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Head posture and malocclusions

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SUMMARY The present study aimed to examine whether any pattern of associations could be found between the posture of the head and neck, and the occurrence of malocclusions. The sample comprised 96 children (45 M, 51 F) aged 7–13 years, sequentially admitted for orthodontic treatment of severe malocclusions. Malocclusions were diagnosed clinically and classified into occlusal, spacing, and dentitional anomalies and their subdivisions. Craniovertical, craniocervical, and cervicohorizontal postural variables were recorded from lateral cephalometric radiographs taken with the subject standing with the head in the natural head position (mirror position).

A clear pattern of associations between crowding and craniocervical posture was found. Subjects with anterior crowding, i.e. more than 2 mm lack of space in the upper or lower anterior segments of the dental arch, had craniocervical angles that were on average 3–5 degrees larger than subjects without crowding ($P < 0.05$, $P < 0.01$). The findings were in agreement with the soft tissue stretching hypothesis, according to which the sagittal development of the dentoalveolar arches is impeded by the increased dorsally-directed soft tissue pressure in subjects with extended craniocervical posture.

Introduction

It has been demonstrated earlier that the craniocervical posture, unlike craniovertical posture, is related to skeletal development of the face. In extended craniocervical posture increased anterior facial height, reduced sagittal jaw dimensions, and a steeper inclination of the mandible are generally observed, whereas when the head is flexed in relation to the cervical column there is, on average, a shorter anterior facial height, larger sagittal jaw dimensions and a less steep inclination of the mandible (Solow and Tallgren, 1976). It has likewise been demonstrated that growth changes in craniocervical posture are related to corresponding changes in the growth pattern of the facial skeleton (Solow and Siersbæk-Nielsen, 1986), and that in individuals with a large or a small craniocervical angle the subsequent facial development can, to some extent, be predicted (Solow and Siersbæk-Nielsen, 1992). In view of these associations the relationship between craniocervical angulation and the occurrence of malocclusions is of particular interest, but little information is available on the subject. An association between head posture and the development of malocclusions was proposed by Schwartz (1926), who observed, in children with upper airway obstruction, a sleep position with an extremely extended head posture. He suggested that this posture might be one reason for the development of Angle Class II malocclusions. An association between Class II occlusion and forward head posture, which presumably can be defined as a forward cervical inclination combined with an extended craniocervical angle, was described by Rocabado *et al.* (1982) as 'the strongest evidence they had been able to observe in the relationship between head posture and malocclusion'. Huggare and Harkness (1993), on the other hand, from a study of head posture in 13 Class II and 17 Class I children concluded that distal occlusion and increased overjet were associated with a flexed head posture and a backward bend of the spine.

In order to further clarify this relationship it was the aim of the present investigation to

Table 1 Clinical classification of malocclusion[1].

Sagittal molar occlusion	distal occlusion ≥ 1/2 cusp (unilateral, bilateral) (Angle Class II)
	mesial occlusion ≥ 1/2 cusp (unilateral, bilateral) (Angle Class III)
Sagittal incisal occlusion	extreme maxillary overjet ≥ 6 mm
	anterior crossbite (1–3 lower incisors)
	mandibular overjet ≥ 0 mm (all lower incisors)
Vertical incisal occlusion	deep bite ≥ 5 mm
	open bite ≥ 0 mm
Transversal molar occlusion	posterior crossbite ≥ 1 cusp (unilateral, bilateral)
	scissors bite ≥ 1 cusp (unilateral, bilateral)
Transversal incisal occlusion	midline displacement: ≥ 2 mm
Space anomalies	crowding ≥ 2 mm, (anterior/R/L segment, upper/lower arch)
	spacing ≥ 2 mm, (anterior/R/L segment, upper/lower arch)
Anomalies of tooth formation	absent teeth
	peg-shaped incisors

[1]Modified from Björk *et al.* (1964).

examine whether any pattern of associations could be found between the posture of the head and neck and the occurrence of the various traits of malocclusions in a group of children selected for orthodontic treatment.

