Original Article

SNA and SNB Measurements: A Comparative Assessment between Measurements in Conventional 2D Cephalogram and 3D Cone-Beam Computed Tomography-Generated Values

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Abstract

Background: The aim of the investigation was to clearly locate subspinale (point A) and supramentale (point B) on three-dimensional (3D) cone-beam computed tomography (CBCT) images and to compare the angular and linear measurements that are dependent on these anatomic landmarks with two-dimensional (2D) manual and digital cephalometric tracings. **Materials and Methods:** A sample of 30 North Indian subjects between 13 and 22 years of age who required CBCT imaging for treatment planning was taken. For each patient, standardized film and digital cephalograms were taken. Standardized head positioning was done for CBCT imaging. The following four groups were evaluated for statistical analysis: Group 1: Dolphin, Group 2: CBCT, Group 3: Manual tracing 1, and Group 4: Manual tracing 2. Analysis of variance was applied to find out the differences in parameters among groups. **Results:** The results showed that the differences between most of the measurements derived from the landmarks identified on film and digital 2D cephalometric radiographs compared with CBCT-derived cephalograms were statistically significant. Point A, which is difficult to locate on 2D cephalograms, could be identified and measured accurately and more reliably on 3D CBCT-generated cephalograms. **Conclusion:** 3D CBCT-generated cephalograms can be successfully used for accurate and reliable cephalometric analyses.

Keywords: Cephalogram, CBCT, subspinale, supramentale

Introduction

In orthodontics, diagnosis is of an anatomic or morphologic nature because dentofacial anomalies that concern the orthodontist are, in their final analysis, deviations from an accepted anatomic norm. These anatomic deviations may be pathognomonic of, or sequelae to certain local and general bodily disturbances of prenatal or postnatal origin, or both.[1] Two-dimensional (2D) cephalometric measurements from lateral and frontal cephalograms have been widely studied, since the advent of cephalometrics by Broadbent[2] and Hofrath[3] in 1931. Since the development of cephalometric radiology, numerous cephalometric analyses have been proposed. Nevertheless, a cephalometric analysis is a 2D representation of a three-dimensional (3D) structure. Thus, these measurements on radiographic images are subject to projection and/or measurement errors, and personal variations.[4]

Craniometric landmarks are easily distinguishable in skulls but not in cephalograms. Wrong identification of the landmarks may lead to wrong measurements of variables, both angular and linear, which are dependent on those landmarks. This may result in an error in the

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diagnostic or prognostic values of 2D cephalograms. In contrast, cone-beam computed tomography (CBCT) gives a 3D image of a 3D bony and soft-tissue structure, which has a better definition of edges and borders, which leads to more accurate diagnostic value.[5]

The SNA and SNB angles have long been recognized as informative indicators of upper and lower facial prognathism and as useful guides in the diagnosis and treatment of malocclusion. As such, these angles play fundamental roles in a number of cephalometric analyses, such as those proposed by Riedel and Steiner. It is therefore of considerable interest to determine normative values for these variables.[6] Previous *in vitro* studies on dry skulls suggested that measurements from CBCT-synthesized cephalograms are different from those of conventional cephalograms.[7] The purpose of this study was to determine whether CBCT-synthesized cephalograms provide the same measurements as conventional cephalograms or there is a statistically significant difference when applied to patients.

Materials and Methods

North Indian subjects, 15 females and 15 males, between 13 and 22 years of age who required cephalometric radiographs at the Department of Orthodontics and Dentofacial Orthopaedics in Rajasthan University of Health Sciences, College of Dental Sciences, Jaipur, were selected for the study.

Inclusion criteria

1. Those subjects who required orthodontic treatment and for which lateral cephalogram and CBCT were required for orthodontic diagnosis and treatment planning
2. No history of prior orthodontic treatment
3. No massive intraoral metal restoration or implant.

Exclusion criteria

1. Obese subjects whose excess soft tissue could interfere with locating anatomic points
2. Subjects with facial asymmetry whose landmarks could introduce variations due to the differences between the two non-midline structures
3. Subjects with known craniofacial defects that would confound landmark identification
4. Patients who underwent orthognathic surgery
5. Teeth with periodontal defects.

