A Cephalometric Study of FH-SN Angle in Different Sagittal Skeletal Patterns among Patients Seeking Orthodontic Treatment

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Abstract

Introduction: Frankfort horizontal (FH) plane and Sella-Nasion (SN) plane are commonly used reference planes in orthodontic cephalometry. Any variation in this angulation from its accepted 7 degree can affect the cephalometric diagnosis. The objective of the study was to determine an average FH-SN angle among patients seeking orthodontic treatment.

Materials and Methods: One hundred lateral cephalograms were obtained from the records of patients who came for orthodontic treatment in Orthodontics and Dentofacial Orthopaedic Unit. Cephalometric tracing was done on acetate tracing paper of 0.004 inch thick using 3H pencil of 0.5 mm. Mean and standard deviation of FH-SN angle of the samples was calculated. One way analysis of variance and independent-samples t-test were used for assessing the relationship between dependent and independent variables at P-value of 0.05.

Results: Average FH-SN angle was found to be 7.57° (SD = 2.57°). FH-SN angle was found to be 7.97° (SD = 2.66°) in Class I subjects, 7.44° (SD = 3.10°) in Class II subjects and 7.25° (SD = 2.45°) in Class III subjects. FH-SN angle did not vary significantly among different sagittal skeletal patterns (P value > 0.05). There was no gender variation of FH-SN angle (P value > 0.05). The angle between the posterior vertical maxillary plane and Frankfort plane (PM-FH) was found to be 102.94° (SD = 5.10°) in Class I subjects, 102.57° (SD = 4.64°) in Class II subjects and 103.62° (SD = 4.23°) in Class III subjects. Similarly, the angle between the posterior vertical maxillary plane and sella-nasion plane (PM-SN) was found to be 110.91° (SD = 6.07°) in Class I subjects, 110.01° (SD = 5.07°) in Class II subjects and 110.88° (SD = 4.30°) in Class III subjects.

Conclusion: The average FH-SN angle was found to be 7.57° (SD = 2.57°). There was no variation in FH-SN angle in different sagittal skeletal patterns. FH-SN angle did not exhibit sexual dimorphism. The use of the PM line in evaluating the positioning of the horizontal FH and SN planes can help us establish which of the two planes is more reliable.

Keywords: Cephalometric Study; FH-SN Angle; Variation; Sagittal Skeletal Patterns; Posterior Vertical Maxillary Plane

A Cephalometric Study of FH-SN Angle in Different Sagittal Skeletal Patterns among Patients Seeking Orthodontic Treatment

116

Introduction

Cranial base inclination and possible consequences on the development of malocclusion have been studied for many years and different hypotheses have been discussed [1-5]. An understanding of craniofacial anatomy is considered the fundamental basis of orthodontic practice. Frankfort horizontal plane (FH) and the anterior cranial base (sella to nasion line [SN]) are the commonly used reference planes or lines for orientation in the routine cephalometric evaluation of orthodontic and/or orthognathic surgery patients. The relationship between these two reference planes (FH and SN) was demonstrated in 1957 by Daugaard-Jensen, who registered in her collective an almost constant mean angle of 7° during growth [6]. The literature suggests that the angle between these lines is relatively constant at 7° and the true horizontal axis or constructed FH is obtained by tracing a line in a clockwise direction approximately 7° from SN [7-9]. However, this constancy has not yet been sufficiently proven by reliable evidence.

The angle between FH and SN is assumed to be 7° and any variation from this can affect the cephalometric diagnosis. However, this constancy has not yet been sufficiently proven. Hence, assessment of FH-SN angle is essential before drawing any cephalometric conclusion. There is paucity of data on variation on FH-SN angle in Nepalese patients. Therefore, this study was carried out to determine average FH-SN angle among patients seeking orthodontic treatment.

