

ORIGINAL ARTICLE

COMPARISON OF TWO CRANIAL BASE LENGTHS AND FOUR ANGLES AMONG THREE SAGITTAL SKELETAL BASES IN ADULT POPULATION OF DISTRICT PESHAWAR, PAKISTAN

 Gul Meena,  Mashal Afridi,  Ahsan Mehmood Shah,  Aatikh Javaid,  Muhammad Saood,  Syed Suleman Shah

Department of Orthodontics and Dentofacial Orthopedics, Khyber College of Dentistry, Peshawar, Pakistan

ABSTRACT

Background: Research has shown that cranial base length, flexure and inclination play a role in the skeletal malocclusion in sagittal and vertical dimensions. The objectives of this study were to compare the two cranial base lengths and four angles among three sagittal skeletal bases in adult population of district Peshawar, Pakistan.

Materials & Methods: This cross-sectional study was conducted in the Department of Orthodontics, Khyber College of Dentistry, Peshawar, Pakistan from February 2020 to March, 2020. Ninety lateral cephalograms were selected for the year 2019 from the database of department, with 30 from each group; Skeletal Class I, II and III. SN length (mm), SBa length (mm), N-S-Ba, N-S-Ar, SN-FH and SBa-FH were our ratio variables and were described by mean, range and SD with 95% CI for mean. Twelve hypotheses were tested each by one-way ANOVA and when it showed significant difference, then by post hoc Dunnett's t test.

Results: The sample included 90 cephalograms; 30 each in Class I, II and III, including 38 men and 52 women with mean age 22.54 ± 5.70 years. SN length (mm) was similar in Class II 68.1 ± 2.15 and Class III 68.7 ± 2.01 to Class I (control) 68.4 ± 1.56 ($p = .487$). SBa length was similar in Class II 45.5 ± 2.48 and Class III 44.9 ± 2.23 to Class I 44.6 ± 1.76 ($p = .281$). N-S-Ba angle was similar in Class II $126.7^\circ \pm 2.26$ and Class III $127.3^\circ \pm 2.70$ to Class I $127.1^\circ \pm 2.22$ ($p = .614$). N-S-Ar angle was significantly greater ($p < .0001$) in Class II $128.2^\circ \pm 2.45$ than Class I $123.3^\circ \pm 1.97$, and significantly greater ($p = .030$) in Class III $124.6^\circ \pm 1.70$ than Class I. SN-FH angle was similar ($p = .193$) in Class II $7.9^\circ \pm 1.32$ to Class I $7.4^\circ \pm 1.40$ and similar ($p = .356$) in Class III $7.0^\circ \pm 0.94$ to Class I. SBa-FH angle was similar in Class II $57.3^\circ \pm 2.19$ and Class III $56.8^\circ \pm 1.45$ to Class I $56.1^\circ \pm 1.90$ ($p = .058$).

Conclusions: Anterior cranial base length (SN length), posterior cranial base length (SBa length), N-S-Ba angle, SN-FH angle and SBa-FH angle were similar in Skeletal Class II to Class I and in Class III to Class I. N-S-Ar angle was greater in Skeletal Class II than Class I and in Class III than Class I.

KEY WORDS: Cranial Base; Skull Base; Mandible; Maxilla; Jaw; Malocclusion; Growth; Adults; Pakistan.

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1. INTRODUCTION

1.1 Background: During development of the craniofacial complex, a significant part is played by

Corresponding Author:

Dr. Ahsan Mehmood Shah
Associate Professor and Head
Department of Orthodontics and Dentofacial
Orthopedics
Khyber College of Dentistry, Peshawar, Pakistan
E-mail: ahsanmshah@gmail.com

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the cranial base. The three dimensional growth of cranial base is a factor in the development of the jaws and facial structures because the maxilla and mandible articulate with it. Thus, the length, flexion and inclination of the cranial base is believed to have an impact on the type of skeletal malocclusion.^{1,2} Consequently, the basic characteristics of the cranial base and its relationship with the sagittal relationship of the jaws has gotten the consideration of numerous orthodontic researchers.³

In a study in Besançon, France, Hildwein, et al.⁴ found that for the SN length (mm) in Skeletal Class II (64.3 ± 3.2) compared to Skeletal Class I base (63.3 ± 2.9), the difference was non-significant

($p > .05$). They also found a significant difference ($p < .05$) in the N-S-Ba angle between Skeletal Class II ($134.2^\circ \pm 5.1$) and Class I base ($131.1^\circ \pm 4.1$).

