

# Does the Eastman correction over- or under-adjust ANB for positional changes of N?

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**SUMMARY** Cephalometric analyses are useful for planning and provision of orthodontic treatment. A and B points are used to resemble the anterior part of maxilla and mandible and N represents the anterior part of the cranial base. The position of N may influence measurements of SNA, SNB, and ANB and changes of N in the antero-posterior plane are thought to have a larger influence on the above measurements than vertical ones. Several methods have been proposed to address this issue, such as the Wits appraisal, the 'Individualized ANB', and the 'Eastman correction'; the latter is mainly used in the UK. This study used a geometrical model of a lateral cephalogram with standard Caucasian average values for SN length, position of A and B points for male and female patients. Linear and angular measurements were digitized using Dolphin™ Imaging software. N was moved in antero-posterior and vertical planes and subsequent changes of SNA, SNB, and ANB were measured and the Eastman correction applied. The correction overestimated the SNA and ANB values in the opposite direction to the directly measured SNA and ANB when N moved posteriorly towards S: The directly measured values tended to show a Class II relationship but the correction indicated a Class III skeletal base. As N moved anteriorly, the Eastman correction overestimated the measured Class III skeletal relationship; SNA did not fall below 81 for correction in the opposite direction. Vertical positional changes had little impact on the underlying ANB and correction was not indicated clinically.

## Introduction

The use and evaluation of the lateral cephalogram can be a valuable diagnostic tool in planning and provision of orthodontic treatment. It allows for more reliable quantification of the skeletal or dentoalveolar findings than information derived from clinical examination.

It is not surprising that, due to the diagnostic potential of the lateral cephalogram, there are many cephalometric analyses available and a large number use SNA (angle between Sella–N–A point) and ANB (angle between A point–N–B point), which are used to resemble the relationship of the maxilla to the cranial base and maxilla and mandible to one another.

SN is used to represent the anterior cranial base and it undergoes minimal change during growth. On the other hand, N does not really lie on the anterior cranial base but at the junction between the suture of the frontal and nasal bones. Growth changes at N have led to multiple cephalometric analyses to assess the validity of angular measurements and to overcome the inherent problems in using N as a stable reference point (Jacobsen, 1975).

Calculation of the ANB angle is comparatively easy. A and B are midline structures and therefore easily identified on a lateral cephalogram. However, they are influenced by alveolar bone remodelling during orthodontic tooth movement of the labial segments. The angles SNA and

ANB (Reidel, 1952) rely on correct vertical and horizontal measurements and landmark identification.

Apart from being affected by length of the anterior cranial base, ANB is also affected by the degree of inclination of the maxillary and mandibular incisors and rotation of the jaws to each other as well as to the cranial base. Bishara *et al.* (1983) noted that SNA is affected by the length and cant of SN and the relative upward or downward position of N. Beatty (1975) as well as Hussels and Nanda (1984) demonstrated how ANB can be influenced by the anterior face height. Linear measurements of two different patients could result in the same ANB because of different distances between A and B point resulted in identical values but did not necessarily indicate the same skeletal base relationship, thereby rendering the ANB measurement less useful. The reverse applies in cases where the lengths of the jaws are the same but the patients have different ANB (Ferrazzini, 1976). Also, ANB is not necessarily stable over time as it has been shown to diminish with age (Bishara *et al.*, 1983).

Jacobsen (1975) introduced the Wits appraisal to avoid using the cranial base as a reference plane. The Wits appraisal however relies on reproducible identification of the functional occlusal plane, which firstly can be difficult to identify reliably and secondly also varies with dento-alveolar and skeletal changes. Oktay (1991) found that the Wits appraisal is no more reliable than the ANB angle. Del

The 'Eastman correction' is used to address the above-mentioned inaccuracies for assessment of the angle ANB and was first described by Mills (1982). The correction states that for every 1 degree that the angle SNA falls below the standard value of 81 degrees, half a degree should be added to the ANB angle and vice versa. The correction is restricted for cases where the SN-maxillary plane angle is the standard  $8 \pm 3$  degrees. No information has been published on the methodology of how the correction was established.

### Aim of study

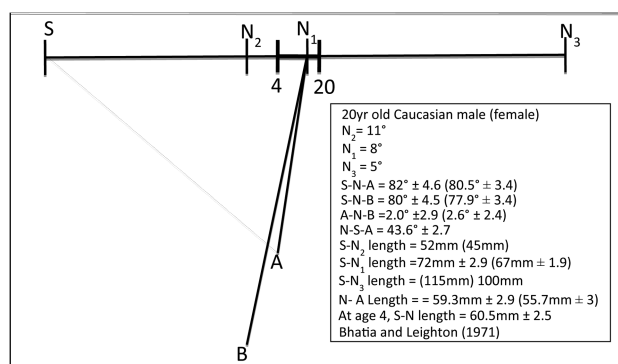
The null hypothesis was that the Eastman correction appropriately adjusts the ANB irrespective of the position of N.

