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International Journal of Current Research
Vol. 10, Issue, 01, pp.64690-64695, January, 2018

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

A COMPARATIVE CEPHALOMETRIC STUDY TO ASSESS THE RELIABILITY OF VARIOUS VERTICAL CEPHALOMETRIC PARAMETERS FOR ASSESSMENT OF GROWTH PATTERN

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ARTICLE INFO

Article History:
Received 26th October, 2017
Received in revised form
19th November, 2017
Accepted 04th December, 2017
Published online 31st January, 2018

Key words:
Vertical growth pattern,
Cephalometrics,
Malocclusion,
Divergence, Reliability.

ABSTRACT

Introduction: Determination of growth pattern in a vertical dimension is of utmost importance to orthodontist. Various analyses and parameters are present but they do pose shortcomings of variability even in same individual. Hence this study was aimed at determining reliability of various parameters and find which of the parameters can be used singly and which can be used in combination to aid in diagnosis and treatment planning.

Materials and methods: Cephalometric radiographs of 90 individuals were examined and comparative analysis using all ten parameters was done. Statistical analysis including mean, standard deviation, coefficient of variance were used to describe the distribution of all these parameters in the entire sample. Pearson's correlation coefficient was used to find correlation between various variables.

Results: Ramus/FHP angle showed the most homogenous distribution while as Steiner's mandibular plane angle showed most variable distribution in the entire sample. Among the linear parameters total anterior facial height showed most homogenous distribution. Also strong correlations were found between Ramus/FHP angle and basal plane angle, basal plane angle and articulare angle, basal plane angle and saddle angle.

Conclusion: Among angular variables Ramus/FHP and among linear variables total anterior facial height could be used reliably to assess the growth pattern.

Citation: Dr. Mariya Qadir, Dr. Mohammad Mushtaq and Dr. Sneh Kalgotra, 2018. "A comparative cephalometric study to assess the reliability of various vertical cephalometric parameters for assessment of growth pattern.", *International Journal of Current Research*, 10, (01), 64690-64695.

INTRODUCTION

Orthodontists always have been in a quest of searching and trying to define ideal facial appearance and proportions. Orthodontics has evolved from being merely a subject involving correction of malaligned teeth to a science seeking not only correction of malaligned teeth but achieving complete balance in underlying skeletal structures and overlying soft tissue drape. Various efforts have been made to classify malocclusions based on presenting features, underlying etiology, dimension of malocclusion. In the past much attention has been paid to classify malocclusion in anteroposterior or saggital plane (Bock, 2007). It has been realized that in order to achieve ideal treatment goals it is necessary to treat the malocclusion in all three dimensions. For that it becomes necessary to classify and define malocclusions in other two dimensions as well. Often craniofacial descrepancies present with a combination of malalignment in different dimensions (Neger, 1951). Vertical descrepancies can be assessed clinically and cephalometrically as well.Various authors have developed different methods to assess vertical relation like Tweed introduced Frankfurt mandibular plane angle (Tweed, 1946), followed by Bjork (Björk, 1947), Wylie and Johnson (Wylie, 1952), Steiner (Steiner, 1953), McNamara (McNamara, 1984), and various others (Ricketts, 1960). Craniofacial growth should be balanced in all three dimensions to have an ideal facial form (Janson, 1994). Clinically vertical excess and deficiency may present as a long face, open bite, excessive gingival display (Schendel, 1976), short face, overclosure of lips (Opdebeeck, 1978) respectively.Clinical implications of assessment of growth pattern are varied and significant.

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It determines complete diagnosis of a malocclusion, treatment planning decision like pattern of extraction, type of mechanics employed, considerations of natural compensation that might have taken place to hide the underlying discrepancy. Inability to assess the vertical discrepancy leads to faulty diagnosis, inefficient treatment planning, and an increased susceptibility to relapse (Enoki, 2004; Cook, 1994). Various authors have proposed different parameters for assessment of growth pattern in a vertical dimension but most of them have shortcomings either in terms of identification of landmarks (Paranhos *et al*., 2014), changes in position of landmarks with change in position of jaws (Paranhos *et al*., 2014), being not applicable to all the population groups (Shaikh, 2009). Few studies have compared the clinical efficiency of various vertical parameters (Maheen, 2016; Rizwan, 2011). Hence this study is aimed at assessing accuracy of various vertical parameters an understand which parameter / parameters is most reliable and can be used singly or in combination. Also a new parameter, Ramus/FHP angle introduced (Mostafa, 2012), was studied to understand its relation with growth pattern in a vertical direction.

