Associations between the Postural Orientation of Sella–Nasion and Skeletodental Morphology

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The orientation of the sella-nasion line to true vertical in natural head posture is found to be correlated with some measures that describe internal craniofacial morphology.

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Biologic mechanisms of the form-function interaction are still among the least understood components of orthodontic diagnosis, with few studies documenting constancy or change in function during growth. While standards exist for the comparison of a patient's morphology to mean norms, few standards are available for the evaluation of function. Nevertheless, current orthodontic treatment planning often includes therapy intended to modify function.

The current interest in functional orthopedics is based on the concept that alteration of postural relationships among craniofacial components leads to altered patterns of growth. Functional appliance therapy, although popular, must still be based on a limited understanding of normal and abnormal function, and the biomechanical relationships between muscle activity and skeletal form.

In the past ten years, several investigators have studied associations between head posture and skeletodental form. Using lateral cephalometric radiographs taken in the natural head position, moderate correlations have been found between the angulation of sella-nasion to vertical and certain skeletodental variables. The findings of SOLOW AND TALLGREN (1976) in adult males and of POSNICK (1978) AND SOLOW, SIERSBAEK-NIELSEN AND GREVE (1984) in male and female children, raise fundamental questions concerning growth and development.

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Among these questions are: — do postural relationships precede and cause changes in craniofacial anatomy? If they do, to what extent can one modify postural relationships, and to what extent will this influence the growing craniofacial and dental structures?

Resolution of these questions could lead to new methods for predicting abnormal development and planning appropriate therapy, but the difficulties of measuring functional variables such as head posture, lip posture, and mandibular rest position still leave large gaps in our knowledge of these mechanisms and their clinical and biologic significance.

This study employs a new fluid-level device to record standing head posture and then reproduce that posture on the cephalometric radiograph. This device makes it possible to simplify and standardize the technique of establishing natural head position prior to the radiographic procedure, so that radiographic measurement of head posture can be accomplished without the need to resort to multiple x-ray exposures to evaluate reliability (SHOWFETY ET AL. 1981 AND 1983).

The resulting radiograph allows a simultaneous quantitative assessment of both head posture and morphology that is analogous to the method used for measurement of head posture relative to a gravity-defined vertical by SOLOW AND TALLGREN (1976) AND POSNICK (1978).

In this project, a group of untreated orthognathic surgery candidates were radiographed in natural head position, and the relationships between certain craniofacial morphologic features and the angulation of the sella-nasion line to true vertical (S-N/V) were examined.

The null hypothesis tested is that there is no relationship between the S-N line orientation and the selected radiographic delineators of craniofacial anatomy. The alternative hypothesis is that there is some association.

Specific questions addressed in this study are:

1. Do identifiable correlations exist between certain anatomic variables and the angulation of S-N to vertical?
2. Is there a morphologic difference between those with habitual flexed head posture and those with extended head posture (as defined by the S-N/V angle)?

DOWNS (1956) studied natural head position in order to refine orthodontic diagnosis, because he had found that the radiographic facial angle of some patients did not relate to clinical observation. His conclusion was that occasional discrepancies between cephalometric facial typing and photographic facial typing disappear when an adjustment is made for those persons who do not have a level Frankfort plane.

MOORREES AND KEAN (1958) tested the hypothesis that the natural head position of individuals is relatively constant over time. They found a standard deviation 2.05° for the differences between two successive measurements of the angulation of S-N to vertical in 66 young adult females.

They observed that the relationship of the intracranial reference lines to vertical within the sample varied more than the registration of natural head position of one person recorded at two different times.

They also stated that obtaining cephalometric radiographs in natural head position, and using the true vertical line for reference purposes, was just as reproducible as the routine use of such lines as the Frankfort horizontal or the S-N line. They observed that two individuals may have similar profiles when standing in natural head position, yet have very different internal anatomy as described by conventional cephalometric analysis.