A study in Hong Kong, China, by Chin, et al.⁵ found that N-S-Ba was significantly different ($p < 0.001$) among the three skeletal bases and Class II skeletal base ($131.9^\circ \pm 5.2$) had a larger angle compared to Class I (130 ± 4.4), and Class III (127 ± 3.7) had a smaller angle compared to Class I. They found no significant difference ($p > .05$) in SN length and SBa length among the three Skeletal classes.

A recent study in Rawalpindi, Pakistan, by Shah, et al.⁶ found no statistically significant difference between the three Skeletal Classes for N-S-Ba angle ($p = .442$) and the N-S-Ar angle ($p = .332$).

Although many textbooks explain that cranial base lengths and angles have a role in the presenting skeletal malocclusion;^{7,8} recent evidence has sometimes claimed otherwise.^{9,10}

1.2 Research Problems, Knowledge Gaps & Research Questions: We are unaware of the difference of the sella to nasion (SN) length, sella to basion (SBa) length, nasion-sella-basion angle (N-S-Ba), nasion-sella-articulare angle (N-S-Ar), sella-nasion to Frankfort horizontal plane angle (SN-FH), and sella-basion to Frankfort horizontal plane angle (SBa-FH) among the three sagittal skeletal bases in the adult population of district Peshawar, Pakistan. This unawareness constitutes our six research problems.

No data or studies could be retrieved regarding these problems; these are our six knowledge gaps.

Would these six parameters be different among the three sagittal skeletal bases in the adult population of district Peshawar, Pakistan are our six research questions.

1.3 Research Objectives

RO 1-6: To determine the difference of SN and SBa lengths and N-S-Ba, N-S-Ar, SN-FH and SBa-FH angles among the three sagittal skeletal bases in the adult population of district Peshawar, Pakistan are our six research objectives.

1.4 Research (Null) Hypotheses

H_{01} : SN length is similar in sagittal Skeletal Class II to Class I in adult population of district Peshawar, Pakistan.

H_{02} : SN length is similar in sagittal Skeletal Class III to Class I in adult population of district Peshawar, Pakistan.

H_{03} : SBa length is similar in sagittal Skeletal Class II to Class I in adult population of district Peshawar, Pakistan.

H_{04} : SBa length is similar in sagittal Skeletal Class III to Class I in adult population of district Peshawar, Pakistan.

H_{05} : N-S-Ba angle is similar in sagittal Skeletal Class II to Class I in adult population of district Peshawar, Pakistan.

H_{06} : N-S-Ba angle is similar in sagittal Skeletal Class III to Class I in adult population of district Peshawar,

Pakistan.

H_{07} : N-S-Ar angle is similar in sagittal Skeletal Class II to Class I in adult population of district Peshawar, Pakistan.

H_{08} : N-S-Ar angle is similar in sagittal Skeletal Class III to Class I in adult population of district Peshawar, Pakistan.

H_{09} : SN-FH angle is similar in sagittal Skeletal Class II to Class I in adult population of district Peshawar, Pakistan.

H_{010} : SN-FH angle is similar in sagittal Skeletal Class III to Class I in adult population of district Peshawar, Pakistan.

H_{011} : SBa-FH angle is similar in sagittal Skeletal Class II to Class I in adult population of district Peshawar, Pakistan.

H_{012} : SBa-FH angle is similar in sagittal Skeletal Class III to Class I in adult population of district Peshawar, Pakistan.

1.5 Operational Definitions

Skeletal Class I: Included cephalograms with class I skeletal relationship/ base; ANB angle ranging from 1° to 4° , which is the normal value for ANB angle.

Skeletal Class II: Included cephalograms with class II skeletal relationship/ base; ANB value of $\geq 5^\circ$.

Skeletal Class III: Included cephalograms with class III skeletal relationship/ base; ANB value of $\leq 0^\circ$.