MATERIALS AND METHODS

The study was carried out on the patients received in the Out-Patient Department of the Department of Orthodontics & Dentofacial Orthopaedics. The sample for this study consisted of 90 subjects which included 53 males and 37 females. Those subjects between the age group of 15-35 years, who did not undergo any prior orthodontic treatment and had a full complement of permanent teeth up to 2nd molars were selected for the study. It was ensured that the subjects selected had no caries or missing teeth, periodontal problem, TMJ abnormality, any associated syndrome and had not undergone any surgery. Lateral standardized cephalograms were taken by a single operator using the same X-ray device and a standardized procedure, with cephalograms being taken in Natural Head Position based on the work of Solow and Tallgren (Solow, 1971).

The cephalograms were made with the mandible in the intercuspal position with an anode to midsubject distance of 5 feet. Thyroid shield and lead apron were worn by the subject to reduce radiation exposure. The procedure was approved by the ethical committee of the institution and a written consent was obtained from each participant. Lateral cephalogram was traced upon an A4 size acetate paper with a 2B or 3HB hard lead pencil over well-illuminated viewing screen. The linear measurements were recorded with a measuring scale up to a precision of 0.5 mm. The angular measurements were analysed with a protractor up to a precision of 0.5°. The reference points, planes and angles used are shown in Figure 1. and Figure 2.:

The entire sample was divided into three groups namely

- Normodivergent (falling within mean and standard deviation)
- Hypodivergent (falling below mean and standard deviation)
- Hyperdivergent (falling above mean and standard deviation)
- using all the parameters to rule out any bias due to sample grouping.

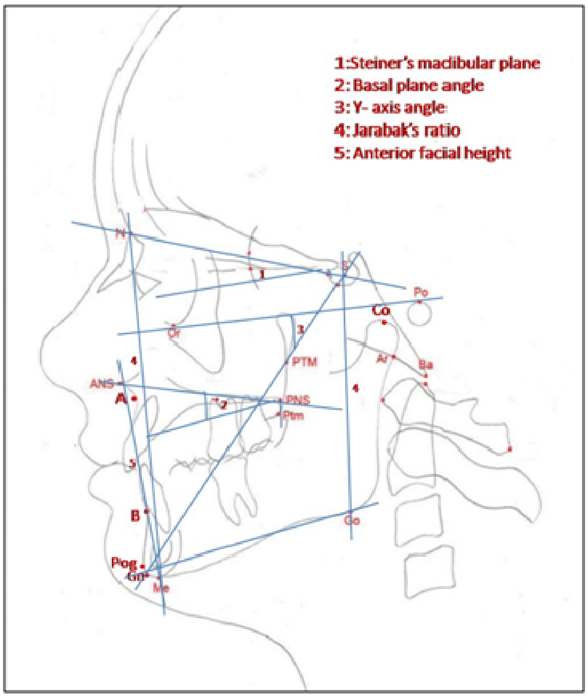

Figure 1. Shows diagrammatic representation of Steiner's mandibular plane angle, basal plane angle, Y- axis angle, Jarabak's ratio and anterior facial height

