ORIGINAL RESEARCH PAPER

Volume - 9 | Issue - 10 | October - 2020 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

RELIABILITY OF DIGITAL CEPHALOMETRY OF CBCT DERIVED DIGITAL CEPHALOGRAM

Orthodontology

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ABSTRACT

AIM: The purpose of this study was to evaluate the reliability of cephalometric measurements derived from 1) manual tracing of lateral cephalogram and 2) digitization of CBCT generated lateral cephalogram using Dolphin imaging software.

METHODOLOGY: 20 patients of age group 15-45 years, who reported to the Department of Orthodontics, were subjected to digital lateral cephalogram and full skull CBCT. Cephalometric measurements from lateral cephalogram were derived using manual tracing. Lateral cephalograms derived from CBCT were evaluated using Dolphin imaging software.

RESULTS: Significant changes for the examined variables were not detected for the two groups compared. Both the methods were found to be reliable.

CONCLUSION: CBCT generated lateral cephalogram can be used as effectively as the conventional lateral cephalogram for cephalometric evaluation. Hence, whenever a CBCT volume is already available, further radiation exposure and expense for a lateral cephalogram can be avoided.

KEYWORDS

Cone-Beam computed tomography; Cephalometry; Orthodontics; Diagnosis.

INTRODUCTION

Diagnosis and treatment planning for orthodontic patients depends on a combined evaluation of case history and records like study models, intraoral and extraoral photographs, and radiographs traditionally comprising panoramic radiographs and cephalograms.[1] Cephalometric analyses are performed to determine deviations in the skeletal and dentoalveolar relationship by identifying specific landmarks on both hard and soft tissues to consecutively calculate the spatial and angular relationship between them.[2]

Computed tomography (CT) has been used successfully to represent the true 3-dimensional (3D) morphology of the skeletal structures of the cranium. Although CT scanning was introduced into medical practice in 1971, its application in dentistry has been limited to special patients due to high levels of radiation and scanning costs.[2] In the 1980s, devices emerged in the United States that employ the Cone-Beam technique, which is a special type of computed tomography in which the X-ray beam that generates the image features a special conic shape, unlike conventional CT (CCT), which uses a fan-shaped beam known as fan beam.[3]

The advent of cone-beam computed tomography (CBCT) for craniofacial imaging provides volumetric information that allows development of virtual three-dimensional (3-D) models that can be quite valuable in locating impacted teeth, visualizing the temporomandibular joints and diagnosing asymmetries in complex craniofacial patients.[6] These advances in imaging have improved considerably the identification of hard-to-detect structures, which may increase the accuracy and reliability of orthodontic diagnosis and treatment planning. Cone-Beam CT allows all conventional dental radiographs to be reconstructed and then added to the multiplanar and 3D reconstructions. Furthermore, measurements made from volumetric CT feature a 1:1 ratio, unlike conventional cephalometric radiography, whose magnification may vary from 4.6% to 7.2%.[3]

In order to be able to compare the new modalities with our current databases, algorithms have been created to extract information from the CBCT image and to simulate a conventional lateral cephalogram, P-A cephalogram and panoramic projection. Previous in vitro and in vivo studies comparing both conventional cephalograms and CBCT-extracted cephalograms reported some statistically significant differences that did not reach clinical significance.[6]

Thus, the purpose of this study was to evaluate the reliability of cephalometric measurements derived from 1) manual tracing of lateral cephalogram and 2) digitization of CBCT generated lateral cephalogram using Dolphin imaging software.

MATERIALS AND METHODOLOGY

Inclusion Criteria

- Age group of 15-45 years
- Acceptable pleasing profile
- Stable occlusion

Exclusion Criteria:

- Facial deformity
- Cleft lip and palate
- Gross facial asymmetry
- Pregnancy
- Poor quality lateral cephalogram and CBCT

METHOD OF COLLECTION OF DATA

20 patients who satisfied the inclusion criteria were subjected to the following radiations:

- Digital lateral cephalogram
- Full skull CBCT

Digital lateral cephalograms were obtained by positioning the patients in a cephalostat in natural head position with ear rods in place. The head position was fixed so that the sagittal plane remained parallel to the film and perpendicular to the ground.

