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The Relationship Between Estimated and Registered Natural Head Position

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ABSTRACT

Objective: To study the inherent relationship between registered and estimated natural head position and further explore the nature of natural head position.

Materials and Methods: Thirty-one pretreated patients were included in this study. Both registered natural head position (RNHP) and estimated natural head position (ENHP) were obtained. For RNHP, mirror orientation was used to help to adjust the subject's head position. For ENHP, two approved standard photographs were studied by the assessors before estimation. Correlation analysis was used to analyze the relationship between two angles: Rphoto/Rxray and Ephoto/ Eray.

Results: A significant correlation was found between RNHP and ENHP, both on the photographs and on the cephalograms.

Conclusion: There is a strong correlation between RNHP and ENHP. RNHP is the subjective perception of the subject and gets some objective meaning by mirror orientation. ENHP is the subjective perception of assessors and gets objective meaning by a standardization session in advance. The mirror orientation of RNHP and the advance standard study of ENHP are crucial for validity and accuracy of NHP as an extracranial reference plane.

KEY WORDS: Registered natural head position, Estimated natural head position.

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INTRODUCTION Return to TOC

Experienced orthodontists know that conventional cephalometric results, especially individual numbers, can sometimes be misleading in the diagnosis of craniofacial discrepancies. One of the inherent reasons for this is that traditional cephalometric methods usually rely on intracranial reference lines. The landmarks defining these lines are subject to change undoubtedly during growth and may vary greatly among different persons.

Downs,[1] in one of his articles introducing three different persons with nearly the same photographic facial typing, or profile, disclosed different cephalometric facial typing because of the variation in the cant of the Frankfort horizontal plane. Björk[2] demonstrated similar discrepancies in one of his studies in which two Bantus with almost identical profile showed remarkable variation in the inclination of the cranial base.

A rather reliable and stable referent plane is required when one hopes to accurately compare abnormal with normal subjects or to study what has happened during treatment. This is especially vital in long-term craniofacial growth and development research. An extracranial referent plane, such as natural head position (NHP), may be able to overcome this problem. NHP is a standardized position of the head in an upright head posture with the eyes focused on a point in the distance at eye level.[3,4] Actually, NHP appeared earlier than any intracranial reference plane. Before the invention of the cephalostat, NHP was used by anthropologists to study dry skulls.[4] It was first introduced to orthodontics in the 1950s for the study of craniofacial growth and treatment.[1,5,6] Its stability and reproducibility over both short and long time intervals has been proven by several research works, especially the longitudinal serial studies of Cooke.[7–9] In his studies, 20 of 618 adolescents went through 15 sequential years of observation from age 12 to 27 years and demonstrated that NHP is a reference line that has significant stability.

Another feature of NHP is that it represents the true life appearance of human beings, which gives it much realistic significance. When you actually treat a patient, you want to improve his or her profile and not just correct the numbers based on intracranial reference lines. Also, in the studies of craniofacial growth and development, if you reference this likely more stable straight profile, you will get a valid and more meaningful view of growth than just superimposing those serial records on not easily seen and more variable intracranial references.

Unfortunately, NHP seems to be difficult to obtain since nearly all cephalograms are taken with the Frankford plane parallel to the earth. There are two basic methods to getting the NHP. In the first method, the head of the patient is orientated to his or her NHP, and a mark or a plumb line is used as a registration point in the radiographs or photographs. NHP registered by this method is called registered natural head position (RNHP) and it is noted by the mark or the plumb line. In the second method, a patient's conventional cephalograms or lateral facial photographs have been taken and then rotated to their NHP under the judgment of an experienced specialist. NHP obtained by this method is named estimated natural head position (ENHP). For the former, a mark or a plumb line must be present before taking any radiographs and photos. Cephalograms and photos taken without such a mark by default have to use ENHP to determine NHP.

Despite the possibility for error based on the judgment of individual clinicians when using ENHP, research has demonstrated that the systematic and random differences between these clinicians are very small.[10–12] It has been said that ENHP gives a more natural head position and is a more reliable reference line than RNHP.[12–14] Others have pointed out that ENHP will be influenced by the facial form.[15] However, no one has touched on the essential characteristic of the relationship between them and the true essence of NHP. This article is

designed to address that question.

