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Original research

Which intracranial plane can be used instead of the true horizontal plane?

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Purpose
The aim of this study was to evaluate the reliability of the Frankfort horizontal (FH), sella-nasion horizontal (SN-h), optic, and orbitooccipital planes by assessing their variabilities relative to a true horizontal line (TrH) in Class 1, 2, and 3 patients.

Materials and Methods
Eighty-one pre-treatment lateral cephalometric radiographs (LCRs) (27 each from Class 1, Class 2, and Class 3 based on ANB (°) were taken in the natural head position (NHP). NHP was created using a laser level creating the true vertical line and the TrH perpendicular to the true vertical. The inclinations of the anatomic reference planes were compared with the TrH.

Results
The orbitooccipital and FH planes were closest to the TrH, with mean values of -0.55 ± 3.26 and -0.60 ± 3.67, respectively. The mean value for the SN-h was 3.33 ± 4.40, whereas the mean value for the optic plane was 4.46 ± 4.58. The ranges were high for all anatomic planes: -9.03° to 8.22° for the FH plane, -8.79° to 6.49° for the orbitooccipital plane, -9.87° to 13.16° for the SN-h, and -4.21° to 16.43° for the optic plane. No significant differences were found in relation to skeletal patterns (orbitooccipital plane; p=0.05, FH plane: p=0.115, SN-h; p=0.156, optic plane; p=0.063, respectively). Regarding sex, there was a significant difference in the optic plane in only Class 1 females (p=0.024).

Conclusion
The FH and orbitooccipital planes are not the same TrH, but they are the closest reference planes. Variations in reference planes affect diagnosis and therapy.

Keywords: *Orthodontics, cephalometry, natural head posture, intracranial plane, true horizontal, laser level*

Introduction

Lateral cephalometric radiographs (LCRs) play a crucial role in orthodontic diagnosis and treatment. They are used to assess dental and facial relationships before, during, and after treatment. Throughout the treatment process, LCRs help evaluate changes in tooth movements, facial development, post-treatment modifications, the maxillomandibular relationship, the cranium, and the soft tissue profile (1). Various intracranial and extracranial reference planes are used in measurements that form the foundation of cephalometric analyses to determine skeletal discrepancies in the anteroposterior plane (2). The most well-recognized intracranial reference lines are based on the anterior cranial base, specifically the sella to nasion (SN) line, and the Frankfort horizontal (FH) plane. The SN plane is biologically significant as it represents the anterior cranial base. The sella serves as an essential anatomic reference, marking the central point of the pituitary fossa within the midsagittal plane, while the nasion is located at

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the intersection of the internasal and frontonasal sutures.

The FH plane is defined by a reference line extending from the porion, which marks the uppermost part of the external auditory meatus, to the orbitale, the lowest boundary of the inferior orbital rim (3). Differences in the inclinations of the SN and FH planes may lead to diagnostic inconsistencies and discrepancies when interpreting measurements obtained from the same individual (4). Burstone *et al.* (5) proposed establishing a horizontal reference line that passes through the sella and is positioned 7° below the SN plane. In the present study, this line is referred to as the SN horizontal (SN-h) plane. As an alternative to the FH plane, Sassouni (6) proposed the optic plane, which relies on multiple landmarks to enhance precision. The optic plane is constructed using two reference planes: the supraorbital plane, which follows a tangential path along the superior contour of the anterior clinoid process and the roof of the orbit, and the "infraorbital plane," which extends tangentially along the lower boundary of the sella turcica and the orbital floor. The optic plane is then defined by bisecting these two planes.

Due to the difficulty in identifying the porion point on radiographs, Park *et al.* (7) compared the compatibility of the orbitoccipital plane and the FH plane and concluded that they could be used interchangeably. Although both planes share the orbital point as a common reference, their secondary reference points differ: the FH plane uses the porion, while the orbitoccipital plane is defined by the inion point. Intracranial cephalometric planes exhibit variability and challenges in landmark identification, as they are heavily influenced by the definition and location of reference points. Even slight changes in the inclination of an intracranial reference plane can impact skeletal and soft tissue analyses, potentially leading to variations in diagnostic interpretations (4). Extracranial planes are less variable than intracranial planes, as they provide guidance independent of skeletal landmarks within the head. LCRs should be taken in the natural head position (NHP), which ensures a biologically appropriate head alignment similar to the posture maintained when focusing on a distant object at eye level (8). Determining NHP in this manner enhances measurement reliability and facilitates consistent comparisons. This approach allows cephalometric planes to be analyzed relative to the true vertical line (TrV), which is parallel to a freely suspended plumb line, and the true horizontal line (TrH), which is oriented perpendicularly to the TrV. The stability of NHP is also influenced by head and neck muscle function (9).