Full skull CBCT scans were obtained using Soredex Scanora 3D CBCT machine. The settings used were 70-90 kV, 12.5 mA current with exposure time of 6 seconds and patient's head was positioned in such a way that the Frankfort horizontal plane was parallel to the floor.

PROCEDURE

The raw images of full skull CBCT were exported using Scanora software into DICOM files. The DICOM files were loaded into ON DEMAND software. 2D lateral cephalographic images were derived from CBCT data using this software (FIG 1). The required adjustments such as brightness and contrast were done to visualize the required landmarks better and was saved in a JPEG format.

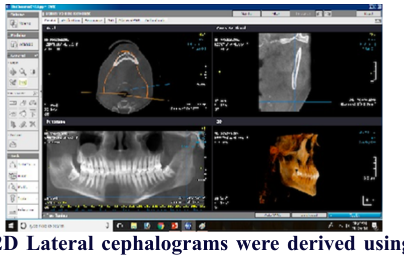


Figure 1: 2D Lateral cephalograms were derived using the ON DEMAND software.

PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

The CBCT generated lateral cephalograms, were then loaded onto the DOLPHIN Imaging software. The digital tracing was done using Dolphin Imaging Software Version 11.9 (Dolphin Imaging).

Landmark identification was carried out by a single operator on the digital images using a mouse-driven cursor and then stored in the Dolphin Imaging archive (FIG 2). A total of 54 landmarks were defined on each CBCT generated lateral cephalogram and 8 selected angular and linear measurements were taken and saved into an excel sheet.

For the manual tracing measurements, the digital lateral cephalogram of each patient was traced manually on acetate sheet and evaluated using conventional method. The required angular and linear measurements from the manual tracing were also saved on to the excel sheet (FIG 3).

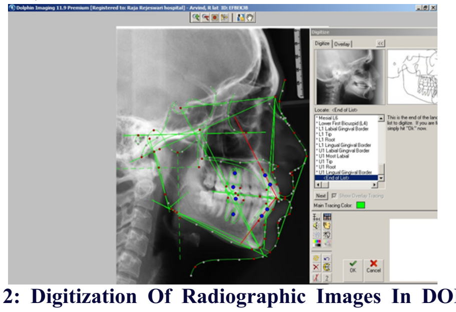
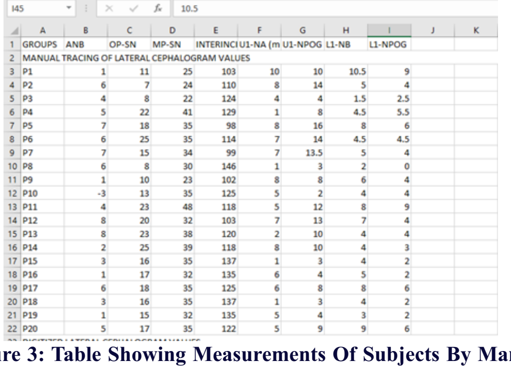


Figure 2: Digitization Of Radiographic Images In DOLPHIN Imaging(ver 11.9).



GROUPS	ANB	OP-SN	MP-SN	INTERINCI	U1-NA (m	U1-NPOG	L1-NB	L1-NPOG
MANUAL TRACING OF LATERAL CEPHALOGRAM VALUES								
P1	1	11	25	103	10	10	10.5	9
P2	6	7	24	110	8	14	5	4
P3	4	8	22	124	4	4	1.5	2.5
P4	5	22	41	129	1	8	4.5	5.5
P5	7	18	35	98	8	16	8	6
P6	6	25	35	114	7	14	4.5	4.5
P7	7	15	34	99	7	13.5	5	4
P8	6	8	30	146	1	3	2	0
P9	1	10	23	102	8	8	6	4
P10	-3	13	35	125	5	2	4	4
P11	4	23	48	118	5	12	8	9
P12	8	20	32	103	7	13	7	4
P13	8	23	38	120	2	10	4	4
P14	2	25	39	118	8	10	4	3
P15	3	16	35	137	1	3	4	2
P16	1	17	32	135	6	4	5	2
P17	6	18	35	125	6	8	8	6
P18	3	16	35	137	1	3	4	2
P19	1	15	32	135	5	4	3	2
P20	5	17	35	122	5	9	9	6

Figure 3: Table Showing Measurements Of Subjects By Manual Method.

