Applications of Imaging Technologies in Maxillary Cyst Assessment

ADEMIR HORIA STANA[1], OTILIA LAVINIA STANA (GAG)[2], GHEORGHE CIOBANU[1], ANCA PORUMB[3]*, CALIN GHEORGHE CIOBAN[4], RAMONA AMINA POPOVICI[5], ALEXANDRA MOGA[5]

[1]Vasile Goldis Western University of Arad Faculty of Medicine and Pharmacy, Department of Radiology and Medical Imaging, 86 Liviu Rebreanu Str., 310414, Arad, Romania

[2]Vasile Goldis Western University of Arad Faculty of Dentistry Department of Prosthodontics, 86 Liviu Rebreanu Str., 310414, Arad, Romania

[3] University of Medicine and Pharmacy, Dental Medicine Department, 10 -1st December Str., 410068, Oradea, Romania

[4] Vasile Goldis Western University of Arad Faculty of Dentistry Department of Oral Implantology, 86 Liviu Rebreanu Str., 310414, Arad, Romania

[5] Victor Babes University of Medicine Timisoara, Faculty of Dentistry, 2 Eftimie Murgu Sq., 300041, Timisoara, Roamnia

The use of dental radiographies is nowadays indispensible for the clinician, and the evolution of x-rays provide quality images of the anatomic structures. The indications for a radiographic exam must be based on a clinical examination of the patient. Although the most used radiographies in dentistry are the retroalveolar and the panoramic one, it is considered that the indication for a CBCT scanning should be professional justified and evaluated as a balance between the benefits and the risk of exposure at radiation. The CBCT scans provide good quality images of the anatomic structures, with an accurate delimitation of the pathologic lesions, fact that allows the practitioner to proper evaluate the surrounding structures. CBCT technique uses an x-ray beam shaped like a cone that records 3D images in a single gantry rotation (360 degrees) within 6-20 seconds, with a radiation dose that depends on several factors. The comparison of the radiation dose of the CBCT (11-674 μSv) and the panoramic radiography (2.7–24.3 μSv) demonstrates that the CBCT requires a higher dose of radiation, but the high image quality is competing with the ones obtained with MSCT (280–1,410 μSv). The panoramic radiography uses an x-ray beam that is angled at aproximately 8 degrees, providing the practitioner a 2D radiographic image of the anatomic structures. The disadvantages of the panoramic radiography are the overlapping of the anatomic structures, the distortion and the blurry image. The study is based on the measurements of cystic lesions of the mandibular and maxillary bone that were present on radiographies and CBCT scans of 25 patients. The result of the measurements was that significative differences were found between the panoramic image of the cyst and the reconstructive image that the CBCT

Keywords:dental radiographies, CBCT,X-ray

The dental radiography nowadays is an indispensable exam in order to obtain a correct diagnosis. It uses roentgen equipment that can be calibrated to obtain dental radiographies, but also cranial radiographies. The dental equipment contains in its metallic cupola the same components that are being described at the roentgen device.

The standard dental radiography it can certify as an intraoral, retroalveolar, isometric and ortoradial radiography. It first has been described in year 1907 by Cieszinschi and later on, in year 1911 the technique has been improved by Dieck that has developed a particular incidence called *Dieck* incidence.

Dieck's incidence offers the practitioner extra information regarding the teeth, the socket, dental septum and near anatomical structures. The main disadvantage is its limited dimensions, providing information about a minimal surrounding area. The radiography uses an intraoral and retroalveolar film that offers us an image of 2 or 3 teeth. The radiographic film has a 3/4 cm dimension, with the same structure as an usual radiographic film, but with a finer granulation that can provide a more accurate image. The film is sensitive to the radiations on both sides, but it should be positioned with the hole oriented occlusally. A vertical position is necessary for the canines and incisors and a horizontal position for the premolars and molars. The dental film must be positioned in such a way that it should surpass with 2 mm the occlusal margin. The endobuccal and retroalveolar incidence is isometric (the principle was explained by Cieszynschi) and contains all the necessary maneuvers in order to obtain a radiological image with dimensions as close to the dimensions of the tooth. The exposure time must be between 1-2 s until 2 s for the incisors and increases until the molars[1].

Ortoradiality refers to the orientation of the central radius in an horizontal plan, in such a way that the central radius should be oriented for each tooth continuing the geometric radius of an imaginary circle that represents the dental arch. In case of overlapping, especially of the premolar or molar roots, the radiography is corrected through mezio-/distoexcentric incidences[1].

The bite-wing radiography on the conventional retroalveolar radiographies due to the inclination of the radiation fascicle a false image is obtained when it comes to the marginal periodontium, a marginal line for the vestibular periodontium and a parallel one for the oral periodontium. To repair this inconvenient, in year 1916, Howard Raper describes the bite-wing technique. This technique uses a dental film with the dimensions 3 cm/4 cm with a paper wing attached. The film can be positioned vertically or horizontally. The film is places retroalveolar with the paper wing between the antagonist teeth in

* email: anca.porumb@yahoo.com; Phone (+40)726286237

occlusion. On this radiography we can visualize the antagonist's crowns, one third of the coronal root and the periodontium. This technique is used in identifying proximal caries and the early pathological changes of the periodontium. This particular technique is not indicated in advanced marginal periodontitis because the severe bone loss cannot be correctly appreciated [1].

The occlusal film radiography. This is an old technique that was developed before the retroalveolar technique, and uses a dental film that has 4 cm/5 cm dimensions, that is positioned in the oral cavity between the dental arches. It is a very useful technique, especially in case of trismus.The occlusal film radiography can be obtained using two techniques: the isometric and ortoradial technique (that is similar to the retroalvelar technique) and the axial technique[1].

