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# Variation of Cranial Base Morphology among Different Sagittal Skeletal Malocclusion – A Cephalometric Study in Nepalese Population

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## Abstract

**Introduction:** Variation of cranial base morphology among different sagittal skeletal malocclusion has been evaluated previously by many studies. However, the findings of these studies conducted in different population differ due to racial/ethnic differences. **Objective:** To obtain measurement data for various cranial base parameters and evaluate the variation in cranial base morphology among different sagittal skeletal malocclusion in Nepalese population. **Materials and Methods:** Manual tracing and measurement of 4 different cranial base parameters [linear- Anterior Cranial Base Length (ACBL), Posterior Cranial Base Length (PCBL) and Total Cranial Base Length (TCBL); angular - Cranial Base Angle (CBA)] were done on 90 pretreatment lateral cephalogram of healthy adult orthodontic patients. Study samples were matched for age and were equally distributed among three different sagittal skeletal malocclusion group using ANB angle. [skeletal Class I: 30, skeletal Class II: 30 and skeletal Class III: 30]. Analysis Of Variances [ANOVA] followed by Least Significant Difference (LSD) post hoc test was used to determine difference in cranial base measurements among three sagittal skeletal group. **Results:** While comparing the cranial base parameters among different sagittal skeletal class, mean value for all the parameters reduced systematically from skeletal Class II, via skeletal Class I, to skeletal Class III group. However, a statistically significant difference was found only for TCBL between skeletal Class II and skeletal Class III ($p < 0.01$). **Conclusions:** A significant difference in TCBL among different sagittal skeletal malocclusion was observed in Nepalese adults.

**Keywords:** Cranial Base Morphology, Sagittal Skeletal Malocclusion, Nepalese Population

## 1. Introduction

Cranial base is an important structure of craniofacial complex. It forms the floor of cranial vault and supports the brain. Extending from the foramen caecum (anteriorly) to basioccipital bone (posteriorly), it separates the cranium from face. Cranial base is divided into anterior (sella-nasion) and posterior part (sella-basion) by sella turcica which lies near its centre. The maxilla appears attached to anterior part while the mandible to posterior part with two parts of cranial base forming an angle to each other known as cranial base angle. Because of this articulation of both jaws to cranial base, it has been assumed that cranial base morphology has considerable influence on sagittal relationship of maxilla and mandible, thus determining sagittal skeletal malocclusion[1].

Over the years, several studies have evaluated variation of cranial base morphology among different sagittal skeletal malocclusion. The differences in the findings of these studies conducted in different population[2–6] (i.e., Caucasian[2,3], Chinese[4] and Turkish[5] Indian[6]) are largely attributed to racial/ethnic differences. Hence, it is essential to obtain

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cranial base measurement data specific to each population and develop individual cranial base standards. We did not found any published study evaluating cranial base morphology and its variation among different sagittal skeletal malocclusion in Nepalese adults when a electronic literature search using key words "cranial base", "skeletal malocclusion" and "Nepalese population" was done. Hence, the present study was undertaken to obtain measurement data for various cranial base parameters and evaluate the variation in cranial base morphology among different sagittal skeletal malocclusion in Nepalese population.

## 2. Materials and Methods

Pretreatment lateral cephalogram of ninety patients, thirty from each sagittal skeletal group were selected from cephalometric database of Department of Orthodontics, Kathmandu University School of Medical Sciences according to following criteria:

### Inclusion Criteria:

- Good quality cephalograms of healthy patients (age> 18 years) with normal growth pattern (SN-MP=32±5 degree) and ANB angle
  - For skeletal Class I group: ANB angle (0-4 degree)
  - ForsSkeletal Class II group: ANB angle (> 4 degree)
  - For skeletal Class III group: ANB angle (< 0 degree)

### Exclusion Criteria:

- Cephalograms of patients having any known genetic/craniofacial abnormalities, growth related disorders, with history of facial trauma and or who had undergone orthodontic treatment/ craniofacial surgery
- Cephalograms of patients with positional errors as reflected by ear rod markers.
- Cephalograms in which landmarks could not be identified because of artifacts, motion, resolution disparity or lack of contrast.