MATERIALS AND METHODS Return to TOC

Obtaining RNHP

Thirty-one patients were randomly chosen and agreed to participate in this research before starting their orthodontic treatment. The study protocol was reviewed and approved by the Institutional Review Board of Stomatological School of Peking University.

A method similar to that of Raju et al[16] was used to mark the NHP on the subject's lateral radiographs and photos. The method is as follows. (1) A mirror, 10 × 10 cm, is hung on the wall and can be moved vertically depending on the patient's height. A pair of footprints is printed on the ground 2 m away and opposite to the mirror. (2) The patient is asked to stand on the footprints facing the mirror, which is adjusted according to the patient's stature, with his or her head upright and relaxed while looking straight ahead into the reflection of his or her eyes. The patient is told to sway his or her head up and down several times to adjust and settle into this standard position. The patient's visual axis should be at eye level. (3) A metal perpendicular line (two twisted, 0.010-inch ligature wires) is placed at the right side of the patient's right face about 15 cm away, with a hanging 1-kg weight at the end of the line. Keep the patient in that head position and cast lateral light on his or her right face. There will be a line shadow on the face. Mark the line out on the patient's face by two points (the upper one on the external canthus lever and the lower one on the mandibular lower boundary lever) using a mark pencil (Ø = 2 mm). (4) Two blunt heads of pins (Ø = 2 mm), which have been cut down before, are prepared and attached on the marked points by transparent tape separately on the patient's face. (5) Take the cephalogram and facial photograph of the patient by the conventional method. A straight line is drawn connecting the two opaque points on the cephalogram (formed by the heads of pin) and the two mark points on the facial photograph, which represent the true vertical line of that patient on the radiograph or facial photograph. This is the RNHP of the patient.

Obtaining ENHP

Upon examination of the obtained 31 cephalograms and lateral facial photographs, the soft tissue profile in 6 cephalograms were not clear, and in one facial photo, the upper mark was hidden by the patient's hair. The data from these 7 patients were removed from this study, leaving 24 cephalograms and lateral facial photographs.

The remaining images were scanned and saved as digital image files in a computer and processed using Adobe Photoshop 7.0 to modify the opaque points in the cephalograms and mark points on the photographs using nearby hues until they could not be recognized.

These modified images were then shared with three certified orthodontists for assessment of the ENHP. Before starting, they were asked to discuss the concept of NHP and were shown two lateral facial photographs in NHP that had been approved by Moorrees and Lundström.[11] Then, the orthodontists were separated and assessed the ENHP for the 24 patients' cephalograms and photos. The process was as follows. A circle was formed around the head of each of the cephalograms and photographs with Adobe Photoshop to avoid the possible influence of visualizing the conventional straight edges of the photographs and radiographs. The images were rotated by the orthodontists until the head position coincided with the orthodontists' estimation of NHP in the doctor's mind and then saved. The vertical edge of the screen was believed to be the true vertical line for the purpose of ENHP. This process was repeated one time again 2 weeks later by each of the orthodontists.

Measure and Statistics

The lateral facial photos and cephalograms of all 24 patients in RNHP and in ENHP were printed. A line was drawn from soft tissue nasion through soft tissue pogonion. For RNHP (Figure 1), the true horizontal line was perpendicular to the line connecting the two artificial opaque points on the cephalograms or the two mark points on later facial photographs. For ENHP (Figure 2), the true horizontal line was perpendicular to the vertical screen edge. The upper-anterior angle intersected by the plane through soft tissue nasion and soft tissue pogonion and connecting the line with the true horizontal line was measured (NP_S/HOR). NP_S/ HOR for RNHP is termed *Rphoto* (for lateral facial photographs) or *Rxray* (for cephalograms), and NP_S/ HOR for ENHP is termed *Ephoto* or *Exray*. A correlation analysis was used to compare these two angles.

