Can the Treatment of Dental Malocclusions Affect the Posture in Children?

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Objective: *The aim of this study was to investigate whether the treatment of the dental malocclusions can affect the postural attitude in children.* ***Study design:*** *Sixty patients aged 9-12 years in mixed dentition were enrolled. The patients underwent an orthodontic evaluation for dental malocclusion and a postural examination by means of a vertical laser line (VLL) and a stabilometric–baropodometric platform. The children were treated with a functional appliance according to the type of malocclusion for two years. The position of the head and of the atlanto-occipital joint (C0-C1) respects to the VLL, the typologies of podalic support and the distribution of the body weight on the feet were evaluated before and after the orthodontic treatment.* ***Results:*** *A significant correction of the position of the head, with a physiological extension of C0-C1, a significant improvement of the typology of podalic support and a homogeneous distribution of the body weight on the feet were observed after the treatment of the malocclusions.* ***Conclusion;*** *From our results, the treatment of dental malocclusion can contribute to ameliorate the postural attitude in children.*

Keywords*: child; malocclusion; posture*

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INTRODUCTION

The human posture is defined as "the spatial relationship among the anatomical segments of the body, which maintain balance under dynamic and static conditions, according to the environment and to the motor goals" [1]. Many studies have investigated the various factors that can affect the body posture: mood states, anxiety, head and neck positions, the tongue, oral functions (respiration, swallowing), oculomotor and visual systems, and the inner ear [2-4].

The hypothesis of a correlation between the stomatognathic system and the body balance has been always a debated topic. Recently the scientific community recognized the existence of some correlation, through an official document i.e. the national guidelines in posturology [5].

Already in the 80s, Rocabado found that specific occlusal traits seem to influence the balance control [6]. A malposition of the jaw may induce an unbalancing on the whole body, since the jaw is functionally connected to the cranial structures and to those of the cervical district through the hyoid bone [7-8]. According to Sakaguchi [9], there is a mutual influence between the mandibular position and the body posture, for a change in mandibular position affects the body posture as well as a change in the body posture may affect the mandibular position. Many Authors demonstrated the beneficial effect of a correct dental occlusion on several muscles[10,11] . This is especially relevant in children, where the chance to achieve postural rebalancing during growth could allow greater stability over time. According to such studies, the repositioning of the tongue, favouring the functional restoration of swallowing and breathing, could promote a correct growth and development in paediatric patients [12].

 doi 10.17796/1053-4625-46.3.11

The attempts to determine the relationship between the stomatognetic system and the body posture have been not completely conclusive. Few studies tried to correlate dental malocclusion with postural disorders and most of them have been hampered by a series of limitations, such as the paucity of subjects, incomplete sample descriptions and a limited number of parameters and/or conditions tested.

Pérez-Belloso *et al* did not found a direct relationship between the stomatognathic system and the structures of the lower limb (hip, knee, and foot) even if a strong correlation between dental malocclusion and the position of the baricentre emerged[13] .

Similarly, Pernetti *et al* ran multiple regression models to evaluate associations between each malocclusion trait and posturographic parameters, denying the existence of any clinically relevant correlation [14].

Given the wide variety of malocclusions, this lack of correlations may be due to the impossibility of correlating a type of dental malocclusion to a postural attitude. Rather, investigating the changes in posture with respect to the correction of malocclusion over time could allow evaluating the influence of the dental occlusion on posture.

Therefore, due to the clinical impact that a correlation between dental malocclusion and the body posture may have, additional research about this topic can be justified. The aim of this study was to assess whether the treatment of the dental malocclusions could affect the postural attitude in children.

MATERIALS AND METHODS

Sample selection

This cohort study was carried out in a period of four-years, from 2014 to 2018. Sixty pediatric patients (29 females and 31 males) aged 9-12 years (mean age 10$\pm$0.6) and in mixed dentition were consecutively enrolled. The patients underwent an orthodontic evaluation for dental malocclusion and a postural examination. Eligibility criteria were: mixed dentition, presence of dental-skeletal malocclusion, signed consent to the orthodontic treatment (by parents or caregivers). Exclusion criteria were: scoliosis or any physical disease requiring physiotherapy exercises, history of macro trauma in the head region or in the vertebrae, chronic diseases and syndromes affecting the balance (i.e. vestibular dysfunction, ocular motility diseases, scoliosis, Down syndrome, Ehlers- Danlos syndrome…etc.), cleft lip and cleft palate, structural asymmetries.