All the cephalograms acquired were taken from the same digital cephalometer **(Planmeca Promax, Planmeca Oy, Helsinki, Finland)** and had the calibration ruler for determination of magnification. Hard copies of images were obtained on 8"X10" radiographic film using compatible X-ray printer (**Drypro Sigma 2, Konica Minolta, Tokyo, Japan**) and manual tracing was done using standard protocols. Calibration of the actual size of each image in millimeters was done based on measurement of the known distance (10 mm) between the two fixed points of the ruler on the cephalogram. Using a millimeter ruler and protractor four (3-linear and 1-angular) cranial base parameters were measured to the nearest 0.5 mm and 0.5° respectively (Table 1) and (Figure 1). After adding magnification factor to the obtained linear measurements final values were recorded and were entered into an Excel spreadsheet. To avoid intra-observer bias all the assessments (tracing as well as measurement) were done by the same investigator (RKM). Also, only five cephalograms were analyzed daily to minimize errors due to the human fatigue. To evaluate the errors due to landmark identification, tracing and measurement 15 cephalograms were randomly selected. With a three weeks gap, all the landmarks were replotted. Manual tracing and measurements were repeated on these cephalograms.

**Table 1.** Cranial base parameters (linear and angular) used in the study

| S. No. | Cranial Base Parameters | Description |
|---|---|---|
| **Linear Parameters** | | |
| 1. | Anterior Cranial Base Length (ACBL) | Distance between "Sella (S)" and "Nasion (N)" |
| 2. | Posterior Cranial Base Length (PCBL) | Distance between "Sella (S)" and "Articulare (Ar)" |
| 3. | Total Cranial Base Length (TCBL) | Distance between "Nasion (N)" and "Articulare (Ar)" |
| **Angular Parameters** | | |
| 4. | Cranial Base Angle (CBA) | Angle between "Nasion (N)", "Sella (S)" and "Articulare (Ar)" |

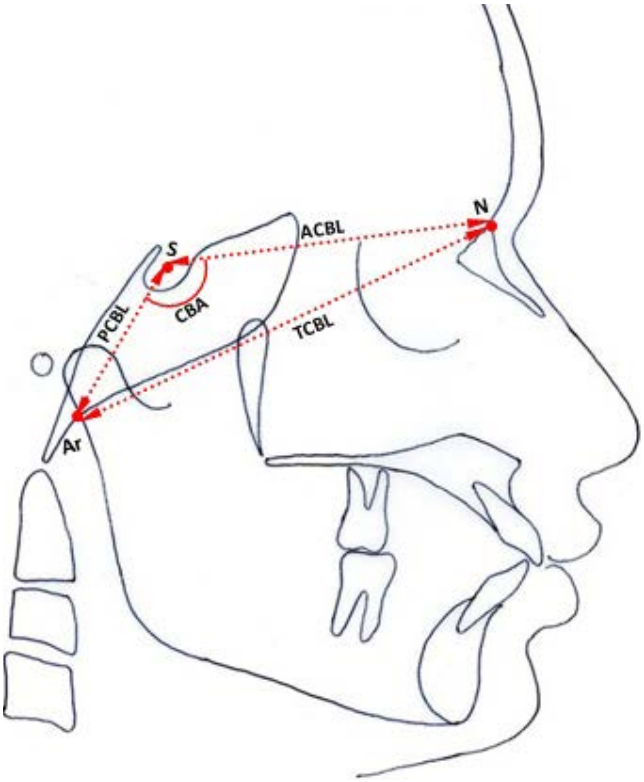



**Figure 1.** Cranial base parameters used in the study (ACBL, anterior cranial base length; PCBL, posterior cranial base length; TCBL, total cranial base length; CBA cranial base angle).

