

# *The influence of cephalostatic ear rods on the positions of the head and neck during postural recordings*

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This study examined the effect of cephalostatic ear rods on the positions of the head and neck. The method error was assessed for postural recordings of the head and neck position made with and without ear rods. A photographic angle was correlated with the postural angles on x-ray film. The material compared 33 dental students who were recorded with ear rods in and with ear rods out. Subjects were chosen randomly to repeat the postural recordings. The differences between the mean for each postural variable were subjected to comparative analysis, using Student's t test for paired samples. A significant difference ( $p \leq 0.05$ ) was found between the means of the inclination of the cervical spine to the true horizontal and the means of the photographic angle. The mean values for the remaining postural variables showed an insignificant but consistent pattern of axial extension of the cervical spine. Cephalostatic ear rods may alter head and neck position during postural recordings. The method error made for recording total head and neck position with ear rods was higher than without ear rods. The difference in the photographic angle was found to have a moderate positive correlation with the difference in the cervical inclination and the total head and neck position. These data suggest that lateral cephalostatics without ear rods may be used to record total head and neck position and the photographic technique may be used as a quick, inexpensive method for the clinician to determine head and neck positional changes before and after treatment. (AM J ORTHOD DENTOFAC ORTHOP 1989;95:312-8.)

Obtaining reproducible head and neck positions is important in anthropologic and dental-related research for analysis of craniofacial morphology, dentofacial structural relationships, mandibular rest position, and mandibular trajectory of closure. The association between craniofacial morphology and the posture of the head and cervical column in different groups was examined by Solow and Tallgren<sup>1-3</sup> and Solow, Barrett, and Brown.<sup>4</sup> The results indicated that the position of the head was found to display a comprehensive set of correlations with the craniofacial morphology.

A close relationship between cervical posture and occlusion was established by Gresham and Smithells.<sup>5</sup> The authors found that three times the number of chil-

dren with an Angle Class II malocclusion demonstrated deeper than normal concavity of the cervical spine, shortening of the neck from C2 and C7, and greater cervical inclination and cranial backward bending than children with normal occlusion.

Darling, Kraus, and Grasheen-Wray<sup>6</sup> evaluated eight subjects to assess the relationship between mandibular vertical dimension at rest (VDR) and head posture. VDR was defined as the vertical distance measured from points from the tip of the nose to the chin with the mandible relaxed. The relaxed position of the mandible was determined for each subject by pronouncing the letter /m/ three times, opening and closing the jaw, and swallowing. The authors found that a reduction of forward head position coincided with a gradual increase in VDR.

Evaluation of the mandibular trajectory of closure with a mandibular kinesiograph was performed by Goldstein and associates<sup>7</sup> to determine the influence of cervical posture on mandibular position. The authors tested four postural attitudes: natural sitting posture (NP), forward head posture (FHP), maximal forward head posture (MFHP), and military posture (MP). The results indicated that alterations of the anteroposterior head and neck posture apparently have an immediate

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effect on the trajectory of mandibular closure in a normal population. As the head moved anteriorly relative to the natural upright posture of the spine, the vertical distance of mandibular closure significantly decreased. When the head moved posteriorly and the cervical spine was straightened, the anterior excursion of the mandible through the interocclusal space decreased.

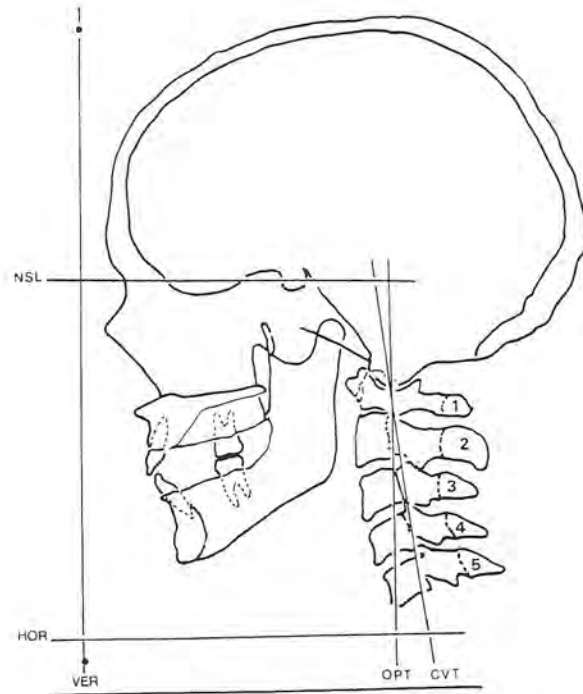
Because these previous studies have demonstrated that subtle postural changes are associated with dentofacial structural growth, position, and function,<sup>1-7</sup> researchers sought a method to define and measure the natural head position.<sup>17-23</sup> The introduction of roentgenographic cephalometry by Broadbent<sup>17</sup> allowed investigators to register the craniocervical angle and the cervical inclination and curvature. Postural recordings of the head are reliable within a few degrees.<sup>1,20,22</sup>

