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The effect of violin playing on the bony facial structures in adolescents

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SUMMARY Holding a violin between shoulder and chin needs a special kind of muscle function. The purpose of this investigation was to determine whether this kind of muscular activity is a modifying factor for facial growth in adolescence.

The bony facial dimensions of 24 adolescent violin students attending colleges of music with a playing history of 5–11 years were measured from lateral and posteroanterior cephalograms and panoramic tomograms of the jaws. The dimensions were compared with those of sex- and age-matched controls.

Significant differences were found between violin players and controls. The players had higher faces, especially on the right side of the lower face and in the right mandibular ramus. The players also had more proclined upper and lower incisors than the controls.

It is concluded that the overall greater facial height in violinists reflects the increased face muscle activity and the higher bony dimensions of the right side of the face are due to the muscular activity produced on that side to balance the load caused by the violin on the left. The greater proclination of the incisors is the result of an altered balance of muscular activity between tongue and lip, and the pressure of the violin to the chin.

Introduction

Children playing wind instruments have been found to have a smaller anterior facial height and wider dental arches than controls in an investigation by Brattström *et al.* (1989). A modified pattern of orofacial muscle activity as one possible reason for these dentofacial morphological differences was discussed in the study. Brattström and co-workers (1991) also studied the dentofacial morphology of professional opera singers and found an increase in facial height, evidently caused by their facial muscle hyperactivity and respiratory hyperfunction. The bony facial structures of professional violin and viola players have recently been investigated (Kovero *et al.*, 1997). The players had smaller facial heights, more proclined maxillary incisors and greater mandibular lengths than their matched controls. This was considered to result from the orofacial muscle activity and pressure exerted on the chin when playing the violin.

The aim of the present study was to determine whether dentofacial morphological differences between violin players and their matched controls are already present in adolescence.

Subjects and methods

The subjects were 24 adolescent violin players (21 girls and 3 boys) from the Institutes of Music of Western and Eastern Helsinki. Their mean age was 13.6 years (range 11.4–18.2) and they had played on average for 7.5 years (range 5–11). At the time of the investigation they were playing an average of 8.8 hours a week (range 6–22 hours). All played right-handed, that is, held the instrument at the left.

The 24 controls were selected from schoolchildren receiving general dental or orthodontic treatment at the Institute of Dentistry, University of Helsinki. They were individually matched with the study group according to sex and age (±1.0 years). Orthodontic patients were selected as controls for the five violinists who had received, or were receiving, orthodontic treat-

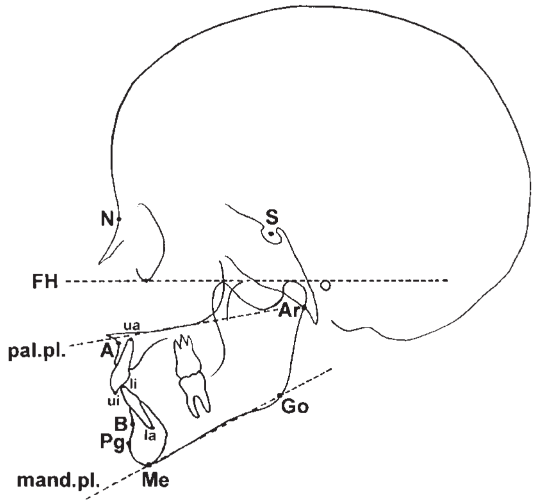

Figure 1 Reference points on the lateral cephalograms: sella (S), nasion (N), subspinale (A), submentale (B), pogonion (Pg), menton (Me), gonion (Go), articulare (Ar), maxillary incisor apex (ua), maxillary incisor incisal edge (ui), mandibular incisor incisal edge (li), mandibular incisor apex (la). Reference lines: Frankfort horizontal plane (FH), palatal plane (pal.pl.), mandibular plane (mand.pl.).

