PHOTOGRAPHIC ASSESSMENT OF CEPHALOMETRIC MEASUREMENTS IN SKELETAL CLASS I SUBJECTS : A COMPARATIVE STUDY

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ABSTRACT

Photographic evaluation is a very close representation of the appearance of the person, especially in Orthodontics. With the advent of cephalometrics, the emphasis shifted to the assessment of bony foundation of the face and positions of teeth. However, it was soon realized that the correction of hard tissues to the normal values need not always bring about an improvement in the facial appearance. The aim of this study is to investigate the relationship between craniofacial measurements obtained from cephalometric radiographs and analogous measurements from profile photographs in skeletal class I subjects. Lateral cephalograms and standardized facial profile photographs were obtained from a sample of 35 skeletal class I subjects. Angular and linear measurements were done using FACAD Software at Saveetha Dental College , Chennai. Statistical tests were done using SPSS Software. The statistical tests done were Pearson's correlation test and linear regression . On comparing the angular and linear cephalometric and photographic measurements, significantly high correlation was found. The study was found to be statistically significant with P value <0.001. The FMA value showed the highest correlation. The photographic method of measuring cephalometric values has been found to be a highly significant and reliable tool, provided standardized protocol is followed. Hence, it may be considered a feasible and practical diagnostic alternative , particularly if there is a need for a low-cost and non-invasive method.

Key Words : Angular parameter, linear parameter, photographic assessment

INTRODUCTION

The outcome of an orthodontic treatment is assessed by the final improvement in facial aesthetics. The binding relationship between orthodontic treatment and facial esthetics has made the facial outline an important guideline for the treatment planning (Krishnan, Pandian and Kumar, 2018).

Accurate diagnosis is most important for orthodontic treatment outcomes and the diagnostic tools aid act as guides to accurate diagnosis. Diagnosis involves development of a comprehensive database of patient's information (Ferrario *et al.*, 1993)(Halazonetis, 2007),(Dimaggio *et al.*, 2007). The data is derived from case history, clinical examination and other diagnostic aids such as casts, radiographs and photographs. Cephalometry is considered as a gold standard in orthodontics diagnosis. However, it has many limitations of which radiation exposure is most concerning. Today, with rising concern about radiation exposure, unnecessary irradiation should be avoided as there is no threshold dose below which biologic damage can occur.

There is an increased need for alternative methods that can give equal if not better results. Importance of clinical photography in orthodontics practice is well known both for diagnosis as well as to monitor the progress in treatment. Photographic analyses are inexpensive and may help in better assessment of the harmonic relationship among the external craniofacial structures (Ferrario *et al.*, 1993)(Mehta, Sagarkar and Mathew, 2017)(Ozdemir *et al.*, 2009). It is a low cost, low technique sensitive method to assess craniofacial morphology. As the same aspects of facial appearance are related to the morphology of the underlying hard tissues, standardized facial photography might be a useful tool for characterizing craniofacial anatomy (Ferrario *et al.*, 1993).

Historically facial photography has been part of both pretreatment and post-treatment records. The use of photography for diagnosis and treatment plan has been emphasized by many authors. Graber states that the photograph assumes even greater importance when dentists didn't even have equipment for taking cephalograms. He considered photography as an essential tool in orthodontics. Photographic analyses are inexpensive and do not expose patients to potentially harmful radiation. It can be readily used to assess the posture of the head and face. Photogrammetry , which involves measurements directly from photographs , was described as a useful technique despite landmark location errors caused by variable magnifications of the image from projection distortion lens shape (Moorrees and Kean, 1958). Previously our team had conducted numerous clinical trials (Kamisetty, 2015; Krishnan, Pandian and Kumar S, 2015; Viswanath *et al.*, 2015; Sivamurthy and Sundari, 2016; Felicita and Sumathi Felicita, 2017; Samantha *et al.*, 2017; Vikram *et al.*, 2017) , lab animal studies(Ramesh Kumar *et al.*, 2011; Jain, Kumar and Manjula, 2014; Rubika, Sumathi Felicita and Sivambiga, 2015; Felicita, 2017; Krishnan, Pandian and Kumar, 2018) and in - vitro studies(Felicita, Chandrasekar and Shantha sundari, 2012; Dinesh *et al.*, 2013; Felicita, 2018) over the past 5 years. The desire to reduce exposure of patients to radiation has led us to the current study. This study investigates the relationship between craniofacial measurements obtained from cephalometric radiographs and analogous measurements from standardized facial profile photographs of selected class 1 subjects so as to ascertain if photographs can replace radiographs as a diagnostic tool.

