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*** Title Page**

Influence of the Occlusal Plane Inclination on ANB and Wits Assessments of Anteroposterior Relationship of the Jaws

Abstract

Although assessments of anteroposterior relationships are vital for orthodontic treatment planning, they have not been precisely achieved by current cephalometric and non-cephalometric resources. ANB and Wits are the most popular cephalometric measurements applied in clinical Orthodontics, although they present recognized drawbacks. It has been demonstrated that facial vertical features, especially occlusal plane angle, play an important influential role in their assessment, contributing for their unreliability. In order to further understand the influence of the occlusal plane inclination, ANB and Wits were analyzed in cephalo-lateral radiographs of 122 finished orthodontic cases. The cases were primarily allocated in two groups: high occlusal plane angle and low occlusal plane angle. There was a tendency for inconsistency between ANB and Wits assessments in the high occlusal plane angle group and a tendency for consistency in the low occlusal plane angle group. Cranial base influences on ANB and Wits assessments were investigated by allocation of the individuals in sub-groups. Any of the considered cranial base factors was decisive for lack or presence of consistency between ANB and Wits assessments. The clinician shall be warned of possible misinterpretations when uses ANB and Wits to assess anteroposterior relationship of the jaws, especially in high occlusal plane angle patients.

Keywords: Cephalometrics, Anteroposterior Relationship, ANB, Wits, Occlusal Plane

Introduction

Angular measurements are geometrically sensitive and may give false results.[1,2,3,4,5,6,7,8,9,10,11,12] The ANB angle,[13,14] used to determine anteroposterior maxillary-mandibular relationship varies according to the extension and inclination of the anterior cranial base.[3,4,5] Moreover, ANB varies according to the patient's age, vertical and anteroposterior position of Nasion,[15,16] upward or downward rotations of the jaws and degree of facial prognathism.[17]

Due to the intrinsic lack of certainty of the angular methods of assessment, many linear measurements have been proposed, in order to determine the actual anteroposterior relationship of the jaws. As examples, distance between the perpendiculars drawn from the Sella-Nasion line to points A and B,[1] distance between perpendiculars drawn from the occlusal plane to points A and B (Wits appraisal),[3] anteroposterior dysplasia indicator,[7] distance between perpendiculars drawn from the Frankfort plane to points A and B,[11,18] distance between perpendiculars drawn from palatal plane to points A and B[19] and distance between perpendiculars drawn from the bisector of the maxillary-mandibular planes angle to points A and B.[20,21]

Routinely, ANB and Wits are the most common cephalometric tools to assess antero-posterior jaw discrepancies. In a simplistic view, the relationship between maxilla and mandible considering the anterior cranial base (ANB) is refined by a local jaw measurement (Wits), in order to eliminate its interferences. The combination of ANB and Wits, one complementing each other, can well diagnosis skeletal discrepancies and consequently well address treatment strategies.[22]

Since ANB and Wits assess the same skeletal discrepancy, they should, theoretically, show good agreement. In reality, the correlation between both is not strong as expected,[22,23,24,25,26] which suggests weakness in one of the two or both assessment tools.

As an important fact, ANB and Wits are related to vertical features. There is influence of the occlusal plane angle and facial height on the ANB assessment.[10] However, there is no statistically significant correlation between ANB and SN -Y Axis angle[27] or between ANB and the mandibular plane angle.[15] The Wits appraisal is also influenced by the occlusal

plane angle.[3,4,5,8,10,11,23,28,30,31] Actually, small variation on the occlusal plane angle causes greater effect on the Wits measurement than on the A point, B point, Nasion or ANB angle.[32]

Independently of the nature of the influence, geometric or biological, recognition of its source helps the orthodontist to better understand the potential drawbacks involved in their interpretation. Our study primarily targets to verify if ANB and Wits assessments show consistent results in patients who present high or low occlusal plane angles. Secondly, if specific cranial base features play important geometric influences in such assessment or not.

Material & Methods

Sample

The sample is comprised of 122 Brazilian patients, 44 males (36%) and 78 (64%) females, who sought for Orthodontic treatment in private practice (MDS). The mean age of the sample at the time of initial records was 13.3 (± 5.3) years of age.
The sample included 29 patients Class I (24%), 82 patients Class II, division 1 (67%), 7 patients Class II, division 2 (6%) and 4 patients Class III (3%).
The sample was selected based on the following criteria: consecutive chronological orthodontic cases which started from 1995 to 2003, in patients whom were treated and were taken standardized initial and final records.
Patients were rejected for the project based on the following criteria: lack of initial (T1) or final (T2) cephalo-lateral radiograph and patients who presented any craniofacial deformity.
For all patients, the orthodontic treatment was performed by the same orthodontist (MDS), applying the same orthodontic technique: Straight-wire fixed appliance, slot 0.018 brackets molar bands and progressive sequence of orthodontic wires. Headgears and lip bumpers were installed when indicated.
Orthodontic treatment was addressed without extractions in 99 cases (81%). Upper and lower premolars extractions were performed in 11 cases (50% of 19%), upper premolars extractions in 10 cases (45% of 19%) and lower premolars extractions in 2 cases (9% of 19%).

Data Collection

Pre-treatment records (T1) and post-treatment records (T2) included cephalo-lateral radiographs taken using the same cephalostat, at the same records center. Cephalometric landmarks (Figure 1) were identified and traced in orthodontic acetate paper by the orthodontist (MDS). All the landmarks were digitalized and all the measurements computed using the DFPlus software by the same technician (TP).

Landmarks and Measurements

The following landmarks were identified and digitalized (Figure 1):

1. Basion (Ba): the most inferior and posterior point on the anterior margin of the foramen magnum.
2. Sella (S): the center of the pituitary fossa of the sphenoid bone.
3. Nasion (N): the junction of the frontal and nasal bones, at the fronto-nasal suture.
4. Anterior Nasal Spine (ANS): the tip of the median anterior bony process of the maxilla.
5. A Point (A): the deepest point on the concavity at the anterior surface of the maxilla.
6. B Point (B): the deepest point on the concavity at the anterior surface of the mandibular symphysis.
7. Gonion (Go): the midpoint of the angle of the mandible.
8. Gnathion (Gn): the most anterior and inferior point on the contour of the symphysis. Determined by bisecting the angle formed by the mandibular plane and the Nasion-Pogonion line.
9. Menton (Me): the most inferior point on the mandibular symphysis.

Occlusal Plane (OP): plane formed by the half distance point between the incisal edges of upper and lower incisors and the mesial cuspid tips of bilateral upper permanent first molars.

The following measurements were computed (Figure 2):

1. S-N: distance (mm) between the landmarks Sella and Nasion, determining the extension of the anterior cranial base.
2. NSBa: angle (°) between the anterior and posterior cranial bases.
3. ANB: angle (°) between A Point, Nasion and B Point.
4. Wits: distance between the perpendicular projection of the A and B points on the occlusal plane (Figure 3).
5. S-Go: distance (mm) between the landmarks Sella and Gonion, representing the posterior facial height.
6. N-Me: distance (mm) between the landmarks Nasion and Menton, representing the anterior facial height.

7. SNOP: angle (°) between the anterior cranial base (S-N) and the occlusal plane (OP).
8. Y Axis: smaller angle (°) between the cranial base (Ba-N) and the Sella-Gnathion (S-Gn) line.
9. Antero-Posterior (AP) Proportion: ratio between posterior and anterior facial heights.
10. Anterior (Ant) Proportion: ratio between upper facial height (N-ANS) and lower facial height (ANS-Me).

