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Photographic & Cephalometric Analysis of Craniofacial Structures in Indian Population - A Correlative Study

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ABSTRACT

Background- Radiographic cephalometrics and photographic systems are the most suitable and therefore the most commonly used. Not only can they provide points and landmarks for measurements, but they can also offer an analytical and complete evaluation of the unique craniofacial aspect of the person who is being investigated.

Materials and method- Standardized right profile photographs of subjects were taken in the Natural Head Position (NHP), with maximum intercuspation and lips at rest. Digital Lateral skull radiographs were taken with CS 8100 (Carestream Dental). The exposure parameters for the digital cephalographs are 74kV, 8mA and 10secs. The radiographic and photographic measurements was analysed with Digimizer (Medcalc Software, version – 4.6.1.0) image analysis software for windows. The software calculated all the measurements once all the landmarks were properly identified on each record that had been previously scaled to life size.

Result- A'N'B' shows the greatest correlation to its analogous cephalometric measurement ANB (r = 0.65) in sagittal assessment and in vertical assessment FMA' shows the greatest correlation (r = 0.67). Lowest coefficients were obtained for A'-B' Perp(r = 0.33) in saggital assessment and AFH'(r = 0.37) in vertical assessment.In linear regression analysis where A'N'B(r^2 = 0.67) and FMA'(r^2 = 0.68) shows the best results. Lower values were obtained in A'-B' Perp(r^2 = 0.17) and AFH'(r^2 = 0.22).

Conclusion- photographic analysis could be used as an alternative when cephalograms cannot be obtained due to lack of availability of equipment concerns with radiation exposure and in analysis of large number of samples in epidemiological studies

1. INTRODUCTION

Cephalometrics, after being introduced by Broadbent in 1931, provides important diagnostic information about the relationship between skeletal and dental structures.[1] Unnecessary irradiation of patients may be avoided, since there is no threshold dose below which biologic damage does not occur.[2]

In addition to cephalometric radiographs, soft tissue evaluation has been carried out by means of different methods such as anthropometry, two- or three dimensional photogrammetry and three-dimensional imaging techniques. Among these methods, two-dimensional photogrammetry has the advantage of being a basic, noninvasive, cost-effective, and quick method that requires minimal time and equipment in the assessment of soft tissue.[3]

The evaluation of craniofacial morphology is an indispensable tool in clinical practice and in research, and can be achieved with different approaches.[4] Radiographic cephalometrics and photographic systems are the most suitable and therefore the most commonly used. Not only can they provide points and landmarks for measurements, but they can also offer an analytical and complete evaluation of the unique craniofacial aspect of the person who is being investigated.[5,6]

Photographic analyses are inexpensive, do not expose the patient to potentially harmful radiation, and could provide better evaluation of the harmonic relationships among external craniofacial structures, including the contribution of muscles and adipose tissue. However, the lack of morphologic balance among different skeletal components can often be masked by compensatory soft tissue contributions.[7,8]

Furthermore, because the patients are not accustomed to viewing and interpreting cephalograms or their tracings, presentation of the information to the patient in a meaningful manner is challenging. Photographs, on the other hand, provide a more conventional documentation of the soft tissues of the face, and most facial-plastic surgeons work primarily from photographs, and various soft tissue facial analyses based on standardized diagnostic photographs have been described.[9-11]

As cephalometric analysis constitutes the gold standard for diagnosing craniofacial morphology in clinical practice, the possibility of predicting cephalometric values through photographs may be relevant as a non-invasive diagnostic tool, especially for epidemiologic research.[12,13] This study aimed to investigate the relationship between craniofacial measurements obtained from cephalometric radiographs and analogous measurements from standardized facial profile photographs.

2. MATERIALS AND METHOD

The study was conducted in the Department Of Orthodontics and Dentofacial Orthopaedics, Kothiwal Dental College & Research Centre, Moradabad. (Uttar Pradesh).The sample size of 150 was selected on a random basis from the outpatient department of Kothiwal Dental College & Research Centre.

Eligibility Criteria of subjects / sample:

Inclusion Criteria:

1. Subjects were in the age group (range) of 18 - 28 years.
2. Subjects comprised of both gender.
3. No previous orthodontic or surgical treatment.
4. All 6 Maxillary anterior teeth present.

