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A study to assess the reliability and identification of craniofacial landmarks in CBCT generated 2D cephalograms compared to digital cephalograms

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Abstract

Introduction: Lateral cephalograms are widely used in Orthodontics as a vital tool for treatment planning in orthodontics. The projection and identification errors of cephalometric analyses determine their reliability. In this study, we sought to ascertain whether the method utilized to synthesize CBCT cephalograms affected the repeatability of the cephalometric measurements, as well as whether cephalometric measurements made on patients' CBCT-synthesized cephalograms have been comparable with measurements made on conventional cephalograms. **Methods:**CBCT-generated cephalograms along with the Conventional digital cephalograms have been selected and parameters were studied using Steiner's analysis. 7 Linear and 9 angular measurements were done. The linear and angular measurements required for different analyses were determined for cephalometric analysis software named Nemoceph (updated version 7). **Results**: The values of the 2 imaging modalities do not show any statistically significant difference. The correlation coefficient/r-value shows that both Digital cephalograms and CBCT cephalograms are highly reliable**.Conclusion:** So, we can conclude that both conventional digital lateral cephalogram and CBCT-generated cephalogram can be readily used for craniofacial landmarks identification.

KEYWORDS: Digital cephalogram, CBCT cephalogram, Landmarks.

INTRODUCTION

For orthodontic patients, a combination of research casts, extraoral as well asintraoral images, and radiographstypically consisting of cephalograms and panoramicare used to make the diagnosis and plan the course of treatment.

In order to fully understand the diagnosis as well asa treatment plan for growth prediction, stability of post-treatment, and surgical evaluation, a cephalometric radiograph is a crucial tool for orthodontic practice as well as research. In orthodontics, cephalograms have been used for more than 50 years to examine the relationship between the skeleton and teeth. The diagnostic value of radiographs is limited because they depict 3D structures as 2D images, which introduces inherent characteristics like distortion, superimposition, and magnification of the craniofacial complex's structures. In certain dental specialties, medical computed tomography (CT) was used in an effort to get around these restrictions. However, the use for orthodontic purposes was compromised due to higher cost, higherexposure toradiation, and the presence of abnormalities caused by metallic brackets, which damaged the quality of the attained image. CBCT is a new generation of tomographs designed specifically to produce images of the head and neck. The CBCT application has grown dramatically since the first pieces of equipment were introduced, particularly in orthodontics.[1]

CBCT offers a less radiation-intensive and less expensive alternative to traditional CT systems when applied to the craniofacial region.[2]
The CBCT approach has proven its worth in the dental practice when performing craniofacial measurement, overcoming the challenges posed by radiographs in recent times. It exhibits the features of interaction with the data previously seen in MSCT but at substantially low radiation dosage than MSCT. The ability to work with previously stored data is the primary benefit of tomographic scans. This allows for the creation of new images as well as the reconstruction of synthesized cephalograms which are equivalent to conventional radiographs, all from a single 3Dmeasurement. These new opportunities provided by CBCT allow for evaluations along the three aspect planes and enable a more customized inquiry into the condition of each patient.[3]
Our objectives in this research have been to ascertain whether the reproducibility of the cephalometric measurements is affected by the method used to synthesize CBCT cephalograms and whether the cephalometric measurements made on patients' CBCT-synthesized cephalograms have been comparable with measurements made on the conventional cephalograms.

