Effect of an intraoral splint on head and neck posture

Gregg R. Root, M.M.S.,* Steven L. Kraus, B.S.,* Samuel J. Razook, D.D.S., and Gerald S. Samson, D.D.S.*****

Emory University, School of Medicine, Atlanta, Ga.

The interrelationship of mandibular posture and head and neck posture has been reported.[1-4] The vertical dimension of occlusion (VDO) is one component of mandibular posture. Changes in VDO are capable of altering muscle and soft tissue forces about the mandible,[5] and the VDO may be changed by loss of teeth,[6,7] the insertion of complete dentures,[2,5] or the insertion of an intraoral splint.[8-10]

The postural position of the mandible was shown to change with changes in head position,[1,3,4,11] and the insertion of an intraocclusal splint to increase VDO affected both the resting position of the mandible[8-10] and the craniovertical angle, that is, the tilt of the head.[12] Other components of cervical posture response have been described,[13-16] but the effect of insertion of an intraocclusal splint on head and neck posture has only been determined for the craniovertical angle.

Head and cervical posture has been measured by using photographs[13] and by using cephalometric profile radiographs.[14-16] In the photographic technique, head posture was evaluated by an angle determined by a horizontal line through the seventh cervical vertebra and the tragus of the ear. Solow and Tallgren[14-16] used cephalometric profile radiographs to identify three angles representing head and neck posture (Fig. 1). The craniovertebral joint (tilting of the head) was represented by the angle NSL/OPT; cervical lordosis was represented by the angle OPT/CVT; and the inclination of the cervical column was represented by the angle CVT/HOR. Total head and neck position was also determined (angle NSL/VER). Although the radiographic technique of Solow and Tallgren[14-16] allows measurement of specific components of head and neck posture, it is in most instances not as clinically feasible as the photographic technique of Cureton.[13] If a relationship between radiographic measurements and photographic measurements were demonstrated, the validity of photographic measurements would be supported. In addition, an effective and less expensive alternative to cephalometric radiographs for measurement of posture would be suggested.

This investigation tests the hypotheses that (1) there is no change in head and neck posture with insertion of an intraoral splint that increases the VDO in normal subjects, and (2) there is no relationship between the values obtained by using the photographic method and the values obtained from the radiographic method of postural recording.

MATERIAL AND METHODS

The subjects were 12 healthy students from Emory University dental and physical therapy schools. They included four women and eight men 23 to 33 years of age.

The criteria for selection included range of motion in the cervical spine within normal limits and absence of pain; an absence of head and neck signs or symptoms such as pain on palpation of cervical joints C2-3 through C5-6, active trigger points on palpation of the trapezius, levator scapulae, rhomboideus, supraspinatus, suboccipital, scalenes, suprahyoid, infrahyoid, masseter, and temporal muscles; no pain with compression to the cervical spine; no history of temporomandibular joint (TMJ) surgery; no history of TMJ dysfunction; no intercapsular TMJ noises on examination; no pain with forced biting; and no active respiratory distress. All subjects had a complete complement of teeth (excluding third molars). The sampling method was accidental, nonprobability. A signed consent form was obtained for each subject.

The design was a within-subject comparison of three experimental conditions. A total of four radiographs and four photographs were made of each subject. The first radiograph and photograph served as the postural baseline. The three experimental conditions (no splint, splint at rest, splint 8 mm beyond rest) were randomly sequenced in each subject. A radiograph and photograph followed each experimental condition. The condition of no splint was used as a control to indicate the extent to

*Registered Physical Therapist, Clinical Faculty, Division of Physical Therapy, Department of Rehabilitation Medicine.

**Assistant Professor, Department of Prosthetics, Emory University, School of Dentistry.

***Assistant Clinical Professor, Department of Orthodontics, Emory University, School of Dentistry.

which the test procedure reproduced the baseline head posture.