Materials and Methods

A cross-sectional study was conducted among 100 patients at Orthodontics and Dentofacial Orthopedic Unit, Department of Dentistry, Institute of Medicine, Tribhuvan University Teaching Hospital, Kathmandu, Nepal. The patients who were 16 years and above, who had varying degrees of skeletal and/or dentoalveolar malocclusions, who had never received previous orthodontic treatment and with complete diagnostic records including availability of good quality cephalometric radiographs were enrolled in the study. Patients having subjects with congenital anomalies/syndromes and marked asymmetries, previous history of trauma to face and neck region, poor quality radiograph with image distortion and previous surgery involving jaws were excluded. Ethical clearance [165(6-11-E)2/073/074] was obtained from the Institutional Review Board, Institute of Medicine.

One hundred lateral cephalograms were obtained from the records of the enrolled patients. Age, gender, malocclusions (Class I, II and III), FH-SN angle, PM-FH angle and PM-SN angle were recorded on a self-designed proforma. Six parameters, namely Beta angle, W angle, Wits appraisal, FH-SN angle, PM-FH angle and PM-SN angle were measured. Three parameters, namely Beta angle, W angle and Wits appraisal using best of three method were used for determination of sagittal skeletal discrepancy. FH-SN angle was measured to know any variation in FH-SN angle in different sagittal skeletal classes, i.e. Class-I, Class-II and Class-III malocclusions. The angles made by posterior vertical maxillary plane (PM) with FH plane (i.e. PM-FH) and SN plane (i.e. PM-SN) were measured. The evaluation of lateral cephalograms was carried on the x-ray view box using cephalometric protractor (ormocepha; Ormco Corporation, 13K27, 760-0000) on acetate tracing paper of 0.004 inch thick using 3H pencil of 0.5 mm. Cephalometric Landmarks are shown in the figure 1a and 1b.
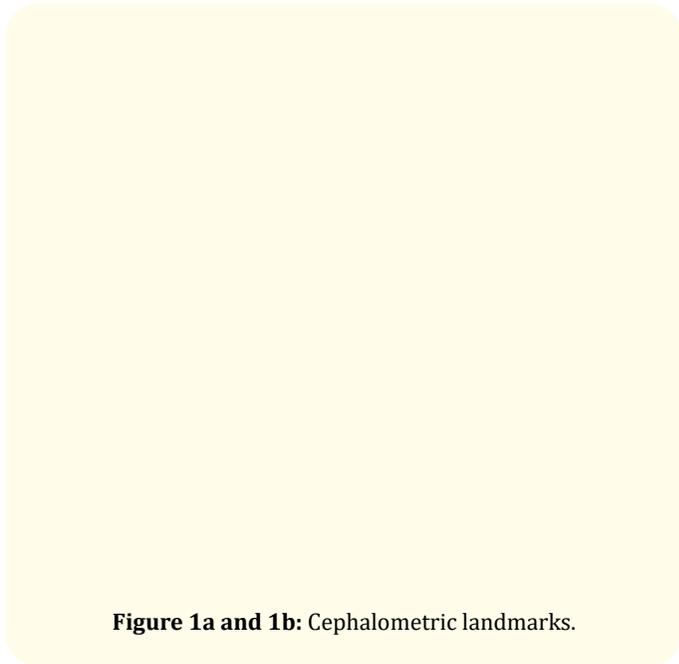
Figure 1a and 1b: Cephalometric landmarks.

Twenty five percent of the samples were randomly selected and remeasured after 2 weeks to measure the reliability. Intraclass correlation coefficient was performed to check for intra observer agreement. The data were entered into Microsoft excel 2010. Mean, standard deviation, frequency and percentage were calculated. Intraclass correlation coefficient was used to assess the intraobserver reliability. One way analysis of variance (ANOVA) was used for assessing the relationship between sagittal skeletal class I, II and III malocclusion and FH-SN angle. Independent samples t-test was

A Cephalometric Study of FH-SN Angle in Different Sagittal Skeletal Patterns among Patients Seeking Orthodontic Treatment

117

performed to assess the association between gender related difference on FH-SN angle. The reliability of the method was analyzed using Dahlberg's formula that determined the method error [10]. The statistical analyses were performed using the SPSS program, version 21 (SPSS Inc, Chicago).

