

## Assessment of Antero-Posterior Skeletal and Soft Tissue Relationships of Adult Indian Subjects in Natural Head Position and Centric Relation

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### Abstract:

**Background:** The aim of this study was to verify the intra-individual reproducibility of natural head position (NHP) in centric relation (CR) position, to prove the inter-individual differences in the Frankfort horizontal plane and sella-nasion line compared with the true horizontal line, and to establish linear norms from A-point, B-point, Pog as well as soft tissue A-point, soft tissue B-point, and soft tissue Pog to nasion true vertical line (NTVL) in adult Indian subjects.

**Methods:** Lateral cephalograms (T1) of Angle's Class I subjects were taken in NHP and with bite in CR. A second lateral cephalogram (T2) of these subjects with ANB angle in the range 1-4° were taken after 1 week using the same wax bite and both the radiographs were analyzed based on six angular parameters using cephalometric software (Do-it, Dental studio NX version 4.1) to assess the reproducibility of NHP. Linear values of six landmarks were taken in relation to NTVL, and the mean values were calculated. A total of 116 subjects were included in this study.

**Results:** When the cephalometric values of T1 and T2 were analyzed, it was found that, the parameters showed a  $P < 0.001$ , indicating the reproducibility of NHP in CR. Mean values for point A, point B, Pog and their soft tissue counterparts were also obtained.

**Conclusion:** The study proved that NHP is a reproducible and accurate when recorded with the mandible in CR. Linear norms for skeletal Class I subjects in relation to NTVL were established.

**Key Words:** Centric relation, nasion true vertical line, natural head position

### Introduction

The desire for improved facial aesthetics is a major driving force for people seeking orthodontic treatment, for which

accurate and reliable diagnosis is important. Cephalometric diagnosis is an inevitable component of orthodontic treatment. We are in constant search of methods to fine tune the accuracy of data obtained from cephalograms. Orthodontists have been using intracranial reference lines such as sella-nasion (SN) and Frankfort horizontal (FH) planes for analyzing antero-posterior position of the maxilla and mandible, when it comes to assessing orthodontic and orthognathic surgical cases. However, these lines do not always coincide with facial esthetics, and they also show a tendency toward inter individual discrepancy.

Thus, the need of a reproducible reference positional plane for diagnostic radiographs is important for the diagnosis and treatment of orthodontic patients and two-jaw surgery patients.<sup>1</sup> It is at this juncture that the relevance of natural head position (NHP) and centric relation (CR) comes into the limelight.

Broca in 1862 defined NHP as "when man is standing, and his visual axis is horizontal, he is in a natural position."<sup>2</sup>

In 1958, Moorrees and Kean put forth a more specified definition of NHP as "a standardized and reproducible orientation of the head in space when one is focusing on a distant point at eye level." It was around this period that NHP was introduced into orthodontics and was slowly being advocated as a craniofacial reference system as it supposedly had a good intra-individual reproducibility to a true vertical plumb line.<sup>3-5</sup>

NHP has also a characteristic of being the representation of the true-to-life appearance and ease of being registered.

It is also required for an orthodontist to have a reliable and repeatable maxillo-mandibular relation and CR is known to be the single most repeatable position.<sup>1</sup>

CR is the relation of the mandible to the maxilla when the properly aligned condyle-disk assemblies are in the most superior position against the eminentiae irrespective of the vertical dimension or tooth position. At the most superior position, the condyle-disk assemblies are braced medially. Thus CR is also the midmost point. A properly aligned condyle-disk assembly in CR can resist maximum loading by the elevator muscles with no sign of discomfort.<sup>6</sup>

The purpose of this study is to verify the intra-individual reproducibility of the NHP in CR position, to prove the

inter-individual differences in the FH plane and SN line compared with the true horizontal line (THL), and to establish linear norms from A-point, B-point, Pog as well as soft tissue A-point, soft tissue B-point, and soft tissue Pog to nasion true vertical line (NTVL) in adult Indian subjects.

