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Head posture and dentofacial morphology in subjects treated for scoliosis

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Head posture and dentofacial status of sixteen females and six males 12 to 34 years of age, who had been treated for scoliosis with a Boston-brace in their teens was investigated clinically and radiologically. When compared to an age and sex-matched sample the main findings were an increased craniocervical angle, particularly in frontal view; rotated orbital, maxillary and mandibular planes, a midline shift of the lower dental arch and a flattened atlas dorsal arch combined with an elongation of the dens axis. There was also a high prevalence of lateral malocclusions and developmentally missing premolars among the scoliotic patients. *Proc Finn Dent Soc 1991, 87: 151—8*

Key words: Asymmetry, dentofacial morphology, head posture, scoliosis

Scoliosis is a lateral deviation of the vertebral column, often discovered in childhood and progressing during growth. Mostly its etiology remains unknown though genetic transmission has been suggested. Sixty to eighty percent of the afflicted are girls. The treatment of scoliosis is either conservative by means of different kind of braces or in more severe cases by surgical correction of the spine (Vanden Brink and Edmonson 1980, Berkow 1982).

Extensive research has been published on the effects on the dentofacial complex of treatment of scoliosis by the use of the Milwaukee brace (Howard 1926, 1929, Bunch 1961, Logan 1962, Alexander 1966, v Stöckli 1967, Logan 1968, Duyzings 1969). However, only few studies have been published on the possible influence of the condition *per se* on the dentofacial complex.

Wachsman (1960) did not find any association between scoliosis and dental malocclusion whereas Müller-Wachendorff (1961) in 85 % of 194 scoliotic children reported some kind of malocclusion and also Mühlbach and Rink (1977) observed the prevalence of malocclusions in scoliotic children to exceed 80 %. Prager (1979) studied 63 subjects suffering from either scoliosis, morbus Scheuermann or other postural abnormalities of unspecified origin, and found an increased prevalence of dentoalveolar anomalies, particularly with regard to crossbites in these patients.

Foster (1965), Proffit et al. (1968) and Björk and Kuroda (1968) have presented case reports about severe malocclusions in patients with poor body position related to general muscular weakness.

A lateral deviation of the spine as seen in

Fig. 1. Patient treated for scoliosis with a Boston-brace.

scoliosis would presumably have an effect on head position. As the head position, particularly as studied in the frontal view, has been found to be intimately related to asymmetric dentofacial development (Pirttiniemi et al. 1989) our intention here was to study the head posture and dentofacial morphology of young adults treated for scoliosis.

Subjects and methods

Twenty-two subjects, 16 females and six males 12 to 34 years of age (mean age 17.8 years), all of whom had been treated for scoliosis at the Oulu University Central Hospital by use of a Boston brace (Fig. 1), participated in this study. Mean age at the start of treatment was 13.3 yrs and the mean treatment time 1.7 years. For this study the following examinations were made:

— clinical examination of dental occlusion
— alginate impressions for plaster casts
— roentgenograms (orthopantomograms, cephalograms in frontal- and lateral projections). The lateral- and frontal roentgenograms were made using natural head position technique described by Showfety et al. 1983 and Huggare (1985, 1989).

From the records of the scoliotic patients, the pre- and posttreatment angular deviations of the spine ("scoliosis angle") and the location of the apical vertebra (the most laterally displaced) were recorded.

An equal number of natural head position cephalograms of age and sex-matched subjects from a sample comprising healthy north Finnish children (Huggare 1987) and of subjects having had their orthodontic treatment at the Institute of Dentistry, University of Oulu were used as controls for the lateral cephalometric analysis. As frontal radiographs from these subjects were not taken, natural-head position frontal radiographs of an equally matched sample comprising 22 healthy school children and dental students were used as controls for the frontal analysis. The controls for dental occlusal analysis on plaster casts comprised age and sex-matched healthy schoolchildren and students without any history of orthodontic treatment.

The variables measured as indicative of head posture, morphology of the craniofacial and upper part of the cervical spine are presented in Figs. 2—5.

