Transactions of the Illinois State Academy of Science
(2023) Volume 116, pp. 1-6

received 11/22/22
accepted 2/15/23

Correlations Between Cranial Angles and Classification of Malocclusion in Anatomically Modern *Homo sapiens*

Emily Bone and *Miranda Karban
Illinois College, 1101 West College Avenue, Jacksonville IL 62650
*Correspondence: miranda.karban@mail.ic.edu

ABSTRACT

Dental malocclusion describes incorrect alignment of the maxillary and mandibular first molars. This causes irregular bite alignment and can result in other physiological issues related to the jaw or mouth. Many studies have been conducted to look for correlations between various craniofacial angles and classification of malocclusion. However, most of these studies focused on differences between classes without comparing these differences between multiple age groups. This study investigates correlations between the cranial base angle, maxillary protrusion angle (SNA), mandibular protrusion angle (SNB) and classification of malocclusion, as well as sexual dimorphism and developmental variations of those angles. Measurements were collected from a longitudinal sample of anatomically modern human cranial radiographs, ranging in age from 5.0 to 16.2 years. Results showed a significant difference in mandibular protrusion between the youngest and oldest sampled age groups, significant difference in maxillary protrusion between males and females at the youngest sampled age group, and significant differences in the mandibular protrusion angle between each of the three classes of malocclusion. These findings can help to further our understanding of the relationship between craniofacial development and the classification of malocclusion.

INTRODUCTION

Dental malocclusion is caused by disproportionate growth of the mandible and/or maxilla during fetal development. This can be caused by many factors, both genetic and developmental, leading to misalignment of the jaws and teeth (Nishitha et al., 2014). Angle's (1900) classification is the most commonly used system of classifying malocclusion, and is based on the relative positioning of the first maxillary and mandibular molars (Rinchuse and Rinchuse, 1989). According to Angle's (1900) system of classification, there are three classes of malocclusion, as illustrated in Figure 1. Class I is described as having a normal first molar alignment, but with the presence of crowding and other alignment irregularities. Class II malocclusion occurs when the mandibular first molar is seated more posteriorly than the maxillary first molar. This pattern presents as an overbite where the maxillary teeth protrude anteriorly in relation to the mandibular teeth. In Class III, the mandibular first molar is seated more anteriorly than the maxillary first molar. This pattern creates an underbite in which the mandibular teeth protrude anteriorly past the maxillary teeth.

While both genetic and developmental causes of dental malocclusion are thought to exist, a distinct set of craniofacial factors have not yet been found to cause variation in dental malocclusion (Nishitha et al., 2014). Many previous studies have aimed to connect various cranial angles to malocclusion, including the cranial base angle, maxillary protrusion (SNA) angle, and mandibular protrusion (SNB) angle (Dhopatkar et al., 2002; Andria et al., 2004; Nishitha et al., 2014; Camci and Salmanpour, 2020). These studies have come to con-

Figure 1. Illustration of Angle's (1900) classifications of malocclusion, (A) Class I, shown in subject Burlington 392M, 12.0 years, (B) Class II, shown in subject Burlington 183M, 12.0 years, and (C) Class III, shown in subject Bolton-Brush B2429F, 11.7 years.

flicting conclusions on whether there is a link between these angles and dental malocclusion class (Andria et al., 2004). Some studies have indicated that classification of malocclusion is not correlated to a single cranial angle, but is instead linked to a more complex relationship between multiple angles and developmental factors (Guyer et al., 1986). Additional research has investigated whether sexual dimorphism is related to dental development in regards to skeletal growth and shape (Coquerelle et al, 2011). Other studies have found that there is a significant correlation between mandibular and maxillary length and malocclusion classification, but that the cranial base angle had no significant relation or correlation to classification of malocclusion (Polat and Kaya, 2007).

