Australian Journal of Basic and Applied Sciences, 3(2): 706-712, 2009
ISSN 1991-8178

Cephalometric Assessment of Sagittal Relationship Between Maxilla and Mandible among Egyptian Children

[1]Nadia L. Soliman, [1]Mona M. El-Batran, [2]Wael A. Tawfik

[1]Associate Professor of Biological Anthropology
[2]Assist. Professor of Orthodontics

Abstract: The aim of this study was to provide a reliable parameter for assessment of sagittal jaw relationship. 155 lateral cephalometric radiographs for Egyptian children (99 boys and 56 girls), with mean age 10.5years ±1.39. Six linear and nine angular measurements were derived from nineteen reference landmarks. No sex or age differences were detected in all parameters except a larger S-N distance in boys (6.77mm. vs. 6.55mm.). The most homogenously distributed parameters were A-B distance followed by AS-BS, ANB, AF-BF, AP-BP (C.V. = 15.80; 46.81; 54.83; 57.20 and 72.40 respectively). The least homogenous parameter was AO-BO distance (C.V. = 84.74). Significant positive correlations were found between the linear parameters (Sagittal and vertical); between sagittal parameters and the angles formed by the inclination of A-B plane with the studied Sagittal planes; between the sagittal parameters and the facial divergence angles. A significant negative correlation between the sagittal parameters and the facial contour angle ($p< 0.05$, $p< 0.001$) was also found. In conclusion: Sagittal parameters (AS-BS, AF-BF, AP-BP, and AO-BO) could be used alternatively with ANB angle particularly when identification of nasion point is difficult. No single parameter or one approach can be used to give an accurate picture for the jaw relationship.

Key words: Cephalometric analysis, Sagittal references planes, sagittal jaw relationship, Angle ANB, Children

INTRODUCTION

Since the beginning of 1900s century, even before Angle`s classification on malocclusion, the relationship between the maxilla and the mandible was considered a good tool in studying the growth pattern of skeletal discrepancies (Oktay, 1991). Numerous studies have been attempted to provide suggestive information about the exact nature of this relationship (Nanda and Merrill, 1994).

The antero-posterior jaw relationship with respect to cranial anatomy reference planes presents inherent inconsistencies because of variations in craniofacial physiognomy (Jacobson, 1988; Haynes and Chau, 1995). In assessing the relationship between upper and lower jaws, there is some dispute whether the dental base only should be taken into consideration or the dento- alveolar structure also should be used (Sarhan, 1982).

Establishment of this horizontal jaw relationship can be defined using distances, angular measurement or both together. However the linear measurements have distinct advantages over angular ones in that there are fewer variables affecting its accuracy, and there is less error of measurements (Moyer and Book stein 1979, Jarvinen 1986; Nanda and Merrill, 1994).

A number of approaches have been designed for assessment of this relationship. Various cranial reference planes have been used as baseline from which degrees of jaw dysplasia are determined (Chang, 1987; Freeman, 1981; Oktay, 1991; Nanda and Merrill, 1994). A first step towards a description of this jaws relationship was the introduction of points A and B by Downs (1948). Riedel (1952) introduced the ANB angle. In the following years, a number of publications revealed the geometric factors that can affect ANB angle (Freeman 1981; Pancherz and Sack, 1990; Oktay, 1991). Jacobson (1975) introduced the wits appraisal based on the functional occlusal plane as a reference plane. Kim and Vietas (1978) introduced a suggested anteroposterior dysplasia indicator (APDI) which is consisting of a combination of three angles (facial angle, A-B plane angle and the palatal angle). Yong and Suhr (1995) advocated an equivalent angle to APDI (The angle between A-B plane and the palatal plane. Chang (1987) recommended the AF-BF distance based on the Frankfurt horizontal plane. Nanda and Merrill (1994) suggested an alternative plane (palatal plane), for the assessment of sagittal jaw relationship.

Corresponding Author: Nadia Lashin Soliman, Oral and Dental Medicine Research Department
E-mail nadialsoliman@hotmail.com

The sagittal jaw relationships are difficult to evaluate and can vary in response to many intervening factors as rotation of the jaws during growth, vertical relationship between jaws, the relative stability of the reference planes during growth, Lack of validity of the various method proposed for their evaluation, age, gender and racial origin as well as facial type (Jacobson 1975; Freeman 1981; Richardson, 1982; Bishara *et al*, 1983; Oktay, 1983; Jarvinen 1986)

On the basis of these concepts, the aim of the present study was to provide a more precise reliable parameter for assessment of sagittal jaw relationship.