The isometric occlusal radiography is based on the isometric and ortoradial principles and the radiographic image resulted is similar to the retroalveolar one. The inclination of the central radius will be craniocaudal and the tip of the localizing cone will correspond to the projection of the dental apex on the skin [1].

The occlusal radiography in an axial incidence was described in 1930 by C.O.Simpson. The difference between the two occlusal techniques is the position of the central radius that is oriented along the teeth axis. The radiographic image reveals the teeth as opaque circles with a transparency in the middle. The indications for the occlusal film in axial incidence are multiple: to establish the vestibular or oral position of the impacted teeth, to evaluate the vestibular and oral cortical bone, to identify the lesions of the hard palate and to localize the radiopaque calculi in the submandibular gland [1].

The panoramic radiography provides a larger perspective of the jaws, obtaining a radiographic image of one or both dental arches together with the surrounding bone. This radiographic technique requires special roentgen equipment. The technique was developed by Dr.Y.V.Paatero, but as the years followed it has been remarkably improved with an equal quantity of irradiation as that of the retroalveolar technique. It is useful for extended pathological processes but it cannot replace the standard radiography that can provide us with more details about the surrounding area. The radiographic image is bigger (almost 2x times) due to the position of the film towards the teeth. It cannot offer us proper information about the occlusal relations and the sinus modifications should not be diagnosed based on this radiographic technique [1].

Cranial frontal radiography. This radiographic technique is based on a postero-anterior incidence of the skull, positioning the patient with the face down. This technique together with all its versions is indicated in that particular cases in which the practitioner need information about the frontal sinus, the relations between the superior arch and the maxillary sinus, but also information about the mandible. In dentistry, in order to evaluate correctly the relation between the superior dental arch and the maxillary sinus it is recommended a *face down* incidence. This technique is not very useful for the evaluation of the middle face structures due to the overlapping of the bone structures [1].

Semi axial cranial radiography also called the Water's incidence, its indications are for a better image of the anatomic elements of the middle face, eliminating the bone overlapping. In dentistry it is frequently used in obtaining an accurate image of the maxillary sinus, detaching its inferior third of the temporal bone making it totally visible, an advantage especially for the odontogenic maxillary sinusitis.

Cranial profile radiograph. The central radius is perpendicularly oriented on the medio-sagittal plane and on the film, the distance source-film being 2 m. The big disadvantage regarding this type of technique is the overlapping of the structures, which in some cases makes the analysis difficult. This radiographic technique is used for the diagnosis of dento-maxillary anomalies, offering the orthodontist the so called teleradiography. Malpositions, shape anomalies of the dental arch, and intermaxillary relations can be analyzed on this particular radiography, before and after the orthodontic treatment[1].

Mandible-lateral radiography it is a very popular technique that allows obtaining a radiographic image of half of the mandible without overlapping of the opposite half. It cannot be useful to identify the pathology of the menton and it implies that the central source of radiation is 1 m away situated from the film. This type of technique is used when trismus doesn't allow retroalveolar or panoramic radiography and for the inferior wisdom teeth's pathology.

Axial mandible radiography. This type of technique is used for the mandible and the oral floor. The dental film is place intraoral and the central radiation source is oriented caudo-cranial, perpendicularly on the film, passing through the medio-sagittal plane.

Radiographic examination of the temporomandibular junction. The temporo-mandibular articulation is the most complex and solicited articulation of the human body, having multiple functions: mimic, fonation, mastication. The radiographic examination of this articulation is a difficult one because of its position at the base of the skull, surrounded by dense bone structures. There are about 50 methods to evaluate radiographic the TMJ, and practice has shown that the hardest technique is the Schuller incidence (an oblique lateral transcranial radiography) which offers the practitioner a lateral image of a single TMJ, some authors considering that this type of radiography highlights only the articular space and the articular surfaces of the external 1/3 part. Another described method is the Parma radiography, as being a simple technique due to its conic projection, allowing the condyle that is situated closer to have a more defined image, closer to normal. The disadvantage consists in the fact that the articular space cannot be evaluated because of the overlapping of the temporo-zygomatic arch. The irradiation associated with this radiographic technique is big, being explained by the fact that the distance between the source and the film is very short[1].

Cone-beam computer tomography. Dentomaxillofacial Radiology has come a long way since its initial application, after the discovery of x-rays, in 1895 [2]. The conical beam computed tomography (CBCT) technique represents an evolution within standard modes of image scanning and reconstruction of computed tomography (CT). The advantages are a fast image acquisition (around 18 s) from a single low radiation dose scan, the efficient dose for the CBCT technique being comparatively smaller than the one achieved using a standard CT [3]. The use of CBCT in dentistry is starting to become very popular, taking into consideration the good performance, the relatively low cost compared to other CT investigations and the low dose of irradiation make this investigation an elective one [4-9]. The CBCT technique uses image data obtained after a 360 degree scan around the head of the patient, and image reconstruction is made using an algorithm for volumetric tomography [10]. Uses of CBCT in dentistry are several, starting from implantology to oral surgery and oral diagnosis [11]. The x-ray beam that the CBCT utilizes is shaped like a cone, with the radiation source forming the apex, and the beam diameter from 4 cm to 30 cm [12, 13, 14].