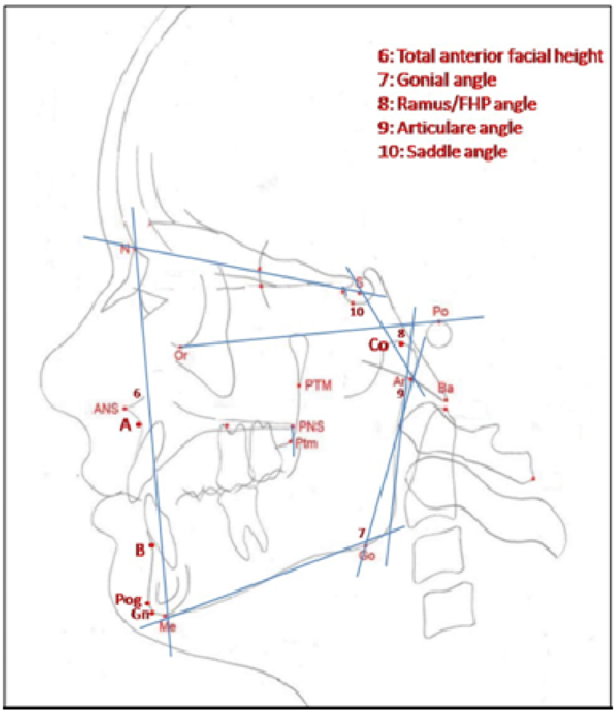

Figure 2. Figure 2 shows diagrammatic representation of total anterior facial height, gonial angle, Ramus/FHP angle, articulare angle and saddle angle.

Following parameters were measured in this study:

Statistical analysis

The data of the study was subjected to descriptive tests and mean, standard deviation,and coefficient of variation for each measurement were calculated using SPSS. Correlation in different vertical jaw parameters was studied to see for their interchangeability.

RESULTS

In order to analyze the data, within the entire sample, class strata of were Steiner's mandibular plane angle, basal plane angle, Y-axis angle, Jarabak's ratio, lower anterior facial height, total anterior facial height, gonial angle, Ramus/FHP angle, articulare angle and saddle angle were defined. The assessments of vertical jaw relationship, by ten methods of analyses, showed the differences in distribution of cases in each skeletal group as shown in Table 2:

Measurement with least homogenous distribution was the Steiner's mandibular plane angle (CV=18.79). The results showed that there was statistically significant and highly correlated relationship between parameters used in the study for assessment of vertical jaw relationship as shown in table 4. The correlation was very strong between basal plane angle and gonial angle (r=0.995), basal plane angle and articulare angle (r=0.995), basal plane angle and saddle angle (r=0.995). Moreover, strong correlations existed between basal plane angle and Ramus-FHP angle (r=0.994), Steiners mandibular plane angle and articulare angle (r=0.993), Steiner's mandibular plane angle and saddle angle (r= 0.992). Lowest significant positive correlation was present between lower anterior facial height and Jarabak's ratio (r= 0.051), lower anterior facial height and Y- axis angle (r= 0.143), saddle angle and total anterior facial height (r= 0.263) as shown in Table 4. When angular and linear parameters were compared, high significant positive correlation was found between total anterior facial height and Y-axis (r= 0.981). Among linear parameters total anterior facial height and Jarabak's ratio (r= 0.981), showed a strong correlation.

Table 1. Parameters used in study

S.no.	Parameter	Formation
1.	Steiner's Mandibular plane angle (^{0})	Angle between SN plane and Go-Gn
2.	Basal plane angle (^{0})	Angle between maxillary and mandibular plane
3.	Y-axis angle (^{0})	Angle between S-Gn and FH plane
4.	Jarabak's ratio	Ratio between posterior facial height(S-Go) and anterior facial height(N-Me)
5.	Lower anterior facial height (^{0})	Linear distance between ANS and Me
6.	Total anterior facial height (mm)	Linear distance between N and Me
7.	Gonial angle (^{0})	Angle between Ar-Go line and Go-Me line
8.	Ramus-FHP angle (^{0})	Angle between tangent to posterior border of ramus and Frankfurt Horizontal plane
9.	Articulare angle (^{0})	Angle between S-Ar line and Ar-Go line
10.	Cranial base angle (^{0})	Angle between N-S line and S-Ar line

*Cephalometric parameters consisting of angles and linear measurements.The angular measurements were measured in degrees and linear measurements in millimetres.

Table 2. Comparison of assessments of sagittal jaw relationship by all method of analysis

Comparison of assessments of vertical jaw relationship			
Parameter	No. of cases in each skeletal category		
	Normodivergent	Hypodivergent	Hyperdivergent
Steiner's Mandibular plane angle	42	25	23
Basal plane angle	40	29	21
Y-axis angle	15	32	43
Jarabak's ratio	50	24	16
Lower anterior facial height	32	36	22
Total anterior facial height	35	36	19
Gonial angle	25	24	41
Ramus-FHP angle	40	18	32
Articulare angle	37	22	31
Cranial base angle	34	15	41

*Comparative distribution of all the ten parameters in the entire sample, which itself was divided into three classes (Hypodivergent, Normodivergent, Hyperdivergent) based on the mean values of all the parameters.

