

CONTINUING EDUCATION ARTICLE

Fifteen-year reproducibility of natural head posture: A longitudinal study

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Natural head posture continues to be widely used as the logical reference position for the evaluation of craniofacial morphology. The basic underlying premise is that the long-term clinical reproducibility (variability) of natural head posture is significantly less than the variability of conventional reference planes with respect to the vertical. This study reports the 15-year longitudinal reproducibility of natural head posture. Twenty Chinese adults in Hong Kong, who had initial natural head posture radiographs at age 12 years, were followed up and had repeated cephalograms after 15 years. The method error (reproducibility) after 15 years was 2.2°, which compared favorably with the 5-year reproducibility (method error = 3.0°) and the 5 to 10 minutes reproducibility (method error = 1.9°). The individual variability of natural head posture reproducibility increased slightly over time. After 15 years the variance of natural head posture (4.8° [= 2.2²]) remains significantly less than the variance of intracranial reference planes to the vertical (25° to 36°). Cephalometric analyses based on natural head posture therefore remain valid over time. (*Am J Orthod Dentofacial Orthop* 1999;116:82-5)

Natural head posture (NHP) has been shown to be correlated to craniofacial morphology,¹⁻³ to future growth trends,⁴ and to respiratory needs.^{5,6} Currently, NHP is being increasingly used as the logical reference and orientation position for the evaluation of craniofacial morphology and the publication of illustrations.⁷⁻¹¹ NHP orientation has twin benefits. The true horizontal reference plane in NHP is a less variable reference plane in the short-term than conventional cephalometric reference planes,^{8,11-15} and variables based on NHP better describe true-life appearance.⁷⁻¹²

Underpinning these potential clinical benefits of routine recording of NHP lateral cephalometric radiographs is the long-term clinical reproducibility of NHP. The previous evidence is equivocal, with no previous longitudinal study having monitored untreated "orthodontic-age" children into adulthood. The hypothesis that NHP is stable over time was supported by Tallgren et al,¹⁶ by Tallgren and Solow,¹⁷ and by Chow et al,¹⁸ but not by Fränkel,¹⁹ or by Ferrario et al²⁰ Fränkel's sample included children who were treated with functional appliances and the data may have been distorted by postural changes caused by the appliances

and resulting from alterations in muscle activity and in respiration. Daly et al,²¹ for example, found that the fitting of a bite-opening device was followed by an extension of the head. The studies of Tallgren et al¹⁶ and Tallgren and Solow¹⁷ evaluated adult complete denture wearers, whereas studies by Chow et al¹⁸ provided cross-sectional data that may have masked individual variations. Previous studies of NHP reproducibility were of only 6 months' duration or less.^{1,8,12,13,15,22-25}

Cooke²⁶ reported in a 5-year longitudinal study that NHP reproducibility deteriorated slightly over time but showed signs of stabilizing after 1 to 1½ years. The method error was 1.9° after 1 to 2 hours, 2.3° after 3 to 6 months and 3.0° after 5 years. The individual variability of NHP was shown in this study to increase after 5 years. It is not known if NHP reproducibility would worsen after 5 years, and it is therefore not known if cephalometric analyses based on NHP remain valid over time.

This current study quantifies the 15-year reproducibility of NHP using a longitudinal sample of 12-year-old Chinese children initially recorded in NHP in 1982 as part of an overall dental health study.

SUBJECTS AND METHODS

The Sample

A total of 618 randomly selected 12-year-olds in Hong Kong were first assessed in NHP in 1982. The lateral cephalometric radiographs were recorded as part of an overall health survey, and all subjects were

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offered comprehensive care, including orthodontic, treatment.^{10,11} Five years later, 30 subjects who returned for treatment, had the NHP radiographs repeated.²⁶ In this current study, 20 further subjects returned for orthodontic assessment after 15 years and had updated cephalograms recorded in NHP (10 males and 10 females). All subjects signed an informed consent, and the protocol was approved by the relevant ethical committee.

Cephalometric Technique and Natural Head Posture

All recordings were performed with the subjects in the standing orthoposition NHP with a mirror eye reference as previously described.^{10,11,26} No individual radiographs were repeated.