Subjects

The present investigation was based on data obtained from a study of the relationships between dentofacial morphology, and symptoms and signs of TMD (Sonnesen, 1997; Sonnesen *et al.*, 1998). The sample comprised 96 Caucasian children (45 M, 51 F) aged 7–13 years, sequentially admitted for orthodontic treatment at three North Zealand (Denmark) Municipal Dental Health Services. The children had been selected for orthodontic treatment by the Danish procedure for screening the child population for severe malocclusions entailing health risks (Danish Ministry of Health, 1990; Solow, 1995). No subjects had craniofacial anomalies, systemic muscle or joint disorders or symptoms of upper airway obstruction.

Methods

Malocclusions, classified according to Björk *et al.* (1964), were diagnosed during the intra-oral examination and recorded by the orthodontist responsible for the screening at each clinic (Table 1). Cephalometric radiographs were taken with the subject standing in the orthoposition with the head in the natural head position (mirror position) and with the teeth in occlusion (Solow and Tallgren, 1971). In all three orthodontic clinics, the radiographs were taken with the same type of radiographic equipment, a Dana Cephalix cephalometer that is vertically adjustable to record standing subjects. For the present study, nine digitized reference points (Figure 1) were

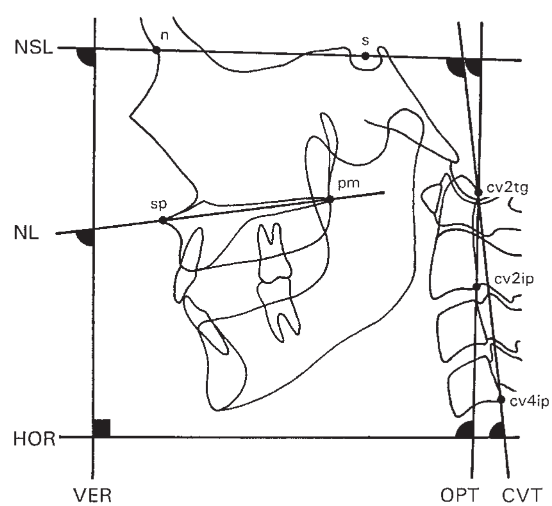

Figure 1 Reference points and lines on the cephalometric films. NSL: nasion–sella line. NL: nasal line through sp and pm. OPT: odontoid process tangent through cv2ip and cv2tg. CVT: cervical vertebra tangent through cv4ip and cv2tg. VER and HOR: true vertical and horizontal lines.

used for calculation of nine postural angles representing the craniovertical, craniocervical and cervicohorizontal postural relationships and the curvature of the cervical column (Table 2). In order to introduce redundancy in the descriptions, four reference lines were used, two to represent the head (NSL, NL), and two the upper cervical column (OPT, CVT).

Associations between malocclusion traits and postural variables were expressed in terms of Spearman rank order correlation coefficients. Since the sample comprised boys and girls of different ages, each correlation significant at the $P < 0.05$ level was further tested for the possible effect of gender and age by multiple logistic regression analyses with stepwise backward elimination (malocclusion trait = $\beta_1 \times$ postural variable + $\beta_2 \times$ gender + $\beta_3 \times$ age + intercept). The associations between malocclusion traits and postural variables were also visualized by calculation of the average postural differences between subjects with and without each category of malocclusion listed. The statistical significance of the average differences was tested with unpaired *t*-tests.

For assessment of the reliability of the measurements, 26 films were randomly chosen from the recorded series. The reference points were removed, and were subsequently marked and digitized again, the variables were recalculated and the differences between the two series were analysed. No significant mean differences were found. The method error (Dahlberg, 1940) ranged from 0.27 to 0.64 degrees, and the coefficients of reliability (Houston, 1983) from 0.97 to 1.00.

Table 2 Postural variables.