The statistical significance of any differences between the measurements in the scoliotic subjects and the controls was calculated by using t-tests for paired observations. In order to evaluate any possible association between the craniofacial measures, the scoli-

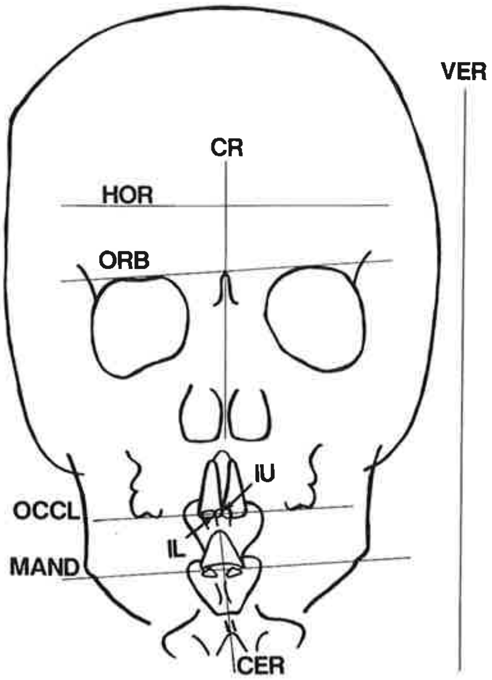


Fig. 2. Points and lines for analysis of the posteroanterior cephalogram.

VER = True vertical indicated by a plumb line;
CR = Cranial central line, drawn through the crista galli and anterior nasal spine;
HOR = Cranial horizontal line, the line perpendicular to the cranial central line;
CER = Cervical line, indicating the course of the cervical spine,
ORB = Orbital plane, tangent to the extreme cranial point on the supraorbital margins;
OCCL = Maxillary occlusal plane, tangent to the extreme inferior cusps of the molars of the maxilla;
MAND = Mandibular plane, a line drawn through the highest points in the antegonial notches of the mandible;
IU = Interincisal point of the maxilla, the contact point between the maxillary central incisors;
IL = Interincisal point of the mandible, the contact point between the mandibular central incisors.

osis angle and the location of the apical vertebra, Spearman correlation coefficients were calculated.

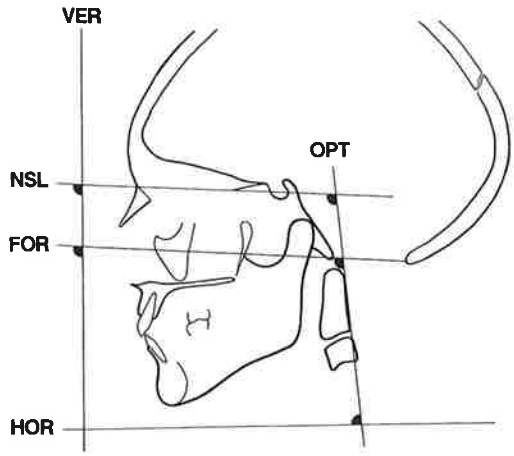


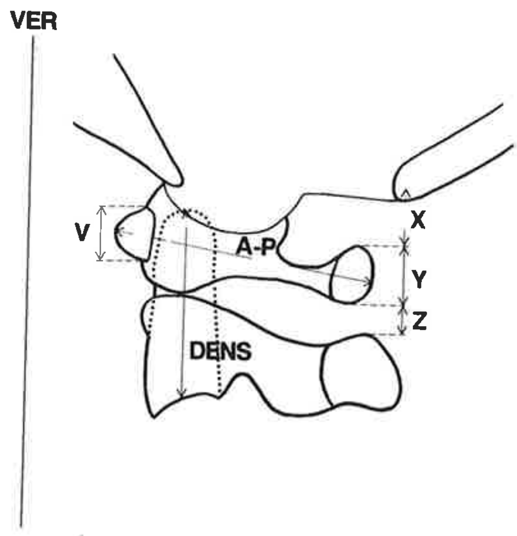
Fig. 3. Lines for head posture analysis on the lateral cephalogram.

VER = True vertical plumb line projected onto the film;
HOR = True horizontal, line perpendicular to the true vertical;
NSL = Nasion-sella line, line through nasion and sella;
FOR = Foraminal line, line through basion and opisthion;
OPT = Odontoid process tangent line, posterior tangent to the odontoid process.

Results

In the frontal position the head was, as an average, significantly more deviated in relation to the cervical spine (CR/CER) in the scoliotic patients than in the controls (Table 1). The head tilt was strongly associated ($p \leqslant 0.001$) with the lateral location of the apical vertebra. Seventeen subjects out of twenty with the apical vertebra on the right side of their vertebral column had a compensatory craniocervical deviation to the opposite side. Also in the lateral view a slightly increased craniocervical deviation (FOR/OPT) was recorded in the scoliotic patients (Table 2).

