Original Article

# Correlation of Craniofacial Measurements between Cephalometric Radiographs and Facial Photographs

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## Abstract

**Objective:** The aim of this study was to correlate the linear and angular measurements between lateral cephalogram and lateral photographs.

**Method:** An observational cross-sectional study was carried out at the department of orthodontics, Karachi Medical and Dental College, Karachi, Pakistan. The study was conducted for six months from 30th October 2016 to 30th April 2017. Inclusion criteria included no previous orthodontic or surgical treatment, having all six maxillary anterior teeth present, no craniofacial trauma and no neurologic disturbances. Exclusion criteria includes those patients in whom radiation exposure cannot be given. A sample of 179 patients was selected which included 49 males and 139 females and they were examined by the researcher. A lateral cephalogram and a digital single lens reflex (DSLR) camera was used to obtain the linear and angular craniofacial measurements. A standard lateral cephalogram and standardized lateral photograph of each patient was taken respectively and then their measurements were taken with respect to different variables. Cephalogram measurements taken were as follows: (1) SNA (sella-nasion to A point); (2) SNB (sella-nasion to B point); (3) SNMP (sella-nasion to mandibular plane); (4) total facial height; (5) lower facial height; and (6) mandibular length. Whereas photographic measurements taken were as follows: (1) TN'A' (angle between tragion-soft tissue nasion line and soft tissue nasion-soft tissue A-point line); (2) TN'B' (angle between tragion-soft tissue nasion line and soft tissue nasion-soft tissue B-point line); (3) FH'MP' (angle between soft tissue Frankfort plane and soft tissue mandibular plane); (4) CP'MP' (angle between cranial plane and soft tissue mandibular plane); (5) lower facial height; (6) total facial height; (7) mandibular length; and (8) chin projection. The lateral cephalogram and lateral photographs measurements of patients were compared respectively and the Pearson correlation between them was calculated using SPSS 20.

**Results:** The results obtained showed that there was a moderate correlation between SNA and TN'A', SNB and SN'B', SNMP and FH'MP' whereas the correlation between facial heights and lower facial heights was very weak and CP and CP'MP' holds no correlation between them. All the correlations found between were statistically significant and had linear, positive co-relation between them.

**Conclusion:** Photographs can be used in place of lateral cephalogram X-rays for diagnostics and treatment planning.

**Keywords:** Cephalometry, dental photography, diagnosis, radiation, malocclusion.

**IRB:** Approved by Ethical Review Committee, Karachi Medical and Dental College, dated 7th Oct 2016.

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## Introduction

Cephalometry was introduced by Broadbent in 1931 after which drastic change arose in the diagnostic evaluation of facial forms and different craniofacial features[1]. Lateral cephalogram holds great importance for diagnostics and treatment planning, but it is not possible for every institute and research laboratory in Pakistan to afford the expensive apparatus of cephalogram for their students and researchers.

The basic diagnostic records in orthodontics fall into three categories: (1) study casts, (2) radiographs including orthopantomogram (OPG) and cephalogram and (3) clinical photographs[2]. Among these, more emphasis is given to the first two. But recently, the third part of diagnostic tool i.e. photographs are getting more importance in diagnosing

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malocclusion and deformities. Generally speaking, aesthetically pleasing faces demonstrate fine skeletal patterns, but it is not always true. The three most common ingredients in a negative facial outcome are: (1) occlusion-directed treatment planning, (2) no facial diagnosis and (3) no facial treatment plan. Therefore, we need to replace our inside-out thinking with an outside-in perspective to ensure a more predictable overall treatment result. Models, cephalometrics and photographic analysis together should provide the cornerstone for successful diagnosis[3].

Linear and angular measurements on lateral cephalogram have a major role in diagnosing and assessing growth and development abnormalities. We can assess any deviation from normal skeletal and dental relationship through these measurements using variety of analysis[4-5]. Although cephalometrics is important and evaluates skeletal and dental characteristics, but it has its own disadvantages, i.e. the radiation exposure to the patient, it is technique-sensitive and requires a cephalostat to hold the head in the same reproducible position. Radiation protection is of major importance in orthodontics as majority of patients coming to orthodontic clinics constitute of children and adolescents and in most cases a series of radiographs is taken in the course of treatment. Because of the increased lifetime risk for stochastic radiation effects, it would be desirable to perform imaging in the complete absence of ionizing radiation[6-8].