Systematic and Random Errors

In order to calculate the systematic and random errors, a sub-sample of 5 randomly selected radiographs were re-traced and re-digitalized. Systematic error was not statistically significant and random method error, defined according to Dahlberg formula[33] ($\sqrt{\sum d^2/2n}$), ranged from 0.5 mm for S-Go to 1.0 mm for Wits and from 0.3 degree for Y Axis to 1.2 degree for NSBa.

Statistical Methods

All the data were computed by the SPSS software (Release 10.0). Descriptive statistics and normal distributions were verified for each variable. Paired t-tests were performed to evaluate treatment changes (T1-T2). Pearson product-moment correlation coefficients were calculated between T1 and T2 variables. The significance level of $p \leq 0.05$ and $p \leq 0.01$ were established.

Groups Allocation

Based on the descriptive statistics of the total sample (all cases), two occlusal plane angle groups were constituted. The median of 15.3° for SNOP angle divided the patients in high and low occlusal plane angle groups.

Sub-Groups Allocation

Based on the descriptive statistics of the total sample (all cases), the median of 73.0 mm for S-N distance divided the patients in short or long anterior cranial base sub-groups. Again, based on the descriptive statistics of the total sample (all cases), the median of 123.4° for NSBa angle divided the patients in small or large cranial base angle sub-groups.

Results

Descriptive statistics including all cases, before (T1) and after (T2) treatment, were presented in Table 1. Paired t-test showed significant differences for all variables, except for the cranial base angle (SNBa) and for the anterior proportion (Table 1).

Descriptive statistics, before (T1) and after (T2) treatment, for the high and low occlusal plane angle groups were presented in Tables 2 and 3. Descriptive statistics, before (T1) and after (T2) treatment, for the small and large cranial base angle groups were presented in Tables 4 and 5.

There was significant Pearson product-moment correlation ($p \leq 0.01$) between ANB and Wits, considering T1 and T2 data (Table 6). The lowest correlations were found between ANB and Wits, when comparing T1 and T2 data.

Paired t-tests were applied between T1 and T2 data for ANB and Wits assessments in the high occlusal plane angle (Table 7) and low occlusal plane angle (Table 8) groups.

In the high occlusal plane angle group, the statistically significant differences between T1 and T2 showed by the ANB assessment were not showed by the Wits assessment for all the groups (Table 7). There was clear disagreement between the results provided by each one of the assessments.

In the low occlusal plane angle group, the statistically significant differences between T1 and T2 showed by the ANB assessment were confirmed by the Wits assessment for the long anterior cranial base group and for the large cranial base angle group. Statistically significant difference was practically confirmed by ANB and Wits assessments for the short anterior cranial base and not confirmed by both assessments for the small cranial base angle group (Table 8). There was agreement between the results provided by each one of the assessments.

Discussion

Since ANB and Wits are not decisive ways to assess anteroposterior discrepancies and hold significant variation, expressive overlap between the groups could provide “noised” results. In order to eliminate proficiency bias, all the cases were treated by the same clinician and by the same orthodontic technique. Sample allocation, delineating groups which present similar pretreatment conditions, intends to provide results relatively free of contamination by susceptibility bias. Furthermore, since all the patients who met the inclusion criteria were accounted for the study, its external validity holds potential clinical interest.

The most common doubts of the clinical orthodontist spin around two major dilemmas: is there a skeletal malocclusion present in this case or not? If there is, is it up to what degree? Although ANB and Wits are cephalometric tools widely applied to evaluate anteroposterior relationships of the jaws, there is a significant intrinsic lack of certainty in both assessments. Consequently, there is an intensive search for new and better cephalometric and non-cephalometric diagnostic resources targeting to assess jaw discrepancies.

Such intense research occurs because vital orthodontic decisions depend on correct assessment. Treatment objectives and treatment plans are, although not exclusively, deeply driven by cephalometric information. If diagnosis is incorrect, treatment plans may be inadequate and treatment time may be extended, at least. If it happens, other consequences, as patient and parents disappointment, are natural consequences.

Rich literature provides new formulas to assess skeletal discrepancies and further research on traditional measurements, as ANB and Wits, is still necessary. First of all, because such cephalometric measurements are easy to perform and secondly, because they are popular, facilitating communication among colleagues. Research on traditional measurements searches further understanding of their limitations. If the limitations are masterized, it is expected better application of their useful information. In different words, understanding of drawbacks tune-up answers.

Understanding of what occurs at the target area depends on trust of what is going on the reference area, because all landmarks are just relative to each other. Measurements increase or decrease with no discrimination of which area is off, or if both are off. For ANB, many sources of errors have been identified,[17] as extension and inclination of the anterior cranial base, position of the Nasion and vertical features.[10] From all the influential parameters imbued on the ANB assessment, the most important is the anterior facial height, reflected on the increase of the S-N to occlusal plane angle, on the distance of B point to Nasion and on the distance of A point to B point.[10,12]

Wits appraisal[3] was presented to overcome the fallacies of the ANB angle.[10] However, as it is made by the projections of A and B points on the occlusal plane and because the occlusal plane inclination depends directly on facial growth direction, dental eruption and alveolar bone development, its drawbacks also demand careful attention before individual application.

Beside normal biological variation, many sources of influences naturally increase variation. The normal range of ANB angle is 2° ± 3°, [14, 34] and such considerable variation[35,36] make individual application just a broad estimation. Wits distance should be 0 mm in females and -1 mm in males with a skeletal Class I relationship[3] and holds important variation as well.[11,23,28,29,30,37]

Geometric effects make the occlusal plane angle to modulate ANB and Wits assessments. Our study targeted to identify agreement or disagreement between ANB and Wits assessments in high occlusal plane angle and low occlusal plane angle groups, controlling for anterior cranial base size and cranial base angulation sub-groups.

General view of the effects of the treatment shows growth effects on the anterior cranial base (S-N) but not significant changes in the cranial base angle (Table 1). ANB and Wits have significantly decreased with treatment, what was expected, since approximately ¾ of the sample presented Class II malocclusion in T1 and orthodontic mechanics was driven to decrease initial ANB in the most of the cases. Vertical growth occurs on the posterior and anterior facial heights, however, relatively more on the posterior height, increasing the anteroposterior proportion. In the relation between the upper and lower anterior heights of the face, the anterior proportion, significant changes did not occurred.

ANB and Wits assess the same problem but hold just fair correlation. As described before,[22,23,24,25,26] our results support that one of the two or both assessments hold weakness *per se*. The sample was divided in groups and sub-groups, in order to reduce biases, as explained before.

Our results showed uncertainty when ANB or Wits were used as assessment tools. There was clear lack of consistency between ANB and Wits assessments in the high occlusal plane angle group. Our results indicated that the antero-posterior maxilla-mandibular relationship changed significantly for all the sub-groups, but the same did not happen when assessed by Wits. It is suggested that in the high occlusal plane angle group ANB may have overestimated anteroposterior positioning of the jaws and/or Wits may have underestimated anteroposterior positioning of the jaws.

