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PHOTOGRAPHIC ASSESSMENT OF CEPHALOMETRIC MEASUREMENTS

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ABSTRACT

Objective: To investigate the relationship between craniofacial measurements obtained from cephalometric radiographs and analogous measurements from profile photographs. **Materials and Methods:** Lateral cephalograms and standardized facial profile photographs were obtained from a sample of 25 subjects. Intraclass correlation coefficients (ICCs) were calculated from repeated photographic measurements to evaluate method reliability. Analogous cephalometric and photographic measurements were compared. **Results:** The reliability of the photographic technique was satisfactory. Most measurements showed ICCs above 0.86 and highly significant correlations (P # .001) with cephalometric variables. The FMA angle showed the best results for vertical assessment (r 2 0.94). **Conclusions:** The photographic method has proven to be a repeatable and reproducible tool provided that a standardized protocol is followed. Therefore, it may be considered a feasible and practical diagnostic alternative, particularly if there is a need for a low-cost and non-invasive method.

KEYWORDS: Photographic assessment; cephalometric measurements; orthodontcs

INTRODUCTION

In orthodontics accurate diagnosis is most important for successful treatment outcomes, and diagnostic tools guide us for accurate diagnosis. Diagnosis involves development of comprehensive data base of patient's information.[1-3] The data is derived from case history, clinical examination and other diagnostic aids such as study casts, radiographs and photographs. Today diagnosis and treatment planning place great emphasis on evaluation of the function of soft tissues and their role in functional aesthetics, whereas the cephalogram has been shown to have questionable validity and reliability in the evaluations of soft tissues. The analysis of the soft tissue profile of the face was a concern for the pioneers of orthodontics such as Angle and Case at the end of 19th century and the beginning of 20th. For more than 100 years, anthropologists have measured the human face and skull.[4] It has been documented that Korbitz designed devices similar to anthropometric tools to create a diagnostic image showing the relationship of teeth in occlusion to the face.[4-7] Ruppe designed the gnathometer and Van Loon constructed gnathostatic casts. In 1922 Simon invented the gnathostatic image, based on photographs and Schwarz projected portions of gnathostatic casts to form a cephalometric - like tracing.[8] Andersen developed gnatho-physiognomical photographs that were a composite of photographs of the head and study models. In 1931, Broadbent and Hofrath introduced roentgenographic cephalometrics, which integrated craniometrics and radiography. After the standardization of the radiographic technique, the importance of the soft tissue facial analysis was downplayed and dentoskeletal relationships became the deciding factor in diagnosis and treatment planning.[9,10] Today cephalometrics still provides important diagnostic information about relationship between skeletal and dental structures. Traditional roentgenographic cephalometrics includes the analysis of sagittal, vertical and transverse skeletal and dental relationships and the soft tissue profile. Although cephalometrics is the standard for characterizing skeletal and dental craniofacial morphology in clinical practice, it might not be practical for large epidemiologic studies.[11-15] But there are certain limitations to cephalometry for example patient's who have cephalograms taken absorb small amounts of radiations, second, cephalometrics requires a radiation source and a head holder to make the technique accurate. Therefore, it would be beneficial to have a low cost, low technology technique to assess craniofacial morphology. Because, some aspects of facial appearance are related to the morphology of underlying hard tissues, standardized facial photography might be useful tool for characterizing craniofacial anatomy.[1,4] 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. Graber stated that the photograph assumes even greater importance when dentist do not have equipment for taking cephalograms, he considered photographs as essential diagnostic tool. From lateral view, facial height, facial depth, mandibular angle and the position of upper and lower lips are the main factors that characterize facial patterns.[16,17] Photographic analysis are inexpensive, do not expose the patient to potentially harmful radiation, it can be readily used to assess the posture of head and face and compare those relationships existing among different craniofacial structures. Photographs are widely used for documentation in the dental profession. The limitations of measurements recorded from photographs are similar to those of cephalogram. 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 from lens shape.[18] This study focused on the investigation of the relationship between craniofacial measurements obtained from cephalometric radiographs and analogous measurements from standardized facial profile photographs by means of regression prediction models.

MATRIALS & METHODS

1. Lateral cephalograms and standardized facial profile photographs were obtained from a sample of 25 subjects.
2. Lead Acetate paper.
3. 0.35mm pencil
4. Viewer box.