## Materials and methods

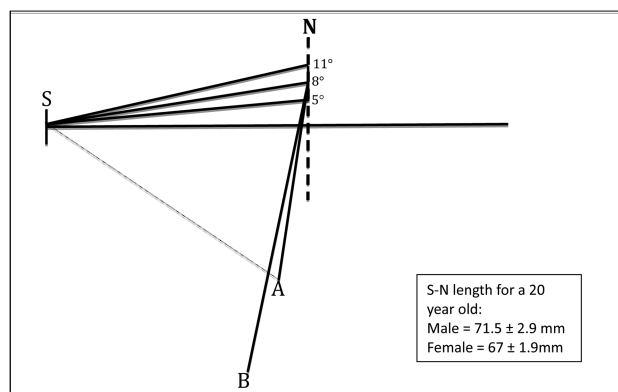
Dolphin™ Imaging (version 11) is a dedicated orthodontic software that allows storage, manipulation, and processing of patient images and radiographic records. It allows for

The software however only allows the measurement of the vertical change of the position of N by millimetres rather than changing the angulation of SNMx in degrees. Hence for each millimetre interval, the SNMx was measured by hand to ensure that the value stayed within the SNMx range of 5–11 degrees.

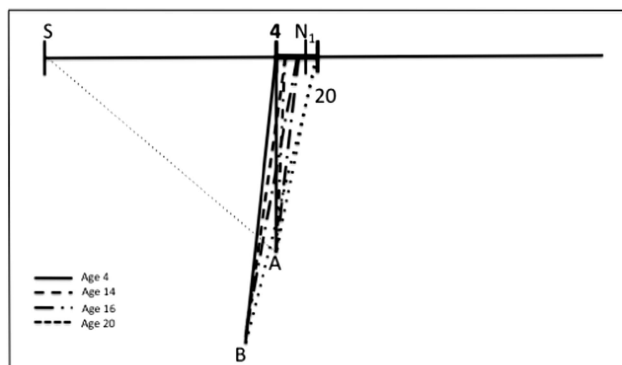
N was moved antero-posteriorly (Figures 1 and 3) and vertically (Figure 2). Changes in the angles SNA, SNB, and ANB were subsequently measured. The Eastman correction was then applied to determine the accuracy of the correction and its influence on angle ANB.



**Figure 1** Theoretical geometrical model for a 20-year-old male and female (values in brackets where different) with calculated SN lengths at the limits of SNMx in the antero-posterior plane to allow for application of the Eastman correction. The bold interval indicates the SN length of relevance from age 4 to 20.



**Figure 2** Theoretical geometrical model for a 20-year-old male and female with an average SN length.



**Figure 3** Theoretical geometrical model with calculated SN lengths in the antero-posterior plane to allow for application of the Eastman correction. The red interval indicates the SN length of relevance from age 4 to 20 years. Values 4 and 20 indicate position of N at respective patient age. Angles SNA, SNB, and ANB were measured.

In the antero-posterior plane, SN lengths were measured when angle SNMx was at 5 and 11 degrees for Figures 1 and 3, respectively. N was moved posteriorly until an ANB value of a Class II skeletal base was measured ( $N_2$ ) and anteriorly until an ANB value of a Class III skeletal base was obtained ( $N_3$ ). The skeletal base of maxilla and mandible however had been left unchanged to one another and was still Class I. When N was moved towards  $N_2$  or  $N_3$ , the measured ANB value gave a different classification of skeletal discrepancy to that calculated when the Eastman correction was applied. The calculated SN lengths at  $N_2$  and  $N_3$  however were not used in this study as these cannot be encountered clinically: they were beyond the limits of normal variation and are outside the growth parameters between the ages of 4 and 20 years and their respective 2 SDs. This study used data that were derived from measurements between the values for a 4-year-old and a 20-year-old patient as these were more likely to resemble a clinically relevant scenario. The Eastman correction was subsequently calculated for evaluation of its accuracy.

The measured ANB and the corresponding Eastman correction for ANB were then classified according to its skeletal discrepancy: 2–4 degrees for Class I, ANB >4 degrees for Class II, and ANB <2 degrees for Class III. Measurements were re-taken for analysis of repeatability.

