Journal of Cranio-Maxillo-Facial Surgery 43 (2015) 1284–1288

Contents lists available at ScienceDirect

Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

Sensitivity and specificity of cone beam computed tomography in thin bony structures in maxillofacial surgery — A clinical trial

P. Thönissen*, M.A. Ermer, R. Schmelzeisen, R. Gutwald, M.C. Metzger, G. Bittermann

Department of Oral and Craniomaxillofacial Surgery, University Medical Center Freiburg, Hugstetter Straße 55, D-79106 Freiburg, Germany

ARTICLE INFO

Article history:
Paper received 5 February 2015
Accepted 19 May 2015
Available online 29 May 2015
DRKS-ID: DRKS00007667

Keywords:
CBCT
Specificity
Sensitivity
Accuracy
Cystic lesion

ABSTRACT

Introduction: Cone-Beam Computed Tomography (CBCT) has become widely used in dentistry and maxillofacial surgery. Accuracy, sensitivity and specificity of thin bony structures below 0.5 mm have been subject of some in vitro studies. This prospective in vivo study investigates the correlation between preoperative CBCT-imaging and intraoperative clinical examination of thin bony structures. We hereby present results from daily clinical routine.
Methods: A total number of 80 sites in 64 patients has been examined to differentiate between preoperative 3D imaging and clinical measurements on cystic lesions in maxilla and mandible. Different CBCT-devices with a voxel size ranging from 0.08 mm to 0.4 mm were used.
Results: Overall-specificity found for detecting thin bony structures of the human jaw is 13.89%, overall sensitivity is 100%, positive predictive value (PPV) is 58.67% and negative predictive value (NPV) is 100%.
Discussion: Image quality is the key to make use of additional information CBCT provides and depends on spatial, temporal and contrast resolution. CBCT does not depict reliably thin bony structures of the jaw, even if high voxel resolution is used.
Conclusion: In selected cases using high resolution protocols should be considered despite affecting the patient with higher doses of radiation.

1. Introduction

Cone-beam computed tomography (CBCT) has become widely used in dentistry and maxillofacial surgery (Mozzo et al., 1998). In Germany, the current number of CBCT studies is approximately 340,000 per year and is still increasing (Patzelt, 2011). Compared with standard panoramic radiographs, it allows the three-dimensional survey of anatomical structures of the head, although the effective dose is heightened. In contrast to conventional medical CT, CBCT combines less effective radiation dose with lower cost and easier accessibility (Scarfe and Farman, 2008, De Vos et al., 2009). It is suitable not only for preoperative diagnostics but also for real-time intraoperative assessment (Klatt et al., 2013).

CBCT uses flat-panel detectors (FPD) on which a diverged pyramidal or cone shaped beam is directed. The X-ray source rotates at least 180°–360° around the region of interest (ROI) and produces 150 to 600 single images. Raw data are collected by the device and are usually sent as DICOM files to the processing unit. CBCT is providing isotropic voxels, which easily allow a multiplanar reconstruction (Scarfe et al., 2012; Scarfe and Farman, 2008). The reconstruction algorithm, on which current developments are based, was first introduced by Feldkamp et al. (Feldkamp et al., 1984).

Subjective image quality is influenced by spatial resolution, temporal resolution, contrast resolution, reconstruction algorithms, and artifacts (Spin-Neto et al., 2012; Schulze et al., 2011). Voxel size and field of view (FOV) contribute to spatial resolution, mA settings to contrast resolution. Spatial resolution is limited to the individual volume elements on the FPD, detector blurring, focal spot blurring, and scan time (Chen et al., 2008; Ballrick et al., 2008).

However, due to acquisition parameters, subjective image quality, and artifacts, practitioners recognize the nonconformity of preoperative CBCT images and clinical findings concerning thin radiopaque structures such as the cortical bone in the jaw. Some in vitro studies have tried to examine the influence on subjective

* Corresponding author.
E-mail address: Philipp.nikolaus.thoenissen@uniklinik-freiburg.de (P. Thönissen).

http://dx.doi.org/10.1016/j.jcms.2015.05.002

image quality (Patcas et al., 2012; Sun et al., 2011; Leung et al., 2010; Loubele et al., 2009).

This prospective in vivo study investigates the correlation between preoperative CBCT imaging and intraoperative clinical examination of thin bony structures. In this study, we compared CBCT images taken from different CBCT devices which go together in relevant parameters mentioned previously. In respect to those, this study reproduces results from daily clinical work.

The reliability of CBCT is subject to investigating image quality in detecting and measuring thin bony structures of the jaw of less than 0.5 mm in this in trial, which included 64 patients. These sites rise on existing dental cysts. Dental cysts are common pathologic condition of the maxilla and mandible. By consuming space, they thin, erode, and fenestrate the bony covering. Physiologically expected bone will be lost by the spreading of the cysts. This is the reason for the existence of thin bony structures comparable to physiological occurrences such as the orbital floor or nasal septum.