Orthodontic evaluation

All the submitted cases for evaluation were carried out by the two clinicians who had previously undergone calibration to standardize their procedures. The assessment of dental occlusion was carried out after performing plastic models. Molar relationship was determined according to Angle's classification as class I, II or III [15].

Although not considered for the results of this study, one of the clinicians (MGG) calibrated, digitally traced, and collected the skeletal, dental, and soft tissue measurements using Ortho TP® for the cephalometric analysis as routinely done before starting the functional treatment.

Postural evaluation

Postural examination with the vertical laser line (VLL) and stabilo-baropodometric platform analysis (Biopostural System® Stabilo-baropodometric platform CE-0124) in static and dynamic posture were performed.

Vertical laser line (VLL)

All patients were positioned in a standardized position, standing relaxed, with their arms along the body in order to take the photographs with a digital camera for the postural analysis.

A vertical laser line (VLL) perpendicular to the floor and passing through the tragus of the ear was projected. The patients were evaluated in lateral view to perform two examinations.

a. Examination of the position of the head. A correct position of the head was considered with the VLL passing through the tragus of the ear, being the occipital plane parallel to the floor and the bi-pupillary plane parallel to the horizon. A forward position of the head was considered in case of the VLL posterior to the tragus while a backward position of the head in case of the VLL anterior to the tragus

b. Examination of the atlanto-occipital joint (C0-C1). The patients were asked to open the mouth at maximum. In physiological conditions, this movement is accompanied by a slight occipital extension of 6 degrees to allow the posterior rotation of the mandible, but the head does not move respect to the VLL [6] . The excess of extension was considered if the patients bended the head back and the excess of flexion if the patients beneded the head forward respect to the VLL[6] .

Stabilo-baropodometric platform

The stabilometric and baropodometric evaluation of static podalic support was instrumental (Biopstural System®- CE-0124). The patients were positioned on a carpet (350 cm x 100 cm) with graphic references for the positioning of the feet.

The system uses a platform of 40x40 cm (1600 strength sensors) with resistive technology for acquisition through high frequency. The platform shows the image of the real support surface for each foot, highlighting the different pressure areas with a colorimetric scale [16-18]. Two examinations were recorded.

a. Typology of foot. According to the weight distribution on forefoot, middle-foot and hindfoot, the typology of "normal" (i.e. 50% of the support on the heel, 13% on the first metatarsal and 37% on the fifth metatarsal), "cavus" (i.e. congenital or acquired malformation of the foot vault: the support area is limited to the heel and fifth metatarsus) or "flat" foot (i.e. congenital or acquired malformation of the foot vault, which presents a lower arch: the support area is larger than normal) is defined. The abnormalities can be more or less severe, according to the distribution of the pressure areas. An improvement in the distribution homogeneity is considered as "amelioration" while a complete correction is considered as "normalisation" of a flat or a cavus foot [19-20].

b. Distribution of body weight on the two feet. The distribution of body weight on the right foot and on the left foot, expressed as a percentage, was recorded. The ideal, substantially symmetric, weight distribution is of 50% ± 2 on each foot. Therefore 48% on a foot and 52% on the other one is the maximum physiological discrepancy in the absence of dysmetria of the lower limbs [21].

Treatment

The children were treated with a functional orthodontic appliance (Mouth Slow Balance, MSB, class I, II or III) according to the type of malocclusion.

The MSB device is suitable for the treatment of malocclusion in primary or mixed dentitions. It is an evolution of the Bionator, built on an individualized bite and obtained by means of a three-dimensional dynamic-functional squaring [22]. The construction bite, taken on the basis of a three-dimensional functional dynamic squaring, was described in a previous study [23] .

Statistical analysis

The collected data were arranged in data collection sheets and statistically processed using Minitab statistical software. The data were analysed using McNemar test for paired comparisons of pre- (T0) and post- (T1) treatment categorical results.