In contrary, in the low occlusal plane angle group, the statistically significant differences between T1 and T2 showed by the ANB assessment were confirmed by the Wits assessment for the long anterior cranial base sub-group and for the large cranial base angle sub-group. The statistically significant difference detected by ANB in the short anterior cranial base sub-group was practically confirmed by the Wits assessment. No statistically significant differences were detected by both assessments for the small cranial base angle sub-group. There was consistency between the results provided by each one of the assessments.

Evaluating the assessments, there was a trend of inconsistency for the high occlusal plane angle group and a trend of consistency for the low occlusal plane angle, whatever it was the cranial base sub-group considered. Such fact suggests that any influence of the cranial base considered by the research model was capable to bend ANB or Wits assessment toward the consistency or the inconsistency direction, even though our research model was not designed to quantitatively evaluate cranial base influences.

Conclusion

ANB and Wits are cephalometric measurements that present important drawbacks, although they are routinely applied in clinical Orthodontics. Our results support that there is

a tendency for lack of consistency between ANB and Wits assessments in high occlusal plane angle patients, exposing lack of certainty in one or both measurements. In low occlusal plane angle patients, ANB and Wits assessments showed consistency. Furthermore, our research model could not detect clear geometric influence of the cranial base in the lack or presence of consistency between ANB and Wits assessments.

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Legends

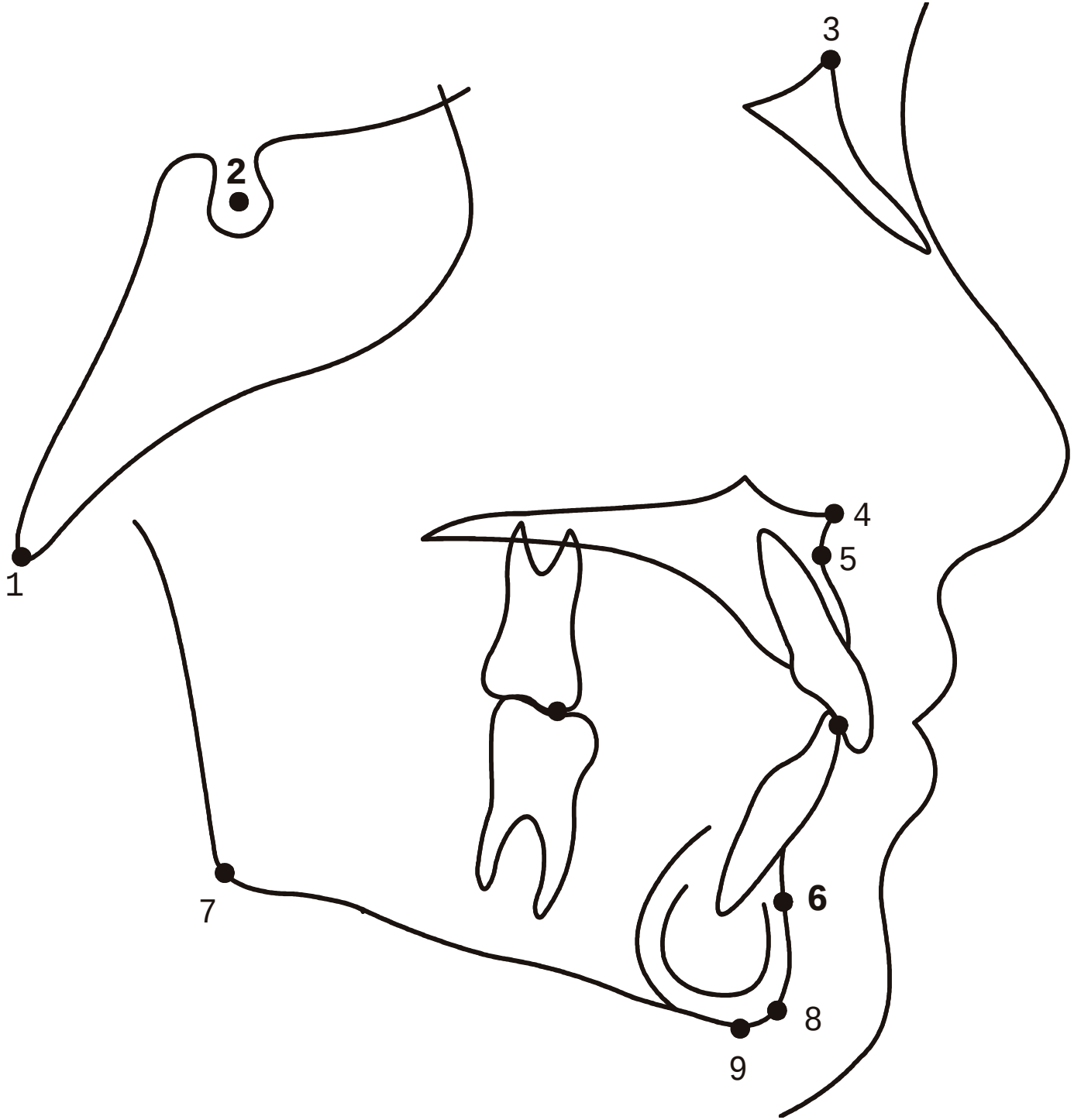
Figures

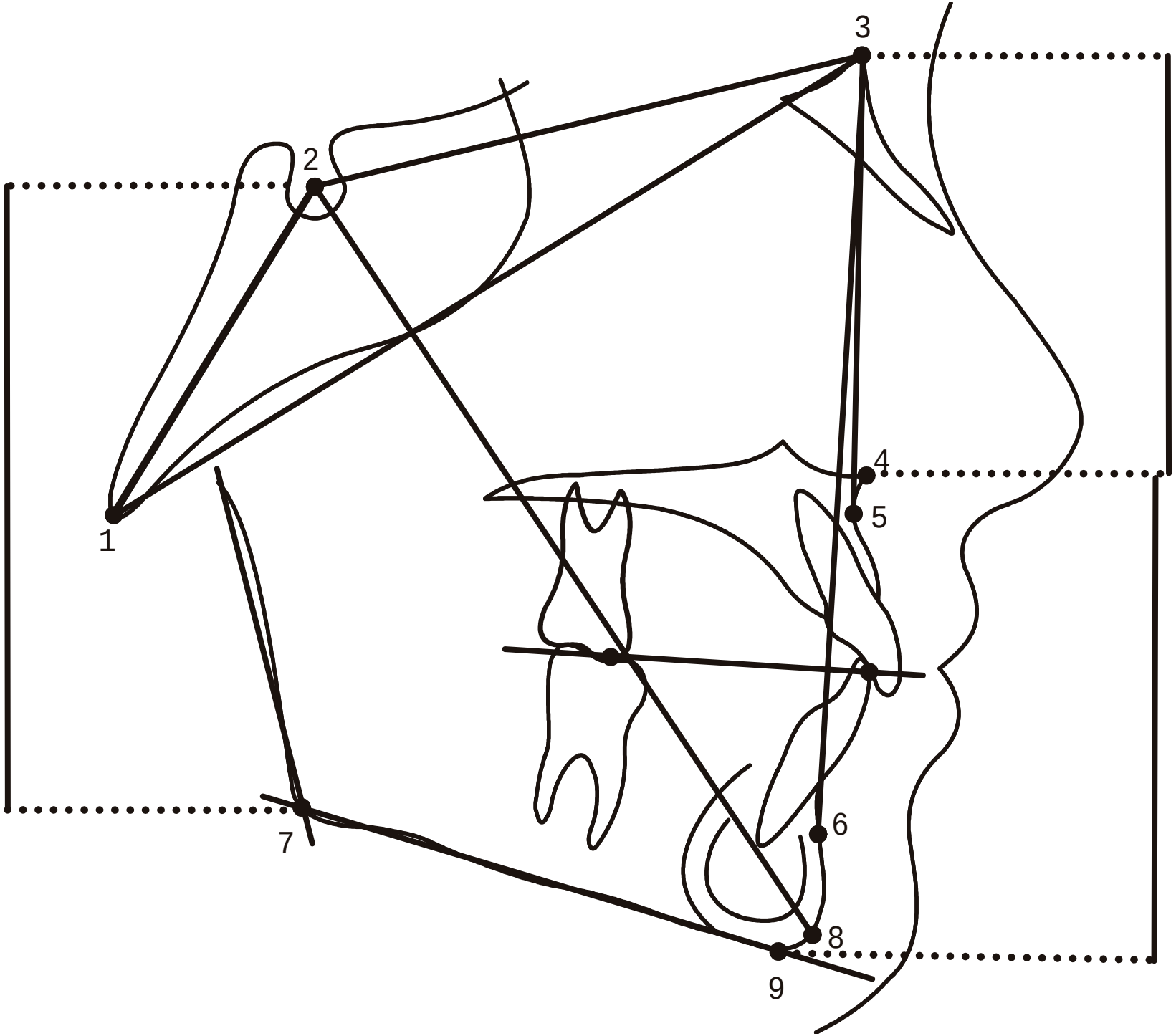
1. Cephalometric landmarks.
2. Cephalometric measurements.
3. Wits appraisal.
4. Normal occlusal plane.
5. High occlusal plane angle.
6. Normal anterior cranial base.
7. Short anterior cranial base.