Although the relationship between intracranial planes and TrH has been explored in the literature, no studies have evaluated the relationship between the orbitoccipital plane and TrH. Individual variation in reference plane inclination may lead to inaccuracies in diagnosis and treatment planning. The aim of this study was to compare the TrH line with four intracranial reference planes of the craniofacial complex—FH, SN-h, optic, and orbitoccipital—across different skeletal anteroposterior malocclusions and sexes. The main null hypothesis of this study was that the angular deviations between the TrH and the intracranial reference planes—FH, SN-h, optic, and orbitoccipital—do not differ across different skeletal anteroposterior classifications or between sexes.

Material and Methods

Ethical approval

This retrospective study received ethical approval from the Research Ethics Committee of Recep Tayyip Erdoğan University (approval number: 2024/70). LCRs were obtained from individuals seeking orthodontic treatment at the Faculty of Dentistry, Department of Orthodontics. The study was conducted in accordance with the applicable ethical principles of the World Medical Association Declaration of Helsinki of 1964 and later versions (10).

Sample size determination

The sample size was determined using G*Power 3.1 software (Heinrich-Heine University, Düsseldorf, Germany). Based on a 95% confidence level (1-α), 90% statistical power (1-β), an effect size of d = 0.42, and a one-way analysis of variance (ANOVA) power analysis, a minimum of 72 patients was determined to be necessary. However, the present study included 81 patients, resulting in an actual statistical power (1-β) of 93% (11).

Study design and patient selection

Lateral cephalometric radiographs (LCRs) were obtained using a Planmeca Promax 2D S2 panoramic dental imaging unit (Planmeca Oy; Helsinki, Finland) with exposure settings of 66 kVp, 10 mA, and 10.5 seconds. Before initiating treatment, all patients provided written consent, granting permission for their data to be used in scientific research. The sample consisted of 81 subjects (36 males and 45 females), all of Turkish origin, aged between 16 and 30 years. Each subject underwent a true lateral cephalogram and a lateral photograph.

Sample selection criteria included individuals with a complete permanent dentition, regardless of the presence of third molars. Participants were required to have no significant facial or jaw asymmetry and no history of harmful oral habits such as thumb sucking, tongue thrusting, or mouth breathing. Additionally, they must not have undergone any prior orthopedic or surgical treatment of the head or face and were required to have good vision without the need for eyeglasses. Further exclusion criteria included the presence of cleft lip-palate or other congenital deformities, a history of previous orthodontic treatment or surgical procedures involving the upper or lower jaw, and any signs or symptoms of temporomandibular joint dysfunction (TMD).

Recording protocol

Radiographs were taken with participants in the orthoposition natural head posture (NHP), as first described by Molhave (12) and later adapted and refined by Solow and Tallgren (13). To achieve orthoposition, participants performed a slight walking motion, allowing them to tilt their heads forward and backward with gradually decreasing amplitude until they felt a natural balance. Body posture and head position were carefully controlled, and if necessary, "walking on the spot" and "head bending" were repeated.