This study investigates three craniofacial angles which have been proposed to correlate with patterns of malocclusion (Dhopatkar et al., 2002). The cranial base angle, also known as the saddle angle, is typically measured radiographically using the following skull landmarks: *basion* (Ba), *sella turcica* (S), and *nasion* (N). The anterior limb of this angle has been shown in other studies to significantly correlate with the position of the maxilla, while the posterior limb has been shown to correlate with the position of the mandible (Dhopatkar et al., 2002). The maxillary protrusion (SNA) angle is measured radiographically using the following landmarks: *sella turcica* (S), *nasion* (N), and the most concave point of the midsagittal maxilla between the anterior nasal spine and the most inferior region of the bone (Point A). The SNA angle relates to occlusion of the teeth as it describes protrusion of the maxilla in relation to the rest of the skull. The mandibular protrusion (SNB) angle is measured radiographically using the following landmarks: *sella turcica* (S), *nasion* (N), and the most concave point of the anterior midsagittal mandible (Point B). The SNB angle relates to occlusion of the teeth as it describes protrusion of the mandible in relation to the rest of the skull.

This study aims to determine whether any relationship exists between these three craniofacial angles and subjects' classification of malocclusion. Additionally, this study assesses sexual dimorphism in the angle measurements and developmental changes in the angle measurements over time. Using lateral cranial radiographs from the American Association of Orthodontists Foundation (AAOF) Legacy Growth Collection, measurements of the cranial base angle, SNA angle, and SNB angle were collected and compared across three longitudinal age groups.

MATERIALS & METHODS

Measurements of cranial base angle and facial protrusion (SNA and SNB) angles were collected from a longitudinal sample of lateral human cephalograms. A sample of 30 subjects (15 male and 15 female) were measured, with 10 subjects (5 male and 5 female) represented in each class of malocclusion. Subjects were measured at three longitudinal age points (Age 1: 5.0-6.3 years, Age 2: 11.0-12.1 years, and Age 3: 15.0-16.2 years). These age points were chosen due to their relation to important growth phases in development of the jaws and teeth (Albert et al., 2019). Age 1 is closely related to the time frame in which deciduous teeth begin to be lost and adult central incisors begin to erupt (AlQahtani et al., 2010). Age 3 relates to when the mandible has completed or nearly completed its growth to adult size. Age 2 falls between these major developmental periods, providing data on ongoing development of the jaws and teeth.

Subjects were sampled from the University of Toronto Burlington Growth Study, the Case Western Bolton-Brush Growth Study, and the Fels Longitudinal Study (American Association of Orthodontists Foundation, 2022). These growth studies primarily represent North Americans of European descent, and the radiographs were collected in the mid-1900s. Subjects were selected based on availability of radiographs at each of the sampled age groups, with the goal of having an equal number of subjects in each class of malocclusion and with an equal number of males and females within each class.

A single observer used the program tpsDig2 (Rohlf, 2015) to collect measurements of the SNA (maxillary protrusion), SNB (mandibular protrusion), and cranial base angles on each radiograph. The cranial base angle was measured as the angle from *nasion* (N), to *sella turcica* (S), to *basion* (Ba) (Dhopatkar et al., 2002), as illustrated in Figure 2. The SNA angle was measured as the angle measured from *sella turcica* (S), to *nasion* (N), to Point A (A). Point A is the most concave point of the midsagittal maxilla between the anterior nasal spine and the anterior inferior part of the maxilla from which the incisors erupt (Nishitha et al., 2014), as shown in Figure 3. The SNB angle was measured as the angle from *sella turcica* (S), to *nasion* (N), to Point B (B). Point B is the most concave point of the anterior midsagittal mandible (Lorenzo et al., 1998), as shown in Figure 4.

Before finalizing measurements of the whole subject pool, a test of intraobserver error was performed to ensure accuracy and precision of measurement technique. Measurements of the cranial base, SNA, and SNB angle were repeated for a sample of five subjects at each class at the youngest age point, resulting in a total of 15 radiographs being measured twice. The first and second round of measurements were measured by the same observer. Next, *t*-tests were performed to determine whether a significant difference existed between the two sets of measurements. Results of this test showed no significant difference between the two rounds of measurement, with p-values of 0.7913 for the cranial base angle, 0.8962 for the SNA angle, and 0.3913 for the SNB angle.

After all angle measurements were collected, *t*-tests were conducted to determine whether significant angle differences exist between the sexes, between age groups, and between malocclusion classes.