The increase in VDO was the independent variable. The VDO was defined as the vertical dimension of the face when the teeth were in maximum intercuspation. The measurement of the VDO was determined by two arbitrary points, one above and one below the mouth in midline. A mandibular, intraoral splint was used to increase the VDO. The various craniofacial morphologic patterns presented by the subjects were controlled by the individualized constructions of the intraoral splint used.[14] A mandibular rather than maxillary splint was used to minimize the effects that the intraoral splint might have had on tongue positioning.[12]

Procedure for increasing the vertical dimension of occlusion

Fabrication of the splint for use at the rest position was accomplished through the following procedure. Impressions of the mandibular dental arch were made and poured in artificial stone. A plastic sheet 0.020 mm thick was heated and vacuum-pressed against the casts. The sheet was trimmed, tried in the mouth for fit and comfort, and placed aside. The subject was in a standing, unbraced position and was instructed to (1) open wide, (2) repeat "Mother" and "Mississippi" three times each, (3) lick the lips, (4) swallow, and (5) relax. The vertical dimension of rest (VDR) was then measured from two arbitrary points, one placed on the nose and one placed on the chin in the facial midline. The procedure was repeated until three consistent measurements were obtained. The plastic form was then placed in the mouth while the subject was in a standing, unbraced position. A cold-curing autopolymerizing orthodontic acrylic resin was mixed to a doughlike consistency and placed over the plastic form in the region of the molars and premolars. The subject was then allowed to close into the soft acrylic resin to the predetermined VDR measurement. After the acrylic resin hardened, the splint was removed from the mouth, trimmed, and polished.

The fabrication of the splint at 8 mm above rest position was accomplished as follows. A separating medium was placed over the hardened acrylic resin in the molar and premolar regions of the splint. The subject was in a standing, unbraced position with the splint in the mouth. A cold-curing autopolymerizing orthodontic acrylic resin was mixed to a doughlike consistency and placed over the splint in the region of the molars and premolars. A thickness of wedge equal to the combined measurement of the difference between VDO and VDR plus 8 mm was placed between the maxillary and mandibular central incisors. The subject was instructed to close until contact was made. After hardening, the acrylic resin was trimmed and polished. The additional acrylic resin splint made at 8 mm beyond the rest position could now be removed and placed in position at will, allowing a random sequencing of the splints during testing. The splints were made 1 to 3 days before data collection.

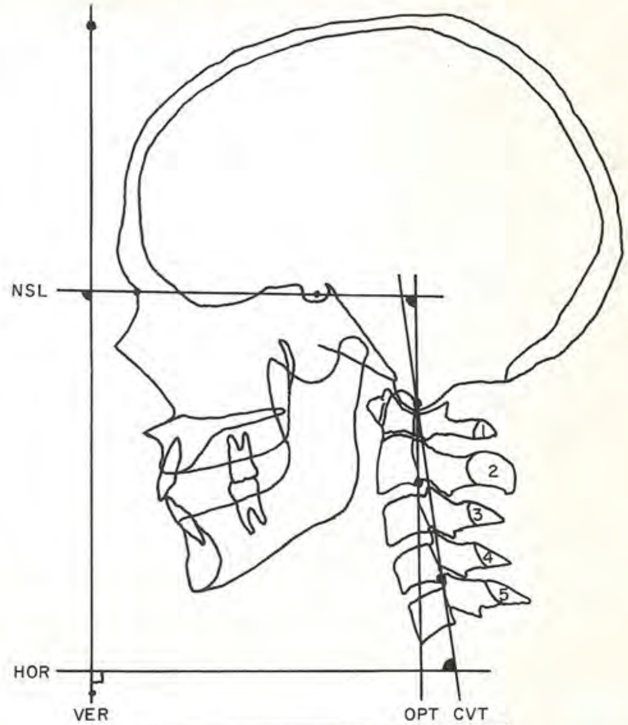

Fig. 1. Reference points and lines used to determine three components of head and neck position (NSL/OPT, OPT/CVT, CVT/HOR). Angle NSL/VER represents total head and neck position. (Modified from Solow and Tallgren.[16])

Radiographic technique

The radiographic technique was similar to that described by Solow and Tallgren.[14,15] Cephalometric radiographic equipment (Moss Corporation, Chicago, Ill.) was used with a vertically adjustable x-ray source and a focus of .8 mm. The focus median plane distance was 152 cm and the film median plane distance was 15 cm. Reliability was maintained at $r = 1$. No corrections were made for the radiographic enlargement. A 1/32 inch lead solder wire was mounted in front of the cassette to indicate true vertical on the film.