The Wilcoxon Two-Sample test was used as nonparametric test for paired data to compare the median of numerical variable podalic discrepancy, measured before and after treatment. A p value of <0.05 was considered statistically significant.

Ethical considerations

The study was planned and carried out in compliance with the Declaration of Helsinki and Good Clinical Practice. All patients and their caregivers were informed about the research and signed an IRB approved informed consent.

RESULTS

Sixty pediatric patients (29 females and 31 males) aged 9-12 years (mean age 10± 0.6) and in mixed dentition were consecutively enrolled from 2014 to 2018.

Out of 60 patients, 18 patients had dental class I with crowding, 30 patients dental class II and 12 patients dental class III. With respect to the VLL, 15 patients showed a correct position of the head, with the VLL passing through the tragus of the ear; 29 patients had a forward position of the head; 16 patients had a backward position of the head. The open mouth exam showed a correct position of the head with a physiological extension of 6 degrees of C0-C1 in 10 cases. An excess of extension of C0-C1 was recorded in 19 cases while a flexion of C0-C1 was found in 31 cases.

As for the typology of podalic support, in 9 cases out of 60 cases a correct support was found; a cavus foot was noted in 45 cases (31 bilaterally, 10 right foot and 4 left foot); a bilaterally flat foot was recorded in 6 cases. About 30% of patients (18/60) had a symmetric distribution of the weight on the two feet while 70% (42/60) showed an imbalance.

A MSB device was constructed for each patient, according to the dental malocclusion type. Patients were treated for about two years, with monthly examination. After the therapy, all patients were orthodontically and posturally re-evaluated.

After the treatment

The correction of the dental malocclusion (i.e. achievement of molar class I and correct dental alignment) was obtained in 51 out of 60 patients. As for the remaining patients, 3 dropped out the treatment because they did not wear the appliance and 6 patients obtained a correction of the malocclusion in the period following the one under consideration.

As regards the position of the head, after the treatment, 53 patients showed a modified position of the head respect to the VLL while 7 patients, already in a correct position, maintained it. Out of 53 patients, 23 patients reached the ideal position of the head (p<0.05), with the VLL passing through the tragus of the ear (Tab.1) (Fig. 1). Of the remaining patients, 19 patients still improved the position of the head without reaching the ideal position, while 10 patients, who at T0 had the head on the tragus (8) or backward (2), reached a forward position at T1 (Fig 2). These 10 patients actually performed a hyper-correction (Fig.3) and therefore a longer-term assessment, beyond two years, was necessary to assess the actual result at the end of growth.

Table 1: Position of the head at T0 and at T1. The correct position was reached in *n*=23 patients (*n*=12 + 11) (p <0.05)

		T1 = after treatment			
		n patients	correct (*n*)	forward (*n*)	backward (*n*)
T0=before treatment	*n* patients	60	30	26	4
	correct (*n*)	15	7	8	0
	forward (*n*)	29	12	16	1
	backward (*n*)	16	11	2	3

As regards the open mouth exam, a significant number of 32 patients reached a correct position of the head (p<0.05), with a physiological extension of 6 degrees (Table 2). However, with few exceptions of hypercorrection, all other patients improved their cervical posture, still remaining in excess of extension or flexion (Fig.4).

After the therapy, the assessment of the typology of podalic support and body weight distribution on foot surface with stabilometric-barododometric platform showed an impressive improvement. In 53 patients (88%) (p<0.05) a gain in the typology of podalic support was achieved; 17 of them reached a foot normalisation and 36 had a notable amelioration (Table 3) (Fig. 5-6).

As concerns the body weight distribution on the two feet, the number of patients presenting a physiological difference between the right and left foot significantly increased from 18 to 37 (from 30% to 62%) (p<0.05) (Table 4). In seven patients, a slight imbalanced condition evolved. On the other hand, all the 16 patients maintaining a foot discrepancy over to the physiological limit of 50 ± 2% still had an improvement towards the ideal weight distribution. In fact, comparing the medians of the podalic support discrepancies, a significant decrease in the values before and after the treatment was observed (3.5% *versus* 10.30%, p<0.05 according to Wilcoxon test).

Figure 1: Improvement of the head position, with the VLL passing through the tragus of the ear, in six patients (a-b-c-d-e-f) at T0 and T1.