CVM Stage 5: Cervical vertebral maturation stage indicating that growth has ended one year before. The 2nd, 3rd and 4th cervical vertebrae appear square in shape on the lateral cephalogram, with their lower boundaries having a notch.

CVM Stage 6: Cervical vertebral maturation stage indicating that growth has ended two years before. The 2nd, 3rd and 4th cervical vertebrae appear rectangular vertical in shape on the lateral cephalogram, with their lower boundaries having a notch.

2. MATERIALS AND METHODS

2.1 Design, Settings and Duration: This was a cross-sectional study carried out in the Department of Orthodontics, Khyber College of Dentistry, Peshawar, Pakistan from February 2020 to March, 2020. The data was collected for the period from January 1, 2019 to December 31, 2019 from the database of this Department. Ethical approval was granted by the Institutional Ethical Review Committee.

2.2 Population and Sampling: Peshawar is the capital of Khyber Pakhtunkhwa province of Pakistan. The population of district Peshawar was 4,331,959 in 2017 census, with presumed population of 4,500,000 in 2019. With 64.3% assumed population in age > 14 years (adult), it would be 2,893,500 adults; our population of interest.

The sample size was based on H_{A1} and H_{A2} , the hypotheses of difference. We assumed that true SN length in sagittal Skeletal Class I (control) group was distributed normally, having mean 68 mm and SD 2.75 mm and we assumed that true SN length

in sagittal Skeletal Class II group was distributed normally, having mean 70 mm and SD 2.75 mm. Here we desired the ratio of sample size (sample 2/ sample 1) as 1.0. The minimal sample size to detect a difference with a power of 80% at 95% confidence level came to be 30 for each group. The same process was repeated for Class I and Class III (with same data as for Class II) groups and same sizes were calculated. Hence we had three groups, each with 30 cephalograms.^{11,12}

The technique was non-probability consecutive sampling.

All pretreatment lateral cephalograms showing normal vertical growth pattern with cervical vertebral maturation (CVM) stage 5 or 6 and with good contrast and clearly visible landmarks were included. Those with syndromes, trauma or asymmetries, and patients who had had orthopedic or orthodontic therapy were excluded. As per operational definitions given in introduction, group 1 included 30 cephalograms from Skeletal Class I, group 2 included 30 cephalograms from Skeletal Class II and group 3 included 30 cephalograms from Skeletal Class III.

2.3 Equipment and Procedure: The lateral cephalometric radiographs were traced with a micro-tip pencil on an acetate paper and then the required measurements were done by a single researcher. Counter checking by another researcher was done to allow us to remove the intra-observer bias.

Following landmarks were used for linear and angular measurements used in this study as shown in Figure 2.3.

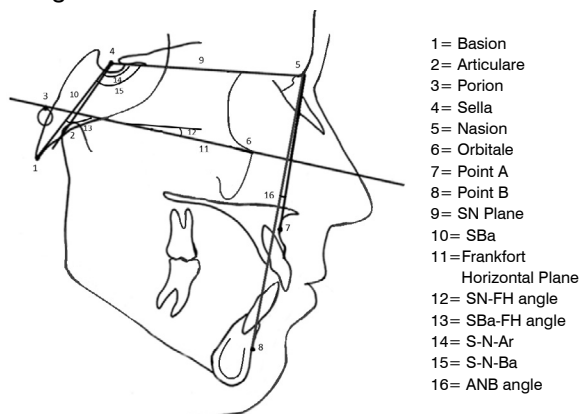


Figure 2.3: Cephalometric landmarks for determining the linear and angular measurements in adult population of district Peshawar, Pakistan

2.4 Data Collection Plan: We had two demographic variables; sex and age in years. Our study had six research variables; SN length (mm), SBa length (mm), N-S-Ba (degrees), N-S-Ar (degrees), SN-FH (degrees) and SBa-FH (degrees). These were measured on the ratio (numeric) scale. Skeletal base was a grouping variable with three categories; Skeletal Class I, Skeletal Class II, Skeletal Class III. They were

measured on the nominal scale.