Image reconstruction of the CBCT obtained data is the process of obtaining a volumetric data set from a sequence of images. The images are developed with more than one million pixels per image, with 12-16 bits assigned to each pixel. One of the biggest advantages of the CBCT technique is that the obtained data can be reconstructed, unlike the CT, with a personal computer [15]. The technology is described by a good image reconstruction, in any plane with high fidelity and good resolution of high contrast structures [12]. A drawback of the CBCT is the limited detectability of the low contrast structures, probably due to the x-ray scatter and low DQE [12, 15]. The major disadvantage of the CBCT is the artifacts (that can be due to the x-ray beam, patient related, scanner related), inadequate bone density determination, image noise [16, 17, 18]. Some authors have sustained the use of the CBCT technology in order to evaluate the bone density, although the reliability is being questioned [16-18]. While scanning, the image value of a voxel of an organ depends on the position of the image volume so that different areas in the scan can show different gray scale values, although these areas possess same densities. The radiodensity values of the CBCT are frequently higher than the same CT values [14]. But still, the CBCT technique has in an important way modified the perception on the use of 3D imaging in dentistry, and has become an integral part of the diagnostic toolset. The possibility to obtain 3D images will result in advanced diagnostic capabilities and a proper treatment planning compare with the 2D radiographs [19]. Nowadays, the most common application of the CBCT technique is the preoperative planning of implants, due to the clear characteristics of the image and the American Academy of Oral and Maxillofacial Radiology (AAOMR) and European Association of Osseointegration (EAO) recognize the benefit of cross-sectional imaging for implant patients in 2000 and 2002 [20]. The 3D image allows to evaluate the potential implant sites, the exactly bone dimensions and to choose the correct implant size and angulation.

The use of CBCT in orthodontics is still a current preoccupation based on the fact that the patients are at a young age with higher cancer risk, especially at young female patients. Selection criteria from the AAOMR regarding the CBCT investigation at young patients, suggest that it is indicated to be used preoperative to evaluate the dental structures/anomalies and presurgical to visualize and estimate the asymmetry, the postoperative CBCT is not likely indicated [20].

Although, in its early times CBCT technology was indicated in implantology and dental imaging, today the indications spread to a fully face and skull base exploration and image reconstruction [21]. Ultimately, CBCT proved its efficiency of an accurate 3D analysis of the upper airway, being a useful tool in the diagnosis of the presence and the severity of obstructive sleep apnea. The imaging of the temporal bone is also a novelty regarding this technique that provides artifact-free high-resolution images [21].

In order to compare and evaluate a technology, it must be compared with the existing gold standards. Considering the standard exploration being the conventional medical CT, Hashimoto et al. have conducted studies in order to compare the performance between the CBCT and medical multidetector CT for dental use; their conclusion after analyzing the image quality and reproducibility, was that the CBCT produced high quality images in comparison with the helical CT, with less radiation exposure [22, 23]. It concluded that the technology is very useful in the maxillofacial radiology, hard tissue evaluation is specific, but the weak soft tissue evaluation remains one of the disadvantages. Accuracy is another advantage of the CBCT technology, a study performed by Razavi et al. in 2010, using Accuitomo at a voxel size of 0.125 mm the resulting images were characterized with a better resolution and the thickness measurements of the cortical bone surrounding the dental implant were more accurate than those obtained with an i-Cat NG system at a voxel size of 0.3 mm. The scan time that the CBCT needs in order to obtain quick image collection in approximately a minute or less, fact that reduces the possibility of motion artifacts [24].

Another advantage that the CBCT technique provides is the choices for field of view (FOV), quality that allows to orient the irradiation to a specific area of interest to dentists, while decreasing the irradiation of other tissues [25,26].

The limitations of cbct – the dentist is often the one who reads the images, in comparison with the general medicine where the radiologist is the one who does the interpretation.

It is important that the practitioner verifies that the radiological equipment is well calibrated and there is sufficient brightness and contrast together with reduced ambient light [27]. Gutierez et al have discussed that the usual desktop display is not proper for diagnostic radiology [26]. It is important to know that in some cases there is the need to refer to an oral and maxillofacial radiologist in order to obtain a proper expertise in the correct conditions [27].

Another limitation of the CBCT technique is that, the technology proves limited contrast resolution due to high scatter radiation during image acquisition and inherent flat panel detector related artifacts [28, 29]. Considering that for the examination of the hard tissue, the use of the CBCT would be benefic, it is still not sufficient for the soft tissue evaluation [30].

Limitations have also been noted in the radiation dose that the CBCT technology needs, being generally agreed that the radiation dose of the CBCT is importantly lower than that of a conventional CT [31]. The radiation dose of the CBCT is influenced to an order of magnitude by several factors as region of interest, FOV, patient size and resolution. All combined, this parameters influence the patient's exposure to radiations [27]. International Commission on Radiological Protection (ICRP) reports that the risk of adult fatal malignancy related to CBCT is between 1/100.000 and 1/350.000, and when this technology is used for children, the risk increases becoming twice higher as that of an adult [32-34]. Although, the patient benefits of using the CBCT investigation technique for the diagnosis of different pathologies and for the presurgical treatment planning is uncontested.

The American Academy of Oral and Maxillofacial Radiology and the European Academy Of DentoMaxilloFacial Radiology consented that in order to perform CBCT the practitioner must have license with proper theoretical and practical training regarding this specific technology [34, 35]. The radiology technician who operates with the machine needs to know about the different parameters that could affect the image quality, and that each CBCT scan must be followed by an imaging report. A frequent error is that often the operator focuses only on the region of interest, instead examining the entire image. For images that involve the dento-alveolar area, a trained general dentist could manage to do the interpretation. But, for those images that imply different surrounding areas like nasal floor, paranasal sinuses and craniofacial structures, the interpretations must be done by a maxillofacial radiologist. An accurate clinic exam is completed with the additional information provided by the CBCT technology that can bring new information to the patient's benefit. After several studies, it has been shown that the CBCT technology is superior to conventional 2D image techniques when it comes to identifying the location of hard tissue pathologies, the quantity and quality of the surrounding bone.

