ORIGINAL ARTICLE

Redefining Subspinale in Hypodivergent, Normodivergent and Hyperdivergent Patients

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OBJECTIVE: To ascertain the reliability of three alternate points to Point A in vertical and horizontal planes for different growth patterns.

METHODOLOGY: Pre-treatment lateral cephalograms of 121 patients were traced and Points A1, A2, and A3 were identified. The sample was divided into three groups according to growth patterns. The angles SNA1, SNA2, and SNA3 were measured and compared with SNA to determine their reliability in the horizontal plane. The vertical distances NA1, NA2, and NA3 were measured and compared with NA to detect their reliability in the vertical plane. Descriptive statistics were calculated using SPSS version 23. A Pearson correlation test was applied to determine the significant correlation between these three points and Point A in all three groups. ANOVA was used to compare the means of all vertical and horizontal parameters in all three groups.

RESULTS: In the horizontal plane, a minimum mean difference was found between SNA2 and SNA while SNA3 showed the maximum deviation from SNA. In the vertical plane, NA2 and NA3 showed the minimum deviation from NA while the maximum mean difference was found between NA1 and NA. Also, SNA showed the strongest correlation with SNA2, while NA showed the strongest correlation with NA2 and NA3. However, ANOVA showed non-significant differences between vertical and horizontal parameters in all three groups.

CONCLUSION: Point A2 was shown to be the most reliable point in all three groups for both vertical and horizontal parameters. The growth pattern did not significantly affect it.

KEYWORDS: Growth Pattern, Lateral Cephalogram, Point A, Reliability, SNA Angle.

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INTRODUCTION

The introduction of cephalometry by Broadbent in 1931 popularized the use of lateral cephalograms in Orthodontics.[1] At present, cephalometric analysis has become imperative for orthodontic diagnosis and treatment planning.[2] Manual or digital tracing of the cephalogram is followed by landmark identification, which serves to find out and interpret numerous linear and angular measurements. However, failure to accurately identify the landmarks results in most errors in cephalometric analysis.[2] This may be a consequence of the difference in radiolucencies of neighboring hard tissues or overlap from surrounding soft tissues. It may also be caused by developing teeth affecting the shape of the anterior maxilla or syndromes associated with anatomical defects in the hard and soft tissues.[3]

One of the commonly used cephalometric landmarks is the "Point A" or "Subnasale." It is defined as the deepest point of the concavity on the premaxilla or alveolar bone between the anterior nasal spine (ANS) and Prosthion.[4,5] It serves to determine the anteroposterior position of the maxilla in relation to the anterior cranial base or the mandible by using the angle SNA and ANB, respectively.[6] Difficulty in locating Point A may be due to abnormal variations in the structure of the maxilla owing to conditions such as cleft lip and palate[7], silent sinus syndrome,[8] Binders Syndrome, Down's Syndrome, nasomaxillary hypoplasia, etc.[3] Point A is essential to a number of cephalometric analyses presented by Mc Namara, Steiner, Downs, Wits, etc. to analyze the skeletal and dental relationships in all three planes.[9] Therefore, it is important to find all the alternative points to aid in the identification of Point A accurately.

Van der Linden[10], Jarabak and Fizzel[11], Jacobson R. and Jacobson A[12] are a few of the authors who have offered alternatives to Point A in the past. All these landmarks were compared with Point A in a study conducted by Patel9 and found the point devised by Jacobson et al.[12] to be the most reliable among the three. A few other alternate points were also given by Bongaarts and Tindlund. Bongaarts et al.[7] utilized Prosthion and the palatal plane to formulate an

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alternate point. Tindlund et al[13] used the anterior border of the maxilla to construct the Point A alternative (Max P). Any error in the identification of Point A or ANB angle can affect SNA and alter the interpretation of the sagittal analysis. These variations may be attributed to an alteration in the position of the Nasion, vertical relation of Points A and B, occlusal plane inclination, distance between the Nasion and Point A, or inclination of maxillary incisors.[14]

The position of Point A may also vary according to the growth pattern of the patient. This may be due to the difference in inclination of the Sella-Nasion (SN) plane and the palatal plane (ANS-PNS). Hyperdivergent subjects may exhibit increased inclination of all five of Sassouni's planes.[15] On the contrary, hypodivergent patients would present with a decreased inclination of these planes.[16] Moreover, hypodivergent subjects show retroclined or upright incisors while hyperdivergent subjects often possess bidental protrusion.