The Parameters Measured Were As Follows:

PARAMETERS	DEFINITIONS
ANGULAR MEASUREMENTS (˚)	
ANB	Difference between SNA and SNB angles
OCCLUSAL PLANE TO SN PLANE	Angle between occlusal plane and SN plane
MANDIBULAR PLANE TO SN PLANE	Angle between mandibular plane and SN plane
INTERINCISAL ANGLE	Angle between long axis of upper incisor and long axis of lower incisor
LINEAR MEASUREMENTS	
UPPER INCISOR TO NA LINE	Linear distance between the most anterior point of the maxillary central incisor and the NA line
UPPER INCISOR TO N-POG LINE	Linear distance between the most anterior point of the maxillary central incisor and the N-POG line
LOWER INCISOR TO NB LINE	Linear distance between the most anterior point of the mandibular central incisor and the NB line
LOWER INCISOR TO N-POG LINE	Linear distance between the most anterior point of the mandibular central incisor and the N-POG line

Thus 2 sets of cephalometric measurements were taken for each patient, which are as follows:

- Measurements derived using manual tracing of the digital lateral cephalogram.
- Measurements derived from CBCT generated lateral cephalogram using Dolphin imaging software.

Statistical Analysis

Statistical Software:

The data was entered in Microsoft Excel. Thereafter; it was processed and analyzed using the Statistical Packages for Social Sciences, SPSS software version 22.

Statistical Methods:

Results of continuous measurements are presented as mean SD (Min-Max) and results of categorical measurements are presented as number (%). Significance is assessed at 5 % level of significance at 95% confident interval. One-way ANOVA was conducted to find the difference between the two groups.

RESULTS

Table 1 Shows The Comparison Of Angular Measurements Among The Two Methods. There Was No Statistically Significant Difference Seen.

Angular measurements	Manual		CBCT		F	p
	Mean	SD	Mean	SD		
ANB	4.05	2.89	4.15	2.94	0.056	0.95 Not significant
Occlusal plane to SN plane	16.35	5.62	15.37	5.35	0.418	0.66 Not significant
Mandibular plane to SN plane	33.25	6.31	33.26	6.34	0.011	0.99 Not significant
Interincisal angle	120.00	14.19	119.55	13.27	0.006	0.99 Not significant

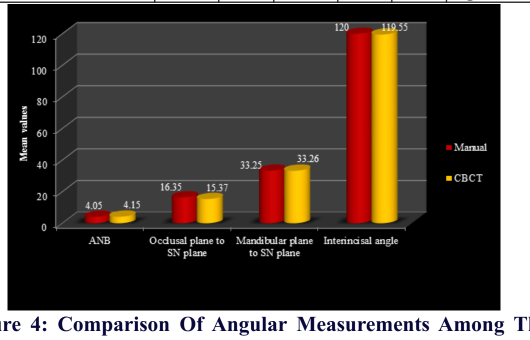


Figure 4: Comparison Of Angular Measurements Among The Three Methods

Table 2 shows the comparison of linear measurements among the two methods. There was no statistically significant difference seen.

Linear measurements	Manual		CBCT		F	P
	Mean	SD	Mean	SD		
Upper incisor to NA line	5.25	2.79	5.19	2.93	0.069	0.93 Not significant
Upper incisor to N-POG line	8.43	4.45	9.36	4.97	0.572	0.57 Not significant
Lower incisor to NB line	5.35	2.37	5.53	2.60	0.166	0.85 Not significant
Lower incisor to N-POG line	4.18	2.28	4.59	2.97	0.309	0.74 Not significant