Applications of CBCT are not limited, being used in several dental interventions and giving the practitioner the possibility to evaluate and plan correctly the intervention.

In Implantology – in this case, the information provided by the CBCT technology offers the practitioner a large amount of information regarding the bone height and width, the thickness and morphology of the ridge, the localization of the inferior alveolar nerve for a correct placement and size of the implant [36]. The implant placement planning procedure that uses a surgical guide and the CBCT technology is a safe clinical procedure that helps the practitioner to avoid intra-operatory accidents like the trauma of the inferior alveolar nerve or the maxillary sinus penetration. The 3D images provided by the CBCT help avoiding the associated problems in surgical procedures by giving accurate and useful information.

In oral surgery – CBCT images give the practitioner the possibility of a safe and optimal removal of the impacted wisdom teeth and canines. The 3D images offer quality information about the localization and relations with the surrounding anatomical structures compared to 2D cephalographs [37]. A study of more than 100 patients found bifid canals in 65% of patients when the CBCT technology was used in scanning [38].

In Orthodontics – one single CBCT scan can provide all the information the orthodontist needs for a correct diagnosis and a treatment plan, information that in the past were provided by the lateral cephalograph, the panoramic radiograph, the antero-posterior cephalogram, temporo-mandibular joint tomograms, at a relatively same radiation dose. Also from the same data set, the technology allows the design of virtual orthodontic study models [39].

In Endodontics – the CBCT scans provide accurate information regarding the root canals and their morphology and localization, before the endodontic therapy [40]. The comparison between the 2D-radiographs and the CBCT images reveals the fact that the canals in multi-canal teeth are more easily to identify, increasing the success of the treatment [41]. An in vitro study proved the superiority of the CBCT imaging in the diagnosis of apical periodontitis (84%) compared to the 2D-radiographs (71%), while apical periodontitis was found histologically 93% of the time [42]. The CBCT technology can be helpful when it comes in the differential diagnosis of the endodontic pathology from the pain resulting following a sinus infection.

Experimental part

Material and methods

The panoramic radiographs and the intraoral ones are the basic imaging techniques used in dentistry. Panoramic radiographs produce a single image of the anatomic structures, teeth, a temporo-mandibular joint. Due to the fact that during the radiation exposure the x-ray central source and its detector rotate synchronously around the patient's head producing basically a curved surface radiography. In order to overcome the inconvenient, the panoramic radiography can be associated with intraoral ones. Since 1990 cone beam computed tomography devices are giving the practitioner accurate images of the hard tissue, with a lower radiation dose, easier technology and lower cost compared with multislice CT. Panoramic and intraoral radiographies are still the basic imaging methods in dentistry.

CBCT is a modern technology that offers a complex imaging due to a rotating gantry to which an X-ray source and detector are fixed. Almost all CBCT devices use a digital flat panel detector (FPD) instead of an image intensifier. The patient during the examination can be standing or sitting, and the height and diameter of the field of view (FOV) vary from small to large examinations [50, 51]. The devices that allow variations of the resolution and FOV are indicated in the dentomaxillofacial imaging. The images are recorded in a single gantry rotation (180-360 degrees) when the x-ray source and 2D detector move around the patient's head. The image acquisition time ranges between 6 and 20 seconds [52]. When the basic images are taken, the CBCT unit starts to reconstruct the primary projection frames to provide standard viewing of the coronal, sagittal and axial images. The irradiation dose may vary dependent on the equipment type, exposure settings, tube current (mA), the energy/potential (kV) and also is the scanned tissue are radiosensitive [53].

In our study we have included the panoramic radiographies and CBCT scans of 25 patients that have presented at the general dentist accusing dental and facial pain. The standard radiography that the general dentist required was the panoramic radiography. After the panoramic exam, because the image was not concluding the patients were referred to an oral surgeon and after the clinical local and general examination, the decision was to recommend the patient the CBCT scanning exam.

We have included 25 patients (15 females and 10 males), 6 patients were included in the age group 17-30 years, 8 patients in the age group 31-40 years, 7 patients in

Imaging method	Effective dose [μSv]
Intraoral radiograph	<1.5
Panoramic radiograph	2.7–24.3
Cephalometric radiograph	<6
Dentoalveolar CBCT (FOV height <10 cm)	11–674 (61)
Craniofacial CBCT (FOV height >10 cm)	30–1,073 (87)
MSCT maxillo-mandibular	280–1,410

Table 1
EFFECTIVE DOSE FROM CONVENTIONAL DENTAL IMAGING TECHNIQUES (i.e. INTRAORAL, PANORAMIC AND CEPHALOMETRIC RADIOGRAPH), CONE BEAM COMPUTED TOMOGRAPHY (CBCT) AND MULTISLICE COMPUTED TOMOGRAPHY (MSCT) IN μSv [47].

the age group 41-50 years and 4 patients over 60 years. Another inclusion criteria was the presence in the preliminary panoramic radiography a radiotransparent extended cystic lesion in the mandibular or maxillary bone. The exclusion criteria was the existence of tumors without clear delimitations, that couldn't be measured.

The study is based on the initial measurement of the suspicious lesion on the panoramic radiography based on the transparency delimited area and the re-measurement on the CBCT sections with the same software (Xelis Dental Viewer). After the two types of measures were effectuated we have compared the measurement in order to prove the substantial differences between the two radiography technologies.

