Comparison Between Cephalometric Measurements Derived from Cone Beam Computed Tomography and Lateral Cephalogram

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ABSTRACT

Objective: To compare the mean craniofacial linear and angular measurements derived from cone beam computed tomography synthesized lateral cephalogram and those obtained from conventional cephalogram.
Study Design: Comparative cross-sectional study.
Place and Duration of Study: Armed Forces Institute of Dentistry (AFID), Rawalpindi Pakistan, from Feb 2017 to Nov 2018.
Methodology: Sample size was 32. Following linear measurements were evaluated; anterior facial height, right side and left side of mandibular length, nasal spine length, Upper and lower incisors to A-Pog distance. These measurements were obtained by both means i.e., conventional cephalogram and cone beam computed tomography synthesized cephalogram. Each of the measurement were taken twice by the single operator with a difference of two weeks.
Results: No significant difference was found among measurements obtained through lateral head film cephalograph and cone beam synthesized cephalograph except for mandibular length (for which p=0.04).
Conclusions: Cone beam computed tomography synthesized lateral cephalogram can be suggested as a substitute to conventional lateral cephalogram. Especially in conditions when cone beam computed tomography is already required for treatment planning thus reducing supplementary x- ray exposure and expenditure of an additional x-ray.

Keywords: Cephalometry, Cone beam computed tomography, Lateral head film.

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INTRODUCTION

Diagnosis and treatment planning in orthodontics evolved through examination aided by extensive pictures and radiographs. Direct craniometrics and anthropometric measurements were done before the introduction of any radiographic technique.[1] Cephalometry is considered anindi spens able scientific and research tool in orthodontics. Studies analyzing 3D cone beam computed tomography are enthusiastically being experimented in field of orthodontics. Although advances during past decades has revolutionized the pathway of future modernized orthodontics.

Lateral cephalometry, discovered by Brodie in 1931,[2,3] is two–dimensional representation of three dimensional anatomic structures. Assessment and measurements done on lateral cephalogram are limited by distortion, magnificationand overlapping of landmarks, as a result accuracy of measurements is compromised.[3] Furthermore patients head position and magnification further compromisethe consistency of measurement.[4] Another main drawback of lateral cephalometry is that lower border of mandible is double due to superimposition of right and left side of mandible.[5] The bench mark for cephalometric assessment has not been distinct yet. Conventional imaging techniques have been requested due to an advanced likelihood of inaccuracies while recognizing landmark and creating manual measurements.[6]

A numeral researcheshave evaluated the effectiveness of measurements derived from digitized cephalogram and those derived from manualtracing methods, and declared that the digital method can formulate linear and angular dimensions in a well-organized fashion. These outcome, however, are not approved in the literature. Further, since cephalometric measurements are subject to personal errors as in land mark identification, dimension analysis techniques, and excellence of radiographic assessment,[7] ways are required that will reduce such faults. Novel skills arerising, hopeful at civilizing the fineness of such evaluations.

CT scan was invented in 1972 by God frey Houns feild and Allan Cormack, but its use is limited in craniofacial region because of extensive radiation dose.[8] Cone Beam Computed Tomography was first introduced in Europe in 1998, and it has revolutionized the era of orthodontic and maxillofacial treatment planning. As compared to CT it emits less amount of radiation

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and image is less likely to magnified and distorted than 2-D radiographic images.[9] Designation of 3D points on multi-planar reconstruction view appears to be more reliable and reproduce able as compared to other radiographic modalities used for maxillofacial regions. During imaging the scanner revolves around the head of patient obtaining series of different 600 pictures, the software acquires the facts and recreate it, which is called digital volume that is composition of 3 dimensional voxels which can be manipulated by specific softwares.[10] Many studies have evaluated how to develop 2D-lateral cephalograph from 3D CBCT. However these studies did not reflected on the potential disparity persuaded by utilization of different types of reorientation methodology.

The objective of study was to compare linear cephalometric measurement performed on lateral cephalogram and CBCT synthesized lateral cephalogram. The rationale of this exercise was to conclude whether CBCT synthesized lateral cephalogram could be used instead of conventional cephalogram for craniofacial linear and angular measurements and analysis.

METHODOLOGY

A comparative-cross sectional study was conducted in Armed Forces Institute of Dentistry (AFID), Rawalpindi Pakistan for the period of 21 months i.e., from February 2017 to November 2018. The research was accepted by Institutional ethical review committee (905/Trg-ABP1K2). Informed consent was obtained from all patient before using their treatment records for the aim of study (Annexure A). Sample size was calculated using G power 3.1.9.2 software, keeping the value of effect size as 0.8, alpha error as 0.05, beta error as 0.2, probability and power 0.8, a sample size of 32 was calculated.[11] Patients were selected using non probability consecutive sampling.

Inclusion Criteria: Subjects of both gender with age between 14-25 years having complete permanent dentition and normal facial proportions were included in the study.

Exclusion Criteria: Patients with facial asymmetry or syndromic condition, any kind of pathology and trauma were excluded.