## 3. Statistical Analysis

All the statistical analyses were carried out using the Statistical Package for Social Sciences version 16.0 (SPSS Inc, Chicago, IL). Intra-observer reliability and reproducibility for repeated measurements were determined using Intraclass Correlation Coefficient (ICC). Normality of data distribution was checked using Kolmogorov-Smirnov test. All the cranial base parameters showed a normal distribution. Mean, standard deviation and standard error mean were calculated for all cranial base measurements. Analysis of variances [ANOVA] was used for analyzing difference in mean for cranial base measurements of three sagittal skeletal group. When a significant difference was observed for any cranial base parameter Least significant difference (LSD) post hoc test was used to determine individual difference The level of significance was noted at three levels (*$p < 0.05$); (**$p < 0.01$); (***$p < 0.001$).

## 4. Results

ICC values for repeated cephalometric measurements were more than 0.9 for all the cranial base parameters. ICC value of 0.75 is indicative of low agreement while ICC value of > 0.75 is indicative of a good agreement. This suggested of a very high Intra-observer reliability and reproducibility. The mean age of subjects in the study was (20.57 ± 1.95) years. A comparison of mean age of subjects among three sagittal skeletal group showed no significant difference (Table 2).

Table 3 shows mean, standard deviation and standard error value of measurement for each cranial base parameter (linear and angular) of patients with different sagittal skeletal group. While comparing among different skeletal class mean value of measurement for all the parameters i.e. ACBL, PCBL, TCBL and CBA was found to reduce systematically from skeletal Class II, through skeletal Class I, to skeletal Class III group (Figure 2). However, a statistically significant difference among different skeletal class was found only for TCBL between skeletal Class II and skeletal Class III ($p < 0.01$).

## 5. Discussion

Cranial base morphology in different sagittal skeletal malocclusion has been an area of interest to orthodontist since long. Due to racial/ethnic differences a considerable variation exists between the results of previous studies conducted in different population[4-6]. Hence the present study was conducted to obtain cranial base measurement

**Table 2.** Comparison of mean age of subjects among different sagittal skeletal malocclusion group

| Parameter | Group | N | Mean | SD | P† value |
|---|---|---|---|---|---|
| Age(years) | Class I | 30 | 20.70 | 1.78 | NS |
| | Class II | 30 | 20.63 | 1.90 | |
| | Class III | 30 | 20.40 | 2.20 | |

SD, standard deviation; NS, not significant; †ANOVA (one-way analysis of variance)

**Table 3.** Comparison of measurement values of cranial base parameters (linear and angular) among different sagittal skeletal malocclusion

| Cranial Base Parameters (Linear and Angular) | Group | N | Mean | SD | SEM | P value† | CL I-CL II‡ | CL I-CL III‡ | CL II-CL III‡ |
|---|---|---|---|---|---|---|---|---|---|
| **Linear Parameters** | | | | | | | | | |
| ACBL(mm) | Class I | 30 | 65.07 | 3.80 | 0.69 | NS | NS | NS | NS |
| | Class II | 30 | 66.38 | 2.98 | 0.54 | | | | |
| | Class III | 30 | 64.42 | 3.77 | 0.69 | | | | |
| | Total | 90 | 65.29 | 3.59 | 0.37 | | | | |
| PCBL(mm) | Class I | 30 | 33.88 | 4.58 | 0.83 | NS | NS | NS | NS |
| | Class II | 30 | 34.61 | 3.35 | 0.61 | | | | |
| | Class III | 30 | 33.45 | 3.51 | 0.64 | | | | |
| | Total | 90 | 33.98 | 3.84 | 0.40 | | | | |
| TCBL(mm) | Class I | 30 | 88.74 | 5.63 | 1.02 | * | NS | NS | ** |
| | Class II | 30 | 91.14 | 4.08 | 0.74 | | | | |
| | Class III | 30 | 87.48 | 5.59 | 1.02 | | | | |
| | Total | 90 | 89.18 | 5.30 | 0.55 | | | | |
| **Angular Parameters** | | | | | | | | | |
| CBA(degree) | Class I | 30 | 125.43 | 5.59 | 1.02 | NS | NS | NS | NS |
| | Class II | 30 | 127.10 | 5.87 | 1.07 | | | | |
| | Class III | 30 | 123.75 | 7.78 | 1.42 | | | | |
| | Total | 90 | 125.42 | 6.56 | 0.69 | | | | |