MATERIAL AND METHODOLOGY

In this cross-sectional study , a total of 35 cephalograms and profile photographs of subjects exhibiting class I skeletal malocclusion was selected . These subjects reported to the Department of Orthodontics in Saveetha Dental College , Chennai , Tamil Nadu between June'19 to March '20. Their data were retrieved from the patient record provided by the university.

Selection criteria included subjects between the age group of 20-45 years who exhibited skeletal Class I patterns (ANB >4°) , with all permanent teeth up to second molars. They had no history of orthodontic treatment or orthognathic surgery. Subjects with history of craniofacial trauma, congenital anomalies, neurological disturbance, pathological migration and mutilated cases were excluded from the study.

Both digital photographic and radiographic records were analyzed with FACAD software (Fig.1). Traditional cephalometric angular and linear measurements and analogous photographic ones were used for this study. The angular measurements used were – Frankfort horizontal – mandibular plane angle (FMA), ANB angle, facial angle(FPA), Gonial angle and convexity angle,. The linear measurements used were - Anterior facial height (AFH),Posterior facial height(PFH) and Lower Anterior facial height (LAFH). Statistical analysis was done using SPSS software. Pearson's correlation test and linear regression test was done to compare the angular and linear measurements made on the lateral cephalogram and profile photograph of the subjects.

RESULTS AND DISCUSSION

. Table-1 shows the descriptive statistical tests showing the mean, standard deviation and significance of the study results. Pearson's correlation showed significantly high correlation between angular and linear measurements between the two techniques. Among the angular measurements , FMA (0.953) showed the highest correlation between photographic and cephalometric methods. This was followed by facial angle (0.698), gonial angle (0.51) and ANB angle(0.465). Least correlation was found in convexity angles (0.287), which was found to be not significant (p = 0.095) [Table 2]. Among the linear measurements the highest correlation was found in anterior facial height (AFH),(0.81) followed by LAFH (0.74) and PFH (0.574). [Table 2]. The linear equation for the statistically significant correlations was graphed. (Figures 2-9).

The purpose of this study was to acquire average parameters that could define the soft-tissue facial profile of the given subjects. As the profile varies according to the malocclusion, the present study used only Skeletal Class I participants to avoid confusions due to variations in the magnitude of measurements between subjects. The characteristics of the soft-tissue profile are affected by many factors, including ethnicity (Krishnan, Pandian and Kumar, 2018). This study is a theoretical one and is based on well-known mathematical and physical formulae.

Cephalometric analysis constitutes the current goal standard for diagnosing skeletal craniofacial morphology in orthodontics clinical practice. There are various cephalometric parameters to evaluate growth patterns. However, the photographic assessment is a great diagnostic tool for epidemiologic studies as it is cost effective and doesn’t expose the patient to potentially harmful radiation (Ferrario *et al.*, 1993; Halazonetis, 2007). The standardized photographic technique has several advantages, even though direct anthropometry is another practical alternative for craniofacial morphology diagnosis. Because the subjects do not move, it is easier to take measurements, there are no skin pressure related errors, and the period of interaction with the subject is potentially shorter (Gomes *et al.*, 2013). Also, measurements can be performed repeatedly and the data stored permanently, which makes longitudinal follow- ups feasible (Ozdemir *et al.*, 2009)(Han *et al.*, 2010) .