MATERIAL AND METHODS

Lateral cephalometric radiographs of 155 Egyptian children with normal occlusion were selected from the films available in the Orthodontic department's files in the National Research Centre. The sample consists of 99 boys and 56 girls. Their ages ranged between 8 to 13.9 years with mean age 10.5 years and standard deviation 1.39 and they are healthy and classified as upper middle socio-economic levels. They are selected on the bases of normal growth with good occlusion criteria, fully erupted permanent maxillary and mandibular incisors, with normal morphology, correct over jet /overbite, no cross bite or transverse anomalies, no or only minor crowding, no history of orthodontic treatment and had no congenitally missing teeth. The dental occlusion was identified from their study dental cast and from clinical examination. All cases are with bilateral class I relationship, good molar relationship (up to less than half a cusp deviation).

Landmarks Identification:

All of the lateral cephalometric radiographs had been taken in a standardized manner in centric occlusion. All were scanned and performed with automated digitizer at a high resolution (600 d p I). The following hard tissue landmarks were identified according to (Downs, 1948; Chang, 1986; Jarvinen, 1986; Ishikawa *et al*, 2000) by using Dental tracer© NileDelta software program.

The Reference Points Are:

Nasion (N); sella turcika (S); porion (Po); orbital (Or); anterior nasal spine (ANS); posterior nasal spine (PNS); mesiobuccal cusp tip of upper first permanent molar (UMBC); mesiobuccal cusp tip of lower first permanent molar (LMBC); incisal edge of upper central incisor (Ui); incisal edge of lower central incisor (Li); gonion (Go); menton (Me), pogonion (Pog); point A (A); point B (B).

The Reference Planes:

The following planes were determined from the digitized reference points: sella nasion plane (NSL); frankfurt horizontal (FL); palatal plane (PL); and occlusal plane (Occl); The occlusal plane was determined anteriorly by the midpoint between the incisal edges of upper and lower central incisors and posteriorly by the mid point of the distance between the mesio-buccal cusp tip of maxillary and mandibular first permanent molars (UMBC, LMBC respectively). The selected references planes according definition described by Downs 1948; Chang 1986; Ishikawa *et al* 2000 (Figure 1).

Identification of Distances:

The antero- posterior linear relationship of the maxilla to the mandible described by perpendicular lines from points A and B onto the different four reference planes was established as follows: The points at which perpendicular lines meet the horizontal reference planes. (NSL, FL, PL, Occl) were digitized as: AS, BS, AF, BF, AP, BP, AO, BO respectively.

The linear measurements of the distance between point A and B projected onto the previously mentioned selected horizontal reference planes were measured to the nearest mm. Also, the vertical distance between maxilla and mandible, A-B distance was measured in mm (Figure 2).

Angular Measurements:

In addition to the linear parameters mentioned above, the following angular measurements which were thought to influence the antero-posterior jaw relationship were also recorded. These angles are as follows:
NSL/A-B (Taylor and Hitchcock1966); FL/A-B (yang and suhr1995); PL/ A-B (Nanda and Merrille 1994); Occl /AB (Bishara *et al* 1983).

Facial divergence angles were measured (NSL/FL, NSL/PL, NSL/Occl); ANB angle and facial contour angle (NAPog) are also measured (Figure1).

In order to minimize measurements error all the linear and the angular measurements were performed by two investigators working independently. Each investigator performed each measurement twice on different occasion when their initial measurements were within 0.2 mm or 0.5 degree of each other, the average of the two was used. If the disparity was greater, each made two additional measurements.

