ORIGINAL ARTICLE CE AJO-DO

# Variability of the inclination of anatomic horizontal reference planes of the craniofacial complex in relation to the true horizontal line in orthognathic patients

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**Introduction:** The purpose of this study was to assess the reliability of the Frankfort horizontal (FH), sella-nasion horizontal, and optic planes in terms of their variabilities in relation to a true horizontal line in orthognathic surgery patients. **Methods:** Thirty-six consecutive presurgical orthognathic patients (13 male, 23 female; age range, 16-35 years; 30 white, 6 African Caribbean) had lateral cephalometric radiographs taken in natural head position, with a plumb line orientating the true vertical line, and the true horizontal line perpendicular to the true vertical. The inclinations of the anatomic reference planes were compared with the true horizontal. **Results:** The FH plane was found to be on average closest to the true horizontal, with a mean of $-1.6^\circ$ (SD, $3.4^\circ$), whereas the sella-nasion horizontal and the optic plane had means of $2.1^\circ$ (SD, $5.1^\circ$) and $3.2^\circ$ (SD, $4.7^\circ$), respectively. The FH showed the least variability of the 3 anatomic planes. The ranges of variability were high for all anatomic planes: $-8^\circ$ to $8^\circ$ for the FH, $-8^\circ$ to $15^\circ$ for the sella-nasion horizontal, and $-6^\circ$ to $13^\circ$ for the optic plane. No significant differences were found in relation to patients' sex, skeletal patterns, or ethnic backgrounds. **Conclusions:** The clinically significant variability in the inclinations of anatomic reference planes in relation to the true horizontal plane makes their use unreliable in orthognathic patients. (Am J Orthod Dentofacial Orthop 2014;146:740-7)

Orthognathic surgery can lead to significant esthetic and functional changes in the dentofacial complex. Therefore, accurate diagnosis and treatment planning are imperative. Since the simultaneous introduction of lateral cephalometric radiographs by Broadbent[1] in 1931, diagnosis and treatment planning in orthodontics has relied heavily on the use of reference planes. Numerous cephalometric planes have been proposed in the literature; however, the 2 most frequently documented are the intracranial sella-nasion plane (SN; drawn from sella, the point representing the geometric center of the pituitary fossa in the midsagittal plane, to nasion, the intersection of the internasal and frontonasal sutures, in the midsagittal plane) and the Frankfort horizontal plane (FH; drawn from porion, the most superior point of the outline of the external auditory meatus, to orbitale, the lowest point on the inferior orbital rim). These cephalometric planes have their shortcomings, including individual variability and difficulties in landmark identification. Therefore, researchers have proposed the use of other planes to find the most reliable and least variable. Sassouni[2] recommended constructing a plane relying on multiple landmarks for greater accuracy and proposed using the "optic plane" as a substitute for the FH plane. The optic plane is constructed as follows: a "supraorbital plane" is drawn tangent to the superior contour of the anterior clinoid process and the roof of the orbit; an "infraorbital plane" is drawn tangent to the lower border of sella turcica and the floor of the orbit; the optic plane bisects the angle formed by the supraorbital and infraorbital planes. Sassouni thought that the optic plane was a preferable alternative to the FH plane because it was based on more easily identifiable skeletal structures. Burstone et al[3] suggested the construction of a

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horizontal line through sella, 7° down from the SN line, which will be referred to in this article as the SN-horizontal (SN-h) plane.

Reference planes can be either intracranial or extracranial; intracranial planes may be significantly affected by landmark identification and location, whereas extracranial planes may provide less variability. Taking lateral cephalometric radiographs in natural head position (NHP) has been recommended because it provides a physiologically natural position of the head, such as with a person viewing a distant object at eye level.[4-6] Recording the NHP as such not only enhances reproducibility but also allows cephalometric planes to be compared with a true vertical line (TrV), drawn parallel to a plumb line hanging from a ceiling, and a true horizontal line (TrH), drawn perpendicular to the TrV.[7]

It has been suggested that using TrH as an extracranial reference plane may be more reliable than the commonly used intracranial planes, and this is particularly important in orthognathic patients.[8] Therefore, it is crucial that when intracranial planes are used in orthognathic patients, the plane must have an inclination close to the TrH. The importance of the variability of intracranial reference planes is demonstrated in Figure 1. Even a few degrees of difference in the inclination of a horizontal plane, such as the FH plane from the TrH, may lead to a considerable effect on the results of skeletal or soft-tissue analyses. For example, in a subject with average lower and middle anterior facial heights, a 2° difference in the inclination of the FH plane from the TrH can cause a difference of 4 mm in the sagittal position of pogonion in relation to a vertical line perpendicular to the FH plane.