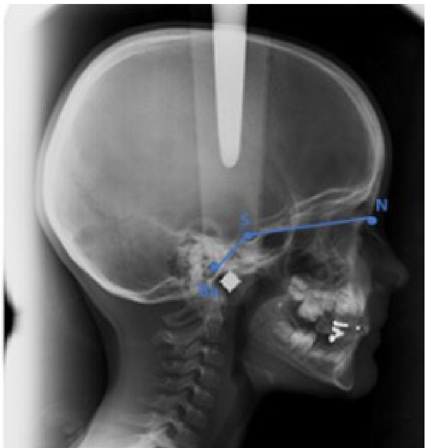

Figure 2. Cranial base angle, measured between nasion (N), sella turcica (S), and basion (Ba). (Shown in subject Burlington 608F, 6.0 years).

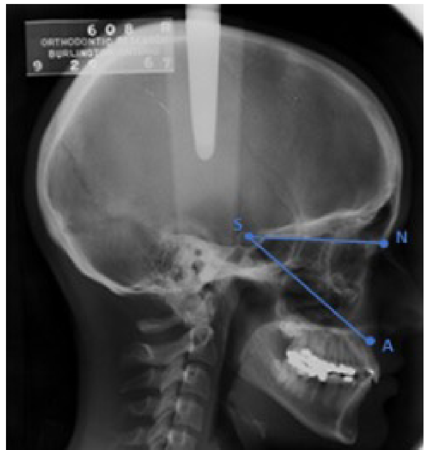

Figure 3. SNA angle, measured between nasion (N), sella turcica (S), and Point A. (Shown in subject Burlington 608F, 12.08 years).

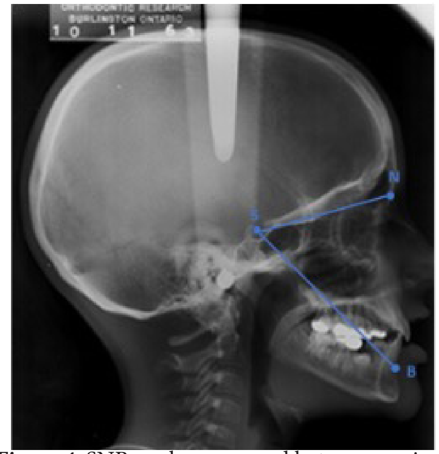

Figure 4. SNB angle, measured between nasion (N), sella turcica (S), and Point B. (Shown in subject Burlington 608F, 16.0 years).

RESULTS

Average angle measurements for each age group are shown in Tables 1-3.

Average angle measurements for males versus females from each class of malocclusion are shown in Table 4.

The *t*-tests revealed some significant patterns of angle variation relating to sexual dimorphism, development, and malocclusion. For the test of sexual dimorphism, the only significant angle difference between males and females was found in the SNA angle at the youngest age group (Table 5).

The only significant developmental angle change was in the SNB angle, which was found to differ significantly between the youngest and oldest age groups (Table 6).

Significant differences were found in the cranial base angle between individuals classified as having Class III malocclusion compared to those having both Class I and Class II malocclusion (Table 7). Additionally, significant differences were found in the SNA angle between individuals in Class I versus Class II and in Class II versus Class III. Finally, a significant difference was found in the SNB angle measurement between each of the classes of malocclusion.

DISCUSSION

Sexual Dimorphism. The significant sexual dimorphism in SNA angle found in the youngest age group is likely due to the difference in incisor eruption timelines between the sexes (Poureslami et al., 2015). Females typically lose their deciduous central incisors and show eruption of their adult cen-

Table 1. Ranges and averages for each angle measurement in the Class I malocclusion sample pool.

Measurements (in Degrees) of Angles for Class I						
Group	SNA Angle		SNB Range		Cranial Base Angle	
	Range	Avg.	Range	Avg.	Range	Avg.
Age 1 (5.0-6.3 years)	77.96-90.62	81.81	72.27-80.32	77.07	120.65-136.39	127.22
Age 2 (11.0-12.1 years)	77.0-89.64	83.42	74.17-84.62	80.20	121.31-134.54	126.68
Age 3 (15.0-16.2 years)	80.93-87.51	85.19	77.98-83.94	81.75	119.15-138.12	125.64

Table 2. Ranges and averages for each angle measurement in the Class II malocclusion sample pool.