### Methods

Data were collected from 116 patients (47 males, mean age 24.6 years; 69 females, mean age 21.7 years) visiting A.J. Institute of Dental Sciences, Mangalore to receive treatment and volunteers who wished to take part in the study, in the age group 18-40 years, with informed consent.

The objectives of this study were:

To verify intra-individual reproducibility of NHP in adult patients in CR.

To prove inter-individual variability of FH plane and SN line to THL.

To establish linear norms from A-point, B-point, Pog as well as soft tissue A-point, soft tissue B-point, and soft tissue Pog to NTVL in adult Indian subjects.

The possibility of adopting NHP and CR as a useful position for diagnosing orthodontic cases and orthognathic, instead of FH or SN line will be evaluated.

### Inclusion criteria

Normal healthy adult individuals, both males and females, in the age group 18-40 years, of angles Class I molar relation and Class I skeletal pattern with ANB angle 1-4°.

### Exclusion criteria

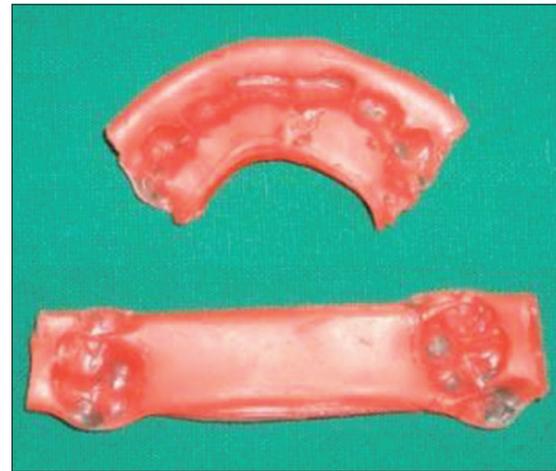
History of orthodontic treatment or orthognathic surgery.

Presence of intra-oral prosthesis spanning more than three units.

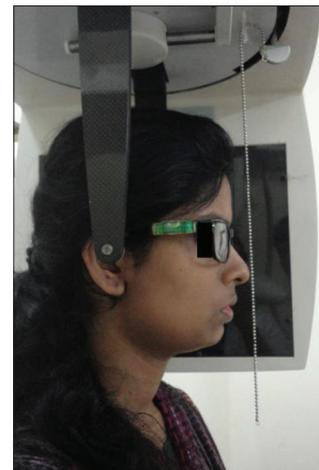
Absence of more than two molars, excluding third molars.

A CR record by Roth technique<sup>7,8</sup> (power centric method) using a two piece wax bite (Figure 1) was recorded for each individual before taking the lateral cephalogram.

NHP registration was done using the Solow and Tallgren<sup>9</sup> method, where the subject were asked to stand with their feet a shoulder width apart, and arms relaxed (Figure 2). They were made to wear an eyeglass with an attached fluid leveler, staring at their own eyes, on a mirror placed about 120 cm away (Figure 3). This will be done after exercising their necks up and down, thereby attaining a relaxed position. The subjects were asked to bite on their previously made CR wax records, in lips relaxed manner.



**Figure 1:** Wax bite of anterior and posterior segments.



**Figure 2:** Positioning of the head without the support of ear rods, with the fluid leveler and metal plumb line in place and the subject biting onto previously recorded centric relation bite.



**Figure 3:** Natural head position attained with the fluid leveler and the subject staring at a mirror positioned about 120 cm away.

A metal chain (plumb line) was dropped in front of the subject, which will help to attain the NTVL and radiographs will be recorded using KODAK 8000C Machine (78 Kvp, 12 MA, 0.9 s exposure). The ANB angle was measured in the first digitized

cephalogram (T1), using imaging Software Do-It Ceph, Dental studio NX version 4.1. Those subjects with ANB in the range 1-4° were included in the study.

After a week interval, a second lateral cephalogram (T2) was recorded of all selected subjects, following the same criteria.