Dental photography gives us a low-cost and low technique sensitive procedure to evaluate the craniofacial morphology. It consist of extra-oral and intra-oral photographs. Dental photographs can help us in examining all the macro-, mini-, and micro-aesthetic features. American board of orthodontics have given some criteria for photographs which include patient's head oriented accurately in all three planes of space and on Frankfort horizontal, ears exposed for the purpose of orientation, eyes open and looking straight ahead, glasses removed,soft tissue areas are of concern and of diagnostic value (should be recorded in these photos), white or light background, free of shadows and distractions, quality lighting revealing facial contours and photographs should be approximately one-quarter life size. To determine if the photographs are one-quarter life size, the vertical distance from the hairline to the inferior border of the patient's chin is measured. If, for example, this is eight inches, the same dimension on the photograph should be two inches or one-fourth the actual measurement[9].

Lateral facial photograph requires 90 degrees from the side. Photograph method includes sitting upright looking into one's own eyes in a mirror placed oppositely, alignment of Frankfurt planes and in habitual occlusion with lips in relaxed position[10].

Usually only one profile (right profile matching up with lateral cephalogram) is taken. For a patient with facial asymmetries, both right and left profile should be taken. Frame extending to above the top of the head in front of the nose and below the chin. Back of head is not necessarily required; the remaining free space should be in front of profile. Patient assumes a natural head position and looks straight ahead in a relaxed manner keeping jaws closed, and lips also relaxed. Subjects with long hair should always be asked to tuck them behind the ear, so that Frankfort horizontal line can be assessed accurately. Light should always fall on the patient profile (light always from point of nose) so that it clearly shows mandibular margin keeping patient's shadow out of the picture. If portrait is lit from back of the head, the angle of jaw is not shown clearly, and the nasolabial line will be unflatteringly lit (pouchy cheek). Importance of profile photograph is that profile can change during orthodontic treatment. Therefore, it is very important to have profile views both before and after treatment[11].

Profile image permits the visualisation of the contours of chin, nose and neck area as well as the profile of image like convex, concave or straight. Profile-smile image allows one to see the angulation of maxillary incisors[12].

Cephalometry is an expensive and technique-sensitive procedure. In developing countries, not everyone can afford the expensive apparatus and the radiation exposure is also hazardous for the patients. Facial photographs could be used an alternative in situations when there is a need for a low-cost and non-invasive method.

Cephalometric analysis constitutes the current gold 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[13].

Cephalometric measurements have been compared with profile photographic measurements in many studies for example Liliane et al. showed that photographic method has proven to be an alternative to cephalogram[14].

A research was carried out in Karachi Medical and Dental College in order to identify an alternative way to obtain cephalogram measurements with the help of profile photographs of patients whose cephalogram was taken. It is difficult to use cephalograms on large-scale epidemiological studies. Not everyone can afford to have expensive cephalometric apparatus especially in developing countries. Hence, the objective of this study was to correlate the linear and angular measurements between lateral cephalogram and lateral photographs in order to specify if both techniques give same results.

**Patients and Methods**

An observational cross-sectional study was carried out at the department of orthodontics, Karachi Medical and Dental College (KMDC), Karachi, Pakistan. The study was conducted for six months (30$^{th}$ April 2016 to 30$^{th}$ October 2016) after the approval of synopsis from the IRB of the KMDC. Non-probability procedure of sampling was used. With consecutive sampling technique a sample size of 179 was calculated by OpenEpi calculator with 95% confidence interval and margin of error ± 5%[15,16].

The patients with no previous orthodontic or surgical treatment, having all six maxillary anterior teeth present, no craniofacial trauma and no neurologic disturbances were included in the sample. Exclusion criteria includes patients who are contraindicated to radiation exposure.

A sample of 179 patients was selected which included 49 males and 139 females. They were examined by their researcher, after thorough history and clinical examination, following which the patients were recruited for the study. Verbal informed consent was taken from the patients. Standard lateral cephalograms was obtained for all subjects. A standardized lateral photograph of each subject was taken with a digital single lens reflex (DSLR) camera with the patient's head in natural head position that corresponded to Broca's natural head position'17. Before taking the photo, two landmarks were identified by palpation and then adhesive tape was placed on those points. One was the lowest point on the infraorbital rim of right eye and other was the angle of mandible. Each subject held a scale in front of the nose as a measurement scale for the resulting image. All tracings and measurements were done under ample light and in a comfortable position. All measurements were recorded on a predesigned proforma.

