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RELIABILITY OF CONE BEAM COMPUTED TOMOGRAPHY – DERIVED SOFT TISSUE MEASUREMENTS IN ORTHODONTICS: A RETROSPECTIVE STUDY

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KEYWORDS

Cone beam computed tomography,
Lateral cephalometry,
Soft tissue.

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ABSTRACT

Introduction: Recently, there are many investigations in a trail to shift from the direct three- dimensional image to CBCT derived cephalometric image takes place. It is important to investigate whether it is possible to use a CBCT derived cephalometric image to direct three-dimensional image, by comparing the angle and linear measurements of soft tissue structures assessed from a midsagittal projection using 3D cone-beam computed tomography (CBCT) compared with those evaluated through derived lateral cephalometric imaging. **Aim**: to evaluate the dependability and reliability of soft tissue orthodontic measurements acquired from derived cone beam computed tomography (CBCT). **Materials and Methods:** Forty CBCT scans; from the archive of Oral Radiology department Suez Canal University, Ismailia, Egypt, were used. Landmark identification carried out using OnDemand3DApp program (cybermed Inc., Seoul, Korea) imaging software. Ten linear ratios and five angles were measured three times. Independent T-test used in this study to analyze the distinctions between two imaging modalities (direct CBCT and derived images at a significant level of probability (*P*£0.05). **Results**: There were no statistically significant differences were found between the direct CBCT and the derived imaging types in all measurements assessed, with the exception of the upper lip in reference to the E-line, which demonstrated a highly significant result. **Conclusion***:* The derived CBCT can be considered a reliable approach for creating a database of facial soft tissue and can be utilized as a substitute for traditional lateral cephalograms when the patient's CBCT is already available, thereby minimizing the patient's exposure to radiation.

INTRODUCTION

Lateral cephalometric radiography serves as a crucial diagnostic tool in orthodontic assessment, enabling the evaluation of both hard and soft tissues in the head and teeth. Cephalometric analysis is traditionally performed on skull lateral tele-radiographs for orthodontic diagnosis and treatment planning. Over the past three decades, diagnostic imaging technology has undergone a significant transformation. The advent of three-dimensional imaging allows for visualization of subjects in multiple planes, moving beyond the limitations of traditional two-dimensional assessments [(1)]. CBCT has changed the way dentistry practiced since 1988. This technique is an important method that

accurately assesses the skeletal structures in the craniofacial area using a 1:1 image scale, without any magnification However, it is of limited value in the assessment of soft tissue facial characteristics[2,3].

Facial esthetics is considered an important factor with regard to the perceptions of society and individuals in relation to themselves. The soft tissue analysis is used as a reliable guide for orthodontic treatment and soft tissue changes hence, reaching the final decision of the treatment plan [4]. The nasolabial angle and the angle of the upper lip indicate the positioning of the upper incisor as well as the thickness of the soft tissue that covers these teeth. The evaluation of these angles is crucial for assessing the upper lip and can play a significant role in making extraction decisions [5].

Recently, conventional radiographic projections can be derived from CBCT volume data, and traditional lateral cephalometric analysis can be done on these derived views with similar precision and accuracy to extract soft-tissue measurements better compared with the reproducibility of those of conventional lateral cephalometric radiographs are thus appropriate for longitudinal studies. [6]

This research aims to evaluate the dependability and reliability of soft tissue orthodontic measurements acquired from derived cone beam computed tomography.

MATERIALS AND METHODS

This work was approved by the Research Ethics Committee of faculty of Dentistry, Suez Canal University coded 362/2021.

