ORIGINAL RESEARCH

Predictive Equation for Construction of Anatomic Porion with Machine Porion as Reference Point

Kamath Apoorva Shrinivas[1], Shetty Suhani Sudhakar[2], Greeshma Kannan[3], Praveena Shetty[4], Dilip Daniel Quadras[5], Siddhartha Raghava[6]

Abstract

Aim: The aim of the study was to find a relationship between anatomic porion (PoA) and machine porion (PoM) and to construct PoA with the help of machine porion.

Methodology: About 200 pretreatment lateral roentgenic cephalograms were used for the study. Perpendicular distances of PoA and PoM were measured from Sella–Nasion (SN) plane and SN perpendicular plane. The results were tabulated. With the help of statistical analysis, predictive equation was derived to construct PoA and PoM. *p*-value was set at $p < 0.05$.

Results: Anatomic porion distance from SN was 24.35 ± 3.96 and from SN perpendicular was 12.89 ± 4.56. Distance of PoM from SN was 22.46 ± 4.20 and from SN perpendicular was 16.76 ± 4.89. Sexual dimorphism was also seen.

Conclusion: There is a relationship between the PoM and PoA, thus, PoA, which is more reliable, can be constructed with the help of PoM, which is easy to reproduce.

Clinical significance: To overcome the inherent limitations of PoA and PoM, the present study aimed to find a relationship between the two so as to easily construct PoA that is more reliable while taking advantage of the ease of reproducibility of PoM.

Keywords: Anatomic porion, Frankfort horizontal plane, Lateral cephalogram, Machine porion.

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Introduction

The lateral cephalogram, along with its related cephalometric analyses, has been routinely used in diagnosis of orthodontic patients and further in treatment planning.[1] Traditionally, intracranial reference planes have been used, and the first known plane was the Camper plane, proposed in 1768 by Peter Camper.[2,3] However, over time the most commonly used reference planes in the diagnosis of orthodontic patients have been the Sella–Nasion (SN) plane and the Frankfort horizontal (FH) plane.

The FH plane was initially described by Von Ihering in 1872. It was later modified in the World Congress of Anthropology, in Frankfort, Germany, in 1882, hence the name.[4,5] The FH plane is constructed from the orbitale to the porion both of which lie on the external surface of the skull, and hence can be visualized clinically using softtissue landmarks. This is in contrast to intracranial planes such as the SN plane. Also, since it can be easily visualized clinically, it helps to orient a clinician to the patient's face, chin, and palate around it.[4]

The FH plane is the most frequently used plane of reference for classification and is considered to relate closely to the true horizontal when the patient is in a natural head position (NHP).[6–8] The variation of this plane to the true horizontal is around zero degrees which implies that it represents a horizontal to the earth's surface. Also, the FH plane has a close positional relationship with the basic sense organs of hearing and balance (porion) and vision (orbitale). Hence, it bears a distinctive significance in the facial region both anatomically and biologically.[4]

The FH plane is constructed from the orbitale (Or) to the anatomic porion (PoA). The orbitale is the lowermost point of the inferior orbital rim. The porion is defined as the superior margin of the porus acusticus externus.[9] However, this cannot be readily delineated on a lateral cephalogram, and hence the use of a machine porion (PoM) was advocated by Broadbent in 1931, Tweed in 1946, and Downs in 1948.[10–12] The PoM is the radiographic marker of the ear rods of the cephalostat which is used for the positioning of the patient's head during a lateral cephalogram.[9] However, studies have shown that the PoM is not reliable in the construction of the FH plane and can vary up to a centimeter from the PoA.[4]

To overcome the inherent limitations of PoA and PoM, this study aimed to find a relationship between the two, if any, so as to easily construct PoA that is more reliable while taking advantage of the ease of reproducibility of PoM.