The medical profession has reused its metal instruments since the very beginning. To take a cephalogram there is a minor risk of infection or cross-contamination, which may linger in the minds of patient’s as well as the clinician. This is completely eliminated in case of Photography. Conversely the photographic techniques also have some shortcomings , such as distortion from the distance between lens and the subject, which causes objects near the camera to appear layer than those from it (Bishara, Jorgensen and Jakobsen, 1995a; Han *et al.*, 2010). However, this factor is only critical when attempted to compare structures located in different planes of space. Most landmarks obtained from lateral photographs in the current study are at the midline, so this issue should minimally affect the measurements (Bishara, Jorgensen and Jakobsen, 1995b). Also, the angular measurements used mostly overcome the problems of magnification.

On comparing the angular cephalometric and photographic variables for the skeletal Class I subject it was found that FMA, ANB, FPA, convexity and gonial angles have good corelation with the analogous photographic measurements ($p<0.001$).The FMA angle showed highest correlation followed by facial angle and gonial angle. This is similar to the study by Pooja Mehta et al (Mehta, Sagarkar and Mathew, 2017), where angular measurements had a good relationship when compared between cephalometric and photographic variables (Mehta, Sagarkar and Mathew, 2017). Also according to Rosas Gomes et al (Gomes *et al.*, 2013), the FMA’ and ANB’ were photographic variables that best explained the variability of the analogies cephalometric measurement. This was the same result obtained by Pogulwar S et al(Pogulwar *et al.*, 2014).

On comparing the linear cephalometric and photographic variables for Skeletal Class I subjects, it was found that there was a high correlation of cephalometric parameters like AFH, PFH and LAFH with the analogous photographic measurements (P<0.001).

Though cephalogram provide us with accurate measurements, their major disadvantage is the exposure of patients to radiation. Within the results we can conclude the photographs can be used as an alternative to cephalograms. The limitations of this study was that the sample size was small. Also the study focuses only on Skeletal class I subjects. Further research in this field is needed to prove the importance of photographs.

CONCLUSION

The photographic material of measuring analogues cephalometric variables are found to have high correlation in angular and linear variables . Hence , photographs can be used as an alternative to cephalograms according to this study.

AUTHOR CONTRIBUTIONS

All authors have equally contributed.

CONFLICT OF INTEREST

No conflict of interest.

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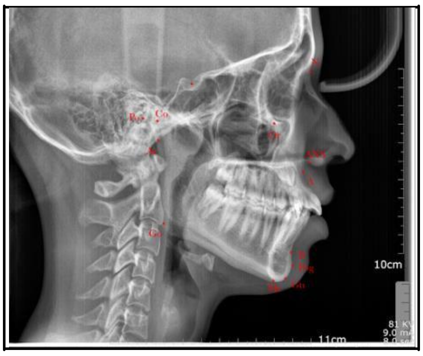

(A) **(B)**

Figure. 1. (A) Cephalometric points on lateral cephalogram (B) Analogous points on profile photograph

Table. 1. Descriptive statistics for Cephalometric and Facial photographic measurements

	Mean	**Std. Dv**	**Min**	**Max**
CEPHALOMETRIC MEASUREMENTS				
FMA	25.58	4.74069	15.9	33.5
ANB	2.65	1.66315	0.1	5.4
FPA	88.09	3.41183	82.7	93.8
Gonial Angle	125.61	5.55088	116	134
Convexity	3.65	2.04110	1.1	7.8
AFH	108.3	15.24318	70.8	130.1
PFH	51.98	7.28569	34.5	67.4
LAFH	60.02	9.41392	37.3	73.7
PHOTOGRAPHIC MEASUREMENTS				
FMA'	26.05	4.88740	17.1	36
ANB'	6.49	1.64316	3.1	9.8
FPA'	90.61	2.36122	86.7	97.3
Gonial Angle'	124.73	5.03428	117.9	134.6
Convexity'	13.66	3.05210	5.5	19.2
AFH'	122.11	20.75075	77	158.7
PFH'	55.14	8.08150	36.6	64.7
LAFH'	64.79	11.98446	39.3	89.7