Forty patients were chosen randomly with all types of jaw relationship. These subjects were with an average age of 18-30 years with average 24.1± 4.7 years. Cone beam CT images were acquired using SCANORA 3DX, Model:SBR3D-2, Manufacturer is SOREDEX, Country Finland, manufacturing year: June 2013, with 230-240V~50/60Hz (1A continuous) having total filtration min.2.7mm Al 85 KV and magnification 0.5mm. Fifteen widely used cephalometric variables; ten linear ratios and five angles. These selected landmarks representative members of soft tissue component of craniofacial form and they had previously been demonstrated to have acceptable level of reliability. (Table 1). Radiographic images were traced digitally by **OnDemand3DAp** version 1.0.9.2469. Each image was traced three times. The quality of the derived images was enhanced through the scanner program. The chosen measurements encompassed both the vertical and anteroposterior aspects of the craniofacial structure. Ten linear and five angular soft tissue variables were measured (**Table 1 and Figure 1**).

Table (1) *Ten linear and five angular soft tissue variables*

Angular Measurements	Linear Measurements
1. Facial profile angle.	1. Nasal projection.
2. Naso-labial angle.	2. Upper lip length
3. Naso-facial angle	3. Upper lip thickness
4. Facial convexity.	4. Upper lip prominence
5. H-angel	5. Maxillary prognathism
	6. Lower lip prominence
	7. Mandibular prognathism
	8. Anterior labial gap
	9. E-line (upper lip)
	10. E-line (lower lip)

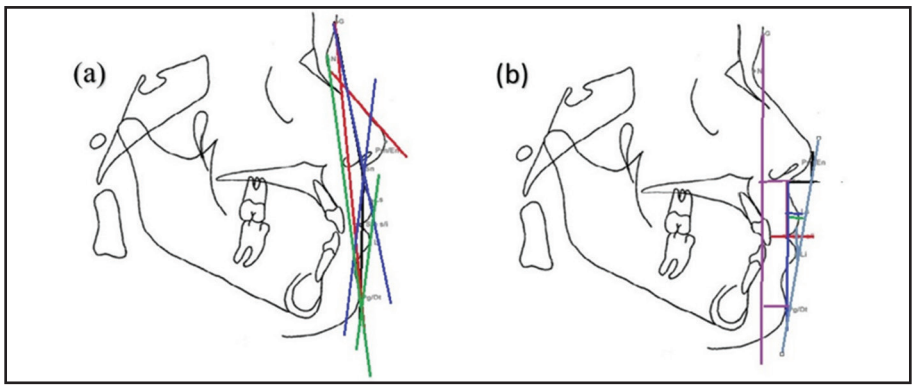

Fig. (1) (a) Angular measurements and (b) Linear measurements

Statistical analysis

All statistical analyses were conducted using the standard software package SPSS version 20, based in Chicago, Illinois, USA. Independent T-test was used in this study to compare measurement differences in two imaging modalities (direct CBCT and derived) images at a significant level of probability (P£0.05).

Intra-observer reliability

To evaluate intra examiner reliability, a selected measurement (Nasolabial angle) of a randomly 8 sample subjects; three readings; was re-measured by the same examiner (the candidate). Reproducibility of measurements was assessed by statically analyzing the difference between triple (Nasolabial angle) measurements. So, the accuracy of the measurements was determined by the following equation:

$$(Sx) = Std.Dev/\sqrt{(n)}$$

Where Sx = error of the measurement

Std.Dev.= standard deviation

n =number of measurements

$(Sx) = 1.18/\sqrt{(8)}$

$1.18/2.82 = 0.417$

Table (2) *Readings of nasolabial angle of 8 samples from direct CBCT:*

	Nasolabial angle Reading 1	Nasolabial angle Reading 2	Nasolabial angle Reading 3	Mean	±SD
Case 1	99.7	103.6	103.8	102.37	2.31
Case 4	105.6	105.3	105.5	105.47	0.15
Case 6	88.0	88.0	86.0	87.33	1.15
Case 9	90.4	92.1	86.9	89.80	2.65
Case 11	92.2	93.4	92.5	92.70	0.62
Case 15	102.7	100.9	103.2	102.27	1.21
Case 20	118.0	116.7	117.3	117.33	0.65
Case 30	99.8	101.2	100.6	100.53	0.70
		Total for 8 cases		**99.72**	**1.18**