Variable	Mean	SD
Craniovertical		
NSL/VER	96.3	6.10
NL/VER	89.3	5.88
Craniocervical		
NSL/OPT	94.6	7.53
NSL/CVT	98.9	7.93
NL/OPT	87.7	7.64
NL/CVT	92.0	7.97
Cervicohorizontal		
OPT/HOR	91.6	7.60
CVT/HOR	87.4	7.28
Cervical curvature		
OPT/CVT	4.3	2.66

Sample size = 96.

Results

The categories of malocclusion traits recorded in the present study are listed in Table 1, and the descriptive statistics for the postural variables are given in Table 2.

Associations between malocclusions and head posture were analysed for those malocclusion traits and combinations of traits that occurred with prevalences larger than 5 per cent.

Anomalies of occlusion and of tooth formation showed only few associations with the nine postural angles (Table 3a,b). Bilateral distal molar occlusion (Angle Class II) showed significant low correlations with the craniocervical angles, and subjects with bilateral distal molar occlusion had craniocervical angles (NSL/OPT, NSL/CVT) that were 3–4 degrees smaller than subjects without these malocclusion traits ($P < 0.05$) and a cervical column that was 3 degrees more retroclined (CVT/HOR, $P < 0.05$). However, the multiple logistic regression analyses of these associations showed that they were all due to the effect of gender (Table 3a). Apart from these associations, only extreme overjet, deep bite and anterior crossbite showed a few scattered associations with the postural variables.

For space anomalies, on the other hand, a clear pattern of associations with head posture was found. The occurrence of crowding showed a set of low but significant correlations with the craniocervical angles (Table 4a, r = 0.20–0.31, $P < 0.05$, $P < 0.01$). Subjects with anterior crowding, i.e. more than 2 mm lack of space in the upper or lower anterior segments of the dental arch, had craniocervical angles that were on average 3–5 degrees larger than subjects without crowding (Table 4b, $P < 0.05$, $P < 0.01$). Anterior spacing occurred with a lower prevalence than crowding, and although the differences did not reach the $P < 0.05$ level of significance, these subjects showed a matching pattern of average craniocervical angles that were 2–6 degrees smaller than subjects without spacing.

Table 3 (a) Correlations between head posture and malocclusion: occlusal anomalies and anomalies of tooth formation.

	Postural variables								
	Craniovertical		**Craniocervical**				Cervicohorizontal		Cervical curvature
Malocclusion	NSL/ VER	NL/ VER	**NSL/ OPT**	**NSL/ CVT**	**NL/ OPT**	**NL/ CVT**	OPT/ HOR	CVT/ HOR	OPT/ CVT
Sagittal occlusal anomalies									
Distal molar occlusion (Angle Class II)									
unilateral	–	–	–	–	–	–	–	–	–
bilateral	–	–	**–0.24**[1]	**–0.24**[1]	**–0.23**[1]	**–0.21**[1]	0.21[1]	0.22[1]	
unilateral or bilateral	–	–	–	–	–	–	–	–	–
Extreme maxillary overjet	–	–	–	–	–	–	–	–	–0.23[2]
Anterior crossbite	–	0.25*	–	–	–	–	–	–	0.29**
Vertical occlusal anomalies									
Deep bite	–0.20*	–	**–0.23***	**–0.21***	–	–	–	–	–
Transversal occlusal anomalies									
Unilateral crossbite	–	–	–	–	–	–	–	–	–
Midline deviation	–	–	–	–	–	–	–	–	–
Anomalies of tooth formation									
Agenesis, peg-shaped incisors	–	–	–	–	–	–	–	–	–

Spearman correlation coefficients between the head posture variables and the categories of malocclusion listed. Malocclusion categories occurring with a prevalence less than 5 per cent have been deleted. Non-significant correlations have been deleted. Data for the craniocervical postural angles are shown in bold. Each significant correlation was tested for the effects of gender and age by stepwise multiple logistic regression analyses.
Sample size = 96. *$P < 0.05$; **$P < 0.01$; no significant effect of gender or age.
[1]$P < 0.05$; due to effect of gender. [2]$P < 0.05$; due to effects of posture and gender.