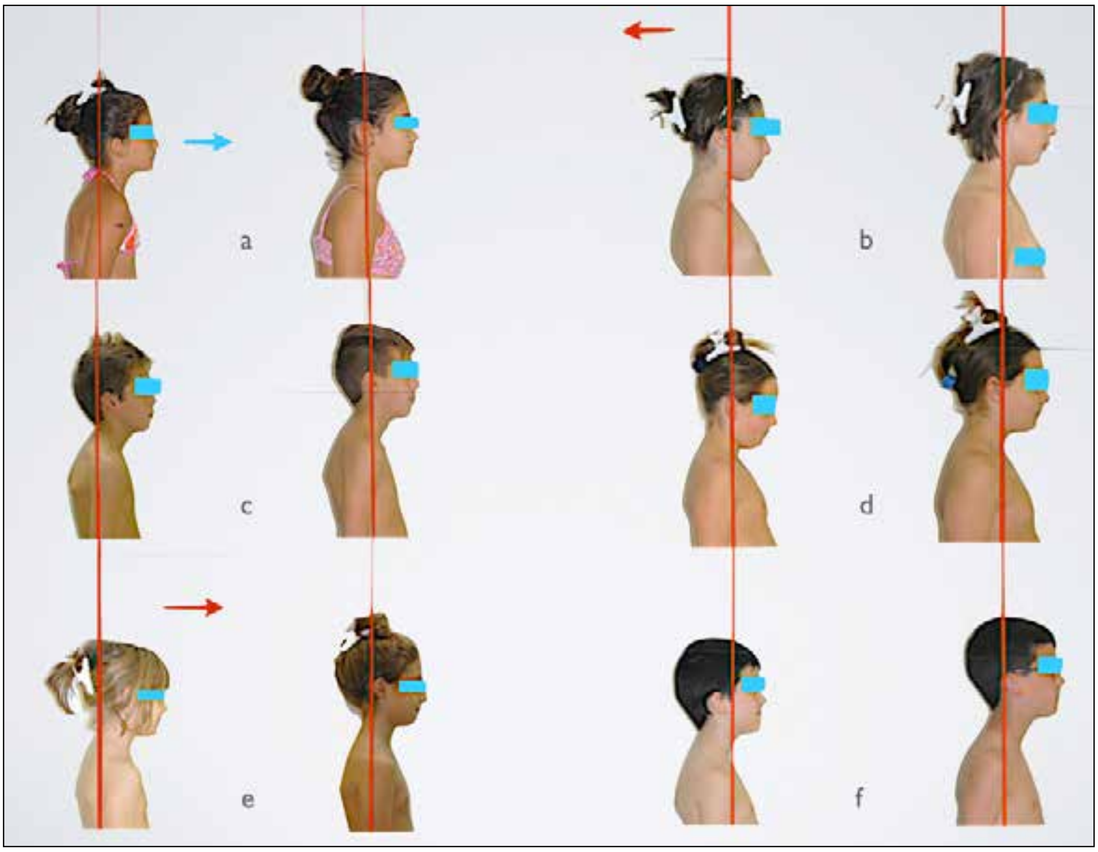


Figure 2: Hyper-correction of the head position in two patients (a-b). Both had a correct head position at T0 and showed a moderately forward head position at T1.