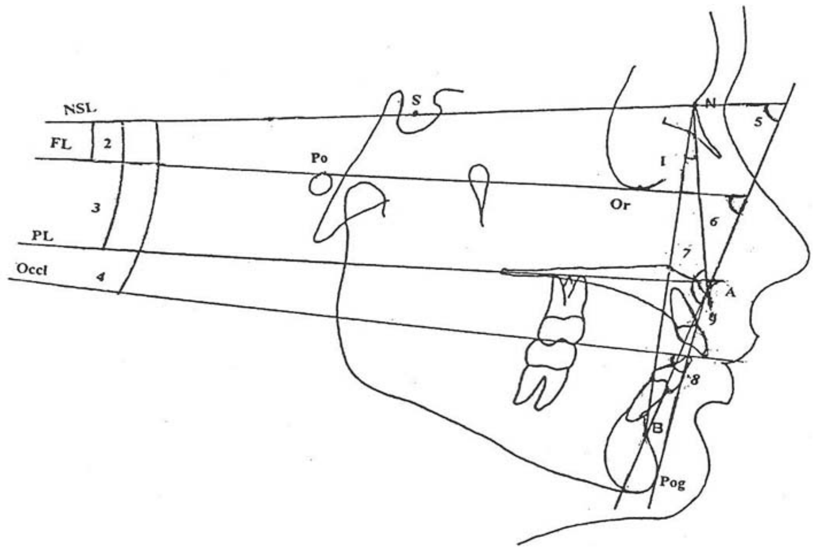

Fig. 1: References planes and angles: Sella - Nasion plane (NSL); Frankfurt horizontal (FL); Palatal plane (PL); Occlusal plane (Occl); (1) ANB angle; (2) NSL/FL; (3) NSL/PL; (4) NSL/Occl; (5) A-B/ NSL; (6) A-B/ FL; (7) A-B/ PL; (8) A-B /Occl, (9) NAPog.

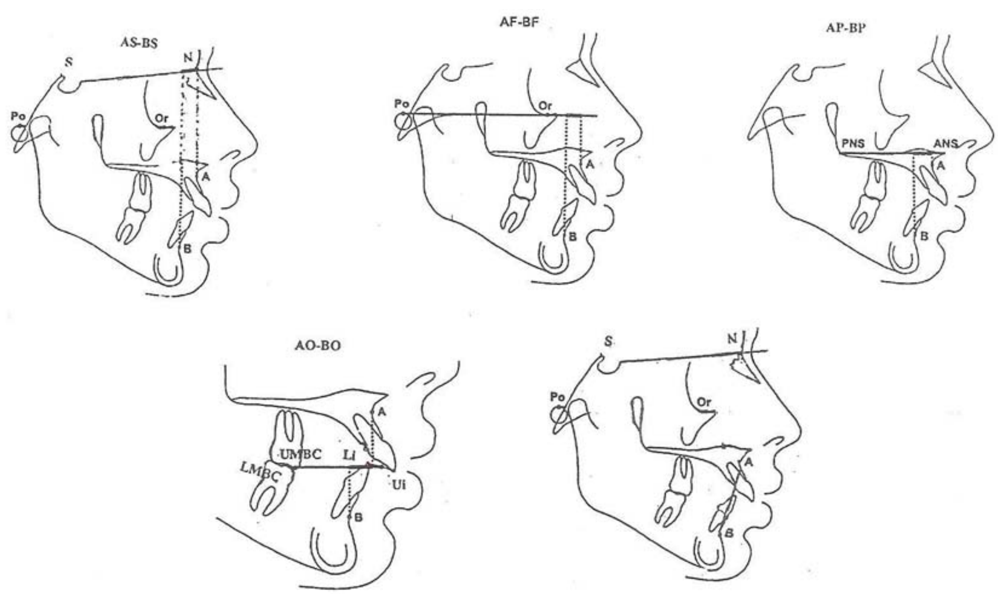

Fig. 2: Identification of distances perpendicular lines meet the horizontal reference planes. (NSL, FL, PL, Occl) were digitized as: AS, BS, AF, BF, AP, BP, AO, BO respectively.

Statistical Analysis:

Descriptive statistics including the Means (x), the Standard Deviations (SD), Range, and Coefficient Variability (CV) for each measurement for both sexes were calculated. Student's t test was applied to determine any significant sex difference in measurements and Coefficient Correlation analysis was done. All analysis was done using SPSS version 9.

RESULTS AND DISCUSSION

Results:

Means and Standard deviations of the linear and angular measurements are presented in table (1). No statistical significant differences were found between both sexes except in S-N distance where boys showing higher measurements (6.77mm vs 6.55). There for all the measurements belonging to both sexes except S-N were pooled.