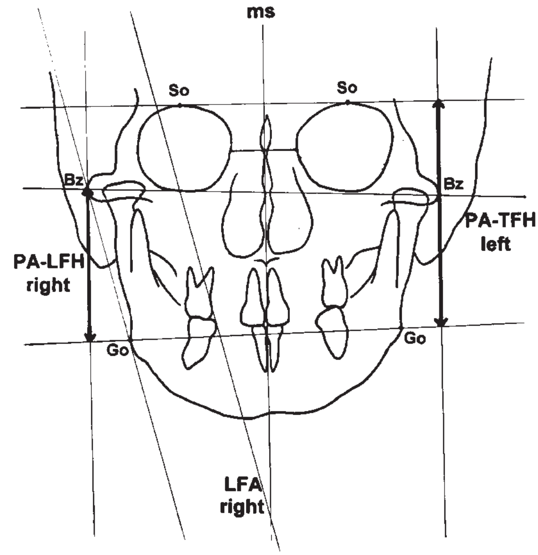

Figure 2 Reference points on PA cephalograms: supraorbitale (So), bizygomatic (Bz), gonion (Go). The So points were connected to the line So–So, the Bz points to the line Bz–Bz and gonions to the line Go–Go. The medial orbital margins were connected with a line parallel to So–So at the height of the base of the crista galli. From the midpoint of this line a line was drawn through the anterior nasal spine: this was the constructed median sagittal plane (ms). Through each Bz point a line was drawn parallel to the median sagittal plane. From these vertical lines the right and left total facial heights (PA-TFH) and right and left lower facial heights (PA-LFH) were measured. PA-TFH was determined as the distance between the line So–So and the line Go–Go, and PA-LFH as the distance between the line Bz–Bz and the line Go–Go. The lower face angle (LFA) was determined as the angle between the median sagittal plane and the line connecting the Bz and Go points on each side. The midlines of the dental arches were examined using the constructed median sagittal plane as reference. If the dental arch midline deviated from the ms, the deviation was measured and its sidedness registered.

ment. None of the violinists or controls had severe facial asymmetries or malocclusions such as scissors or cross-bite. None of the controls had played a violin.

The subjects were asked about the duration of their violin playing in years and about the number of weekly playing hours. Each subject and control underwent a radiographic examination comprising lateral and posteroanterior (PA) cephalograms and a panoramic tomogram of the jaws.

The lateral cephalograms were taken in a rigid cephalostat (Wehner 517) with a film–focus distance of 154 cm (140 cm from median sagittal plane to focus), the linear enlargement being 10 per cent for points situated in the median plane. Posteroanterior cephalograms were taken using a Bucky skull board, with the patient positioned with the Frankfort plane horizontal and the tip of the nose touching the vertically positioned skull board. The film–focus distance was 100 cm. The enlargement of the PA cephalogram varies for different frontal planes. In the present study it was 17–18 per cent at the plane of gonions, 13–14 per cent at the plane of Bz points and 8–9 per cent at the plane of So points, depending on the horizontal dimension of the nose. Panoramic tomograms were taken with a PM 2002 CC (Planmeca Oy, Helsinki, Finland). The enlargement in the ramus region was 20 per cent.

The cephalometric landmarks identified from the lateral cephalograms are presented in Figure 1, and the measurements made are listed in Table 1.

The cephalometric landmarks detected from the PA cephalograms, together with the measurement method, are presented in Figure 2. The midlines of the dental arches were examined from PA cephalograms using the constructed median sagittal plane (ms in Figure 2) as a

Table 1 Lateral cephalometric comparison of 24 adolescent violin players (VP) and their 24 matched controls (C). The linear measurements are presented without correction for enlargement (10 per cent).

