mean age of 7.3 ± 1.7 years (range: 5-10 years) enrolled in a screening procedure for celiac disease (pediatric screening) between September 2014 and October 2015. This project was approved by the Ethical Committee of the University of Rome "Tor
Vergata" (N° 58/16) and informed consent was obtained from the parents of all subjects.
Each child underwent an orthodontic, orthoptic, and ophtalmological examination.
17 subjects, 8 males and 9 females, were excluded from the survey according to the following exclusion criteria: complex craniofacial malformations, syndromes, active orthodontic treatment and scarce collaboration. The remaining 84 subjects (49 males; 35 females) were included in the study. Orthodontic diagnosis was mainly performed on the basis of clinical examination and of dental casts. For each subject details of the molar and canine relationships, transversal relationships (presence/absence of bilateral cross-bite, or unilateral cross-bite with midline deviation), dental and facial midline, and oral habits were collected. The occlusal relationship was classified according to the Angle classification: Class I molar relationship (the mesiobuccal cusp of the permanent maxillary first molar occludes in the buccal groove of the permanent mandibular first molar), Class II molar relationship (the mesiobuccal cusp of the permanent maxillary first molar occludes mesial to the buccal groove of the permanent mandibular first molar) Class III molar relationship (the mesiobuccal cusp of the permanent maxillary first molar occludes distal to the buccal groove of the permanent mandibular first molar) (10). Posterior cross-bite was recorded when at least one maxillary molar occluded palatally to the opposing mandibular molar (11). Furthermore, coincidence of dental midlines with the facial midline as well as the presence of oral habits were recorded (12, 13). None of the subjects received any orthodontic treatment.
The 84 subjects selected for the study were then examined at the Department of Orthoptic at the same University. The recorded orthoptic data included the corneal reflex, Cover test, ocular motility exam, and convergence test. The evaluation of the ocular motility function (MOE) was

performed asking the patient to fix an object in 9 gaze positions assessing the normality, the deficiency or excess of eye movements, as well as the presence of nystagmus. The Cover test was conducted by covering and uncovering in turn each eye while the patient fixated on a small object. The purpose of the test was to determine any re-fixation movement in the uncovered eye. Each eye was considered as a single entity and any axial defects (heterophoria) were detected by the presence of re-fixation movements in the uncovered eye (dissociation of the right and left eyes). The ophthalmologist quantified the degree of phoria by passing a test card featuring increasing prism diopter values before the eyes until the re-fixation movement disappeared. The Ocular Convergence test was performed to determine the degree of tonic (dynamic), fusional and accommodative convergence. The test evaluated the distance of the convergence near point. This test used a luminous stick, which is slowly approximated, on both eye's plane, until the base of the nose. In normal subjects the convergence of both eyes could be harmonious, symmetric and simultaneous until this point. A convergence between 3-4 cm has been considered as normal, between 5-7 cm as sufficient and up 7 as insufficient (6).

All records were examined by the same expert clinician (ADL) who was blind to patient data and orthodontic condition in order to eliminate inter-examiner differences and examiner bias.

Repeatability of the diagnosis was tested on 20 randomly selected subjects examined at least 2 weeks after the initial examination. Cohen's Kappa test coefficient was calculated to determine the reliability of determining each dental anomaly in the 2 evaluation periods. An analysis of the sex influence on the prevalence of ocular motility and convergence disorders was performed. Then, an analysis of the prevalence of the orthoptic defects into the sagittal and transversal malocclusions was conducted. Since the sagittal Class of malocclusion included 3 subclasses (I/II/III Angle Class) an analysis of the prevalence of orthoptic defects into the sagittal malocclusion group was conducted, too. Pearson's Chi-Square test with Yates' correction and Fisher's exact test were conducted to assess the association between dento-skeletal malocclusion and orthoptic defects. Statistical analysis was performed with SPSS software (version 11.0, SPSS, Chicago, III). The statistically significant level of $p < 0.05$ was set.

Results

A Kappa score of 0.89, which indicated a high level of agreement between the first and second evaluation, was recorded for orthodontic evaluation.

Ocular motility disorders were present in 44.9% of males and in 57.1% of females, while convergence defects were present in 10.2% of males and in 2.9% of females; no significant differences were detected according to the sex of subjects (Table 1). Ocular motility disorders were more frequent in subjects with Angle Class III malocclusion (66.7%) than in subjects with Angle Class II (59.1%) and Class I (45.8%) malocclusion. Convergence defects were equally frequent in Angle Class I and Class II malocclusion (5.1%); none subject in Angle Class III malocclusion exhibited convergence defect. The occurrence of ocular motility and convergence defects in sagittal Classes of malocclusion was not

Table 1 - Orthoptic defects distribution by sex.

Defect	Males (49)		Females (35)		Total (n=84)		x^2 test p value
Ocular motility	22	44.9%	20	57.1%	42	50%	NS
Convergence	5	10.2%	1	2.9%	6	7.1%	NS

Table 2 - Orthoptic defects distribution by sagittal skeletal classes of malocclusion.