Discussion

The present study showed only few significant associations between sagittal, vertical or transversal anomalies of occlusion and the various categories of posture. Subjects with bilateral distal occlusion (Angle Class II) had smaller craniocervical angles and larger cervicohorizontal angles than subjects without this type of malocclusion. These associations were the opposite of those proposed by Schwartz (1926) and Rocabado *et al.* (1982), but were in agreement with those reported by Huggare and Harkness (1993). In view of the finding in the present study that these associations were due to the effect of gender, the different results reported in these studies might be due to dissimilarities in the composition of the samples.

For space anomalies, a clear pattern of associations was observed. The study demonstrated that in this group of children with severe malocclusions requiring treatment but without diagnosed obstruction of the upper airways, lack of space in the dental arches was associated with an increase in the craniocervical angulation.

The association between head posture and the space conditions in the dental arches has not been studied before, but the question of the aetiology of crowding, i.e. a lack of space for the teeth in the jaw bases, is a classic problem in orthodontics. Several hypotheses have been advanced in explanation, e.g. (1) a discrepancy between the size of the teeth and the size of the jaws, (2) absence of approximal wear resulting from the lack of abrasive particles in the modern diet (Begg, 1965; Helm and Prydsö, 1979),

Table 3 (b) Head posture and malocclusion: occlusal anomalies and anomalies of tooth formation.

Malocclusion traits and combinations of traits	N	Craniovertical NSL/VER	Craniovertical NL/VER	**Craniocervical NSL/OPT**	**Craniocervical NSL/CVT**	**Craniocervical NL/OPT**	**Craniocervical NL/CVT**	Cervicohorizontal OPT/HOR	Cervicohorizontal CVT/HOR	Cervical curvature OPT/CVT
		Mean differences in postural variables (degrees)								
Sagittal occlusal anomalies										
Distal molar occlusion (Angle Class II)										
unilateral	15	2.2	1.8	**2.4**	**3.2**	**2.0**	**2.8**	–0.2	–1.1	0.8
bilateral	54	–0.7	0.1	**–3.5***	**–3.6***	**–2.7**	**–2.9**	2.8	2.9*	–0.1
unilateral or bilateral	69	0.6	1.2	**–2.7**	**–2.3**	**–2.0**	**–1.6**	3.3	2.9	0.4
Extreme maxillary overjet	35	–0.4	0.8	**–1.8**	**–2.9**	**–0.6**	**–1.8**	1.4	2.6	–1.2*
Anterior crossbite	6	4.6	5.3	**–0.6**	**2.7**	**0.2**	**3.5**	5.1	1.8	3.3**
Vertical occlusal anomalies										
Deep bite	31	–2.7*	–1.7	**–3.7***	**–3.2**	**–2.7**	**–2.1**	1.0	0.4	0.5
Transversal occlusal anomalies										
Unilateral crossbite	20	–0.1	–0.9	**0.7**	**0.1**	**–0.2**	**–0.7**	–0.7	–0.2	–0.5
Midline deviation	13	1.8	1.0	**1.9**	**1.2**	**1.1**	**0.4**	–0.2	0.6	–0.8
Anomalies of tooth formation										
Agenesis, peg-shaped incisors	13	0.1	–0.7	**–1.0**	**–0.4**	**–1.7**	**–1.2**	1.0	0.5	0.6

The table presents mean differences in postural variables between subjects with and without the categories of malocclusion listed. Malocclusion traits occurring with a prevalence less than 5 per cent have been deleted. Data for the craniocervical postural angles are shown in bold. Total sample size = 96. *$P < 0.05$; **$P < 0.01$.

(3) the result of forces exerted on the dental arches by the tongue and the circumoral musculature (Weinstein *et al.*, 1963; Lear and Moorrees, 1969; Proffit, 1978), and (4) nasal mucosal swelling (Woodside *et al.*, 1991).

The findings of the present study thus introduce yet another factor which could affect the occurrence of crowding in the dental arches, namely the posture of the head in relation to the cervical column: the craniocervical posture.