25 lateral cephalometric tracings done and measurements for FMA, PFH, AFH, LAFH and ANB (lower anterior facial height) Facial (FNP) angle were made.25 photographic (profile view) tracings done and again measurements for FMA', PFH', AFH' LAFH' and ANB' and Facial (FNP') angle were made.

THE INCLUSION CRITERIA

1. No previous orthodontic or surgical treatment.
2. All six maxillary anterior teeth present.
3. No craniofacial trauma.
4. No congenital anomalies.
5. No neurologic disturbances.

PHOTOGRAPHIC PROCEDURE

Standardized right profile photographs were taken in the natural head position (NHP), with maximum intercuspation and lips at rest. Glasses were removed and hair piled high on the head to ensure that the patient's forehead, neck, and ears were clearly visible. To obtain an NHP, a 75 × 30 cm mirror was hung on a tripod, which allowed vertical adjustments according to the subject's height. Patients were asked to keep feet slightly apart and arms relaxed and to stand a step behind a line drawn 120 cm from the mirror.[4-8] To achieve the ''orthoposition,'' patients were instructed to tilt their head up and down with decreasing amplitude until they felt relaxed, take a step forward, and keep looking straight ahead into the reflection of their eyes in the mirror (Fig. 1).[9,18]

CAMERA SPECIFICATIONS

The digital camera with NIKON D5100 With 18-55mm LENS was used for study (Fig. 2).

COMPUTERIZED ASSESSEMENT

Both digital photographic and radiographic records were analyzed with Dolphin Imaging Software. Traditional cephalometric angular and linear measurements and analogoue photographic ones were used for sagittal and vertical assessment (Fig. 3 & Fig. 4).

RESULTS

Comparison between angular & linear measument

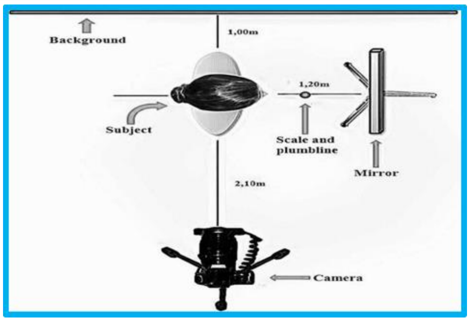

Fig. 1

Fig. 2

Fig. 3

Fig. 4

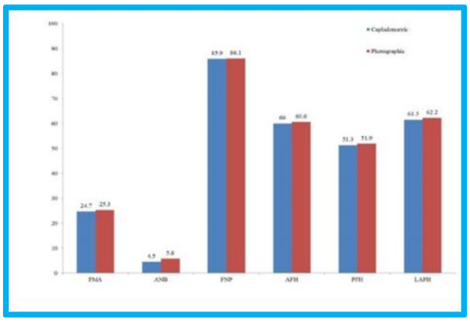

Fig. 5

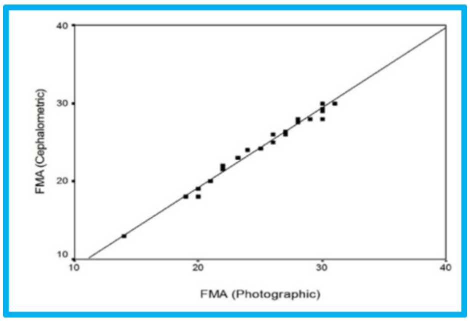

Fig. 6a: The scatter plot illustrating linear regression analysis between

measurements between two technique & correlation between cephalometric and photographic measurements are summerized in Table 1 & Table 2. Significant differences were found for three photographic variables: FMA', FNP' LAFH' (P # 0.5 to P # 1), while FNP showed higest correlation betwwen the two techniques (85.9) (Fig. 5). Values are Mean ± Standard Deviation. P-value by paired 't' test, after confirming the underlying normality assumption. P-value <0.05 is considered to be statistically significant. The average FMA and ANB differs significantly between two techniques (P-value <0.001 for both). The average FNP did not differ significantly between two techniques (P-value >0.05). The average AFH, PFH and LAFH differs significantly between two techniques (P-value <0.001 for all). Highly significant correlations (P # .001) were found for most sagittal and vertical diagnostic variables. Coefficients ranged from moderate to strong. The highest coefficients were found between FMA vs FMA' (r=0.92), FNP vs FNP'(r=0.97) and ANB vs ANB'(0.93) (Table 2, Fig. 6a - 6f). Linear regression results are listed in Table 3. Overall, the photographic variable that best explained the variability of its analogous cephalometric measurement was the A'N'B' angle (r = 0.86). Among the photographic variables used for vertical diagnosis, FMA' showed the best results