Different investigators suggest that the physical restraints on the positioning procedures imposed by the ear rods of standard cephalostats may influence the angulation of the head and neck.<sup>20,22,24</sup> Most standard cephalostatic equipment is mounted in a fixed position and consequently cannot be adjusted forward, backward, sidewise, or rotated. Only vertical adjustments are provided. The subject therefore must move his head often to fit the ear rods, potentially altering the angulation of the head and neck when a radiograph is made. Moorrees and Kean,<sup>22</sup> for example, suggest that when patients line up in the cephalostat, if the transmeatal axis is not perpendicular to the midsagittal plane, immobilization of the head with ear rods introduces a degree of asymmetry proportional to the deviation of the transmeatal axis from the midsagittal plane. Previous studies have used a mirror, light source, or the self-balance position to orient the head. The registration of the head and neck has been made with the subject sitting or standing.<sup>1,20,22,23</sup>

The current investigation examined the validity of cephalostats to record the head and neck positions by comparing the head and neck positions with ear rods inserted and with ear rods removed. In addition, as part of a search for a relatively simple nonradiologic method of postural recording, the change in the head and neck position between the two experimental conditions (ear rods in and ear rods out) made during cephalostatic recordings was compared with the change in head and neck positions between the two experimental conditions made during photographic recordings.

## MATERIALS AND METHODS

The subjects were 37 healthy students from Emory University Dental School. Four subjects were excluded because they were too tall ( $\geq 74$  inches) to sit under the



**Fig. 1.** Reference points and lines used to determine the three components of head and neck position ( $NSL/OPT$ ,  $OPT/CVT$ , and  $CVT/HOR$ ). The angle  $NSL/VER$  represents total head and neck position. (Modified from Natural head position in standing subjects by Solow B, Tallgren A. *Acta Odontologica Scandinavica* 1971;29:591 by permission of Norwegian University Press.)

cephalostatic head holder. A total of 33 students, 10 women and 23 men, aged 22 to 40 years, with a mean age of 27 years, participated in the study.

Subjects were screened for normal, pain-free cervical range of motion, signs and symptoms of vestibular and/or equilibrium problems, and current problems associated with nasal obstructions—that is, colds and active symptoms of head, neck, face, and/or jaw pain.

A radiograph and photograph were taken for each subject. Recordings were made with the ear rods in and then with the ear rods out in groups of three and five subjects.

Ten subjects were chosen randomly to return for a second session to repeat the test observations. The values obtained from the 10 subjects in the second session were compared with those of the first session to establish a level of reliability in the procedures.

The reference points and planes used to describe head and neck position on the radiograph were taken from Solow and Tallgren (Fig. 1).<sup>1</sup> The reference points and lines used to describe the postural variable on the photograph were taken from Cureton (Fig. 2).<sup>18</sup>





Fig. 2. Reference points and lines representing head posture on photographs.

### RADIOGRAPHIC TECHNIQUE

The radiographic equipment used was the Quint Sectograph\* with a motorized, vertically adjusted x-ray source and a focus of 0.8 mm. A  $\frac{1}{32}$ -inch lead solder wire was mounted in front of the cassette to indicate a true vertical on the film. The wire was aligned vertically by means of a spirit level. Reliability of the wire alignment was maintained at  $r = 1.00$ .