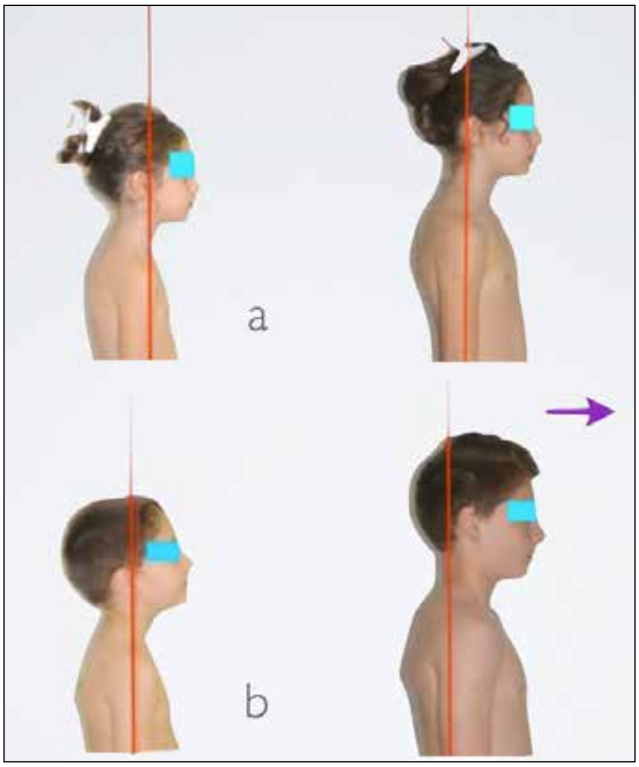


Table 2: C0-C1 extension at T0 and T1. Physiological extension of 6° was reached in *n*= 32 patients (*n* =12 + 20) who had extension or flexion at T0 (p <0.05).

		T1 = after treatment			
		***n* patients**	**correct (*n*)**	**extension (*n*)**	**flexion (*n*)**
T0=before treatment	*n* patients	**60**	**40**	**10**	**10**
	correct (*n*)	10	8	2	0
	extension (*n*)	19	12	7	0
	flexion (*n*)	31	20	1	10

Table 3: Typology of podalic support at T0 and T1

		T1 = after treatment			
		***n* patients**	**correct (*n*)**	**ameliora-tion (*n*)**	**no change (*n*)**
T0=before treatment	*n* patients	**60**	**17**	**36**	**7**
	bilateral normal (*n*)	9	1	6	2
	bilateral flat (*n*)	6	4	1	1
	left cavus (*n*)	4	2	2	0
	right cavus (*n*)	10	1	5	4
	bilateral cavus (*n*)	31	9	22	0

Figure 3: Temporary hyper-correction of the head position at T1 but correct head position at the end of the growth.

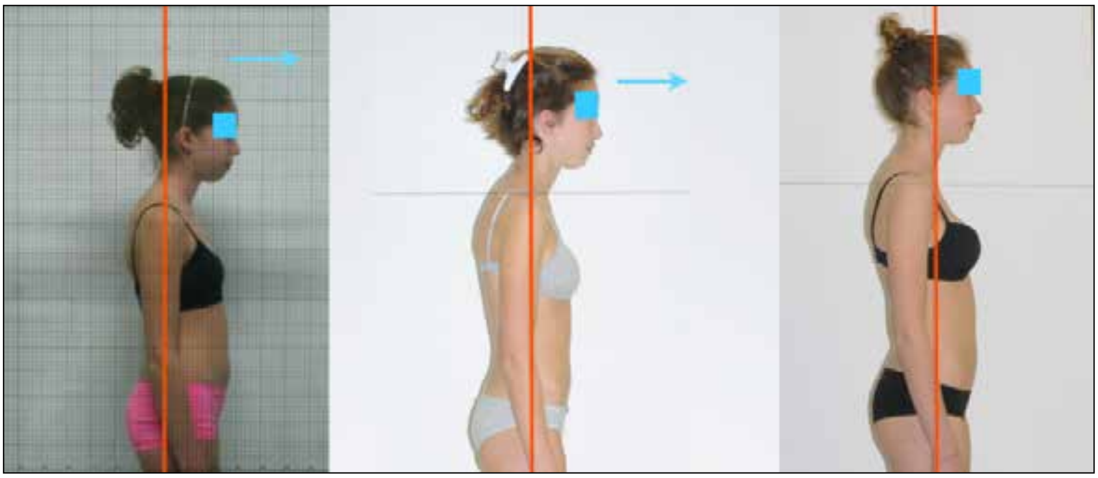


Figure 4: Improvement of the head position (evidenced with the "open mouth test") in six patients (a-b-c-d-e-f) at T0 and T1.