Table 1: The comparison of Angular and Linear measurements between two techniques

Measurements	Cephalometric (n=25)	Photographic (n=25)	P-value
Angular (Degrees)			
FMA	24.7 ± 4.5	25.3 ± 4.4	0.001
ANB	4.5 ± 2.1	5.8 ± 2.3	0.001
FNP	85.9 ± 3.3	86.1 ± 3.3	0.221
Linear (mm)			
AFH	60.0 ± 3.8	60.6 ± 3.8	0.001
PFH	51.3 ± 8.8	51.9 ± 8.7	0.001
LAFH	61.5 ± 5.6	62.2 ± 5.6	0.007

Table 2: Correlation coefficients between Cephalometric and Photographic Measurements

Measurement Parameters		All Subjects (n=25)	
Cephalometric	**Photographic**	**Correlation Coefficient (r)**	**P-value**
FMA	FMA’	0.992	0.001
ANB	ANB’	0.930	0.001
FNP	FNP’	0.971	0.001
AFH	AFH’	0.987	0.001
PFH	PFH’	0.999	0.001
LAFH	LAFH’	0.978	0.001

Table 3: Linear regression analysis between cephalometric and photographic measurements (n=25)

Cephalometric variable (Y)	Photographic variable (X)	Intercept (a)	Slope coefficient (b)	P-value	SE of estimate	Coefficient of determination (R^2)
FMA	FMA’	-1.198	1.021	0.001	0.590	0.983
ANB	ANB’	-0.396	0.848	0.001	0.779	0.860
FNP	FNP’	1.517	0.980	0.001	0.810	0.940
AFH	AFH’	0.353	0.985	0.001	0.632	0.973
PFH	PFH’	-0.797	1.004	0.001	0.477	0.997
LAFH	LAFH’	1.009	0.973	0.001	1.185	0.955

(r = 0.98). Pearson’s correlation coefficients ‘r’. P-value <0.001 indictae highly significant correlation between cephalometric and photographic measurements. Higher the value of R^2 indicates the better agreement between two techniques and vice-versa. SE: Standard error [Table 3].

DISCUSSION

Cephalometric analysis constitutes the current goal standard for diagnosing skeletal craniofacial morphology in orthodontics clinical practice. However, the photographic assessment is a great diagnostic tool for epidemiologic studies as it is cost-effective and does not expose the patient to potentially harmful radiation.[1,2] Through the repeatability test it was found that the linear and angular measurements useful for characterizing morphology can be reliably measured from facial photographs, which corroborates previous studies.[3-5,10,11,15–18] There are many advantages & shortcomings of photographic technique. A standardized photography protocol also includes accurate establishment of landmarks. Considering that most photographic measurements were performed based on anatomic points achieved by palpation.[4,5] Conversely, the photographic technique has some shortcomings, such as the distortion from the distance between the lens and the subject[4,15] which causes objects near the camera appear larger than those from it. However, this factor is only critical when attempting 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.[15] In addition, angular variables were most commonly used, which partially overcomes the problem of magnification. Head posture & jaw opening or lip straining by mentalis muscle constriction is another source of error concerns.[2,11] Studies have also reported significantly larger values for LAFH’ and PFH’ in male subjects, which agrees with our findings.[1,16] However, the

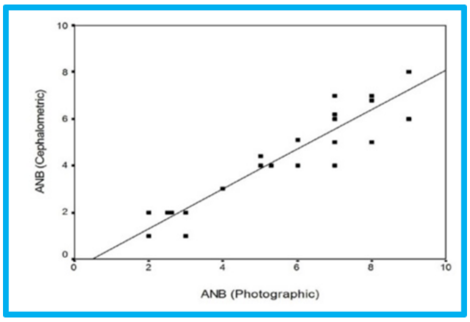

Fig. 6b: The scatter plot illustrating linear regression analysis between Cephalometric and Photographic