RESULTS

Table 3 and figure 2 shows the statistical analysis of the comparison between soft tissue linear measurements from direct CBCT and derived images. The independent sample t-test conducted at a significance level of 0.05 (P≤0.05) revealed no statistically significant differences among the direct CBCT and derived imaging types across all measurements, with the exception of the upper lip in relation to the E-line, which demonstrated a highly significant result. For the soft tissue angular measurements There are no statistically significant differences between the direct CBCT and derived imaging using the independent sample t-test at a significant level of probability (p£ 0.05).

Table (3) *Comparison between soft tissue linear and angular measurements between direct CBCT and derived CBCT*

Variables	Direct CBCT		Derived CBCT		P value	Significance
	Mean	SD□	Mean	SD□		
UL with E line	-1.32	2.80	-1.36	3.03	0.000	S
LL with E line	0.41	3.36	0.64	3.45	0.763	NS
ULP	6.38	3.01	6.46	3.10	0.901	NS
LLP	6.67	2.43	6.78	2.43	0.838	NS
MAX (Pro)	13.69	6.71	13.79	6.53	0.900	NS
MAN (pro)	11.30	10.17	10.95	9.90	0.882	NS
ULL	18.65	2.95	19.01	2.99	0.582	NS
ULT	5.01	1.50	4.93	1.53	0.824	NS
AL(Gap)	5.83	1.88	5.88	1.96	0.918	NS
NASAL (PRO)	13.57	2.45	13.71	2.30	0.822	NS
Naso facial	37.08	4.48	36.66	4.17	0.665	NS
Facial Profile	164.65	6.89	163.90	6.99	0.619	NS
Nasolabial	102.43	16.61	99.77	7.81	0.842	NS
H (angle)	19.92	4.93	20.34	5.73	0.738	NS
(conv)	15.41	6.57	15.87	6.53	0.756	NS

SD= Standard Deviation t-test (p£0.05) NS=Non-significant S= Significant n=40

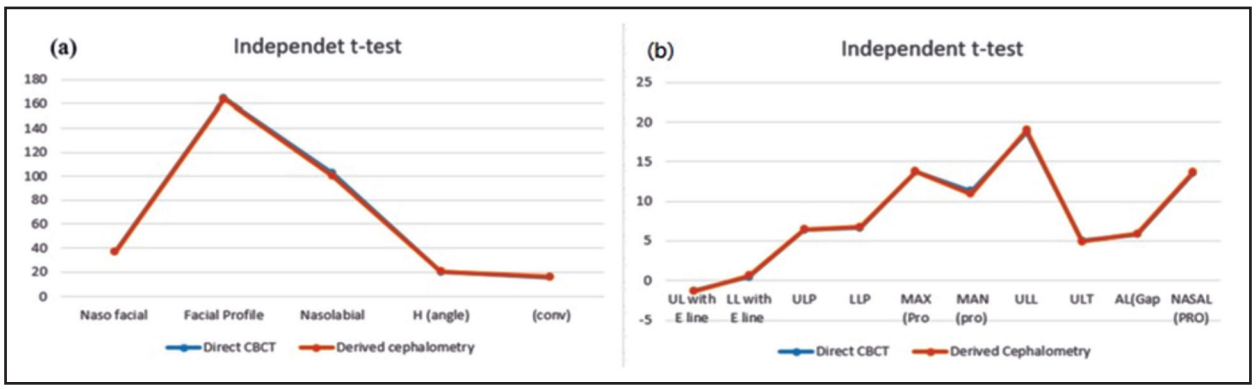

Fig. (2) Comparison between direct CBCT & derived CBCT linear and angular measurements: In- dependent t-test (a) linear chart for linear measurements, (b) linear chart for angular measurements