Tables

1. Descriptive statistics for T1 and T2 data, considering all cases. Paired t-test for the difference between T1 and T2.
2. Descriptive statistics (T1) for high and low occlusal plane angle groups.
3. Descriptive statistics (T2) for high and low occlusal plane angle groups.
4. Descriptive statistics (T1) for small and large cranial base angle groups.
5. Descriptive statistics (T2) for small and large cranial base angle groups.
6. Pearson correlation coefficient between ANB and Wits, for T1 and T2 data.
7. Paired t-test between ANB and Wits, including T1 and T2, for high occlusal plane angle group.
8. Paired t-test between ANB and Wits, including T1 and T2 data, for low occlusal plane angle group.

Figure

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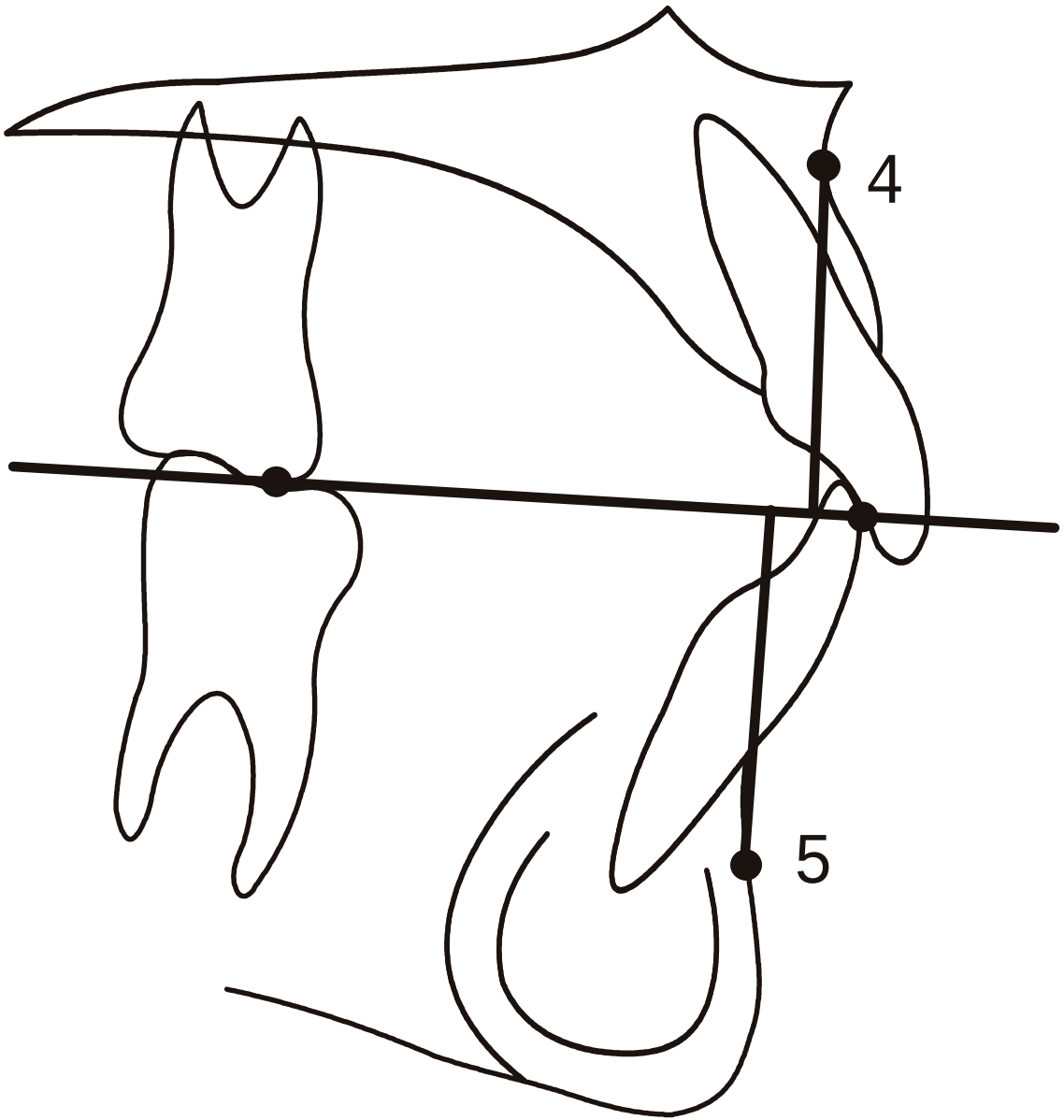
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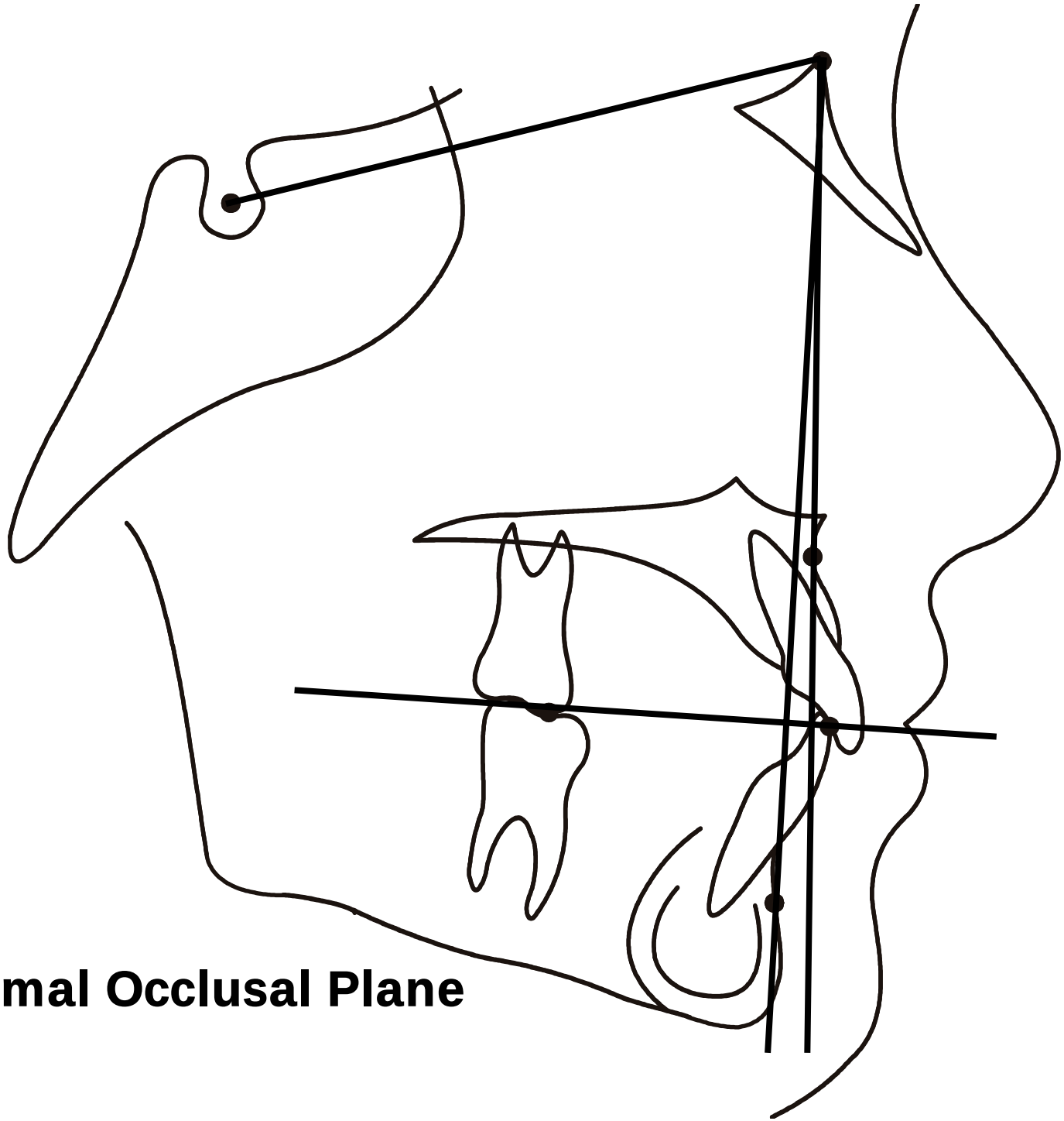
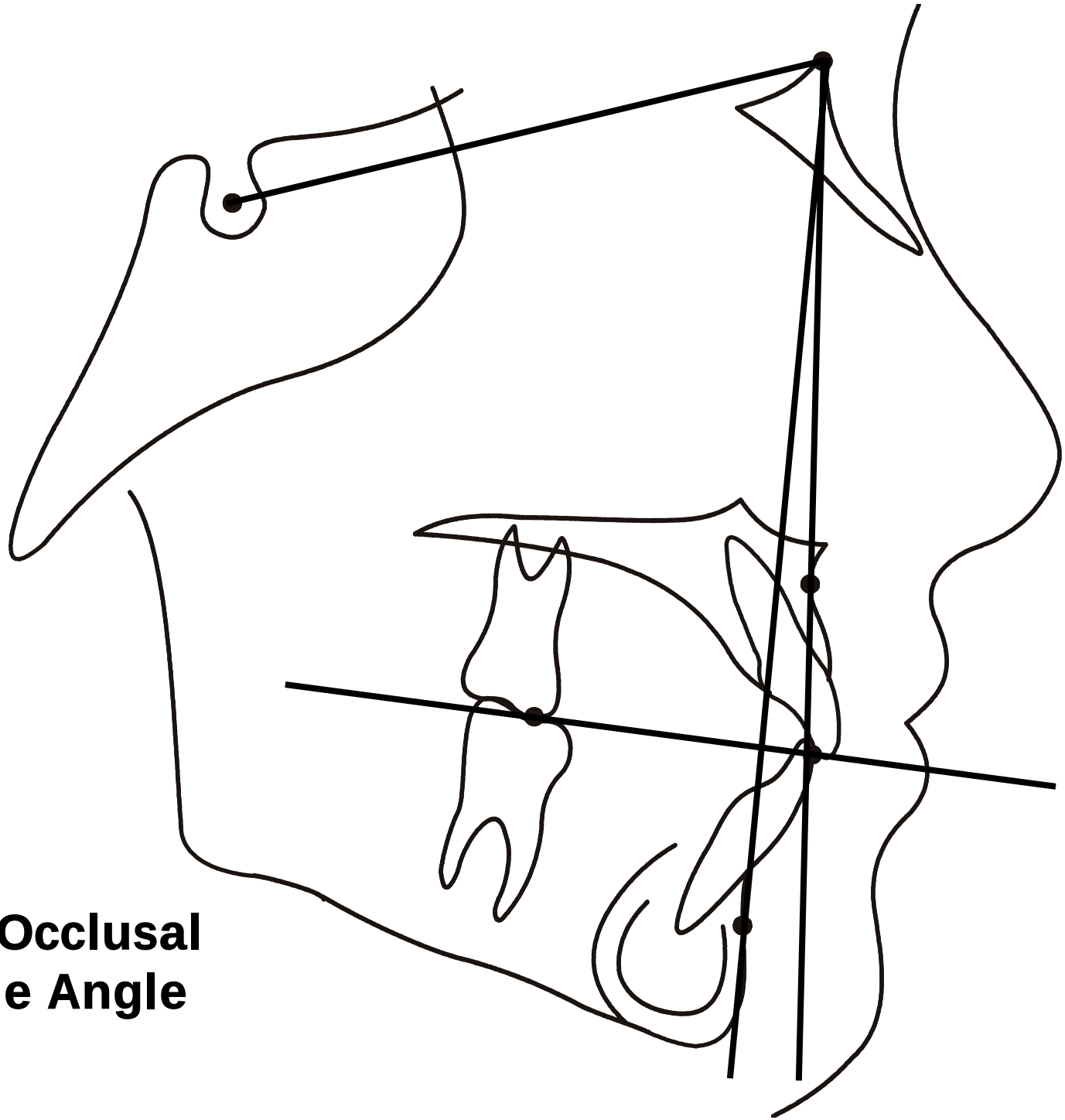
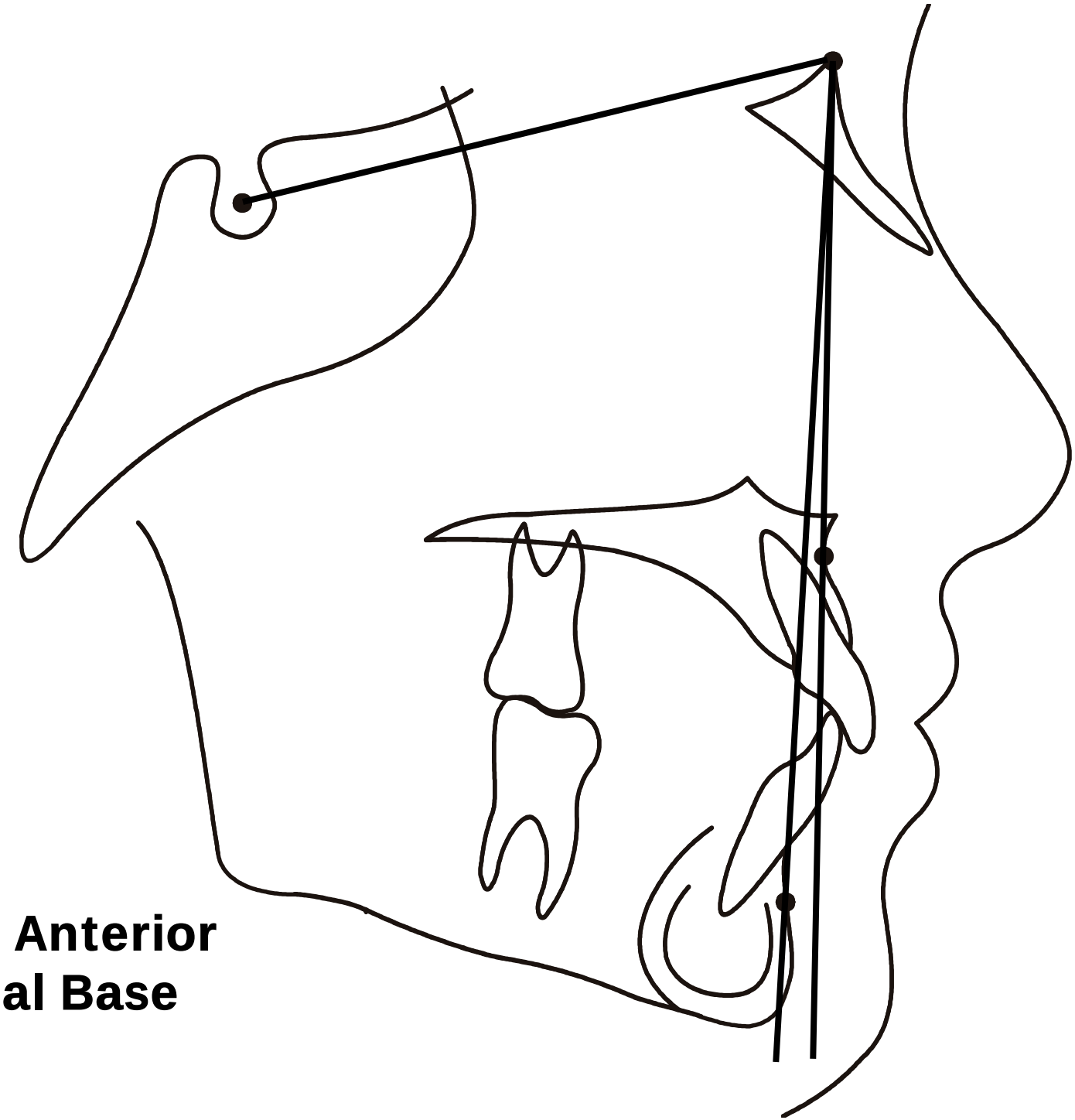