Exclusion Criteria:

1. Presence of any craniofacial syndrome.
2. Presence of any Congenital Anomalies.
3. Presence of any Neurological Disturbances

Methodology:

Photographic Procedure:

Standardized right profile photographs of subjects were taken in the Natural Head Position (NHP), with maximum intercuspation and lips at rest. Dots with permanent marker were placed on anatomic landmarks obtained by palpation. A protractor, placed on the tip of the nose and the soft tissue pogonion, and a plumb line recorded the NHP angle.[5]

A Digital Camera (Cannon EOS 200 D, Cannon, Tokyo, Japan) mounted with the same lens and flash, was used for all photographic records. The camera was used in its manual position to achieve maximum image quality according to the local lighting condition. A 15 cm vertical scale was adapted in a plumb line, to indicate the True Vertical (VER). The scale was positioned in the midsagittal plane to allow later measurements at life size (1:1).[5]

Radiographic Procedure:

Digital Lateral skull radiographs were taken with CS 8100 (Carestream Dental). The exposure parameters for the digital cephalographs are 74kV, 8mA and 10secs. Cephalometric Radiographs were taken in NHP with maximum intercuspation and lips at rest. A chain with 100gm weight hung at its end was suspended infront of the patient, in the midsagittal plane to register the VER. A protractor, modified with a plumb line[8] was placed at the tip of the nose and the soft tissue pogonion to check if the same position achieved during photographic record has also been obtained during radiographic record to eliminate the possibility of cephalostat interference while achieving NHP.[5]

Photographic measurements to be considered for evaluation:

A) Sagittal assessment:

(1) Wits', soft tissue maxillomandibular linear discrepancy[5];

Linear distance A'-B' obtained after the transfer of FH'OP' angle to the photograph held in maximum intercuspation.

(2) A'-B' perp, soft tissue maxillomandibular linear discrepancy[5];

Linear distance between perpendiculars dropped from Point A & Point B to Frankfurt horizontal plane.

(3) A'N'B', soft tissue maxillomandibular angular discrepancy[5];

Angle formed between Soft tissue Point A – Nasion – Point B.

(4) FNP', soft tissue facial angle[5];

Angle formed between line formed by soft tissue Nasion & Pogonion with Frankfurt horizontal plane.

(5) N'-Sn-Pog'[5];

Angle formed between soft tissue Nasion - Subnasale - Pogonion..

(6) N'-Sn-B', soft tissue angle of facial convexity[5];

Angle formed between soft tissue Nasion - Subnasale – Point B.

(B) Vertical assessment:

(7) Tr-Go'-Me', soft tissue gonial angle[5]; Angle formed between soft tissue Tragion - Gonion - Menton.

(8) FMA', soft tissue Frankfurt to mandibular plane angle[5]; Angle formed between soft tissue Frankfurt Horizontal Plane - Mandibular Plane.

(9) OPA', soft tissue Frankfurt to occlusal plane angle[5]; Angle formed between soft tissue Frankfurt Horizontal Plane - Occlusal Plane.

(10) AFH' (N'-Me'), soft tissue anterior facial height[5]; Linear distance between soft tissue Nasion to Menton.

(11) LAFH' (Sn-Me'), soft tissue lower anterior facial height[5]; Linear distance between soft tissue Subnasale to Menton.

(12) PFH' (Tr-Go'), soft tissue posterior facial height.[4], Linear distance between soft tissue Tragion & Gonion.

Cephalometric measurements to be considered for evaluation[5]:

A) Sagittal assessment:

(1) Wits, maxillomandibular linear discrepancy;

Linear distance between perpendiculars dropped from Point A & Point B to Occlusal Plane.

(2) ANB, maxillomandibular angular discrepancy; Angle formed between Point A - Nasion - Point B.

(3) FNP, facial angle; Angle formed between line formed by Nasion & Pogonion with Frankfurt horizontal plane.

(4) N-ANS-Pog; Angle formed between Nasion - Anterior Nasal Spine - Pogonion

(5) N-ANS-B, angle of facial convexity; Angle formed between Nasion - Anterior Nasal Spine - Point B

B) Vertical assessment:

(6) Ar-Go-Me, gonial angle; Angle formed between Articulare - Gonion - Menton.

(7) FMA, Frankfurt to mandibular plane angle; Angle formed between Frankfurt Horizontal Plane - Mandibular Plane.

(8) OPA, Frankfurt to occlusal plane angle; Angle formed between Frankfurt Horizontal Plane - Occlusal Plane.

(9) AFH (N-Me), anterior facial height; Linear distance between Nasion to Menton.

(10) LAFH (ANS-Me), lower anterior facial height; Linear distance between Anterior Nasal Spine to Menton.

(11) PFH (S-Go), posterior facial height; Linear distance between Sella to Gonion.