2.5 Data Analysis Plan

2.5.1 Data Normality, Descriptive Statistics and Estimation of Parameters:

The data for the six variables will be subjected to Skewness and Kurtosis for its distribution. In case of normal distribution, it will be described by mean, minimum, maximum, range and SD. Estimation of parameters for the population will be presented as confidence interval (CI) at 95% confidence level (CL) for mean. The comparison between the groups will be based on parameters for the population, not on the statistics of the sample. If the CIs are overlapping, these will be similar, otherwise dissimilar; higher or lower as the case may be.

2.5.2 Hypotheses Testing: All the six hypotheses will be substantiated through one way-ANOVA test. Where this test shows significant difference, post-hoc Dunnett's t test (two sided)¹³⁻¹⁴ will be applied to see the difference of Skeletal Class II to Class I and of Skeletal Class III to Class I, all at alpha .05. IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY) will be used for data analysis.

3. RESULTS

3.1 Demographic Profile: Out of 90 lateral cephalograms, 38 belonged to men and 52 to women. Group 1 had 10 men and 20 women and group 2 and group 3 both had 14 men and 16 women. The mean age was 22.54±5.70 (18-43) with range of 25 years. Mean age for Group 1 was 22.63±5.17 years, for Group 2 it was 23.01±6.44 years, and for Group 3, it was 22.54±5.56 years.

3.2 Normality of data for research variables:

Skewness and Kurtosis were performed to check the normality of our data. Data for all variables was found to have a normal distribution. (Table 3.2)

Table 3.2: Normality tests for the cranial base lengths and angles in adult population of Peshawar, Pakistan (n=90)

Variables	Skewness	Kurtosis	Data Distribution
SN length (mm)	-0.347	-0.561	Normal
SBa length (mm)	-0.088	-0.862	Normal
N-S-Ba	0.014	-0.322	Normal
N-S-Ar	0.450	-0.297	Normal
SN-FH	-0.312	0.227	Normal
SBa-FH	0.148	-0.129	Normal

3.3 Descriptive Statistics and Estimation of Parameters:

Descriptive statistics along with the parameters estimation are shown in Table 3.3 for the six research variables for all the three groups.

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The anterior cranial base length (SN) was similar in group 2 and group 3 to group 1. The posterior cranial base length (SBa) was similar in group 2 and group 3 to group 1. The flexure angle N-S-Ba was similar in group 2 and group 3 to group 1. The flexure angle N-S-Ar was slightly increased in group 2 as compared to group 1. It was similar in group 3 to group 1. The anterior cranial base flexure angle SN-FH was similar in group 2 and group 3 to group

1. The posterior cranial base length SBa-FH was similar in group 2 and group 3 to group 1. (Table 3.3)

3.4 Hypothesis Testing

3.4.1 SN length in the three skeletal classes (H_{01} , H_{02})

According to one-way ANOVA test, the difference of mean SN length (mm) among the three groups was statistically non-significant, with p-value .487, so no need for post hoc Dunnett's t tests. (Table 3.4.1)

Table 3.3: Descriptive statistics & estimation of parameters of cranial base lengths and angles in adult population of Peshawar, Pakistan (n=90)

Variable	Group	Sample Size	Sample statistics					95% CI for mean	
			Mean	Min.	Max.	Range	SD	Lower	Upper
SN Length (mm)	Group 1	30	68.40	65.00	72.00	7.00	1.56	67.81	68.98
	Group 2	30	68.10	64.00	71.00	7.00	2.15	67.29	68.90
	Group 3	30	68.70	65.00	72.00	7.00	2.01	67.94	69.45
SBa Length (mm)	Group 1	30	44.62	41.00	48.00	7.00	1.76	43.96	45.28
	Group 2	30	45.50	41.00	49.00	8.00	2.48	44.58	46.43
	Group 3	30	44.90	41.00	50.00	9.00	2.23	44.06	45.73
N-S-Ba angle	Group 1	30	127.12	124.00	131.00	7.00	2.22	126.28	127.95
	Group 2	30	126.70	122.00	131.00	9.00	2.26	125.85	127.54
	Group 3	30	127.30	121.00	131.00	10.00	2.70	126.28	128.31
N-S-Ar angle	Group 1	30	123.33	120.00	127.00	7.00	1.97	122.59	124.06
	Group 2	30	128.24	122.00	133.00	11.00	2.45	127.32	129.16
	Group 3	30	124.64	122.00	128.00	6.00	1.70	124.00	125.27
SN-FH angle	Group 1	30	7.40	4.00	10.00	6.00	1.40	6.87	7.92
	Group 2	30	7.91	5.00	10.00	5.00	1.32	7.42	8.41
	Group 3	30	7.00	5.00	9.00	4.00	0.94	6.64	7.35
SBa-FH angle	Group 1	30	56.13	53.00	62.00	9.00	1.90	55.42	56.84
	Group 2	30	57.30	53.00	61.00	8.00	2.19	56.47	58.12
	Group 3	30	56.84	54.00	59.00	5.00	1.45	56.29	57.38