Participants were positioned 30 cm from a wall, where a 30×40 cm mirror was mounted at their eye level. They were instructed to stand upright with their arms at their sides while gazing into their own eyes in the mirror. This step helped regulate overall body posture and ensured a consistent visual target. To determine the NHP, we used a laser level mounted on a custom tripod (Bosch, Universal Level 360 Set, Germany). A laser level is an electronic device that produces a single or cross-shaped solid line for precise alignment. It can also be used to place soft tissue reference markers. Positioned 45 cm from the left side of the patient's face, the laser level projected a green cross-light onto the left facial profile. Once the self-balanced neutral posture was established, the laser beam was activated, projecting a vertical green light onto the patient's face. Two reference points were marked on the vertical green laser light by projecting green light markers onto the skin. These composite skin markers, which were radiopaque on X-rays, were applied sequentially to follow the true vertical reference line. The composite markers created a radiopaque shadow that served as a natural vertical axis, enabling cephalograms to be oriented in the NHP. However, due to minor head movements during breathing, marking both points simultaneously was often impractical. Therefore, the upper point was marked first, followed by the lower point, ensuring that the first composite marker remained aligned with the upper reference point. The NHP was accurately transferred to the cephalogram by aligning the radiopaque skin markers with the true vertical line (TrV) (14–16). The record protocol is provided in the supplementary content. The planes used for measurements in the present study are shown in Figure 1. The inclinations of the FH, SN-h, optic, and orbito-occipital planes were evaluated in relation to the true horizontal (TrH) line. Angles measured below the TrH were defined as negative, while those above it were defined as positive. The ANB angle was used to classify skeletal relationships into three study groups: skeletal Class I, II, and III. Skeletal Class I was defined as $0° \leq ANB \leq 4°$, skeletal Class II as ANB>4°, and skeletal Class III as ANB <0°ANB<0°. All measurements were conducted by two orthodontists with 10 and 5 years of experience, respectively, using AudaxCeph Advantage Cephalometric X-ray Analysis Software Ver 4.2.0.3101 (Ljubljana, Slovenia).

Measurement error

An orthodontist (M.G.) with 10 years of expertise performed all measurements. After 1 month, the same examiner (M.G.) re-analyzed 30 randomly chosen LCRs to assess measurement errors. The intraclass correlation coefficient (ICC) was used to examine the intraobserver agreement between the first and second trials performed by the same orthodontist and the interobserver agreement between an orthodontist (M.G.) with 10 years of expertise and an orthodontist (B.B.G.) with 5 years of expertise.

Statistical analysis

The statistical analysis was performed using the IBM SPSS software (version 21.0, SPSS, Armonk, NY, USA). Descriptive statistics are expressed as mean and standard deviation (SD). The Shapiro-Wilk test was used to evaluate the normality of the data, and Levene's test was used to assess variance homogeneity. One-way ANOVA was performed to compare skeletal groups. Repeated measures ANOVA was used to analyze the interindividual variability of craniofacial reference lines concerning TrH, followed by the Bonferroni post-hoc test for pairwise comparisons. Sex-based differences within each group were analyzed using the independent samples t-test. A p-value of <0.05 was considered the significance level for statistical analysis.

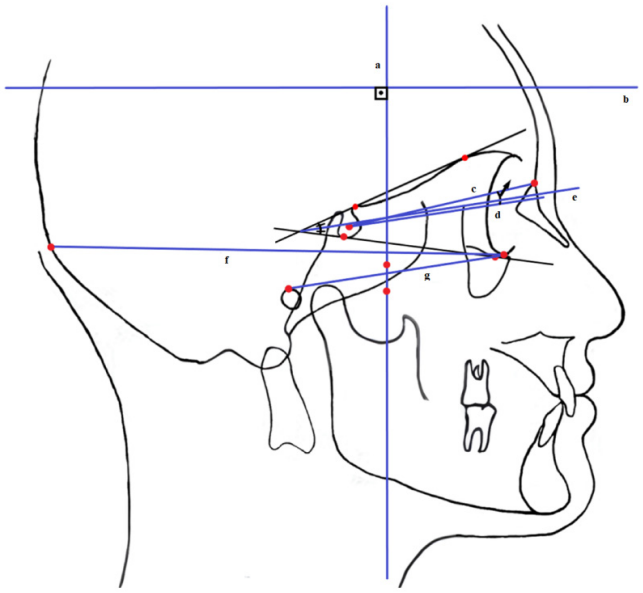

Figure 1. *Demonstration of the planes for using lateral cephalometric measurements.* ***(a)*** *TrV plane passing through two composite markers.* ***(b)*** *The TrH was obtained by drawing a perpendicular to the TrV line.* ***(c)*** *The SN plane was drawn from sella to nasion,* ***(d)*** *the SN-h was drawn as a horizontal line through the sella, 7° down from the sella-nasion line.* ***(e)*** *The optic plane was drawn as the bisection of the angle formed by the supraorbital and infraorbital planes.* ***(f)*** *The orbitooccipital plane was drawn from inion to orbitale.* ***(g)*** *The FH plane was drawn from porion to orbitale.*