However, none of the previous studies detected the reliability of the alternate points in hypo-, normo- and hyperdivergent subjects. Furthermore, the earlier studies conducted in the Asian population have been done on a smaller sample size. Therefore, the aim of this study is to determine the reliability of these three alternate points for Point A in horizontal and vertical planes for hypodivergent, normodivergent, and hyperdivergent subjects.

METHODOLOGY

This descriptive cross-sectional study was conducted at the Orthodontic Department of Liaquat College of Medicine and Dentistry and Qamar Dental Hospital, Karachi. The sample size was obtained using the study conducted by Jain et al.[17], with the help of OpenEpi, Version 3, open-source calculator, keeping the confidence interval at 95% and the power at 80%. The minimum sample size was calculated to be 104 and the sampling technique was consecutive sampling. The Ethical Approval was obtained before the data collection was begun. Pre-treatment lateral cephalograms of 121 patients were obtained according to the following inclusion and exclusion criteria:

Inclusion criteria:

1. Patients with good quality pre-treatment lateral cephalograms with clearly visible craniofacial structures taken in the Natural Head Position
2. Presence of healthy permanent maxillary incisors

Exclusion criteria:

1. History of trauma, maxillofacial surgery, or orthodontic treatment
2. Congenital disorders e.g. cleft lip and palate
3. Resorption of central incisor roots.
4. Alveolar bone resorption around the maxillary central incisors
3. Patients with poor quality pre-treatment lateral cephalograms where point A and its alternate points were not visible clearly.

The lateral cephalograms were traced manually over an X-ray view box on lead acetate paper with a 2B lead pencil. All the required cephalometric landmarks were identified. **(Figure 1) (Table 1) Table 2** describes the linear measurements and angular measurements used for the analysis.

The total sample was divided into three groups according to growth patterns, to check for the influence of growth patterns on the reliability of the alternate points. Group 1 included subjects with horizontal growth pattern i.e. MMA < 21°. Group 2 included subjects with normal growth pattern

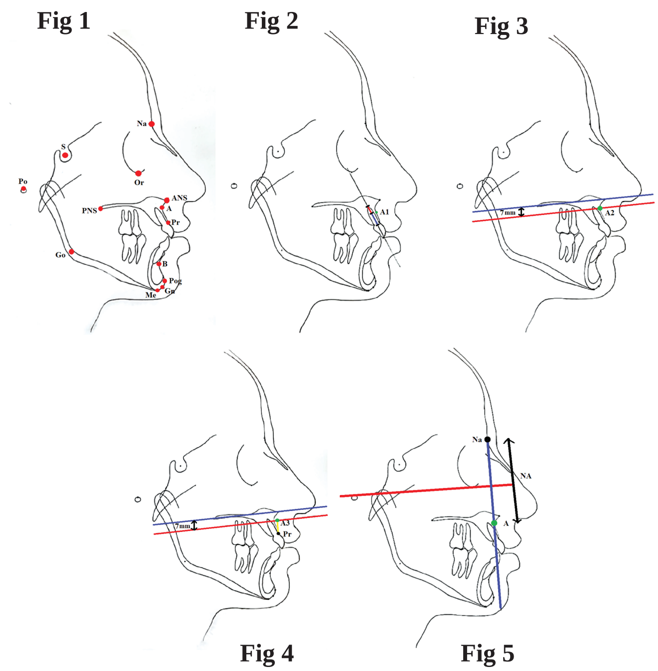

Fig 1 **Fig 2** **Fig 3** **Fig 4** **Fig 5**

i.e. MMA = 25° ± 4°.Group 3 included subjects with vertical growth pattern i.e. MMA > 29°.

All three alternate points for point A were located and evaluated in each of the three groups. Point A1 was suggested by Jacobson et al.[12], the point 3 mm labial to the long axis of the root of the maxillary central incisor (Figure 2). Point A2 was proposed by Tindlund et al[13], the point where a line parallel to and 7 mm below the palatal plane intersects the anterior margin of the maxilla (Figure 3). Point A3 was devised by Bongaarts et al.[7], a point 7mm below the palatal plane projected perpendicular from the point Prosthion (Figure 4).