MATERIALS AND METHODS –

The sample size was fifty (50) [25 Conventional digital cephalograms & 25 CBCT-generated 2D Cephalograms of the same patient collected from the department archive] for this radiographic cephalometric study.
After receiving institutional ethics approval, the study was launched. The present study, a cephalometric radiography investigation, was conducted between 2015 and 2016 at the Guru Nanak Institute of Dental Sciences and Research Center of Panihati. It fulfills the exclusion and inclusion criteria for the research. Fifty lateral cephalograms of patients prior to treatment have been acquired by the departmental archive's cephalometric database. The same digital cephalostat was used to capture each cephalogram that was obtained. X-Mind PANOD.The CBCT images were taken from the CBCT machine [My ray sky view]. CBCT (Myray "Blue Sky Machine, Variable-Field, Conical, 90 Kvp, H.R. Zoom, Pulsed Emission, 10 Ma(max)) Nnt Viewer"software was given in the patient's DVD drive by which CBCT synthesized lateral cephalometric image can be produced. Frankfort's horizontal plane has been positioned parallel to floor in digital cephalometric images. The following criteria were used to select the sample:
1.Patients indicated for CBCT for diagnostic purposes.
2. High-quality digital cephalograms taken for pretreatment record.
3.Cephalograms with prominent soft tissue outline.
The exclusion criteria of sample selection were –
1.Patients who had previous orthodontic treatment,extractionhistory of systemic diseasegross facial asymmetry, or craniofacial anomalies.
2.Conventional cephalograms from analogue machine.
3.Enlargement of image on conventional digital cephalogram more than 2%.
4.Clarity of the film was compromised.
Images from CBCT-generated cephalograms as well as traditional digital cephalograms were stored on a desktop. After opening digital imaging software Nemoceph first a new patient ID was created. Then start image capture option was clicked on the Nemoceph software page. The image capture was done from that folder. The configuration of the image type was done. Next the start tracing option was clicked. Thereafter the image calibration option was clicked. Afterthat automatically different landmark identification options came. Different landmarks were identified by a single observer and the finish tracing option was clicked. Arbitrary diagrams or drawings of soft tissue and hard tissue come automatically and can be modified or adjusted according to need. Finally,the save the tracing option was clicked after the drawing adjustment. Then parameters for Steiner's analysis were clicked different values came. Finally, save the parameters and store themon the desktop.
For single patient's soft copy images of digital cephalogram were traced 5 times by a single operator at different time intervals. Similarly soft copy images of CBCT-generated cephalograms were also traced 5 times. Both tracing parameters were compared by statistical data analysis to find out any significant difference present or not between the two types of imaging modality.
Landmarks used to measure angles and lines were Sella, Nasion, Point A, Point B, Gonion, and Gnathion,which are used in Steiner analysis.
Parameters were studied using 7 Linear and 9 angular measurements have been made. They were as follows - 1."SNA[angle], 2.SNB[angle], 3. SND[angle], 4. ANB[angle], 5.Posterior condylion to SN[mm], 6.Pog to SN[mm], 7.Occl to SN[angle], 8.GoGn to SN[angle], 9.U1 to NA[mm], 10.L1 to NB[mm], 11.Pog to NB[mm], 12.U1 to L1[angle], 13.U1 to NA[angle], 14.L1 to NB[angle]", 15.Upper lip[mm], 16.Lower lip[mm]