Table 3. Descriptive statistics of pooled group

	Mean	SD	CV (%)
Steiner's Mandibular plane angle	32.14	6.04	18.79
Basal plane angle	25.03	2.03	8.11
Y-axis angle	62.04	4.90	7.89
Jarabak's ratio	63.01	4.80	7.61
Lower anterior facial height	63.54	5.41	8.51
Total anterior facial height	117.32	5.80	4.94
Gonial angle	124.33	5.77	4.64
Ramus-FHP angle	94.55	3.22	3.40
Articulare angle	140.80	6.78	4.81
Saddle angle	120.22	4.79	3.98

*Assessment of variability of each parameter in entire sample statistically using Cofficient of variance. Coefficient of variance was expressed in percentage.

As it can be seen on table 2, parameters like Steiner's mandibular plane angle, Jarabak's ratio, basal plane angle showed the greatest percentage in normodivergent group among all ten indicators of the vertical skeletal relationship, total anterior facial height, lower anterior facial height showed greatest percentage in hypodivergent group while as Y- axis angle showed showed the greatest percentage in hyperdivergent group. As it can be observed from table 3, the angular measurements with most homogenous distribution in the group were Ramus-FHP angle (CV=3.40) followed by saddle angle and gonial angle. In linear measurements, most homogenously distributed parameter was TAFH (CV=4.94).

Table 4. Correlation matrix for Steiner's MPA, Basal plane angle, Y-axis angle, Jarabak's ratio, LAFH, TAFH, Gonial angle, Ramus/FHP angle, Articulare angle and saddle angle (r- correlation coefficient; p- value).

CORRELATION MATRIX

		Steiner,s MPA	Basal plane angle	Y-axis angle	Jarabak's ratio	LAFH	TAFH	Gonial angle	Ramus-FHP angle	Articulare angle	Saddle angle
Steiner's MPA	r										
	P-value										
Basal plane angle	r	0.658									
	P-value	<0.001									
Y-axis angle	r	0.938	0.973								
	P-value	<0.001	<0.001								
Jarabak's ratio (%)	r	0.942	0.975	0.994							
	P-value	<0.001	<0.001	0.184							
LAFH	r	0.939	0.972	0.143	0.051						
	P-value	<0.001	<0.001	0.052	0.4878						
TAFH	r	0.990	0.994	0.981	0.981	0.978					
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001					
Gonial angle	r	0.991	0.995	0.985	0.985	0.983	0.518				
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				
Ramus-FHP angle	r	0.988	0.994	0.968	0.968	0.961	0.924	0.954			
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Articulare angle	r	0.993	0.995	0.988	0.988	0.987	0.880	0.794	0.974		
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Saddle angle	r	0.992	0.995	0.986	0.986	0.984	0.263	0.361	0.952	0.868	
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	

Statistically Significant Correlation(P-value<0.001).Pearson correlation: weak correlation (± 0.01 < r < ± 0.5); moderate correlation (± 0.5 < r < ± 0.8); strong correlation (± 0.8 < r < ± 1)

DISCUSSION

It is essential to assess craniofacial skeletal pattern in all three dimensions as it is pivotal in orthodontic diagnosis and treatment planning. For that various facial and cephalometric analyses were presented way back in the past (Angle, 1899; Broadbent, 1931; Ricketts, 1957). The pattern of facial skeleton in a vertical dimension is highly significant as it determines the types of orthodontic mechanics employed as well as difference in treatment prognosis (Ricketts, 1957). Tweed has defined the relation between vertical skeletal pattern (FMA), and stability of mandibular incisors (Kharbanda *et al*., 1991). Vertical growth is last to cease and hence its pattern determination can also help in prevention of relapse. Different methods have been used to assess the vertical pattern of the patient in different cephalometric analysis and a lot hetereogenity existed between these values even in a single individual making interpretation and diagnosis difficult (Tweed, 1946; Ioi *et al*., 2007; Bock, 2007). Also different parameters have been designed to find out contribution of different parts to vertical malocclusion making the diagnosis still more difficult. Hence this study was aimed to ease the process of diagnosis by assessing which parameters can be used singly or in combination and accurately assess the malocclusion. The mean value of Steiner's mandibular plane angle (32.14^0) in present study is similar when compared to Steiner's original value (32°) (McNamara, 1984). According to this study Steiner's mandibular plane angle is highly variable and is not a reliable parameter to assess the growth pattern. This may be due to variable position of Gnathion (Gn) which is dependant on spatial position of chin. Y-axis was observed to be quite variable which is in agreement with a study conducted by Paranhos *et al*. (2014), in which they reported that Y-axis was inadequate to assess vertical dysplasia, as the position of Gnathion (Gn) varies with sagittal malocclusion.Inaequacy of Y-axis was also observed in another study conducted by Schudy (Schudy, 1964). Basal plane angle showed a high variance in the present study.