Cephalometric and photographic measurements were taken with subject to 14 variables. 3 angular and 3 linear measurements were taken in cephlometric measurements and 4 angular and 4 linear measurements were taken in photographic measurements which were as follows:

Cephalometric measurements were taken as: (1) sella-nasion to A-point (SNA): angle between sella-nasion plane and nasion-A point plane; (2) sella-nasion to B-point (SNB): angle between sella-nasion plane and nasion-B point plane; (3) sella-nasion to mandibular plane (SNMP): angle between sella-nasion plane and mandibular plane; (4) total facial height (TFH): linear distance from nasion to menton; (5) lower facial height (LFH): linear distance from anterior nasal spine to menton; and (6) mandibular length (ML): linear distance between gonion and gnathion[17].

Photographic measurements were taken as: (1) TNA: angle between tragion-soft tissue nasion line and soft tissue nasion-soft tissue A-point line; (2) TNB: angle between tragion-soft tissue nasion line and soft tissue nasion-soft tissue B-point line; (3) FHMP: angle between soft tissue Frankfort plane and soft tissue mandibular plane; (4) total facial height: linear distance soft tissue nasion and soft tissue menton; (5) lower facial height: linear distance between sub-nasal and soft tissue menton; (6) mandibular length: linear distance between M-point and soft tissue menton; (7) CPMP: angle between cranial plane (tragion to soft tissue nasion) and soft tissue mandibular plane; (8) chin projection: linear distance between Z-point (found by sketching a perpendicular line to the soft tissue Frankfort horizontal line with its origin at T; the crossway of this line and soft tissue mandibular length is marked as Z point) and soft tissue pogonion[17].

Data was analyzed using SPSS 20. Sexual dimorphism was evaluated by independent sample t-test. The intra-class correlation coefficients (ICC) and corresponding 95% confidence interval was estimated to measure the reliability of repeated tracings.

**Result**

The sample of patients was selected at KMDC (n= 179) which consisted of 49 males and 130 females. The patients examined had a maximum age of 35 and minimum age of 12, the mean age of patients was found to be 18.26 ± 4.27 years.

The measurements of variables were compared using statistical software SPSS 20 and then appropriate conclusions were made. Correlations between the measurements of variables were found empirically and graphically.

Table 1 represents the descriptive statistics; it lists the variables range and mean ± standard deviation of all thephotographic (TNA= 64-91 degrees, TNB= 54-81 degrees, FHMP= 10-58 degrees, CPMP= 30-67 degrees, PLFH= 17-30 mm, PTFH= 17-51 mm, PML= 17-34 mm, CP= 28-51mm) and cephalogram measurements (SNA= 74-93 degrees, SNB= 68-91 degrees, SNMP= 19-60 degrees, TFH= 93-144 mm, LFH= 49-68 mm, ML= 56-85 mm).

Table 2 represents the empirical results of correlations found between the measurements of cephalometric and lateral photograph the correlations between SN'A'-TN'A' (r= 0.367), SN'B'-TN'B' (r= 0.390) and SNMP-FH'MP' (r= 0.330) were found to be moderate and positively significant, whereas the correlation between LFH-PLFH (r= 0.133) and TFH-PTFH (r= 0.119) was found to be very weak. The results were found to be positively significant.

Fig. 1 represents the graphical representation of correlations by means of scatter plots. The plots are made with respect to the photographic and lateral cephalogram measurements of variables. The variables were plotted against each other on the x- and y-axis, respectively. The cephalometric variable measurements were taken on the x-axis, whereas the lateral photographic measurements of variables were taken on the y-axis. The plots were plotted as follows: SNA was plotted against TNA, SNB was plotted against TNB, SNMP against FHMP and CP against CPMP. By the graphical representation of variables, we can easily identify that there is a moderate correlation between SNA and TN'A', SNB and TN'B', SNMP and FH'MP', whereas the correlation between facial heights and lower facial heights is found to be very weak and there is no correlation found between the measurements of CP and CP'MP'. From the plots of variables SNA and TN'A', SNB and TN'B', SNMP and FH'MP' and facial heights and lower facial heights, we can see that there is a little variation around the line of best fit, whereas from the plot of CP and CP'MP', we can see that there is a greater variation around the lineof best fit. Linear, uphill and positive correlations can be seen through the scatter plots and outliers were found in measurements. We can conclude that association is found between the photographic and cephlometric measurements of variables.