(12) LPFH (Ar-Go), lower posterior facial height. Linear distance between Articulare to Gonion.

Computerized Assessment

The radiographic and photographic measurements was analysed with Digimizer (Medcalc Software, version – 4.6.1.0) image analysis software for windows. The software calculated all the measurements once all the landmarks were properly identified on each record that had been previously scaled to life size. Computerized analysis of facial morphology through radiographs and photographs was performed by the same operator.

3. STATISTICAL ANALYSIS

Descriptive statistics were given for each photographic and cephalometric variable.

Data were summarized as Mean ± SD (standard deviation). Cephalometric measurements were compared with analogous photographic to assess Pearson correlation coefficients.Linear regression analyses were made between cephalometric (dependent variable to be estimated) and photographic (independent variable) measurements that achieved correlation coefficients greater than r = 0.7. Levels of P < 0.05 were considered statistically significant.

Statistical significance

Level of significance "p" is the probability signifies level of significance. The mentioned p in the text indicates the following:

p > 0.05 Not significant(ns)

p <0.05 Just significant(*)

p <0.01 Moderate significant(**)

p <0.001Highly significant(***)

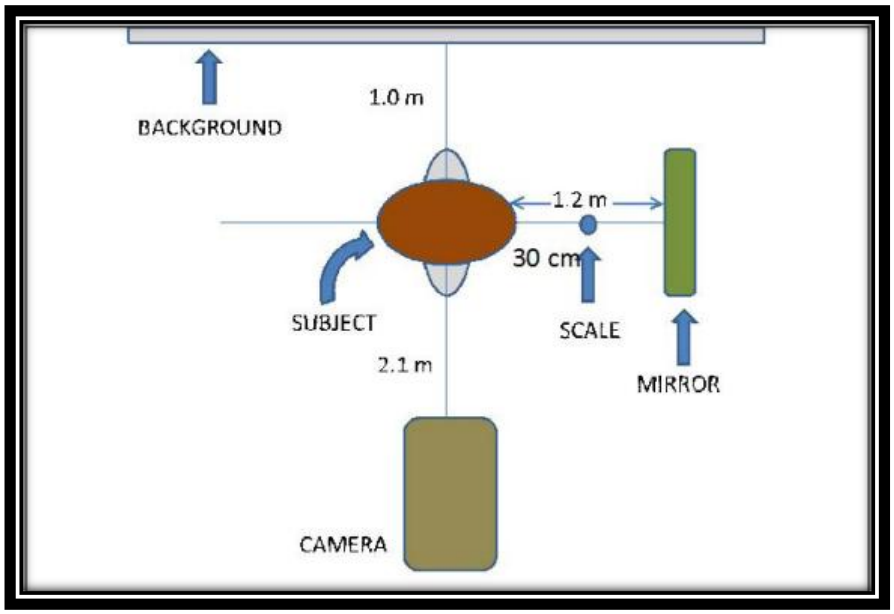


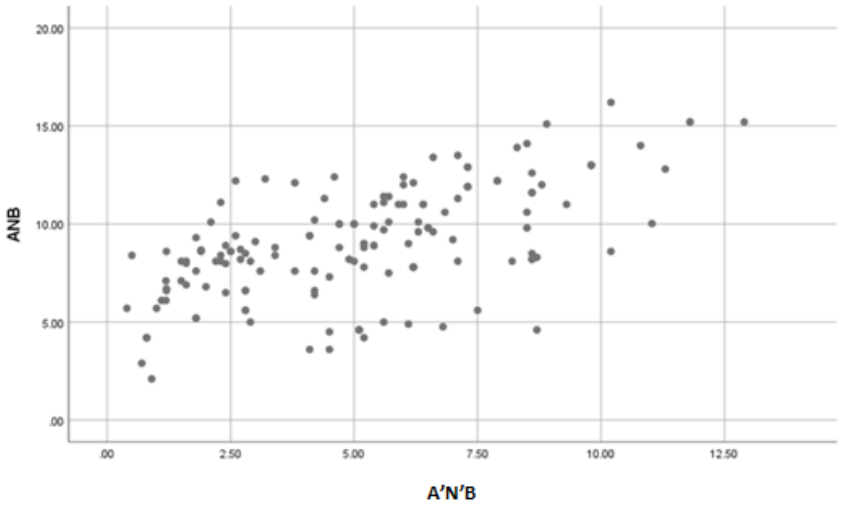
Fig 1 - Photographic Setup

4. RESULT

Descriptive statistics of cephalometric measurements. In sagittal assessment mean value of Wits is 2.96 ± 2.15. Mean value of ANB is 5.56 ± 2.75. Mean value of FNP is 85.20 ± 4.89. Mean value of N-ANS-Pog is 165.64 ± 7.92. Mean value of N-ANS-B is 161.34 ± 7.23. Mean value of Ar-Go-Me is 124.12 ± 6.82. Mean value of FMA is 26.90 ± 6.48. Mean value of OPA is 10.60 ± 5.08. Mean value of LAFH is 62.01 ± 7.83. Mean value of AFH is 109.79± 7.39. Mean value of PFH is 71.443 ± 6.29. Mean value of LPFH s 44.33 ± 4.38.(Table 1)