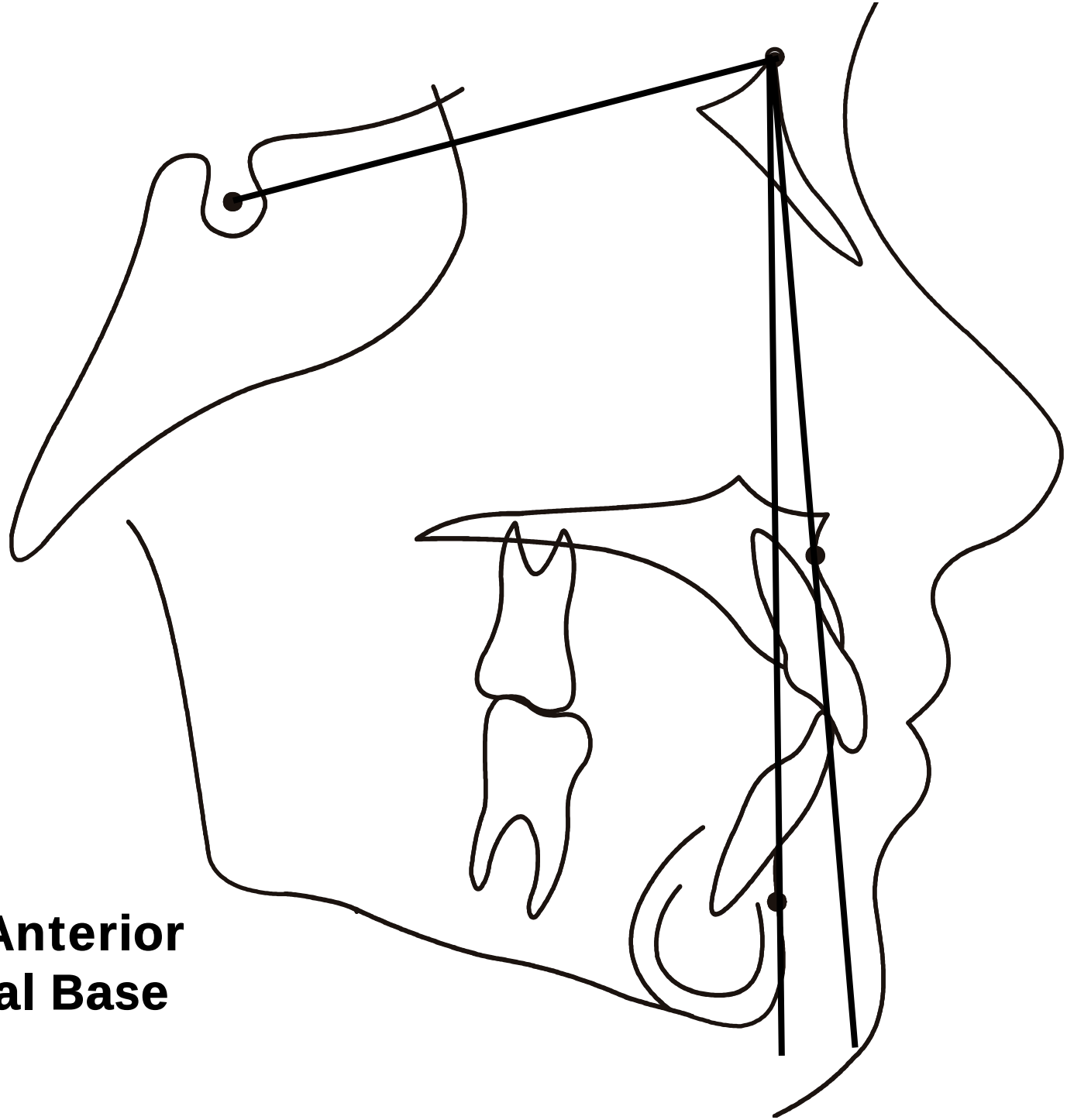
Normal Occlusal Plane



High Occlusal Plane Angle



Normal Anterior Cranial Base



Short Anterior Cranial Base

Table

Descriptive Statistics for T1/T2 and Paired t-Test for All Cases

Variables	N	Mean T1	SD	Mean T2	SD	Mean Difference	SD	p
S-N (mm)	122	72.4	3.8	74.0	3.8	1.6	2.2	0.01**
SNBa (°)	122	123.5	5.1	123.3	5.3	-0.2	2.3	0.26
ANB (°)	122	3.8	2.5	2.8	2.3	-1.1	1.8	0.01**
Wits (mm)	122	2.1	4.1	1.3	2.9	-0.8	2.7	0.01**
S-Go (mm)	122	73.9	6.8	79.2	5.9	5.3	5.0	0.01**
N-Me (mm)	122	118.5	8.4	124.3	7.8	5.8	6.2	0.01**
SNOP (°)	122	14.9	4.2	14.1	4.0	-0.8	3.2	0.01**
Y Axis (°)	122	85.0	3.8	85.4	3.8	0.4	1.7	0.01**
AP Proportion	122	0.62	0.04	0.63	0.04	0.01	0.02	0.01**
Ant Proportion	122	0.43	0.02	0.43	0.02	0.01	0.02	0.30