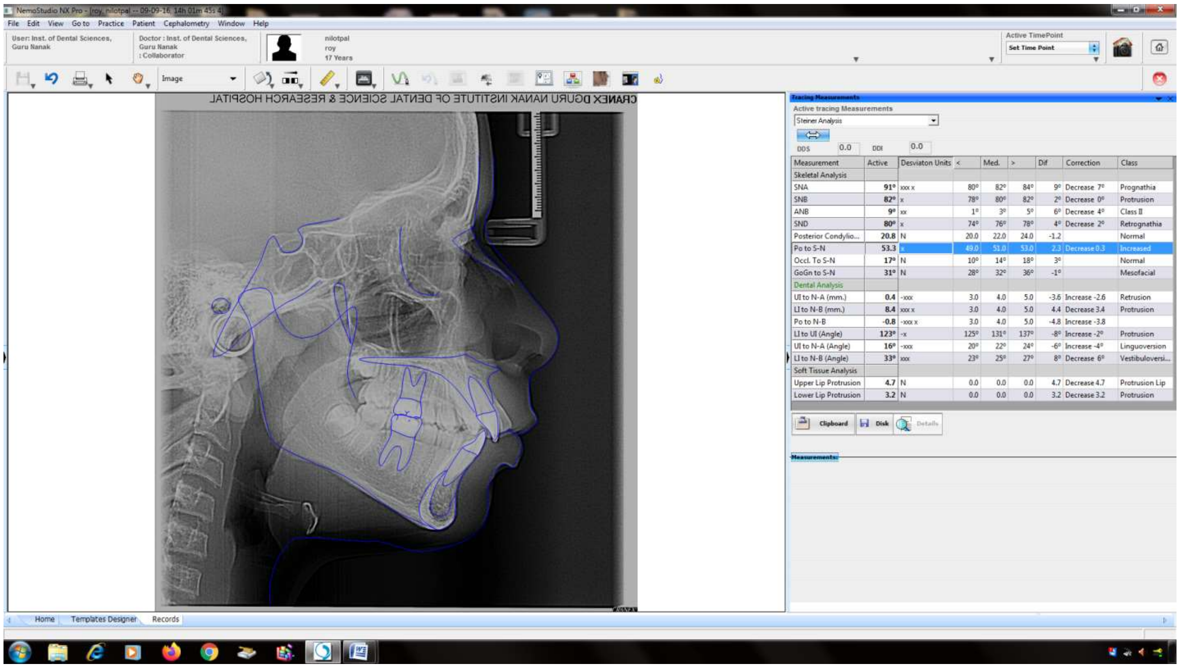
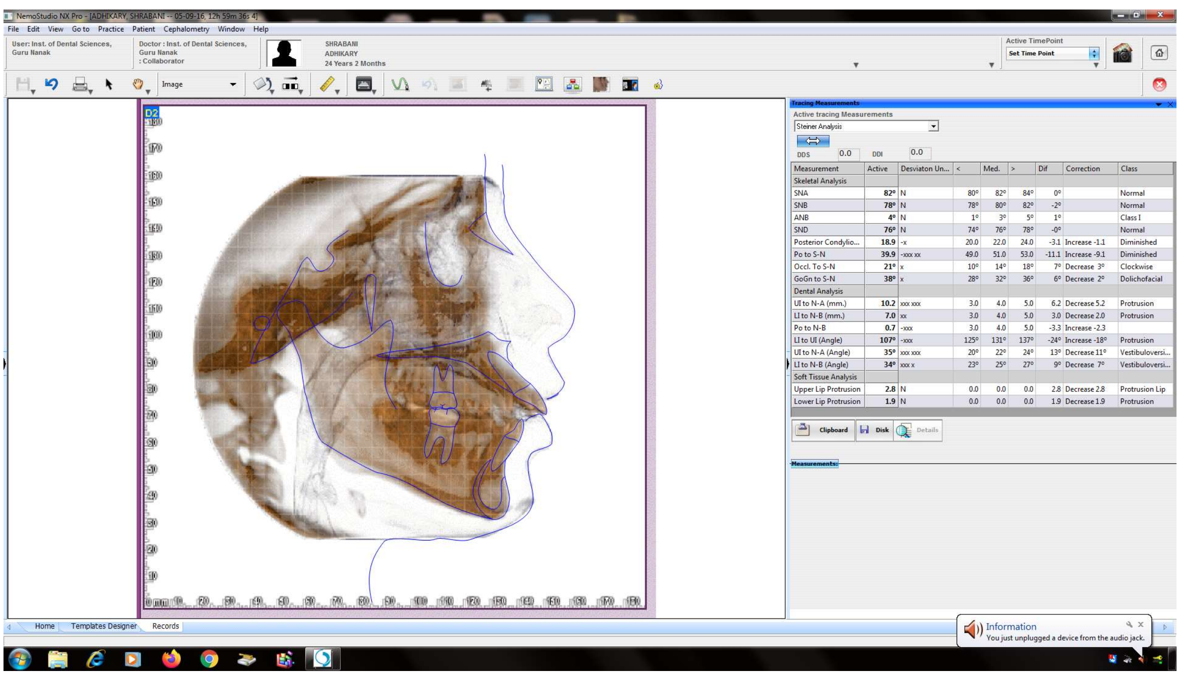


Figure 1- Digital cephalogram with Steiner analysis

Figure 2 - CBCT generated cephalogram with Steiner analysis



STATISTICAL ANALYSIS

A cross-sectional study was conducted and traced by Nemo ceph updated version 7. Then 9 angular and 7 linear measurements were doneand values were analyzed by data analysis.