Table 1 – Descriptive Statistics of Cephalometric Measurements

	N	Minimum	Maximum	Mean	Std. Deviation
Wits	150	.00	9.60	2.96	2.15232
ANB	150	.40	12.90	5.56	2.75722
FNP	150	60.60	94.40	85.2099	4.8866
N-ANS-PoG	150	149.60	179.60	165.637	7.92923
N-ANS-B	150	146.00	176.70	162.34	7.23442
Ar-Go-Me	150	102.60	142.70	124.122	6.82832
FMA	150	8.90	50.10	26.9063	6.48075
OPA	150	1.20	25.30	10.6099	5.08119
LAFH	150	6.30	78.20	62.0091	7.83933
AFH	150	94.60	150.00	109.7996	7.39932
PFH	150	58.40	90.50	71.4633	6.29292
LPFH	150	34.50	67.10	44.3335	4.38333

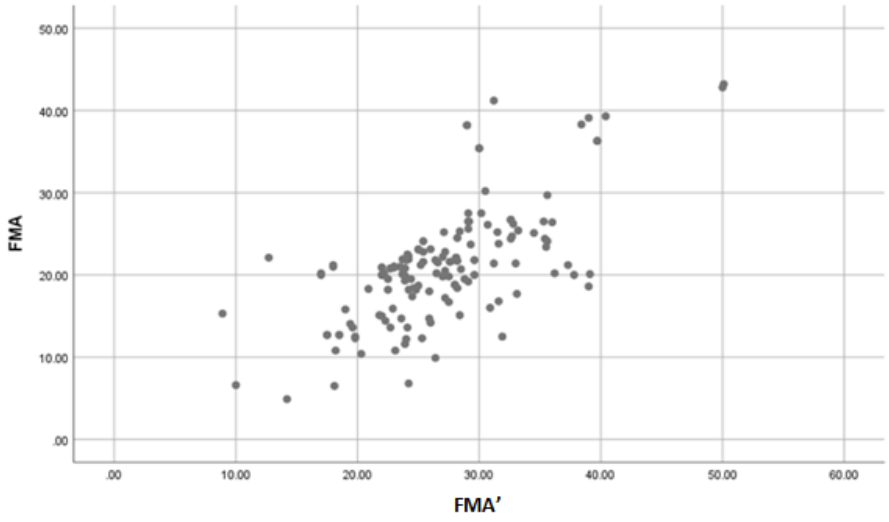


Graph 1 - Scatterplot illustrating linear regression results between cephalometric and photographic measurements ANB vs A'N'B' showing positive correlation as the pattern of rising dots slopes from lower left to upper right

Table 2 shows Descriptive statistics of photographic measurements. In sagittal assessment mean value of Wits' is 4.39 ± 3.34. Mean value of A'-B' Perp is 9.17 ± 4.03. Mean value of ANB is 9.11 ± 2.83. Mean value of FNP is 88.62 ± 4.26. Mean value of N-ANS-Pog is 158.66 ± 5.32. Mean value of N-ANS-B is 153.86 ± 6.25. Mean value of Tr-Go'-Me' is 117.58 ± 10.32. Mean value of FMA is 21.35 ± 7.64. Mean value of OPA is 9.53 ± 6.51. Mean value of AFH is 110.12 ± 11.17. Mean value of LAFH is 66.94 ± 6.82. Mean value of PFH is 61.66 ± 8.74.