DISCUSSION

Facial soft tissue evaluation holds significant importance in the context of orthodontic patient diagnosis. For correct orthodontic diagnosis and understanding the facial characteristics of any orthodontic patient. It is essential to understand the average characteristics of facial soft tissues in specific regions of the face. This requires establishing the database of soft tissue in relation to gender, age, ethnicity, race and weight **Starbuck *et al.*** [7]

Recently, there is movement from traditional 2D cephalometric analysis to new 3D cephalometric techniques. The introduction of CBCT in the orthodontic field and oral and maxillofacial surgery delivers an accurate photorealistic digital 3D depiction of a patient's facial features. The resulting data is helpful as a diagnostic tool, for preoperative planning, postoperative evaluation and communication with patients **Maal *et al.*** [8]. Due to advancements in X-ray technology, digital radiology has gained significant importance and is now routinely employed in orthodontic diagnosis. CBCT derived cephalograms are considered the most recent efficacy of the soft wares introduced in the field of CBCT technology. Hence, CBCT-synthesized images can successfully replace direct CBCT image? The objective of this study was to assess the reliability of derived CBCT soft tissue orthodontic measurements. In practice, a high level of accuracy is needed to use 3D image-based measurements. A selected fifteen widely used cephalometric variables (Table1) were observed in the resulting measurements between cephalometric images directly from CBCT datasets and derived cephalometric radiographs. The current study proved the non-significance of all linear and angular measurements between the two modalities except for only one linear measurement (upper lip with E-line) was significant at the 95% level of confidence (Table 3).

The only significant linear measurement; upper lip with E-line; measurement (Table 2) could be explained by: 1. variation in upper lip due to patient's lip was not relaxed during imaging, short upper lip and thickness of vermillion boarder. 2. measuring might be not accurate due to lack of cases number selected and increased variation between the selected cases. 3. Error in defining the parameters in 3DonDemand software could be considered as a possible factor. 4. **Fourie et al**.[9] It was clarified that variations in voxel size can impact the image resolution, and this resolution's effect on further analysis may affect the reproducibility and precision of measurements. 5. Artifacts arise from a variety of sources and can diminish the quality of CBCT images to different extents **Sinha *et al*.**[10] Regarding the nasolabial angle, the results of the present study; the angle is in agreement with the results of **Xu *et al.***[11] " non-significant" who explained many factors that could the affect the reading of this angle as the length of philtrum crest on both sides, width of mouth and may be affected by head position and facial expression at the process of image acquisition. The non-significance of the measurements can be explained as there is no differences between the measurements of the two approaches. Meaning that they are very close to each other with no obvious difference in the measurements. This can consider the captured CBCT is reliable approach. In day to day practice, CBCT imaging is essential imaging modality to know the effective use of this technology. It is necessary to know the advantages as well as its limitations. The newer technology with artifact reducing software and with high definition has reduced all these limitations. As technological advancements progress, we can anticipate improved imaging that will contribute to more accurate diagnoses.

CONCLUSION

Based on the methodology used and the results gained from the current study, the following conclusions were reached out:

- The derived CBCT is regarded as a dependable method for establishing a database of facial soft tissue.
- Images obtained from Cone Beam Computed Tomography (CBCT) can serve as a viable alternative for soft tissue analysis in place of traditional cephalometric images, particularly when the patient's CBCT data is already accessible, thereby minimizing the patient's radiation exposure.
- It may be regarded as more dependable than traditional lateral cephalograms

Limitations

The restricted number of patients available during the study period prevented us from conducting the research on a larger sample size. Additional validation using patient data will be necessary to establish the reliability of the CBCT synthesized cephalograms

RECOMMENDATIONS

The recommendations of the present study are: Given that the involved landmarks in light of the lateral soft tissue findings in the present study, it is advisable to conduct further research to identify additional landmarks that can enhance the reliability of 3D cephalometric analysis derived from CBCT images

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