A hydraulic chair had a swivel base to position each subject under the cephalostat. The chair was mounted on top of a specially made dolly with caster wheels. The dolly allowed the examiner to move the chair forward and backward and side to side, and to rotate under the cephalostat to adjust the external auditory meatus of each subject to the ear rods. The final adjustment was accomplished by the vertical adjustment of the cephalostat.

The head was oriented by a fiber-optic light beam to maintain the midsagittal line in a vertical plane at 15 cm from the cassette and 152 cm from the focus median plane of the x-ray source. An examiner, standing behind the subject, corrected any deviation of the head and neck relative to the alignment of the light beam. This procedure allowed the examiner to maintain a fixed distance of the midsagittal plane of the head to the x-ray source and cassette. The chair faced a bare white wall to eliminate visual distractions.

A 1-inch thick plywood board, measuring 12 × 16 inches, was constructed and attached with C clamps to the foot plate of the hydraulic chair. The plywood board provided a comfortable footrest for subjects to place their feet during postural recordings. Tape measures to



Fig. 3. Radiographic technique with ear rods out.

simulate x and y axes were run along the outside length and width of the plywood board. Similarly tape measures were placed along the outside length and width of the chair seat and along the floor next to the dolly. Foot, buttock, and chair positions were recorded from the tape measures and reproduced for each subject between experimental conditions (Fig. 3).

### PHOTOGRAPHIC TECHNIQUE

The tragus of the ear was marked with a black skin marker and C7 was located and marked with a dow rod. A 35-mm camera (A E 1 Cannon) was positioned on a tripod. The camera was directly behind, but in the same alignment as, the x-ray source. After the radiograph was taken, the motorized Quint Sectograph was moved to take the photograph. The camera was positioned so that all subjects were close to the center of the view finder. The level of the camera was checked with a spirit level. Reliability of camera alignment was maintained at  $r = 1.00$ . A vertical plumb line was placed between the camera and the subject to be used as a natural vertical on the photograph.

### DATA COLLECTION PHASE

The subjects rehearsed the following instructions outside the cephalostat: (1) sit forward in the chair with your feet positioned comfortably, shoulder width apart,

\*Universal Corporation, Los Angeles, Calif.



**Table I.** Method errors measured in degrees\*

Angle	Reference points and planes on photographs and radiographs (N = 12)		Postural recordings (N = 10)	
	In	Out	In	Out
Photo angle	0.46	0.20	3.24	3.53
NSL/OPT	0.00	0.25	3.71	3.66
OPT/CVT	0.25	0.00	1.40	1.77
CVT/HOR	0.20	0.20	3.10	3.19
NSL/VERT	0.27	0.00	4.90	2.52

$$*S \sqrt{\frac{(X_2 - X_1)^2}{2n}}$$

(2) sit up straight maintaining the normal curve in your back, (3) shrug your shoulders to ease tension, (4) nod your head backward and forward in decreasing amplitude until you find a comfortable position, (5) hold that position and breathe normally, and (6) bring your back teeth together gently.

Changes in pulse rate were monitored before and during postural recordings in all subjects and remained less than 70% of the resting pulse rate. An increase of 70% or greater in resting pulse rate reflects significant variation in the subject's emotional state.

The subjects took their positions on the cephalostat and repeated the positioning procedures. A radiograph followed shortly by a photograph were made. A 5-minute rest period followed, after which the subjects took their positions again in the cephalostat, this time with the ear rods removed. The foot, buttock, and chair were repositioned at the appropriate marks recorded from the tape measures. The subject repeated the positioning procedures. A radiograph and photograph were taken.

### MEASUREMENTS

The angle NSL/OPT represented upward or downward tilting of the head at the occipitoatloid joint; the angle OPT/CVT represented change in cervical curvature; the inclination of the cervical column in relation to true horizontal was represented at the angle CVT/HOR; and the total change in head position was represented by the angle NSL/VERT (Fig. 1).

The method errors for marking the reference points and planes on the radiographs and photographs were established. Twelve consecutive radiographs and 12 consecutive photographs were marked twice on tracing paper. The method errors,

$$S \sqrt{\frac{(X_2 - X_1)^2}{2n}}$$

where S represents the method error, X<sub>2</sub> the second set of values, X<sub>1</sub> the first set of values, and n the sample size, were determined from the calculated values of the postural variables on the radiographs and photographs. The method errors of postural recordings from each postural variable were then determined between the second and first sessions.