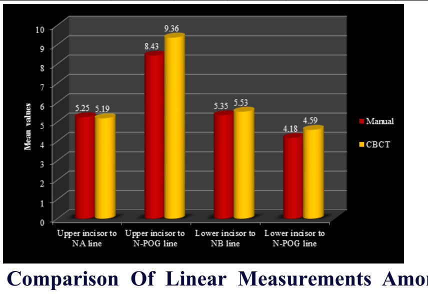


Figure 5: Comparison Of Linear Measurements Among The Three Methods

DISCUSSION

Cephalometry is a valuable tool for diagnosing skeletal imbalance and for assessing growth, response to treatment and long-term stability after orthodontic treatment. Cephalometric evaluation of patients with orthodontic needs has traditionally been performed by lateral and frontal cephalograms.[3] Conventional cephalometric analysis is performed by tracing radiographic landmarks on acetate overlays and measuring linear and angular values. Despite its widespread use in orthodontics, the technique is time-consuming and has the disadvantage of being subject to random and systematic error. The main sources of errors include technical measurements, radiographic acquisition and identifying landmarks. Most errors occur in landmark identification and are influenced by clinician experience, landmark definition, image density and sharpness. The reduction of a three-dimensional (3D) structure to a two-dimensional (2D) image adds to the difficulty.

With the rapid evolution of computer radiography, digital tracing has slowly replaced the manual tracing methods. Three techniques are commonly reported: the first uses digitizer pads for tracing conventional cephalometric films and software programs to compute the measurements; the second uses scanners or digital cameras to export cephalometric images to measurement programs; and the third transmits digital radiographs directly to a computer database. The use of both digital radiography and conversion of manual film to a digital format offers several advantages—it is easy to use, allows several analyses to be performed at a time, promises convenience when generating treatment predictions, takes up less storage space, allows superimposition of images, provides the option to manipulate the size and contrast of the image and provides the ability to archive and improve access to images to overcome the problem of film deterioration, which has been a major source of information loss in craniofacial biology. Moreover, patients benefit from reduced radiation dose and elimination of chemicals and associated environmental hazards if a direct digital cephalograph is used for image capture. However, several drawbacks are also present, such as difficulty in landmark identification related to the 2D representation of a 3D structure, superimposition of bilateral structures and the need for a digital cephalometric radiographic machine as well as a software program. Furthermore, the quality of digital images is affected by their resolution, pixel size, shades of grey (bit) and compression format.[14]

Although replacement of conventional 2D radiographs with 3D imaging appears to be a trend, CBCT is not suitable for regular, daily orthodontic patients because of its higher radiation dose than conventional radiography. The lack of 3D standard population norms has also restricted CBCT from routine orthodontic use. Since normative data for 3D CBCT volumes and new 3D paradigms are yet to be determined, it is important to evaluate the correspondence between CBCT and conventional radiography during this transitional period. If CBCT-derived cephalograms prove to be equivalent to conventional cephalograms, the radiation exposure associated with conventional radiography can be eliminated in patients for whom a CBCT scan is required for 3D imaging.

In light of this, the present study is mainly aimed at determining whether lateral cephalogram derived from a CBCT can be used as reliably as a digital lateral cephalogram, which is routinely used for orthodontic diagnosis.

In the present study the sample size consisted of 20 patients of both sexes selected according to inclusion criteria. Conventional lateral cephalograms and CBCT data were collected and scanned and converted into JPEG images. The radiographic images were then loaded onto the DOLPHIN Imaging software. The digital tracing was done using Dolphin Imaging Software Version 11.9 (Dolphin Imaging). Once captured using the software, calibration of the actual size of each image in millimetres was based on the measurement of the known distance (100 mm) between the two fixed points of the Dolphin ruler on the screen. This calibration standardized all images. Landmark identification was carried out by a single operator on digital images using a mouse-driven cursor and then stored in the Dolphin Imaging archive. A total of 54 landmarks were defined on each cephalogram (Figure 2) and 8 selected parameters (4 angular and 4 linear) were measured and saved in excel sheets. For the manual tracing measurements, the hard copy of the digital lateral cephalogram of each patient was traced manually on acetate sheet and evaluated using conventional method. The required angular and linear measurements from the manual tracing were also saved on to the excel sheet (FIG 3).

Thus 2 sets of cephalometric measurements were obtained for each patient, i.e

(1) measurements derived from manual tracing of the lateral cephalogram

(2) measurements derived from digitized CBCT generated lateral cephalogram using Dolphin imaging software.

