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SIDS plane: A simple and innovative alternative to Frankfurt horizontal plane

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Abstract

AIMS AND OBJECTIVES: To derive a new horizontal plane which can be a suitable alternative to Frankfurt horizontal plane (FH plane).

MATERIALS AND METHODS: 200 pre-treatment lateral roentogenic cephalograms from patient records in the department of orthodontics and dentofacial orthopaedics were traced. The landmarks were identified and marked and the measurements were carried out. Patients with all skeletal relationships were included in the study. The angle formed between the lines connecting anatomic porion, orbitale and machine porion was measured and tabulated. Dimorphism between the genders if any was also evaluated.

RESULTS: The mean angulation between the planes from the anatomic porion to orbitale to machine porion (PoA-Or-PoM) in our sample is 3.14 ± 2.17°. PoA to Or to PoM angulation for males is 2.57° and for females is 3.4°.

CONCLUSIONS: SIDS plane also called as derived FH plane given here is a reliable and easily reproducible alternative to the FH plane.

Keywords:

Cephalogram, Frankfurt horizontal plane, orbitale, orthodontics, porion, SIDS

Introduction

Roentgenographic cephalometry introduced by Hofrath in Germany and Broadbent in USA in the 1930s has become a crucial part of orthodontic treatment planning.[1,2] Postero-anterior and lateral cephalogram are the two types of a cephalogram. Cephalometric analysis entails the use of reference planes of which horizontal reference planes are a vital component. Frankfurt Horizontal (FH) plane is one of such horizontal plane.

FH plane introduced in 1872 by Von Ihering is constructed from the external auditory meatus to lowest point on the inferior margin of the orbit. This was later modified in the World Congress of Anthropology, in Frankfurt, Germany in 1882 as plane passing through the upper border of each ear canal or external auditory meatus (Porion/Po) and through the inferior border of the orbital rim (Orbitale/Or). FH plane is the best anatomical barometer for a true horizontal plane as it is closely related to natural head position which is the ideal position to record a cephalogram.[3,4] This has been incorporated by various authors in cephalometric analysis over the years. Various analytical parameters and norms are in tandem with the FH plane.

Orbitale is defined as lowest point on the infraorbital margin and porion is defined as the outer and upper margin of the porus acousticus externus. As 'anatomic

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porion'(PoA) is difficult to identify even for an experienced clinician, many authors have used 'machine porion' (PoM) while constructing the FH plane.[2,5,6] Machine porion is defined as the radiographic marker in the ear rod which is placed on the external auditory meatus. However, the FH plane constructed from PoM was not found to be as accurate to the one constructed from PoA.[3,7,8]

Thus taking advantage of the reproducibility of PoM and overcoming the difficulty in identifying the PoA, here, we present a new horizontal plane, SIDS plane, which is a derived FH plane.

SIDS plane (Derived FH plane):

The derived FH plane was developed in the department of orthodontics and dentofacial orthopaedics at the institute. It uses Or, PoA, PoM as reference landmarks for its construction. These reference landmarks were connected with lines in order to arrive at the SIDS plane [Figure 1].

Materials and Methodology

The study was performed on 200 pre-treatment lateral roentogenic cephalograms from patient records in the department of orthodontics and dentofacial orthopaedics at the institute. Patients in the age limit of 18–35 years were included in the study out of which 61 were males and 139 were females. Patients with all the skeletal relationships were included in the study.

The cephalograms obtained were traced and the landmarks were identified. Lastly, all the measurements were performed. All cephalograms were taken with the same machine following the standardized technique using a constant distance from the focus to the mid-sagittal plane of 155 cm. The distance from the mid-sagittal plane to the film was fixed at 10 cm. The central X-ray beam was oriented at right angle to the film passing through the ear rods. All the cephalograms included were of good quality with readily identifiable landmarks.