An appropriate statistical analysis was applied on the measurements of variables obtained through cephalograms and photographs. The analysis consisted of Pearson correlation which was used to determine correlations between the variables, the scatter plots were made in order to interpret the results graphically and t-tests were applied on photographic measurements in order to find reliability of estimates. The data set of variables of photographic measurements (n= 179) was first explored in order to check that the data meets the normality assumptions of t-test the q-q plots were used to determine the normality of data set graphically.

Fig. 2 lists the q-q plots from which we can see that the data is normally distributed and follows normal distribution. The q-q plot of CP shows that the data points are close to the line and shows that the data set of CP is normally distributed, the q-q plot of PLFH, PML and PTFH shows that there are few high outliers in the data set but all

Table 1. Descriptive statistics of cephalometric (SNA, SNB, SNMP, LFH, TFH, CP, ML) and photographic measurements (TNA, TNB, FHMP, PLFH, PTFH, CPMP, PML)

| Cephalometric measurements | Range | Mean ± S.D | Photographic measurements | Range | Mean ± S.D |
|---|---|---|---|---|---|
| SNA | 74-93 degree | 81.82 + 4.506 | TNA | 64-91 degree | 78.37 + 5.882 |
| SNB | 68-91 degree | 77.74 + 4.369 | TNB | 54-81 degree | 69.75 + 5.263 |
| SNMP | 19-60 degree | 33.30 + 7.642 | FHMP | 10-58 degree | 39.30 + 8.672 |
| TFH | 93-144 mm | 112.44 + 9.839 | CPMP | 30-67 degree | 49.73 + 8.236 |
| LFH | 49-68 mm | 63.41 + 7.548 | PLFH | 17-30 mm | 22.68 + 2.975 |
| ML | 56-85 mm | 69.06 + 5.880 | PTFH | 17-51 mm | 38.10 + 4.301 |
| | | | PML | 17-34 mm | 24.32 + 3.771 |
| | | | C.P | 28-51 mm | 40.04 + 4.922 |

*SNA= Sella-nasion to A-point * SNB= Sella-nasion to B-point *SNMP= Sella-nasion to mandibular plane *TFH= Total facial height *LFH= Lower facial height * ML= Mandibular length *TNA= angle between tragion-soft tissue nasion line and soft tissue nasion-soft tissue A-point line *TNB= angle between tragion-soft tissue nasion line and soft tissue nasion-soft tissue B-point line *FHMP= angle between soft tissue Frankfort plane and soft tissue mandibular plane *CPMP= angle between cranial plane (tragion to soft tissue nasion) and soft tissue mandibular plane *PLFH= Photographic Lower facial height *PTFH= Photographic Total facial height *PML= Photographic mandibular length *CP= Chin projection

Table 2. Correlation between cephalometric (SNA, SNB, SNMP, LFH, TFH, CP) and photographic (TNA, TNB, FHMP, PLFH, PTFH, CPMP) measurements

| Variables | Correlation |
|---|---|
| SNA-TNA | 0.367 |
| SNB-TNB | 0.390 |
| SNMP-FHMP | 0.330 |
| LFH-PLFH | 0.133 |
| TFH-PTFH | 0.119 |

Table 3. Estimates of reliability of photographic method

| | Test Value = 0 | | | | |
|---|---|---|---|---|---|
| | T | df | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference |
| TNA | 178.267 | 178 | .000 | 78.369 | 77.50 - 79.24 |
| TNB | 177.322 | 178 | .000 | 69.749 | 68.97 - 70.52 |
| FHMP | 60.628 | 178 | .000 | 39.296 | 38.02 - 40.58 |
| CPMP | 80.784 | 178 | .000 | 49.732 | 48.52 - 50.95 |
| PLFH | 101.984 | 178 | .000 | 22.676 | 22.24 - 23.11 |
| PTFH | 118.529 | 178 | .000 | 38.101 | 37.47 - 38.73 |
| PML | 86.286 | 178 | .000 | 24.318 | 23.76 - 24.87 |
| C.P | 108.829 | 178 | .000 | 40.039 | 39.31 - 40.77 |

points lie near the line which means data is normally distributed, the q-q plot of CPMP, TNA, TNB and FHMP shows that the data set is skewed to the left as we can see the points are above and below the line and are following a slight curve pattern which means the data is normally distributed.

Correlations were found between the measurements of different variables. Correlations ranging between 0.3-0.5 were concluded as moderate, whereas correlations ranging between 0.1-0.3 were concluded as weak correlations. From the study positive and significant correlations were found. The results obtained were reliable.