One-way ANOVA was conducted to find the difference between the two groups. In our study when we compared the mean values of study parameters among the two groups, we found that there was statistically no significant mean difference between the parameters of both groups at p value <0.05.

A similar study was conducted by Vandana Kumar, John Ludlow, Lucia Helena Soares Cevidanes, and André Mol in 2008. They compared measurements from synthesized cone-beam computed tomography (CBCT) lateral cephalograms using orthogonal and perspective projections with those from conventional cephalometric radiographs. Thirty-one patients were imaged using CBCT and conventional cephalometry. CBCT volume data were imported in Dolphin 3D. Conventional image measurements were corrected for known magnification. Linear and angular measurements were compared between image modalities using repeated measures analysis of variance. They concluded that measurements from in vivo CBCT synthesized cephalograms are similar to those based on conventional radiographic images. Thus, additional conventional imaging may generally be avoided when CBCT scans are acquired for orthodontic diagnosis.[12]

In our study, CBCT scans were taken using SORDEX SCANORA CBCT machine which has an exposure time of 6 seconds, compared to the NEW TOM CBCT scanner which has an average exposure time of 30 to 40 seconds. Hence the subjects in our study had a significantly lower radiation exposure.

Another in-vivo study done by U Oz, K Orhan and N Abe compared the linear and angular measurements made on two-dimensional (2D) conventional cephalometric images and three-dimensional (3D) cone beam CT (CBCT) generated cephalograms derived from a 3D volumetric rendering program. 16 cephalometric landmarks were identified and 18 widely used measurements (11 linear and 7 angular) were performed by 2 independent observers. No statistical significance was found for Vista Dent OC measurements ($P > 0.05$). They concluded that measurements from in vivo CBCT-generated cephalograms from MaxilimH software were found to be similar to conventional images. Thus, owing to higher radiation exposure, CBCT examinations should only be used when the inherent 3D information could improve the outcome of treatment.[13]

In this study, they have used 3D CBCT images which are reconstructed from a volumetric rendering program for deriving the measurements from CBCT images. So, the use of three co-ordinated (x, y and z) to identify landmarks in 3D system resulted in greater error in identifying certain landmarks like Go and Me. Unlike this, in our study we have created a 2D image from the 3D CBCT for identifying the landmarks, which resulted in easier and more accurate identification of landmarks using only 2 co-ordinates (x and y).

CBCT data sets can provide undistorted 3D morphology, making it possible to identify craniofacial structures more naturally. However, landmark identification in 3D is not simple. Kumar et al stressed that, because assessment of anatomic landmarks in 3D is still under development, the transition from the 2D to the 3D analysis could be achieved by using CBCT synthesized cephalograms[2].

The results of this study are consistent with the findings published in 2005 by Nakajima et al who, after evaluating Cone-Beam CT technology, concluded that 3D images provide useful information for orthodontic diagnosis and treatment planning. Furthermore, it is relevant to mention that the measurements made by Cone-Beam Computed Tomography feature a 1:1 ratio while conventional radiography exhibits a magnification of up to 7.2%, according to Bergensen[3].

One need not, however, abandon conventional two-dimensional cephalometric measurements in moving to three-dimensional technology since 3D images can be rendered in 2D, similarly to a radiograph. Besides, cephalometric landmarks can also be traced on 3D images. According to Halazonetis, new cephalometric landmarks are likely to be introduced and many new cephalometric analyses, similar to existing two-dimensional analyses, are bound to be created.

CONCLUSION

This study was conducted on a sample of 20 patients selected from the outpatients to the Department of Orthodontics and Dentofacial Orthopaedics, Rajarajeswari Dental college & Hospital, Bangalore. This study was done to compare conventional and cone beam computed tomography-generated cephalograms.

Conventional lateral cephalograms and CBCT-generated cephalograms of 20 patients of both the sexes between age group of 15-45 years with acceptable pleasing profiles were produced. The CBCT images were loaded onto DOLPHIN Imaging software and digitized. 54 landmarks were identified, and 8 selected angular and linear measurements were taken using the software. Manual tracings of the conventional lateral cephalograms were also made and all the 8 angular and linear parameters were measured.