Measurements (in Degrees) of Angles for Class II						
Group	SNA Angle		SNB Range		Cranial Base Angle	
	Range	Avg.	Range	Avg.	Range	Avg.
Age 1 (5.0-6.3 years)	76.93-91.35	81.48	71.42-82.21	75.10	115.74-138.36	129.48
Age 2 (11.0-12.1 years)	75.29-88.81	80.44	68.01-81.05	76.10	112.46-138.24	128.16
Age 3 (15.0-16.2 years)	75.49-88.47	81.21	73.10-81.37	76.87	123.45-138.43	128.34

Table 3. Ranges and averages for each angle measurement in the Class III malocclusion sample pool.

Measurements (in Degrees) of Angles for Class III						
Group	SNA Angle		SNB Range		Cranial Base Angle	
	Range	Avg.	Range	Avg.	Range	Avg.
Age 1 (5.0-6.3 years)	74.32-95.02	84.94	74.68-88.99	82.06	116.41-131.63	122.90
Age 2 (11.0-12.1 years)	78.29-95.58	84.95	74.74-93.61	83.12	113.21-131.53	123.55
Age 3 (15.0-16.2 years)	76.48-94.75	85.52	74.57-90.80	83.66	112.61-134.08	124.03

Table 4. Average angle measurements in male versus female subjects at Age 1 (5.0-6.3 years), Age 2 (11.0-12.1 years), and Age 3 (15.0-16.2 years).

Measurements (in Degrees) of Angles in Male Versus Female Subjects							
Group	Age	SNA Angle Avg.		SNB Range Avg.		Cranial Base Angle Avg.	
		Male	Female	Male	Female	Male	Female
Class I	Age 1	79.85	83.77	76.19	77.95	127.91	126.53
	Age 2	81.94	84.89	79.13	81.27	128.49	124.87
	Age 3	84.42	85.97	80.97	82.52	125.31	125.96
Class II	Age 1	78.95	84.01	72.98	77.22	131.36	127.60
	Age 2	79.02	81.87	75.86	76.35	129.85	126.26
	Age 3	80.03	82.38	76.63	77.11	125.97	130.70
Class III	Age 1	82.10	87.79	80.60	83.52	124.74	121.05
	Age 2	83.41	86.49	81.85	84.38	122.29	124.81
	Age 3	85.92	85.11	84.57	82.74	123.49	124.57

tral maxillary incisors earlier in development than males (AlQahtani et al., 2010). On average, females have eruption of their adult central maxillary incisors 2 months earlier than males. The average age of adult maxillary central incisor eruption is 6.7 years of age in females and 6.9 years of age in males (AlQahtani et al., 2010). Eruption of the maxillary incisors impacts the placement of point A, thereby causing variation in the measurement of the SNA angle. Because the SNA angle is measured from the most concave part of the maxilla, between the inferior nasal ridge and the incisors, the presence of unerupted adult teeth affects the outcome of this angle measurement.

No significant sexual dimorphism was found in either the SNB or cranial base angle. The lack of significant sexual dimorphism in the SNB angle is likely due to the closer eruption timeline for mandibular incisors compared to maxillary incisors. On average, male and female mandibular incisors erupt within a month of each other (AlQahtani et al., 2010, Poureslami et al., 2015). Additionally, mandibular protrusion may not be a sexual dimorphic feature, despite sex-related variation in mandibular size (Weber et al., 1993). Previous studies have found there to be little sex-related variation in mandibular shape or development between the ages of 4 to 14 years (Coquerelle et al, 2011). This could explain the lack of sexual dimorphism found in our age groups. The cranial base angle was not found to be significantly different between the sexes, as seen in previous studies (Mana et al., 2016). While the average values between males and females were found to vary slightly, the difference was not significant and overlap was seen between the male and female cranial base angle ranges.

Table 5. Results of sexual dimorphism *t*-tests, including p-values *t*-scores, and degrees of freedom (DOF).