[1,3–6]Department of Orthodontics, Srinivas Institute of Dental Sciences, Mangaluru, Karnataka, India

[2]Consultant Orthodontist, Hebbal, Bengaluru, Karnataka, India

Corresponding Author: Shetty Suhani Sudhakar, Consultant Orthodontist, Hebbal, Bengaluru, Karnataka, India, Phone: +91 8660459208, e-mail: suhanishetty93@gmail.com

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Methodology

The study was carried out on 200 (61 males and 139 females) pretreatment lateral roentgenic cephalograms of patients undergoing orthodontic therapy in the Department of Orthodontics and Dentofacial Orthopaedics in Srinivas Institute of dental sciences, Mangaluru after obtaining ethical committee certificate

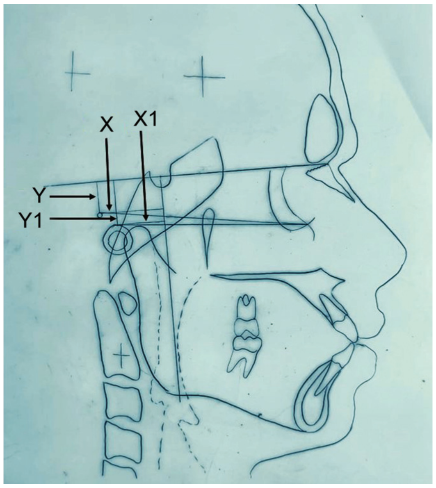

Fig. 1: Construction of *X*, *X*1, *Y*, and *Y*1 on cephalogram

from the institute with reference number 20/07/2021-1. Sample size estimation was determined by GPower v. 3.1.9.4, the software used to estimate the sample size had been estimated. Considering the effect size to be measured (ρ) at 23%, i.e., the correlation coefficient between the variables at 0.23, power of the study at 90%, and the alpha error at 5%, the total sample was estimated to be 191 that was rounded off to 200.

Patients in the age-group of 18–35 years with well-balanced facial proportions and without any gross facial asymmetry were included in the study. Patients with periodontal pathologies or any degenerative conditions were excluded.

The cephalograms used in the study were all recorded from the same machine taken in the duration of 2020–2022. The conventionally set standards were followed. A constant distance of 155 cm and 10 cm was maintained from the focus to the mid-sagittal plane and from the mid-sagittal plane to the film, respectively. The central X-ray beam was directed perpendicular to the film, passing through the ear rods. Good-quality cephalograms that satisfied all the inclusion criteria with easily identifiable landmarks were selected for the study. Black lead micropencil of 0.3 mm (Staedler Mars GmbH & Co., Nuernberg, Germany) was used to trace the cephalograms on cellulose acetate tracing sheets. Following tracing, all the landmarks were identified and the measurements were carried out (Fig. 1).

After a gap of 2 weeks post the initial tracing and measurements, to offset errors in any of these steps, 35 cephalograms were randomly chosen, retraced, and remeasured ($p > 0.05$). The measurements obtained were not corrected for any linear enlargement (that was approximately an average of 7% in the median plane).

The various landmarks were identified in the lateral cephalogram. The SN plane was drawn between the Sella, marked in the center of Sella turcica and the Nasion point, located at the sutural junction of the frontal bone with the nasal bone. The Or was defined as the lowest-possible point on the bony right and left orbital rims. The PoM was identified as the center of the line joining the mid points of the ear rods of the cephalostat. The PoA was the highest point on the bony outline of the external auditory meatus.

The SN plane was constructed using the landmarks defined. Following this, a perpendicular was dropped from the Sella on the PoM–Or plane. The distance of PoM in the horizontal (*x*-axis) and vertical (*y*-axis) to this perpendicular was measured. The same process was repeated for PoA. Further, the angulation between PoM, Or, and PoA was measured. The investigation was performed by two investigators to reduce bias.

Table 1: Descriptive table for the study parameters among study subjects

Parameters	*Mean*	*SD*	*Min*	*Max*
X (distance between Po-A and SN perpendicular)	24.35	3.96	3	34
*X*1 (distance between Po-M and SN perpendicular)	22.46	4.20	12	34
Y (distance between Po-A and SN)	12.89	4.56	1	27
*Y*1 (distance between Po-M and SN)	16.76	4.89	3	31

Statistical Analysis

Microsoft Excel (Redmond, Washington, USA) was used for data compilation. The mean and standard deviation of the angle PoA–Or–PoM were 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