Table 3 lists the estimates of photographic measurementsof all the variables. It list the estimates of reliability. Among the photographic measurements of variables (n= 179), the t-tests were applied (test value= 0) on photographic measurements in order to test the null hypothesis that the sample came from a population with a specific mean.The t-test was applied and p-value  0.05 was taken as significant. Statistically significant results were obtained.

For TNA, TNB, FHMP, CPMP, PLFH, PTFH, PML and CP the p-values were obtained  0.00 which is statistically significant. The 95% confidence interval estimates for each variable were found which shows the interval within which the parameters of measurements lie.

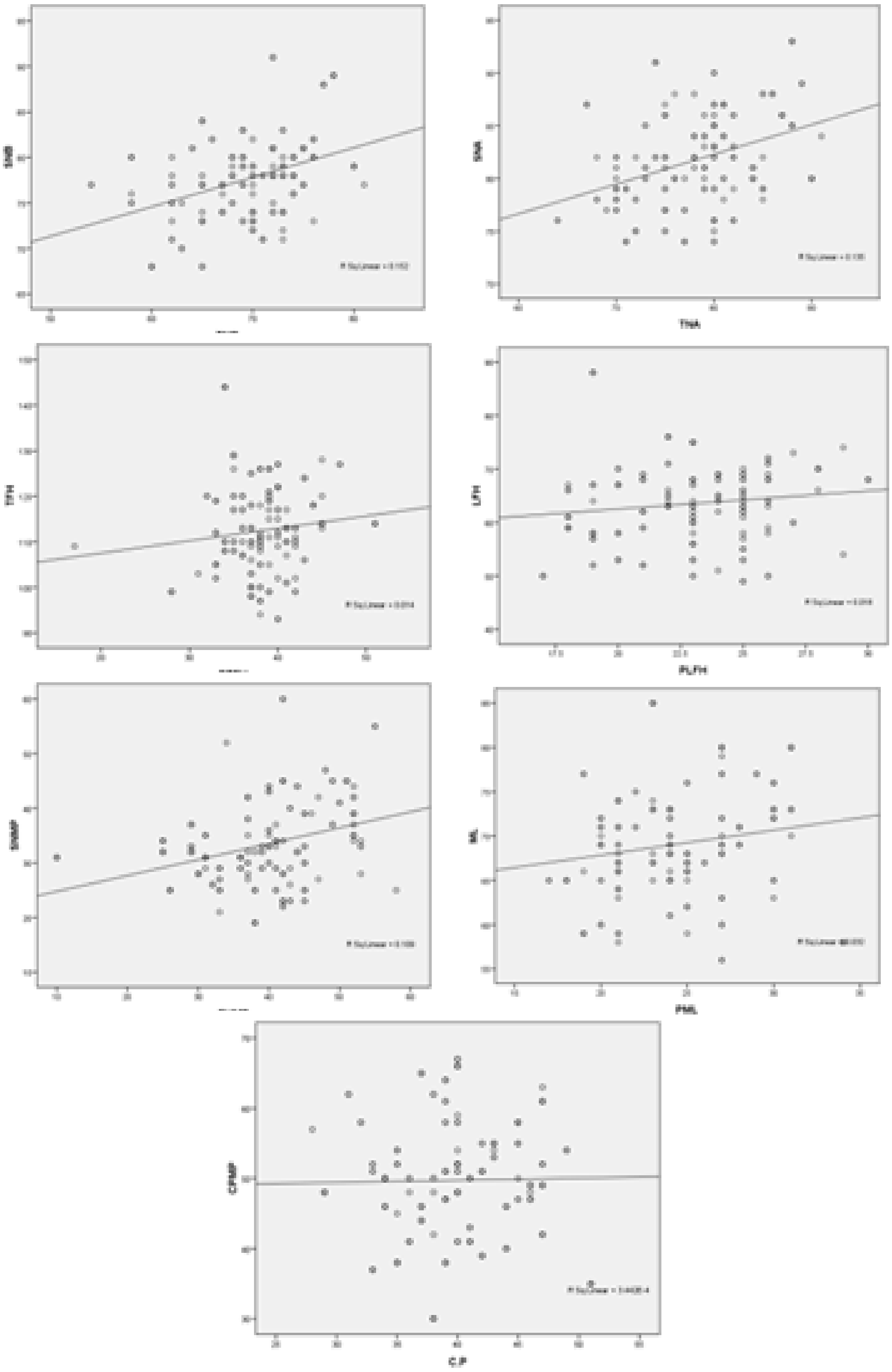


Fig 1. The figure represents different scatter plots between measurements of lateral cephalogram (SNA, SNB, SNMP, LFH, TFH, CP) and lateral photographs (TNA, TNB, FHMP, PLFH, PTFH, CPMP) of patients (n= 179)