***T*-Test Results for Differences Between Male and Female Subjects**									
Group	SNA			SNB			Cranial Base Angle		
	P-Value	T-score	DOF	P-Value	T-score	DOF	P-Value	T-score	DOF
Age 1 (5.0-6.3 years)	0.0061*	2.9660	28	0.0616	1.9469	28	0.2083	1.2880	28
Age 2 (11.0-12.1 years)	0.0913	1.7487	28	0.3286	0.9944	28	0.5288	0.6378	28
Age 3 (15.0-16.2 years)	0.5489	1.0273	28	0.9686	0.0397	28	0.5414	0.6183	28

Table 6. Results of developmental changes *t*-tests, including p-values *t*-scores, and degrees of freedom (DOF).

***T*-Test Results for Differences Between Age Groups**									
Group	SNA			SNB			Cranial Base Angle		
	P-Value	T-score	DOF	P-Value	T-score	DOF	P-Value	T-score	DOF
Age 1 vs. 2	0.5290	0.6334	58	0.1634	1.4115	58	0.80073	0.2450	58
Age 2 vs. 3	0.3955	0.8560	58	0.4500	0.7605	58	0.6326	0.4806	58
Age 1 vs. 3	0.3301	0.9822	58	0.0249*	2.3027	58	0.7446	0.3273	58

Table 7. Results of malocclusion class *t*-tests, including p-values *t*-scores, and degrees of freedom (DOF).

***T*-Test Results for Differences Classes of Malocclusions**									
Group	SNA			SNB			Cranial Base Angle		
	P-Value	T-score	DOF	P-Value	T-score	DOF	P-Value	T-score	DOF
Class I vs. II	0.0245*	2.3102	58	0.0001*	4.1186	58	0.1701	1.3891	58
Class II vs. III	0.0017*	3.2846	58	0.0001*	6.4068	58	0.0019*	3.2529	58
Class I vs. III	0.1753	1.3722	58	0.0025*	3.1557	58	0.0427*	2.0723	58

Developmental Differences. The significant difference in the SNB angle between Age 1 (5.0-6.3 years) and Age 3 (15.0-16.2 years) can be explained by the anterior development of the mandible during late childhood and adolescent development. As the jaw develops during major growth periods between 5 and 15 years of age, the mandible undergoes anterior growth relative to the rest of the skull (George, 1978; Kerr, 1979). During puberty, both males and females experience mandibular growth which can be seen as significant in increasing the SNB angle value from age 5 to age 15 (Banafsheh and Nanda, 2004). The SNB angle captures this mandibular protrusion, quantifying how far forward the mandible sits in relation to the rest of the skull.

No significant difference was observed in either the SNA angle or cranial base angle between the three age groups. The maxilla reaches 85% of its adult size by 5 years of age, with steady growth continuing from 5 until around 11 years of age, when growth slows and finally plateaus at the age of 15 years (Albert et al., 2019). The maxillary protrusion captured by the SNA angle, therefore, was not found to change significantly between the sampled age groups. Other studies have found that the cranial base angle remains relatively stable after five years of age (Dhopatkar et al., 2002). It is not surprising, therefore, that no significant developmental difference was observed in the cranial base angle between the sampled age groups.

Classes of Malocclusion. Class I malocclusion describes a normal first molar alignment with other irregularities occurring elsewhere, typically anterior to the first molars (Rinchuse and Rinchuse, 1989). Class II is defined as an overbite, where the upper first molar is located anterior to the lower first molar (Rinchuse and Rinchuse, 1989). Class III describes an underbite, where the lower first molar protrudes past the upper first molar (Rinchuse and Rinchuse, 1989). Measures of overall maxillary and mandibular protrusion, therefore, can be related to certain classes of malocclusion, as discussed below.

SNA Angle. The significant difference in the SNA angle between Class I and II and between Class II and III likely relates to the SNA angle's quantification of maxillary protrusion relative to the rest of the skull. Because Class

II malocclusion describes protrusion of the maxillary dentition relative to the mandibular dentition, the SNA angle of Class II subjects differs significantly from the other two classes.