Parameter	VP group (n = 24) mean ± SD range	C group (n = 24) mean ± SD range	Difference between groups (paired t-test) x	P
SNA(°)	81.96 ± 3.14 75.5 – 87.0	83.19 ± 2.98 78.5 – 89.0		
SNB (°)	78.63 ± 3.04 73.0 – 84.5	79.88 ± 2.63 76.0 – 87.0		
ANB (°)	3.33 ± 2.11 –1.0 – 8.0	3.31 ± 1.73 0.5 – 8.0		
SNPg (°)	79.67 ± 3.19 74.0 – 85.0	81.08 ± 2.65 78.0 – 88.5		
FH/NPg (°)	88.02 ± 2.56 82.0 – 93.0	88.92 ± 2.46 86.0 – 95.0		
SN/mand.pl (°)	31.08 ± 4.87 24.0 – 41.0	31.06 ± 4.07 24.0 – 38.5		
SN/pal.pl. (°)	7.48 ± 4.27 0.0 – 16.5	5.85 ± 3.78 0.0 – 12.5		
Pal.pl/mand.pl. (°)	23.60 ± 4.81 16.0 – 35.5	25.21 ± 5.09 15.5 – 37.5		
NSAr (°)	124.35 ± 5.79 117.0 – 137.5	122.73 ± 4.62 114.5 – 132.0		
SArGo (°)	142.10 ± 5.58 132.0 – 153.0	143.21 ± 6.03 134.5 – 155.5		
ArGoMe (°)	125.58 ± 5.24 118.0 – 136.0	126.33 ± 4.10 117.0 – 135.0		
Ar–Go (mm)	46.73 ± 4.58 38.0 – 54.5	45.10 ± 3.50 39.5 – 52.0		
Go–Me (mm)	74.44 ± 3.61 65.0 – 81.5	75.75 ± 3.14 71.0 – 83.0		
Max.inc./pal.pl.(°)	111.96 ± 6.73 100.0 – 121.0	107.71 ± 6.41 95.0 – 118.5	4.25	0.0278*
Mand.inc./m.p1. (°)	97.81 ± 6.06 82.0 – 108.0	93.25 ± 5.44 85.0 – 107.0	4.56	0.0039**
AFH (N–Me) (mm)	118.40 ± 7.80 101.0 – 132.5	117.15 ± 4.41 105.0 – 124.5		
LFH (Me–pal.pl.) (mm)	65.56 ± 5.95 52.5 – 77.0	65.56 ± 4.30 55.5 – 72.5		
PFH (S–Go) (mm)	78.67 ± 5.04 68.5 – 90.5	76.46 ± 4.33 68.5 – 85.5		

*P < 0.05
**P < 0.01.

reference. If the dental arch midline deviated from the median sagittal plane, the deviation was measured and was recorded as being towards the lower or higher of the PA-LFH side.

The vertical and gonial symmetry of the mandible was analysed from the panoramic tomogram of the jaws according to the method described by Mattila *et al.* (1995).

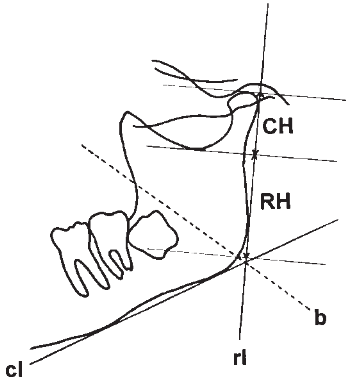

Figure 3 Lines used in measurements from panoramic tomograms (according to Mattila *et al.*, 1995): ramus line (rl), corpus line (cl), bisector of gonial angle (b). Three perpendiculars were drawn to the ramus line: through the condylion point, through the lowest point of the incisura mandibulae, and through the intersection of the outline of the angulus and the bisector of the gonial angle. These perpendiculars thus determined the condylar height (CH) and the ramal height (RH).

Figure 4 Posteroanterior cephalogram of a girl (age 14) who had been playing the violin for 9 years and was playing 8 hours a week at the time of the examination. Slight right-side dominance of the lower face is seen.

The reference points, lines and angles used are shown in Figure 3.

All measurements are presented without correction for enlargement.

The study was approved by the Ethical Board of the Institute of Dentistry, University of Helsinki.

Error of method

The error of the method included double determination of the cephalometric landmarks used in measurements from radiographs. This error was calculated using the formula:

$$S = \sqrt{\frac{\sum d^2}{2N}}$$

where d is the difference between two measurements and N is the number of double determinations. It was found, with one exception (FH/NPg 4 per cent), that the error of the method was less than 3 per cent of the total biological variance.

Results

The results of the radiographic measurements are shown in Tables 1, 2 and 3.

In the lateral cephalograms statistically significant differences between the groups were found only in the inclinations of the incisors: max. inc./pal. plane (mean difference 4.3 degrees) and mand. inc./mand. plane (4.6 degrees) (Table 1).

The PA cephalograms showed statistically significant differences in the right (mean difference 8.3 mm) and left (6.5 mm) PA-TFH and in the right PA-LFH (4.9 mm) (Table 2).

The panoramic tomograms revealed statistically significant differences between the groups in the right ramal height (mean difference 2.8 mm) and in the right gonial angle (–2.9 degrees) (Table 3).