Data have been registered into a Microsoft Excel spreadsheet for statistical analysis, and GraphPad Prism version 5 and SPSS 20.0.1 were used for further analysis.Numerical variables that were normally distributed have been compared by utilizing the student's independent sample t-test.One-tailed or two-tailed tests can be performed using each of these statistics. Following the determination of the t-value, the p-value can be determined by referring to a table that contains values derived from the t-distribution of Student. If the computed p-value is lower than the threshold selected for the “statistical significance, that is typically the 0.10, 0.05, or 0.01 level, then the alternative hypothesis is accepted, and the null hypothesis has been rejected”. This is the case when the null hypothesis is rejected. A statistically significant p-value was defined as ≤ 0.05.

RESULTS

The present researchoutcomes demonstrate that there has been no statistically significant variationamong the 2 imaging modalities' seven linear and nine angular measurements.The angular measurements don’t depict any statistical significance.The angular and linear measurements (mm) from the 2 categories of imaging modalities are not statistically significantly various (p>0.05), as Table 2 demonstrates.

Table 1. Linear measurements & angular measurements by the 2 imaging modalities (mm & degree)

Variables	Conventional	CBCT	T-statistics	p-value	r -value
1.SNA[angle]	82.24±3.67	81.16±3.19	0.0821	0.9349	0.8967
2.SNB[angle]	78.68± 3.99	78.92±3.40	0.2286	0.820	0.935
3.ANB[angle]	3.24±2.04	3.12±2.10	0.2042	0.8391	0.9104
4.SND[angle]	75.68±3.87	75.96±3.49	0.268	0.789	0.9143
5.Posterior condylion to SN[mm]	26.25±7.91	23.32±8.01	2.853	0.874	0.808
6. Pog to SN[mm]	46.68±8.66	42.44±6.25	1.515	0.0662	0.725
7.Occl - SN[angle]	18.96±3.82	19.64±3.86	0.625	0.5345	0.9021
8.GoGn - SN[angle]	29.76±6.55	29.64±6.92	0.0629	0.9501	0.969
9.U1 - NA[mm]	8.96±3.86	8.76±3.69	0.1945	0.8466	0.9741
10.L1 - NB[mm	5.78±2.61	5.63±3.04	0.1810	0.8572	0.897
11.Pog - NB[mm]	2.61±2.12	2.28±1.90	0.5811	0.5639	0.8983
12.U1 - L1 angle	120.76±5.23	119.24±4.64	0.4126	0.681	0.976
13.U1 to NA angle	31.32±9.81	30.84±9.34	0.176	0.865	0.965
14.L1 to NB angle	5.78± 2.61	5.63±3.85	0.181	0.857	0.897
15.Upper lip[mm]	1.56±0=4.38	1.78±4.56	0.453	0.675	0.785
16.Lower lip[mm]	1.49±2.68	1.67±3.57	0.176	0.453	0.563