CBCT were done for those patients fulfilling inclusion criteria. The CBCT data set which was utilized in this research was employed by the New Tom VGi 3D [QR systems, Verona, Italy] conferring to department regular imaging protocols. During imaging process patient was instructed to sit in up right position with Frank furt horizontal plane parallel to the floor. Subjects were taught to bite in maximum inter cuspation and not to swallow and to avoid other types of movements during the clinical process Exposure settings were 110 kV, 4mA, 18-16 cm field of view, 0.3mm voxel size, 3.6 seconds exposure time. Synthesized CBCT cephalometric radiographs were obtained utilizing the CBCT data employing 3D imaging software.[12]

Cephalometric descriptions were obtained with a multitomo graphic X-ray unit. They were acquired with a constant 13 mA, 85 KVP and 11 seconds exposure through 2.5 mmAl filtration. Sensor matrix 64* 1312 pixels, Image field 64*131.2mm, Magnification of cephalograph was 1.13. Sensor of cephalographic Image was 26*24. The total time dispensed was 4 minutes at 27°C working temperature.

These linear measurements were evaluated: anterior facial height which was formed by plane from nasion to menton point, right side and left side of mandibular length which is measured from condy lion tognathion, nasal spine length which is the measurement between anterior nasal spine (ANS) and posterior nasal spine(PNS), upper and lower incisors to plane A-pog which was measured by distance between the most labial portion of upper central incisor and from most labial portion of lower central incisor to A-pog plane as shown in the Figure.

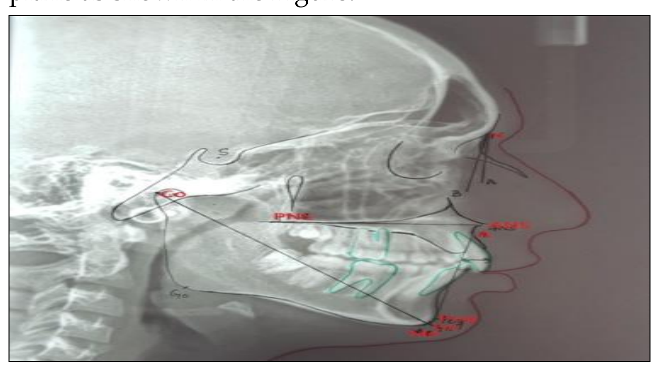

Figure: Cephalograph showing linear facial measurements.

The angular measurement was ANB. Each of the dimensions were taken twice with the difference of two weeks and were carried out by the same operator.

The statistical analysis was done using SPSS version 23. T-test was applied to compare anterior facial height, ANS-PNS and ANB measured through lateral head film and cone-beam computed tomography. ANOVA test was applied to compare mandibular length, upper incisor to A-Pog distance and lower incisor to A-Pog distance measured through lateral head film cephalogram, right and left side of cone-beam computed tomography. The *p*-value of ≤0.05 was considered significant.

RESULTS

Thirty two individuals were selected for this study. Among which 14 (43.7%) were male and 18 (56.3%) were female. Mean age of individuals was 21.18 ± 3.79 years.

Anterior facial height, ANS-PNS and ANB measured through lateral head film cephalograph and cone-beam computed tomography were analyzed using t-test. As the significant *p*-value ≤0.05, no significant difference was found among the measurements as shown in Table-I.

Table-I: Comparison of Mean ± SD of anterior facial height, ANS-PNS and ANB measured by lateral cephalograph and CBCT (n=32).

Variable	Lateral Cephalograph (n=32)	CBCT (n=32)	*p*-value
Anterior Facial Height (mm)	56.29 ± 8.44	56.49 ± 8.53	0.228
ANS-PNS (mm)	55.29 ± 5.99	55.66 ± 5.66	0.102
ANB (Degrees)	3.81 ± 1.20	3.74 ± 1.36	0.377

ANOVA test was applied to compare mandibular length, upper incisor to A-Pog and lower incisor to A-Pog distance measured through lateral head film, right and left side of cone-beam computed tomography. Which shows that there is significance difference in mandibular length (*p*-value=0.040) measured by both modalities as shown in Table-II.

Table-II: Comparison of mean ± SD of mandibular length, upper and lower incisor to A-Pog distance as measured from lateral cephalogram and right and left side of CBCT (n=32).

Variable	Lateral Cephalograph (n=32)	Right Side of CBCT (n=32)	Left Side of CBCT (n=32)	*p*-value
Mandibular Length (mm)	172.54 ± 16.12	170.06 ± 11.72	170.83 ± 11.46	0.040
Upper Incisor to A-Pog (mm)	7.40 ± 1.56	7.01 ± 1.66	7.07 ± 1.68	0.440
Lower Incisor to A-Pog (mm)	4.43 ± 1.89	4.53 ± 1.77	4.40 ± 1.84	0.192

As *p*-value for mandibular length was significant (Table-III), Post hoc test was applied to compare mandibular length measured by lateral cephalograph and right and left side of cone beam computed tomography. It shows significant difference between mandibular lengths measured from both sides of CBCT (*p*-value=0.04) as shown in Table-III.