When selecting an ideal reference plane, one should consider the ease and accuracy of identifying the structures and landmarks on the lateral cephalometric radiographs. Reliability is enhanced by locating landmarks that are in clear contrast from the adjacent structures and those that are stable and not affected by growth.[9] In orthognathic patients, most craniofacial growth is completed before surgery, and thus the landmarks selected will undergo minimal changes. The reference planes should have good reliability, good intraindividual reproducibility, and low interindividual variability, and they should closely resemble the natural horizontal balance of the head or have an average orientation close to the TrH or TrV.[9,10]

The FH plane is frequently used as part of soft-tissue and skeletal cephalometric analyses as a basis for planning jaw positions. Therefore, any significant individual variation may lead to erroneous findings. A 0° meridian reference line dropped vertically from soft-tissue nasion is routinely used in relation to the FH plane. This relies on the assumption that the upper facial morphology is

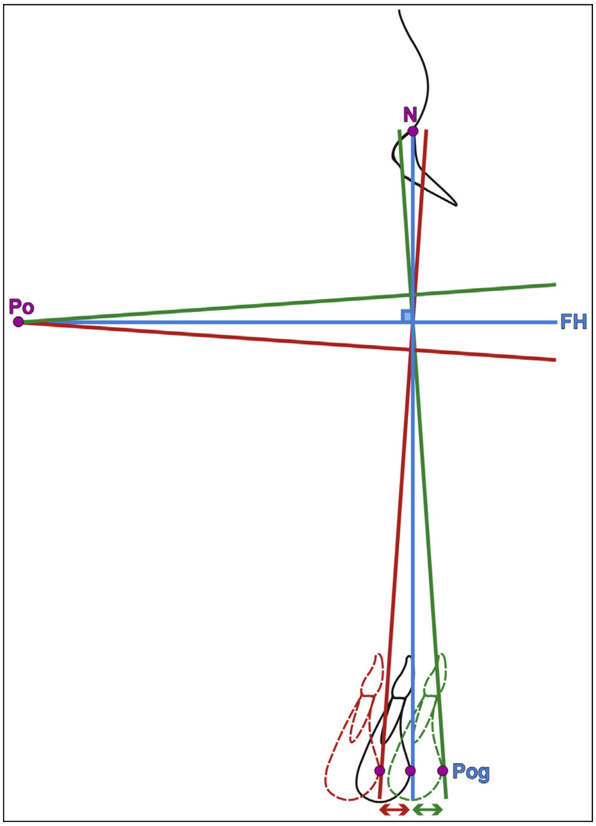


**Fig 1.** Schematic diagram demonstrating the potential influence of the inclination of "horizontal" reference planes. The *horizontal blue line* represents the FH plane as identical to the TrH. The *vertical blue line* is perpendicular to the FH plane, dropped from nasion (*N*). Skeletal pogonion (*Pog*) is on this vertical blue line. A 4° alteration in the inclination of the FH plane around porion (*Po*), either upward (*green line*) or downward (*red line*), will lead to a change in the sagittal position of Pog of 8 mm, based on an average face height (about 100 mm from the FH plane to Pog). The range of variability for the FH plane in this study was −8° to 8°; this would cause potentially clinically significant errors in an analysis with the FH plane.

normal, particularly the sagittal position of soft-tissue nasion. As such, the sagittal positions of the middle and lower facial structures are determined in relation to the 0° meridian, which is itself drawn perpendicular to the FH plane. Although this concept is easy to follow, its accuracy is hindered by several limitations. In surgical patients with great individual anatomic variations, the inclination of the FH plane is likely to be variable; consequently, the 0° meridian may also be incorrect. Furthermore, the morphology of the nasal radix and glabellar region is extremely variable, ranging from a deep concavity to a flat nasal radix; this ultimately affects the sagittal position of soft-tissue nasion.[7] As a result of