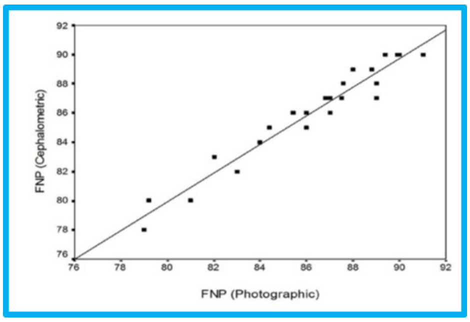

Fig. 6c: The scatter plot illustrating linear regression analysis between Cephalometric and Photographic

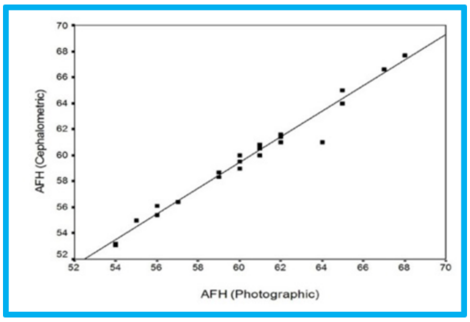

Fig. 6d: The scatter plot illustrating linear regression analysis between Cephalometric and Photographic

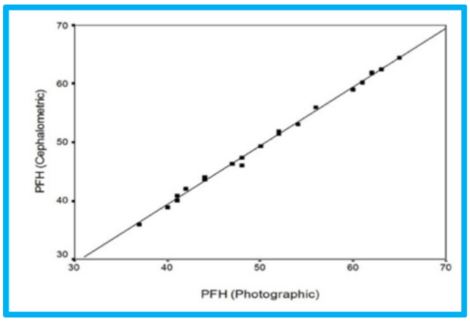

Fig. 6e: The scatter plot illustrating linear regression analysis between Cephalometric and Photographic

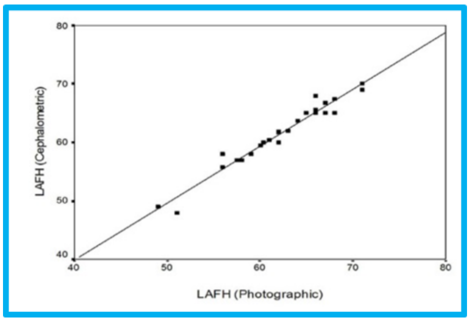

Fig. 6f: The scatter plot illustrating linear regression analysis between Cephalometric and Photographic

LAFH'/AFH' and PFH'/ LAFH' ratios showed no significant gender differences in our study. Highly significant correlations (P # .001) were found between analogous cephalometric and photographic measurements for most sagittal and vertical diagnostic variables. However, Pearson correlation coefficients ranged from weak to strong (0.39 # r # 0.89) [Table 3]. This means that although there was a significant tendency for analogous photographic and cephalometric variables to vary together, this tendency was strong for some measurements and weak for others. In a previous study, Zhang *et al.*[10] reported only low to moderate correlations (0.36 # r # 0.64). Analogous photographic and cephalometric LAFH was the highest one observed (r^2= 0.64). When comparing FMA' with the cephalometric SN.GoMe, the authors found a weak correlation coefficient (r^2 0.42).[10] In contrast, strong correlations were observed between the cephalometric and photographic FMA analogous angles in the study by Bittner and Pancherz (r^2= 0.93) and in the current article (r^2 =0.81). Other authors have found moderate correlations regarding such variables (r^5 0.63). Linear regression analysis showed that the photographic variable that best explained the variability of its analogous cephalometric measurement in the current study was the A'N'B' angle (r^2= 0.86). This means that at least 68% of the variance of the cephalometric assessment can be explained by such photographic measurements given the total sample. This finding largely supports a previous report that found a coefficient of determination of r^2 = 0.63 between analogous soft tissue and skeletal ANB angles.[11] Regarding vertical assessment, FMA' & FNP showed the best results (r^2 = 0.98 r^2 = 0.94).

CONCLUSION

Highly significant correlations between analogous photographic and cephalometric measurements were found for most sagittal and vertical diagnostic variables. The A'N'B, FNP' & FMA' angles were the photographic variables that best explained the variability of its analogous cephalometric measurement. The photographic method was found to be a repeatable, reproducible, low-cost, and non-invasive diagnostic alternative for epidemiologic research provided that a standardized protocol is followed. Further studies are needed to test the diagnostic accuracy of the predictive models obtained.

CONFLICT OF INTEREST & SOURCE OF FUNDING

The author declares that there is no source of funding and there is no conflict of interest among all authors.

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