

# Deviant Frankfort Horizontal Plane: Erroneous Reflections of Cephalometric Values in Vertical Skeletal Discrepancy Cases

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**Abstract** Cephalometrics still remains imperative in diagnosis and therapeutic decision making and with the realisation of the natural head posture, the Frankfort horizontal (FH) plane cannot be considered a true horizontal in all cases due to its commonly deviant relationship, particularly in cases of vertical skeletal discrepancies. The purpose of this study was to highlight the erroneous reflections of maxillary and mandibular positions in cases where the FH plane is deviant from the normal and to construct an alternate reference plane for use in such situations. The sample group came from 55 randomly selected lateral cephalometric roentgenograms. A control group of 20 patients was created from the cephalograms where the FH plane was in a true horizontal relationship and an alternate study reference plane was constructed. An independent t test and Mann-Whitney U test were done for both the groups to compare the values obtained and determine the statistical difference. In the control group, the values obtained were statistically not significant, which proved that our reference plane could be used as an alternative to the FH plane. The study group showed a significant statistical difference, resulting in erroneous analysis if the deviant FH plane was used. Gross errors in diagnosis and treatment planning of orthodontic and surgical cases can occur if deviant FH plane is used in cephalometric analysis.

**Keywords:** frankfort horizontal plane, true horizontal, natural head posture, vertical skeletal discrepancy, devian, reference plane

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## 1. Introduction

We have become a generation of profiles with orthodontic diagnosis and treatment planning based on clinical acumen. However, for the beginners, cephalometrics still remains imperative in diagnosis and therapeutic decision making.

The Frankfort horizontal was originally introduced at an anthropological conference in Frankfurt, Germany in 1884 [1]. It was defined as a plane extending from the left Orbitale to Porion. The plane was considered as the true horizontal and was initially used as a craniometric reference plane for classification purposes. Over the years the Frankfort horizontal and the Sella-Nasion plane have been relied on to aid in the diagnosis of skeletal pattern classification of a patient.

With the realisation of the natural head posture [2,3], the Frankfort horizontal plane cannot be considered a true horizontal in all cases due to its deviant relationship [5], particularly in cases of vertical skeletal discrepancies [6].

The purpose of this study was therefore to highlight the erroneous reflections of maxillary and mandibular

positions, in cases where the Frankfort horizontal plane is deviant from the normal and to construct an alternate reference plane for use in such situations.

## 2. Material and Methods

Lateral cephalometric roentgenograms from 55 randomly selected patients (34 females and 21 males) of ages between 12 to 23 years were analysed. All cephalograms were taken with the same cephalostat machine and by a single operator by a standardized technique. All roentgenograms were taken with patients in natural head position and were of good quality.

In constructing the Frankfort Horizontal plane, the following definition was taken - The line running through the landmarks Orbitale and machine Porion. The different landmarks were defined as follows:

Orbitale - The lowest point on the average of the right and left borders of the bony orbit.

Machine Porion - The midpoint of line connecting the centre points of the radio-opacity generated by each of the two ear rods of the cephalostat.

With the cephalogram taken with patient in natural head position, the lower and lateral edges of the radiographic

film were considered as the true horizontal and the true vertical planes, respectively [7]. The constructed Frankfort Horizontal plane was then compared to this true horizontal, to assess whether the FH plane was parallel to the lower border or whether it was deviant.

Cephalograms where the FH plane was at an angle of  $0 \pm 2^\circ$  to the lower border of the film was considered as being a true horizontal plane. And on cephalograms where the FH plane was deviated more than  $\pm 2^\circ$ , it was considered as being at fault and therefore could not be considered as a true horizontal [9]. Of the 55 randomly selected cases, 31 patients showed the Frankfort horizontal plane having a true horizontal relationship and 24 patients showed this plane deviating at a range of  $2^\circ$ - $20^\circ$  from the true horizontal.

To substantiate this study, a control group of 20 patients was created from the cephalograms where the FH plane was in a true horizontal relationship. The study reference plane was constructed by identifying point Sella, using the following definition: Geometric centre of the pituitary fossa located by visual inspection and constructed in the median plane. The reference plane was then drawn perpendicular to the lateral edge of the radiographic film, which was considered as a true vertical, and the plane was made to pass through point Sella, because of its reliable and stable position [8]. It should be construed that any true horizontal drawn from any other point would mean the same as being projected from point S, by biomathematical principles.