**$p \leq 0.01$

Descriptive (T1) – High and Low Occlusal Plane Angle Groups

Variables	High (N)	Mean	SD	Low (N)	Mean	SD
S-N (mm)	59	71.4	3.8	63	73.3	3.7
SNBa (°)	59	123.0	4.9	63	124.0	5.2
ANB (°)	59	4.4	2.5	63	3.3	2.4
Wits (mm)	59	1.4	4.1	63	2.8	3.9
S-Go (mm)	59	70.7	5.4	63	76.9	6.6
N-Me (mm)	59	118.3	7.9	63	118.7	8.9
SNOP (°)	59	18.2	2.6	63	11.8	2.7
Y Axis (°)	59	86.6	3.5	63	83.5	3.5
AP Proportion	59	0.59	0.03	63	0.64	0.04
Ant Proportion	59	0.43	0.01	63	0.43	0.02

Descriptive (T2) – High and Low Occlusal Plane Angle Groups

Variables	High (N)	Mean	SD	Low (N)	Mean	SD
S-N (mm)	59	73.7	3.8	63	74.3	3.8
SNBa (°)	59	123.0	5.3	63	123.5	5.4
ANB (°)	59	3.2	2.2	63	2.4	2.3
Wits (mm)	59	1.2	3.1	63	1.5	2.8
S-Go (mm)	59	77.8	5.3	63	80.6	6.1
N-Me (mm)	59	126.5	7.1	63	122.3	7.9
SNOP (°)	59	16.2	3.6	63	12.1	3.3
Y Axis (°)	59	87.2	3.4	63	83.8	3.5
AP Proportion	59	0.61	0.03	63	0.66	0.04
Ant Proportion	59	0.43	0.02	63	0.43	0.02

Descriptive (T1) – Small and Large Cranial Base Angle Groups

Variables	Small (N)	Mean	SD	Large (N)	Mean	SD
S-N (mm)	64	72.1	3.6	58	72.7	4.1
SNBa (°)	64	119.6	2.9	58	127.8	3.2
ANB (°)	64	3.7	2.4	58	4.0	2.6
Wits (mm)	64	1.1	4.1	58	3.3	3.8
S-Go (mm)	64	73.0	6.8	58	74.9	6.8
N-Me (mm)	64	117.8	8.9	58	119.4	7.8
SNOP (°)	64	15.3	3.9	58	14.4	4.5
Y Axis (°)	64	85.6	3.5	58	84.3	4.0
AP Proportion	64	0.61	0.04	58	0.62	0.05
Ant Proportion	6464	0.43	0.02	58	0.43	0.02

Descriptive (T2) – Small and Large Cranial Base Angle Groups

Variables	Small (N)	Mean	SD	Large (N)	Mean	SD
S-N (mm)	64	73.6	3.6	58	74.5	4.0
SNBa (°)	64	119.7	4.0	58	127.3	3.5
ANB (°)	64	2.8	2.1	58	2.8	2.5
Wits (mm)	64	0.9	3.1	58	1.9	2.7
S-Go (mm)	64	78.6	6.1	58	79.9	5.5
N-Me (mm)	64	124.4	7.9	58	124.3	7.8
SNOP (°)	64	13.9	4.0	58	14.2	4.1
Y Axis (°)	64	86.2	3.6	58	84.5	3.9
AP Proportion	64	0.63	004	58	0.64	0.04
Ant Proportion	64	0.43	0.02	58	0.43	0.02

Pearson Correlation (T1-T2)
ANB and Wits
All Cases

Variables	ANB T1	Wits T1	ANB T2	Wits T2
ANB T1	-	-	-	-
Wits T1	0.76**	-	-	-
ANB T2	0.72**	0.49**	-	-
Wits T2	0.65**	0.74**	0.71**	-

**$p \leq 0.01$

Paired t-Test
ANB and Wits (T1 and T2)
High Occlusal Plane Angle Group

Sub-Groups	Variables	N	Difference	p
Short Anterior Cranial Base	ANB T1 and ANB T2	38	1.1	0.01**
	Wits T1 and Wits T2	38	0.1	0.95
Long Anterior Cranial Base	ANB T1 and ANB T2	21	1.4	0.01**
	Wits T1 and Wits T2	21	0.3	0.64
Small Cranial Base Angle	ANB T1 and ANB T2	36	1.3	0.01**
	Wits T1 and Wits T2	36	-0.2	0.72
Large Cranial Base Angle	ANB T1 and ANB T2	23	1.1	0.01**
	Wits T1 and Wits T2	23	0.6	0.41

**$p \leq 0.01$

Paired t-Test
ANB and Wits (T1 and T2)
Low Occlusal Plane Angle Group

Sub-Groups	Variables	N	Difference	p
Short Anterior Cranial Base	ANB T1 and ANB T2	29	0.9	0.05*
	Wits T1 and Wits T2	29	1.1	0.07
Long Anterior Cranial Base	ANB T1 and ANB T2	34	0.9	0.01**
	Wits T1 and Wits T2	34	1.6	0.01**
Small Cranial Base Angle	ANB T1 and ANB T2	28	0.5	0.23
	Wits T1 and Wits T2	28	0.6	0.31
Large Cranial Base Angle	ANB T1 and ANB T2	35	1.3	0.01**
	Wits T1 and Wits T2	35	2.0	0.01**

*$p \leq 0.05$; **$p \leq 0.01$

*** Revision Notes (no author identifiers please)**

"Influence of the Occlusal Plane Inclination on ANB and Wits Assessments of Anteroposterior Relationship of the Jaws"

Suggested Alterations Made
Please Check the New Version

1) Title was changed as suggested.
2) Abbreviations were changed as suggested.
3) Further explanation about occlusal plane was provided as suggested.
4) Method error values were corrected. Numbers from a draft version were not updated in the submitted version. The draft numbers refer to size effect, in order to calculate type II error. Excel file with the correct Method error values is provided for confirmation (See Excel file Attached).
5) Terminology was changed as suggested.
6) Tables were merged and eliminated as suggested.
7) Representative composite tracings included as suggested.
8) Discussion:

The efficacy of ANB and Wits assessments is not easily addressed. We provide in the attached file (it is not part of the article) the Pearson coefficients of correlation as you have suggested. They do not explain very much. Why? Because there is significant noise in the system and it produces considerable overlap between the groups.