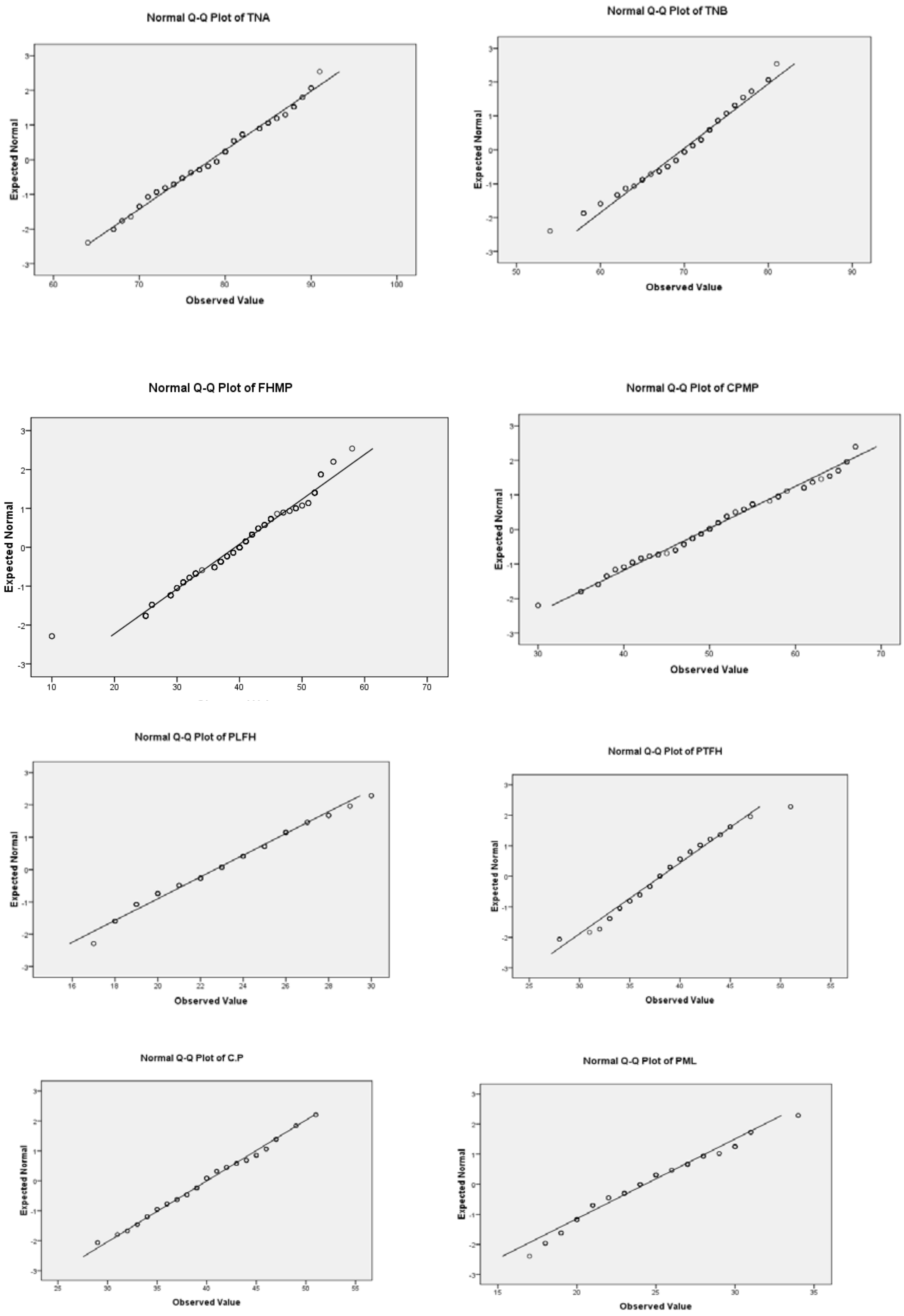


Fig 2. Q-q plot showing normal distribution of data.