Table 3.4.1: Comparison of mean SN length (mm) in Skeletal Class I (controls), Class II and Class III in adult population of district Peshawar, Pakistan

Group	N	Mean SN Length		Sum of Squares	d.f.	Mean Square	F	p-value
Group 1	30	68.40	Between Groups	5.40	2	2.70	0.725	.487
Group 2	30	68.10						
Group 3	30	68.70	Within Groups	324.20	87	3.72		
Total	90	68.40		529.60	89	One-Way ANOVA		

H₀₁ was accepted; indicating that the anterior cranial base length was similar in Skeletal Class II as compared to Skeletal Class I. H₀₂ was accepted; indicating that the anterior cranial base length was similar in Skeletal Class III as compared to Skeletal Class I.

3.4.2: SBa length in the three skeletal classes (H₀₃, H₀₄)

According to one-way ANOVA test, the difference of mean SBa lengths (mm) among the three groups was statistically non-significant, with p-value .281, so no need for post hoc Dunnett's t tests. (Table 3.4.2)

H₀₃ was accepted; indicating that the posterior cranial base length was similar in Skeletal Class II as compared to Skeletal Class I. H₀₄ was also accepted; indicating that the posterior cranial base length was similar in Skeletal Class III as compared to Skeletal Class I.

3.4.3 N-S-Ba angle among the three skeletal bases (H₀₅, H₀₆)

According to one-way ANOVA test, the difference of mean N-S-Ba angle among the three groups was statistically non-significant, with p-value .614, so no need for post hoc Dunnett's t tests. (Table 3.4.3)

H₀₅ was accepted; indicating that the N-S-Ba angle was similar in Skeletal Class II as compared to Skeletal Class I. H₀₆ was also accepted; indicating that the N-S-Ba angle was similar in Skeletal Class III as compared to Skeletal Class I.

3.4.4 N-S-Ar angle among the three skeletal classes (H₀₇, H₀₈)

3.4.4.1: According to one-way ANOVA test, the difference of mean N-S-Ar angle among the three groups was statistically significant, p-value being <.0001. (Table 3.4.4.1)

Table 3.4.2: Comparison of mean SBa length (mm) in Skeletal Class I (controls), Class II and Class III in adult population of district Peshawar, Pakistan

Group	N	Mean SBa Length		Sum of Squares	d.f.	Mean Square	F	p-value
Group 1	30	44.62	Between Groups	12.24	2	6.12	1.287	.281
Group 2	30	45.50						
Group 3	30	44.90	Within Groups	413.87	87	4.74		
Total	90	45.01		426.12	89	One-Way ANOVA		

Table 3.4.3: Comparison of mean N-S-Ba angle in Skeletal Class I (controls), Class II and Class III in adult population of district Peshawar, Pakistan

Group	N	Mean N-S-Ba angle		Sum of Squares	d.f.	Mean Square	F	p-value
Group 1	30	127.12	Between Groups	5.68	2	2.844	0.490	.614
Group 2	30	126.70						
Group 3	30	127.30	Within Groups	504.72	87	5.80		
Total	90	127.04		510.41	89	One-Way ANOVA		

Table 3.4.4.1: Comparison of mean N-S-Ar angle in Skeletal Class I (controls), Class II and Class III in adult population of district Peshawar, Pakistan

Group	N	Mean N-S-Ar angle		Sum of Squares	d.f.	Mean Square	F	p-value
Group 1	30	123.33	Between Groups	388.41	2	194.20	45.459	<.0001
Group 2	30	128.24						
Group 3	30	124.64	Within Groups	371.67	87	4.27		
Total	90	125.40		760.08	89	One-Way ANOVA		