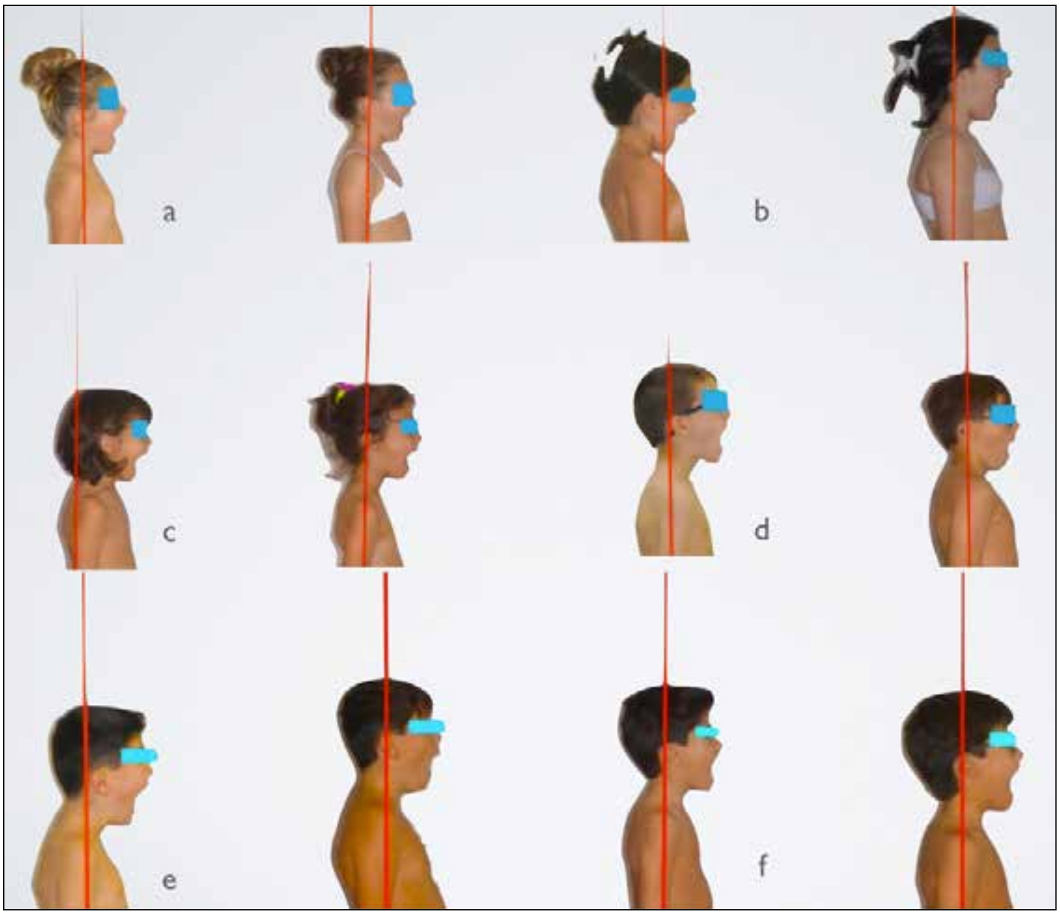


Table 4: Discrepancy of podalic support at T0 and T1. The number of patients with a correct discrepancy between the right and left foot significantly increased at T1 (from *n*=18 to *n*=37, p<0.05)

		T1 = after treatment		
		n patients	correct discrepancy (*n*)	discrepancy >2% (*n*)
T0=before treatment	*n* patients	**60**	**37**	**23**
	correct discrepancy (*n*)	18	11	7
	discrepancy >2% (*n*)	42	26	16

Figure 5: Normalization of the typology of podalic support: correction of a cavus foot (on the left) into a normal foot (on the right) after the therapy.