RESULTS Return to TOC

The correlation scattergrams of Rphoto/Rxray and Ephoto/Exray (Figures 3 and 4) show some linear correlation of RNHP and ENHP. This linear correlation was stronger on photographs than radiographs. The correlation statistic (Table 1) shows that RNHP and ENHP have a significant correlation, both on the photographs and on the cephalograms. The average correlation coefficient for the photographs was .733 and for the cephalograms .508 when comparing Ephoto/ Exray with Rphoto/Rxray. The average difference between angle Rphoto and Ephoto is 0.47° ± 1.42° and 0.622° ± 1.48° between Rxray and Exray.

DISCUSSION Return to TOC

NHP was identified by Moorrees[3,4] as a standardized position of the head in an upright posture with the eyes focused on a point in the distance at eye level. Many of the reports of NHP record the marks or line that represent the NHP before or at the time the lateral radiographs or photographs of the patients are taken, using a method similar to that depicted in this article. This method is termed the *registered natural head position* (RNHP). Clinicians have to teach the subjects who are involved to familiarize and settle their heads into a self-balanced natural head position and then, as much as possible, make a sequentially adjustment with a mirror orientation.

Some NHP experts get their NHP by rotating the existing lateral cephalograms or photographs to NHP by their “keen” eyes on individual judgement.[10–14] Two reasons underlie this idea. First, there are a multitude of images that were taken in the traditional method and not in RNHP, for example, the data in several craniofacial growth and development centers. Therefore, to research preexisting data concerning NHP, another method is necessary. Second, some people believe any experienced orthodontist can adjust a person's face to a natural and straight position by watching the subject's profile and that this method will not vary significantly from RNHP.

In the present study, the results show a significant correlation between ENHP and RNHP for both the facial photograph and the cephalogram. The correlation coefficients are .733 and .508, respectively, which are not regarded as being very strong, but the difference between the average Rphoto and Ephoto or Rxray and Exray is very small. The average difference between Rphoto and Ephoto is 0.47° ± 1.42° and 0.622° ± 1.48° between Rxray and Exray. The biggest average angular difference is 0.74° degree among the three estimators, which appeared on Doctor-j in his judgment of photographs. Compared to Lundström[10,12] who examined 28 subjects with four assessors, one had a 1.4° discrepancy and the other three assessors' average difference between ENHP and RNHP was within 0.0° to 0.8°.

In this article, we will not discuss the intercorrelation between assessors, which was detailed in Lundström's papers.[10,12] Also, we will not discuss how ENHP could be influenced by facial morphology, which has been pointed out by Demetrios and Halazonetis.[15] We want to focus on only the following phenomenon: there is a significant correlation between RNHP and ENHP, meaning that either can represent the NHP of a patient with acceptable accuracy. What is the fact behind it?

When we reinspect the process for RNHP and ENHP, we find two very important adjustments. For RNHP, it is the mirror orientation, and for ENHP, it is the advance study of approved NHP standard photographs reported by Moorrees and Lundström.[12]

When we take the RNHP, we ask the subject to stand upright, look forward, and settle his or her head straight and relax, with no extension and no flexion. The subject will use his or her proprioception based on sensors within the bony labyrinth of the internal ear and his eyes to manage the muscles and tendons and bones to settle his or her head into a position of his or her self-balance. This process will be influenced by many factors including physiological, psychological, and pathological factors.

Some researchers have shown that nasal obstruction will contribute to a more extended head position.[17] Also, the individual's unconscious attempt to mask his or her facial disharmony may influence this position.[12,15] Therefore, each subject may give a unique position potentially different from the others' NHP. That is just like boot camp, where a line of recruits are ordered “eyes front” by the officer. The first time, the soldiers will give the upright head position they believe to be upright and eyes front, but these positions may be different from one another. Thus, a final adjustment with successive mirror orientation is necessary.

Moorress[3,4] advocated the use of a small mirror, but not a vertical mirror, which was used by Lundström,[10–12] and asking the subject to look at the reflection of his or her eyes in the small mirror. The subjects were also told to sway their heads to adjust and make sure the visual axis is horizontal at last. Thus, through this last adjustment, we may get a uniform head position for every subject. The same thing will happen in the boot camp: after several days' drill with the officer's adjustment, the recruits can show you exactly the same head position when they hear “eyes front.”