More recently, Fränkel (1980) has presented a similar idea in which a grid registered on the radiographic image of the occipital bone is used in cephalometric analysis. The horizontal baseline of this grid is parallel to true horizontal, and the radiograph is oriented in the patient's natural head position through the use of clinical photographs. Fränkel states that poor postural behavior must be regarded as a major contributory factor to skeletal maldevelopment. He questions whether cephalometrics can provide the information needed to evaluate the relationship between functional factors and skeletal development, and therefore recommends a clinical analysis of facial type and postural behavior of the orofacial musculature.

Woodside and Linder-Aronson (1979) report on radiographs taken of 16 children in standing natural head position before and after adenoidectomy, and similarly on 16 controls. On the basis of the inclination of the S–N line to a vertical reference chain in the radiographic field, they found that mouthbreathers had a significantly lower S–N/V angle. This indicates that their head posture was more extended, or bent backward, than it was in the controls. That difference between groups could no longer be found one month after adenoidectomy.

In a study evaluating the effect of total nasal obstruction on head posture, Vig et al. (1980), using thirty young adults, found that nasal obstruction resulted in progressive extension of the head relative to a gravity-defined vertical.

One of the first to describe the relationship of intracranial anatomy to the posture of the head was Björk (1955). Solow and Tallgren (1976) later described associations between craniofacial morphology and the posture of the head and cervical column. They found the extension of the head in relation to the cervical column to be moderately correlated with a large anterior and small posterior facial height, small anteroposterior craniofacial dimensions, large inclination of the mandible to the anterior cranial base and to the nasal plane, facial retrognathism, a large cranial base angle, and a small nasopharyngeal space.

In an investigation on children, Posnick (1978) found extension of the head in relation to the cervical column associated with a large anterior face height, a small anteroposterior craniofacial dimension, facial retrognathism, steep inclination of the mandible to the palatal plane, large anterior dental height, and small inclination of the lower incisors to the mandibular plane. Radiographs were taken with the children in standing natural head position without head support.

The major studies of natural head position are compared in Table 1.

— Materials and Methods —

The initial sample consisted of 55 adult females presenting for evaluation for orthognathic surgical correction of severe malocclusion. Selection criteria included age over 15 years, female, no congenital deformity, no traumatically induced deformity, no myofascial pain dysfunction syndrome, and no previous history of head or neck surgery.

Cephalometric radiographs incorporating natural head position were a part of the evaluation. Eliminating those with inadequate radiographic records reduced the final sample to 43 radiographs that met research standards. All radiographs were taken by the same technician.

The age distribution of the sample is shown in Table 2.

Table 1

Natural Head Position Studies

	N	Sex	Age	Body Position	Visual Target	S–N/V	S.D.
Moorrees and Kean (1958)	61	F	18–20	Seated	Mirror	85.0°	7.6
Solow and Tallgren (1971)	120	M	22–30	Standing	None	90.4°	5.2
	120	M	22–30	Standing	Mirror	87.4°	4.7
Posnick (1978)	78	MF	7–12	Standing	None	83.6°	4.8
Callahan (1982)	13	M	24–36	Standing	Distance	82.0°	3.7
Showfety (this study)	43	F	15–46	Standing	Distance	81.2°	4.6

Note: Values for S–N/V have been transformed to the definition in this study.

Natural Head Positioning Procedure

Angulation of the head is measured relative to a gravity-defined vertical reference chain on a radiograph taken in natural head position (NHP). The technique of positioning the patient and exposing the radiograph is described elsewhere (Showfety et al. 1983). Briefly, the head positioning procedure is:

1. Explain the procedure while casually observing the subject and attaching the fluid-level device to the subject's head.
2. Instruct the subject to step forward while looking out of a window at the other end of the hall.
3. Adjust the fluid-level device to center the bubble when the head is in natural posture.
4. Repeat steps 2 and 3 until a consistent head posture is established.
5. Reposition the subject in the cephalostat with the bubble centered, and expose the radiograph.

Cephalometric Landmarks Traced

Radiographic landmarks traced from the cephalometric film for use in the cephalometric analysis follow Riolo et al. (1974)

The points used are:

A Point A, the most posterior point (deepest concavity) on the curve of the maxilla between the anterior nasal spine and the crest of the dental alveolus.

