

## Natural head position: key position for radiographic and photographic analysis and research of craniofacial complex

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### ABSTRACT

The Frankfort horizontal is a useful compromise for studying skulls but not for orienting the natural head position (NHP) in the living because it is normally distributed around a true extracranial horizontal. Nonetheless, orthodontists dealing with living subjects, rather than inert crania, have used this Frankfort horizontal faithfully in cephalometry. Because the cant or inclination of all intracranial reference lines is subjected to biologic variation, they are unsuitable for meaningful cephalometric analysis. Registration of head posture in its natural position has the advantage that an extracranial vertical or a horizontal perpendicular to that vertical can be used as reference line for cephalometric analysis. Purpose of this paper is to provide an updated review of various methods to reproduce and record the NHP.

**Keywords:** *Natural head position, radiographic cephalometry, true vertical line.*

### INTRODUCTION

Natural head position (NHP) is a standardized and reproducible orientation of the head in space when one is focusing on a distant point at the eye level, for example, watching the sunset on the beach. Artists, anatomists, and anthropologists have used NHP to study the human face throughout the ages. In the 1860s, craniologists realized that skulls also had to be oriented in a manner approximating the NHP of the living to conduct meaningful comparative studies of the crania from various racial populations. After considerable deliberation of the German Anthropological Society, support was solicited and reached in 1884 for the so-called Frankfort Agreement,<sup>1</sup> that is, the plane through the left porion and the left orbitale, to achieve uniformity in craniometric research. The Frankfort horizontal supposedly yields maximal differences in the configuration of the cranium between racial groups and smallest variability within each group.<sup>2</sup> The Frankfort horizontal is a useful compromise for studying skulls but not for orienting NHP in the living because Frankfort plane location in the living is normally distributed around a true extracranial horizontal. Nonetheless, orthodontists dealing with living subjects, rather than inert crania, have used this Frankfort horizontal faithfully in

cephalometry. The timely warnings of Downs<sup>3</sup> were completely disregarded; it was he who had shown in his classic analysis that discrepancies between cephalometric facial typing and photographic facial typing disappear when the Frankfort plane is not horizontal, but tilted up or down.

Since intracranial landmarks are not stable points in the cranium, their vertical relationship to each other is therefore also subject to biologic variation (e.g. sella to nasion, porion to orbitale), as pointed by Bjerin<sup>4</sup> and Thurow.<sup>5</sup> Bjork's<sup>6</sup> studies of facial prognathism also illustrate the unreliability of intracranial reference lines in cephalogram. Variation in the inclination of the intracranial reference lines is also well illustrated in a study by McNamara.<sup>7</sup> Contradictory results in clinical findings and cephalometric data are particularly disturbing to the maxillofacial surgeons who cannot rely on 'recipe' treatment planning, as is often done in orthodontics. With combined orthodontic and orthognathic surgery treatment, drastic changes can be made and differential diagnosis of the facial disharmony then becomes critical to determine the correct treatment plan. These conflicting results between clinical and cephalometric findings occur when intracranial reference lines deviate in their inclination from those shown in cephalometric norms. As if by design, patients with Class II malocclusion

are portrayed with the head turned down before treatment and with the head up after the treatment to reinforce the accomplishment of the therapy, that is, correction of the retrognathic mandible. Because the cant or inclination of all intracranial reference lines is subject to biologic variation, they are unsuitable for meaningful cephalometric analysis. Registration of the head in NHP has the advantage that an extracranial vertical or a horizontal perpendicular to that vertical can be used as a reference line for cephalometric analysis. The purpose of this paper is to provide an updated review of various methods to reproduce and record NHP clinically and cephalometrically.

### Reproducibility of natural head position

The concept of NHP was introduced to orthodontics in 1958 in papers by Moorrees and Kean,<sup>2</sup> Molhave,<sup>8</sup> and others. In 1998, Cooke and Wei<sup>9</sup> reported the reproducibility of NHP close to 2° on repeated radiographs. The reproducibility was better (1.9°) with patients looking at a mirror, than without a mirror (2.7°). They also investigated the use of ear post, and commented that no significant difference in the reproducibility was found between the NHP recordings taken with and without ear posts. In a landmark paper in 1992, Lundstrom and Lundstrom,<sup>10</sup> in a group of 52 subjects aged 10–14 years, where NHP was recorded photographically and transferred to the cephalogram reported that reproducibility of NHP was close to 2° as compared with sella–nasion, basion–nasion, and porion–orbitale, which showed standard deviations between 4.5° and 5.6°. This, combined with their research findings, supported the use of NHP for cephalometric analysis of dentofacial anomalies. According to Dvorsin,<sup>11</sup> reorientation of radiographs according to standardized photographs made at the NHP is a reliable and objective method to standardize the radiographs at the NHP for cephalometric analysis.

### Methods to obtain natural head position

A technique for establishing NHP was developed by Solow and Tallgren.<sup>12</sup> They recommended the patient to firstly walk around and relax. The standing patient should then perform decreasing forward and backward head oscillations, before allowing the head to settle into a ‘self-balance’ position. Patients were then asked to look into a reflection of their eyes in a mirror at 200 cm distance. Male subjects typically looked up more when asked to view the mirror.<sup>9</sup> Cooke and Wei<sup>9</sup> advised that patients sway less when standing in the cephalometer if their feet are at a comfortable distance apart and slightly diverging.