Photographic technique

The photographic technique was similar to that described by Cureton.[13] The tragus of the ear was marked with a black skin marker and the spinous process of C-7 was located and marked with a dow rod 4 inches long divided into four equal 1-inch segments. A 35 mm camera was positioned on a tripod 4 feet from the subject. The camera was level with the tragus of the ear.

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

Reliability was maintained at $r = 1$. A lead shield was placed between the camera and the radiographic source.

Positioning procedure

The intention position (eyes looking ahead, arms in neutral position, lower extremities in a neutral posture parallel to each other) from standing to walking (orthoposition) was used.[14,15] The subjects were rehearsed outside the cephalometer as to desired body posture. They were instructed to take five steps in place and to gently rock the head to establish a self-balance position. No external orientation source (mirror) was used. During rehearsal of positioning, the subjects were instructed to move the feet to facilitate correct positioning. During testing, the positioning within the cephalometer was critical. A spotter watched to make sure the head and neck position remained the same while the head-holder was lowered and the ear rods inserted. The ear rods were gently inserted into the external auditory meatus. The radiograph was made and the subject was asked to remain in the same position. As the ear rods were removed and the head-holder was raised, a spotter again made sure the head and neck position remained the same. The lead shield was moved and the photograph was taken within 10 seconds after the radiograph.

Data collection procedure

Each subject was given written and verbal instructions and allowed to rehearse the postural (self-balance) position before testing. The camera was adjusted for correct height. Next, the head-holder was lowered and ear rods were inserted to acclimate the subject to the test procedure. A 5-minute rest period followed, during which the subject sat in a chair to reduce possible fatigue. At the end of the 5-minute rest period, the participant stood in the test area and took five steps in place, then gently rocked the head to establish the self-balance position. The head-holder was lowered and the ear rods were inserted. The subject was asked to gently bring the teeth together. The baseline radiograph and baseline photograph were then made in that order. A 5-minute rest period followed, during which the participant sat in a chair. Next, according to a predetermined random sequence, one of the following experimental conditions was initiated: no splint, splint at rest, and splint at 8 mm beyond rest. Once one of the test conditions was initiated, the subject walked for 8 minutes. At the end of 8 minutes, the subject stood in the test area, established the self-balance position with the teeth in occlusion with the opposing arch or the splint, and the second radiograph and photograph was made. If inserted, the splint was removed. A 5-minute readjustment period followed. The subject sat in a chair during all rest periods. At the end of 5 minutes, the next test condition was initiated according to the random sequence assigned. Again, the subject walked for 8 minutes. At the end of 8 minutes, the subject again stood in the test area and established the self-balance position with teeth in occlusion with the opposing arch or the splint. The third radiograph and photograph were made. If inserted, the splint was removed, and a 5-minute readjustment period followed. The last test condition was then initiated. The subject again walked 8 minutes, then stood in the test area, establishing a self-balance position with the teeth in occlusion with the opposing arch or the splint. The final radiograph and photograph were made. Any splint was removed, the subject rested, and was then dismissed.

Table I. Mean change from baseline, mean, standard deviation, and minimum and maximum degrees of angles recorded for the radiographs and photographs

	Mean change from baseline	Mean	SD	Minimum	Maximum
Angle NSL/OPT					
Position 1		94.37	6.71	87.5	110.5
Position 2	0.34	94.71	6.81	86.5	112.5
Position 3	1.05	95.42	6.86	87.5	111.5
Position 4	1.38	95.75	6.13	87.5	111.0
Angle OPT/CVT					
Position 1		6.87	2.87	0.5	11.0
Position 2	−0.08	6.79	2.96	1.5	12.5
Position 3	−0.08	6.79	3.02	2.0	12.5
Position 4	0.25	7.12	2.85	2.0	12.0
Angle CVT/HOR					
Position 1		86.17	6.12	78.0	97.0
Position 2	0.66	86.83	4.93	80.0	94.0
Position 3	0.54	86.71	5.12	80.0	94.5
Position 4	−0.05	86.12	4.77	79.0	95.0
Angle NSL/VER					
Position 1		97.42	3.84	91.0	102.5
Position 2	0.83	98.25	4.50	91.0	106.0
Position 3	1.33	98.75	4.81	89.5	108.0
Position 4	1.45	98.87	4.67	90.5	106.5
Photograph					
Position 1		49.75	5.40	42.0	60.0
Position 2	1.17	50.92	5.22	42.0	58.0
Position 3	1.50	51.25	4.53	45.0	58.0
Position 4	1.12	50.87	5.09	42.0	59.0

Positions: 1 = baseline; 2 = no splint; 3 = splint at rest; 4 = splint at 8 mm.