This is due to the fact that palatal plane and mandibular plane are subjected to different inclinations depending upon growth and dentoalveolar compensation (Asad, 2009). Linear values like lower anterior facial height and total anterior facial height do not show much variability. Wylie and Johnson (1952) stressed on using the linear measurements in assessing the sagittal and vertical jaws relations as angle can only assess the relative position of the three (or four) points which establish the lines that structure the angle. The vertical relation is better measured by the sum of posterior angles and the Jarabak ratio with less variability as is in agreement with other studies (Asad, 2009).

The new parameter Ramus/FHP angle showed least variability, showing that ramal angulation was a very reliable factor in assessment of malocclusion in a vertical dimension. This is in accordance with a study conducted by Mostafa *et al*. (2012). According to the same study it was observed that the gonial angle highly represents the mandibular plane rotation, more than the mandibular plane angle. This was evident by correlating ramus/Frankfort horizontal angle with both the gonial and mandibular plane angles, and a positive correlation was found only with the gonial angle. Correlation between various skeletal parameters has already been reported in the literature (Asad, 2009; Bahrou, 2014). Present study showed a significant correlation between all skeletal variables except Jarabak's ratio and lower anterior facial height. This is in agreement with other studies (Asad, 2009). Over the last 50 years, many cephalometric parameters have been proposed to describe jaw relationships, and the conjunctive use of different parameters has been recommended for the assessment of the jaw discrepancy in individual patients. Clinicians with increasing frequency are treating malocclusions in conjunction with orthognathic surgery. A method of maxillomandibular assessment that provides accurate data on this relationship at an early age would be highly desirable.

Conclusion

- There was a statistically significant and high correlation between basal plane angle, Ramus/FHP angle, gonial angle, articulare angle and saddle angle, used for assessment of vertical jaw relationship.
- Angular methods used for assessing jaw relationship such as Ramus/FHP, saddle angle, gonial angle, and linear measurements such as total anterior facial height followed by Jarabak's ratio could demonstrate superiority for assessing vertical jaw relationship over other methods such as Steiner's mandibular plane angle, lower anterior facial height which showed more variability.
- The Ramus/FHP, saddle angle, gonial angle are a diagnostic tool to evaluate the vertical jaw relationship more consistently.
- Based on the obtained results, it can be concluded that Ramus/FHP, saddle angle, gonial angle, total anterior facial height can be used one instead of another for the assessment of vertical skeletal relationship, while as lower anterior facial height, Y axis, Steiner's mandibular plane angle should be used in combination with other indicators of this relationship for a more realistic diagnosis.
- Ramu/FHP was found to be least variable indicating that it was the most homogeneously distributed parameter (CV=3.40) and is more accurate in vertical jaw relationship when compared with other angular and linear measurements and among linear parameters total anterior facial height was more reliable.
- No single measurement is perfect in all the cases. A combination of different measurements should be used to have a true assessment of vertical jaw relationship.

Limitations and future directions

Ramus/FHP angle is a new parameter and further studies assessing its relationship with various skeletal patterns need to be assessed. Evaluating skeletal pattern using a two dimensional technique like cephalometry may pose certain limitations in this study (Kusnoto *et al*., 2015; Park *et al*., 2015). CBCT is a better method of evaluating jaw relationships but do share added disadvantage of a higher radiation dose (Huerta, 2015; Navarro, 2013).

Conflicts of interest: None

Acknowledgements: None

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