The mandibular, occlusal and orbital planes (MAND; OCCL; ORB) were more rotated with regard to the horizontal plane



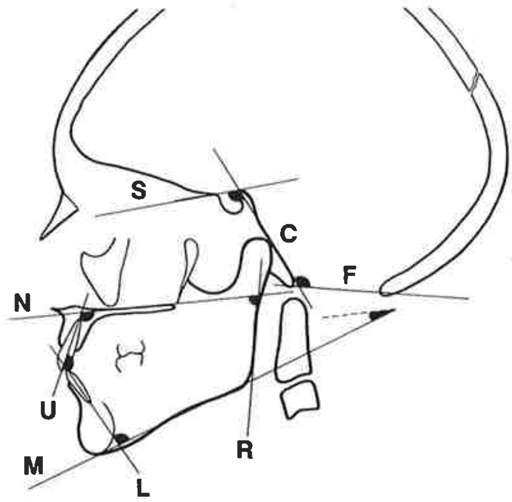


Fig. 4. Points and lines for analysis of cervicovertebral morphology.
A-P = Length of the atlas, distance between extreme anterior point on the anterior tubercle and extreme posterior point on the dorsal arch of atlas;
DENS = height of dens axis of the second cervical vertebra;
V = Height of the anterior tubercle of atlas;
X = Distance between opisthion and extreme superior point of the dorsal arch of the atlas (parallel to the true vertical);
Y = Height of the atlas dorsal arch, distance from the extreme superior to the extreme inferior point of the arch (paralell to the true vertical);
Z = Intervertebral space C_1—C_2, distance between extreme inferior point on the dorsal arch of atlas and extreme superior point on the processus spinosus of the second cervical vertebra (parallel to the true verical);
VER = True vertical plumb line projected onto the film.

Fig. 5. Lines used for analysis of dentofacial morphology.
C = Clivus plane, dorsal tangent to the clivus, excluding dorsum sellae;
F = Foraminal plane, line through basion and opisthion (same as FOR in Fig. 3);
L = Lower incisor axis, line through the apex and incisal edge of the most labial mandibular incisor;
M = Mandibular base plane, line through gnathion and gonion;
N = Nasal floor plane, main direction of the nasal floor;
R = Ramal plane, tangent to the dorsal surface of the ramus, excluding the condyle;
S = Sphenoidal plane, tangent to the planum sphenoidale;
U = Upper incisor axis, line through the apex and incisal edge of the most labial maxillary incisor.

(HOR) and the dental arch midline shift (IU; IL), particularly in the lower jaw, was more pronounced in the scoliotic patients than in the controls (Table 1). There was no correlation between these parameters either with the scoliosis angle or with the vertical or lateral location of the apical vertebra.

The angulation between the clival and sphenoidal planes (C/S) was steeper while a more obtuse angulation was found between the clival and foraminal planes (C/F) in the scoliosis group (Table 2).

The height of posterior arch of the first cervical vertebra (Y) was smaller while that of

TABLE 1. Means, standard deviations and significances of the differences between variables for frontal head position and craniofacial asymmetry in 22 subjects treated for scoliosis and their age and sex-matched controls

	Controls		Treated		Paired t-test
	$\bar{X}$	SD	$\bar{X}$	SD	p
CR/VER	2.1	1.56	2.3	1.45	0.254
CR/CER	2.7	1.55	4.9	2.65	0.004**
ORB/HOR	0.6	0.82	1.7	1.37	0.002**
OCCL/HOR	0.3	0.57	2.6	1.78	0.000***
MAND/HOR	0.7	0.70	2.9	2.03	0.000***
IU-CR (mm)	0.8	0.70	1.1	0.86	0.061
IL-CR (mm)	0.7	0.70	1.2	0.95	0.028*

* $p \lesssim 0.05$
** $p \lesssim 0.01$
*** $p \lesssim 0.001$

the dens axis (DENS) was larger than in controls (Table 2).

The scoliotic subjects had an increased prevalence of lateral malocclusions, a tendency for a narrow upper dental arch and a slightly decreased overbite. The prevalence

TABLE 2. Means, standard deviations and significance of differences between variables of lateral head position, cervicovertebral and dentofacial morphology in 22 subjects treated for scoliosis and their age and sex-matched controls

	Controls		Treated		Paired t-test
	$\bar{X}$	SD	$\bar{X}$	SD	p
Head posture variables (in degrees):					
NSL/VER	95.3	5.38	95.1	5.44	0.89
FOR/VER	90.1	6.68	92.3	7.80	0.35
NSL/OPT	91.1	7.56	94.0	8.47	0.23
FOR/OPT	85.5	8.53	91.2	8.66	0.06
OPT/HOR	94.5	9.06	90.5	6.76	0.12
Cervicovertebral variables (in mm):					
V	10.2	1.30	10.7	1.46	0.16
X	13.4	3.10	13.4	4.14	0.97
Y	9.2	1.97	8.1	1.72	0.03*
Z	6.0	3.27	5.0	2.85	0.34
A-P	47.7	2.30	48.6	2.75	0.14
DENS	34.5	2.00	35.7	2.76	0.03*
Dentofacial variables (in degrees):					
C/S	116.2	5.42	112.0	7.07	0.03*
C/F	122.0	4.60	124.9	4.47	0.05*
N/M	22.4	4.28	23.1	5.61	0.67
N/R	84.7	6.05	86.9	7.50	0.30
M/R	117.5	5.65	117.8	7.68	0.87
N/U	109.9	7.99	111.7	5.62	0.24
L/M	96.4	5.13	94.7	7.97	0.42
U/L	130.2	7.92	128.8	9.92	0.61

