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The reliability of cone-beam computed tomography (CBCT) – Generated frontal cephalograms☆

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ABSTRACT

Background: The purpose of this study was to evaluate the reliability of measurements from cone-beam computed tomography (CBCT)-generated frontal cephalogram.
Materials and methods: CBCT and conventional posteroanterior (PA) cephalograms were taken from 30 adult patients. CBCT image was set according to the Frankfurt-Horizontal (FH) plane as the horizontal plane and the midsagittal reference (MSR) plane. The CBCT frontal cephalograms were generated using the orthogonal Raycast method (group $CT_{raycast}$), the orthogonal maximum intensity projection (MIP) method (group CT_{MIP}) after the head reorientation according to the reference planes, and the generator tool provided by the employed 3-dimensional (3D) imaging software (group $CT_{generator}$), respectively. The differences between the CBCT-generated frontal cephalograms and conventional PA cephalograms (group PA_{ceph}) were compared by paired *t*-test ($p < 0.05$).
Results: The significant differences were shown in two measurements for group $CT_{raycast}$, in 12 measurements for group CT_{MIP}, and in eight measurements for group $CT_{generator}$. It was confirmed that the CBCT frontal cephalograms, generated by means of the Raycast method (Group $CT_{raycast}$), were more comparable to the conventional PA cephalograms in their measurements than were the others (Groups CT_{MIP}, $CT_{generator}$).
Conclusion: This study may well suggest that frontal cephalograms derived by 3D CBCT reorientation can be effectively employed in clinical applications.

1. Introduction

Recently, cone-beam computed tomography (CBCT) has become an important source of 3D volumetric data. It has been widely used in craniofacial morphometric analysis (Kapila et al., 2011; Hohlweg-Majert et al., 2011). It is recommended that CBCT be used in the cases of cleft palate, unerupted teeth, supernumerary teeth, root resorption, and orthognathic surgery planning in which conventional radiography cannot supply satisfactory diagnostic information. In the field of orthodontics, multiplanar reformation (MPR) measurement using 3-dimensional (3D) image analysis is being attempted, though 2-dimensional (2D) cephalometry remains an easier approach to diagnosis and measurement (Grauer et al., 2009). However, there are certain diagnostic limitations, both in positioning craniometric points on a 3D image and in converting a 3D image to a 2D image (Cevidanes et al., 2006). Therefore, in most cases, the measurement by CBCT is used adjunctively.

In order to maximize the utility of CBCT in orthodontic practice, dental imaging software programs have been developed that produce cephalograms based on 3D CBCT images (Farman, 2005). Many studies have compared such virtual cephalograms with original 2D cephalograms and their actual measurements. Some of those studies have approved the accuracy and reproducibility of virtual lateral cephalometric radiographs generated by CBCT (Kang et al., 2007; Kumar et al., 2008; Cattaneo and Melsen, 2008; Cattaneo et al., 2008; van Vlijmen et al., 2009a, b; Moerenhout et al., 2009). These results suggest that CBCT-generated virtual cephalograms can replace corresponding original 2D cephalograms.

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However, studies on frontal cephalograms from CBCT are rare. van Vlijmen et al. (2009a, b) demonstrated the significant difference between frontal radiographs obtained from CBCT scans and conventional PA radiographs of human skulls. They reported that there was a clinically relevant difference between angular measurements performed on conventional PA cephalometric radiographs, compared with measurements on frontal cephalometric radiographs constructed from CBCT scans, owing to different positioning of patients in both devices. Positioning of the patient in the CBCT device appeared to be an important factors in cases where a 2D projection of the 3D scan was made (van Vlijmen et al. 2009a, b). Alternatively, a device known as the Head Posture Aligner (HPA), suggested by Sun et al. (2009), can be used with CBCT. But reference planes on a 3D CBCT image can be set up and