Table 2 – Descriptive Statistics of Photographicic Measurements

Descriptive Statistics for Photographic measurements All Subjects (n = 150)					
	N	Minimum	Maximum	Mean	Std. Deviation
WITS'(mm)	150	.38	17.70	4.2581	3.33613
A'-B' PERP(mm)	150	2.20	23.90	9.17	4.03072
A'N'B'	150	1.10	15.90	9.1111	2.83456
FNP'	150	77.90	100.40	88.6271	4.26424
N'-Sn-PoG'	150	144.10	176.10	158.6628	5.32562
N'-Sn-B'	150	142.30	176.30	153.8673	6.25633
Tr-Go'-Me'	150	90.84	144.10	117.5811	10.32391
FMA'	150	4.90	44.20	21.3566	7.64322
OPA'	150	1.10	27.00	9.5388	6.51327
LAFH'	150	45.10	80.30	66.9427	6.82141
AFH'	150	1.15	127.60	110.1292	11.17409
PFH'	150	41.30	85.19	61.6606	8.74317

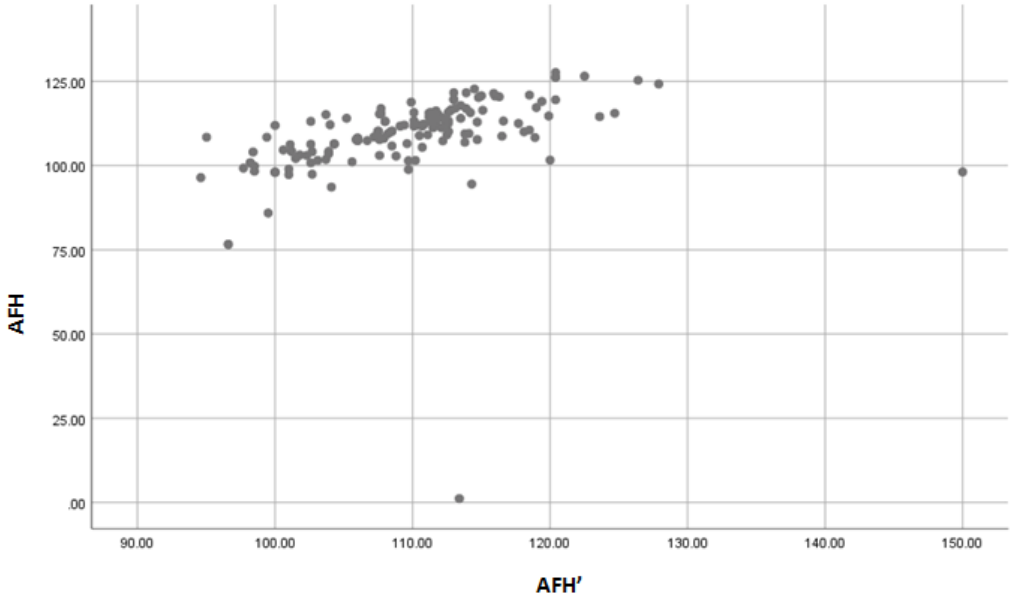


Graph 2 - Scatterplot illustrating linear regression results between cephalometric and photographic measurements FMA vs FMA'.

Table 3 shows the correlation coefficients where A'N'B' shows the greatest correlation to its analogous cephalometric measurement ANB (r = 0.65) in sagittal assessment and in vertical assessment FMA' shows the greatest correlation (r = 0.67). Lowest coefficients were obtained for A'-B' Perp(r = 0.33) in saggital assessment and AFH'(r = 0.37) in vertical assessment.

Table 3 – Correlation Coefficients between Cephalometric and Photographic Measurements

PEARSON CORRELATION COEFFICIENTS			
Measurement Parameters		All Subjects (n = 150)	
Cephalometric	Photographic	Correlation(r)	Significance
Sagittal			
Wits	Wits'	0.35	**
Wits	A'-B' Perp	0.33	**
ANB	A'N'B'	0.65	**
FNP	FNP'	0.42	**
N.ANS.Pog	N'.SN.'Pog'	0.62	**
N.ANS.B	N'.SN'.B	0.56	**
Vertical			
ArGoMe	Tr.Go'.Me'	0.62	**
FMA	FMA'	0.67	**
OPA	OPA'	0.62	**
LAFH (ANS-Me)	LAFH' (Sn-Me')	0.52	**
AFH (N-Me)	AFH' (N'-Me')	0.37	**
LPFH (Ar-Go)	PFH' (Tr-Go)'	0.39	**
PFH (S-Go)	PFH' (Tr-Go)'	0.47	**
*. Correlation is significant P≤ 0.05 **Correlation is significant P≤ 0.01			



Graph 4 - Scatterplot illustrating linear regression results between cephalometric and photographic measurements AFH vs AFH'.

Table 4 shows the linear regression analysis where A'N'B(r^2 = 0.67) and FMA'(r^2 = 0.68) shows the best results. Lower values were obtained in A'-B' Perp(r^2 = 0.17) and AFH'(r^2 = 0.22).