Results

Out of 100 patients, 56 were male. Age of the patients ranged from 16 - 40 years. Mean age of the patients was 20.59 ± 4.493 year. Average FH-SN angle was 7.57° ± 2.754°. FH-SN angle was smallest (7.258°) in Class III and largest (7.971°) in Class I malocclusion (Table 1).

Sagittal skeletal patterns	N	Mean (Degree)	SD (Degree)	P-value
Class I	35	7.971	2.667	0.549*
Class II	34	7.441	3.106	
Class III	31	7.258	2.459	

Table 1: Distribution of FH-SN angle in different sagittal skeletal pattern (n = 100).

*Not significant (ANOVA test, P-value > 0.05).

The FH-SN angle does not vary significantly among different sagittal skeletal patterns i.e. in Class I, Class II and Class III (p > 0.05). So, the Null Hypothesis was accepted as there was no variation of FH-SN angle in different sagittal skeletal patterns (p > 0.05). FH-SN angle doesn't exhibit sexual dimorphism (Table 2).

Gender	N	Mean (Degree)	SD	P-value
Male	44	7.307	2.590	0.400*
Female	56	7.777	2.882	

Table 2: Gender wise variation of FH-SN angle (n = 100).

*Not significant (independent sample t test, P-value > 0.05).

The angle between the posterior vertical maxillary plane and Frankfort plane (PM-FH) in male subjects was found to be 103.34° ± 4.65° and in female subjects it was found to be 102.78° ± 4.69°. Similarly, the angle between posterior vertical maxillary plane and sella-nasion plane (PM-SN) in male subjects was found to be 110.64° ± 5.42° and in female subjects it was found to be 110.56° ± 5.06° (Table 3).

The angle between the posterior vertical maxillary plane and Frankfort plane (PM-FH) in Class I subjects was found to be 102.94° ± 5.10°, in Class II subjects it was 102.57° ± 4.64° and in Class III subjects it was 103.62° ± 4.23°. The angle between the posterior

vertical maxillary plane and sella-nasion plane (PM-SN) in Class I subjects was found to be 110.91° ± 6.07°, in Class II subjects it was 110.01° ± 5.07° and in Class III subjects it was 110.88° ± 4.30 (Table 4).

Variables	Male		Female	
	Mean	SD	Mean	SD
PM-FH	103.341	4.567	102.786	4.695
PM-SN	110.648	5.422	110.563	5.065

Table 3: Gender wise variation of PM-FH and PM-SN angles.

Sagittal skeletal patterns	Number	PM-FH		PM-SN	
		Mean	SD	Mean	SD
Class-I	35	102.94	5.10	110.91	6.07
Class-II	34	102.57	4.64	110.01	5.07
Class-III	31	103.62	4.23	110.88	4.30

Table 4: Variation of PM-FH and PM-SN angles in different sagittal skeletal patterns.

Intraclass correlation coefficients for FH-SN, PM-FH, PM-SN, Beta angle, W angle and Wits appraisal were 0.989, 0.991, 0.987, 0.946, 0.972 and 0.969 respectively. This indicated excellent intraobserver agreement for all the variables (Table 5).

Parameters	Intraclass Correlation	95% Confidence Interval	
		Lower Bound	Upper Bound
FH-SN	0.989	0.961	0.996
PM-FH	0.991	0.973	0.997
PM-SN	0.987	0.967	0.995
Beta angle	0.946	0.560	0.985
W angle	0.972	0.923	0.989
Wits appraisal	0.969	0.578	0.992

Table 5: Intraclass correlation coefficients for intraobserver reliability.