The means and standard deviations were determined for the postural variables on the radiographs and photographs. Student's t test for paired samples was used to test the significance of the mean difference for each of the postural variables (*p* ≤ 0.05).

The Pearson r was used to correlate the mean change in the photographic variable with the changes in each of the postural variables on the radiographs (*p* ≤ 0.05).

### RESULTS

The method errors for marking the reference points and planes on the radiographs and photographs (Table I) compare favorably with previous research, suggesting no systematic error in marking reference points and planes.

The method errors for reproducing head and neck position between postural recordings made with ear rods in and ear rods out on different days also are shown in Table I. One subject was excluded from the photographic comparison because of difficulty in visualizing C7 marked with the dow rod on the photograph. Except for NSL/VERT, the differences for each of the postural variables measured with ear rods in and ear rods out were less than 1° (Table I). The method error of the position of the head to the true vertical (NSL/VERT) showed a difference of greater than 2° (Table I).

The means and standard deviations for each of the postural variables made with the ear rods in and out are given in Table II. The differences among the means for each postural variable were subjected to comparative statistical analysis by means of Student's t test for paired

**Table II.** Means, standard deviations, and obtained *t* values between the two experimental conditions for four angles on radiograph and one angle on photograph (N = 33)

Variable	Number of cases	Mean (°)	Standard deviation (°)	Difference mean (°)	<i>t</i> value	Degrees of freedom	Two-tailed probability																																							
NSL/OPT I	33	95.12	8.27	0.19	0.31	32	0.755																																							
NSL/OPT O		94.92	7.35					OPT/CVT I	33	4.80	3.00	0.10	0.41	32	0.682	OPT/CVT O	4.69	2.53	CVT/HOR I	33	90.66	5.34	1.53	2.53	32	0.016	CVT/HOR O	89.13	4.78	NSL/VERT I	33	100.15	5.10	1.13	1.68	32	0.102	NSL/VERT O	99.0	5.20	Photo I	29	49.69	5.09	1.49	2.29
OPT/CVT I	33	4.80	3.00	0.10	0.41	32	0.682																																							
OPT/CVT O		4.69	2.53					CVT/HOR I	33	90.66	5.34	1.53	2.53	32	0.016	CVT/HOR O	89.13	4.78	NSL/VERT I	33	100.15	5.10	1.13	1.68	32	0.102	NSL/VERT O	99.0	5.20	Photo I	29	49.69	5.09	1.49	2.29	28	0.030	Photo O	48.20	5.05						
CVT/HOR I	33	90.66	5.34	1.53	2.53	32	0.016																																							
CVT/HOR O		89.13	4.78					NSL/VERT I	33	100.15	5.10	1.13	1.68	32	0.102	NSL/VERT O	99.0	5.20	Photo I	29	49.69	5.09	1.49	2.29	28	0.030	Photo O	48.20	5.05																	
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Photo O		48.20	5.05																																											

I, Ear rods in; O, ear rods out.

**Table III.** Correlation coefficient (Pearson *r*) of relationship of changes on four angles on radiograph and change in photographic angle (N = 33)

	NSL/OPT	OPT/CVT	CVT/HOR	NSL/VERT
Photo	0.0772	-0.1919	0.4068*	0.4107*

\* $p < 0.05$ .

samples (last three columns, Table II). Significant differences were seen for means of the inclination of the cervical spine to the true horizontal (CVT/HOR) and the photographic angle ( $p \leq 0.05$ , Table II). No statistically significant differences were found for the remaining postural variables.

The values obtained for the correlation coefficient are given in Table III. Positive relationships were seen among the values obtained from the photographs, the CVT/HOR differences, and the NSL/VERT differences ( $p \leq 0.05$ , Table III).