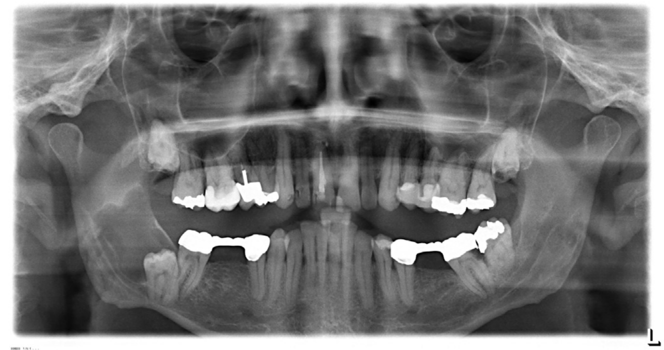

Fig. 1. Orthopantomogram (OPG) showing a follicular cyst on the right mandible. Cysts are often discovered as incidental findings on OPGs, as in this case. The next step in the diagnostic process is to depict the pathology by using cone-beam computed tomography.

2. Material and methods

A prospective study was initiated on 1 March 2011 and ended on 30 May 2014 at our Department for Oral and Maxillofacial Surgery. For use of patient data, ethics approval was obtained from the ethical review committee. Written informed consent was obtained from all study patients according to clinical routine in our department. Ethical approval was given by the Ethics Commission of the University Freiburg (Number 180/13).

The eligibility criterion was the diagnosis of cystic lesions in the maxilla and mandible that were thinning and eroding cortical bone visible on CBCT images. Images showing either no bone or bone thinner than 0.5 mm, where physiologically expected, have been selected.

The time between the CBCT scan and operation was no longer than 3 months. Images obtained from ROI in close proximity to dental implants or dental crowns and images with motion artifact were excluded.

2.1. Data acquisition

CBCT examinations were performed with a different voxel size ranging from 0.13 to 0.49 mm by using the Scanora 3D (Soredex, Tuusula, Finland) and the Pax-Zenith 3D (Vatech, Gyeonggi-do, Korea), Galileos (Sirona, Bensheim, Germany), Carestream CS 9000 (Rochester, NY, USA), Planmeca Pro Max 3D (Helsinki, Finland), or Morita Accuimoto (Dietzenbach, Germany). Table 1 shows the specifications of the Scanora 3D and the Pax-Zenith 3D. The distribution of patients to the different devices was random.

2.2. Evaluation of CBCT data sets

CBCT images were screened by three independent viewers for thin bony structures covering cysts in the maxilla and mandible (Fig. 1). This was performed using multiplanar reconstructions by applying Agfa Impax EE (Agfa, Mortsel, Belgium) based on a DICOM dataset for dental imaging diagnosis monitors. Leveling and windowing was set individually. Interrater observer comparison was not conducted. Decisions were made concordantly.

2.3. Surgical examination

Clinical routine for the treatment of benign space-consuming lesions included surgical and clinical examination regarding the consistency of the encircling of cortical bone.

In all cases, we used an intraoral approach to the lesion. In some cases, an endoscope was used to examine the cavity of the cyst. To treat the pathology, the cyst was removed and the cavity was filled with collagen; afterward, the mucosa was closed. Results of the clinical examination were recorded and documented by surgery protocol and/or photography.

2.4. Definition of terminology

Results of the CBCT diagnosis and clinical findings were matched: the ROIs were positive for fenestration in both CBCT imaging and clinical findings. If a positive CBCT finding matched a positive finding in the surgical examination, this influenced sensitivity. Fig. 2 shows an image taken from CBCT in which the cortical bone is not depicted. Fig. 3 shows the clinical correlation with Fig. 2: the corresponding area is covered by bone. This constellation is counted for the false-positive rate.

Findings were negative for no fenestration found in both CBCT imaging and clinical findings (specificity) (Figs. 2 and 3).

Quantitative data for each part are depicted as percentage value with 95% confidence interval (CI).

Table 1
Specifications of the two mainly used cone-beam computed tomography (CBCT) devices: Scanora 3D (Soredex), and Pax Zenith 3D (Vatech).

	Scanora 3D	Pax Zenith 3D
Field of view (mm)	60 × 60/75 × 100/75 × 145/130 × 145	50 × 50/80 × 60/120 × 90/160 × 140/240 × 190/Free FOV
Voxel size, Angaben (mm)	0.133–0.35	0.08–0.4
Detector	CMOS-FPD	CMOS-FPD
Year of manufacture	2011	2011
Rotation time/-angle	–/360°	15-24 s/360°
Gray scale resolution		14 bit; 16384
Pixel size (mm)	0.2	0.2
Active area (mm)	124.8 × 124.8 mm	238.4 × 288 mm

CMOS-FPD, complementary metal-oxide-semiconductor-flat panel detector.