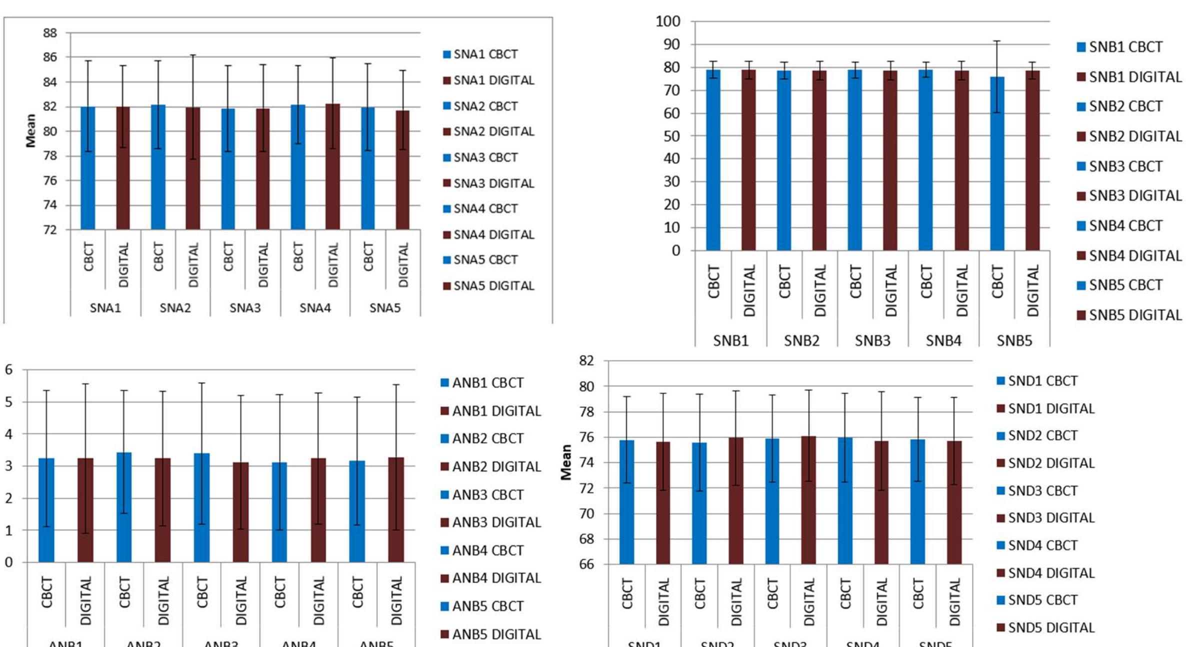


Figure3: Graphical representation of different parameters like SNA, SNB, ANB, SND.

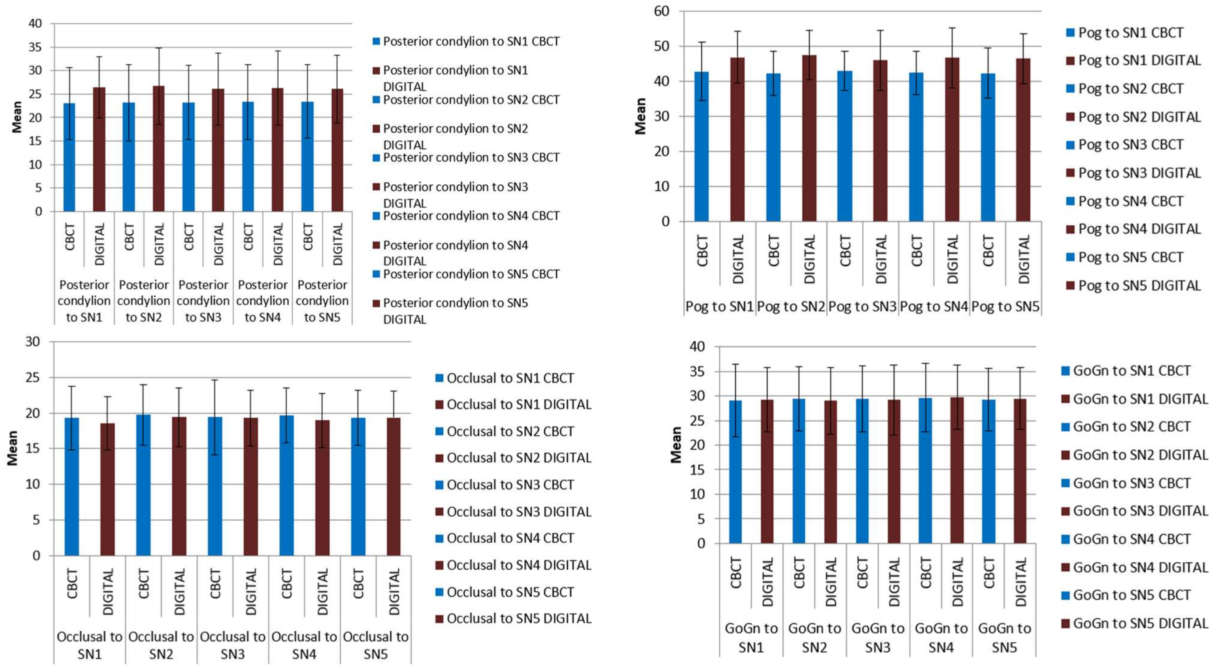


Figure4: Graphical representation of different parameters like Posterior Condylion to SN, Pog to SN, Occlusal to SN, GoGn to SN.