A total of 16 landmarks were marked (Figure 4) on the digitized cephalograms, in both the first (T1) and second (T2) lateral cephalograms. Six angular parameters based on eight reference planes (Figure 5) namely:

1. NTVL to the palatal plane
2. NTVL to E-line
3. NTVL to cervical vertebrae tangent

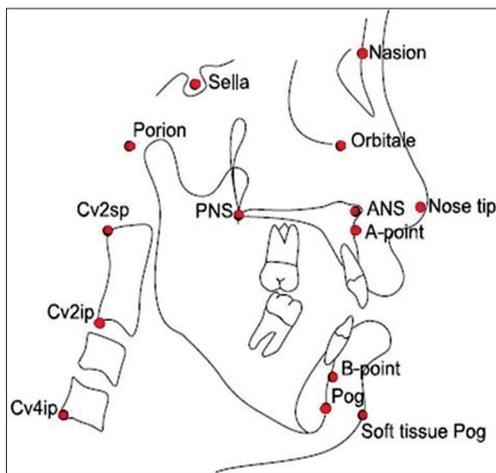


Figure 4: Reference points used in the study.

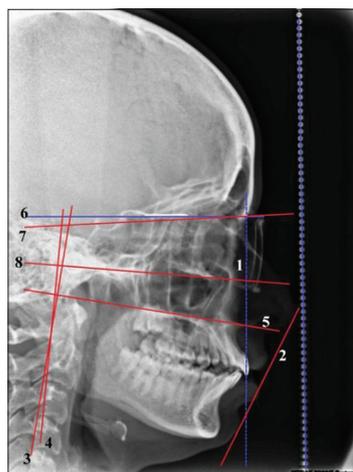


Figure 5: Reference planes used in the study, (1) Nasion true vertical line (NTVL) passing through the nasion point perpendicular to the floor; (2) E-line, tip of nose-soft tissue pogonion; (3) Cervical vertebrae tangent plane the posterior tangent to the odontoid process through CSv4ip; (4) Odontoid process tangent plane, the posterior tangent to the odontoid process through Cv2ip; (5) Palatal plane, anterior nasal spine-posterior nasal spine; (6) True horizontal line passing through nasion point perpendicular to the NTVL; (7) Sella-nasion plane; (8) Frankfort horizontal plane, porion-orbitale.

4. NTVL to SN
5. THL to odontoid process tangent (OPT)
6. SN to OPT.

were assessed to prove the intraclass reliability and reproducibility of NHP.

The six parameters were selected for the following reasons:

NTVL/E line: Reproducibility of facial aesthetics,  
 NTVL/palatal plane: As an intramaxillary reference line,  
 NTVL/cervical vertebra tangent and OPT: The cervical vertebrae reference,  
 NTVL/SN: Anterior cranial base (SN) reference,  
 SN/OPT: Anterior cranial base to cervical vertebrae reference. Also the THL to FH plane and SN plane angles were measured, and compared to norms<sup>10</sup> (THL-FH = 0°, THL-SN = 7°).

Linear measurements of A-point, B-point, Pog to NTVL were evaluated. Linear measurements of soft tissue A-point, soft tissue B-point, soft tissue Pog to NTVL were also evaluated (Figure 6). Method error in digitizing landmarks was performed in randomly selected 15 subjects. Method of error in positioning was determined in 116 subjects. The parameters taken into consideration were SN/NTVL, SN/OPT, and OPT/THL.

**Statistical analysis**

All statistical analyses were performed using Statistical Package for Social Sciences software package (SPSS for Windows - Version 17.0) for analysis using interclass correlation coefficients, one sample *t*-test, and Pearson correlation coefficients. The mean, standard deviation, minimum, and maximum was calculated for each variable.