Class I malocclusion, which includes proper alignment between the maxillary and mandibular first molars, is less likely to show the same level of maxillary protrusion as seen in Class II. The SNA angle of subjects with Class III malocclusion was found to vary significantly from subjects with Class II malocclusion because these two classes differ substantially in the relative positioning of the maxilla and mandible. The SNA angle measurement was able to capture this morphological variation.

SNB Angle. The significant difference in SNB angle between all three classes of malocclusion indicates the importance of the mandible's position relative to the rest of the skull in defining malocclusion. Class I subjects would be expected to show a normal level of mandibular prognathism, while Class II subjects would likely show mandibular retrusion or a slightly abnormal mandibular position. Class III subjects would most likely show mandibular protrusion. The position of the mandible impacts first molar alignment, and therefore malocclusion classification. Because the SNB angle captures information on mandibular positioning, this angle was found to vary significantly between the three classes of malocclusion.

Cranial Base Angle. The cranial base angle of subjects with Class III malocclusion was found to be significantly different from those in Classes I and II. This difference in cranial base angle measurement can likely be explained by Class III's connection with a pattern of both maxillary retrusion and mandibular protrusion. Additionally, Class III cranial base angle measurements' averages were smaller than that of Class I and Class II within each age group as seen in other research (Sanggarnjanavanich et al, 2014). The two limbs of the cranial base angle have been found to correlate with the positioning of the maxilla and mandible, as discussed above. Because Class I malocclusion does not typically involve as much irregularity in mandibular or maxillary position, the cranial base angle in Class I subjects was found to vary significantly from those in Class III. Class II malocclusion is often associated with an opposite pattern of jaw positioning than is seen in Class III. This difference in relative maxillary and mandibular positioning, therefore, may explain the significant difference found in the cranial base angle between these two classes.

A previous study found the cranial base angle to be significantly larger in a subgroup of Class II than in Class I (Dhopatkar et al., 2002). While we found the average cranial base angle to be slightly larger in Class II than in Class I, this difference was not significant. One possible explanation for this discrepancy is that Dhopatkar et al. (2002) included two separate divisions for Class II malocclusion while our study does not make this division.

SUMMARY

The results of this study could help to further our understanding of the physiological factors of malocclusion classification, and could help clinicians to develop a better classification system of malocclusion that includes information on craniofacial angles. While Angle's (1900) classification has been the most widely used classification system for dental malocclusion, a growing field of research is pointing to a need for a more specific classification system that includes more than three groups. Another possibility would be to study malocclusion along a continuum rather than as a series of classes. While this study finds that there are developmental interactions between the measured angles and class of malocclusion, more research is needed to determine whether a true causal connection can be made.

Future studies could investigate whether cranial base angle measurements falling outside of a defined "normal" range are correlated to the classification of malocclusion (Lorenzo et al., 1998). If a correlation is found, it could help to improve diagnosis and treatment of malocclusion, as well as improving the malocclusion classification system. This may also aid the American Association of Orthodontists and the American Board of Orthodontists in the formation of a more accurate malocclusion classification system.

ACKNOWLEDGEMENTS

The authors would like to thank the American Association of Orthodontists Foundation Craniofacial Growth Legacy Collection for providing access to the measured radiographs. Special thanks to the University of Toronto Burlington Growth Study, the Case Western Bolton-Brush Growth Study, and the Fels Longitudinal Study from which the cranial radiographs were sampled. This study was made possible by use of materials from the Burlington Growth Centre, Faculty of Dentistry, University of Toronto, which was supported by funds provided by Grant (1) (No. 605-7-299) National Health Grant (Canada), (data collection); (2) Province of Ontario Grant PR 33 (duplicating) and (3) the Varsity Fund (for housing and collection).

LITERATURE CITED

Albert, A.M., Payne, A.L., Brady, S.M, and Wright, C. 2019. Craniofacial Changes in Children-Birth to Late Adolescence. ARC Journal of Forensic Science 4(1):1-19.

AlQahtani S.J., Hector,M.P., and Liversidge, H.M. 2010. Brief Communication: The London Atlas of Human Tooth Development and Eruption. American Journal of Physical Anthropology 142:481-490.

American Association of Orthodontists Foundation. 2022. AAOF Craniofacial Growth Legacy Collection. https://www.aaoflegacycollection.org/aaof_home.html.

