Is Lateral Cephalogram is superior to Photograph in assessment of vertical facial height measurements in Orthodontic treatment? A descriptive analytic study.

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ABSTRACT

Objective: To assess correlation between the vertical facial height measurements on the lateral cephalograms and photographs in orthodontic treatment.
Study Design: Descriptive analytic study
Place and Duration: At Orthodontics Department of Margalla College of Dentistry, Margalla Institute of Health Sciences, Rawalpindi from 1st December, 2017 to 31st May, 2018.
Methodology: Adult patients more than 18 years of age needing orthodontic treatment, were included. Lateral cephalograms were traced for all patients and ratio of Upper Anterior Facial Height to Lower Anterior Facial Height and that of Lower Anterior Facial Height to Total Anterior Facial Height was measured for all the patients. Profile photographs of all the patients were also taken on which the same ratios were measured. Correlation between the ratios measured on lateral cephalogram and profile photographs was determined.
Results: A total of 192 patients from both genders were selected. Pearson correlation test was used to determine the correlation. For Upper Anterior Facial Height to Lower Anterior Facial Height ratio on lateral cephalograms and photographs, r=0.498, p=0.000 with r^2=0.24 showing a moderate correlation. For Lower Anterior Facial Height to Total Anterior Facial Height ratio on lateral cephalograms and photographs, r=0.389, p=0.000 with r^2=0.152, also showing a moderate correlation.
Conclusion: Photographs cannot be solely relied on for the diagnosis of vertical facial proportions because facial soft tissues may develop in proportion or disproportion to the underlying skeletal structures. Photographs should be considered as a supplement to and not the substitution for lateral cephalograms.
Keywords: Mesh, Orthodontic treatment, Cephalograms, Photographs, Cephalometry, Facial heights, Radiation, Esthetics

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INTRODUCTION

For determining facial esthetics and harmony, upper, lower, and total anterior facial heights are routinely examined in orthodontic practice[1]. An understanding of anterior facial heights is necessary due to an increasing awareness among patients about the need for orthodontic treatment to improve their facial esthetics[2]. It is important to know that many sagittal anomalies may actually be the result of disproportionate vertical facial heights and the orthodontist can use this information in treatment planning[3]. The soft tissue paradigm shift has placed greater emphasis on the clinical examination of the patient. The goals of orthodontic treatment are achieving balanced soft tissue proportions. Clinicians need to carefully assess the effects of dental and skeletal changes on the soft tissue profile when managing orthodontic treatment in order to estimate facial changes along with occlusal improvements[4].

Lateral cephalograms are routinely used to assess vertical facial proportions of a patient. They provide us information about the growth rotation of the jaws and their vertical deficiencies or excesses[5]. The main drawback of lateral cephalograms is that patients are not used to examining and interpreting cephalograms or their tracings. It becomes difficult to communicate with the patient or convince him/her about a particular treatment plan using radiographs. Expensive equipment is required for taking lateral cephalograms not

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available in every clinical setting. Also, patients are exposed to harmful radiation in the process. This is true for children under 15 years of age in whom thyroid gland is highly radiosensitive[6,7]. Photographs, on the other hand, provide better information about facial proportions and esthetics and are a better tool through which we can communicate with the patient. Taking photographs is also less time consuming. The growing interest in non-invasive diagnosis and radioprotection concerns has opened doors for the orthodontists to search for ways to make diagnosis from photographs without using the ionizing radiation of lateral cephalograms[8-11].