ACBL, Anterior cranial base length; PCBL, Posterior cranial base length; TCBL, Total cranial base length; CBA Cranial base angle; SD, Standard deviation; SEM, standard error mean; CL I, Class I; CL II, Class II; CL III, Class III; NS, not significant. *p < 0.05; **p < 0.01; †ANOVA (one-way analysis of variance); ‡ LSD (least significant difference)

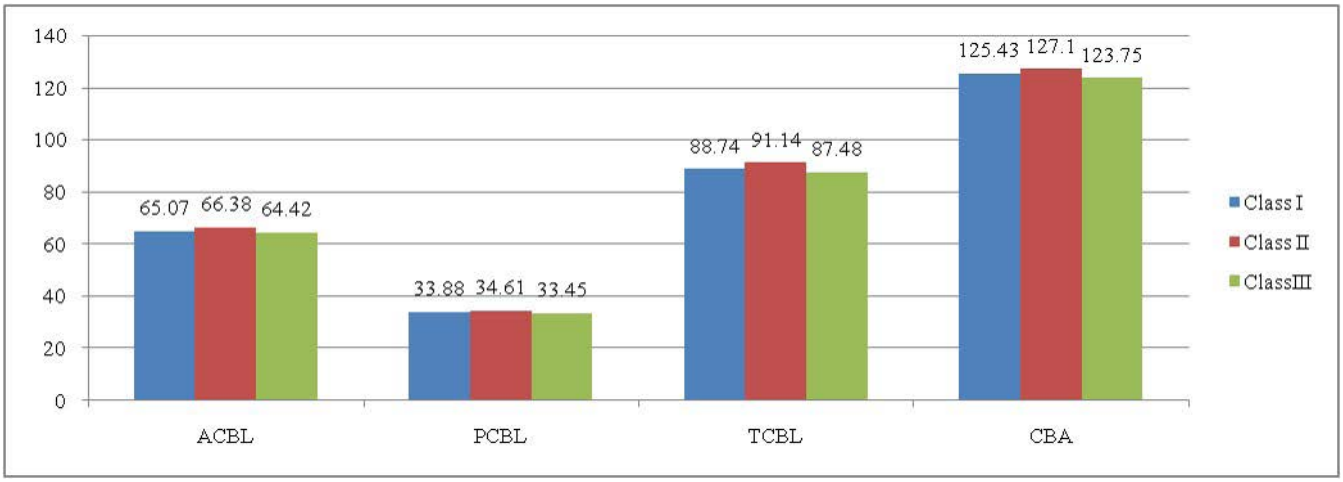



**Figure 2.** Bar diagram showing comparison of mean value of measurement for each cranial base parameter of subjects with different sagittal skeletal malocclusion (ACBL, anterior cranial base length; PCBL, posterior cranial base length; TCBL, total cranial base length; CBA cranial base angle).

data specific to Nepalese population and evaluate the variation in the morphology of cranial base among different sagittal skeletal malocclusion in Nepalese adults.

Growth of cranial base is said to reach 98% by 15 years of age[7–9]. Hence to avoid the differences due to growth the patients above 18 years of age were included in our study.

For cephalometric purpose, cranial base extends from nasion (N) to basion (Ba) and is divided into anterior (sella-nasion) and posterior part (sella-basion) by sella (S) which lies near its centre. As identification of Ba point is associated with greater errors, we took articulare (Ar) as posterior limit of cranial base in place of Ba[10,11]. Also Bjork[12] has advocated the use of articulare over basion because of its easier identification.

To evaluate the morphology of cranial base four different parameters [linear- ACBL, PCBL, TCBL; angular- CBA] were measured in the present study. Hopkin et al.[2] using articulare as posterior limit of cranial base, analyzed cranial base dimensions among different classes of malocclusion and found that cranial base length and angle progressively reduced from Class II via Class I to Class III. While, Dibbets[3] and Chin et al.[4] used basion as posterior limit of the cranial base and reported with a similar finding. A recent meta analysis by Gong et al.[8], also concluded that ACBL, TCBL and CBA were significantly smaller in Class III malocclusion and greater in Class II with intermediate values for Class I controls. In agreement with the findings of these studies, we found that the mean measurement value for all the cranial base parameters i.e. ACBL, PCBL, TCBL and CBA to reduce systematically from skeletal Class II, through skeletal Class I, to skeletal Class III group.