ANS Anterior nasal spine.

Ar Articulare, the intersection of the images of the posterior border of the condyle neck and the basilar portion of the sphenoid.

B Point B, the most posterior point (deepest concavity) on the anterior surface of the symphyseal outline of the mandible.

Ba Basion, the inferior tip of the anterior margin of the foramen magnum.

Table 2

Age Distribution of the Sample

Age	15–19	20–24	25–30	30–34	35–39	40–44	45–46
Number	2	5	10	16	5	4	1

C Condylion, the most superior point on the curvature of the condyle head.

FH Frankfort horizontal, P–O.

Gn Gnathion, the most antero-inferior point on the contour of the symphysis.

Go Gonion, the midpoint of the angle of the mandible, located where it is crossed by the bisector of the angle formed by the line of the mandibular plane and the line formed by the posterior border up to Ar.

L1e Incisal edge of lower central incisor.

L1r Root apex of the mandibular central incisor.

L6 The most occlusal point on the buccal groove of the lower first permanent molar.

Me Menton, the most inferior point on the contour of the bony chin, relative to the mandibular plane.

N Nasion, the most anterior point at the frontonasal suture.

Occ Occlusal plane.

P Porion, the most superior point on the image of the bony external auditory meatus.

PNS Posterior nasal spine.

Pog Pogonion, the most anterior point on the bony chin.

O Orbitale, the most inferior point on the lower border of the orbit.

PTM Pterygomaxillary fissure (the most inferior point).

S Sella Turcica.

U1e Incisal edge of upper central incisor.

U1r Root apex of the maxillary central incisor.

U6 Mesial cusp tip of the maxillary first permanent molar.

V True vertical line, defined in the cephalometric radiograph by a weighted chain.

W The radiographic image of the ends of the wire imbedded in the fluid-level device.

Midpoints between right and left images were used to represent bilateral landmarks. Linear dimensions are represented by two cephalometric points joined by an arrow (→) Angles are represented by the three points defining the angle, separated by dashes, or the two lines defining the angle separated by a slash. Linear distances not measured directly between points are measured either parallel (h) or perpendicular (v) to the Frankfort plane (FH).

Tracings were made on frosted acetate film with a 0.5mm lead pencil, and landmarks identified by a circled dot. Angular measurements were made with a protractor to the nearest 0.5°, and linear measurements with a dial caliper to the nearest ¼ millimeter. All tracings and measurements of lateral cephalometric radiographs were done and rechecked at a later date by one operator (K.S.).

Method Error

The methods used to reduce variations in technique in this study are similar to those of SOLOW AND TALLGREN (1971).

However, good radiologic hygiene practice does not permit double determination procedures for the natural head position radiography, since that would offer no patient benefit. All radiographs taken in this study were required in the normal course of diagnosis. These same considerations are the reason for the rejection of 12 of the group of 55 initially selected for study.

The method of double determination could still be used to establish the method error for the measurement of the radiographs. Ten lateral head films were traced and measured twice, at least two weeks apart.

The standard error of the tracing method was similar to that reported by other workers (RICHARDSON 1966, BAUMRIND 1971 AND SOLOW 1976).

Statistical Analysis

Hypothesis testing for correlational analysis is done against the assumption that there is no correlation between two variables. The null hypothesis is that $r=0$, indicating that the correlation coefficient for the population is zero.

The level of significance between groups, and for Pearson product-moment correlation coefficients, was set at the $r=.01$ level. This implies that of the 58 comparisons in this study at the .01 level of confidence, it can be expected that about one of the resulting correlations could demonstrate statistical significance due solely to chance.

Lower correlations, not considered significant, will be discussed when they support other significantly higher correlations. Correlations approximating r=0.45 are considered clinically significant, because at this level NHP would account for approximately 20% of the variability of the anatomic measurement under discussion.