Bahrou et al correlated facial heights with different mandibular rotation measurements using lateral cephalograms[12]. Ahmed et al used lateral cephalograms to correlate skeletal facial heights with their soft tissue parameters[13]. Kharbanda et al also used lateral cephalograms to compare facial heights in males and females and also in Indian subgroups[14]. Similarly, hundreds of studies have been carried out both locally and internationally on the use of photographs to determine facial proportions and angles. Dimaggio and colleagues used lateral photographs for assessment of soft tissue profile of children with various occlusal classes[15]. Johnston et al defined the range of acceptable lower face vertical proportion using a series of facial profile silhouettes[16]. But few studies have been carried out to correlate the measurements of lateral cephalograms and photographs. Di Blasio evaluated the feasibility of noninvasive measurement of the ANB angle using photographic and ultrasonographic methods[17]. Kim et al investigated differences in facial proportions between beauty pageant contestants and ordinary young women of Korean ethnicity using three-dimensional (3D) photogrammetric analyses[18]. Machado and colleagues used proportions from frontal photographs of the face to estimate age in a Brazilian population[19]. Yeung et al aimed to establish norm values for facial proportion indices among 12-year-old southern Chinese children, and identified gender differences in facial proportions using photographs[20]. Another study also established the facial and smile proportions in young adults and compared the results with ideal or divine proportions using photographs[21]. All of these studies failed to correlate the facial height measurements on lateral cephalogram with the photographs and vice versa.

The alternate use of photographs for clinical diagnosis, treatment planning and patient communication offers a low cost and time saving solution. Moreover, photography can be used to carry out more extensive research on a larger scale. Hence, the objective of this study was to assess the correlation of vertical facial height measurements between the lateral cephalograms and photographs for patients with orthodontic treatment needs. So this study was conducted with an objective to assess correlation between the vertical facial height measurements on the lateral cephalograms and photographs in orthodontic treatment.

METHODOLOGY

This descriptive analytic study was conducted at the Orthodontics Department of Margalla College of Dentistry, Margalla Institute of Health Sciences (MIHS) from 1st December, 2017 to 31st May, 2018. A total of 192 patients, male and female were selected from archives of Orthodontics Department of Margalla College of Dentistry,(MIHS) by non-probability consecutive sampling. Adult patients, more than or equal to 18 years of age were included in the study because increases in facial height and eruption of teeth continue throughout life, but decline to the adult level. Another reason for choosing adults is that facial fat loss occurs with age. Patients with craniofacial syndromes, facial asymmetry and previous orthodontic treatment were excluded from the study.

All the patients in the archives had signed an informed written consent permitting their records to be used for research purposes. Lateral cephalogram of each patient included in the study followed a standardized protocol in which the patient's Frankfurt horizontal plane was kept parallel to floor. The ear cones were inserted in patient's right and left auditory canals to which the Frankfurt positioner had been attached. Patient was aligned with the Frankfurt positioner and his lips were at rest. The forehead clamp was used to vertically stabilize the patient.

Lateral cephalograms were traced manually in a dark room using matt acetate tracing paper 0.07 mm thick, size 30 x 21 cm, attached to the radiographs with adhesive tape. Points and lines were marked with a black lead pencil (Goldfish® Autocrat 5000 Eraser Tip Pencil # 2½ HB), millimeter ruler and soft eraser. When double images of the anatomical bony structures were visualized, both images were traced and a mean position between them was found for determining the cephalometric points. On the cephalogram (Figure-1) upper anterior facial height (UAFH) was determined by measuring the linear distance between Nasion (N) and Anterior Nasal Spine (ANS) while the linear distance between Anterior Nasal Spine (ANS) and Menton (Me) was identified as thelower anterior facial height (LAFH).

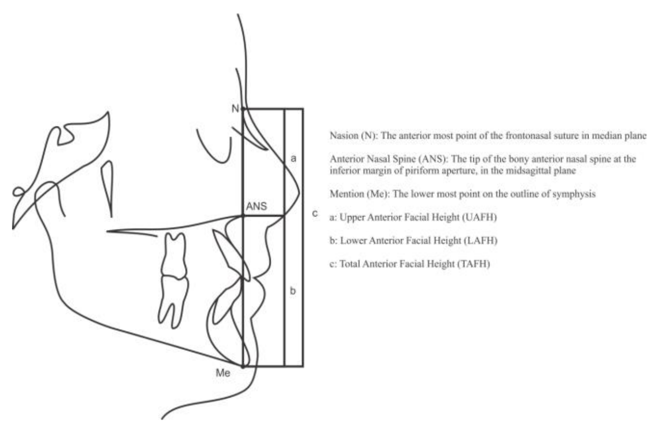

Figure-1: Anterior facial height measurements taken on lateral cephalogram[12]

Adapted from: Bahrou S, Hasan AA, Khalil F. Facial proportions in different mandibular rotations in class I individuals. Int Arab J Dent. 2014;392(3559):1-0.