3.4.4.2: One-way ANOVA gives us the difference between the two groups with minimum and maximum means; here group 2 (Class II) and group 3 (Class III). Of course, it is not our research problem or hypothesis. We need the difference between Class II and Class I (H_{07}) and between Class III and Class I (H_{08}). That is why post-hoc Dunnett's t test was applied for pair-wise comparisons between Class II & Class I, and between Class III & Class I. H_{07} was rejected; showing that N-S-Ar angle is significantly larger in Skeletal Class II than Skeletal Class I. H_{08} was also rejected; showing that N-S-Ar angle is significantly larger in Skeletal Class III than Skeletal Class I. (Table 3.4.4.2)

3.4.5 SN-FH angle among the three skeletal classes (H_{09} , H_{010})

3.4.5.1: According to one-way ANOVA test, the difference of mean of SN-FH angle among the three groups was statistically significant, p-value being .020. (Table 3.4.5.1)

3.4.5.2: Post-hoc Dunnett's t test was applied for pair-wise comparisons between Class II & Class I, and between Class III & Class I. H_{09} was accepted; showing that SN-FH angle is similar in Skeletal Class II and Skeletal Class I. H_{010} was also accepted; showing that SN-FH angle is similar in Skeletal Class III and Skeletal Class I. (Table 3.4.5.2)

Table 3.4.4.2: Comparison of mean N-S-Ar angle in Skeletal Class II vs. Class I and Class III vs. Class I in adult population of district Peshawar, Pakistan

Group	N	Mean N-S-Ar angle	Difference of means	95% CI of difference		Stand. Error	p-value	Decision
				Lower	Upper			
Skeletal Class I	30	123.33	-4.91	-6.11	-3.71	0.533	<.0001	H_{07} rejected
Skeletal Class II	30	128.24						
Skeletal Class I	30	123.33	-1.31	-2.51	-.11	0.533	.030	H_{08} rejected
Skeletal Class III	30	124.64						

Table 3.4.5.1: Comparison of mean SN-FH angle in Skeletal Class I (controls), Class II and Class III in adult population of district Peshawar, Pakistan

Group	N	Mean SN-FH angle		Sum of Squares	d.f.	Mean Square	F	P value
Group 1	30	7.40	Between Groups	12.67	2	6.33	4.106	.020
Group 2	30	7.91						
Group 3	30	7.00	Within Groups	134.24	87	1.54		
Total	90	7.43		146.91	89	One-Way ANOVA		

Table 3.4.5.2: Comparison of mean SN-FH angle in Skeletal Class II vs. Class I and Class III vs. Class I in adult population of district Peshawar, Pakistan

Group	N	Mean SN-FH angle	Difference of means	95% CI of difference		Stand. Error	p-value	Decision
				Lower	Upper			
Skeletal Class I	30	7.40	-0.51	-1.23	.20	0.320	.193	H_{09} accepted
Skeletal Class II	30	7.91						
Skeletal Class I	30	7.40	0.40	-.32	1.12	0.320	.356	H_{010} accepted
Skeletal Class III	30	7.00						

Table 3.4.6: Comparison of mean SBa-FH angle in Skeletal Class I (controls), Class II and Class III in adult population of district Peshawar, Pakistan

Group	N	Mean SBa-FH		Sum of Squares	d.f.	Mean Square	F	p-value
Group 1	30	56.13	Between Groups	20.73	2	10.36	2.933	.058
Group 2	30	57.30						
Group 3	30	56.84	Within Groups	307.52	87	3.53		
Total	90	56.75		328.58	89	One-Way ANOVA		

3.4.6 SBa-FH angle among the three skeletal classes (H_{011} , H_{012})

According to one-way ANOVA test, the difference of mean SBa-FH angle among the three groups was statistically non-significant, with p-value .058, so no need for post hoc Dunnett's t tests. (Table 3.4.6)

H_{011} was accepted; indicating that the SBa-FH angle was similar in Skeletal Class II as compared to Skeletal Class I. H_{012} was accepted; indicating that the SBa-FH angle was similar in Skeletal Class III as compared to Skeletal Class I.