Results and discussions

The number of patients that participated in this study was 25, resulting that 60% of them were females and 40% were males and the predominant age group was 30-40 years old. Regarding the comparison between the measurements upon the cystic image on the panoramic radiography and the one on the CBCT reconstruction, we obtained the following results: differences between 0-1 mm were found in 3 cases, differences between 1-2 mm were found in 19 cases and differences >2 mm were identified in 3 cases. These differences in measurements are based on the radiographic's technology characteristics, characteristics that determine a better and accurate radiographic evaluation on the CBCT scans due to the fact that the anatomic structures are better defined and delimited, the image quality is superior to the panoramic one allowing the clinician to appreciate objectively the 3D dimensions of the cyst and its relations with the cortical bone and the surrounding anatomic structures, anticipating possible intra-operatory accidents.

The CBCT scans and measurement of a patient with the significant differences:

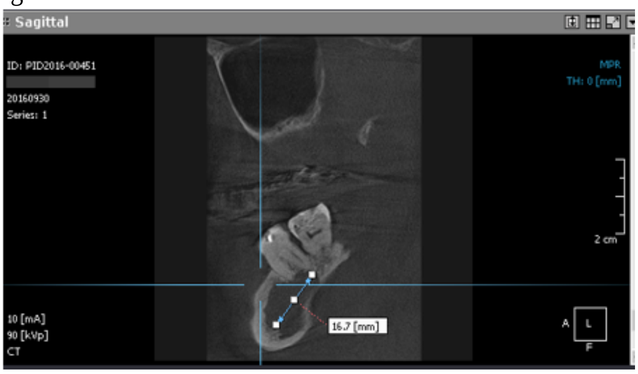

Fig.1. a CBCT scan, the visualization in the sagittal plan; a mandibular cyst with the mesio-distal dimension of 11.4 mm

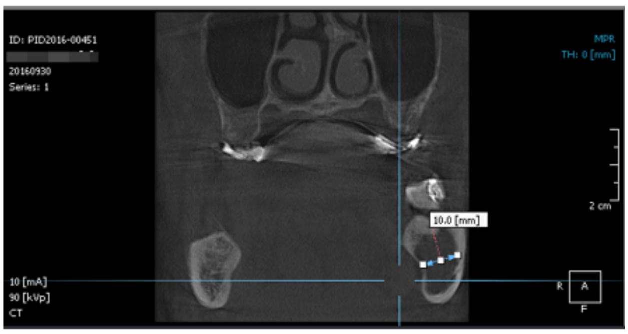

Fig.2. CBCT scan, the visualization of a cyst, its dimensions and relations with the vestibular and lingual cortical bone, measuring 10 mm

Another representative case in which the panoramic radiography offered a blurry 2D image (fig.6), without clear

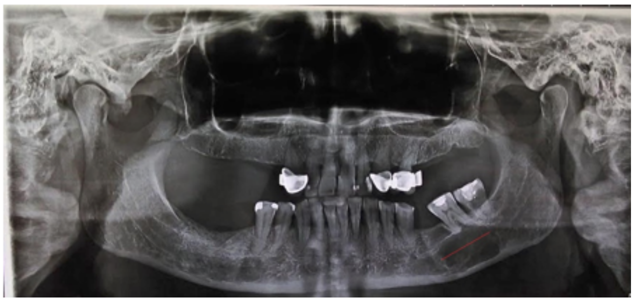

Fig.3. the panoramic radiography of the same patient, with the mandibular cystic lesion; the dimension measured mesio-distal was 13 mm; its limits are not clearly delimited

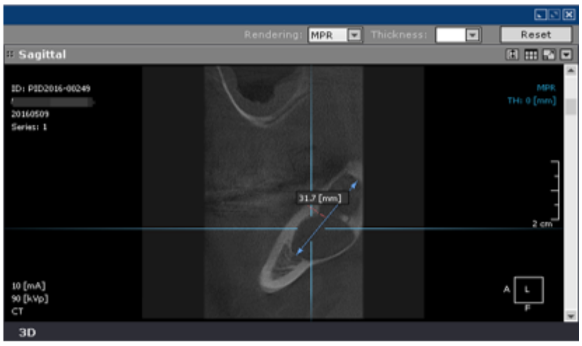

Fig. 4. the mesio-distal diameter of the mandibular cyst, with clear delimitations

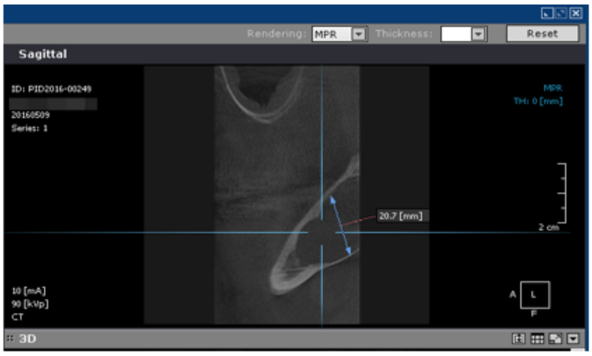

Fig. 5. The vestibule-lingual diameter of the cyst and the cortical bone (the sagittal plan cannot be evaluated on a 2D panoramic radiograph)

Fig. 6. The panoramic image of the same mandibular cyst, without clear delimitation (3.1cm)

delimitations, with overlapping structures in comparison with the CBCT scans (fig.3, fig.4).

The correlation between the age groups and the differences (mm) found in the comparison of the measurements on the panoramic standard radiography and the CBCT 3D images (fig.7).