Defect	Angle Class I (59)		Angle Class II (22)		Angle Class III (3)		x^2 test p value
Ocular motility	27	45.8%	13	59.1%	2	66.7%	NS
Convergence	3	5.1%	3	5.1%	0	0%	NS

Table 3 - Orthoptic defects distribution by transversal skeletal malocclusions.

Defect	Bilateral cross-bite (17)		Unilateral cross-bite and midline deviation (13)		x^2 test p value
Ocular motility	11	64.7%	11	84.6%	Significant only midline deviation
Convergence	1	5.9%	2	1.5%	NS

statistically significant (Table 2). With regard to the distribution of orthoptic defects in subjects with bilateral cross-bite and unilateral cross-bite associated to midline deviation no significant differences were found for prevalence of convergence defects. A statistically significant correlation was found between ocular motility disorders and unilateral cross-bite with midline deviation (Table 3).

Discussion

The aim of the present study was to analyze the possibility of significant association between different dental malocclusions and ocular disorders in a sample of growing subjects.

As the examined subjects had been referred to an orthodontic department the prevalence rates of dental anomalies does not indicate the absolute prevalence rates of these dental malocclusions in the general population. One study (14) has revealed the association between malocclusions, wrong posture and ocular convergence disorders. The Authors pointed out that only malocclusions on vertical plane (deep or open bite) were prevalent to other occlusal defects showing a different distribution of the dominant eyes in the open, deep and normal bite children (14).

There are many known correlations between musculature controlling eye movements and the stomatognatic system (14). Several studies (4, 5, 15) have shown the relationships of dental occlusion, the oculomotor system and visual stabilization. Gangloff et al. (15) reported that alterations of the manducatory system could induce a perturbation of the visual stabilization and generate postural imbalance. Lin and White (4) revealed that associations exist between temporomandibular disorders and oculomotor function suggesting a higher prevalence of ocular convergence defects in adults with myofascial pain, limited maximal opening, and pain in the neck and shoulder area. With regard to the correlations between dental occlusion and the muscles responsible for ocular motility, Sharifi-Milani et al. (5) showed that occlusion plays a fundamental role in posture through its influence on vision, which is one of the key elements of equilibrium and posture. The Authors noted that some adults with occlusal disharmony modified their visual focusing at the end of treatment with occlusal splint. Also Monaco et al. (6) investigated the link between mandibular deviation and the general muscle structure, particularly the muscles responsible for ocular motility. The Authors noted that in mandibular latero-deviation subjects ocular convergence defects occurred in greater frequency and so they underlined how the eyes influence on the head, neck and shoulders posture can be associated with the occlusion

modification.
Some Authors (3, 7-9) after studying the prevalence of visual defects, as myopia, astigmatism and hyperopia, in sagittal and transversal malocclusions assessed that the association between visual defects and dental malocclusions could be the result of some global developmental delay or a visual defect could affect the growth of skeletal and dental structures by altering the postural system.
However, studies that relate dental malocclusions, midline deviation, and eye motility and convergence disorders in growing subjects are limited in literature. The sagittal and transverse dental relationships did not demonstrated significant association with any specific test for the ocular convergence. The only significant association was found between the unilateral cross-bite with the midline deviation and ocular motility. Unilateral posterior cross-bite is usually accompanied by a lateral functional shift of the mandible in a transverse direction with the mandibular dental midline deviated toward the cross-bite side relative to the maxillary midline (16). Recently, EMG studies (17) have shown that the activity of the temporal and masseter muscles in unilateral cross-bite patients is disturbed. During chewing the activity of the temporal muscle is asymmetric due to an adaptation to avoid cuspal interferences. Cross-bite is a morphological malocclusion, frequently associated to oral habits (18), that predispose to functional disturbances (17, 19) related to the asymmetric condylar displacement in the glenoid fossa with a consequent differential growth of the condyles (20). The altered muscular function of the masticatory system can induce some modification on the general muscle structure, particularly the muscles responsible for ocular motility, with a consequent defects in visual focusing (5).
In view of the significant correlations determined by the study between orthodontic and orthoptic findings in growing subjects, we recommend an interdisciplinary examination for patients presenting with cross-bite and midline deviation.

Conclusion

Ocular motility defects had a significantly greater prevalence in subjects exhibiting a midline deviation. The importance of role of orthodontic diagnosis among interdisciplinary treatment in growing children should be recognized. Further studies are needed to investigate the behavior of the orthopaedic-orthodontic approach for the correction of the midline deviation in pediatric subjects in eye motility disorders.

Authors' contribution

Patrizio Bollero, DDS, PhD, participated in the design of the study and drafted the manuscript.
Paola Cozza, MD, DDS, MS, conceived of the study, participated in its coordination.
Giulia Di Fusco, DDS, participated in the design of the study and performed the statistical analysis
Giuseppina Laganà, DDS, PhD, collected data and participated in the design of the study.
Roberta Lione, DDS, PhD, participated in the design of the study and coordination.
Maria Rosaria Ricchiuti, DDS, PhD, collected data, participated in the design of the study and drafted the manuscript.

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