There are four major reasons for the noise:

- Both ANB and Wits present significant weakness.
- ANB might be compared with Wits at T1 or T2. If ANB taken from T1 is compared with ANB taken from T2, we assume that the treatment and/or growth did not alter the measurements, which is not true.
- Cephalometric landmarks are relative and not absolute. Longer anterior cranial base does not necessarily mean N forward, because Sella may be

forward, as large cranial base angles does not necessarily mean steep anterior cranial base because posterior cranial base may be backward.

- There is considerable variation involved in the sample. It could not be different; ANB and Wits address the same problem: dental positioning and dental positioning in a large sample always hold important variation.

The following paragraph was included:

"Since ANB and Wits are not decisive ways to assess anteroposterior discrepancies and hold significant variation, expressive overlap between the groups could provide "noised" results. In order to eliminate proficiency bias, all the cases were treated by the same clinician and by the same orthodontic technique. Sample allocation, delineating groups which present similar pretreatment conditions, intends to provide results relatively free of contamination by susceptibility bias. Furthermore, since all the patients who met the inclusion criteria were accounted for the study, its external validity holds potential clinical interest."

Proficiency, susceptibility and transfer bias = mentioned by Dr. Lysle Johnston in:
"A comparison of one-stage and two-stage nonextraction alternatives in matched Class II samples". Am J Orthod Dentofac Orthop 1995;108:118-31.

(See Ranking Attached; See Power Point file Attached)

9) Class I and III were included because the purpose of the article is not to identify assessment problems allocating individuals in their groups by malocclusion. The purpose of the article is to study the effects of the geometric position of the jaws on their anteroposterior relationship assessment. Geometric position of the jaws is independent of malocclusions.
10) Further explanation provided, as suggested.

Ranking of Coefficients of Correlation of Pearson (ANB and Wits) Not Part of the Article

- Low occlusal plane angle, small cranial base angle (T1) - 0.93
- High occlusal plane angle, large cranial base angle (T1) - 0.90
- High occlusal plane angle, long cranial base (T1) - 0.86
- High occlusal plane angle, short cranial base (T1) – 0.85
- Low occlusal plane angle, short cranial base (T1) – 0.84
- Low occlusal plane angle, long cranial base (T1) – 0.82
- High occlusal plane angle, small cranial base angle (T1) – 0.81
- Low occlusal plane angle, long cranial base (T2) – 0.78
- Low occlusal plane angle, small cranial base angle (T2) – 0.78
- High occlusal plane angle, short cranial base (T2) – 0.76
- High occlusal plane angle, large cranial base angle (T2) – 0.74
- High occlusal plane angle, long cranial base (T2) – 0.74
- Low occlusal plane angle, large cranial base angle (T1) – 0.73
- High occlusal plane angle, small cranial base (T2) – 0.72
- Low occlusal plane angle, large cranial base angle (T2) – 0.72
- Low occlusal plane angle, short cranial base (T2) – 0.57

All significant at $p \leq 0.01$

Following Slides Are Explanation to the Reviewer

They Are Not Part of the Article

Pearson Correlation (T1-T2)
High Angle Occlusal Plane
Short and Long Anterior Cranial Base

Long \ Short	ANB T1	Wits T1	ANB T2	Wits T2
ANB T1		0.85**	0.62**	0.69**
Wits T1	0.86**		0.53**	0.75**
ANB T2	0.83**	0.61**		0.76**
Wits T2	0.63**	0.59**	0.74**	

*p ≤ 0.05; **p ≤ 0.01

Pearson Correlation (T1-T2)
High Angle Occlusal Plane
Small and Large Cranial Base Angle

Large \ Small	ANB T1	Wits T1	ANB T2	Wits T2
ANB T1		0.81**	0.63**	0.68**
Wits T1	0.90**		0.40*	0.71**
ANB T2	0.83**	0.73**		0.72**
Wits T2	0.65**	0.71**	0.74**	

*p ≤ 0.05; **p ≤ 0.01

Pearson Correlation (T1-T2)
Low Angle Occlusal Plane
Short and Long Anterior Cranial Base

Long \ Short	ANB T1	Wits T1	ANB T2	Wits T2
ANB T1		0.84**	0.40*	0.60**
Wits T1	0.82**		0.33	0.75**
ANB T2	0.87**	0.70**		0.57**
Wits T2	0.74**	0.85**	0.78**	

*p ≤ 0.05; **p ≤ 0.01

Pearson Correlation (T1-T2)
Low Angle Occlusal Plane
Small and Large Cranial Base Angle

Large \ Small	ANB T1	Wits T1	ANB T2	Wits T2
ANB T1		0.93**	0.57**	0.75**
Wits T1	0.73**		0.53**	0.75**
ANB T2	0.81**	0.65**		0.78**
Wits T2	0.62**	0.84**	0.72**	

*p ≤ 0.05; **p ≤ 0.01

Other Material

variable	1A	2A	3A	4A	5A	1B	2B	3B	4B	5B	ABS (1A-1B)	ABS(2A-2B)
S-N	74.3	67.1	73.2	72.8	75.6	73.9	66.7	72.3	73.1	74.1	0.4	0.4
SNBa	125.4	125.8	131.2	129.2	126.2	127.4	125.8	133.8	130.9	125.2	2	0
ANB	1	4.9	0.9	3.8	8.7	1.2	5.9	2.5	2.3	8	0.2	1
Wits	-0.7	1.5	0.4	3.7	7.1	-1.7	2.1	1.9	1.8	5.3	1	0.6
S-Go	72.4	73.2	84.7	83.4	75.1	72.2	73	84.6	82.8	76.4	0.2	0.2
N-ANS	49.9	50.1	53.5	54.2	56.1	50.8	47.6	53.6	54	54.8	0.9	2.5
ANS-Me	63.3	63.8	67.8	64.5	73.9	63.4	65.2	66.8	64	73.4	0.1	1.4
SN-OP	13.9	13.9	7.4	5.7	18.7	16.4	14.3	7.6	7	17.9	2.5	0.4
Y Axis	82.2	83.5	80.2	78.3	86.5	82.9	84	80.2	78.6	86	0.7	0.5

ABS(3A-3B)	ABS(4A-4B)	ABS (5A-5B)	(dif1)2	(dif2)2	(dif3)2	(dif4)2	(dif5)2	SUM	2n	SUM/2n	Root Square
0.9	0.3	1.5	0.16	0.16	0.81	0.09	2.25	3.47	10	0.347	0.589067059
2.6	1.7	1	4	0	6.76	2.89	1	14.65	10	1.465	1.210371844
1.6	1.5	0.7	0.04	1	2.56	2.25	0.49	6.34	10	0.634	0.796241169
1.5	1.9	1.8	1	0.36	2.25	3.61	3.24	10.46	10	1.046	1.022741414
0.1	0.6	1.3	0.04	0.04	0.01	0.36	1.69	2.14	10	0.214	0.46260134
0.1	0.2	1.3	0.81	6.25	0.01	0.04	1.69	8.8	10	0.88	0.938083152
1	0.5	0.5	0.01	1.96	1	0.25	0.25	3.47	10	0.347	0.589067059
0.2	1.3	0.8	6.25	0.16	0.04	1.69	0.64	8.78	10	0.878	0.937016542
0	0.3	0.5	0.49	0.25	0	0.09	0.25	1.08	10	0.108	0.328633535