Results

Intra-class correlation (ICC) analysis was used to assess intra-rater and inter-rater agreement. An ICC greater than 0.9 indicates excellent reliability, values between 0.75 and 0.9 indicate good reliability, values between 0.5 and 0.75 indicate moderate reliability, and values below 0.5 indicate poor reliability (17). All measurements demonstrated excellent intra-rater reliability, with an ICC value of at least 0.901. Inter-rater reliability was also high, with all measurements achieving an ICC value of at least 0.851, indicating good reliability (Table 1). Table 2 presents the variability of reference planes among patients with skeletal Class I, II, and III patterns. Among the analyzed planes, the FH and orbito-occipital planes exhibited the least variation, making them the closest to the TrH in terms of mean inclination. No statistically significant difference was observed between these two

planes regarding their inclination relative to TrH (p>0.05). The SN-h plane followed in proximity. Pairwise comparisons revealed statistically significant differences between the SN-h plane and the FH and orbito-occipital planes in relation to TrH across all skeletal classifications and total assessments ($p < 0.001$). The optic plane showed the greatest deviation in mean inclination from TrH. Significant differences were observed between the optic plane and the FH and orbito-occipital planes across all skeletal classifications and overall assessments in relation to TrH ($p < 0.001$). Additionally, pairwise comparisons demonstrated significant differences between the optic plane and SN-h in skeletal Class II and total assessments ($p < 0.001$). However, no significant differences were found across all reference planes when compared between different skeletal classes. Table 3 presents the variations in anatomic reference planes by sex within each skeletal classification in relation to TrH. The results demonstrated no significant differences in variability between the sexes, except for the optic plane (p=0.024).

Discussion

The natural head position (NHP) refers to a consistent and replicable posture in which the head is held straight, and the eyes are fixed on a point at eye level in the distance. This means that the line connecting the eyes is directed toward a distant point at eye level, ensuring that the visual axis remains horizontal (18). When conducting studies involving head positioning and craniofacial analysis, it is crucial to standardize the head positioning method and minimize measurement errors in craniofacial features (19). For this investigation, all lateral cephalometric radiographs (LCRs) were taken by the same operator using the same cephalostat.

The concept of NHP is influenced by various physiological, psychological, and pathological factors, making it challenging to identify all the elements that determine an individual's head posture in a relaxed, standing position (20). Several studies have indicated that individuals with temporomandibular disorders (TMDs) exhibit altered head and cervical spine postures (21,22), while other studies have found no

Table 1. *Intraobserver and interobserver agreement scores.*

	Intraobserver reliability			Interobserver reliability		
Reference Plane/ TrH	**ICC**	**Lower 95% CI**	**Upper 95% CI**	**ICC**	**Lower 95% CI**	**Upper 95% CI**
Orbito-occipital / TrH	0.911	0.823	0.957	0.851	0.823	0.957
FH/TrH	0.901	0.805	0.952	0.887	0.800	0.937
SN-h/TrH	0.944	0.884	0.973	0.892	0.808	0.940
Optic Plane/TrH	0.906	0.809	0.955	0.903	0.828	0.947

TrH; True Horizontal, CI; Confidence Interval, ICC; Intraclass Correlation Coefficient

Table 2. *Interindividual variability of the craniofacial reference lines in relation to the TrH line.*