An intra-individual comparison between the right and left sides revealed asymmetry in the violinists, with statistically significant differences in PA-LFH (1.9 mm) and in ramal height (1.1 mm) measured from the panoramic tomogram, the right side being larger with regard to these dimensions.

In the controls, statistically significant asymmetry was found in ramal height, the left side being 0.8 mm (mean) higher, and in the gonial angles, the right angle being 2.0 degrees greater (mean), both of these measured from the panoramic tomogram. Also in the controls, the dental midlines deviated from the constructed median sagittal plane more often towards the

Table 2 Posteroanterior (PA) cephalometric comparison of 24 adolescent violin players (VP) and their 24 matched controls (C). No correction made for enlargements.

Parameter	VP group (n = 24) mean ± SD range	C group (n = 24) mean ± SD range	Difference between groups (paired t-test) x	P
Right TFH (mm)	106.40 ± 7.41 94.0 – 119.5	98.10 ± 6.32 79.5 – 108.5	8.29	0.0001***
Left TFH (mm)	105.08 ± 6.35 94.0 – 117.0	98.56 ± 6.68 82.5 – 110.0	6.52	0.0001***
Right LFH (mm)	66.88 ± 5.56 49.0 – 76.5	62.00 ± 4.82 50.0 – 69.0	4.88	0.0015**
Left LFH (mm)	65.02 ± 4.27 55.0 – 76.0	63.19 ± 4.43 53.5 – 71.0		
Right LFA(°)	16.19 ± 3.03 12.5 – 24.0	15.58 ± 2.21 12.0 – 20.5		
Left LFA(°)	15.71 ± 2.57 12.5 – 22.5	15.60 ± 2.56 10.0 – 20.0		

**$P < 0.01$.
***$P < 0.001$.

Table 3 Comparison of vertical and gonial symmetry of the mandible in 24 adolescent violin players (VP) and their 24 matched controls (C) assessed from panoramic tomograms according to the method of Mattila *et al.* (1995).

Parameter	VP group (n = 24) mean ± SD range	C group (n = 24) mean ± SD range	Difference between groups (paired t-test) x	P
Right condylar height (mm)	22.73 ± 2.85 18.5 – 30.0	23.29 ± 3.14 17.0 – 32.5		
Left condylar height (rnm)	23.25 ± 2.67 19.5 – 28.0	23.38 ± 3.20 17.5 – 30.0		
Right ramal height (mm)	43.69 ± 4.29 35.0 – 50.0	40.94 ± 4.03 34.0 – 51.0	2.75	0.0099**
Left ramal height (mm)	42.58 ± 4.84 35.0 – 54.0	41.75 ± 4.10 35.0 – 50.5		
Right gonial angle (°)	122.38 ± 6.28 108.0 – 135.5	125.29 ± 5.39 115.0 – 137.0	–2.92	0.035*
Left gonial angle (°)	122.44 ± 7.20 107.5 – 137.0	123.27 ± 6.38 112.5 – 137.0		

*$P < 0.05$.
**$P < 0.01$.

side of the lower PA-LFH. No consistent trend towards lower PA-LFH was noted in the dental midline deviations from the median sagittal plane in the violinists.

Discussion

The present study of the dentofacial bony morphology of adolescent violin players revealed that the players had greater facial height