Table 1: Landmarks

Landmark	Definition
Sella	Midpoint of the cavity of Sella Turcica
Nasion	Anterior point of the intersection between the nasal and frontal bones
Orbitale	The lowest point on the inferior margin of the orbit
Porion	Midpoint of the upper contour of the external auditory canal
Point A	The innermost point on the contour of the premaxilla between anterior nasal spine and the incisor
Prosthion	The point of the maxillary alveolar process in the midline that projects most anteriorly
ANS	Point on the anterior tip of the bony process of maxilla
PNS	The tip of the posterior spine of the palatine bone, at the junction of the hard and soft palate
Gonion	Midpoint of the contour connecting the ramus and body of the mandible.
Menton	The most inferior point on the mandibular symphysis
Point A1	A point 3 mm labial to the point between the apical one-third and the coronal two-thirds of the root of central incisor.
Point A2	Point where a line parallel to and 7 mm below the palatal plane intersects the anterior margin of the maxilla.
Point A3	a point 7mm below palatal plane projected perpendicular from point prosthion

Table 2: Angular and Linear Measurements

Name	Definition
Angular Measurements	
SNA	Position of Point A to the anterior cranial base in the sagittal plane
SNA1	Position of Point A1 to the anterior cranial base in the sagittal plane
SNA2	Position of Point A2 to the anterior cranial base in the sagittal plane
SNA3	Position of Point A3 to the anterior cranial base in the sagittal plane
MMA	Inclination of maxillary and mandibular plane to each other - shows growth pattern
Linear Measurements	
NA (Figure 5)	Vertical distance between Nasion and the projection of Point A on the Nasion-perpendicular line
NA1	Vertical distance between Nasion and the projection of Point A1 on the Nasion-perpendicular line
NA2	Vertical distance between Nasion and the projection of Point A2 on the Nasion-perpendicular line
NA3	Vertical distance between Nasion and the projection of Point A3 on the Nasion-perpendicular line

The angles SNA1, SNA2, and SNA3 were compared with SNA to detect the reliability in the horizontal plane. The vertical distances NA1, NA2, and NA3 were compared with NA to check for reliability in the vertical plane (Figure 5). To eliminate any error in measurement, 30 subjects were selected at random and their measurements were obtained after 1 week by the principal investigator.

STATISTICAL ANALYSIS

All the statistical tests applied on the data set were conducted using SPSS version 26. Descriptive statistics were calculated for the sample as a whole in the vertical and horizontal planes. The mean, standard deviation, and 95% confidence interval of angles SNA, SNA1, SNA2, and SNA3 were calculated for all three groups. Similar calculations were done for linear variables NA, NA1, NA2, and NA3 for all three groups. The data was found to be normally distributed. Therefore, the Pearson correlation coefficient was applied and any statistically significant correlation between Point A and all three alternate points was observed in both vertical and horizontal planes. Comparison of means of vertical and horizontal parameters according to all three growth patterns was done using one-way ANOVA. The level of significance was set at $P<0.05$.

RESULTS

Descriptive statistics of the sample as a whole in the vertical and horizontal planes were calculated. The maximum mean value in the sample was observed for SNA3 (86.22±5.10) in the horizontal plane and NA1(61.24±5.10) in the vertical plane. In the horizontal plane, SNA2 (82.85) showed a minimum difference in mean and SNA3 (86.22) showed a maximum difference in mean from the mean value of SNA (82.64). In the vertical plane, NA3 (59.15), closely followed by NA2 (59.17), showed a minimum difference in mean and NA1 (61.24) showed a maximum difference in mean from the mean value of NA (57.50). This is shown in Table 3.

For all three groups, the descriptive statistics of angles SNA, SNA1, SNA2, and SNA3 as well as for linear variables NA, NA1, NA2, and NA3 are displayed in Table 4.

The analysis in the horizontal plane shows that the highest value of mean was observed for SNA3 (group 1 -

Table 3: Descriptive Statistics for the entire sample

Measurements	Mean	Standard Deviation
Horizontal parameters		
SNA	82.64	4.46
SNA1	81.45	4.76
SNA2	82.85	4.49
SNA3	86.22	5.10
Vertical parameters		
NA	57.50	4.79
NA1	61.24	5.10
NA2	59.17	4.33
NA3	59.15	4.47

Table 4: Descriptive statistics for hypodivergent, normodivergent and hyperdivergent subjects

Measurements	Hypodivergent-Group 1	Normodivergent-Group 2	Hyperdivergent-Group 3
n	25	63	33
Horizontal parameters			
SNA	83.20±3.97	82.83±4.63	81.85±4.49
SNA1	82.20±3.84	81.49±5.09	80.79±4.78
SNA2	83.28±3.96	83.08±4.63	82.09±4.62
SNA3	86.92±3.93	86.25±5.33	85.64±5.49
Vertical parameters			
NA	58.48±3.92	56.86±4.48	57.97±5.81
NA1	61.80±4.46	60.29±4.95	62.64±5.57
NA2	60.52±4.03	58.56±4.23	59.30±4.61
NA3	60.52±4.27	58.60±4.38	59.15±4.70