*Std Dv indicates standard deviation; Min, minimum; Max, Maximum

Table. 2. Pearson’s Correlation test between Cephalometric and Facial photographic measurements

	Pearson’s Correlation (r)	**Sig. (2-tailed)**
ANGULAR MEASUREMENTS		
FMA-FMA'	.933	.000

ANB-ANB'	.465	.000
FPA-FPA`	.698	.000
Gonial angle- Gonial angle'	.510	.002
Convexity- Convexity'	.287	.095
LINEAR MEASUREMENTS		
AFH-AFH'	.810	.000
PFH-PFH'	.574	.000
LAFH-LAFH'	.740	.000

*****FMA indicates Frankfort-Mandibular plane angle; FPA, Facial Plane angle;AFH, Anterior Facial Height; PFH, Posterior Facial Height; LAFH, Lower Anterior Facial Height

*Sig, Significance

It has been inferred that there is a positive correlation between angular measurements in cephalogram and facial photograph which is statistically significant ($p<0.05$), except for convexity angle which is not statistically significant ($p=0.095$). Among the angular measurements, it was observed that FMA angle in a cephalogram has the highest correlation ($r=0.933$) to its analogous photographic measurement. Also , there is a positive correlation between linear measurements in cephalogram and facial photograph which is statistically significant ($p<0.05$). Among the linear measurements, anterior facial height (AFH) in cephalogram had the highest correlation ($r=0.810$) to its analogous photographic measurement.

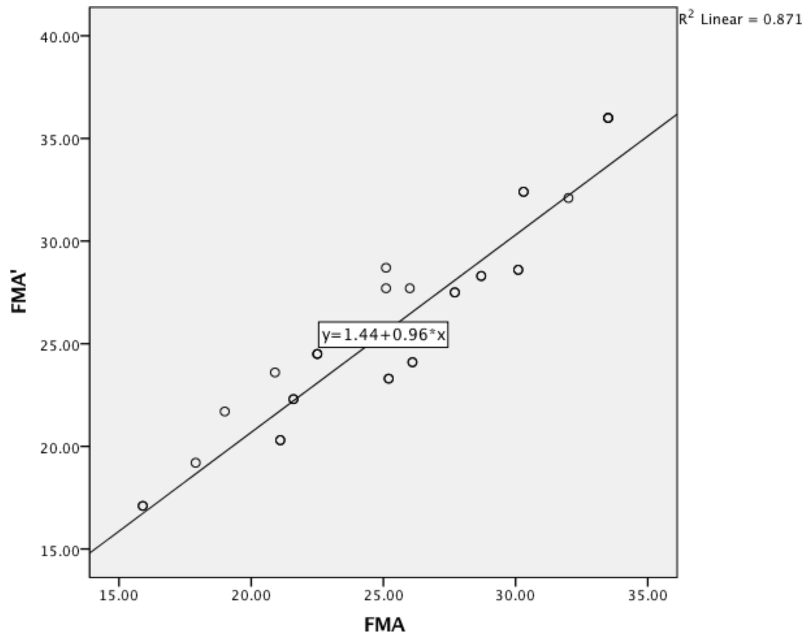

Figure. 2. Scatter plot of correlation between FMA angle in Cephalogram and Facial photograph. The X-axis represents the FMA angle in a cephalogram . The Y-axis represents the FMA angle in Facial photographs (FMA'). Pearson's correlation test was done to assess the correlation between cephalometric and photographic measurements ; r= .933, p value = 0.00. Linear regression equation , FMA' = 1.44+ 0.96 x FMA.