**RESULTS**

The following tabulations are to prove the reproducibility of the angular parameters, determination of degree of error in digitizing as well as positioning, determination of mean values

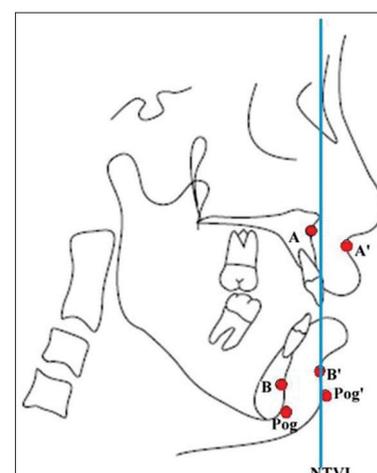


Figure 6: Linear values measured i.r.t nasion true vertical.

of the linear parameters in relation to NTVL and variability of FH and SN to THL when compared to two previous studies, one by Solow and Tallgren<sup>11</sup> and the other by Huggare (Table 1 and Chart 1).<sup>12</sup>

Intra-class correlation coefficient was done on the six angular parameters namely NTVL to palatal plane, NTVL to E-line, NTVL to cervical vertebrae tangent, NTVL to SN, THL to OPT and SN to OPT were done.

It could be deduced from the analysis that there are no significant differences between the values of T1 and T2. The  $P < 0.001$  suggest that the reproducibility of all the parameters were high. There was only a slight comparative decrease in the reproducibility of NTVL to palatal the plane, this might be due to the variance in locating the PNS in the lateral cephalograms (Table 2).

Method error study was performed to determine the errors in digitizing. Method errors in digitizing were calculated in

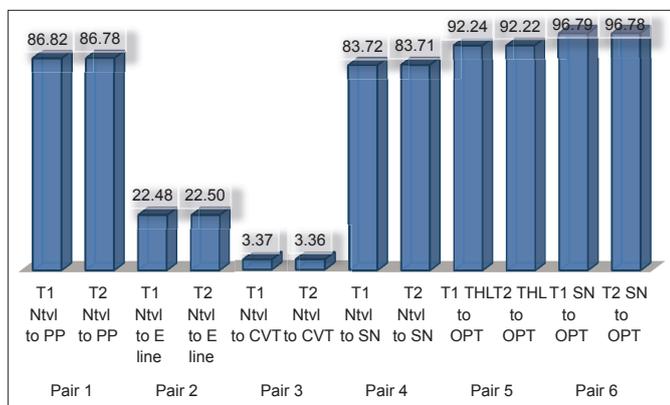


Chart 1: Mean value of six angular parameters at T1 and T2.

15 randomly selected subjects. Each T1 lateral cephalogram was retraced by the same observer 1 week after the initial tracing. Double determinations of three variables (SN/NTVL, SN/OPT, and OPT/THL) were calculated using Dahlberg’s formula.<sup>13</sup> The equation used was  $\sqrt{\frac{\sum dsq}{2n}}$ , where “d” is the difference between two measurements of a pair (square of the value was taken) and “n” is the number of paired measurements. The degree of error of all three parameters was below one degree, showing that the digitizing was relatively precise (Table 3).

Table 3 shows method error study performed to determine the errors in positioning. It was performed in all 116 subjects and compared with a degree of errors in previous studies performed by Huggare<sup>11</sup> (n = 33) and Solow and Tallgren<sup>12</sup> (n = 120). The variables taken in these studies were also SN/NTVL, SN/OPT, and OPT/THL. The equation used here was again Dahlberg’s formula. The errors in all three parameters were less than that of both the previous studies (Table 4 and Chart 2).

Linear measurements of A-point, B-point, Pog, soft tissue A-point, soft tissue B-point, soft tissue Pog to NTVL are evaluated. The mean values for these six parameters obtained from this study were as such:

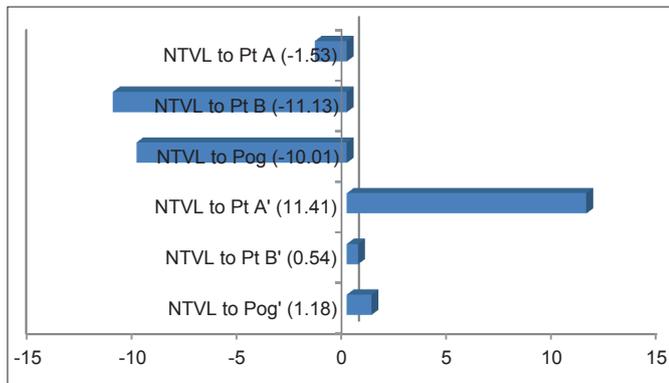
- Point A to NTVL:  $-1.53 \pm 3.1$  mm
- Point B to NTVL:  $-11.13 \pm 5.3$  mm
- Pog to NTVL:  $-10.01 \pm 7.3$  mm
- Soft tissue A-point to NTVL:  $11.41 \pm 3.2$  mm
- Soft tissue B-point to NTVL:  $0.54 \pm 4.4$  mm
- Soft tissue Pog to NTVL:  $1.18 \pm 4$  mm