Andria, L.M., Leite, L.P., Prevatte, T.M., and King, L.B. 2004. Correlation of the Cranial Base Angle and Its Components with Other Dental/Skeletal Variables and Treatment Time. Angle Orthodontist 74(3): 361-366.

Angle, E. 1900. Treatment of Malocclusion of the Teeth and Fractures of the Maxillae. 6th Edition. The S.S. White Dental Manufacturing Company, Philadelphia. pp. 315.

Banafsheh, K.O., and Nanda, R.S. 2004. Comparison of Maxillary and Mandibular Growth. American Journal of Orthodontics and Dentofacial Orthopedics 125(2): 148-159.

Camci, H., and Salmanpour, F. 2020. Cephalometric Evaluation of Anterior Cranial Base Slope in Patients with Skeletal Class I Malocclusion with Low or High SNA and SNB Angles. Turkish Journal of Orthodontics 33(3): 171-176.

Coquerelle, M., Bookstein, F.L., Braga, J., Halazonetis, D.J., Weber, G.W., and Mitteroecker, P. 2011. Sexual Dimorphism of the Human Mandible and Its Association with Dental Development. American Journal of Physical Anthropology 145: 192-202.

Dhopatkar, A., Bhatia, S., and Rock, P. 2002. An Investigation into the Relationship Between the Cranial Base Angle and Malocclusion. Angle Orthodontist 72(5): 456–463.

George, S.L. 1978. A Longitudinal and Cross-section Analysis of the Growth of the Postnatal Cranial Base Angle. American Journal of Physical Anthropology 49(2): 171-178.

Guyer, E. C., Ellis III, E.E., McNamara Jr., J.A., and Behrents, R.G. 1986. Components of Class III Malocclusion in Juveniles and Adolescents. Angle Orthodontist 56(1): 7-30.

Kerr, W.J.S. 1979. A Longitudinal Cephalometric Study of Dento-Facial Growth from 5 to 15 Years. British Journal of Orthodontics 6(3): 115-121.

Lorenzo F., Baccetti, T., McNamara Jr., J.A. 1998. Cephalometric Floating Norms for North American Adults. Angle Orthodontist 68(6): 497-502.

Mana, M.D., Adalian, P., Lynnerup, N. 2016. Lateral angle and cranial base sexual dimorphism: a morphometric evaluation using computerised tomography scans of a modern documented autopsy population from Denmark. Anthropologischer Anzeiger 72(2):89-98.

Nishitha, J., Hamdan, A.M., and Fakhouri, W.D. 2014. Skeletal Malocclusion: A Developmental Disorder With a Life-Long Morbidity. Journal of Clinical Medicine Research 6(6): 399-408.

Polat, Ö., and Kaya, B. 2007. Changes in Cranial Base Morphology in Different Malocclusions. Orthodontics and Craniofacial Research 10(4): 216-221.

Poureslami, H., Aminabadi, N.A, Deljavan, A.S., Erfanparast, L., Sohrabi, A., Jamali, Z., Oskouei, S.G., Hazem, K., and Shirazi, S. 2015. Does Timing of Eruption in First Primary Tooth Correlate with that of First Permanent Tooth? A 9-years Cohort Study. Journal of Dental Research, Dental Clinics, Dental Prospects 9(2): 79-85.

Rinchuse D.J. and Rinchuse, D.J. 1989. Ambiguities of Angle's classification. Angle Orthodontist 59(4): 295-298.

Rohlf, F.J. 2015. The Tps Series of Software. Hystrix, the Italian Journal of Mammalogy 26(1):1-4.

Sanggarnjanavanich, S., Sekiya, T., Nomura, Y., Nakayama, T., Hanada, N., and Nakamura, Y. 2014. Cranial-base Morphology in Adults with Skeletal Class III Malocclusion. American Journal of Orthodontics and Dentofacial Orthopedics 146(1): 82-91.

Weber, J.S., Ursl, C.D., Trotman, C-A. McNamara Jr., J.A., Behrents, R.G. 1993. Sexual Dimorphism in Normal Craniofacial Growth. The Angle Orthodontist 63(1): 47-56