All procedures performed in the study were conducted in accordance with the ethics standards given in 1964 Declaration of Helsinki, as revised in 2013. The study proposal was submitted for approval and clearance was obtained from the ethical committee of our institution. A written informed consent was obtained from each participant.

Two lateral head radiographs (film and digital) and a 3D CBCT image were obtained and used for each subject in the present study. The manual tracings were done and measured by two observers and digital cephalometric measurements were done by the software program Dolphin Imaging 11.5. To analyze the measurements statistically, the data were grouped as follows: Group 1: Dolphin, Group 2: CBCT, Group 3: Manual tracing 1, and Group 4: Manual tracing 2.

Two linear (maxillary incisor to NA or UI-NA and mandibular incisor to NB or LI-NB in mm) and five angular (SNA, SNB, ANB, UI-NA, and LI-NB in degrees) hard-tissue parameters proposed by Steiner were measured in the present study after identification of appropriate landmarks. In addition, two linear measurements—upper incisor root apex to point A (UIRT-A) and lower incisor root apex to point B (LIRT-B)—were performed in a horizontal axis, 7° clockwise directed to the Sella-Nasion (SN) plane. CBCT scans were taken using Carestream CS9300 imaging system (CS 3D Imaging v. 3.5.7; Carestream Health, Inc.) using FOV of 17 × 11 cm. Image volume was reconstructed with isotropic isometric 300 × 300 × 300 μm voxels. The tube voltage ranged from 60 to 90 kVp, tube current was 4 mA, and an exposure time of 11.30 s was used.

The data were analyzed using SPSS v. 20 software (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 20.0, Armonk, NY, USA). Analysis of variance test was performed for the comparisons of the mean values of the variables among the four groups, and $P < 0.05$ was considered statistically significant.

Results

The results are summarized in Table 1. There were statistically significant differences among the mean values of the parameters among different groups ($P < 0.05$). For mean values of SNA angle, the highest mean difference (2.02°) was found to be between the CBCT and Manual tracing 2 groups. For SNB angle, the difference between the Dolphin and CBCT groups was 0.24°, which was the highest. For mean values of ANB angle, the highest mean difference was found between the CBCT and Manual tracing 2 groups (1.23°). In the case of U1-NA (°), the highest mean difference was between the CBCT and Manual tracing 1 groups (2.30°). For UI-NA (mm), the highest mean difference was between the Dolphin and Manual tracing 2 groups (1.24 mm). In the case of LI-NB (°), the highest mean difference was between the CBCT and Manual tracing 2 groups (0.94°). For the mean values of LI-NB (mm), the highest mean difference was between the Dolphin and Manual tracing 2 groups (1.23°). In the case of UIRT-A (mm), the highest mean difference was between the CBCT and Manual tracing 2 groups (1.00 mm). For LIRT-B (mm), the highest mean difference was