## Discussion

Cephalometric analysis constitutes the current gold standard for diagnosing skeletal craniofacial morphology in orthodontics clinical practice. However, the photographic assessment is a great diagnostic tool for epidemiological studies as it is cost-effective and does not expose the patient to potentially harmful radiation[3].

The main purpose of our study was to determine whether we can use lateral photographic measurements in place of lateral cephalogram measurements for the treatment of patients, as it is not easy for every institute and research laboratory in Pakistan to provide an expensive apparatus for students and researchers.

The last 20 years have seen a rise in concerns over the possibility of unnecessary X-ray exposure. The average expected dose from a lateral cephalogram is 3 µSv, which is very minor compared to the International Commission of Radiological Protection's (ICRP) recommendation that the dose limit should be 1 mSv annually for the public[18]. Although this indicates that the risks are very minimal, with the chances of malignancy being less than 1 patient per million[19,20], any reduction in the amount of possible exposure from lateral cephalograms would be beneficial for patients[21].

The results of this research are compared with the research results of Zhang X et al.[17] This research was conducted on the sample of 179 patients, whereas the research carried by Zhang X et al. was carried out on a sample of 326 patients. The correlations obtained between cephalogram and photographic measurements by this study were found to be lower, ranging between 0.199 and 0.390, whereas the correlations found in previous published article were also found to be lower and moderate and varied between 0.356 and 0.690. The highest correlation was found between the sella-nasion to B-point (SNB) and angle between tragion-soft tissue nasion line and soft tissue nasion-soft tissue B-point line (TNB) which was found to be 0.390, whereas the highest correlation found in previously published articles was between the mandibular length and lower facial height measurements, which was found to be 0.690. Though the results obtained by both the researches varied but positive correlations were obtained by both the researches.

Gomes et al. noticed highest coefficients between ANB vs A'N'B' (r= 0.82) as compared to our study in which highest correlation are found between SNB and SNB' (r= 0.390) and FMA vs. FMA' (r= 0.81) and lowest coefficients for LPFH vs. PFH' (r= 0.49) and PFH/AFH vs. PFH'/AFH'(r= 0.47), whereas our study shows lowest coefficient for LFH and PLFH (r= 0.13) and TFH and PTFH (r= 0.11)[14].

On comparing the cephalometric and photographic variables for the entire sample, we found positive and significant correlations for all the variables studied ($r>0$, $p<0.05$). moderate and highly significant correlations were found between the measurements for SN'A'-TN'A' (r= 0.367), SN'B'-TN'B' (r= 0.390) and SNMP-FH'MP' (r= 0.330). Similar results were found by Zhang et al.[16], Gomes et al.[21] and Patel et al.[22] in their studies.

Our study may not be feasible on bearded individuals because of the difficulty in location of points soft tissue Go', Me' and Gn'. The lateral cephalogram and profile photographs used in this study are 2-D representation of 3-D structures. These individually should not be used to judge the aesthetics of an individual.

## Conclusion

This study concluded that photographic measurements can be used in place of lateral cephalogram measurements for post- and pre-treatment of patients as they are reliable and can be implemented through low cost which would be a better alternative for developing countries as they cannot afford expensive apparatus of lateral cephalogram. Photographic technique is a better method than lateral cephalogram as patients will not be exposed to radiations which are hazardous for them.

## Conflict of Interest

Authors have no conflict of interests and no grant/funding from any organisation.

## References


1. Broadbent BH. A new X-ray technique and its application to orthodontia [Online]. Angle Orthod 1981;51:93-114. Available from: http://www.angle.org/doi/abs/10.1043/0003-3219%281981%29051%3C0093%3AANXTAI%3E2.0.CO%3B2. Accessed on February 15, 2018.

2. Proffit WR, Sarver DM, Ackerman JL. Orthodontic diagnosis: The problem-oriented approach. In: Proffit WR, Fields HW, Sarver DM. Contemporary Orthodontics. 5th ed. St. Louis: Elsevier; 2012. p. 150-219.

3. Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning--Part II. Am J Orthod Dentofacial Orthop 1993;103:395-411.

4. Clinical Practice Guidelines for Orthodontics and Dentofacial Orthopedics [Online]. St. Louis: American Association of Orthodontists; 2017. Available from: https://www.aaoinfo.org/d/apps/get-file?fid=12939. Accessed on February 15, 2018.