## DISCUSSION

The results support the contention of Siersbæk-Nielsen and Solow<sup>20</sup> that cephalostatic ear rods can impose physical restraints on the positioning procedure and alter the recorded angular dimensions of the head and neck. The significant change in cervical inclination (CVT/HOR;  $p \leq 0.05$ , Table II) and the mean values for the remaining postural variables when ear rods were in place showed a consistent pattern of axial extension in the cervical spine and at the occipital-atlantal articulation. The pattern of axial extension occurred despite the best efforts of the x-ray technician to lower the ear rods to the same horizontal plane of the subject's ex-

ternal meatuses. In addition the examiners were unable to detect the subtle postural changes when a subjects extended their heads and necks to fit the ear rods. Therefore one may speculate that subtle postural changes occur during cephalostatic recordings and are difficult to observe and control.

The statistical insignificance in the changes of the majority of the postural variables may be attributed to the specially made dolly that enabled the examiner to roll sitting subjects forward and backward and side to side to fit the ear rods. Therefore the need for subjects to move their heads and necks during postural recordings was reduced. Most standard cephalostats are not equipped with a rolling hydraulic chair and may impose greater physical demands during postural recordings, thereby producing greater alterations in head and neck position than in this study.

Reproducibility in total head and neck position (NSL/VERT) examined with and without ear rods showed a larger method error than in previous studies (Table IV). The smaller sample size in our study (Table IV) may have increased the method error in allowing extreme values to skew the results, thus accounting for the larger standard deviations (Table II).

The method error without ear rods agrees with pre-



vious studies that established reliability for recording total head and neck position without ear rods.<sup>22,23</sup> However, previous studies performed without ear rods used a mirror during postural recordings to orient the head and neck.<sup>22,23</sup> Because Solow and Tallgren<sup>1</sup> demonstrated that subjects held their heads 2° to 3° higher when looking into a mirror than in the self-balance position, the current investigation decided to use the self-balance position without ear rods to orient the head during postural recordings. A light source would have to be used to maintain a fixed distance between the x-ray source, the midsagittal plane of the subject's head, and the cassette. The results demonstrated a greater degree of reliability in reproducing total head and neck position (NSL/VERT) without ear rods than with ear rods (Table II). Later cephalostats therefore may be used without ear rods, with subjects in the self-balance position, to examine total head and neck position. For the remaining postural variables, although there were no significant differences with ear rods in and ear rods out, the magnitude of the method errors and the small sample size preclude any conclusions concerning reproducibility, a factor that will be contingent on additional research.

Photographs can be a quick, inexpensive method for the clinical specialist, such as an orthopedic physical therapist, to determine head and neck positional changes before and after treatment. The photographic angle showed a moderate positive correlation with changes in cervical inclination (CVT/HOR) and total head and neck position (NSL/VERT) (Table IV), and agrees with the findings of Root and associates.<sup>24</sup> However, lateral cephalostats, with ear rods in or out, remain the best method for the orthodontist to assess dentofacial and craniofacial morphology and structural development.

## CONCLUSION

Lateral cephalostats with ear rods were shown to alter the position of the head and neck during postural recordings. Subjects extend their heads and necks higher with ear rods in than without ear rods. Dentists who assess cephalostatic x-ray films to determine whether postural changes of the cervical spine are present or who assess dentofacial/craniofacial morphology, structural development, and biomechanical relationships relative to the natural head and neck position may need to reconsider the possibility that such changes may be influenced by the use of the ear rods. The position of the head and neck on x-ray films may not be the subject's presumed natural head and neck position.

**Table IV.** Survey of method errors for position of head in relationship to true vertical (NSL/VERT)

Author	Number of subjects	Method error
Bjerin <sup>23</sup>		
Ear rods out	35	1.62
Ear rods out	35	1.32
Moorrees and Kean <sup>22</sup>		
Ear rods out	66	2.05
Ear rods out	61	1.54
Solow and Tallgren <sup>1</sup>		
Ear rods in	21	2.48
Ear rods in	21	1.43
Siersbaek-Nielson and Solow <sup>20</sup>		
Ear rods in	30	2.25
Present study		
Ear rods in	10	4.90
Ear rods out	10	2.52

In addition total head and neck position determined without ear rods had a smaller method error than with ear rods. Therefore lateral cephalostatic x-ray films made without ear rods may be used to record total head and neck position. Future research using lateral cephalostats without ear rods is needed to determine the reproducibility of cervical inclination (CVT/HOR), cervical lordosis (OPT/CVT), and the craniocervical angulation (NSL/OPT).

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