	Class 1 (n=27)		Class 2 (n=27)		Class 3 (n=27)		Total (n=81)		
Reference Plane/ TrH	**Mean± SD**	**min.-max.**	**Mean± SD**	**min.-max.**	**Mean± SD**	**min.-max.**	**Mean± SD**	**min.-max.**	**P[x]**
Orbito-occipital / TrH	-0.21±3.13[a]	-5.58 - 4.67	0.31±2.44[a]	-3.08 - 5.57	-1.76±3.82[a]	-8.79 - 6.49	-0.55±3.26[a]	-8.79 - 6.49	0.05
FH/ TrH	0.01±3.63[a]	-8.16 - 6.67	-0.01±3.11[a]	-5.61 - 8.22	-1.80±4.03[a]	-9.03 -7.68	-0.60±3.67[a]	-9.03 - 8.22	0.115
SN_h/ TrH	3.70±4.71[b]	-9.87 - 11.42	4.26±3.97[b]	-2.31 - 13.16	2.04±4.35[b]	-5.26 - 9.81	3.33±4.40[b]	-9.87 - 13.16	0.156
Optic Plane/ TrH	4.54±4.78[b]	-4.21 - 12.75	5.88±4.32[c]	-1.61 - 16.43	2.97±4.33[b]	-3.62 - 12.34	4.46±4.58[c]	-4.21 - 16.43	0.063
P[y]	**<.001**		**<.001**		**<.001**		**<.001**		

n: number, x One-Way ANOVA, y Repeated measures ANOVA, Benferroni post-hoc test
Significance on $p < 0.05$ scale, No statistically significant difference exists between measurements with the same lowercase letter in the same column. Different lowercase letters in the same column indicate statistically significant differences between measurements.

Table 3. *Sex variations of anatomic reference planes in relation to the TrH line.*

	Class 1 (n=27)			Class 2 (n=27)			Class 3 (n=27)			Total (n=81)		
Reference Plane/ TrH	**Female (n=15)**	**Male (n=12)**	**P**	**Female (n=15)**	**Male (n=12)**	**p**	**Female (n=15)**	**Male (n=12)**	**P**	**Female (n=45)**	**Male (n=36)**	**p**
Orbito-occipital / TrH	0.26±3.30	-0.80±2.94	0.391	0.03±2.77	0.66±2.01	0.516	-1.04±3.31	-2.67±4.34	0.276	-0.25±3.12	-0.94±3.44	0.347
FH/TrH	0.59±3.42	-0.72±3.90	0.362	-0.52±3.13	0.63±3.10	0.353	-1.42±4.22	-2.28±3.92	0.592	-0.45±3.63	-0.79±3.75	0.679
SN-h/TrH	4.58±5.07	2.61±4.17	0.288	3.97±3.61	4.62±4.51	0.678	2.74±4.99	1.16±3.40	0.357	3.76±4.57	2.80±4.19	0.329
Optic Plane/TrH	6.35±4.18	2.27±4.65	**0.024**	5.93±4.18	5.82±4.68	0.952	3.53±4.68	2.26±3.93	0.457	5.27±4.43	3.45±4.63	0.075

n: number, Significance on $p < 0.05$ scale, independent sample t test

such association (23,24). The literature remains inconclusive regarding whether TMD affects body posture. Consequently, patients with TMD were excluded from this study.

Research by Tallgren and Solow (25) on the hyoid bone position and craniocervical morphology in adults with natural dentition demonstrated that the position of the hyoid bone is synchronized with facial shape, head posture, and cervical posture. Clinically, the hyoid bone's position is significant as it reflects tongue positioning. Woodside and Linder-Aronson (26) hypothesized that mouth-breathing individuals tilt their heads backward to increase airway space. They also observed that adenoid removal, which restores normal airway function, resulted in a less extended head posture. Studies suggest that postural adaptation occurs in response to visual stimuli due to the interaction between the visual and musculoskeletal systems (27). Therefore, this study excluded patients with TMD, mouth-breathing tendencies, tongue thrust, and vision impairments requiring eyeglasses.

Various techniques have been employed to record NHP and determine the true vertical (TrV) on radiographs. These methods range in complexity, from simple cephalometric imaging to more advanced techniques using inclinometers to record head orientation (28–30). However, these methods often face challenges, such as inconsistencies in results and time-consuming procedures (31). Some researchers suggest capturing a photograph of the patient alongside a plumb line and then transferring the TrV from the image to the radiograph. However, this additional step increases the potential for error. A more efficient alternative involves recording the plumb line directly onto the radiograph during image acquisition, eliminating the need for transposition. Nonetheless, studies indicate that achieving NHP in radiographic imaging is more challenging than in photography, and transferring the plumb line from photographs to radiographs is considered a reliable and clinically valid method (8,19,32,33). While the plumb line method is frequently cited, laser levels provide a more consistent and stable reference. Unlike the plumb line, laser levels are not significantly affected by minor environmental vibrations (14). In this study, TrV was recorded using a laser level, similar to the methods used by Chen *et al.* (14), Demetrio *et al.* (15), and Raju *et al.* (16).