Head Extension and Head Flexion Groups

Posnick (1978) used the self-balanced head position, while Callahan (1982) used a distant visual target to orient the head. They reported mean S–N/V angles of 83.6° and 82.0° respectively.

The value of 82° was used in the current study as the division point between "high" and "low" S–N/V values.

Those with low S–N/V values are referred to as *head extenders,* and those with values above 82° as *head flexers.* The term *extension* of the head is used to denote a head-up posture with steep angulation of the anterior cranial base to the true vertical reference chain. The term *flexion* denotes the head-down posture with anterior cranial base more horizontal.

Each morphologic variable was compared between the two groups, using the two-tailed unpaired Student's t-test. The null hypothesis tested was that for each of the morphologic variables the extension group is drawn from a population whose mean value for that variable is equal to that of the population from which the flexion group was drawn. The level of significance was set at .01 for all tests because of the number of analyses performed.

— Results —

Posnick's (1978) study of craniofacial morphology and head posture in male and female children showed variations in the relationships of these variables with age and sex. In the present study, age and sex were standardized in selecting a sample limited to white females over 15 years of age.

A measure of reliability was included in this study to indicate the accuracy of repositioning the subject in the cephalostat. The wire in the fluid-level device should be oriented exactly 90° to the true vertical reference chain with the patient properly positioned in the cephalometric head holder. This angle was measured on average to be 90.2° with a standard error of 0.13° and a 4.0° range.

The results presented in this study are derived from the measurement of lateral cephalometric radiographs of the 43 white female adults studied. Two postural and 31 craniofacial morphologic variables were analyzed.

Findings from the statistical analyses based on the relationships between the S–N/V angle and craniofacial cephalometric features are shown in Tables 3 through 6, presenting postural, anteroposterior, and vertical variables in that order.

Postural Variables

The descriptive statistics for the postural variables S–N/V and FH/V are listed in Table 3. Measurements of anterior cranial base angulation to the true vertical reference (S–N/V) exhibited a bell-shaped curve with an 81.2° mean, with 4 subjects exhibiting an 82° value that precluded their classification as either extenders or flexers.

The postural variable FH/V had an overall sample mean of 90.6° ±3.4° (standard deviation). The extension

Table 3

Head Posture Measurements
Total Sample

	Min	Mean±S.D.	Max	S.E.	Var
S-N/V	74.0	81.2±4.59	92.0	0.70	21.0
FH/V	85.0	90.6±3.43	100.0	0.52	11.7

Table 4

Anteroposterior Measurements
Total Sample

	Mean±S.D.	S.E.	Range	Var
S-N-A	80.34±3.71°	0.56	21.0	13.8
S-N-B	77.39±5.09°	0.77	18.0	25.9
S-N-Pog	78.83±5.01°	0.76	18.0	25.1
S-N-Ba	131.04±5.21°	0.79	25.0	27.1
U1e-U1r/PNS-ANS	114.41±8.65°	1.31	37.0	74.8
L1e-L1r/Go-Me	87.74±9.50°	1.44	44.0	90.2
Co→S (h)	9.87±3.44mm	0.52	18.0	11.8
Co-Gn	116.55±8.42mm	1.28	42.0	71.0
Co-ANS	86.97±5.18mm	0.79	26.0	26.8
PTM→ANS	54.67±3.24mm	0.49	16.0	10.5
U6→L6	2.44±5.33mm	0.81	20.0	28.4
U1e→L1e (h)	5.39±6.66mm	1.01	27.0	44.3
PNS→A	47.88±3.00mm	0.45	13.0	9.0
N-S-Co	127.25±7.77mm	1.18	34.0	60.3

subgroup showed a mean of 88.7°±2.1°, while the mean for the flexion subgroup was 93.5°±3.4° (Table 6).

Anteroposterior Measurements

The S-N-A angle showed a low positive correlation with S-N/V at the .01 level of confidence (Table 5). This measurement demonstrated a statistically significant difference at the .001 level between the extenders (S-N-A mean 78.9°) and flexers (S-N-A mean 82.8°) (Table 6).