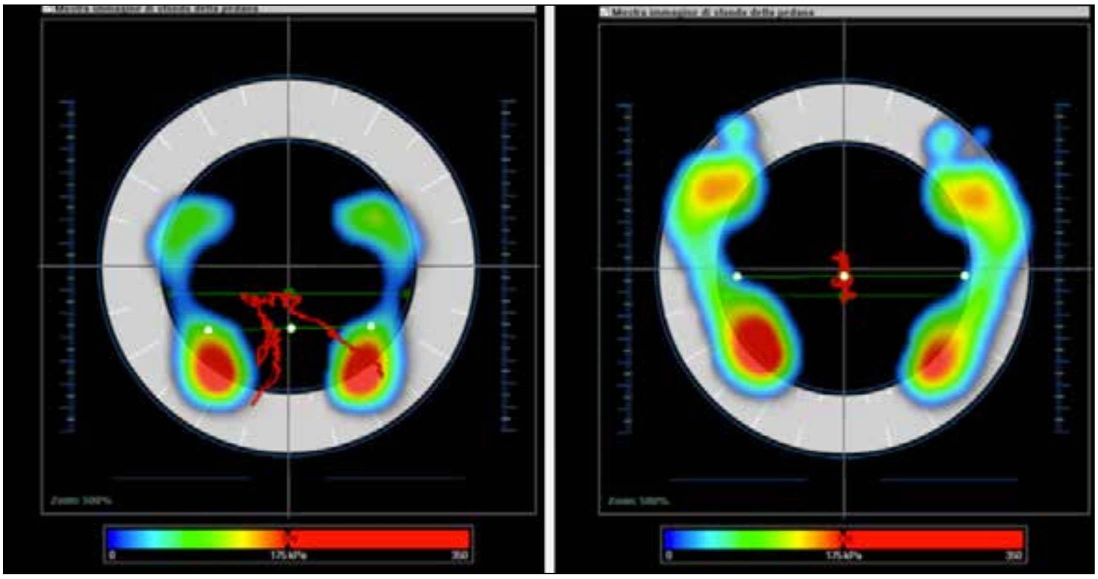
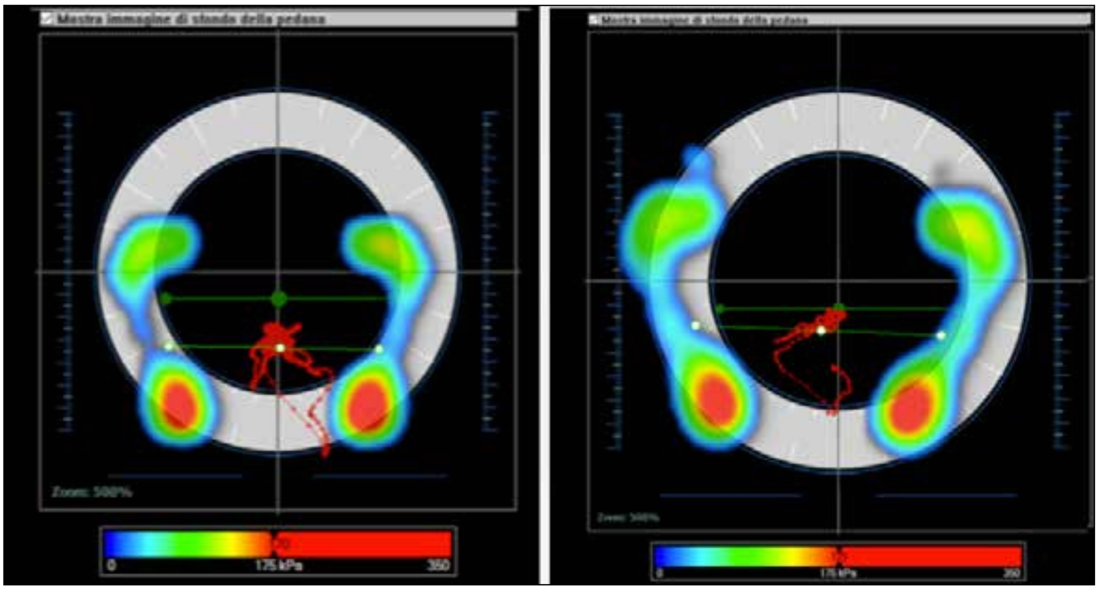


Figure 6: Amelioration of podalic support: change of a marked cavus foot (on the left) into a less severe cavus foot (on the right).