* $p \lesssim 0.05$

TABLE 3. Means, standard deviations and significances of differences between dental arch variables in 22 subjects treated for scoliosis and their age and sex-matched controls

	Controls		Treated		Paired t-test
	$\overline{X}$	SD	$\overline{X}$	SD	p
Upper arch width	34.3	2.98	33.0	1.93	0.09
Lower arch width	31.3	2.08	30.3	2.85	0.14
Overbite	3.6	1.91	2.6	1.93	0.10
Overjet	3.0	1.43	3.7	2.41	0.31

of those with one or more developmentally missing premolars was 26 % (Tables 3 and 4).

Discussion

The sex distribution (73 % females) of the present study sample corresponds well with that reported for scoliosis (60—80 %; Berkow 1982).

As the present subjects all had undergone their treatement for scoliosis by a brace type that does not interfear with dentofacial structures (Fig. 1), the results are probably related to the disorder *per se* and not mainly a sequel to its treatment.

Head posture, and its association with craniofacial aberrations, has been frequently studied in a lateral projection. In spite of the multitude of conditions with a deviant frontal head position, this has not yet been a focus for research. In one previous study, however, dealing with dentofacial characteristics in muscular torticollis patients, the same associations between head tilt and rotation of facial structures was seen (Pirttiniemi et al. 1989). The main dissimilarity here was the fairly unaffected frontal craniovertical angulation (CR/VER) in the scoliotic patients, indicating that in relation to the true vertical the head was not tilted sideways. On the other hand their craniocervical (CR/CER) angulation was far more abnormal than that in the torticollis patients. This is probably due to the difference in the factor causing the deviation of the head. In torticollis direct muscular contraction pulls the head sideways whereas in scoliosis lateral head movement to compensate for deviations occuring in the vertebral spine is unrestricted. Presumably the larger craniocervical (CR/CER) deviations in the scoliotic patients are an expression of this compensation.

We expected that a correlation between head posture variables and the vertical location of maximal bending of the spine would be found. That this was not the case could be attributed to the fact that, in this relatively small sample, the variation in the vertical location of the apical vertebra was very limited. However, there was a high correlation between the lateral position of the apical vertebra and the craniocervical angulation, indicating a compensatory change in the cervical spine inclination in order to maintain a stable head position with regard to the vertical.

TABLE 4. Prevalence of lateral malocclusions in 22 subjects treated for scoliosis and their age and sex-matched controls

	Controls	Scoliotic subjects
Treated or diagnosed scissors- or crossbite	4 (18.2 %)	12 (54.5 %)
Normal lateral occlusion	18 (81.8 %)	10 (45.5 %)

$X^2 = 4.812$, $p < 0.05$

In the lateral view there was also a slight tendency for an increased craniocervical angulation (FOR/OPT). This corresponds well with the findings of a flattened dorsal arch of the atlas and a slightly reduced overbite, as an association between head posture and the morphology of the atlas, and with a reported tendency for open bite associated with a low dorsal arch (Kylämarkula and Huggare 1985, Huggare 1991).

The decreased clival/sphenoidal angulation (C/S), which is a determinant of cranial base flexure, and the increased clival/foraminal angulation (C/F) in association with the slightly increased craniocervical angulation (FOR/OPT), is in line with the findings of Solow and Tallgren (1976), although their definition of the cranial base flexure was somewhat different.

The high prevalence of lateral malocclusions in the scoliotic patients is concordant with one of the main findings in a contemporary study of torticollis patients where a correlation between head tilt and prevalence of lateral malocclusions was found (Pirttiniemi et al. 1989).

We are not able to present an explanation either for the increase in the height of the dens axis in the scoliotic patients or for the fairly high percentage of developmentally missing premolars compared to data from a healthy Finnish population (Haavikko 1971). It opens up an interesting question, however, about a common role of neural crest disorder as a causative factor in both scoliosis (Geschwind and Galaburda 1985) and some forms of deficient development of the oral tissues including the teeth (Johnston and Listgarten 1972).

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