In the present study, the association was evaluated with five measurements of the occurrence of crowding estimated at ≥2 mm in one segment and four measurements of the craniocervical posture. The analysis showed that 16 of the 20 Spearman correlation coefficients and 19 of the 20 mean differences were significant at the 5 or the 1 per cent level, and that none of the correlations were due to an effect of age or gender. Data for the craniocervical postural angles in the groups with and without 'Crowding, total' are listed in Table 5. On average, the children with crowding had a 3–5 degrees more extended craniocervical posture than children without crowding. On the basis of this documentation it seems reasonable to suggest that extension of the craniocervical posture could be a contributory factor in the development of crowding.

The explanation why an extended craniocervical posture is seen in children with crowding could well be the soft tissue stretching mechanism (Solow and Kreiborg, 1977) that describes the effect of extension of the craniocervical angle upon the development of the face. The hypothesis posits that an extension of the craniocervical posture leads to a passive stretching of the soft tissue layer comprising skin, muscles and fascia, that covers the head and neck. Stretching of this convex soft tissue layer creates a dorsally directed force, which impedes the forward-directed component of the normal growth of the face (Figure 2). Such a mechanism would explain the effect of extension of the craniocervical posture on the development of the facial skeleton and, in particular, of the mandible.

Table 4 (a) Correlations between head posture and malocclusion: space anomalies.

	Postural variables								
	Craniovertical		**Craniocervical**				Cervico-horizontal		Cervical curvature
Malocclusion	NSL/ VER	NL/ VER	**NSL/ OPT**	**NSL/ CVT**	**NL/ OPT**	**NL/ CVT**	OPT/ HOR	CVT/ HOR	OPT/ CVT
Crowding, anterior segments									
upper	–	–	**0.25***	**0.30****	**–**	**0.26***	–	–	–
lower	–	–	**–**	**0.27****	**0.20***	**0.26****	–	–	–
upper and lower	–	–	**–**	**0.28****	**–**	**0.25***	–	–	–
total (u or l)	–	–	**0.26***	**0.31****	**0.23***	**0.28****	–	–0.20[1]	–
Crowding, anterior or lateral segments									
total	–	–	**0.28****	**0.31****	**0.25***	**0.27****	–	0.24[1]	–
Spacing, anterior segments									
upper	–	–	–	–	–	–	–	–	–
lower	–	–	–	–	–	–	–	–	–
total (u or l)	–	–	–	–	–	–	–	–	–

Spearman correlation coefficients between the postural variables and the categories of malocclusion listed. Malocclusion categories occurring with a prevalence less than 5 per cent have been deleted. Non-significant correlations have been deleted. Data for the craniocervical postural angles are shown in bold. Each significant correlation was tested for the effects of gender and age by stepwise multiple logistic regression analyses.
Sample size = 96. *P < 0.05; **P < 0.01; no significant effect of gender or age.
[1]P < 0.05 due to effect of gender.

Table 4 (b) Head posture and malocclusion: space anomalies.

		Mean differences in postural variables (degrees)								
		Craniovertical		**Craniocervical**				Cervicohorizontal		Cervical curvature
Malocclusion	N	NSL/ VER	NL/ VER	**NSL/ OPT**	**NSL/ CVT**	**NL/ OPT**	**NL/ CVT**	OPT/ HOR	CVT/ HOR	OPT/ CVT
Crowding, anterior segments										
upper	49	2.1	1.5	**3.9****	**4.8****	**3.4***	**4.2****	–1.9	–2.7	0.9
lower	31	1.4	1.5	**3.2**	**4.3***	**3.3***	**4.4***	–1.8	–2.9	1.1
upper and lower	25	1.8	1.6	**3.4***	**4.7****	**3.2***	**4.5***	–1.7	–2.9	1.3*
total (u or l)	55	1.9	1.6	**4.2****	**5.0****	**4.8***	**4.7****	–2.1	–3.1*	0.8
Crowding, anterior or lateral segments										
total	57	1.3	1.1	**4.6****	**5.2****	**4.1****	**4.7****	–3.0*	–3.6*	0.6
Spacing, anterior segments										
upper	12	–1.6	–0.6	**–1.8**	**–2.5**	**–1.8**	**–2.5**	0.2	0.9	–0.7
lower	5	1.0	0.1	**–3.0**	**–4.3**	**–3.9**	**–6.2**	4.0	6.3	–2.3
total (u or l)	13	–1.5	–1.7	**–2.1**	**–2.9**	**–2.3**	**–3.1**	0.6	1.4	–0.8