#### Statistical analysis

The Bland Altman test was used for repeatability of measurements. The Lin correlation coefficient was used to test concordance of continuous data, measuring the strength of the linear relationship between the skeletal relationship directly measured and the calculated ANB value after Eastman correction (Eastman class) where necessary. The Pearson's chi-squared test was used to establish whether the frequency distribution of the Eastman correction differed from the results obtained from the direct measurements. For

computation of data, we used Stata Version 11.1 (StataCorp LP, College Station, Texas, USA).

#### Results

The Bland Altman test showed good correlation and reproducibility for each measurement, i.e. between  $\pm 1.96$  SD of the difference. The Lin concordance correlation coefficient showed positive correlations between measurements directly obtained and the Eastman correction for all measurements.

#### Movement of N in the antero-posterior plane

Descriptive Statistics were used to analyse the observed correlation and frequency of ANB values of skeletal relationship obtained from direct measurements and after the Eastman correction (expected likelihood  $P < 5$ , Pearson chi-squared  $P = 0.001$ ). Application of the Eastman correction as N moved posteriorly resulted in over-correction of the ANB angle to the opposite direction. As N moved towards S (or  $N_2$ ), the directly measured ANB resulted in a Class II value, as expected. However, upon application of the Eastman correction, there was an over-adjustment and the resulting ANB was a Class III value. When N was moved away from S (towards  $N_3$ ), the directly measured ANB values shifted towards a Class III tendency; the application of the Eastman correction however exaggerated this Class III tendency apart from the data derived from the outer limits. This was due to the fact that movement of N anteriorly did not result in an SNA of less than 81 degrees, so the Eastman correction did not lead to an improvement of the Class III incisor relationship but to a worsening.

#### Movement of N in the vertical plane

The Eastman correction was not applied as the SNA stayed within normal limits for a 20-year-old male and female for as long as SNMx was moved within the limits (5–11 degrees). The data are shown in Table 1. There was only a very minimal change in the SNA values for both male and female with vertical movement of N, which is clinically irrelevant and this would have little impact on interpretation of the cephalometric data.

#### Discussion

Standard Caucasian average values for SN length, SNA, ANB, and position of A in relation to the cranial base were taken from the Bhatia and Leighton (1971) growth study for a 20-year-old male and female, which is the only study the authors are aware of, that has published the average values for both angular and linear measurements of the craniofacial complex for the UK Caucasian population.

This study utilized digital imaging software for measurements and this may have drawbacks. Power *et al.* (2005) compared the use of Dolphin Imaging software

**Table 1** Observed ANB values within the normal limits of SNMx (5–11°).

SNMx	SN length	SNA	SNB	ANB	ANB after Eastman correction
Going upwards from SNMx 8.0° (7.8°), SN length 71.8 mm (66.3 mm), SNA 82.2° (81.2°), SNB 80.4° (78.7°), and ANB 1.8° (2.5°)					
8.7 (8.6)	71.8 (66.5)	81.7(80.4)	79.8 (77.9)	1.8 (2.4)	Not applied due to SNA being within 82 ± 4.6°
9.6 (9.5)	71.8 (66.5)	80.9 (79.6)	79.1 (77.1)	1.9 (2.5)	
10.4 (10.4)	71.9 (66.6)	80.2 (78.8)	78.3 (76.4)	1.9 (2.5)	
11.2 (11.1)	71.9 (66.6)	79.5 (78.2)	77.6 (75.7)	1.9 (2.5)	
12.1 (12.1)	71.9 (66.7)	78.8 (77.4)	76.9 (74.9)	1.9 (2.5)	
Going downwards from SNMx 8.0° (7.8°), SN length 71.8 mm (66.3 mm), SNA 82.2° (81.2°), SNB 80.4° (78.7°), and ANB 1.8° (2.5°)					
7.1 (6.8)	72.0 (66.5)	82.8 (81.8)	81.1 (79.5)	1.7 (2.4)	Not applied due to SNA being within 82 ± 4.6°
6.3 (6.0)	72.0 (66.5)	83.5 (82.4)	81.8 (80.1)	1.7 (2.3)	
5.5 (5.0)	72.0 (66.5)	84.2 (83.2)	82.5 (81.0)	1.7 (2.3)	
4.7 (4.2)	72.1 (66.6)	84.8 (83.9)	83.2 (81.7)	1.6 (2.2)	
3.9	72.2	85.5	83.9	1.6	

SNA values remained within normal limits for 20-year-old male (female) negating the need for application of the Eastman correction.