Table 1: Means and standard deviations of linear and angular measurements in both sexes:

Measurements	Boys(N=99) X ± S.D.	Girls(N=56) X ± S.D.
Linear Measurements		
AS-BS	1.23 ± o.60	1.20 ± 0.52
AF-BF	0.84 ± 0.52	0.87 ± 0.42
AP-BP	0.64 ± 0.49	0.61 ± 0.39
AO-BO	0.39 ± 0.32	0.33 ± 0.26
A-B	3.94 ± 0.60	3.91 ± 0.66
S-N	6.77* ± 0.69	6.55 ± 0.61
Angular Measurements		
ANB	3.89 ± 2.21	4.58 ± 2.32
NSL/FL	7.28 ± 4.72	6.66 ± 4.35
NSL/PL	9.80 ± 5.53	9.75 ± 4.97
NSL/Occl	18.84 ±6.01	16.79 ± 6.67
NSL/A-B	71.29 ±7.80	71.79 ± 6.91
FL/A-B	79.92±20.80	77.59 ± 6.82
PL/A-B	80.09±8.26	81.99 ± 10.06
Occl/A-B	89.46±5.87	88.74 ± 5.44
NAPog	181.95±11.60	182.34 ± 10.72

* P < 0.05

Table (2) represents the measurements used in the assessment of antero-posterior jaw relationship for both sexes combined. According to these coefficient of variability, the measurements with the most homogeneous distribution was A-B distance, followed be AS-BS, ANB, AF-BF and AB-BP (CV= 15.8; 46.81; 54.83; 57.20 and 72.40 respectively). The least homogeneously distributed one was AO-BO distance (CV = 84.74).

Table 2: Range, Means and Standard Deviations of Linear and Angular Measurements, Coefficient of Variability (CV) in pooled sex (N = 155)

Measurements	Range		Mean ± SD	CV
	Minimum	Maximum		
Linear Measurements				
AS- BS	0.04	3.68	1.22 ± 0.57	46.81
AF- BF	0.06	2.92	0.85 ± 0.49	57.20
AP- BP	0.00	2.74	0.06 ± 0.45	72.40
AO-BO	0.00	1.63	0.37 ± 0.31	84.74
A- B	2.95	5.63	3.93 ± 0.62	15.80
Angular Measurements				
ANB	0.09	10.97	4.14 ± 2.27	54.83
NAPog	149.03	205.48	182.09 ± 11.26	06.18

Statistically significant and marked different correlations were found between the sagittal parameters and the linear and angular measurements; this is obviously seen in tables (3, 4 and 5). All the linear parameters (sagittal and vertical) represented in table 3 showing significant and highly correlated relationships where p< 0.05, p< 0.01.

Table 3: Correlation Coefficient between Linear Measurements:

	AS-BS	AF-BF	AP-BP	A0-B0	A-B	S-N♂	S-N♀
AS-BS		.695**	.684**	.191*	.305**	.127	.061
AF-BF			.695**	.193*	.156	.142	.029
AP-BP				.246**	.205*	-.007	.022
A0-B0					.250**	.036	.039
A-B						.053	.401**

* P< 0.05
**p < 0.01

Table 4: Correlation Coefficient between Angular Measurements

	ANB	NAPog	NSL/FL	NSL/PL	NSL/Occl	NSL/A-B	FL/A-B	PL/A-B	Occl/A-B
ANB		.112	-.037	.128	.118	-392**	-.197*	-.59	-429**
NAPog			-.162*	-.241**	.003	.074	.089	.154	.115
NSL/FL				.464**	.73**	-.275**	.144	-.084	-.052
NSL/PL					.454**	-.457**	-.111	-.100	-.038
NSL/Occl						-.637**	-.162*	-.095	.08
NSL/A-B							.459**	.141	.474**
FL/A-B								.153	.189*
PL/A-B									.157
Occl/A-B									

* P< 0.05
**p < 0.01

Table 5: Correlation Coefficient between Linear and Angular Measurements:

	ANB	NAPog	NSL/FL	NSL/PL	NSL/Occl.	NSLA-B	FL/A-B	Pl/A-B	Occl/A-B
AS-BS	.361**	-.327**	.328**	.474**	-.57**	.353**	-.825*	-.321**	-.232**
AF-BF	.408**	-.179-*	-.235	.154	.303**	.225**	-.601*	-.399**	-231**
AP-BP	.364**	-.073	.011	-.224**	.235**	.218**	-.55**	-.309**	-.201*
A0-B0	-.183*	-.244**	.089	.004	.019	.208**	-.105	.099	-.046
A-B	-.087	-.559**	.08	.001	-.09	-.082	.119	.113	-.079
S-N	-.218*	.051	.155	.144	.043	-.031	-.039	.184	.162
S-N	-.272*	.048	-0134	.012	-.117	-.2	.097	.048	.027

* P< 0.05
**p < 0.01

There are significant positive correlations between all the sagittal parameters and the angles formed by the inclination of A-B plane with SN plane; Frankfurt horizontal, palatal and occlusal planes ($P< 0.05$, $P< 0.001$). Also there are positive correlations between AS-BS, AF-BF, AP-BF distances and the facial divergence angels (NSL/FL, NSL/PL, NSL/OCCL) are prominent in table 4and table 5.