Table 4 – Linear Regression Analysis between Cephalometric and Photographic Measurements

Cephalometric Variables(dependent variable)	Photographic Variables(Independent variable)	Intercept Coefficient (a)	Slope Coefficient (b)	Significance	Standard Error of the Estimate	Coefficient of Determination(r^2)
Sagittal Assessment						
Wits	*Wits'*	1.733	0.421	*	1.95	0.20
Wits	*A'-B' Perp*	1.601	0.152	*	0.55	0.17
ANB	ANB'	3.313	0.91	**	1.94	0.67
FNP	FNP'	49.894	0.468	**	6.72	0.57
N.ANS.Pog	N'.Sn.Pog'	20.210	1.192	*	2.19	0.18
N.ANS.B	N'.Sn.B'	19.039	1.152	**	2.03	0.53
Vertical Assessment						
Ar.Go.Me	*Tr.Go'.Me'*	18.234	0.991	**	2.00	0.60
FMA	FMA'	2.989	0.992	**	1.18	0.68
OPA	OPA'	1.129	0.321	**	1.97	0.59

LAFH(ANS-Me)	LAFH'(Sn-Me)'	1.177	0.539	**	1.98	0.50
AFH(N-Me)	AFH'(N'-Me')	9.880	0.901	**	2.40	0.22
LPFH	PFH'	22.996	0.582	*	4.86	0.29
PFH	PFH	54.589	0.319	*	3.12	0.25

*. Correlation is significant P≤ 0.05 **Correlation is significant P≤ 0.01

5. DISCUSSION

Cephalometric analysis constitutes the current gold standard for diagnosing skeletal craniofacial morphology. Historically, facial photography has been part of both pre-treatment and post-treatment orthodontic records. The use of photography for orthodontic diagnosis and treatment planning is emphasized in many orthodontic texts. So evaluation of patient's soft tissue profile becomes one of the most important components of orthodontic diagnosis and treatment planning.[3,14]

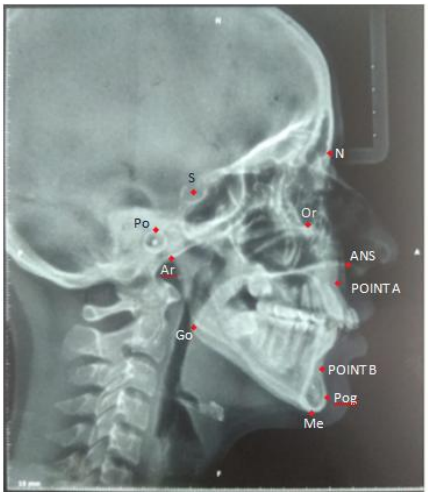


Fig 2 - Points used in Cephalometric analysis

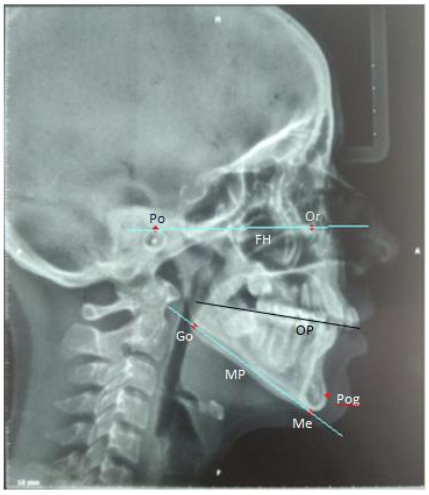


Fig 3 - Planes used in Cephalometric analysis

However, use of photogrammetry in the field of orthodontics can aid in epidemiologic studies where a quick, easy and cost effective diagnostic tool is required.[15,16] But because of its low cost, and no harmful radiation exposure, the photographic assessment is a pronounced diagnostic tool for epidemiologic studies. The standardized photographic technique has numerous advantages as the subject does not move, there are no skin pressure related errors, also it is easier to take measurements, the time needed with the patient is also lesser, also it is easier for the clinician to explain the photographs to the patient rather than a cephalogram. Additionally, measurements can be made repeatedly as well as the data can be stored permanently, making longitudinal follow-up studies possible.[17]

Fig 4 - Points used in Photographic analysis

The study was done to investigate the relationship between craniofacial measurements obtained from cephalometric radiographs and analogous measurements from profile radiographs. Similar studies were done previously by various authors.Gomes et al[18] in a sample size of 123 subjects studied the correlation between craniofacial measurements obtained from cephalometric radiographs and measurements from facial profile photographs by means of regression prediction models.