When it comes to the comparison between the two radiography methods, there are several factors that influence the practitioner's decision. The American National Council on Radiation Protection & Measurements recommends the standard criteria for dental radiographies. The need for CBCT scanning should be professional justified

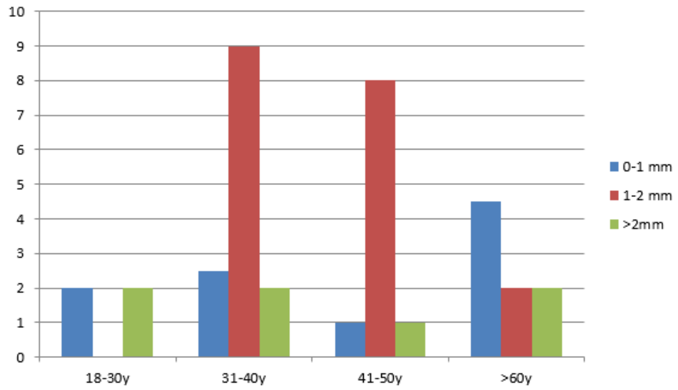

Fig. 7. chart on which we can visualize the differences in measurements on the panoramic radiography and on the CBCT scans in the 4 age groups included in the study

and its clinical benefits should outweigh the risks associated with exposure to ionizing radiation. CBCT supplements or replaces the conventional 2D or panoramic radiography, for a better diagnosis, a treatment plan when the practitioner considers that certain structures are not well captured [43]. Also, the European Academy of Dental and Maxillofacial Radiology published a paper for the basic training requirements for the use of dental CBCT by dentists [44].

Panoramic radiograph offers a ensemble 2D view of the jaws [45, 46]. The advantages are a low radiation dose (Table 1), relatively short exposure time, comfort and simplicity in the interpretation. But, the disadvantages consist in the lower image quality, distortion, overlapping, unequal magnification and elongation [44].

The panoramic radiography technique is based on the principle of narrow-beam rotational tomography, where the X-ray beam is angled at approximately 8 degrees [48] and uses linked motion x-ray tube and receptor [44]. Because of the principles of this technique, the anatomical structures located within the tomographic plane are well delimitated, and those that are situated in front or behind the plane are blurred [48, 49]. Also, the anatomic structures that are located inside the tomography place appear wider and the ones that are located in front of it will appear narrower [44]. Mostly, only the structures that are located in this plane are undistorted, because the differences between the horizontal and vertical magnification are responsible for the distortion. The overlapping disadvantage cannot be avoided in the panoramic radiograph due to the anatomy of the jaws [48]. Horizontal measurements in panoramic radiographs are not reliable because of the distortion and overlapping of the structures [48, 49].

The radiographic technique and the image quality is very important in dentomaxillofacial practice, and we can admit that the Dental Radiography has come a long way since the x-rays have been discovered, in 1895 [2]. The modern technology that is represented by the CBCT represents a great evolution compared to the 2D radiographic techniques offerd by the standard radiography. The advantages that the CBCT technology has over the standard radiographs help the clinician to improve the diagnosis, treatment planning and avoid the intraoperatory accidents. The possibility of reconstruction on the CBCT scans offers a realistic perspective of the anatomic structures with quality images. Although the advantages of the CBCT must be acknowledged, the indications for the CBCT scan must be well clinically justified, with benefits that overweight the risks of exposure to radiations [43]. The fast image acquisition and recording due to a single gantry rotation (180-360 degrees), having the x-ray source move around the patient's head within 6-20 s [52]. The image quality has more than one million pixels per image, with 12-16 bits assigned to each pixel, and the data can be reconstructed with a personal computer [15]. CBCT technology is defined by a good image reconstruction, with high fidelity and good resolution images [12]. The limitations are regarding the limited contrast resolution of the soft tissue, with difficult evaluation [30] and the radiation dose that is substantially influenced by several factors (FOV, region of interest, patient size)(table 1). Although, a study of measurements performed comparatively on skulls sites and on CBCT scans indicates that the CBCT measurements underestimate the real distances that were measured on skull sites, it was proven that this difference are significant only for the skull base [54]. The applications of the CBCT are no longer limited to implantology, giving the practitioner a large amount of information regarding several pathologies.

Conclusions

The performed study allowed as to evaluate 2 radiographic techniques and to identify the measurement differences in the obtained images. Also, the differences regarding the quality of the 2D images and the 3D CBCT scans could not be ignored. From the results we can affirm that the measurements on the panoramic radiography do not represent the exact situation that one found on the CBCT, with major differences (1-2 mm and >2 mm). On the panoramic radiographs a blurry radiotransparecy can be visualized, without the possibility to anticipate the exact degree of demineralization of the bone. The image reconstruction of the CBCT technology offers the possibility to correctly evaluate the size and the delimitations of the cysts, its relations with surrounding anatomic structures and adjacent teeth, the quality and quantity of the remaining cortical bone. Providing all this accurate information, the practitioner can predict and perform a safe intervention, a good diagnosis and an appropriate treatment plan.