The facial contour angle (NAPog) had a significant negative correlation between all the sagittal parameters except AP-BP Distance ($r = - 0.073$).

Discussion:

Various cranial or extra cranial reference planes have been used as baseline from which to determine degree of the jaw dysplasia (Downs 1948, Riedel 1952, Kim and Vietas 1978, Jacobsen 1988, Nada and Merrill 1994, Yang and Suhr 1995, Lux *et al*. 2005).

Numerous studies have reported significant differences and controversial issues between approaches in assessment of this sagittal jaw relationship. This may be due to many intervening factors that contribute to the growth and development of facial skeleton. The controversies in sagittal assessment illustrate the necessity to recognize the weakness of each parameter and which quantitatively describe this relationship.

One must not forget that the growth is a total process, facial Skelton and the dentition are functional parts of the skull as a whole, and therefore, any variations in the occlusal relationship will be the largely related to the facial and cranial structure (Bjork 1951). However, the lines of reference from which sagittal jaw relationship should be assessed must relate to and provide a reliable expression of actual antero- posterior relationship of the jaws. Age related changes have been considered one of the most contributing factors that might influence the suitability and reliability of different approaches since, the age related changes makes the use of fixed norms, questionable (Nanda and Merrill 1994; Lux *et al*. 2005).

Despite individual variations, the age group 8-13.9 years in this study could be useful for obtaining adequate meaningful information with consequent details. As this age period was considered to include the late mixed dentition stage at which the juvenile growth spurt of the facial development was considered to be completed and the onset of the pubescent growth spurt will not started i.e. the velocity of the facial growth was considered to be more or less stable (Lux *et al* 2005). That is why; no significant age and sex difference could be detected.

Concerning the coefficient of variation, the statistical analysis shows that measurements related to SN plane, Frankfurt horizontal and the palatal plane are found to be homogeneous as well as ANB angle CV = 15.80; 46.81; 54.83; 57.20 and 72.40 respectively. However, the least homogonous one was the wits appraisal (AO-BO distance CV = 84.74). This may be attributed in part to the difficulties or inaccuracy in identifying the occlusal plane. Jacobson, 1975; reported that this plane could be changed by the vertical movements of incisors, molars or both. In 1995, Yang and Suhr concluded that wits appraisal is a parameter for evaluation of antero- posterior relationship of the dentition rather than jaws. Roth 1982, suggest that any alternation of the vertical jaw relationship leads to further variation in A-B distance. The present study confirms the previous findings, as there is a significant correlations between AS-BS, AF-BF, AP-BP, AO-BO distances and the length of A-B line ($P<0.05,0.001$). This association provides that these measurements would be a more reasonable choice in assessment both vertical and sagittal jaws relationship. In agreement with Yang and Suhr (1995) who reported that these sagittal planes are highly correlated anatomically to each other, the present study shows presence of high correlation between sagittal measurements, angle ANB, facial contour angle (NAPog) and the A-B vertical distance. Consequently these planes tend to move in the same direction and could be used interchangeably in assessment of jaws dysplasia.

Most of the claims and criticisms about the ANB angel have been based upon the geometric studies. Hence, to overcome the influence of anatomic variation of the nasion point, these sagittal parameters could be used as alternative to the ANB angle. In agreement with Järvinen1986 who concluded that the facial divergence angles not only provide some indication of the mutual rotation between the cranial base and the jaws, but they affect also the distance between points A and B on the SN plane, Frankfurt horizontal, palatal, and occlusal planes. Present study shows a positive high correlation coefficient among points A, B related to these previous reference planes with the facial divergence angles ($p<0.001$). Also, the negative significant correlation between the facial contour angle and distances AS-BS, AF-BF, and AO-BO ($r= -0.33, -0.18, -0.24$ respectively) achieved and confirm that the position of these two points (A, B) on these sagittal planes have a strong impact on the sagittal jaws relationship as well as the facial profile.