**Table 2** Results for the outer limits of data from the Bhatia and Leighton (1971) growth study for patients between the ages of 4 and 20 years.

	Male				Female			
Age	4	14	16	20	4	14	16	20
SN length (mm)	61	69	70	72	58	66	67	69
SNA (°)	92.7	86.1	85.0	82.4	95.7	88.0	87.1	85.2
SNB (°)	87.2	83.0	81.7	80.6	89.1	84.2	83.6	82.4
ANB (°)	5.5	3.1	2.7	1.8	6.5	3.8	3.5	2.8
After Eastman correction	0.0°	0.6	0.7	1.3	-1.0°	-0.2	0.0	0.0

Ages 14 and 16 were used as starting point and 'average values' as the majority of patients attending an orthodontic clinic are in this age range.

(version 8.0) to manual tracing and found the latter to be more reliable for SNA, SNB, and SNMx, with low concordance for ANB. This investigation used Dolphin™ Imaging (11.0), which has since been updated but it still requires accurate landmark identification for good reliability of the cephalometric analysis (Cohen, 2005). We used geometrical model representations drawn on  $1 \times 1$  mm graph paper that were on a 1:1 scale so the captured images showed identical distances for calibration and angular measurements were unaffected by uniform magnification.

Sadat-Khonsari *et al.* (2009) used a theoretical model similar to the one used in this investigation for movement of N in the horizontal plane and found ANB increased as SNA and SNB increased, corresponding to an increase in the length between points A and B, and this is consistent with the findings of our study. Freeman (1981) and Taylor (1969) both found that SNA values of over 86 degrees result in ANB increases and SNA values under 77 degrees result in ANB decreases. A number of investigations based on clinical data (Panagiotidis and Witt, 1977; Järvinen, 1985; Lux *et al.*, 2005) found similar results and came to similar conclusions to our study. In our model, the simulated movement of N for values of patients

between 4- and 20-year of age indicate that assessment of ANB is not reliable. Although the 'true' positions of A and B had not changed relative to one another and the occlusal plane, the skeletal base measurements did change with movement of N although this should ideally not have happened. This confirms that the relationships of A and B point to one another do not always coincide depending whether these are measured relative to the occlusal plane or the base of skull. This is seen in Figure 3. When moving N posteriorly (towards N<sub>2</sub>), direct measurements on our geometrical model for ages 14 and 16 years revealed a Class II tendency. The Eastman correction over-adjusted ANB in the opposite direction (see Table 2), revealing a Class III tendency. When N was moved anteriorly from S (towards M<sub>3</sub>), a Class III tendency was measured on the model and application of the Eastman correction made the Class III tendency worse.

Moving N vertically within SNMx 5–11 degrees for both the male and female models showed that there was very little change in the measurements of angle ANB. Values stayed within a Class I skeletal discrepancy. SNA also stayed within normal limits for each gender. This suggests that changes of the vertical position of N have little impact on the underlying ANB; the Eastman correction is not applicable within the small variation of when SNMx lies between 5 and 11 degrees and SNA is of average value.

Pearson's chi-squared coefficient probability for the three theoretical geometrical models (combined male and female model, the individual male model, and the individual female model) were less than 0.05. The null hypothesis that the Eastman correction adjusts the measured data correctly, returning them to the original value, was therefore rejected.

## Conclusions

Changes in position of N influence SNA, SNB, and ANB but positional variations of N in the antero-posterior plane have a larger impact on ANB than in the vertical plane.



Using the special arrangements of a cephalogram based on Bhatia and Leighton's (1971) data for male and female patients, the Eastman correction overestimated towards the opposite skeletal discrepancy when N was moved posteriorly towards S. Class II ANB values were obtained from direct measurements and the Eastman correction should ideally have corrected those to their original Class I values. Application of the Eastman correction however revealed Class III readings.

When N moved anteriorly, Class III tendencies were obtained from direct measurements and application of the Eastman correction made the discrepancy appear worse because SNA did not fall below 81 degrees, which would have allowed for an improvement of the Class III data.

Varying the SNMx within the limits allowed by the Eastman correction resulted in very little variation of angle ANB. Changes of the position of N in the vertical plane did not lead to clinically significant changes for the Eastman correction to be applied; the values for SNA stayed within average readings for both genders for the majority of the data.

Our study confirms Ishikawa's *et al.* (2000) recommendation to use at least two cephalometric analyses for assessment of the skeletal base. Non-concordance of two cephalometric analyses should lead to careful re-evaluation of the results obtained keeping the clinical findings in mind.

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