Negi et al[19] in 30 subjects compared linear measurements taken directly from subject's faces and from standardized frontal cephalometric radiographs and correlated them with standardized frontal facial photographs of Indian population.

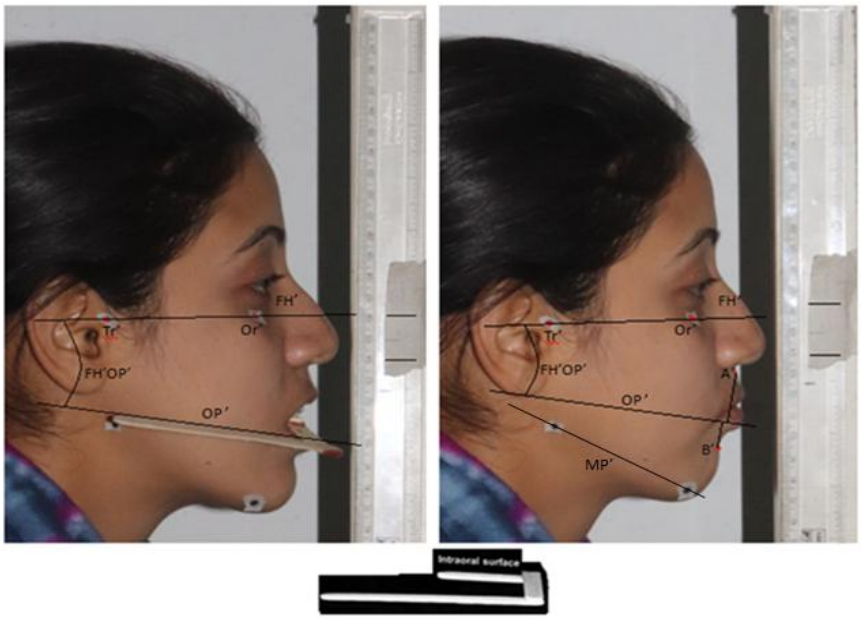


Fig 5 - Planes used in Photographic analysis

Mehta et al[20] in 30 subjects correlated the craniofacial measurements obtained from cephalometric radiographs and analogous measurements from standardized facial profile photographs in skeletal class II cases. Pogulwar et al[21] in a sample size of 25 subjects studied the correlation between cephalometric and photographic measurements.

Patel et al[22] in 60 subjects compared and correlated craniofacial measurements from cephalometric radiographs with analogous measurements from facial photographs in the Gujarati population. Banerjee et al[23] in a sample size of 30 subjects

compared photographic and cephalometric measurements in adult female bengalee population