Table 1 shows that Po-A distance from SN perpendicular (*X*) is 24.35 ± 3.96 and from SN (*Y*) is 12.89 ± 4.56. Distance of Po-M from SN perpendicular (*X*1) is 22.46 ± 4.20 and distance of Po-M from SN (*Y*1) is 16.76 ± 4.89. Gender-wise comparison of mean value was also found to be statistically significant. The distance of Po-A and SN perpendicular was 25.33 ± 3.09 in males, whereas 23.92 ± 4.22 in females, and the distance of Po-M and SN perpendicular was 23.53 ± 4.06 in males, whereas 22 ± 4.18 in females, as shown in Figure 2. The distance of Po-A and SN was 14.29 ± 4.57 in males, whereas 12.28 ± 4.44 in females, and the distance of Po-M and SN was 17.40 ± 4.58 in males, whereas 16.48 ± 5.01 in females, as shown in Figure 2.

Simple linear regression analysis to predict the Po-A position and angulation (Po-A to Or to Po-M) as shown in Table 2 from which a prediction equation was predicted to predict the position of Po-A in relation to Po-M in *X* and *y*-axis as well as prediction equation for Po-A to Or to Po-M angulation in relation to Po-A and Po-M.

Prediction Equation of Po-A on *x*-axis

Po-A = 0.52 × Po-M + 12.61. For every 1-mm increase in Po-M levels, the Po-A will significantly increase by 0.52 mm in the *x*-axis ($p < 0.001$). The variability in Po-A position will be able to explain by Po-M position the in *x*-axis by 31%.

Prediction Equation of Po-A on *y*-axis

Po-A = 0.70 × Po-M + 1.15. For every 1-mm increase in Po-M levels, the Po-A will significantly increase by 0.70 mm in the *y*-axis

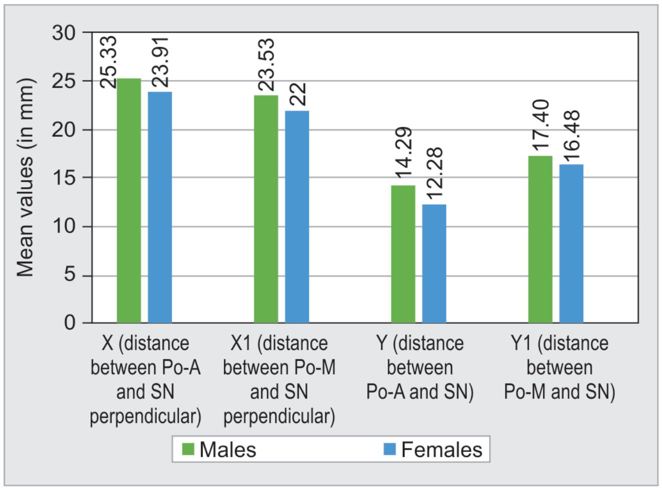

Fig. 2: Mean *X*, *X*1, *Y*, and *Y*1 positions between males and females subject

Table 2: Simple linear regression analysis to predict the Po-A position and angulation (Po-A to Or to Po-M)

Independent variable	*Unstd. coefficients* β	*Std. error*	*t*	*p-value*	R^2
Po-A position by using Po-M on *x*-axis					
Constant	12.61	1.28	9.885	<0.001*	
*X*1 (distance between Po-M and SN perpendicular)	0.52	0.06	9.365	<0.001*	0.31
Po-A position by using Po-M on *y*-axis					
Constant	1.15	0.77	1.510	0.133	
*Y*1 (distance between Po-A and SN)	0.70	0.04	15.984	<0.001*	0.56
Angulation (Po-A to OR to Po-M) by using Po-M and Po-A on *y*-axis					
Constant	1.14	0.33	3.448	0.001*	
Y (distance between Po-A and SN)	–0.52	0.03	–17.104	<0.001*	0.65
*Y*1 (distance between Po-A and SN)	0.52	0.03	18.292	<0.001*	

**p*-value < 0.001 is statistically significant

($p < 0.001$). The variability in Po-A position will be able to explain by Po-M position in the *x*-axis by 56%.

Prediction Equation

Angulation = $-0.52 \times Y + 0.52 \times Y1 + 1.14$. For every 1-degree angulation increase, the distance between Po-A and SN will significantly decrease by –0.52 mm ($p < 0.001$), whereas the distance between Po-M and SN will significantly increase by 0.52 mm on the *y*-axis at $p < 0.001$. The variability in angulation will be able to explain by distance between Po-A and Po-M to SN in *y*-axis by 65%.