References

1. FLOAREA FILDAN, IOAN MIHAI COVALCIC. Radiologie stomatologica: Notiuni de fizica si tehnica radiologica. Editura Medicala Universitara Iuliu Hatieganu Cluj Napoca 1999. 131-179.
2. SCARFE WC, FARMAN AG. Cone beam computed tomography: Aparadigm shift for clinical dentistry. Aust Dent Pract 2007;19:92-100.
3. MOZZO P, PROCACCI C, TACCONI A, MARTINI PT, ANDREIS IA. A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. Eur Radiol 1998; 8: 1558–1564.
4. LUDLOW JB, DAVIES-LUDLOW LE, BROOKS SL. Dosimetry of two extraoral direct digital imaging devices: NewTom cone beam CT and Orthophos Plus DS panoramic unit. Dentomaxillofac Radiol 2003; 32: 229–243.
5. MAH JK, DANFORTH RA, BUMANN A, HATCHER D. Radiation absorbed in maxillofacial imaging with a new dental computed tomography device. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003; 96: 508–513.
6. BIANCHI S, ANGLESIO S, CASTELLANO S, RIZZI L, RAGONA R. Absorbed doses and risk in implant planning:comparison between spiral CT and cone-beam CT. Dentomaxillofac Radiol 2003; 30(1: 16.6):S28.
7. ZIEGLER CM, WOERTCHER R, BRIEF J, HASSFELD S. Clinical indications for digital volume tomography in oral and maxillofacial surgery. Dentomaxillofac Radiol 2002; 31: 126–130.
8. HASHIMOTO K, ARAI Y, IWAI K, ARAKI M, KAWASHIMA S, TERAKADO M. A comparison of a new limited cone beam computed tomography machine for dental use with a multidetector row helical CT machine. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003; 95:371–377.
9. SUKOVIC P. Cone beam computed tomography in craniofacial imaging. Orthod Craniofac Res 2003; 6 Suppl 1: 31–36.