Conclusion:

In the 8- 13.9 age group, the sagittal differences between the maxillary and mandibular apical bases can be evaluated by angle ANB or by linear measurements (AS-BS, AF-BF, AP-BP, AO-BO). The linear measurements could be used as a data relevant to the local population in whom the identification of cephalometric landmark nasion (N) is difficult. In the presence of correlation between the variance analysis, it has been possible to suggest more than one approach in which combination could give the most accurate picture of the jaws relationship. Finally, no single parameter in cephalometric analysis should be relied entirely and interpreted as absolute value.

REFERENCES

Bishara, S.E., J.A. Fahl, L.C. Peterson, 1983 Longitudinal changes in the angle ANB and Wits appraisal: clinical implication American Journal of Orthodontics, 84: 133-139.

BJörk, A., 1951. Some biological aspects of prognathism and occlusion of the teeth. Angle Orthod, 21: 3-27.

Chang, H.P., 1987 Assessment of antroposterior jaw relationship. American Journal of Orthodontics and Dentofacial Orthopedics, 92: 117-122.

Downs, W.B., 1948. Variation in facial relationship: their significance in treatment and diagnosis. American Journal of Orthodontics, 34: 812-840.

Freeman, R.S., 1981. Adjusting ANB angle to reflect the effect of maxillary position. Angle Orthodontist, 51: 162-172.

Haynes, S. and M.N.Y. Chau, 1995. The reproducibility and repeatability of the wits analysis. American Journal of Orthodontics and Dentofacial Orthopedics, 107(6): 640-647.

Ishikawa, H., S. Nakamura, H. Iwasaki, S. Kitazawa, 2000. Seven parameters describing anteroposterior jaw relationships: postpubertal prediction accuracy and interchangeability. American Journal of Orthodontics and Dentofacial Orthopedics, 117: 714- 720.

Jacobson, A., 1988. Update on the wits appraisal. Angle orthodontist, pp: 205-219.

Jacobson, A., 1975. The "Wits" appraisal of jaw disharmony. American Journal of orthodontics, 67: 125-138.

Jarvinen, S., 1986. Floating norms for the ANB angle as guidance for clinical considerations. American Journal of orthodontics and Dentofacial orthopedics, 90: 383-387.

Kim, Y.H., J.J. Vietas, 1978. Anteroposterior dysplasia mediator: an adjunct to cephalometric differential diagnosis. American Journal of Orthodontics, 73: 619-633.

Lux Christopher, J., B. Donald, Christian Conradt, Gerda Komposch, 2005. Age related changes in sagittal relationship between the maxilla and mandible European Journal of Orthdontics, 10: 1-11.

Moyers, R.E., F.L. Bookstein, 1979. The inappropriateness of conventional cephalometric American Journal of Orthodontics, 75: 599-617.

Nanda, R. and R.M. Merrill, 1994. Cephalometric assessment of sagittal relationship between maxilla and mandible. American Journal of orthodontics and Dentofacial orthopedics, 105(4): 328-344.

Oktay, H., 1991. A comparison of ANB, wits, AF-BF and APDI measurements. American Journal of Orthodontics and Dentofacial Orthopedics, 99: 122-128.

Pancherz, H. and B. Sack, 1990. Klinische analysis der winkel SNA, SNB and ANB beider Auswertung von kiefer orthopadischen bhandlungen. Fortschritte der Kieferörthopadie, 51: 309-317.

Richardson, M., 1982. Measurement of dental base relationship. European journal of Orthodontics, 4: 251-256.

Riedel, R.A., 1952. The relationship of maxillary structures to cranium in malocclusion and in normal occlusion. Angle orthodontist, 22: 142-145.

Roth, R., 1982. The "Wits" appraisal - its skeletal and dento-alveolar background. European Journal of Orthodontics, 4: 21-28.

Sarhan, O.A., 1982. A new cephalometric parameter to aid in dental base relationship analysis. Angle orthodontist, 60(1): 59-64.

Taylor, W. and H. Hitchcock, 1966. The Alabama analysis. American Journal of Orthodontics, 52: 245-265.

Yang, S.D., C.H. Suhr, 1995. F-H to AB plane angle (FABA) for assessment of anteroposterior jaw relationships Angle Orthodontist, 65(3): 223-232.