Table 5: Pearson correlation for all the variables in different groups

Hypodivergent - Group 1				
Horizontal parameters		SNA1	SNA2	SNA3
	Pearson correlation	.919**	.992**	.892**
	Significant (two-tailed)	.000	.000	.000
Vertical parameters		NA1	NA2	NA3
	Pearson correlation	.849**	.949**	.945**
	Significant (two-tailed)	.000	.000	.000
Normodivergent - Group 2				
Horizontal parameters		SNA1	SNA2	SNA3
	Pearson correlation	.884**	.977**	.919**
	Significant (two-tailed)	.000	.000	.000
Vertical parameters		NA1	NA2	NA3
	Pearson correlation	.806**	.950**	.946**
	Significant (two-tailed)	.000	.000	.000
Hyperdivergent - Group 3				
Horizontal parameters		SNA1	SNA2	SNA3
	Pearson correlation	.966**	.978**	.924**
	Significant (two-tailed)	.000	.000	.000
Vertical parameters		NA1	NA2	NA3
	Pearson correlation	.926**	.921**	.928**
	Significant (two-tailed)	.000	.000	.000

86.92 ± 3.93) (group 2 - 86.25 ± 5.33) (group 3 - 85.64 ± 5.49) followed by SNA2 (group 1 - 83.28 ± 3.96) (group 2 - 83.08 ± 4.63) (group 3 - 82.09 ± 4.62), SNA (group 1 - 83.20 ± 3.97) (group 2 - 82.83 ± 4.63) (group 3 - 81.85 ± 4.49) and SNA1 (group 1 - 82.20 ± 3.84) (group 2 - 81.49 ± 5.09) (group 3 - 80.79 ± 4.78).

The analysis in the vertical plane shows that the highest value of mean was observed for NA1 in all three groups (group 1 - 61.80 ± 4.46) (group 2 - 60.29 ± 4.95) (group 3 - 62.64 ± 5.57). NA2 and NA3 were observed to have equal means in Group 1 (NA2 - 60.52 ± 4.03) (NA3 - 60.52 ±

Table 6: ANOVA for vertical and horizontal parameters in different growth patterns

			Sum of Squares	df	Mean Square	F	Sig.
Vertical parameters	NA1	Between Groups	129.556	2	64.778	2.558	.082
		Within Groups	2988.494	118	25.326		
		Total	3118.050	120			
	NA2	Between Groups	69.929	2	34.964	1.894	.155
		Within Groups	2178.765	118	18.464		
		Total	2248.694	120			
	NA3	Between Groups	65.761	2	32.880	1.663	.194
		Within Groups	2333.562	118	19.776		
		Total	2399.322	120			
Horizontal parameters	SNA1	Between Groups	28.640	2	14.320	.628	.535
		Within Groups	2689.261	118	22.790		
		Total	2717.901	120			
	SNA2	Between Groups	26.952	2	13.476	.666	.516
		Within Groups	2388.370	118	20.240		
		Total	2415.322	120			
	SNA3	Between Groups	23.562	2	11.781	.449	.639
		Within Groups	3097.413	118	26.249		
		Total	3120.975	120			

4.27), Group 2 (NA2 - 58.56 ± 4.23) (NA3 - 58.60 ± 4.38) and Group 3 (NA2 - 59.30 ± 4.61) (NA3 - 59.15 ± 4.70). The lowest values were observed for NA in all three groups (group 1 - 58.48 ± 3.92) (group 2 - 56.86 ± 4.48) (group 3 - 57.97 ± 5.81).

Pearson correlation coefficient, as shown in Table 5, indicates a highly significant positive correlation between SNA and SNA1, SNA2, and SNA3. Also, it indicates a highly significant positive correlation between NA and NA1, NA2 and NA3. Furthermore, SNA2 shows the highest correlation coefficient in all three groups (Group 1 - .992), (Group 2 - .977) and (Group 3 - .978). Also, NA2 shows the highest correlation coefficient in Group 1 (.949) and Group 2 (.950). However, NA3 shows the highest correlation coefficient in Group 3 (.928).