Measurements

The dependent variable was change in the angles defined as representing head and neck posture on the radiographs: the angle NSL/OPT represented upward or downward tilting of the head in the craniovertebral joint; the angle OPT/CVT represented change in cervical curvature; the inclination of the cervical column in relation to true horizontal was represented by the angle CVT/HOR; and the total change in head position was represented by the angle NSL/VER. The cephalometric reference points and lines identified by Solow and Tallgren[15] were used to define head and neck posture and are shown in Fig. 1. (For detailed definitions see Solow and Tallgren.[15]) Comparison was made between the postural baseline and the posture established after the application of each experimental condition, and the degrees of difference in the angles were recorded. The positive numbers indicate movement toward extension and negative numbers indicate movement toward flexion. The reference points were marked by hand on tracing paper by an experienced orthodontist. For the reliability of locating and marking the reference points on 12 duplicate radiographs, the method error s(i)

$$\sqrt{\frac{E\ (x_2 - x_1)^2}{2n}}$$

was determined for all four angles by the difference between the two identical radiographs. The method error for locating and marking the reference points on radiographs was 0.492 degree.

The photograph reference points and lines were drawn directly on the photographs. A horizontal line was drawn through the seventh cervical vertebra and a line was drawn between the seventh vertebra and the tragus of the ear. The angle between the two lines represented head posture (Fig. 2). Reliability for marking reference points on the photographs was determined by marking 12 duplicate photographs. The method error s(i) for the photographs was 0.478 degree.

The mean and standard deviation was determined for the baseline and the three experimental conditions. A two-way analysis of variance was used to compare the baseline and the experimental conditions. The change from baseline to 8 mm beyond rest on the radiographs and photographs was plotted on a scattergram. A correlation coefficient (Pearson *r*) was calculated for the change observed on radiographs and photographs. Alpha level for all tests was 0.05.

RESULTS

The first hypothesis tested was that no change in head and neck posture occurs with an increase in VDO. The

Table II. Obtained *F* value from analysis of variance of change in degrees of angles between three experimental conditions for the four angles on the radiograph and the one angle on the photograph

	Angles				
	NSL/VER	CVT/HOR	OPT/CVT	NSL/OPT	PHOTO
F value	.24	.05	.03	.10	.18

$p = .05$, F = 2.82, d.f. 47.

Table III. Correlation coefficient (Pearson *r*) of the relationship of the changes on the four angles on the radiograph and the change on the photographic angle and for the sum of the change in the three component angles and NSL/VER.

	NSL/ VER	CVT/ HOR	OPT/ CVT	NSL/ OPT
Photo	.0860	.4628	−.2930	−.2858
Sum of the change in the three component angles	.9240			

mean and standard deviation in head and neck posture in the baseline and the three experimental conditions are given in Table I. The mean increase from the baseline to the experimental condition of 8 mm beyond rest in the angle NSL/VER was 1.45 degrees. The mean for NSL/VER in the postural baseline in the present study was 97.42 degrees. The means established for the postural baseline in all angles measured were higher in the present study than the values established by Solow and Tallgren.[14-16] No significant difference was found between the change of angle from baseline to each of the three experimental conditions on the radiographs and photographs. The *F* value for each angle on the radiograph and the one angle on the photograph is shown in Table II. At the 0.05 alpha level with 47 degrees of freedom, the significant *F* value was 2.82. The *F* values obtained supported the null hypothesis of no change in head and neck posture with an increase in VDO.

The second hypothesis tested was that there is no relationship between the values obtained with the radiographic and photographic methods of recording posture. The values obtained for the correlation coefficient (Pearson *r*) are given in Table III. No relationship was seen between the values obtained from the radiographs and the values obtained from the photographs ($p > .05$). The null hypothesis of no relationship was supported. A correlation was seen between the sum of the changes from baseline to 8 mm beyond rest in the three components (NLS/OPT, CVT/OPT, and CVT/HOR) and the angle NSL/VER on the radiographs. The correlation was significant at the 0.0005 level. The null hypothesis of no relationship between the components and total head position on radiographs was not supported.