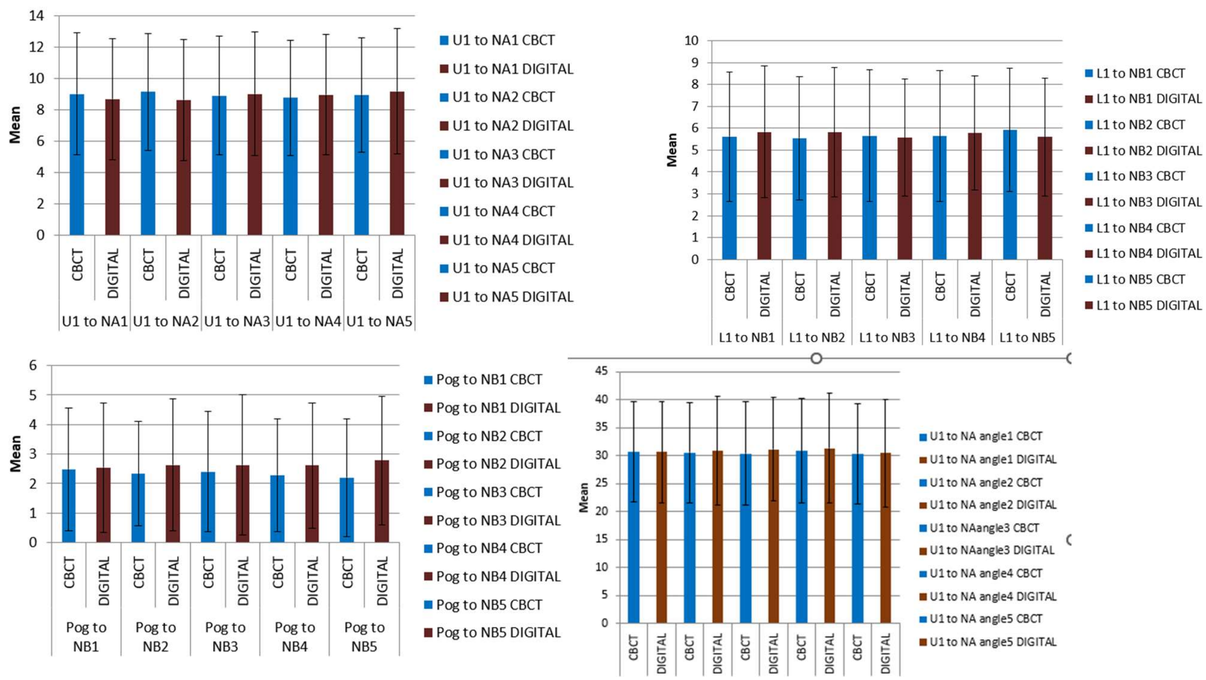


Figure5: Graphical representation of different parameters like U1 to NA, L1 to NB, Pog to NB, U1 to NA.