The SN and FH planes are among the most commonly used intracranial reference planes (4,34). The FH plane, originally adapted from anthropologic craniometric research, is widely regarded as the closest craniofacial reference plane to the true horizontal (TrH) when a patient is in NHP (4,34). However, some studies have reported discrepancies between the TrH and FH planes and have discussed the reliability of NHP (35–37). Foster *et al.* (4) noted that identifying the ear canal location can be difficult, making the SN plane more reproducible and reliable than the FH plane. Conversely, the FH plane was found to be nearly parallel to the TrH. Thus, selecting an appropriate reference plane that is consistent across all patients is critical (4).

Intracranial cephalometric planes exhibit variability and landmark identification challenges, largely due to differences in reference point definitions and locations. Using NHP as an extracranial reference helps reduce these variations within intracranial landmarks, allowing for more accurate evaluations of growth and dentocraniofacial anomalies. The NHP method has proven to be both reliable and reproducible (38).

Head alignment in the axial plane is primarily influenced by inner ear equilibrium via vestibular system stimulation. This is further reinforced by muscle balance and visual input (39). The external occipital protuberance (EOP), an anatomic structure on the posterior surface of the occipital bone, is closely associated with the inion point. The EOP serves as the attachment site for the ligamentum nuchae and the trapezius muscle (40). Considering the two major factors influencing NHP—the visual system and the muscular system—the orbito-occipital plane may be closely related to the TrH, as the orbit represents the visual system and the inion represents the muscular system.

Few studies have examined variations in different anatomic planes relative to TrH. Zebeib and Naini (8) compared the TrH with the FH, SN-h, and optic planes, while Devi *et al.* (41) and Shetty *et al.* (35) compared the FH with TrH. Lundstrom *et al.* (42) analyzed the SN, FH, and Ba-N planes in relation to TrH, while Saood et al. (43) compared the SN and FH planes to TrH. Devi *et al.* (41) stated that although the FH plane was not identical to the TrH, it closely approximated it. Shetty *et al.* (35) examined six intracranial planes in relation to TrH and concluded that FH (-1.06 ± 3.19) could serve as a reference when NHP is unavailable. In contrast, Saood *et al.* (43) reported significant variability in FH inclination (2.34 ± 4.13), which could lead to diagnostic errors and ultimately affect treatment plans.

Zebeib and Naini (8) found that FH (-1.60 ± 3.40) exhibited the least variability, while SN-h (2.10 ± 5.10) and the optic plane (3.20 ± 4.70) showed greater deviations. Our findings align with Zebeib and Naini regarding the inclination of anatomic reference planes relative to TrH. Our results indicate that the orbito-occipital (-0.55 ± 3.26) and FH (-0.60 ± 3.67) planes were the closest to TrH, followed by SN-h (3.33 ± 4.40) and the optic plane (4.46 ± 4.58). Unlike Zebeib and Naini (8), our study also evaluated the orbito-occipital plane across different skeletal classifications, including Class I, II, and III. The optic plane showed the greatest inconsistency, particularly in Class II individuals (5.88 ± 4.32) and Class I females (6.35 ± 4.18).

Marcotte (44) investigated the relationship between head posture and dentofacial proportions, finding a strong correlation between head posture and mandibular anteroposterior positioning. Individuals with prominent chins tended to hold their heads downward, while those with retruded chins adopted an upward head posture. Nanda *et al.* (45) similarly reported a strong correlation between pharyngeal obstruction and mandibular sagittal size and position. Our study included individuals from all skeletal classifications, yet no significant differences were observed in horizontal planes across these groups. This may be due to the multifactorial etiology of malocclusion in our sample. Park *et al.* (7) reported that the orbito-occipital and FH planes could be used interchangeably. Our study corroborates this, showing that the FH and orbito-occipital planes exhibited the least variation and had the most similar mean inclination to TrH (7).