4. DISCUSSION

4.1 SN length among the three skeletal bases (H_{01} , H_{02})

In our study SN length was similar in Skeletal Class II 68.1 mm (95% CI 67.29-68.90) and Skeletal Class III 68.7 mm (95% CI 67.94-69.45) to Skeletal Class I 68.4 mm (95% CI 67.81- 68.98) ($p=.487$).

Similar results are reported by Polat, et al.¹⁵ from Ankara, Turkey ($n=75$) who didn't find any significant difference ($p > .05$) in SN lengths of all the groups being studied.

On the other hand, following three studies reported results in contrary to our study.

Monirifard, et al.¹⁶ from Isfahan, Iran ($n=299$) concluded a significant difference ($p<.03$) in SN length between Skeletal Class I (66.69 mm \pm 3.72) and Class II (67.37 mm \pm 3.69), with larger length for Class II. But for Skeletal Class III (67.02 mm \pm 3.37) to Class I, the difference was non-significant ($p=.2$). Panainte, et al.¹⁷ from Tîrgu Mureş, Romania ($n=44$) found SN length to be significantly larger in Class II (72 mm \pm 3.01) than Class I (70 mm \pm 3.73). But for Skeletal Class III (70.16 mm \pm 3.03) to Class I, the difference was non-significant ($p>.05$). Gong, et al.¹⁸ from China in a meta-analysis including 20 studies with 1121 Class I, 1051 Class II and 730 Class III cases, found significantly larger SN values in Class II and relatively smaller in Class III subjects. Class III malocclusion demonstrated significantly reduced SN length (95% CI: -1.74, -0.53; $p < .001$ vs. Class I; 95% CI: -3.30, -2.09; $p < .001$ vs. Class II).

4.2 SBa length among the three skeletal bases (H_{03} , H_{04})

In our study SBa length was similar in Skeletal Class II 45.5 mm (95% CI 44.58-46.43) and Skeletal Class III 44.9 mm (95% CI 44.06-45.73) to Skeletal Class I 44.6 mm (95% CI 43.96-45.28) ($p=.281$).

Similar results are reported by Polat, et al.¹⁵ from Ankara, Turkey ($n=75$) who didn't find any significant difference ($p > .05$) in SBa lengths among all the groups being studied.

Contrary to our study, Liu, et al.¹⁹ from Shenyang, China ($n=56$) concluded that SBa length (mm) was significantly larger in Class II (48.76 mm \pm 3.93) than Class I (45.38 mm \pm 3.95), and it was smaller in Skeletal class III (43.76 mm \pm 2.43) as compared to class I. Also, Panainte et al.¹⁷ from Tîrgu Mureş, Romania ($n=44$) found SBa length (mm) to be significantly larger in Class II (44.88 \pm 3.25) than Class I (42.8 \pm 2.5). But for Skeletal Class III (42.26 \pm 3.17) to Class I, the difference was non-significant ($p>.05$).

4.3 N-S-Ba angle among the three skeletal bases (H_{05} , H_{06})

In our study N-S-Ba angle was similar in Skeletal Class II 126.70° (95% CI 125.85-127.54) and Skeletal Class III 127.30° (95% CI 126.28-128.31) to Skeletal Class I 127.12° (95% CI 126.28-127.95) ($p=.614$).

Similar to our study, Shah, et al.⁶ in 2015 from Rawalpindi, Pakistan ($n=151$) measured N-S-Ba angle on lateral cephalograms. It was deduced that no statistically significant difference existed between the three Skeletal Classes for N-S-Ba angle ($p=0.442$). Monirifard, et al.¹⁶ from Isfahan, Iran ($n=299$) also concluded that no significant difference existed between Skeletal Class II (131.05° \pm 5.04) to Class I (130.13 \pm 4.88), and Skeletal Class III (129.74° \pm 5.17) to Class I.

Contrary to our study, Gong, et al.¹⁸ in a meta-analysis showed that N-S-Ba angle was greater in Class II than Class I controls ($p<0.001$), while smaller in Class III than Class I ($p<0.001$).

4.4 N-S-Ar angle among the three skeletal bases (H_{07} , H_{08})

In our study, N-S-Ar angle was significantly greater

($p < .0001$) in Skeletal Class II 128.3° (95% CI 127.32-129.16) than Class I 123.3° (95% CI 122.59-124.06), and it was also significantly greater ($p = .030$) in Skeletal Class III 124.6° (95% CI 124.00-125.27) than Class I 123.3° (95% CI 122.59-124.06).