Out of four parameters compared among different skeletal class in this study a statistically significant difference was found only for TCBL between skeletal Class II and skeletal Class III ($p < 0.01$) while no significant difference was observed for ACBL, PCBL and CBA.

Chin et al.[4] evaluated cranial base morphology in the Southern Chinese population found a statistically significant difference for TCBL (NBa) and CBA (NSBa) with no significant difference observed for ACBL (SN) and PCBL (SBa).While Kamak et al.[5] found a statistically significant difference only for CBA1 (NSAr) in the Turkish population. No significant difference was observed for ACBL (SN), PCBL (SBa) and CBA2 (NSBa). On the other hand, Breh and Kamat[6] found a statistically significant difference for all the parameters i.e. ACBL (SN), PCBL 1 (SAr), PCBL2 (SBa), CBA1 (NSAr) and CBA2 (NSBa) in a study conducted in the Indian population. The difference in the findings of these studies and ours might be primarily due to racial/ethnic variations in morphology of cranial base.

In the present study 90 pre-treatment lateral cephalograms of orthodontic patients visiting a tertiary level hospital in Central Nepal were evaluated. Hence further studies with a larger sample size are suggested.

## 6. Conclusion

A significant difference in TCBL among different sagittal skeletal malocclusion was observed in Nepalese adults. For all the cranial base parameters highest mean value was observed in skeletal Class II and lowest in Class III with intermediate values in Class I.

## 7. References


1. Dhopatkar A, Bhatia S, Rock P. An investigation into the relationship between the cranial base angle and malocclusion. Angle Orthod. 2002;72:456–463.
2. Hopkin GB, Houston WJB, James GA. The cranial base as an aetiological factor in malocclusion. Angle Orthod. 1968;38:250–255
3. Dibbets JM. Morphological associations between the angle classes. Eur J Orthod. 1996;18:111–118. https://doi.org/10.1093/ejo/18.1.111
4. Chin A, Perry S, Liao C, Yang Y. The relationship between the cranial base and jaw base in a Chinese population. Head Face Med. 2014;10:31–38. https://doi.org/10.1186/1746-160X-10-31
5. Kamak H, Çatalbas B, Senel B. Cranial base features between sagittal skeletal malocclusions in Anatolian Turkish adults: Is there a difference. J Orthod Res. 2013;1:52–56. https://doi.org/10.4103/2321-3825.116287
6. Breh R, Kamat NV. Cranial base morphology determining sagittal and vertical facial relation: A cross sectional study. Int J Sci Res. 2017;6:1823–1826.
7. Bishara SE. Ortodontia. São Paulo: Ed. Santos; 2004.
8. Thiesen G, Pletsch G, Zastrow MD, do Valle CV, do Valle-Corotti KM, Patel MP, Conti PC. Comparative analysis of the anterior and posterior length and deflection angle of the cranial base, in individuals with facial Pattern I, II and III. Dent Press J Orthod. 2013;18:69–75. https://doi.org/10.1590/S2176-94512013000100016

9. Currie K, Sawchuk D, Saltaji H, Oh H, Flores-Mir C, Lagravere M. Posterior cranial base natural growth and development: A systematic review. Angle Orthod. 2017;87:897–910. https://doi.org/10.2319/032717-218.1
10. Chang ZC, Hu FC, Lai E, Yao CC, Chen MH, Chen YJ. Landmark identification errors on cone-beam computed tomography-derived cephalograms and conventional digital cephalograms. Am J Orthod Dentofacial Orthop. 2011;140:e289–e297. https://doi.org/10.1016/j.ajodo.2011.06.024
11. Gong A, Li J, Wang Z, Li Y, Hu F, Li Q, Miao D, Wang L. Cranial base characteristics in anteroposterior malocclusions: A meta-analysis. Angle Orthod. 2016;86:668–680. https://doi.org/10.2319/032315-186.1
12. Bjork A. Cranial base development. Am J Orthod. 1955;41:198–225. https://doi.org/10.1016/0002-9416(55)90005-1