The following five cephalometric parameters, which depended on the Frankfort Horizontal plane [10], were considered to assess the validity of the study:

1. Antero-posterior maxillary skeletal relation to cranial base as assessed in McNamara analysis by measuring distance of point A from Nasion perpendicular to FH plane.
2. Antero-posterior mandibular relation to cranial base as assessed in McNamara analysis by measuring distance of Pogonion from Nasion perpendicular to FH plane.
3. Growth pattern as assessed in Tweed analysis by measuring angular relationship between Frankfort Horizontal plane and Mandibular plane (Gonion-Menton line).
4. Lower incisor proclination as assessed in Tweed analysis by measuring angular relationship between Frankfort Horizontal plane and long axis of lower incisor.
5. Facial (depth) angle (Nasion-Pogonion line) as assessed in Ricketts analysis by measuring angle between facial plane and the Frankfort Horizontal plane.

Once the constructed true horizontal reference plane was analysed, a study group consisting of 20 patients was created from the cephalograms where the FH plane showed a deviation of greater than  $\pm 2^\circ$  from the true horizontal (lower edge of the film) and the 5 cephalometric parameters mentioned above, were compared between the Frankfort Horizontal plane and our reference plane through point Sella.

### 3. Results

An independent t test was done for both the groups to compare the cephalometric values obtained with the FH

plane and with the true horizontal through Sella, to determine the statistical difference. Due to negative values being obtained with the first 2 parameters, i.e., distance of point A and Pogonion from Nasion perpendicular to FH plane, it resulted in the standard deviation being greater than the mean value. Therefore for the first 2 parameters a Mann-Whitney U test was done.

In the study group, where FH plane deviated from the true horizontal, when the cephalometric parameters between the FH plane and the true horizontal through Sella were compared, the values showed a significant statistical difference.

In the control group, when the 5 cephalometric parameters were compared between the FH plane and the true horizontal through Sella, the values obtained were statistically not significant, which proved that our reference plane could be used as an alternative to the FH plane dependent cephalometric values.

**Table 1. Group Statistics for Control Group**

Group	N	Mean	Std. Deviation	Std. Error mean
N to Pt.A – FH Plane	20	1.50	2.947	.659
True Horizontal	20	1.50	2.606	.583
N to Pog – FH Plane	20	-4.05	4.594	1.027
True Horizontal	20	-3.80	4.213	.942
MA – FH Plane	20	26.15	6.020	1.346
True Horizontal	20	26.00	5.822	1.302
LI - FH Plane	20	50.25	9.290	2.077
True Horizontal	20	50.40	8.738	1.954
N- Pog to FH Plane	20	85.60	2.722	.609
True Horizontal	20	85.60	3.085	.690

**Table 2. Test Statistics for Control Group**

	N to Pt.A	N to Pog
Mann-Whitney U	194.500	189.000
Wilcoxon W	404.500	399.000
Z	-.150	-.299
Asymp. Sig (2 tailed)	.881	.765
Exact. Sig [2*(1 tailed Sig.)]	.883 <sup>a</sup>	.799 <sup>a</sup>

a. Not corrected for ties

b. Grouping variable: GROUP

**Table 3. Group Statistics for Study Group**

Group	N	Mean	Std. Deviation	Std. Error Mean
N to Pt.A – FH Plane	20	-7.10	4.179	.934
True Horizontal	20	.85	3.602	.805
N to Pog – FH Plane	20	-15.40	4.406	.985
True Horizontal	20	-2.20	4.124	.922
MA – FH Plane	20	29.75	5.320	1.109
True Horizontal	20	22.25	4.655	1.041
LI - FH Plane	20	44.35	8.248	1.844
True Horizontal	20	53.20	8.977	2.007
N- Pog to FH Plane	20	79.65	4.107	.918
True Horizontal	20	87.05	2.946	.659

**Table 4. Test Statistics for Study Group**

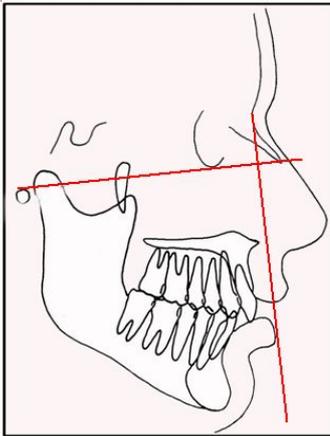
	N to Pt.A	N to Pog
Mann-Whitney U	33.500	4.500
Wilcoxon W	243.500	214.500
Z	-4.520	-5.321
Asymp. Sig (2 tailed)	.000	.000
Exact. Sig [2*(1 tailedSig.)]	.000 <sup>a</sup>	.000 <sup>a</sup>