The table presents mean differences in postural variables between subjects with and without the categories of malocclusion listed. Malocclusion traits occurring with a prevalence less than 5 per cent have been deleted. Data for the craniocervical postural angles are shown in bold. Sample size = 96. *P < 0.05; **P < 0.01.

Table 5 Craniocervical posture in children with and without 'crowding, total'.

Variable	Crowding	*n*	Mean	SD	Mean difference
NSL/OPT	Yes	57	96.5	7.49	4.6**
	No	39	91.9	6.81	
NSL/CVT	Yes	57	101.0	7.67	5.2**
	No	39	95.9	7.37	
NL/OPT	Yes	57	89.3	7.39	4.1**
	No	39	85.3	7.43	
NL/CVT	Yes	57	93.9	7.53	4.7**
	No	39	89.2	7.88	

**$P < 0.01$.

Figure 2 Proposed effect of soft tissue stretching on dentofacial development. Extension of the craniocervical angle leads to caudal traction (a) on the soft tissue cover of the facial skeleton. Due to the convexity of the face this results in dorsally directed forces (b) on the dentofacial structures. From Solow and Kreiborg (1977) with permission.

As one factor which might trigger an extension of the craniocervical posture, the hypothesis posits obstruction of the nasopharyngeal airways. This has subsequently been confirmed by the demonstration of an increase in craniocervical posture in children with adenoids (Solow and Greve, 1979; Woodside and Linder-Aronson, 1979), with enlarged tonsils (Behlfelt, 1990), and with nasal allergy (Wenzel *et al.*, 1985), as well as in patients with obstructive sleep apnoea (Solow *et al.*, 1996) and by experimental blockage of the nasal passage (Vig *et al.*, 1980). The demonstration of a reduced inclination of the maxillary incisors in children with upper airway obstruction due to adenoids (Linder-Aronson, 1970), and that the incisal inclination increases after adenoidectomy (Linder-Aronson *et al.*, 1993) can be taken as indirect evidence of the effect of this mechanism. Before adenoidectomy, such children have an extended craniocervical posture, and the reduced inclination of the incisors can be explained by the ensuing dorsally directed pressure from the soft tissue layer. After adenoidectomy the craniocervical angulation is reduced (Solow and Greve, 1979). This will reduce the dorsally directed pressure from the soft tissue layer, thus allowing the altered equilibrium between labial and lingual forces on the incisors to procline the incisors again. A demonstration of this mechanism was given in an experimental study by Hellsing and L'Estrange (1987), who showed that a 5-degree extension and flexion of the head resulted in a corresponding increase and decrease in the force exerted by the lips on the facial surfaces of the maxillary incisors.

The findings of the present study, as well as the associations between craniocervical angulation and craniofacial development in adults (Solow and Tallgren, 1976) and children (Solow and Siersbæk-Nielsen, 1986, 1992) with no symptoms of upper airway obstruction, suggest that the more marked and reversible dentofacial changes observed in subjects with nasal, nasopharyngeal, and oropharyngeal airway obstruction could be extreme borderline aspects of a general physiological mechanism through which sagittal dentofacial development is restrained by increased craniocervical angulation or released by reduction of the craniocervical angle. Such a mechanism would have clinical implications for the management of space problems in the dental arches and, in particular, for the decision to extract teeth in orthodontic treatment. In view of the importance of such consequences, further research is required to substantiate these hypothetical considerations and, if they can be confirmed, to establish borderline conditions for clinical decisions.

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