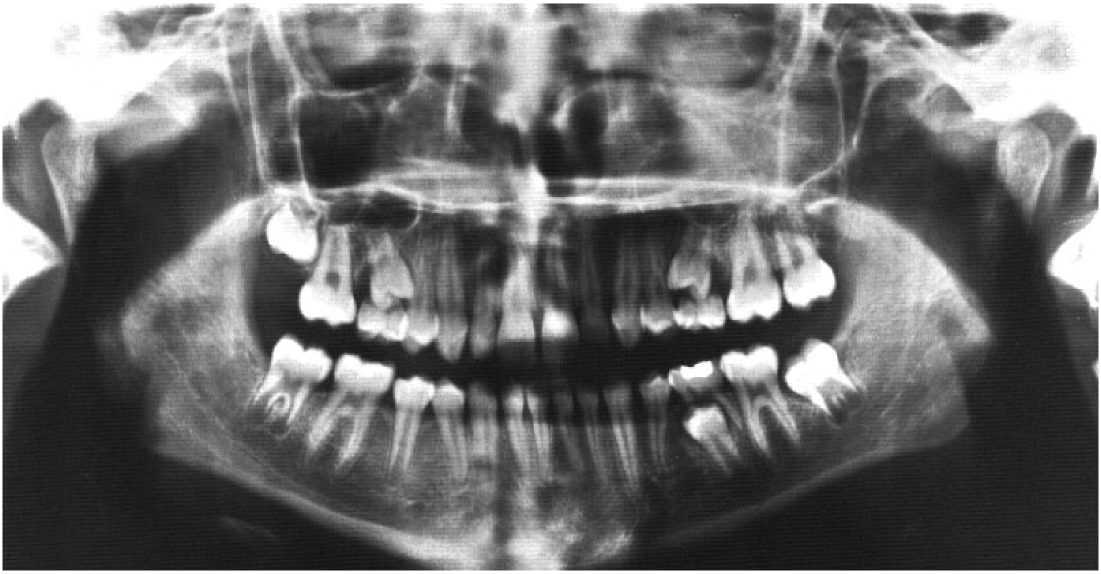

Figure 5 Panoramic tomogram of the jaws of a girl (age 11.4) who had been playing the violin for five years and was playing 9 hours a week at the time of the examination. The right ramus mandibulae is slightly higher than the left, the mandibular midline shifted to the left and the inferior border of the mandible extending downwards just to the right of the symphysis, at the insertion of the anterior part of the right digastric muscle.

measured from the PA cephalogram and mild facial asymmetry with right-side dominance (Figures 4 and 5). The asymmetry was limited to the lower face. Both upper and lower incisors were more proclined in the players than in the controls, and also more proclined than in a Finnish population study (Koskinen and Koski, 1965). The reduced anterior and posterior facial heights seen in adult professional violin and viola players (Kovero *et al.*, 1997) were not observed in the present group of adolescent violin players, although the adolescents and professionals were similar with regard to the increased proclination of maxillary incisors. In the adolescent violinists there was a trend towards a more anteriorly rotated mandible, which may be an initial sign of the development leading to reduced anterior facial height.

In the present matched controls slight mandibular asymmetry was found, the left side being slightly higher and the gonial angle slightly larger on the right side. Many reports have found that the adult human face is normally slightly asymmetric (Pirttiniemi, 1994). Most studies have come to the conclusion that the left side of the face is usually slightly larger, but the opposite has also been suggested (Shah and Joshi, 1978). The normal slight asymmetry is considered to result from the skull base, where asymmetry related to dominance of the hand is a common finding. Unilateral chewing patterns may contribute to asymmetric development of the mandible (Pirttiniemi *et al.*, 1991). However, the bony facial structures of the 24 adolescent controls in the present study (mean age 13.5 years) were fairly symmetric.

The present finding in the violinist group of overall higher face and right-side dominance of the lower part of the face could be considered to result from playing the violin for many hours weekly, with the increased face muscle activity involved. Holding the instrument under the left side of the chin induces balancing muscular activity on the right, and the playing position loads the right temporomandibular area. An increased loading may result in growth (Kiliaridis, 1995). Thus, the aetiology of the slight dominance of the right side of the lower face of the adolescent violinists may include increased functional activity. This conclusion is also supported by the finding that the adolescent violinists had tenderness to palpation in their right lateral pterygoid muscle statistically significantly more often than controls in an investigation of signs and symptoms of temporomandibular disorders in adolescent violinists (Kovero and Könönen, 1996). The increased proclination of the incisors could similarly be explained by an altered balance of muscular activity between the tongue and the lip, contributed by the pressure of the violin under the chin. In spite of all other facial height measurements being greater (though all not statistically significant) in the adolescent violinists than in the controls, the anterior lower face height (Me-pal. plane) was exactly the same in both groups.

It can be concluded that regular violin playing affects the growing dentofacial structures. The structural changes observed are probably caused by an increase in the functional activity of the jaws. A slight but measurable increase in the facial height, especially in the right side of the lower face and an increase in proclination of the upper and lower incisors are seen. It is suggested that these features should be taken into account when evaluating the need for orthodontic treatment for adolescents playing the violin and in planning such treatment.

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