Tracing Technique and Statistical Analysis

The angle between the sella-nasion line and the true vertical (SN/Vert) was used to assess the reproducibility of the head posture (Fig. 1). As growth also occurs over time, long-term studies require careful method control to prevent growth changes from distorting the reproducibility findings. For the short-term repeat films recorded up to 6 months later, the pairs of radiographs were superimposed on the sella turcica and nasion areas, and the landmarks S and N were transferred from the initial to the repeat film by the method originally described by Moorrees and Kean.¹² Because of the growth at sella turcica and in the nasion region, a superimposition technique based on the “best fit” of anterior cranial base structures was used for the repeat film pairs involving recordings made between 1 year and 15 years. This superimposition method has been described by Björk and Skieller²⁷ and has been used in a related study reported by Solow and Siersbæk-Nielsen.⁴

The SN-to-vertical angle was measured by hand with a large protractor to the nearest 0.5°. ^{10,11,26} Dahlberg’s formula

$$\text{Method Error} = \sqrt{\frac{\sum d^2}{2n}}$$

was applied to the difference between the initial and the repeat radiographs for each subject. The paired *t* test was used to determine whether any significant changes in NHP had occurred.

RESULTS

Error of the Method (Table I)

Method errors found from independent repeat tracings (*n* = 10) are summarized in Table I. Errors were larger than for the short-term repeats as growth affected the superimpositions but were smaller than for the 5 year repeats and smaller than in a compar-

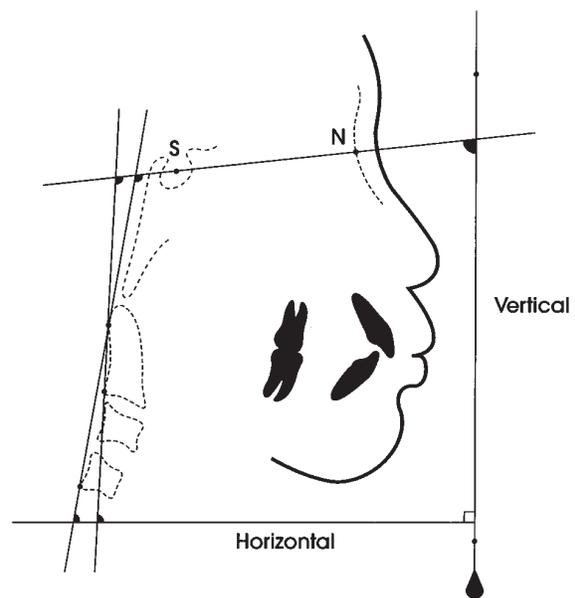


Fig 1. Angle SN to the true vertical used to assess NHP and its changes over time on repeated cephalometric recordings.

ble computerized study.⁴ No systematic errors were detected.

Reproducibility of Natural Head Posture (Table II)

No significant inter-sex differences were found, and the male and female data were combined in Table II. The overall method error (reproducibility) after 15 years was 2.2°, which was less than the method error after 5 years (3.0°). The mean change of SN/Vert (1.18°) was similar to that after 5 years (1.22°) and indicated that, on average, the subjects looked down slightly relative to the original NHP recordings.

The individual overall variability of the head posture (SD = 4.3°) was similar to that after 5 years (4.2°). The range was -4.5° to 6.5° but only 2 of 20 subjects showed NHP changes of 5° or more after 15 years. The 15 year head posture reproducibility therefore compared well to the original repeat recordings after 5 to 10 minutes and to the later repeats after 5 years (Table II).

DISCUSSION

Long-term evaluation of head position, based on measurement of the S-N line to the true vertical (SN/Vert) is complicated by the possible effects of growth. To minimize the effects of growth at sella turcica and in the nasion region, a superimposition technique based on “best fit” of anterior cranial base structures was used, as previously used and described by Solow and Siersbæk-Nielsen⁴ and by Cooke.²⁶ The

Table I. Method errors for the tracing and superimposition techniques used to evaluate changes in NHP on repeat radiographs

Time between cephalometric recordings	Superimposition method	Method error (Dahlberg 1960)* (°)
5-10 Mins	Best fit on sella-nasion area (Moorrees and Kean ¹²)	0.23 (n = 30)
5 Years	Best fit on anterior cranial base structures (Solow and Siersbæk-Nielsen ⁴)	0.95 (n = 30)
15 Years	Best fit on anterior cranial base structures (Solow and Siersbæk-Nielsen ⁴)	0.70 (n = 10)

The original technique had to be modified to allow for the effects of growth between the radiographic recordings.

$$*ME = \sqrt{\frac{\sum d^2}{2n}}$$

Table II. Reproducibility of NHP over time

Time between films	n	Sex	Mean change in SN/Vertical on repeat film (°)	SD(°)	SE	t Value	P Value	Significance of change in head posture	Method error of changes in head posture (reproducibility) (°)
4-10 Minutes	30	15 M 15 F	+0.37	2.21	0.40	0.91	.37	NS	1.88
1-2 Hours	30	15 M 15 F	-0.92	2.61	0.48	1.92	.07	NS	1.93
3-6 Months	15	4 M 11 F	+1.27	3.16	0.81	1.55	.14	NS	2.34
1-1 1/2 Years	10	6 M 4 F	+2.65	3.28	1.04	2.56	.03	P < .05	2.89
2-4 Years	11	6 M 5 F	+2.90	3.96	1.19	2.44	.04	P < .05	3.37
5 Years	30	15 M 15 F	+1.22	4.20	0.77	1.59	.12	NS	3.04
15 Years	20	10 M 10 F	+1.18	4.32	0.97	1.75	.10	NS	2.23

The actual reproducibility is expressed as the method error ($ME = \sqrt{\frac{\sum d^2}{2n}}$, Dahlberg 1940) for the mean angle between the initial and repeat series of radiographs.