Table-III: Post hoc test to compare mandibular length.

Variable	*p*-value
Lateral cephalograph versus right CBCT	0.365
Lateral cephalograph versus left CBCT	0.634
Right cone-beam versus left CBCT	0.040

DISCUSSION

With the advent of modern radiographic modalities in orthodontics, next step is to further modernize the radiographic techniques and take it to next level of 3D representation of 3D anatomic structures. CBCT is novel modality in future orthodontics which is setting a different standard of diagnosis and treatment planning. Advantages of CBCT are; low radiation dose, less expenditure, exact anatomical landmarks can be identified, projection errors can be eliminated, facial asymmetry errors can be terminated, and there is exact landmark identification because there is 3D representation of 3D anatomic structure.[11] Conventional lateral cephalogram has many loop holes as it's the 2D representation of 3D structures which paves way for different types of errors like error of projections and error of identifications which further declines the accuracy of dentofacial analysis. Chief aim of study was to trial the precision of CBCT for diverse angular and linear dimensions and either it can substitute conventional lateral cephalogram.

Bruno Frazo *et al*, in 2011 demonstrated in his studies that CBCT has same reliability as conventional cephalometry.[1] Mandibular length value was significantly different in both types of radiographs i.e. *p*-value=0.04. All other values were same in lateral cephalogram and CBCT synthesized lateral cephalogram.

Kumar *et al*,[12] in 2007 depicted in his study that dimensions were similar between imaging modalities (*p* >0.05)with the exception of mandibular unit length (*p*=0.01). CBCT can produce reliable, accurate high precision projection of anatomic structures. Midsagittal plane dimensions are more accurately viewed on CBCT synthesized lateral cephalogram as compared to conventional lateral cephalogram images. Kumar *et al,* concluded additional lateral cephalogram is not required for dentofacial analysis if CBCT has been already done.[12]

Mazyar *et al,* in 2008 measured different linear measurement including ANS-PNS on dry skull through digital caliper.[13] Then dentate skulls were imaged by CBCT and conventional lateral cephalogram and images were imported to cephalometric analysis programmer (Dolphin) and different linear measurements were calculated on both conventional lateral cephalogram and CBCT synthesized lateral cephalogram. CBCT derived lateral cephalogram values are more relatable to direct dry skull values, which comply with our study.

Vanvlijmen *et al*, in 2009 measured linear and angular values on dry skull and compared with dry skull imaged CBCT synthesized lateral cephalogram and conventional lateral cephalogram.[14] Statistically significant difference between usual lateral cephalogram and 3D model were found for following measurements e.g. ANB and SNB, which is against our study as there was no difference in ANB measured through lateral cephalogram and cone beam computed tomography in our study.

Nal caci in 2010 studied reliability of 3D CBCT synthesized lateral cephalogram and usual one and found that there is no statistically significant divergence between different angular and linear measurements.[15] ANB and LI-A Pogdifference was not significant p >0.05,which abide by our results.

Bholsithi *et al*,[16] reported that 3D measurements are comparable with 2D cephalometric measurements only in midline. Study conducted by Jansen Valeria *et al*, concluded that measurements derived from 3D cone beam does not have any significant advantage on measurements taken from 2D images in terms of efficacy and reliability.[2]

In an in vitro study conducted by Shokri *et al*, they concluded there was significant difference in mandibular length measured from digital lateral cephalogram and CBCT synthesized cephalogram, these results are same as attained by our study. They also observed a significant difference in anterior facial height, contrary to our results.[17] Arvind Hariharan *et al*, concluded that CBCT research work is required to ascertain the reliability and efficacy of CBCT in deriving cephalometric measurements in full skull images.[18]

Study conducted by Ruellas established that CBCT can be used to determine dental asymmetry.[19] Measurements of the molars, canines and the dental regularity with reference to the skeletal midline are consistent when taken with CBCT. Study also show the significant similarity in linear and angular cephalometric measurements acquired by conventional and CBCT derived methods.[20] It also states that use of CBCT in dentistry should be limited since lateral cephalograph deliver lesser amount of radiation as compared to CBCT.

CONCLUSION

Cephalometric descriptions which are derived from CBCT may be utilized to linkthe alteration from 2D to 3D image analysis.Both sorts of synthesized CBCT projections are comparable to conservative cephalogram. CBCT synthesized lateral cephalogram can be suggestedas a substitute to conventional lateral cephalogram when CBCT is previously required for treatment thus reducing supplementary x- ray exposure and expenditure of an additional X-ray.

Conflict of Interest: None.

Authors' Contribution

MK: Coneption of idea, design of research, formulation of manuscript, ABK: Supervisor, conception of idea, design of research, EA: Interpretation and analysis of data, formulation of manuscript, FE: Data collection and compilation.

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