There is a positive correlation between FMA angle in cephalogram and facial photograph which is statistically significant. Hence, it can be inferred that FMA angle can be deduced from facial photograph

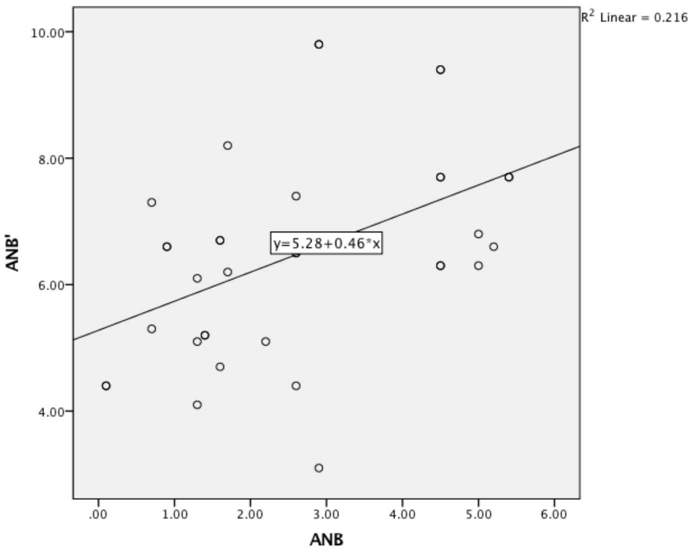

Figure. 3. Scatter plot of correlation between ANB angle in Cephalogram and Facial photograph. The X-axis represents the ANB angle in a cephalogram . The Y-axis represents the ANB angle in Facial photographs (ANB'). Pearson's correlation test was done to assess the correlation between cephalometric and photographic measurements ; r = 0.465 , p= 0.00. Linear regression equation, ANB'=5.28+ 0.46 x ANB.

There is a positive correlation between ANB angle in cephalogram and facial photograph which is statistically significant($p<0.05$). Hence, it can be inferred that ANB angle can be deduced from facial photographs.

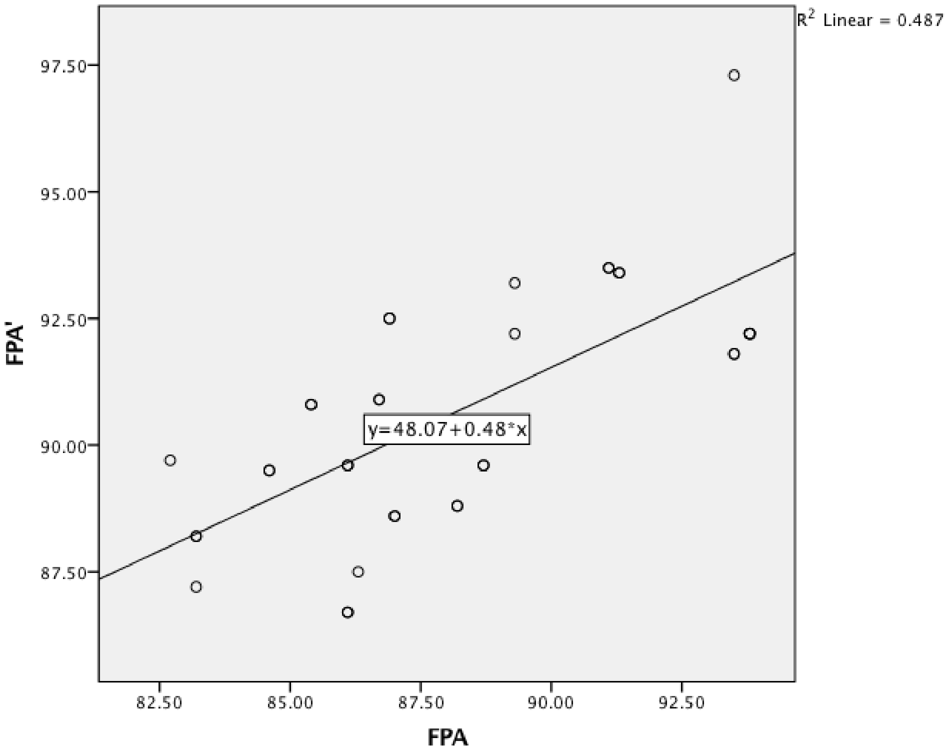

Figure. 4. Scatter plot of correlation between Facial plane angle in Cephalogram and Facial photograph. The X-axis represents the FPA angle in a cephalogram . The Y-axis represents the FPA angle in Facial photographs (FPA'). Pearson's correlation test was done to assess the correlation between cephalometric and photographic measurements ; r = 0.698, p= .000 . Linear regression equation, FPA'= 48.07+0.48 x FPA.