The position of the maxilla relative to the head of the mandibular condyle as measured by Co→ANS showed an overall mean of 87.0mm±5.2mm. This variable showed no statistically significant differences between extenders and flexers, and no correlation with S-N/V.

Table 5

Correlation of Anteroposterior Measurements with S-N/V

	Correlation Coefficient	Probability>R ρ=0
P→O	0.29	0.05
FH/V	0.82	0.0001
S-N-A	0.29	0.05
S-N-B	0.62	0.0001
S-N-Pog	0.62	0.0001
S-N-Ba	−.07	0.61
S-N-Co	−.06	0.61
U1e-U1r/PNS-ANS	−.03	0.83
L1e-L1r/Go-Me	−.09	0.54
Co→S (h)	−.02	0.85
Co→Gn	0.33	0.02
Co→ANS	0.03	0.81
PTM→ANS	−.04	0.75
U6→L6	−.48	0.001
U1e→L1e (h)	−.43	0.003
PNS→A	0.04	0.77

Table 6

Anteroposterior Measurements of
Head Extension and Head Flexion Groups

	Group	Mean±S.D.	S.E.	Prob>T
S–N/V	Ext	77.82±2.28	0.47	.0001
	Flx	85.87±3.22	0.80	
FH/V	Ext	88.69±2.09	0.43	.0001
	Flx	93.50±3.38	0.84	
S–N–A	Ext	78.86±3.22	0.67	.001
	Flx	82.81±3.56	0.89	
S–N–B	Ext	75.13±3.60	0.75	.0003
	Flx	81.18±4.95	1.23	
S–N–Pog	Ext	76.52±3.87	0.80	.0002
	Flx	82.56±4.71	1.17	
S–N–Ba	Ext	131.47±4.48	0.93	.54
	Flx	130.31±6.62	1.65	
U1e–U1r/PNS–ANS	Ext	115.30±8.90	1.85	.73
	Flx	114.37±8.07	2.01	
L1e–L1r/Go–Me	Ext	87.86±10.4	2.17	.79
	Flx	88.68±8.73	2.18	
Co→S (h)	Ext	10.02±2.51	0.52	.44
	Flx	9.12±4.14	1.03	
Co→Gn	Ext	115.82±8.13	1.69	.44
	Flx	118.06±9.37	2.34	
Co→ANS	Ext	86.56±4.09	0.85	.67
	Flx	87.37+6.80	1.70	
PTM→ANS	Ext	54.30±3.16	0.66	.56
	Flx	54.93±3.51	0.87	
U6→L6	Ext	3.13±5.11	1.06	.12
	Flx	0.37±5.50	1.37	
U1e→L1e (h)	Ext	1.86±4.23	0.88	.32
	Flx	0.37±4.80	1.20	
PNS→A	Ext	47.30±3.16	0.66	.33
	Flx	48.25±2.79	0.69	
S–N→Co	Ext	129.21±5.66	1.18	.14
	Flx	124.93±0.28	2.57	

Ext = head extension group (N=23)
Flx = head flexion group (N=16)

Anteroposterior Maxillary length

No correlation with S–N/V was found for the distance from the pterygomaxillary fissure to the anterior nasal spine, or for the distance from the posterior nasal spine to point A. There was also no significant difference between the flexers and extenders.

Anteroposterior Mandibular Position

The two measures of anteroposterior mandibular position, S–N–B and S–N–Pog, both showed moderate correlations with the anterior cranial base angulation to true vertical (S–N/V). These two correlations (r=.628) were significant at the .0001 level.

Both showed significant differences between extenders (S–N–B mean 75.1°) and flexers (S–N–B mean 81.1) at the .001 level.

Anteroposterior Mandibular Length

Mandibular length measurements, such as Co→Gn, yielded lower insignificant correlations (r=.21). Likewise, there was no significant morphologic difference between the extenders (mean 111.9mm) and flexers (mean 111.0mm). No correlation was found between the gonial angle and S–N/V (r-.09).

Like the maxilla, the mandible seems to vary more in position than in size when related to anterior cranial base angulation.