Discussion

Various reference lines have been used in cephalometric, namely Frankfort horizontal plane, SN plane, mid-sagittal plane, coronal plane, and camper plane. Frankfort's horizontal plane has been largely used as a true horizontal line in orthodontics. It is a reliable reference line formed by two internal reference points, they are orbitale (Or) and porion (Po).[2] Orbitale is defined as the lowest point of the infraorbital margin, and porion is the upper margin of the porus acusticus externus.[9]

Frankfort horizontal plane is used as a reference line for cephalometric analysis in diagnosis and treatment plan of orthodontic and surgical cases.[9] But PoA is difficult to locate due to the number of reasons such as petrous temporal bone density, projection juxtaposition of the corresponding left and right pyramids, and kilovoltage employed, which rarely allow satisfactory visualization of such a region.[13,14]

Various authors have been using PoM as an alternative to PoAbecause of the above reasons,[10–12] where PoM is a radiographic marker on the ear rod of the cephalostat that is placed in the external auditory meatus during head positioning of the cephalometric device.[9]

Since position of the ear rod and the size of the external auditory meatus are extremely variable, PoM may be located distant from the true porion. According to a study done by Rickett, the PoM can be untrustworthy and it can vary from true porion by 1 cm.[4] Different locations of PoA and PoM can affect the FH angulation, which in turn can bring about gross error in the treatment planning of orthodontic and surgical cases.[2] In our study, the position of Po-A is 24.35 ± 3.96 from SN line and 12.89 ± 4.56 from SN perpendicular, whereas distance of Po-M from SN is 22.46 ± 4.20 and distance of Po-M from SN perpendicular is 16.76 ± 4.89.

There was a sexual dimorphism seen in the position of Po-M and Po-A in the *x*-axis, which is from SN line, and *y*-axis, which is from SN perpendicular in our study. Distance of Po-A in the *x*-axis was 25.33 ± 3.09 mm and *y*-axis was 14.29 ± 4.57 mm in males, whereas in females, 23.92 ± 4.22 mm in the *x*-axis and 12.28 ± 4.44 mm in the *y*-axis. Distance of Po-M in males was 23.53 ± 4.06 mm in the *x*-axis and 17.40 ± 4.58 in the *y*-axis, whereas in females, 22 ± 4.18 mm in the *x*-axis and 16.48 ± 5.01 mm in the *y*-axis.

The PoA cannot be located accurately and consistently on sagittal cephalograms taken in the closed-mouth position.[15] Thus, in this study, predictive equation was obtained to locate the PoA. Prediction equation of Po-A on the *x*-axis is 0.52 × Po-M + 12.61, whereas prediction equation of Po-A on the *y*-axis is 0.70 × Po-M + 1.15. If the distance of PoM from SN perpendicular drawn from S in the *x*-axis is known to be 23 mm and from SN in the *y*-axis is 16 mm. The position of Po-A in the *x*-axis will be $0.52 \times 23 + 12.61 = 24.57$ mm and the position of Po-A in the *y*-axis will be $0.70 \times 16 + 1.15 = 12.35$ mm, so the position of PoA will be 24.5 behind SN perpendicular and above by 12.35 mm (parallel to SN perpendicular).

Cone-beam computed tomography (CBCT) has shown a marked increase in cephalometric image resolution. There has been increased accuracy in placing cephalometric landmarks, most notably the point porion that is used to determine FH.[16–20] But as CBCT is not taken routinely for an orthodontic treatment, in this study, lateral cephalograms were used to locate the PoA.

The limitation of the study was that the study was limited to particular population, and further studies with a larger sample have to be carried out so that predictive equation can be tested among different populations and conditions.

Conclusion

There is a relationship between PoM and PoA, thus, PoA, which is more reliable, can be constructed with the help of PoM, which is easy to reproduce. Prediction equation of Po-A on the *x*-axis is 0.52 × Po-M + 12.61, whereas prediction equation of Po-A on the *y*-axis is 0.70 × Po-M + 1.15.

Orcid

Shetty Suhani Sudhakar https://orcid.org/0000-0002-8827-318X

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