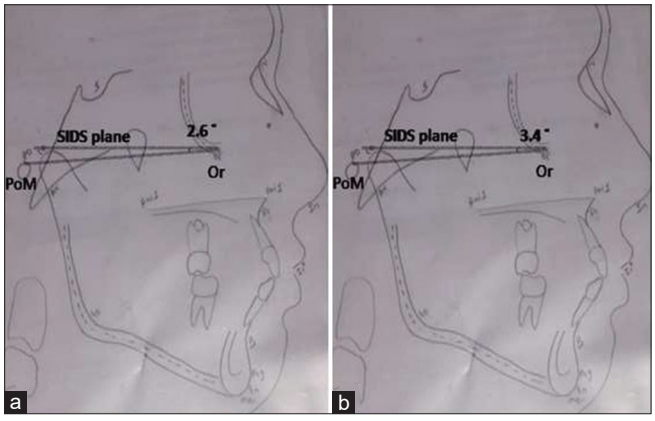

Figure 1: Construction of SIDS plane (a) male value (b) female value

Tracing and measurements were carried out by two investigators in which both were blinded. To determine any potential errors in the tracing of the cephalograms, landmark localization and errors in measurement, 35 cephalograms were randomly selected and retraced, 2 weeks post the initial tracing and measurements ($P > 0.05$). The measurements obtained were not corrected for any linear enlargement (which is approximately an average of 7 per cent in the median plane).

Two definitions of the FH plane were used for in our study:

A line passing through the landmarks Or and PoA.
A line passing through the landmarks Or and PoM.

Definition of the various landmarks:

Orbitale (Or): The lowest possible point on the bony right and left orbital rims.

Anatomical Porion (PoA): The highest point on the bony outline of the external auditory meatus.

Machine Porion (PoM): The centre of the line joining the mid points of the ear rods of the cephalostat.

Sample size estimation: The sample size has been estimated using the software GPower v. 3.1.9.4. Considering the effect size to be measured (ρ) at 23%, i.e. Correlation coefficient between the variables at 0.23, power of the study at 90% and the alpha error at 5%, the total sample size needed was 191 which was rounded off to 200.

Statistical analysis

Microsoft excel (Redmond, Washington, USA) was used for data compilation. The mean and standard deviation of the angle was obtained. Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 (Released 2013 Armonk, NY: IBM Corp.) was used to perform the statistical analyses.

Descriptive Statistics: Descriptive analysis of all the explanatory and outcome parameters was done using mean and standard deviation for quantitative variables, frequency and proportions for categorical variables.

Inferential Statistics: Pearson correlation test was used to assess the linear and angular relationship between PoA and PoM.

Dimorphism between the genders if any was evaluated.

The level of significance was set at $P < 0.05$.

Results

The mean value of PoA-Or-PoM angulation in our sample was 3.14 ± 2.17° as shown in Table 1.

Mann–Whitney Test was done for gender wise comparison which showed a sexual dimorphism. There was significant difference in the PoA-Or-PoM angulation between males and females [Table 2 and Figure 2]. Mean value of PoA-Or-PoM angulation for males is 2.57° and for females is 3.4°.

Thus, in male subjects, SIDS plane is a line constructed 2.57° above the line from machine porion and orbitale through orbitale, whereas in female subjects, the plane is constructed 3.4° above the line from machine porion and orbitale through orbitale point.

Discussion

One of the most important elements in diagnosis and treatment planning in orthodontics is cephalometric analysis. Evaluation of relationship between the maxilla, mandible, dentoalveolar structures and soft tissues by cephalometric analysis depends on a reliable reference plane. The reliability of such a reference plane depends mainly on its reproducibility.[9]

Frankfurt horizontal plane is a reliable reference plane which is constructed using two internal reference points that are anatomical porion and orbitale. FH plane is the best indicator of a true horizontal reference line which has been used widely.[10] Some of the applications of FH plane include its role in the positioning of the head for recording a lateral cephalogram, orthodontic diagnosis and treatment planning, cephalometry for orthognathic surgery and anthropological measurement of the subjects. However, due to difficulties in locating and potential variability of the two internal reference points, FH plane cannot be used as a standard.

Visualization of PoA is difficult in a lateral cephalogram because of its location which is the uppermost portion of the external auditory meatus. This difficulty occurs due to dense petrous temporal bone, projection in contrast to the congruent pyramids and kilo-voltage of the cephalogram machine.[11] Thus in our study, we have eliminated the use of this cephalometric point, i.e. PoA.