DISCUSSION

The correlation between dental occlusion and neuromuscular system has been a matter of medical interest for a long time [24-25]. The relation between mandibular and neck muscles led to intense researches, since early Davies' s studies[26], suggesting mutual influences. According to the main findings of a recent review [27], there is plausible correlation between the masticatory and cervical muscles. Evidences suggest strong interrelatedness of jaw, neck and trunk muscle activity [28]. Since the peripheral occlusal control of the elevator muscles seems to be provided by feedback from periodontal pressure receptors [29], a potential influence of dental occlusion on the mandibular elevator muscles may be assumed. Therefore, muscle interconnection between masticatory and neck muscles may explain why occlusal interferences altering the mandibular muscles pattern could also influence cervical chains, thus affecting postural control. The purpose of this study was to evaluate the postural changes, in terms of position of the head and podalic support, after the correction of malocclusions in children. According to our knowledge, this is one of the few study on such a large sample of patients in paediatric age.

In this research, a postural examination was firs performed, evaluating the position of the head and of the atlanto-occipital joint. According to our results, the correction of the dental malocclusion led to a statistically significant correction of the position of the head, with the VLL passing through the tragus of the ear. Since 70s, the body has been considered as an inverted pendulum [30]. Recent studies [31-32] confirmed that balance strategies are generally bimodal between the head and trunk, as between trunk and the pelvis, thus the position of the head influences in a descending way the whole body.

Our patients underwent also to the open mouth test to evaluate the movement of the atlanto-occipital joint. The atlanto-occipital joint is dissimilar from the functional units of the lower cervical spine. The right and left atlanto-occipital joints together form an ellipsoidal joint that allows the movement of flexion and extension [33]. The center of gravity of the head lies anterior to the atlanto-occipital joint. In normal cervical posture, the momentum arm of the extensor muscles is about double the momentum arm of the head's weight Thus the extensor muscles use approximately half the weight of the head to support normal head posture. If the head is positioned forward, extensor muscles reduces and weight increases. In this head-forward posture, the extensor muscles have to use much more force to balance the head [34]. The unbalance of the position of the head may influence the lower muscular chains and the whole body posture. Huggare *et al* [35] reported a positive effect of the orthodontic treatment on the lordosis of the cervical spine in 16 adults. In the present study, after the functional orthodontic treatment, a significant number of patients reached a correct position of C0-C1, with a physiological extension of the atlanto-occipital joint of 6 degrees with open mouth [6] . As concerns the examination of the podalic support, this research was carried out using the baropodometric analysis. The baropodometric analysis has already been employed by Rosario *et al* [20], and also by other authors in order to investigate the association between dental occlusion and the plantar arch [16] or the correlation between the spinal coronal balance parameters and the baropodometric parameters [17-18]. In the present study, we used the baropodometric analysis in order to determine the podalic support typology (normal, cavus and flat) and to study the weight-bearing distribution on the feet. After the treatment, the number of patients who reached a foot typology normalisation and who had a correct weight-bearing distribution significantly increased ($p<0.05$).

A major limitation to our analysis could be the failure to consider the effects of natural change in growing children. This bias is difficult to exclude given that for ethical reasons it was not possible to form a control group of patients with malocclusion who would not be treated. However, as we did not enroll patients who had scoliosis or any type of diseases requiring physiotherapy, we reasonably find hard to consider as spontaneous the correction of the position of the head. Another possible limitation to our study is the absence of the cephalometric analysis after the treatment. Cephalometry was performed before treatment, as routinely, but none after the treatment. Such a study, obviously, would provide additional information, even though the aim of this study was to observe the correlation between posture and dental -not skeletal- malocclusions.

The correlation between occlusion and posture has long interested a significant number of practitioners. However, some confusion surrounds this topic due to the wide variety of methodology and therapeutic approaches proposed to address it. Taking for granted that the posture is not a cause-and-effect system but rather a complex system, our study would confirm that the correction of the malocclusions contributes to the balance of the posture, supporting the theory that all the systems involved in the posture (muscular skeletal, oculomotor, otovestibular and cranio- mandibular) are essential to maintain balance [33-35]. In view of this, a functional approach to malocclusion could be recommended in order to rebalance functions like breathing and swallowing, besides the muscular tone. Further studies and a longer observational period are needed to eliminate any bias and to investigate the interrelation between occlusion and posture, especially in children.

CONCLUSIONS

This study supports the hypothesis that a correct dental occlusion contributes to rebalancing the body posture, especially of the head, favoring a physiological extension of the cervical tract. Based on our results, a correct occlusion positively affects the podalic support and allows a homogeneous distribution of the body weight on both feet.

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