Table 1: Comparison of the parameters between the groups

Parameters	Groups	Mean	SD	95% confidence interval		*P*
				Lower	Upper	
SNA	Dolphin	82.00	4.610	79.63	84.37	<0.05
	CBCT	83.18	4.319	80.96	85.40	
	Manual tracing 1	81.71	4.607	79.34	84.07	
	Manual tracing 2	81.16	5.141	78.30	83.58	
SNB	Dolphin	78.29	4.370	76.05	80.54	<0.05
	CBCT	78.53	4.652	76.14	80.92	
	Manual tracing 1	78.41	4.900	75.89	80.93	
	Manual tracing 2	78.31	4.876	75.32	80.33	
ANB	Dolphin	3.47	4.418	1.20	5.74	<0.05
	CBCT	4.47	4.200	2.31	6.63	
	Manual tracing 1	3.29	4.150	1.16	5.43	
	Manual tracing 2	3.24	4.070	1.14	5.33	
U1-NA (°)	Dolphin	26.29	12.444	19.90	32.69	<0.05
	CBCT	24.41	12.445	18.01	30.81	
	Manual tracing 1	26.71	11.931	20.57	32.84	
	Manual tracing 2	25.29	13.801	18.20	32.39	
U1-NA (mm)	Dolphin	5.35	3.999	3.30	7.41	<0.05
	CBCT	5.65	4.527	3.32	7.97	
	Manual tracing 1	6.18	5.211	3.50	8.86	
	Manual tracing 2	6.59	5.624	3.70	9.48	
L1-NB (°)	Dolphin	25.72	8.870	20.50	29.62	<0.05
	CBCT	25.53	9.348	20.72	30.34	
	Manual tracing 1	26.29	10.367	20.96	31.62	
	Manual tracing 2	26.47	9.408	21.63	31.31	
L1-NB (mm)	Dolphin	5.06	3.508	3.25	6.86	<0.05
	CBCT	5.76	3.993	3.71	7.82	
	Manual tracing 1	6.24	4.265	4.04	8.43	
	Manual tracing 2	6.29	4.327	4.07	8.52	
UIRT-A (mm)	Dolphin	3.18	1.185	2.57	3.79	<0.05
	CBCT	3.88	1.453	3.14	4.63	
	Manual tracing 1	3.24	1.251	2.59	3.88	
	Manual tracing 2	2.88	1.054	2.34	3.42	
LIRT-B (mm)	Dolphin	3.44	.857	2.68	3.56	<0.05
	CBCT	3.49	1.278	2.75	4.07	
	Manual tracing 1	3.41	1.328	2.85	4.21	
	Manual tracing 2	3.39	.857	2.68	3.56	

SD = standard deviation

between the CBCT and Manual tracing 2 groups (0.10 mm) [Figures 1–3].

Discussion

The results showed statistically significant mean differences for SNA, SNB, ANB, UI-NA (°), UI-NA (mm), LI-NB (°), LI-NB (mm), UIRT-A (mm), and LIRT-B (mm) values among the four groups. The findings of this study are in concordance with the findings of Nalcaci *et al.* who found that the mean differences for SNB and LI-NB angles were 0.36° and −0.41°, respectively, when 2D measurements were compared with 3D measurements.[8] Bholsithi *et al*. found these mean differences to be 0.89°, 0.93°, 5.74°, 0.21°, and 11.84° for SNA, SNB, ANB, UI-NA, and LI-NB angles, respectively, when 2D measurements were compared with 3D CBCT values.[9] Stabrun and Danielsen showed that, in 75% of their cases, the apex of the mandibular incisor could not be located with confidence by the observers using lateral cephalometric radiographs.[10]

Statistically significant mean differences were also found for UI-NA (mm), and they were 0.30, 0.53, and 0.94 mm for Dolphin, Manual tracing 1, and Manual tracing 2 groups, respectively, as compared to CBCT-generated values. For LI-NB (mm), the mean differences were 0.70, 0.48, and 0.53 mm for Dolphin, Manual Tracing-1 and Manual Tracing- 2 groups respectively, as compared to CBCT-generated values. Chidiac *et al.* found that for accuracy of linear distance measurements, there is a statistically significant difference between 2D lateral cephalograms and CT scanograms,