10. CHO PS, JOHNSON RH, GRIFFIN TW. Cone-beam CT for radiotherapy applications. Phys Med Biol 1995; 40: 1863–1883.
11. CA LASCALA*, J PANELLA AND MM MARQUES. Analysis of the accuracy of linear measurements obtained by cone beam computed tomography (CBCT-NewTom). Dentomaxillofacial Radiology (2004) 33, 291–294.
12. MIRACLE AC, MUKHERJI SK. Conebeam CT of the head and neck, part 1: Physical principles. AJNR Am J Neuroradiol 2009;30:1088-95.
13. WHITE SC, PHAROAH MJ. The evolution and application of dental maxillofacial imaging modalities. Dent Clin North Am 2008;52:689-705.
14. SCARFE WC, FARMAN AG. Interpreting CBCT Images for implant assessment: Part 1- Pitfalls in image interpretation. Aust DentPract 2010;20:106-14.
15. SCARFE WC, FARMAN AG. What is cone-beam CT and how does it work? Dent Clin North Am 2008;52:707-30.
16. DE VOS W, CASSELMAN J, SWENNEN GR. Cone-beam computerized tomography (CBCT) imaging of the oral and maxillofacial region: A systematic review of the literature. Int J Oral Maxillofac Surg 2009;38:609-25.
17. ARMSTRONG RT. Acceptability of cone beam CT vs. multi-detector CT for 3D anatomic model construction. J Oral Maxillofac Surg 2006;64(Suppl 1):37.
18. GANZ SD. Conventional CT and cone beam CT for improved dental diagnostics and implant planning. Dent Implantol Update 2005;16:89-95.
19. EUROPEAN COMMISSION. Cone Beam CT for Dental and Maxillofacial Radiology: Evidence Based Guidelines, Radiation Protection Publication 172. European Commission (2012).
20. RUBEN PAUWELS. Cone beam ct for dental and maxillofacial imaging: dose matters. Radiation Protection Dosimetry (2015), p. 1–6.
21. KIVANÇ KAMBUROÐLU. Use of dentomaxillofacial cone beam computed tomography in dentistry. World J Radiol 2015 June 28; 7(6): 128-130
22. HASHIMOTO K, KAWASHIMA S, ARAKI M, IWAI K, SAWADA K, AKIYAMA Y. Comparison of image performance between cone-beam computed tomography for dental use and four-row multidetector helical CT. J Oral Sci 2006;48:27–34.
23. HASHIMOTO K, KAWASHIMA S, KAMEOKA S, AKIYAMA Y, HONJOYA T, EJIMA K, SAWADA K. Comparison of image validity between cone beam computed tomography for dental use and multidetector row helical computed to-mography. Dentomaxillofac Radiol 2007;36:465–71.
24. RAZAVI T, PALMER RD, DAVIES J, WILSON R, PALMER PJ. Ac-curacy of measuring the cortical bone thickness adjacent to dental implants using cone beam computed tomography. Clin Oral Implants Res 2010;23:718–25.
25. PALOMO L, PALOMO JM. Cone beam CT for diagnosis and treatment planning in trauma cases. Dent Clin North Am 2009;53:717–27.
26. GUTIEREZ D, MONNIN P, VALLEY JF, VENDUN FR. A strategy to qualify the performance of radiographic monitors. Radiat Prot Dosimetry 2005;114:192–7.
27. SHAWN ADIBI, D.D.S., F.D.O.C.S., M.ED.; WENJIAN ZHANG, D.D.S., M.S., PH.D.; TOM SERVOS, D.D.S.; PAULA N. O'NEILL, M.ED., ED.D. Cone Beam Computed Tomography in Dentistry: What Dental Educators and Learners Should Know. Journal of Dental Educatio 2012 November;1437-1442.
28. LUDLOW JB, IVANOVIC M. Comparative dosimetry of dental CBCT devices and 64-slice CT for oral and maxillofacial radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:106–14.
29. WHITE SC, PHAROAH MJ. Oral radiology principles and interpretation. St. Louis: Mosby Elsevier, 2009:236–7.
30. FARMAN AG. Self-referral: an ethical concern with respect to multidimensional imaging in dentistry? J Appl Oral Sci 2010.
31. SCHULZE D, HEILAND M, THURMANN H, ADAM G. Radiation exposure during midfacial imaging using 4 and 16-slice computed tomography: cone beam computed tomography systems and conventional tomography. Dentomaxillofac Radiol 2004;33:83–6.
32. EUROPEAN ACADEMY OF DENTAL AND MAXILLOFACIAL RADIOL-OGY. Basic principles for use of dental cone beam CT. At: www.camosci.cz/public/files/pages/00000202_basicprin-ciplesforuseofdentalconebeamct.pdf. Accessed: October 18, 2012.
33. MACDONALD-JANKOWSKI DS, ORPE EC. Some current legal issues that may affect oral and maxillofacial radiology. Part 2: digital monitors and cone-beam computed tomog-raphy. J Can Dent Assoc 2007;73:507–11.
34. VALENTIN J. The 2007 recommendation of the International Commission on Radiological Protection, publication 103. Ann ICRP 2007;37:1–332.
35. CARTER L, FARMAN AG, GEIST J, SCARFE WC, ANGELOPOULOS C, NAIR MK, et al. American Academy of Oral Maxil-lofacial Radiology executive opinion statement on per-forming and interpreting diagnostic cone beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106(4):561–2.
36. HATCHER DC, DIAL C, MAYORGA C. Cone beam CT for presurgical assessment of implant sites. J Calif Dent Assoc. 2003;31:825-33.
37. CHIEN PC, PARKS ET, ERASO F, HARTSFIELD JK, ROBERTS WE, et al. Comparison of reliability in anatomical landmark identification using two-dimensional digital cephalometrics and three-dimensional cone beam computed tomography in vivo. Dentomaxillofac Radiol. 2009;38(5):262-73.
38. NAITOH M, HIRAIWA Y, AIMIYA H, ARIJI E. Observation of bifid mandibular canal using cone-beam computerized tomography. Int J Oral Maxillofac Implants. 2009;24(1):155-9.
39. MAH J, REDMOND R. The evolution of digital study models. J Clin Orthod. 2007;XLI (9):557.
40. BARATTO FILHO F, ZAITTER S, HARAGUSHIKU GA, DE CAMPOS EA, ABUABARA A, et al. Analysis of the internal anatomy of maxillary first molars by using different methods. J Endod. 2009;35(3):337-42.
41. MATHERNE RP, ANGELOPOULOS C, KULILD JC, TIRA D. Use of cone-beam computed tomography to identify root canal systems in vitro. J Endod. 2008;34(1):87-9.
42. PAULA-SILVA FW, WU MK, LEONARDO MR, DA SILVA LA, WESSELINK PR. Accuracy of periapical radiography and conebeam computed tomography scans in diagnosing apical periodontitis using histopathological findings as a gold standard. J Endod. 2009;35(7):1009-12.
43. NATIONAL COUNCIL ON RADIATION PROTECTION & MEASUREMENTS. Radiation Protection in Dentistry (Report No. 145). Bethesda, Md.: NRCP Publications; 2003.
44. A. SUOMALAINEN, E. PAKBAZNEJAD ESMAEILI, S. ROBINSON. Dentomaxillofacial imaging with panoramic views and cone beam CT. Insights Imaging (2015) 6:1–16.
45. LANGLAND OE, LANGLAIS RP, MCDAVID WD, DELBALSO AM (1989) History of Panoramic Radiography. In: Langland OE, Langlais RP, McDavid WD, DelBalso AM (eds) Panoramic radiology, 2th Subedn. Lea & Febiger, USA, pp 3–37.
46. LURIE AG (2004) Panoramic Imaging. In: White SC, Pharoah MJ(eds) Oral radiology. Principles and interpretation, 5th edn. Mosby, China, pp 191–209.
47. EC, EUROPEAN COMMISSION (2012) Radiation protection no. 172: Evidence based guidelines on cone beam CT for dental and maxillofacial radiology. Luxembourg: Office for Official Publications of the European Communities. Available via http://ec.europa.eu/ energy/ nuclear/radiation_protection/doc/publication/172.pdf.
48. WHAITES E (2007) Panoramic radiography (dental panoramic tomography). In:Whaites E, Cawson R (eds) Essentials of dental radiography and radiology, 4th edn. Churchill Livingstone, Elsevier, Spain, pp 187–206.
49. ULF W, GUNILLA T, MCDAVID WD (1989) Theory of rotational panoramic radiography. In: Langland OE, Langlais RP, McDavid WD, DelBalso AM (eds) Panoramic radiology, 2th Sub edn. Lea & Febiger, USA, pp 38–75.
50. NEMTOI A, CZINK C, HABA D, GAHLEITNER A (2013) Cone beam CT: a current overview of devices. Dentomaxillofac Radiol. doi:10.1259/ dmfr.20120443.
51. SCARFEWC, FARMAN AG (2008)What is cone-beamCTand how does it work? Dent Clin North Am. doi:10.1016/j.cden.2008.05.005.
52. SCHULZE R, HEIL U, GROSS D, BRUELLMANN DD, DRANISCHNIKOW E, SCHWANECKE U et al (2011) Artefacts in CBCT: a review. Dentomaxillofac Radiol. doi:10.1259/dmfr/30642039.
53. SUOMALAINEN A, KILJUNEN T, KÄSER Y, PELTOLA J, KORTESNIEMI M (2009) Dosimetry and image quality of four dental cone beam computed tomography scanners compared with multislice computed tomography scanners. Dentomaxillofac Radiol.
54. CA LASCALA, J PANELLA1 AND MM MARQUES. Analysis of the accuracy of linear measurements obtained by cone beam computed tomography (CBCT-NewTom). Dentomaxillofacial Radiology (2004) 33, 291–294.

Manuscript received: 15.12.2016