Method error was calculated using Dahlberg formula. The method error for the variables were between 0.461-1.063 (Table 6).

Parameters	Method error
W angle	1.063
Beta angle	0.945
Wits appraisal	1.042
FH-SN angle	0.461
PM-FH angle	0.612
PM-SN angle	0.680

Table 6: Dahlberg test for assessing method error.

A Cephalometric Study of FH-SN Angle in Different Sagittal Skeletal Patterns among Patients Seeking Orthodontic Treatment

118

Discussion

A reliable reference plane is vital to any radiographic cephalometric study. Reference planes are useful mainly for two purposes. A certain reference plane may be appropriate for one purpose but inappropriate for the other. The mean FH-SN angle in the study was found to be 7.57° ± 2.75° which is very close to the generally accepted 7° advocated in various studies [6-9].

The average FH-SN angle of female subjects of this study was slightly greater than that of male subjects. However, this difference was not found to be statistically significant. FH-SN angle did not exhibit sexual dimorphism in the study.

FH-SN angle was found to be 7.97° ± 2.66° in Class I subjects, 7.44° ± 3.10° in Class II subjects and 7.25° ± 2.45° in Class III subjects and the difference was statistically non-significant. However, Hasan., *et al.* found that FH-SN angle was increased significantly in the Class II group (10.20° ± 3.35°) compared to Class I (8.32° ± 4.27°) and Class III (8.00° ± 3.20°) groups [11]. Also, Alves., *et al.* found an increased FH-SN angle in skeletal Class II (8.42° ± 2.2°) compared to skeletal Class III (7.71° ± 3.4°) [12]. Polat., *et al.* found increased FH-SN angle in Class III group (10.6° ± 3.34°) compared to Class I group (7.77° ± 1.88°) and Class II Div 1 group (8.02° ± 2.59°) [13]. These variations could be due to racial difference and case selection procedures; particularly the ANB angle (for grouping into skeletal classes) may be a confounding factor, because N (Nasion) point is common to both FH-SN angle and ANB angle. In this study ANB angle was not used; instead, Beta angle, W angle and Wits appraisal were measured and best of three method was applied to determine the sagittal skeletal Classes. In none of the cases, the three parameters gave three different sagittal skeletal patterns. In Class II malocclusion, the cranial base angle and length were found significantly greater among Whites but not among Asians [14,15]. Therefore, ethnic differences in genetic background and environmental context may play a role in cranial base morphology. Differences in natural head posture, evolutionary history and genetic origin might contribute to the difference in cranial base orientation and flexure [16].

Variation in FH-SN angle could be due to change in inclination of SN line, FH line or both. If variation of FH-SN angle is due to variation in SN line, cephalometric parameters which use FH line alone should be used for making cephalometric diagnosis but cephalometric reference planes tend to be highly variable and poorly related, hence, cephalometric analysis should be performed using more than one reference plane as stated by Madsen., *et al.* in 2008 [17]. Alternatively, corrected "norms" for SNA and SNB advocated by Moore in 1976 when SN plane is not reliable [18].

In this study, the posterior vertical maxillary (PM) line was used for evaluating the positioning of FH and SN plane. The angle between the posterior vertical maxillary plane and Frankfort plane (PM-FH) in the study subjects was found to be higher than those proposed by Riolo., *et al.* and Veronica., *et al.* [19,20] our study had some limitations. The study did not include ethnic variation. Larger sample size would have been better.

Conclusion

The average FH-SN angle was found to be 7.570 with standard deviation of 2.750. There was no variation in FH-SN angle in different sagittal skeletal patterns. FH-SN angle did not exhibit sexual dimorphism. The use of the PM line in evaluating the positioning of the horizontal FH and SN planes can help us establish which of the two planes is more reliable.

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Conflict of Interest

None.

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A Cephalometric Study of FH-SN Angle in Different Sagittal Skeletal Patterns among Patients Seeking Orthodontic Treatment

119

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