Statistical analyses were done using one-way ANOVA test. The results showed that none of the measurements produced statistically significant values, indicating high reproducibility of landmarks. Thus, we can conclude that CBCT generated cephalograms can successfully replace conventional cephalograms and hence, whenever a CBCT volume is already available, further radiation exposure and expense for a lateral cephalogram can be avoided. CBCT can be used to bridge the transition from 2D to 3D image analysis.

From the results obtained from this study we conclude that-

1. Linear and angular measurements from CBCT-generated cephalograms showed no statistical significance when compared to conventional lateral cephalograms.
2. Both methods of cephalometric analysis were found to be reliable.
3. CBCT generated lateral cephalogram can be used as reliably as the conventional lateral cephalogram for cephalometric evaluation.

REFERENCES:

1. Navarro RD, Oltramari-Navarro PV, Fernandes TM, Oliveira GF, Conti AC, Almeida MR, Almeida RR. Comparison of manual, digital and lateral CBCT cephalometric analyses. Journal of Applied Oral Science. 2013 Apr;21(2):167-76.
2. Cattaneo PM, Bloch CB, Calmar D, Hjortshøj M, Melsen B. Comparison between conventional and cone-beam computed tomography–generated cephalograms. Am J Orthod Dentofacial Orthop. 2008 Dec 1;134(6):798-802.
3. Couceiro CP, Vilella OD. 2D/3D Cone-Beam CT images or conventional radiography: Which is more reliable? Dental Press Journal of Orthodontics.2010;15(5):40-1.
4. Ludlow JB, Gubler M, Cevidanes L, Mol A. Precision of cephalometric landmark identification: cone-beam computed tomography vs conventional cephalometric views. American Journal of Orthodontics and Dentofacial Orthopedics. 2009 Sep 1;136(3):312-e1.
5. Trpkova B, Major P, Prasad N, Nebbe B. Cephalometric landmarks identification and reproducibility: a meta-analysis. American Journal of Orthodontics and Dentofacial Orthopedics. 1997 Aug 1;112(2):165-70.
6. Grauer D, Cevidanes LS, Styner MA, Heulfe I, Harmon ET, Zhu H, Proffit WR. Accuracy and landmark error calculation using cone-beam computed tomography–generated cephalograms. The Angle Orthodontist. 2010 Mar;80(2):286-94.
7. Mozzo P, Procacci C, Tacconi A, Martini PT, Andreis IB. A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. European radiology. 1998 Nov 1;8(9):1558-64.
8. Hilgers ML, Scarfe WC, Scheetz JP, Farman AG. Accuracy of linear temporomandibular joint measurements with cone beam computed tomography and digital cephalometric radiography. American journal of orthodontics and dentofacial orthopaedics. 2005 Dec 1;128(6):803-11.
9. Cevidanes LH, Styner MA, Proffit WR. Image analysis and superimposition of 3-dimensional cone-beam computed tomography models. American Journal of Orthodontics and Dentofacial Orthopedics. 2006 May 1;129(5):611-8.
10. Lou L, Lagravere MO, Compton S, Major PW, Flores-Mir C. Accuracy of measurements and reliability of landmark identification with computed tomography (CT) techniques in the maxillofacial area: a systematic review. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2007 Sep 1;104(3):402-11.
11. Periago DR, Scarfe WC, Moshiri M, Scheetz JP, Silveira AM, Farman AG. Linear accuracy and reliability of cone beam CT derived 3-dimensional images constructed using an orthodontic volumetric rendering program. The Angle Orthodontist. 2008 May;78(3):387-95.
12. Kumar V, Ludlow J, Soares Cevidanes LH, Mol A. In vivo comparison of conventional and cone beam CT synthesized cephalograms. Angle Orthod. 2008;78: 873-879.
13. Oz U, Orhan K, Abe N. Comparison of linear and angular measurements using two-dimensional conventional methods and three-dimensional cone beam CT images reconstructed from a volumetric rendering program in vivo. Dentomaxillofacial Radiology. 2011 Dec;40(8):492-500.
14. Albarakati SF, Kula KS, Ghoneima AA. The reliability and reproducibility of cephalometric measurements: a comparison of conventional and digital methods. Dentomaxillofacial Radiology. 2012 Jan;41(1):11-7.