Anteroposterior Condyle Position

The mandibular positional difference between groups could be due to the position of the condyle. To test for this, anteroposterior measurements of the point Condylion were measured relative to sella (Co→S(h)), but these showed no correlation with the S–N/V variable (r=–.02). Nor was any significant difference found between the Co→S(h) measurement in the extension and flexion groups.

There was also no correlation between S–N–Co and S–N/V for the group as a whole (r=–.06), and no anatomical difference between flexers and extenders.

Anteroposterior Dentoalveolar Measurements

The proclination of the maxillary central incisors as measured by the U1e–U1r/ANS–PNS had a mean value of 114.4°±8.65°. There was no significant difference in this variable between the extension and flexion subgroups, and no correlation with S–N/V.

Mandibular incisor proclination as measured by L1e–L1r/Go–Me was 87.7°±9.5°. There was no significant difference between extension and flexion subgroups and no correlation with the angle S–N/V.

The mean incisor overjet (U1e→L1e(h)) was 5.4mm±6.7mm. This variable also showed no statistically significant difference between the extension and flexion subgroups, but there was a moderate negative correlation with S–N/V for the group as a whole (p=.03).

The U6→L6(h) variable measuring the anteroposterior molar discrepancy shows a 2.4mm±5.33mm mean. Even though a moderate negative correlation was found for the group as a whole, there was no statistically significant difference between the extension and flexion subgroups.

Anteroposterior Flexure of the Cranial Base

The S–N–Ba angle is an indicator of the anteroposterior orientation of the posterior cranial base. This measurement showed a group mean of 131.0°±5.2°, with no differences between extension and flexion subgroups and no correlation with the angle S–N/V.

Vertical Measurements
(Tables 7-9)

Posterior Face Height

None of the indicators of posterior face height, including S→PNS(v), PNS→Go, Co→Go, and Co→S(v), showed significant correlation with S-N/V or a difference between extenders and flexers.

Anterior Face Height

The distance from the anterior nasal spine down to menton (ANS→Me) shows no correlation (r=.04), and no difference between subgroups of extenders and flexers.

However, the distance between nasion and the anterior nasal spine (N→ANS) shows a low negative correlation (r=−.34) not significant at the .01 level.

More significantly, there was an anatomical difference between extenders (mean 54.1mm) and flexers (mean 51.8mm), which is significant at the .002 level. This indicates a 2.2mm difference for N-ANS between the extension and flexion groups.

Angulation of the palatal plane, ANS-PNS/S-N showed a very low negative correlation with S-N/V (r=−.25), with no significant difference between the extension and flexion subgroups.

No significant correlations with S-N/V, or differences between flexers and extenders, were found for S-N/Go-Me, ANS-PNS/Occ, ANS-PNS/Go-Me, or ANS-PNS/FH.

Vertical Dentoalveolar Dimensions

The group mean for the perpendicular distance from the tip of the maxillary central incisor to the anterior nasal spine (U1e→ANS(v)), was 28.8mm±3.7mm. There was a low negative correlation with S-N/V for the group as a whole, but no statistically significant difference was found between the extension and flexion subgroups.

The mean perpendicular distance from lower incisor edge to menton (L1e→Me(v)) was 40.8mm±3.4mm for the total sample. This measurement showed a negative correlation with S-N/V at the 0.001 level of significance, and a

Table 7

Vertical Measurements
Total Sample

	Mean±S.D.	S.E.	Range	Var
S-N/FH	9.04±2.51°	0.38	12.0	6.3
S-N/Go-Me	38.58±7.48°	1.14	31.0	56.0
S-N/PNS-ANS	7.39±3.07°	0.46	13.0	9.4
PNS-ANS/FH	7.88±4.31°	0.65	17.0	18.6
PNS-ANS/Go-Me	31.06±7.72°	1.17	34.0	59.7
Ar-Go-Me	125.76±7.52°	1.14	35.0	56.6
Co→S(v)	18.19±3.06mm	0.46	14.0	9.4
Co→Go	58.62±6.31mm	0.96	29.0	39.9
N→ANS	53.37±2.60mm	0.39	10.0	6.7
ANS→Me	67.37±7.24mm	1.10	35.0	52.5
S→PNS	43.41±2.62mm	0.40	12.0	6.9
PNS→Go	32.67±5.23mm	0.79	24.0	27.4
U1e→ANS	28.81±3.74mm	0.57	17.0	14.0
L1e→Me	40.79±3.44mm	0.52	17.0	11.9
U1e→L1e(v)	1.65±4.57mm	0.69	18.0	20.9

significant 4.2mm mean difference between the extension and flexion subgroups.