There is a positive correlation between FPA angle in cephalogram and facial photograph which is statistically significant($p<0.05$). Hence, it can be inferred that FPA angle can be deduced from facial photographs.

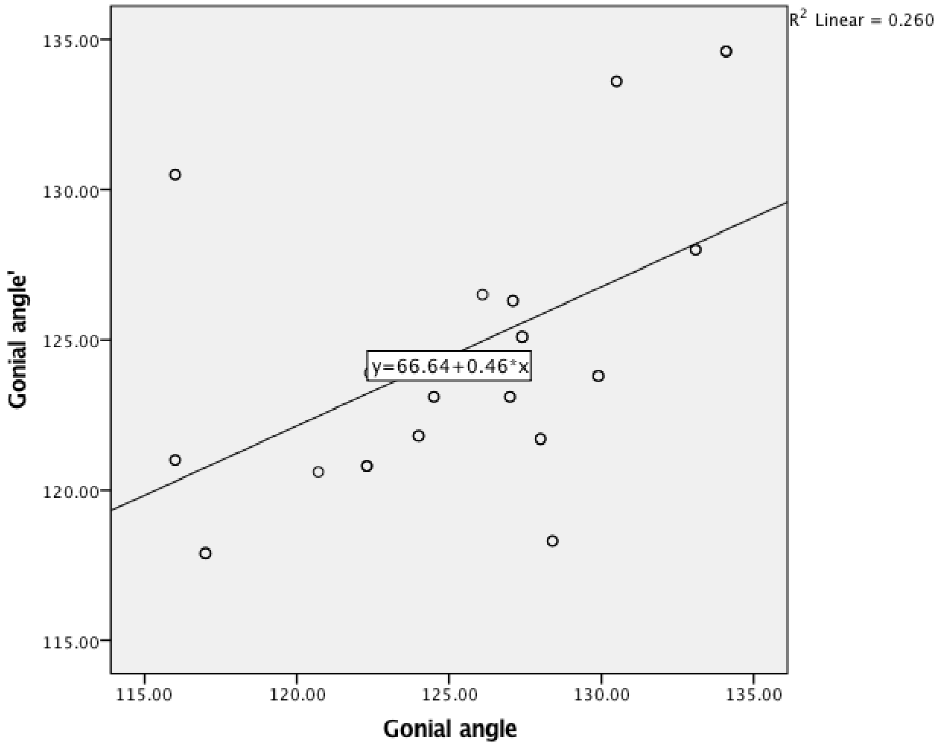

Figure. 5. Scatter plot of correlation between Gonial angle in Cephalogram and Facial photograph. The X-axis represents the Gonial angle in a cephalogram . The Y-axis represents the gonial angle in Facial photographs (Gonial angle'). Pearson's correlation test was done to assess the correlation between cephalometric and photographic measurements ; $r = 0.51$, $p=0.002$. Linear regression equation, Gonial angle'= 66.64+ 0.46 x Gonial angle

There is a positive correlation between Gonial angle in cephalogram and facial photograph which is statistically significant($p<0.05$). Hence, it can be inferred that Gonial angle can be deduced from facial photographs.