The total anterior facial height (TAFH) was determined by measuring the linear distance between Nasion (N) and Menton (Me). These three linear measurements were used to calculate the facial proportion of UAFH/ LAFH and LAFH/ TAFH (Figure-1)[12].

All photographs selected from the archives had followed a standardized protocol. The photographic set-up consisted of a tripod (Pro Series tripod, Series ICON 7860) that held a camera (Canon, model EOS 760D (W); EF-S 18-135mm; 1:3.5-5.6 IS STM Kit; 24.2 MEGA PIXELS CMOS) and a primary flash. The main use of tripod was to keep the camera at the level of the patient according to his height and to avoid taking blurry pictures due to shaky hands. In this way, a correct horizontal position of the optical axis of the lens was achieved (Macro Canon lens100 mm). A 100 mm macro lens was used to maintain the facial proportions.

In order to eliminate undesirable shadows from the contours of the facial profile, the illuminator was switched on in the background of the patient. The camera was used manually. The shutter speed was 1/125 per second, and the aperture size was kept f/11. Photographs were taken in natural head position. Lips were relaxed, adopting a normal position. Glasses had been removed and we ensured that the patient's forehead, neck, and ears were clearly visible during the recording. The profile image for each patient was printed on A4 high-quality paper. The size of each image was kept 8.62x 6.27". Margin of 1" was left on all sides.

Vertical linear measurements of upper anterior facial height (UAFH), lower anterior facial height (LAFH) and total anterior facial height (TAFH) were recorded on photographs (Figure-2) like the way on cephalograms. The linear distance between Glabella (G) and Subnasale (Sn), linear distance between Subnasale (Sn) and soft tissue Menton (Me') and the linear distance between Glabella (G) and soft tissue Menton (Me') were used for determining UAFH, LAFH and TAFH respectively.

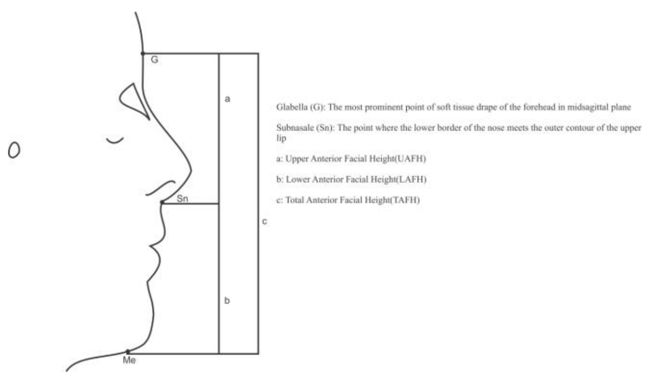

Figure-2: Anterior facial height measurements taken on photographs [12]

Adapted from: Bahrou S, Hasan AA, Khalil F. Facial proportions in different mandibular rotations in class I individuals. Int Arab J Dent. 2014; 392(3559):1-0.

These three linear measurements were used to calculate the two facial proportions of UAFH/LAFH and LAFH/TAFH. All readings were recorded on a chart. Since the size of lateral cephalograms was different from that of photographs taken, the linear measurements had not been correlated. Instead, only the proportion of UAFH to LAFH and LAFH to TAFH were correlated because they are independent of the size of lateral cephalograms and photographs.

Data Analysis: Data was analyzed using Statistical Package of Social Sciences, SPSS 22. Descriptive statistics including mean, standard deviation for each cephalometric and photographic variable were calculated. The Pearson correlation coefficient was used to determine the correlation between the UAFH/LAFH and LAFH/TAFH measured on the lateral cephalogram and those measured on photographs. The coefficient of correlation(r) was used to identify the strength and direction of the relationship between variables.