DISCUSSION

The first hypothesis tested was that no change in head and neck posture occurred with an increase in VDO in normal subjects. The results of the two-way analysis of variance indicate no significant change in head and neck posture with an increase in VDO. Overall head and neck posture was represented by NSL/VER; the mean change from baseline to 8 mm beyond rest was 1.45 degrees. Daly et al.[12] found a mean change of 2.94 degrees with bite opening; and Solow and Tallgren[14,15] found a mean change of 3 degrees between the self-balance and the mirror positions. Both numbers were found to represent significant change in head position. In both studies, the mean change in head position was a raising of the head. The 1.45 degrees found in the present study also represented a change toward a raising of the head.

Several factors may have limited the finding of significant differences during the present study. One factor may have been the small sample size. The mean for the baseline in the angle NSL/VER was 97.42 degrees in the present study. Solow and Tallgren[14,15] found a mean of 89.57 degrees leaving a difference in the two means of 7.85 degrees. The small sample size may not have been representative of a normal distribution. The range of head positions in the present study approximated the ranges established by Solow and Tallgren[14,15] but most of the 12 subjects were at the upper limits of that range. The subjects in the present study may not have been able to raise the head significantly with an increase in VDO because initial values were at the upper end of the physiologic range for head and neck position.

The limited time of insertion of the splint before the radiograph may also have limited the results. Each of the splints was in for a total of 8 minutes before the radiograph was made. Eight minutes has been shown by other studies to be adequate for reflex changes in and around the mouth,[9,16] however, it may not be enough time for postural changes in the head and neck. After 1 hour with bite opening, Daly et al.[12] found significant change in head posture.

Instrumentation may be another factor limiting change in the measured angles with increased VDO. The use of a head-holder to establish a reliable reference plane may have influenced the results. The reproducibility of head and neck position when using the head-holder has been shown in previous studies.[13,14] The high degree of reproducibility shown with the head-holder may not allow for changes to be seen in the postural position of the head and neck. In other words, the head-holder may negate or correct any postural changes that may have occurred with an increase in VDO. The subtle changes in natural head posture may be observed only when the restraints of the head-holder are not used. Further work is needed to establish the effect of the head-holder on the natural head position.

The dependent variable was the change in the angles identified as representing head and neck posture on the cephalometric radiographs. The use of the angles may not fully define head and neck posture. The electromyographic (EMG) activity of the supramandibular muscle has been shown to change with increase in VDO.[5] The EMG activity of the postural muscles of the head and neck may have changed with an increased VDO. EMG activity was not measured in the present study. Inasmuch as posture is a dynamic or ever-changing occurrence, it may not be fully defined by using static instruments such as radiographs and photographs.

The second hypothesis tested was that a correlation exists between the values obtained with the radiographic and the photographic methods of measuring posture. No correlation was shown between the changes in the angle on the photograph and the changes in the angles on the radiograph. The correlation coefficient was the highest, although not statistically significant, for the angle CVT/HOR and the angle on the photograph. The photograph method may most accurately represent changes occurring in the cervical column. A correlation existed for the sum of the changes in the three component angles and the angle NSL/VER, representing total head and neck posture. The three components (tilting of the head NSL/OPT, cervical lordosis OPT/CVT, and inclination of the cervical spine CVT/HOR) combined may accurately represent total head and neck posture.

Several factors may have limited the findings of no relationship between the radiographic and photographic values. The small sample size allowed extreme values to skew the results. In one subject a change of +5 degrees was seen on the photograph and a change of −1.5 degrees was seen on the radiograph in the angle NSL/VER. The correlation coefficient changes dramatically when the subject is not included.

That no significant changes occurred in the position of the head and neck from the baseline to 8 mm beyond rest may have influenced the correlation. As the magnitude of the change increases, the correlation may also increase.

Further research is needed to determine the effect on head and neck posture of changing VDO. Further research is also needed to determine whether radiographs and photographs are effective measurements of postural change.

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Reprint requests to:
MR. GREGG R. ROOT
904 SPRUCEWAY
ABILENE, KS 67410

Contributing author: Pamela Catlin, Ed.D., Associate Professor, Division of Physical Therapy, Department of Rehabilitation Medicine, Emory University, School of Medicine.