Registration error of PoM is lesser when compared to PoA,[7,8,12,13] but FH construction from PoM and Or cannot be used as a substitute for PoA and Or as machine porion has been found to be unsuitable.[14] Thus due to reliability of PoA and reproducibility of PoM, we have derived a reference plane which is constructed at an angle from PoM and Or. The angulation of this plane was found to be 3.14 (S.D. ±2.17) to the plane from the PoM to Or. In studies, so far sexual dimorphism was not found in the FH plane. However, a sexual dimorphism was noted in the subjects in our study. In males, the angulation was found to be 2.57° (S.D. ±1.95) and in females it was noted that the angulation was 3.4° (S.D. ±2.23).

Alternative reference planes have been described in the literature. Optic plane was described as a reference line by Sassouni which is constructed by bisecting supraorbital plane and infraorbital plane.[15] Pittayapat suggested the use of internal acoustic foramen and zygomatico maxillary suture.[16] Park *et al.*[17] have constructed a reference plane constructing using the zygomatic arch. All of the above methods showed great reproducibility but the cephalometric points are not widely used. In our study, SIDS plane is constructed using PoM and Or which are widely used cephalometric points.

Morphological landmarks though reliable may seldom represent the underlying skeletal discrepancies adequately. In such a scenario, constructed landmarks have proven to be more beneficial.[18]

Table 1: Descriptive table for the angulation (PO-A to OR to PO-M) among study subjects

Parameters	Mean	SD	Min	Max
Angulation (PO-A to OR to PO-M)	3.14	2.17	-4	10

Table 2: Gender wise comparison of mean values of Angulation (PO-A to OR to PO-M) using Mann-Whitney Test

Variable	Gender	*n*	Mean	*P*
Angulation (PO-A to OR to PO-M)	Males	61	2.57	0.03*
	Females	139	3.40	

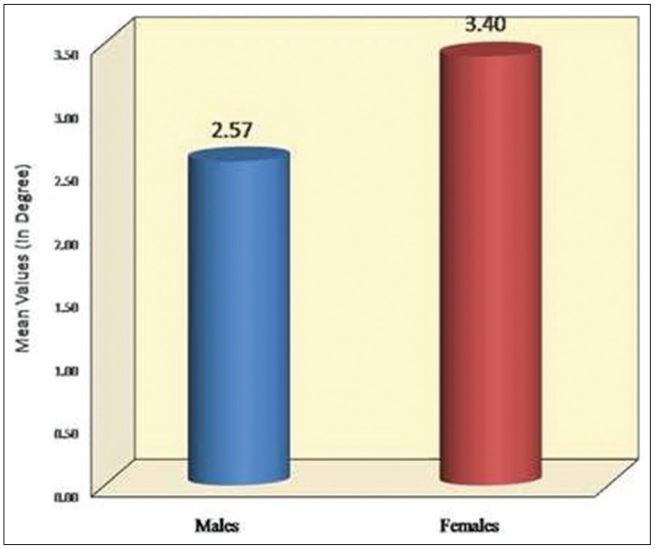

Figure 2: Mean angulation (PO-A TO OR TO PO-M) between Males and Females subjects

It has been demonstrated that 3 dimensional analysis of the skull gives similar results as 2 dimensional analysis with sufficient diagnostic significance.[19] Although a single CBCT scan has the potential to replace all the conventionally used radiographs such as lateral cephalogram, PA cephalogram and digital panoramic cephalograph, one set of conventionally used radiographs produce a lesser radiation dose (2-4 times) than one CBCT. Moreover, the radiation dose of a single CBCT scan is 15-26 times that of a lateral cephalometric radiograph. Hence, it is not deemed suitable for all patients.[20]

The linear relationship of the anatomical porion with respect to the machine porion needs further evaluation. Further, the change in the linear relationship with every degree change in PoM-Or-PoA angulation also needs to be verified. Research to provide this information will be presented in part II of this article.

Conclusion

From our study the following conclusions could to drawn:

The derived FH plane (SIDS plane) given here is reliable and easily reproducible.

The angulation of this SIDS plane was found to be 3.14° (S.D. ±2.17) above the plane from the PoM to the Or through the Or.

SIDS plane is constructed at 2.57° and 3.4° above the line from PoM and Or through Or in males and female subjects, respectively.

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Conflicts of interest
There are no conflicts of interest.

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