RESULTS

A total sample of 192 was subjected to analysis. The mean and standard deviations for each of the recorded variables is shown in Table-I.

Table-I: Descriptive statistics for cephalometric (ceph) and photographic measurements (photo) of UAFH/LAFH and LAFH/TAFH(N=192).

Measurement	Mean	SD
UAFH/LAFH (ceph)	77.95	7.91
UAFH/LAFH (photo)	94.58	9.90
LAFH/TAFH (ceph)	56.91	2.77
LAFH/TAFH (photo)	51.88	3.08

UAFH: Upper Anterior Facial Height, LAFH: Lower Anterior Facial Height, TAFH: Total Anterior Facial Height

The cephalometric ratio of UAFH/LAFH was 77.95±7.91 and was much different from the photographic measurement of the same ratio (94.58±9.90). A statistically significant ($p < 0.01$) correlation was observed between cephalometric and photographic proportions of UAFH/ LAFH with 24% of the variance being explained by the correlation model ($r^2 = 0.24$).The observed strength of correlation was only moderately positive ($r = 0.498$) between the cephalometric and photographic measurements for UAFH/LAFH (Table-II).

The cephalometric ratio of LAFH/TAFH was 56.91±2.77 and was close to the photographic measurement of the same ratio (51.88±3.08). The correlation between the cephalometric and photographic proportions of LAFH/ TAFH was also found to be statistically significant with an approximate 15% of the variance being explained by the correlation model ($r^2 = 0.15$). The strength of this correlation was also only moderately positive ($r = 0.389$) (Table-II).

Table-II: Correlation between cephalometric and photographic measurements of UAFH/LAFH and LAFH/TAFH(N=192).

Variables	Cephalometric UAFH/ LAFH	Photographic LAFH/ TAFH	P-value*
Photographic UAFH/ LAFH	0.498	-	0.000
Cephalometric LAFH/ TAFH	-	0.389	0.000

*Correlation is significant at the 0.01 level

UAFH: Upper Anterior Facial Height, LAFH: Lower Anterior Facial Height, TAFH: Total Anterior Facial Height

DISCUSSION

Because of the radioprotection concerns, diagnostic tools without ionizing radiation like photographs could be of great importance to us. Photographs might be the first record taken as the patient visits and further radiographs can be advised only when needed. Photographs are a low cost alternative to lateral cephalograms. They are also comparatively less technique sensitive.

All the patients included in the study were adults so that the maximum increase in facial height and eruption of teeth had been achieved. By this age, the most substantial growth of the mandible is also complete. Another reason for choosing adults is that facial fat loss occurs with age. Presence of buccal pad of fat or submental fat could have affected our results.

Only pretreatment lateral cephalograms and photographs were included in the study so that any extraction or non-extraction treatment plan does not affect our measurements. Ratios of facial heights were calculated both for lateral cephalograms and photographs instead of facial heights alone because of the differences in sizes of the photographs and radiographs. The actual value of the LAFH depends on the overall size of a patient's face. It also depends on sex, as females usually have smaller faces than males. The use of ratios solves the problems associated with such natural variability.

In this study, we found a moderate correlation between both the ratios i.e. LAFH/TAFH and UAFH/LAFH as measured on lateral cephalograms and photographs. This may be because of many factors such as individual's biological differences in soft tissue thickness, tonicity, weight and other body dimensions. Submental fat and presence of beard in some patients could have affected the true assessment of soft tissue mention. Facial soft tissues (muscles, fat and skin) can develop in proportion or disproportion to the corresponding skeletal structures. Zecca et al found a weaker correlation between vertical soft tissue and lateral cephalometric measurements. They concluded sagittal measurements are more reliable in terms of providing soft tissue diagnosis than lateral cephalometric measurements especially for lower third of the face[5]. The difference in correlation strength can be attributed to the difference in methodology as Zecca et al used angular measurement while the present study relied on linear measurements. Moreover, they had compared the measurements on lateral cephalograms with those on three-dimensional facial soft tissue scan. The difficulty of locating soft tissue landmarks for middle cranial base and soft tissue gonion landmark might have affected their results. In our study, all the soft tissue landmarks were easily discernible.