	Mean	N	SD	Paired differences		Average of raters	P value
				Mean	SD		
Pair 1							
T1 NTVL to PP	86.82	116	4.628	0.034	1.258	0.768	<0.001
T2 NTVL to PP	86.78	116	4.643				
Pair 2							
T1 NTVL to E line	22.48	116	3.708	-0.017	1.071	0.863	<0.001
T2 NTVL to E line	22.5	116	3.71				
Pair 3							
T1 NTVL to CVT	3.37	116	4.258	0.009	1.107	0.933	<0.001
T2 NTVL to CVT	3.36	116	4.235				
Pair 4							
T1 NTVL to SN	83.72	116	4.128	0.009	1.312	0.927	<0.001
T2 NTVL to SN	83.71	116	4.105				
Pair 5							
T1 THL to OPT	92.24	116	5.241	0.017	1.521	0.903	<0.001
T2 THL to OPT	92.22	116	5.254				
Pair 6							
T1 SN to OPT	96.79	116	6.415	0.009	0.955	0.923	<0.001
T2 SN to OPT	96.78	116	6.412				

OPT: Odontoid process tangent, NTVL: Nasion true vertical line, SN: Sella-nasion, CVT: Cervical vertebra tangent, THL: True horizontal line, SD: Standard deviation

These values could be used as definitive norms for the Indian population, with skeletal Class I pattern, when lateral cephalograms are taken in NHP with the mandible in CR. These norms could be used as guidelines for orthodontic tooth movements and orthognathic surgical movements on the sagittal plane (Table 5).

The mean value of THL to FH plane and THL to SN plane angles when compared to norms, THL-FH = 0°, THL-SN



**Chart 2:** Linear measurements taken i.r.t nasion true vertical line.

	n	Degrees
NTVL to SN	116	0.54
THL to OPT	116	0.73
SN to OPT	116	0.18

OPT: Odontoid process tangent, NTVL: Nasion true vertical line, SN: Sella-nasion, THL: True horizontal line

	This study n=116	Huggare <sup>11</sup> n=33	Solow and Tallgren <sup>12</sup> n=120
NTVL to SN	1.18	1.60	1.43
THL to OPT	1.24	1.35	1.43
SN to OPT	1.01	2.10	1.95

OPT: Odontoid process tangent, NTVL: Nasion true vertical line, SN: Sella-nasion, THL: True horizontal line

	Mean	SD	Min	Max
NTVL to Pt A	-1.53	3.120	-5	5
NTVL to Pt B	-11.13	5.305	-22	0
NTVL to Pog	-10.01	7.334	-21	17
NTVL to Pt A'	11.41	3.227	6	18
NTVL to Pt B'	0.54	4.438	-8	12
NTVL to Pog'	1.18	4.012	-8	10

NTVL: Nasion true vertical line

	N	Mean	SD	P value
THL to SN (7)	116	5.25	3.946	>0.05
THL to FH (0)	116	-3.09	2.890	>0.05

SD: Standard deviation, THL: True horizontal line, SN: Sella-nasion, FH: Frankfort horizontal

= 7°. P > 0.05 show that there is a significant deviation of the SN and the FH from the THL. THL to FH plane was found to be -3.09° (sd 2.89°) while THL to SN plane was 5.25° (3.946°).