A positive value indicates that the subjects "looked down" more, on average, for the repeat film.

method error after 15 years (0.7°) was acceptable and was less than previously reported after 5 years (0.95°). However, it was still not possible to fully differentiate changes from growth from changes due to posture. Athanasiou²⁸ evaluated the reproducibility of superimposition on different cranial structures and confirmed that superimposition on cranial base structures had the greatest reproducibility.

Since the concept of natural head posture (NHP) was introduced into the orthodontic literature in the 1950s,^{12,22} many studies have advocated its use in cephalometric analysis.^{1-7,10} Most studies infer that NHP is a single, static position whereas, in fact, NHP, like any body posture, is a small range of positions. Both Fränkel¹⁹ and Lundström²⁹ have supported this concept of NHP as a small range of positions oscillating around a mean posture.

In this present study, NHP has been shown to be remarkably reproducible even after 15 years. In fact, the reproducibility (method error) after 15 years (2.2°) was smaller than after 5 years (3.0°). The short-term reproducibility has been confirmed by other researchers.^{1,8,12,15,29} However, Ferrario,²⁰ using an integrated photographic/radiographic technique, found

NHP to be highly variable and gender dependent. It is not known why the method error reduced between 5 and 15 years. Perhaps older subjects could follow instructions easier or perhaps overall body posture is slightly more stable in older persons.

A feature of NHP reproducibility is the individual variability. The standard deviation (ie, variability) increased slightly over time. It was 2.6° after 2 hours, 4.2° after 5 years, and 4.3° after 15 years (Table II). The change from 5 years to 15 years was not significant. The range in NHP after 15 years was -4.5° to 6.5° but 18 of the 20 subjects showed NHP changes of less than 5° between the initial recording and the repeat radiograph 15 years later. The mean NHP change in SN to the true vertical (SN/Vert) was only 1.2° after 15 years. Overall, this indicates an acceptable individual variability in NHP over time.

In this study, no significant inter-sex differences were found and this confirms the findings previously reported by Cooke.^{10,26} However, one interesting finding in this study was that the mean change (SN/Vert) of NHP after 15 years in males (-0.1°) was smaller than in the females (mean change 2.4°). This means that the females "looked down" more after 15 years. This was different from the

findings of Solow and Tallgren^{3,30} and of Cooke.²⁵ These authors reported that the males “looked up” more (by 3° and 2° respectively) in the repeat recordings whereas no differences were reported in females. Weight differences between males and females were not evaluated in this study, but may be a factor in explaining these observed intergroup differences.

The standard deviation of conventional intracranial cephalometric reference planes (eg, Frankfort, Palatal, S-N) to the true vertical and to each other is 5° to 6°^{8,14,25,30} with a variance of 25° to 36° (SD²). In order to serve as a less variable reference plane, the variance of NHP would need to be significantly less. The variance, (ie, the method error)² of NHP is 9° after 5 years and 5° after 15 years. Quite clearly, NHP (and the true vertical) represents a more reliable (ie, less variable) reference plane for cephalometric analysis, even after 15 years, than the conventional intracranial reference planes.³¹ This study therefore provides evidence, for the first time, of the long-term benefits of NHP cephalometric analysis.

CONCLUSIONS

In this longitudinal study, NHP has been shown to be remarkably reproducible even after 15 years. The reproducibility (method error) of NHP after 15 years (2.2°) compared favorably with the 5 years (method error 3.0°) and the 5 to 10 minutes (method error 1.9°) reproducibility.

A feature of NHP reproducibility is the individual variability. The SD after 15 years (4.3°) was, however, found to be similar to that observed after 5 years (4.2°). Only 2 of 20 subjects showed NHP changes after 15 years of more than 5°. Overall, this indicates an acceptable individual variability in NHP over time.

The variance NHP after 15 years was found to be 4.8° (= 2.2²), and this remains significantly less than the variance of intracranial reference planes to the vertical (25° to 36°). Cephalometric analyses based on natural head posture therefore remains valid over time.

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