The main limitation of this study was the relatively small sample size. However, despite this limitation, the sample was sufficient to yield reliable findings with a test strength of 93%.

Conclusion

The findings of this study indicate that while the FH and orbito-occipital planes are not identical to the TrH, they are the

closest intracranial reference planes. Variability in reference planes may impact cephalometric analysis, influencing both diagnosis and treatment planning. The optic plane demonstrated the greatest deviation from the TrH, particularly in Class II and female Class I individuals. Although the FH and orbito-occipital planes exhibited minimal differences, they were insufficient to replace the TrH definitively. Given these limitations, it is recommended that lateral cephalometric radiographs be taken in the natural head position (NHP) to enhance measurement accuracy and consistency.

Türkçe öz: *Gerçek yatay düzlem yerine hangi intrakraniyal düzlem kullanılabilir? Amaç: Bu çalışmanın amacı, Sınıf 1, 2 ve 3 iskeletsel paterne sahip bireylerde Frankfort horizontal (FH), sella-nasion horizontal (SN-h), optik ve orbito-oksipital düzlemlerin gerçek yatay çizgiye (TrH) göre varyasyonlarını değerlendirerek güvenilirliklerini incelemekti. Gereç ve Yöntem: ANB açısına göre Sınıf 1, 2 ve 3 olarak sınıflandırılmış her gruptan 27'şer olmak üzere toplam 81 hastanın tedavi öncesi lateral sefalometrik radyografileri (LSR) doğal baş postüründe (NBP) alındı. NBP lazer terazi kullanılarak gerçek dikey düzlem (GDD) ile oluşturuldu. GYD ise bu GDD' ye dik olarak elde edildi. Anatomik referans düzlemlerinin eğimleri GYD ile karşılaştırıldı. Bulgular: Orbito-oksipital ve FH düzlemleri, sırasıyla -0.55 ± 3.26 ve -0.60 ± 3.67 ortalama değerleriyle TrH'ye en yakın düzlemler olarak belirlendi. SN-h için ortalama değer 3.33 ± 4.40 iken, optik düzlem için 4.46 ± 4.58 olarak ölçüldü. Tüm anatomik düzlemler için geniş bir aralık gözlendi: FH düzlemi için -9.03° to 8.22°, orbito-oksipital düzlem için -8.79° to 6.49°, SN-h için -9.87° to 13.16° ve optik düzlem için -4.21° to 16.43°. İskeletsel paternlerle ilişkili olarak anlamlı bir fark bulunmadı (orbito-oksipital düzlem; p=0.05, FH düzlemi: p=0.115, SN-h; p=0.156, optik düzlem; p=0.063). Cinsiyet açısından, yalnızca Sınıf 1 kadınlarda optik düzlemde anlamlı bir fark bulundu (p=0.024). Sonuç: FH ve orbito-oksipital düzlemler GYD ile birebir örtüşmemekle birlikte, GYD'ye en yakın referans düzlemler olarak öne çıkmaktadır. Referans düzlemlerindeki varyasyonlar tanı ve tedavi süreçlerini etkileyebilir. Anahtar Kelimeler: Ortodonti; sefalometri; doğal baş postürü; intrakraniyal düzlem; gerçek yatay; lazer terazi*

Ethics Committee Approval: The study design was approved by the Ethics Committee of the Recep Tayyip Erdogan University, Faculty of Medicine (decision date / number: 03.04.2024/70).

Informed Consent: Participants provided informed constent.

Peer-review: Externally peer-reviewed.

Author contributions: MG, BBG, ZK participated in designing the study. MG, BBG, ZK participated in generating the data for the study. MG, BBG, ZK participated in gathering the data for the study. MG participated in the analysis of the data. MG, BBG, ZK wrote the majority of the original draft of the paper. MG, BBG, ZK participated in writing the paper. MG, BBG, ZK has had access to all of the raw data of the study. MG, BBG, ZK has reviewed the pertinent raw data on which the results and conclusions of this study are based. MG, BBG, ZK have approved the final version of this paper. MG, BBG, ZK guarantees that all individuals who meet the Journal's authorship criteria are included as authors of this paper.

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