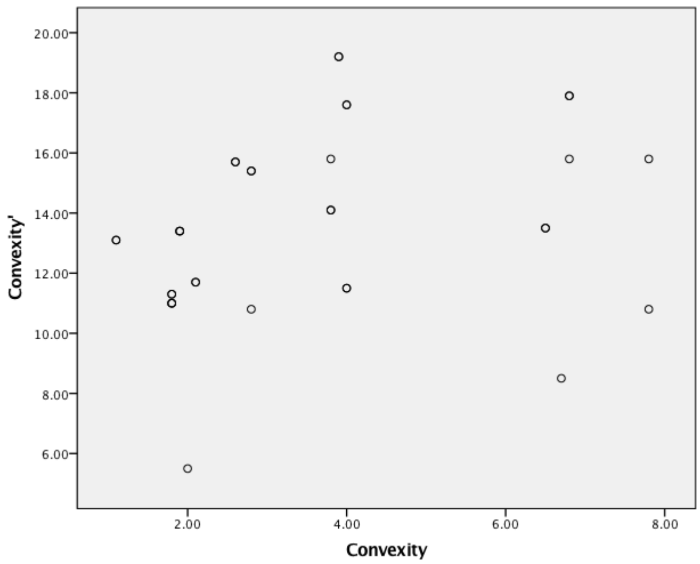

Figure . 6. Scatter plot of correlation between convexity angle in Cephalogram and Facial photograph. The X-axis represents the convexity angle in a cephalogram . The Y-axis represents the convexity angle in Facial photographs (Convexity'). Pearson's correlation test was done to assess the correlation between cephalometric and photographic measurements ; r = 0.287, p= 0.095 . There is a positive correlation between convexity angle in cephalogram and facial photograph which is not statistically significant (p>0.05).

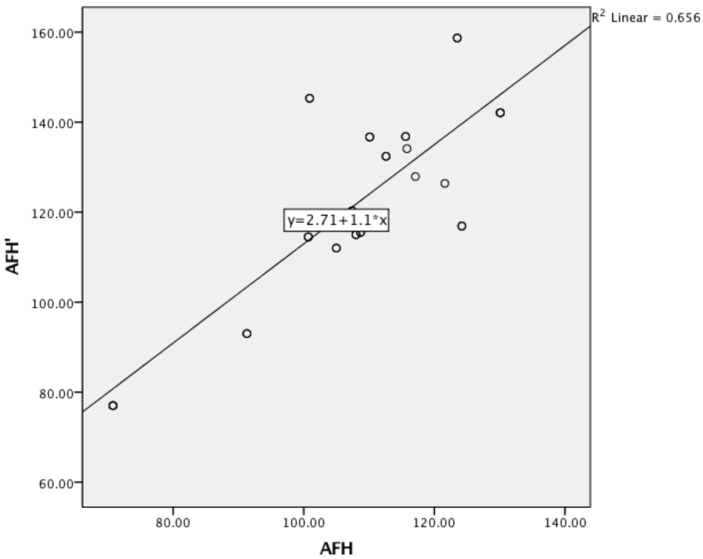

Figure . 7. Scatter plot of correlation between Anterior Facial Height (AFH) in Cephalogram and Facial photograph. The X-axis represents the AFH in a cephalogram . The Y-axis represents the AFH in Facial photographs (AFH'). Pearson's correlation test was done to assess the correlation between cephalometric and photographic measurements ; r = 0.81, p=0.00 . Linear regression equation, AFH'=2.71 +1.1 x AFH There is a positive correlation between AFH in cephalogram and facial photograph which is statistically significant(p<0.05). Hence, it can be inferred that AFH can be deduced from facial photographs.