Vertical overbite showed no significant correlation or subgroup difference.

— Discussion —

There is a conceptual pitfall in extrapolating from mean trends to an individual patient.

The main subgrouping of the data in the present study is the division into high and low S–N/V angle groups. This reveals some clinically and statistically significant differences in bony anatomy between group averages.

These differences are consolidated and illustrated in Fig. 1, which shows a composite of the two subgroup mean tracings superimposed on the anterior cranial base line S–N. The solid line indicates the mean anatomy of the high S–N/V angle (more horizontal) group, and the broken line the low S–N/V angle group.

In general, the low S–N/V angle group

Table 8

Vertical Measurements of Head Extension and Head Flexion Groups

	Group	Mean±S.D.	S.E.	Prob>T
S–N/FH	Ext	10.17±2.30	0.48	.0028
	Flx	7.75±2.29	0.57	
S–N/Go–Me	Ext	41.00±7.43	1.55	.01
	Flx	34.81±6.65	1.66	
S–N/PNS–ANS	Ext	8.26±2.97	0.61	.06
	Flx	6.50±2.68	0.67	
PNS–ANS/Occ	Ext	8.43±4.82	1.00	.29
	Flx	6.93±4.02	1.00	
Ar–Go–Me	Ext	126.13±8.76	1.82	.76
	Flx	125.37±6.65	1.66	
PNS→ANS	Ext	32.86±8.35	1.74	.03
	Flx	27.93±5.88	1.47	
Co→S(v)	Ext	18.02±2.56	0.53	.36
	Flx	19.93±3.39	0.84	
Co→Go	Ext	58.65±6.84	1.42	.56
	Flx	59.81±5.54	1.38	
N→ANS	Ext	54.08±2.60	0.54	.005
	Flx	51.87±2.06	0.51	
ANS→Me	Ext	68.56±7.56	1.57	.29
	Flx	66.06±6.86	1.71	
S→PNS	Ext	43.00±2.27	0.47	.75
	Flx	43.25±2.59	0.64	
PNS→Go	Ext	32.47±5.99	1.24	.21
	Flx	34.25±2.51	0.62	
U1e→ANS	Ext	29.47±3.64	0.75	.07
	Flx	27.37±3.34	0.83	
L1e→Me	Ext	42.00±3.34	0.69	.0028
	Flx	38.81±2.83	0.70	
U1e→L1e(v)	Ext	1.86±4.23	0.88	.32
	Flx	0.37±4.80	1.20	