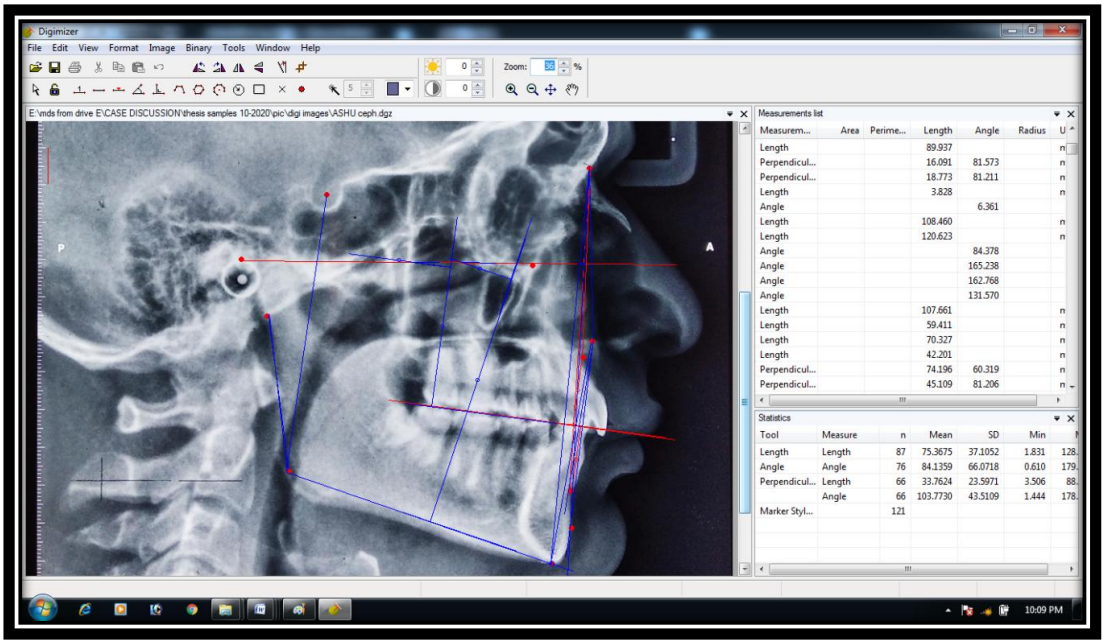


Fig 6 - Cephalometric analysis using Digimizer software

The photographic technique has some shortcomings, such as the distortion from the distance between the lens and the subject which causes objects near the camera appear larger than those farther from it. There are some disadvantages of the photographic technique as well distortion of the image due to the presence of some distance between the subject and the lens as it causes objects farther to the camera appear smaller than those closer to it.[33,56] But this factor is only critical when we are making an attempt to equate structures located in the various planes of space.[24]

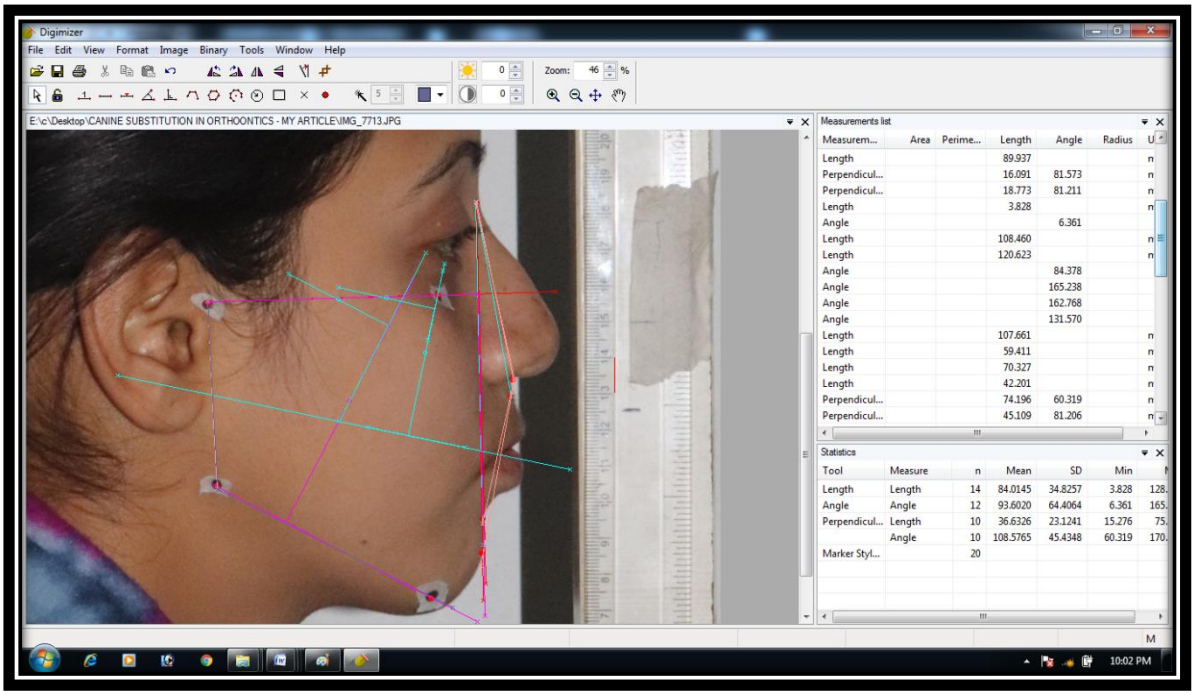


Fig 7 - Photographic analysis using Digimizer software

Most landmarks obtained from the cephalograms and photographs in the current study are at the midline, so this should not affect measurements too much.[56] Furthermore, angular variables were used more often, which partially incapacitates the difficulty of magnification. Furthermore, jaw opening or lip straining by mentalis muscle constriction may increase error.[5,25] A standardized photography protocol also includes accurate establishment of landmarks. Considering that most photographic

measurements were performed based on anatomic points achieved by palpation, hence, only one operator performed computerized analysis and picture taking to eliminate any source of error.

6. CONCLUSION

The A'N'B' and FMA' angles were the photographic variables that showed good correlation with its cephalometric measurement thus the reliability of using photographs is established.Angular measurements showed good correlation than the linear measurementsHence photographic analysis could be used as an alternative when cephalograms cannot be obtained due to lack of availability of equipment concerns with radiation exposure and in analysis of large number of samples in epidemiological studies.

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