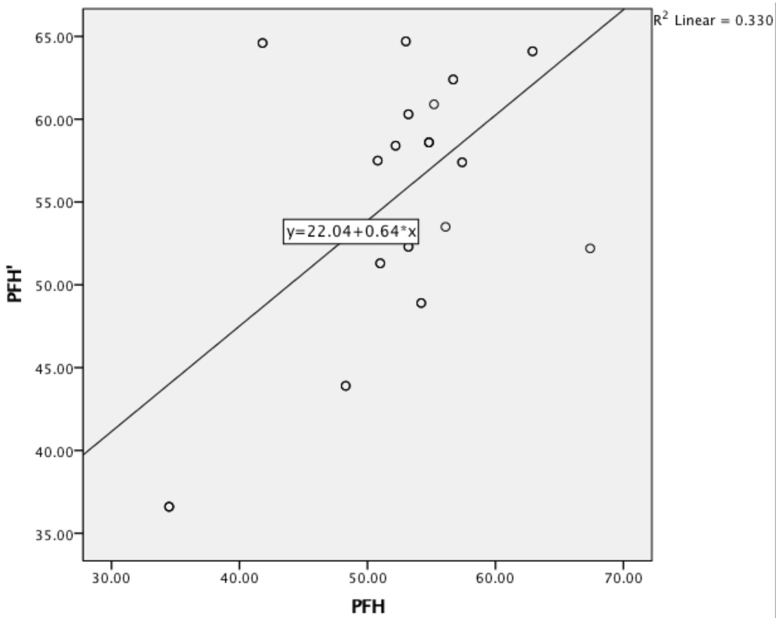

Figure. 8. Scatter plot of correlation between Posterior Facial Height (PFH) in Cephalogram and Facial photograph. The X-axis represents the PFH in a cephalogram . The Y-axis represents the PFH in Facial photographs (PFH'). Pearson's correlation test was done to assess the correlation between cephalometric and photographic measurements ; r = 0.574 , p=0.000 . Linear regression equation, PFH'= 22.04 + 0.64 x PFH.

There is a positive correlation between PFH in cephalogram and facial photograph which is statistically significant(p<0.05). Hence, it can be inferred that PFH can be deduced from facial photographs.

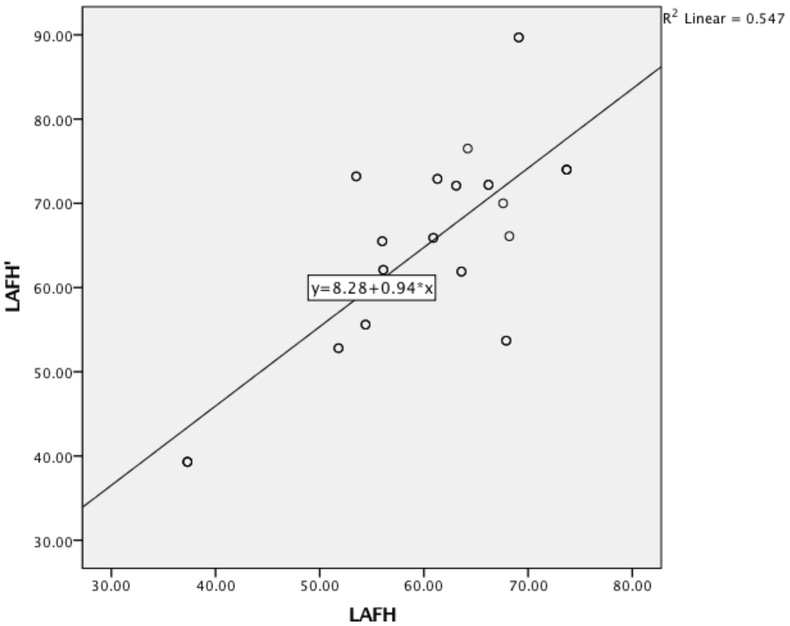

Figure. 9. Scatter plot of correlation between Lower Anterior Facial Height (LAFH) in Cephalogram and Facial photograph. The X-axis represents the PFH in a cephalogram . The Y-axis represents the LAFH in Facial photographs (LAFH'). Pearson's correlation test was done to assess the correlation between cephalometric and photographic measurements ; r= 0.740 , p=0.000. Linear regression equation, LAFH'= 8.28 + 0.94 x LAFH.

There is a positive correlation between L66AFH in cephalogram and facial photograph which is statistically significant($p<0.05$). Hence, it can be inferred that LAFH can be deduced from facial photographs.