Care is needed with the ear post insertion to ensure there is no head movement away from the NHP, and to avoid any change in condyle position within the fossae.<sup>13</sup> Bister et al<sup>14</sup> published a review of the reproducibility of NHP. In their study, they omitted walking and head oscillation exercises, and the radiographer was allowed to interfere and repeat the procedure if the patient’s head was clearly not in NHP. They found reproducibility of 1.4°, and recommended the use of photographs for training of radiographers.

The conventional use of two ear rods to stabilize the head in radiographic cephalometry (lateral and/or frontal radiographic projections) is based on the assumption that the transmeatal axis of humans is perpendicular to the mid-sagittal plane. In cases where the relationship of the left and right ears in their vertical and horizontal relation to each other is asymmetric, the insertion of ear rods results in vertical and/or horizontal rotation of the head, introduces a deficient and misleading image. Thereby, the attempt to determine facial asymmetry of a patient generally results in a compromise rather than as an exact definition. Only the left ear rod should be used in radiographic cephalometry both for the lateral and particularly for the frontal projection. The right ear rod should merely be inserted against any part of the ear, or replaced by a small soft rubber cup, to prevent sideways movement of the head after facial midline is aligned with the midline rural of the cephalostat. Some patients consistently assume a modified NHP,<sup>15</sup> often in an attempt to mask a Class II or Class III facial pattern. For example, an individual with Class II mandibular retrognathism may habitually tilt head backward to mask the Class II appearance. It is necessary for the clinician to identify these individuals, and to adjust their head position toward NHP for record-taking. This head orientation is ‘clinician determined’ and provides a more reliable basis for cephalometric analysis for these individuals.<sup>16</sup>

After positioning the patients in NHP, there are two methods for recording a true vertical or a true horizontal reference line utilizing nature’s forces, the first by using a plumb line<sup>16</sup> and the other, with the help of a fluid level device.<sup>17</sup> Capturing NHP while taking a radiograph without the use of a cephalostat is likely to give poor pictures. Natural head position can be captured on a photograph and then transferred on to a radiograph. This, however, is a tedious procedure. For capturing the radiograph in NHP, a true vertical line on the face can be recorded with a radio-opaque material such that the conventional cephalogram records the true vertical line.<sup>18</sup> This method is found to overcome the drawbacks of the earlier methods of recording NHP. Recently, a method of establishing extracranial reference line on the cephalogram was presented by Bass.<sup>19</sup> They constructed an instrument using protractor and small weight

attached to it for measuring the profile angle (angle between the vertical plumb line and the line joining the tip of the nose and chin) and to transfer it on cephalogram. Xia et al<sup>20</sup> recorded NHP 3 times, in patients with cranio-maxillofacial deformity; first, NHP was recorded with a laser scanning method without the presence of the digital orientation device, second NHP was recorded with the digital orientation device, and third NHP was recorded with the laser scanning method. They concluded that their technique could accurately record NHP in three dimensions and precisely transfer it to a 3D model.

### Natural head position versus natural head posture

Natural head position and natural head posture are terms which have been used synonymously to describe the spatial relationships of the head. Natural head position describes the relationship of the head to the true vertical and natural head posture describes the relationship of the head to the cervical column. Although, the head changes its posture continuously throughout functional activities, Solow and Tallgren<sup>12</sup> selected the 'ortho position' of subjects, namely the momentary interim position when taking the first step forward from a standing to a moving or walking posture, which is reproducible according to Molhave.<sup>8</sup> In any case, the terms NHP and natural head posture are not interchangeable; one is being a standardized procedure applied to all individuals for the analysis of dentofacial morphology and the other an individual characteristic physiologic posture of the head to study the relation between posture and morphologic features.<sup>21,22</sup> Note that only a small mirror should be used to record NHP to force subjects to look straight ahead into the image or their eyes rather than a long mirror that precludes standardization of head position. A longer mirror is needed to accommodate subjects when recording their postural position, which is an individual, non-standardized head position.

A recent study compared the normal soft tissue facial profiles of black Kenyans and Chinese to compare them with each other and with values proposed for whites by taking standardized facial profile photographs in NHP. One hundred and seventy-seven black Kenyans and 156 Chinese with normal occlusion and well-balanced faces were analyzed for various parameters and demonstrated significant differences.<sup>23</sup>

### Advantages of natural head position

The horizontal reference plane in NHP is a less variable reference plane in the short term than conventional cephalometric

reference planes. Variables based on NHP better describe true-life appearance. Besides, NHP has been shown to be correlated to craniofacial morphology, future growth trends, and the respiratory needs. Natural head position has also been used for orientation of the head in studies of oropharyngeal structures and mandibular rest position. Most studies infer that NHP is a single static position. Natural head position, like any body posture is a small range of positions.<sup>12</sup> Recent studies have supported the concept of NHP as a small range of positions oscillating around a mean posture.<sup>24</sup> Methods used to record the NHP of subjects include both cephalometric and photographic. Previous studies used the cephalometric method for assessing the repeatability of the natural position and evaluating the craniofacial morphology. There is a growing concern of radiation hazard and better standardization and equipment. Images are recorded photographically to assess the repeatability and to make qualitative and quantitative evaluations of the craniofacial morphology.

### CONCLUSION

Natural head position has been shown to be the most accurate and reproducible head position. Using NHP, facial planning can be based directly on the face and is not influenced by the cranial base variability. Natural head position (not Frankfort) is the head position which most patients use habitually. True mandibular position can be recorded if the cephalometric radiograph is taken at NHP with centric relation wax bite in place.

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