## 4. Discussion

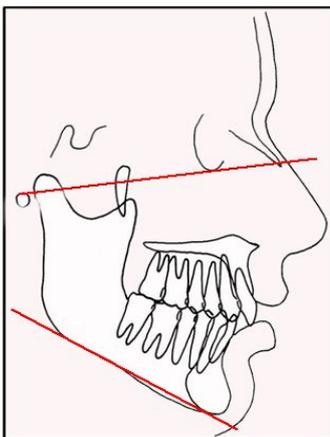
The results of this investigation revealed that in cases where the FH plane was deviant from the true horizontal, the cephalometric values obtained were misleading in diagnosing the skeletal pattern of the patient. Most of the cases showed a retrognathic mandible, due to the divergent relationship of the FH plane to the true horizontal, which resulted in a Nasion perpendicular line converging towards the true vertical and not being parallel, as the construction was meant to be (Figure 1).

When the skeletal parameters of these patients were assessed by other cephalometric analyses, example: SNA, SNB, Witt's appraisal,  $\beta$  angle, etc, the values all showed a comparable diagnosis and not being too conflicting with the clinical diagnosis [12].

The growth pattern in such cases was misleading and resulted in a cephalometric picture of the patient showing a more vertical growth pattern due to the increased angle formed between the divergent FH plane and the mandibular plane. Most of the average growth patients showed a slight vertical growth pattern and in severe horizontal growth patterns, it was reflected as being more close to a case of average growth, due to the opening of the angle caused by the divergent FH plane (Figure 2) [12].

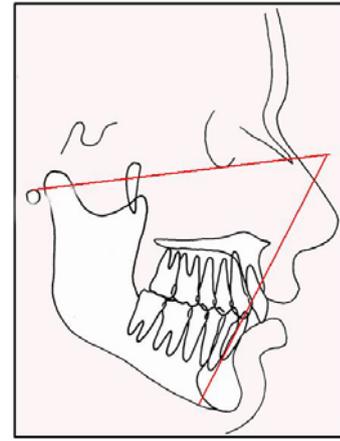


**Figure 1.** McNamara analysis of maxillary and mandibular skeletal base position



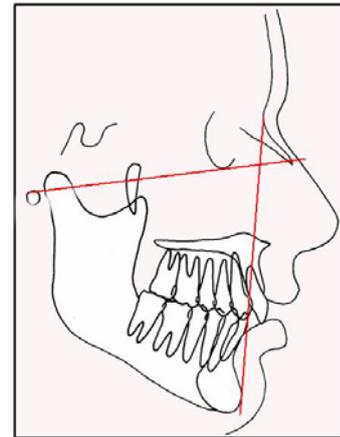
**Figure 2.** Tweed's analysis of growth pattern

The lower incisor inclination when assessed in relation to the faulty FH plane, also showed misleading dental diagnosis, therefore resulting in inaccurate diagnosis and treatment planning (Figure 3).



**Figure 3.** Tweed's analysis of lower incisor proclination

The facial angle which assesses the horizontal position of the chin and also whether the skeletal class II and class III pattern is due to the mandible, is analysed by measuring the angle between Nasion-Pogonion line and FH plane. In cases where the FH plane was divergent, it showed a recessive chin position and a retrognathic mandible due a more acute angle being formed between these 2 planes (Figure 4).



**Figure 4.** Rickett's analysis of facial angle

## 5. Conclusion

From the above discussion, it is evident that a deviant Frankfort Horizontal plane can result in erroneous values of cephalometric parameters dependant on the FH plane. These can result in gross errors in diagnosis and treatment planning of orthodontic and surgical cases. A misjudgement of the plane being considered as the true horizontal, can lead to false conclusions, e.g. when the outcome a particular treatment procedure is evaluated.

In conclusion, it can be said that, in vertical skeletal discrepancy cases it is important to assess the antero-posterior spatial relationship of the maxilla and mandible and where the FH plane is deviant; using an alternate reference plane does become important.

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