**Discussion**

NHP has been utilized throughout ages by artists, anthropologists and anatomists to study the human face. Leonardo da Vinci<sup>14</sup> (1452-1519) and Albrecht Du`rer<sup>15</sup> (1471-1528) used scaffoldings of horizontal and vertical lines on drawings of models positioned in “natural pose” in order to permit more accurate artistic and scientific replication of the human head.<sup>16</sup>

In 1884, the German Anthropological Society reached the “Frankfort agreement” to use a plane passing through the left and right portion landmarks and the left orbitale to achieve uniformity in craniometric research.<sup>17</sup>

Orthodontists still use the FH plane even though Downs<sup>18</sup> had warned in his analysis that discrepancies between cephalometric facial typing and photographic facial typing disappear when FH plane is tilted up or down, rather than the horizontal.<sup>17</sup> Bjerin<sup>19</sup> and Thurow<sup>20</sup> had pointed out that, as intracranial landmarks are not stable, their vertical relationship to each other is also subjected to biological variations, the potion to orbitale and the SN are examples to name a few. Since then many studies have investigated the variability of cephalometric planes such as FH and SN to a true horizontal HOR, Bjerin (1957); Cooke and Wei (1988); Downs (1956); Foster *et al.* (1981); Lundstro`m (1982); Lundstro`m and Lundstro`m (1992); Moorrees and Kean (1958) are some of them. Lundstro`m *et al.* stated that there is a large variability in the inclination of intracranial reference lines related to the extracranial HOR.<sup>21</sup> In addition, it has been shown that anterior-posterior and superior-inferior positioning of N-point affects the magnitude of measurements, which are dependent on this reference line.<sup>22-24</sup>

This study also focuses on placement of the mandible in CR. Presently CR is considered to be the relation of the mandible to the maxilla when the properly aligned condyle-disk assemblies are in the most superior position against the eminentiae irrespective of the vertical dimension or tooth position. Centric occlusion is defined as “the occlusion of opposing teeth when the mandible is in CR.” This may or may not coincide with the maximum intercuspation position.<sup>25</sup> Many techniques have been described to achieve CR, both in the dentulous and edentulous jaws. Kantor *et al.* (1973),<sup>26</sup> Balthazar-Hart (1981),<sup>27</sup> Roth (1981),<sup>8</sup> Gysi *et al.* (1986),<sup>28</sup> Ziebert (1984)<sup>29</sup> are some of them. The present study utilized the Roth’s power centric technique to achieve CR, and like the original technique, used a two piece wax bite.<sup>8</sup>

**Table 6: Values of THL to SN and THL to FH - comparison of various studies.**

Study	THL to FH (0°)	THL to SN (7°)
Bjerin (1957)	4.6	4.0
Cooke (1988)	5.2	5.6
Lundström & Lundström (1992)	5.3	5.6
Atashi and Kachooei (1997)	2.7	3.7
Present study (2014)	3.9	2.8

THL: True horizontal line, SN: Sella-nasion, FH: Frankfort horizontal

The results from this study showed that when intra-class correlation coefficient was done on the six angular parameters ( $P < 0.001$ ) the reproducibility of all the parameters were high. The degree of deviation of SN as well as FH i.r.t the THL was assessed in the study and was seen that both SN as well as FH deviate from THL in a statistically significant manner when their values were compared to the norms of THL to SN 7° and THL to FH 0°. This result is similar to that found in some previous studies. Table 6<sup>30</sup> compares the mean deviation of FH and SN from the normal value, in different studies.

Linear measurements of skeletal Class I Indian subjects in NHP and CR had not been determined before and the values obtained in this study could be considered as norms and could be used as guidelines for orthodontic tooth movements and orthognathic surgical movements on the sagittal plane. However, sexual differences have not been taken into account in this study.

### Conclusion

The following objectives were achieved from the present study:

- Intra-individual reproducibility of NHP in adult subjects in CR was proved.
- It was proved that there is an inter-individual variability of FH plane and SN line to THL, and the values obtained deviated significantly from the normal values (THL to FH - 0°, THL to SN - 7°)
- Linear norms from A-point, B-point and Pog, as well as soft tissue A-point, B-point and Pog to NTVL in adult Indian subjects, were established.

Therefore, it could be considered that the use of NHP and CR for diagnosing orthognathic and orthodontic cases, instead of FH or SN is a feasible method of choice.

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