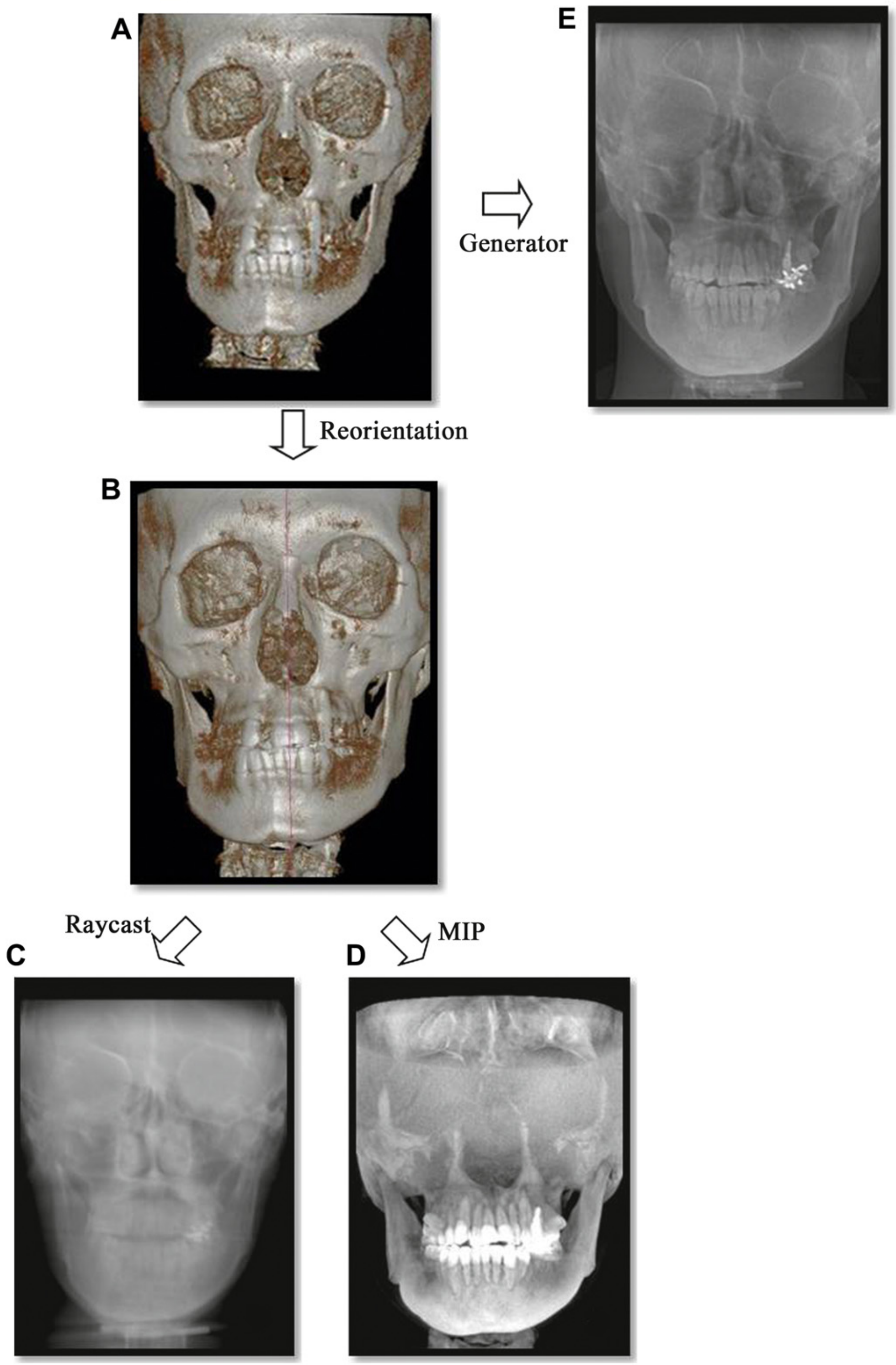

Fig. 1. Image acquisition from CBCT volumetric data: A, unoriented volume; B, oriented to obtain correct head rotation; C, CBCT-generated cephalogram using Raycast method; D, CBCT-generated cephalogram using maximum intensity projection (MIP) method; E, CBCT-generated cephalogram using generator tool.