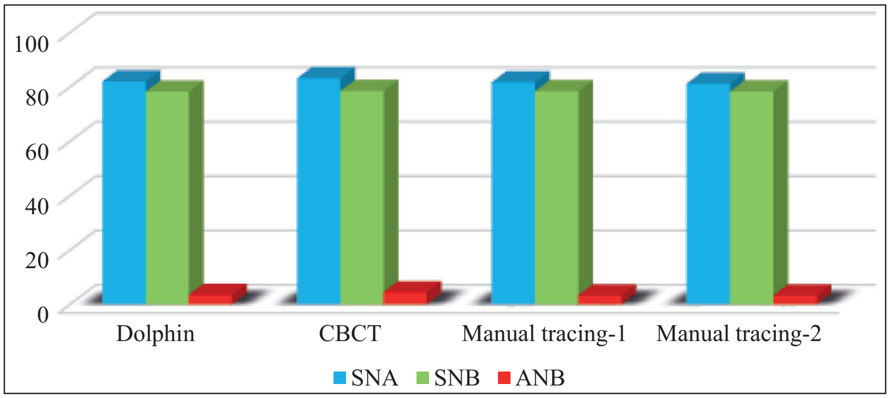

Figure 1: Comparison of mean SNA, SNB, and ANB values among the groups

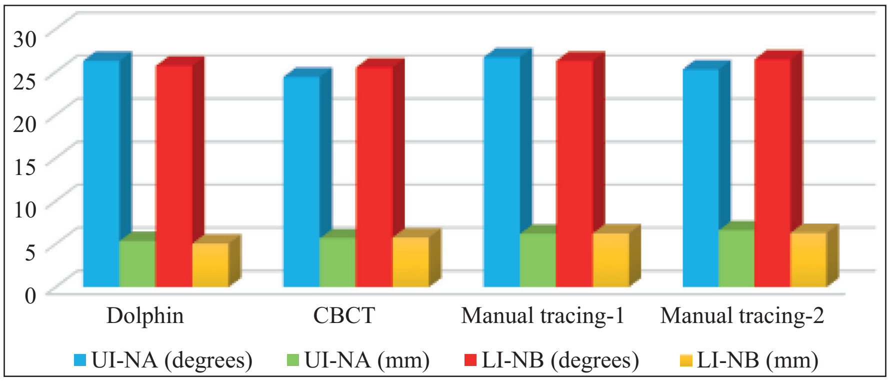

Figure 2: Comparison of mean UI-NA (°), UI-NA (mm), LI-NB (°), and LI-NB (mm) values among the groups

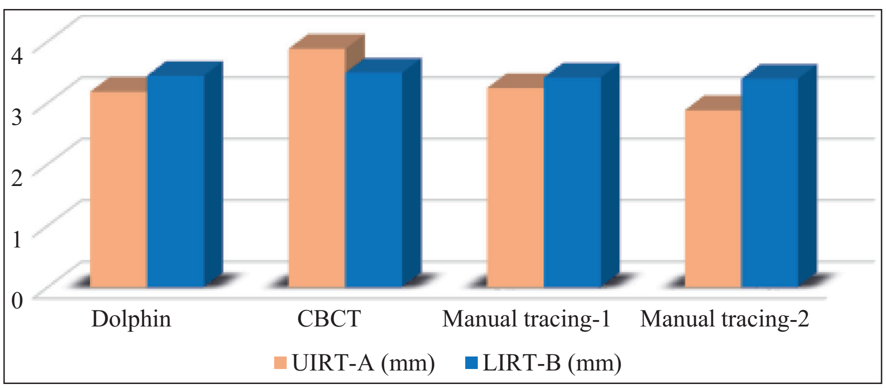

Figure 3: Comparison of mean UIRT-A (mm) and LIRT-B (mm) values among the groups

which is in concordance with our findings.[11] Periago *et al.* conducted a study on 23 dry skulls using Dolphin 3D and found that most measurements were statistically different from direct measurements of the same distances. Sixty percentage of the measurements varied by >1 mm, and 10% varied by 2 mm.[12]

In addition, the horizontal distances between the upper incisor root apex and point A (UIRT-A) and between the lower incisor root apex and point B (LIRT-B) were also measured and compared among the groups, which were found to be significantly different. Because of numerous difficulties in locating point A, van der Linden suggested the use of point L, an alternative to point A, located on the anterior surface of the image of the labial lamella at the region of the apex of maxillary incisors.[13] Jarabak and Fizzell measured the distance between the upper incisor root apex and point A and found that the average linear distance was 2 mm.[14] In this study, the mean linear distance between the upper incisor root apex and point A (UIRT-A) was found to be significantly greater (3.88 mm) in CBCT images.

Conclusion

Cephalometric landmarks that are difficult to locate on 2D cephalograms can be identified and measured accurately and more reliably on 3D CBCT-generated cephalograms. Both the angular and linear measurements are significantly greater in 3D CBCT-generated values. The present study shows that 3D CBCT-generated cephalograms can be successfully used for accurate and reliable cephalometric analyses.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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