Similar to our study, Gong, et al.¹⁸ meta-analysis showed that N-S-Ar angle was significantly smaller in Class III compared to Class I ($p < .001$). But for Skeletal Class II to Class I, the difference was non-significant ($p = .089$).

Contrary to our study, Shah et al.⁶ from Rawalpindi, Pakistan, ($n = 151$) found no statistically significant difference ($p = 0.442$) of the N-S-Ar angle between Skeletal Class II (125.07 ± 5.74) to Class I (125.31 ± 5.14), and Skeletal Class III (123.55 ± 6.97) to Class I. Monirifard et al.¹⁶ from Isfahan, Iran ($n = 299$) also did not find any significant difference in N-S-Ar angle between Skeletal Class II ($124.93^\circ \pm 5.38$) and Class III ($123.09^\circ \pm 5.35$) to Skeletal Class I ($124.10^\circ \pm 4.84$).

4.5 SN-FH angle among the three skeletal bases (H_{09} , H_{010})

In our study, the SN-FH angle was similar ($p = .193$) in Skeletal Class II 7.9° (95% CI 7.42-8.41) to Class I. It was also similar ($p = .356$) in Class III 7.0° (95% CI 6.64-7.35) to Skeletal Class I 7.4° (95% CI 6.87-7.92).

Similar results are reported by Liu, et al.¹⁹ from Shenyang, China ($n = 56$), who did not find any significant difference in the SN-FH angle among the three groups ($p = 0.319$). Monirifard et al.¹⁶ from Isfahan, Iran ($n = 299$), also did not find any significant difference in SN-FH angle between Skeletal Class II ($8.27^\circ \pm 3.01$) and Class III ($9.14^\circ \pm 3.40$) to Skeletal Class I ($8.71^\circ \pm 3.08$).

Contrary to our findings, Polat, et al.¹⁵ from Ankara, Turkey ($n = 75$) concluded a significant difference ($p < .0001$) in SN-FH angle between Skeletal Class III (10.6 ± 3.34) to Class I (7.77 ± 1.88), with larger angles for Class III. But they found no significant difference between Skeletal Class II (8.02 ± 2.59) and Class I.

4.6 SBa-FH angle among the three skeletal bases (H_{011} , H_{012})

In our study SBa-FH angle was similar in Skeletal Class II 57.3° (95% CI 56.47-58.12) and Skeletal Class III 56.8° (95% CI 56.29-57.38) to Skeletal Class I 56.1° (95% CI 55.42-56.84) ($p = .058$).

Similar results are reported by Chin, et al.⁵ from Hong Kong, China ($n = 83$) who didn't find any significant difference ($p = .125$) in SBa-FH angles for the three Skeletal Classes. Polat, et al.¹⁵ from Ankara, Turkey ($n = 75$) found the SBa-FH angle to be similar in Class II to Class I, but significantly larger in Skeletal Class III (64.76 ± 5.49) than Class I (59.46 ± 4.78). Also, Liu et al.¹⁹ from Shenyang, China ($n = 56$) concluded that SBa-FH angle was significantly smaller in Class II (51.98 ± 3.98) than Class I (53.79 ± 2.29), while it was significantly greater in Class III than Class I (53.79 ± 2.29).

4.7 “Marwat’s Logical Trajectory of Research Process” We have adopted this trajectory for our research project. Here are few articles published in this journal using this trajectory.^{20,21}

CONCLUSIONS

Anterior cranial base length (SN length), posterior cranial base length (SBa length), N-S-Ba angle, SN-FH angle and SBa-FH angle were similar in Skeletal Class II to Class I and in Class III to Class I. N-S-Ar angle was greater in Skeletal Class II than Class I and in Class III than Class I.

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CONFLICT OF INTEREST

Authors declare no conflict of interest.

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None declared.

AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

Conception or Design:	GM, MA, AMH
Acquisition, Analysis or Interpretation of Data:	GM, MA, AMH, AJ, MS, SSS
Manuscript Writing & Approval:	GM, MA, AMH, AJ, MS, SSS

All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.



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