Ethnicity might be a factor affecting how soft tissues correlate with their skeletal counterparts. Oh et al conducted a study on Chinese and US populations and could not demonstrate a strong correlation between measurements on lateral cephalograms and clinicians' rankings of facial attractiveness on photographs[3]. The findings of the present study are in agreement with Oh et al which show that ethnicity of the patients in our study might have affected our results too.

Vertical skeletal pattern of a patient might be a factor affecting overlying soft tissues. Bahrou et al carried out a study in which they only used lateral cephalograms to measure the facial proportions,but no comparison was made with those on facial photographs[12]. They found that underlying vertical skeletal pattern affects the overlying soft tissues. Since our study showed moderate correlation between the ratios, we can say that evaluation of proportions and esthetics should be conducted both on lateral cephalograms and photographs. Lower vertical facial proportions can affect facial attractiveness. To determine this, Johnston et al used a series of silhouettes with normal, increased or decreased ratio of LAFH to TAFH and had asked the lay people to rate them[16]. With photographs, other variables that can affect the judge's perception of facial attractiveness are introduced. So, they only used silhouettes to solve this problem. Since our study was not aimed for determining facial attractiveness, we used photographs for measuring the soft tissue proportions. Kharbanda et al determined the vertical facial proportions using the lateral cephalograms only[14]. They only marked the hard tissue points and did not take into account the soft tissue proportions. Photographs were not taken and no correlation determined.

Both angular and linear measurements can be measured on lateral cephalogram and photographs. The results of the present study disagree with Zhang et al who reported a high correlation coefficient values for linear and angular measurements while investigating correlation between lateral cephalometric and photographic measurements of craniofacial form[22]. The difference can be explained by the reliance on linear measurements alone for the present study. Despite the significant correlation, they said that photographs should be used in conjunction to lateral cephalograms and not in their place.

Profile photographs can be used as an accurate diagnostic record for detecting growth patterns in anteroposterior and vertical plane. Sajjadi and colleagues used profile photographs only in their study and no correlation was determined between the measurements on lateral cephalograms and photographs[23].

Angle's Classification of malocclusion might be a factor affecting our results. Mehta et al correlated the angular and linear measurements obtained from cephalometric radiographs and analogous measurements from profile photographs in skeletal class II cases only[24]. They found that angular parameters on lateral cephalogram had insignificant difference compared to the analogous photographic measurements whereas linear cephalometric parameters had a good relationship with analogous photographic measurements. Staudt et al carried out a similar study in Class III patients only and had found that a profile photograph can show a skeletal Class III discrepancy and might be useful for early diagnosis for relatives of Class III patients who ask for a consultation because of its hereditary nature[25]. Vertically, soft- and hard-tissue lower anterior face heights were strongly correlated on lateral cephalogram and photographs in their study. Our sample included Class I, II and III together and did not account for the differences in measurements attributed to a particular skeletal class, hence making it difficult to generalize the findings irrespective of skeletal features.

Gender may be a factor affecting facial heights on lateral cephalogram and facial photographs. Sexual dimorphism was found by Gomes et al.[26] They concluded that LAFH, PFH and PFH/TAFH had no significant differences between males and females on lateral cephalogram but the same measurements when taken on photographs were higher in males. Other studies have also reported significantly larger values for LAFH' and PFH' in male subjects[27-29]. Our sample included both males and females to account for any sexual dimorphism.

CONCLUSION

It was concluded that the Photographs cannot be solely relied on for the diagnosis of vertical facial proportions because facial soft tissues may develop in proportion or disproportion to the underlying skeletal structures. The photographs should be considered as a supplement to and not the substitution for lateral cephalograms.

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AUTHOR'S CONTRIBUTION

Syed ST: Conceived idea, Manuscript writing, Data collection, Data analysis, Data interpretation
Mahmood A: Final review of manuscript
Nazir R: Critical revision, Data analysis

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