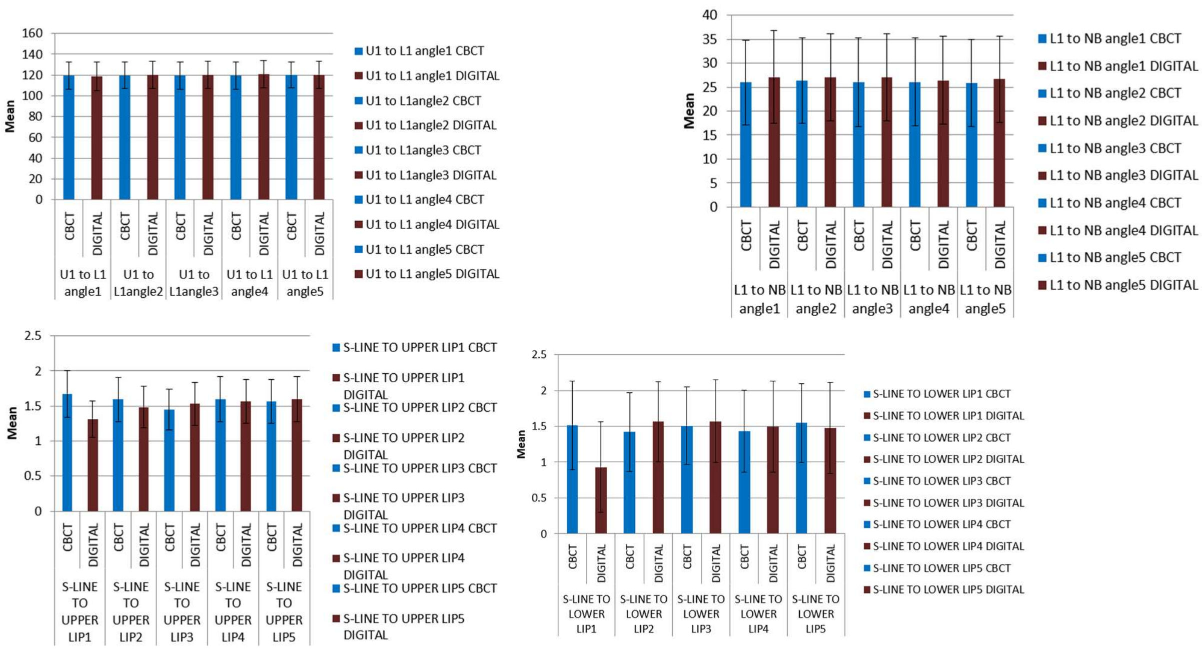


Figure6: Graphical representation of different parameters like U1 to L1, L1 to NB, S line to Upper Lip, S line to Lower Lip.

25 Digital cephalograms and 25 CBCT generated cephalograms are traced. For single patients both digital and CBCT generated cephalograms are traced for 5 times. The p value was found for all linear and angular values which was greater than 0.05(as p –value choosen ≤ 0.05 was considered for statistically significant) and it signifies that the two values for digital cephalogram and CBCT generated cephalogram were not statistically significant . Finally, we can tell in each observation there was no statistically significant difference between two imaging modalities**. Correlation coefficient r-value showsthat both Digital cephalograms and CBCT cephalograms indicate reliable.**

DISCUSSION

Measurement reproducibility is an important component of cephalometric analyses because it demonstrates that the examiner performed satisfactorily in identifying anatomical landmarks. The current study set out to evaluate how well various imaging modalities performed based on the information given by a qualified and certified examiner.

One major problem with cephalometric analysis is the error in landmark identification. According to Chen et al. [12], it is impossible to estimate landmark locations error-free. Since landmark identification errors are the primary cause of tracing errors in cephalometric measurements, efforts should be made to reduce their impact. A number of variables influence how reliable landmark identification is:

1. Cephalometric landmarks nature.
2. Images sharpness and density.
3. Anatomic superimposition and complexity of soft and hard tissues.
4. landmark definition.
5. And training level or experience of the observers.

Analysing the accuracy of linear measurements has been attained by CBCT-NewTom was the focus of a 2004 study by CA Lascala [21] et al. They discovered that the majority of the anatomical locations chosen for this study are outside of the dent maxillofacial region, which is contrary to expectations that this would be a more accurate way to assess the CBCT scanner's accuracy across the entire skull. In actuality, the measurements by the images of CBCT were statistically similar to the actual measurements across the facial area anatomical sites that have been analyzed. The findings demonstrated that actual distances measured on dehydrated skulls were consistently greater than those deduced from CBCT scans. These variations, however, were only noteworthy when comparing measurements between the base of the skull structures—not between other dent maxillofacial structures.

However, the cephalometric analysis could be carried out on CBCT-synthesized cephalograms when more information is needed, like for patients having dental resorption, affected teeth, or surgical planning, where a scan CBCT is necessary.

The superimposition of conventional digital as well as CBCT-derived cephalograms should account for the identification error along with the systemic variations in positions of landmark. We identified the relative contributions of numerous variables which influence landmark identification errors using the generalized estimating equation approach.

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CONCLUSION

In summary, there were no discernible differences in the diagnostic performance and measurement reproducibility between conventional cephalograms and those created using CBCT-synthesized cephalograms.

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