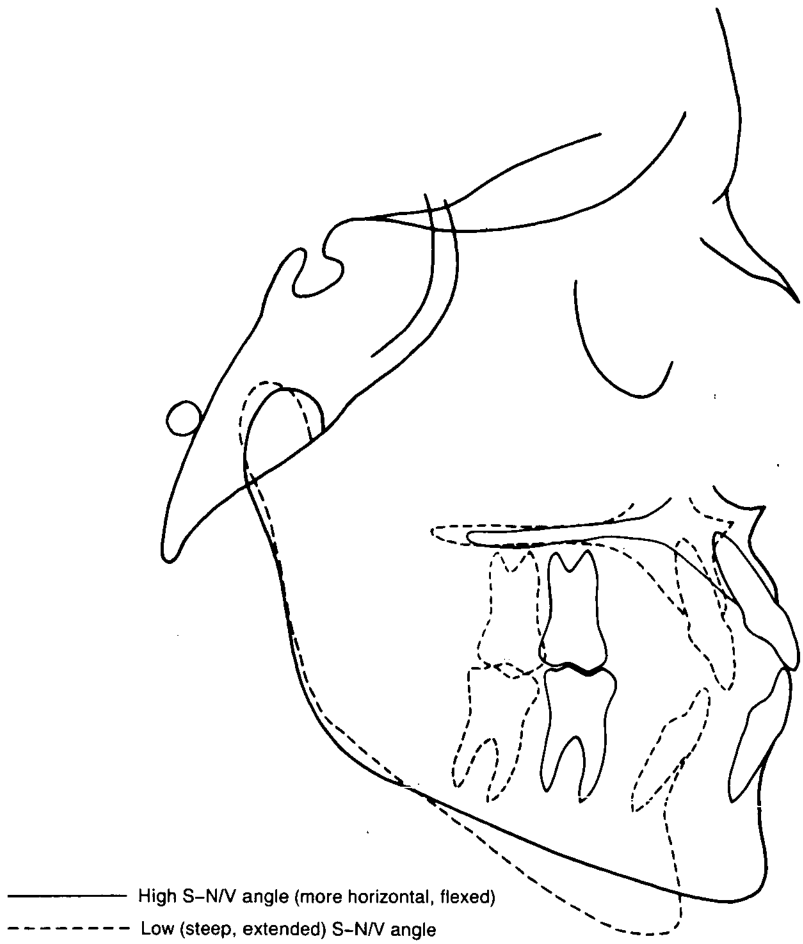

Fig. 1 Mean anatomy of high S–N/V (more horizontal, flexers) and low S–N/V (more vertical, extenders) subgroups, superimposed on S–N. In average natural posture, the face in the broken-line image would be rotated upward.

displayed a large anterior midfacial height, steep inclination of the mandible to the anterior cranial base, facial retrognathism, and large lower anterior dental height. In general, the high S–N/V angle group exhibited the opposite anatomical tendencies. These results are similar to those found by other researchers, and are compatible with the concept of a biologic relationship.

Suggestions for Future Research

These data raise some interesting biologic questions with profound orthodontic relevance. For example —

- Does nasopharyngeal surgery to facilitate respiration affect posture and growth changes?
- If bone morphology is environmentally influenced, can one modify a patient's craniofacial growth by modifying posture?
- If head posture remains constant during growth, can head posture values be used in a regression equation to more reliably predict future growth?

Table 9

Correlation of Vertical Measurements with the S–N/V Angle

	Correlation Coefficient	Probability > R ρ=0
S–N/FH	−.52	0.0002
S–N/Go–Me	−.33	0.02
S–N/PNS–ANS	−.25	0.1
PNS–ANS/Occ	−.13	0.37
PNS–ANS/Go–Me	−.25	0.09
Ar–Go–Me	0.09	0.54
Co→S(v)	−.16	0.29
Co→Go	0.24	0.11
N→ANS	−.34	0.02
ANS→Me	−.15	0.32
S→PNS	0.03	0.82
PNS→Go	0.04	0.78
U1e→ANS	−.29	0.05
L1e→Me	−.48	0.001
U1e→L1e(v)	−.21	0.16

— Summary —

Subgroups based on the angulation of S–N to vertical in normal head posture showed significant differences in the angles S–N–A, S–N–B and S–N–Pog, and the linear measurements N→ANS(v), and L1e→Me(v)

Significant correlations were found between natural head posture and angles S–N–B and S–N–Pog, and linear measurements of U6→L6, and L1e→Me.

— Conclusions —

Natural head position can be reliably determined and recorded on a standard cephalometric radiograph by using with a simple fluid-level device and a standardizing technique.

The interactions of form and function during growth are at best difficult to measure, but this approach may produce some new information regarding the temporal sequence of structural and postural changes.

The angulation of S–N to vertical in natural posture is associated with mandibular position as measured cephalometrically. Further investigation of the determinants of posture and bony morphology are necessary to explain the mechanism of this form-function interaction.

A/O

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