For ENHP, the experienced clinician makes the orientation according to the image of NHP in his or her mind. This image may be different for each clinician. For this reason, we had a discussion in advance of two standard NHP photographs before estimation, which helped to calibrate a uniform image in all the assessors' minds. The same thing is true in boot camp. When the recruits show a different upright head position the first time they hear “eyes front,” the officer will help them to adjust according the officer's image of the standard position. But different officers may have different ideas. So a conference is needed to discuss and come to an agreement on a standard. Thus, the recruits can be drilled to the uniform posture. In much the same way, the experienced clinician can make nearly uniform estimations.

So far, RNHP is actually a subjective perception of the patient, which has been attributed some objective meaning by mirror orientation. In addition, the ENHP is also actually the subjective perception of the assessor, which has added objective meaning by study in advance of the standardized photographs. Therefore, we can state that RNHP comes from the subjective perception of the patient and that ENHP comes from the subjective perception of the assessor. Interestingly, these two subjective perceptions have a close correlation, as shown in this study. When we reflect on the two standard NHP graphs advocated by Moorrees and used in this study before assessment of ENHP, we realize that they were selected from the graphs of RNHP and can then understand.

Every person can position his or her head into NHP by his or her subjective perception, which may be different. However, after mirror orientation, different individuals may have the same NHP. Every person can have an image of NHP in his or her mind, and he or she can use that image to judge and adjust the other person's head position. Those images may be different, but after standardized sessions in advance, individuals can have the almost same image and therefore can adjust the their head to a uniform position.

CONCLUSIONS Return to TOC

- There is a strong correlation between RNHP and ENHP. They are just like the two sides of one coin, and the coin is NHP.
- RNHP comes from the subjective perception of the subject and gets some objective meaning by mirror orientation. ENHP is the subjective perception of assessors and gets objective meaning by a standardization session prior to the assessment.
- The mirror orientation of RNHP and the advance standardization of ENHP are crucial for validity and accuracy of NHP as an extracranial reference plane.

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Table 1. Correlation Analysis of Registered Natural Head Position and Estimated Natural Head Position

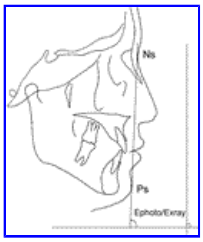
					Paired Differences			
		x̄	*n*	SD	x̄	SD	Coefficient	Significance (Two Tailed)
Doctor-y	Rphoto	86.556	24	2.378	−9.896E-02	−0.210	.455	.026*
	Ephoto-y	86.655	24	2.012				
Doctor-z	Rphoto	86.556	24	2.378	−.582	−1.104	.288	.226
	Ephoto-z	87.139	24	1.685				
Doctor-j	Rphoto	86.556	24	2.378	−.740	−3.184	.879	.000**
	Ephoto-j	87.296	24	2.178				
Photo, average	Rphoto	86.556	24	2.378	−.474	−1.416	.733	.000**
	Ephoto	87.030	24	1.456				
Doctor-y	RXRAY	87.046	24	2.397	.701	3.730	.923	.000**
	Exray-y	86.345	24	2.237				
Doctor-z	RXRAY	87.046	24	2.397	.735	1.249	−.084	.696
	Exray-z	86.310	24	1.415				
Doctor-j	RXRAY	87.046	24	2.397	.430	.707	−.116	.590
	Exray-j	86.616	24	1.518				
X-ray, average	RXRAY	87.046	24	2.397	.622	1.476	.508	.011*
	EXRAY	86.424	24	1.161				

* Correlation is significant at the .05 level (two tailed).
** Correlation is significant at the .01 level (two tailed).

FIGURES Return to TOC

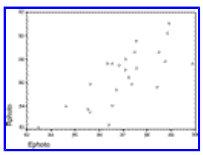
Click on thumbnail for full-sized image.

Figure 1. Registered natural head position represented by angle Rphoto/Rxray



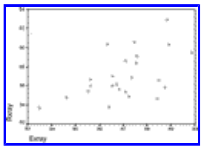
Click on thumbnail for full-sized image.

Figure 2. Estimated natural head position represented by angle Ephoto/Exray



Click on thumbnail for full-sized image.

Figure 3. Correlation scattergram of Rphoto and Ephoto



Click on thumbnail for full-sized image.

Figure 4. Correlation scattergram of Rray and Exray

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