5. Heil A, Lazo Gonzalez E, Hilgenfeld T, Kickingereder P, Bendszus M, Heiland S, et al. Lateral cephalometric analysis for treatment planning in orthodontics based on MRI compared with radiographs: A feasibility study in children and adolescents. PLoS One 2017;12:e0174524. [DOI: 10.1371/journal.pone.0174524].

6. American Academy of Pediatric Dentistry, Ad Hoc Committee on Pedodontic Radiology. Guideline on prescribing dental radiographs for infants, children, adolescents, and persons with special health care needs. Pediatr Dent 2012;34:189-91.

7. Berrington de González A, Darby S. Risk of cancer from diagnostic X-rays: estimates for the UK and 14 other countries. Lancet 2004;363:345-51. [DOI: 10.1016/S0140-6736(04)15433-0].

8. Claus EB, Calvocoressi L, Bondy ML, Schildkraut JM, Wiemels JL, Wrensch M. Dental x-rays and risk of meningioma. Cancer 2012;118:4530-7. [DOI: 10.1002/cncr.26625].

9. Photograph Requirements [Online] St. Louis: American Board of Orthodontics. Available from: https://www.americanboardortho.com/orthodontic-professionals/about-board-certification/clinical-examination/case-record-preparation/photograph-requirements/. Accessed on February 15, 2018.

10. Orthodontic Photo Analysis [Online]. Münster: International Medical College. Available from: http://www.med-college.de/en/wiki/artikel.php?id=148. Accessed on February 15, 2018.

11. Sreesan NS, Purushothaman B, Rahul CS, Shafanath T, Fawaz V. Clinical Photography in Orthodontics [Online]. Int J Oral Health Med Res 2016;3:71-5. Available from: http://www.ijohmr.com/upload/Clinical%20Photography%20in%20Orthodontics.pdf. Accessed on February 15, 2018.

12. Sarver DM. Special considerations in diagnosis and treatment planning. In: Graber LW, Vanarsdall Jr RL, Vig KWL, Huang GJ. Orthodontics: Current Principles and Techniques. St. Louis: Elsevier; 2016. p. 245-88.

13. Ferrario VF, Sforza C, Miani A, Tartaglia G. Craniofacial morphometry by photographic evaluations. Am J Orthod Dentofacial Orthop1993;103:327-37. [DOI: 10.1016/0889-5406(93)70013-E].

14. de Carvalho Rosas Gomes L, Horta KOC, Gandini Jr LG, Gonçalves M, Gonçalves JR. Photographic assessment of cephalometric measurements [Online]. Angle Orthod 2013;83:1049-58. Available from: http://www.angle.org/doi/abs/10.2319/120712-925.1?code=angf-site. Accessed on February 15, 2018.

15. Dean AG, Sullivan KM, Soe MM. OpenEpi: Open Source Epidemiologic Statistics for Public Health [Online]. Available from: www.openepi.com. Accessed on February 15, 2018.

16. Zhang X, Hans MG, Graham G, Kirchner HL, Redline S Correlations between cephalometric and facial photographic measurements of craniofacial form. Am J Orthod Dentofacial Orthop 2007;131:67-71. [DOI: 10.1016/j.ajodo.2005.02.03

17. Feuer DD. The value of the PM reference line for estimating natural head position. Angle Orthod 1974;44:189-93. [DOI: 10.1043/0003-3219(1974)044<0189:TVOTPR>2.0.CO;2].

18. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Ann ICRP 2007;37:1-332. [DOI: 10.1016/j.icrp.2007.10.003].

19. Isaacson KJ, Thom AR, Atack NE, Horner K, Whaites E. Guidelines for the use of radiographs in clinical orthodontics [Online]. London: British Orthodontic Society; 2008. Available from: https://www.bos.org.uk/Portals/0/Public/docs/General%20Guidance/Orthodontic%20Radiographs%202016%20-%202.pdf. Accessed on February 15, 2018.

20. Wall BF, Kendall GM. Collective doses and risks from dental radiology in Great Britain. Br J Radiol 1983;56:511-6. [DOI: 10.1259/0007-1285-56-668-511].

21. Forsyth DB, Shaw WC, Richmond S. Digital imaging of cephalometric radiography, Part 1: Advantages and limitations of digital imaging. Angle Orthod 1996;66:37-42. [DOI: 10.1043/0003-3219(1996)066<0037:DIOCRP>2.3.CO;2].

22. Patel DP, Trivedi R. Photography versus lateral cephalogram: Role in facial diagnosis. Indian J Dent Res 2013;24:587-92. [DOI: 10.4103/0970-9290.123378].