Comparison of means of vertical and horizontal parameters according to all three growth patterns was done using one-way ANOVA (Table 6). This shows a non-significant difference between the vertical parameters as well as the horizontal parameters for all groups.

DISCUSSION

Point A is a key landmark for cephalometric diagnosis in orthodontic patients. However, lateral cephalograms are two-dimensional representations of three-dimensional structures and the superimposition of nearby structures may make identifying this landmark challenging in certain individuals. As a result, it is crucial to develop reliable alternative points for Point A.

Several factors are a source of variation in Point A directly, or indirectly through the ANB angle. Erverdi et al.[14] conducted research showing that a change in incisor inclination alters the location of Point A, which was later advocated by subsequent researchers.[19-22] Studies conducted, thereafter, were directed toward determining the reliability of the alternate points in patients with different incisor inclinations.[17,23]

Palatal plane inclination differs in hypo-, normo- and hyperdivergent subjects.[24] Since both use the palatal plane as a reference, this may serve to affect the reliability of Points A2 and A3 in certain growth patterns. Moreover, subjects exhibit dental proclination due to the neuromuscular forces involved.[25,26] This may affect the reliability of Point A3 which uses prosthion as a reference. However, growth patterns have never been the focus of any prior research in relation to the reliability of Point A alternates. Therefore our study is directed to finding the reliability of alternate points in different growth patterns.

Evaluation of The Horizontal Parameters

In our study, A2 was found to be the most reliable in the horizontal plane. This is dictated by the minimum mean difference between SNA and SNA2. Also, SNA2 shows the highest correlation coefficient with SNA. A3 was shown to be the least reliable in the horizontal plane, with the maximum mean difference between SNA3 and SNA. This may be due to the fact that the construction of Point A3 requires the use of a point prosthion, which is the most anterior bony point on the alveolar bone between the maxillary central incisor. Therefore, it may be subject to change with a difference in incisor inclination and may give us an inaccurate estimate of the position of Point A.

Evaluation of The Vertical Parameters

Points A2 and A3 were found to be more reliable compared to A1 in the vertical plane. NA2 and NA3 showed minimum mean differences and the highest correlation coefficient with NA. On the contrary, NA1 showed the maximum mean difference and the weakest correlation with NA. This may be a consequence of choosing the length of the maxillary central incisor root. Any changes in the length of the root may affect the accuracy of Point A1.

Changes in incisor inclination affect the horizontal parameters since they occur in the anteroposterior plane. Furthermore, changes in the root length of the maxillary central incisor are in the vertical plane, which alters the vertical parameters. Therefore, Point A1 is unreliable in the vertical plane while Point A3 is unreliable in the horizontal plane. Point A2 is neither affected by incisor inclination nor the length of the maxillary central incisor root and is therefore found to be the most reliable alternate to Point A. However, the anterior contour of the maxilla should be sufficiently visible to trace for the Point A2 to be accurate. In cases where the anterior contour of the maxilla is incomprehensible, Point A1 can be used for the sagittal analysis. This can be done by forming the NA1 line, a close estimate of the NA line, that can give us a clearer picture of the sagittal discrepancy.[23]

Comparison between Different Growth Patterns

Our study also revealed that the reliability of these three alternate points does not differ significantly with a difference in growth patterns. This applies to the vertical and horizontal parameters alike. For the analysis in the horizontal plane, Point A2 was the most reliable in all three groups, followed by A1 in groups 1 and 3 but A3 in group 2. This may be due to the fact that a change in the growth pattern is usually accompanied by dental compensations and may affect the Prosthion point for A3, except in normodivergent subjects. In the vertical plane, Point A2 was the most reliable alternate point in groups 1 and 2, whereas, Point A3 was found to have the strongest correlation with A in group 3. This may be due to a change in the palatal plane inclination in group 3 i.e. hyperdivergent subjects. Since pint A2 and A3 both require the palatal plane for reference, their reliability may be influenced by palatal plane inclination. Further studies with a greater number of subjects for each growth pattern need to be conducted to unveil the influence of growth patterns on the reliability of Point A alternates.

CONCLUSION

1. Point A2 was found to be the most reliable and Point A3 was found to be the least reliable alternative to Point A in horizontal and vertical planes for sagittal analysis of the maxilla.
2. Point A1 can be used instead of Point A2 if the anterior contour of the maxilla is not clear enough to identify Point A2.
3. Differences in growth patterns did not significantly affect the reliability of these points in vertical or horizontal planes.

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CONFLICT OF INTEREST

None to declare

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