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Application of cone beam computed tomography for detection of periapical lesions – clinical case

Zastosowanie tomografii wiązki stożkowej do detekcji zmian okołowierzchołkowych – przypadek kliniczny

Abstract

The purpose of the thesis is to show the dental imaging capability of Cone Beam Computed Tomography (CBCT) in comparison with intraoral X-ray images for detection and assessment of periapical lesions before and during treatment as well as to present the use of diagnostic functions in the available software. The thesis presents two clinical cases.

Keywords: CBCT, volumetric tomography, periapical lesions, dental imaging

Streszczenie

Celem artykułu jest pokazanie możliwości obrazowania stomatologicznego za pomocą tomografii wiązki stożkowej w porównaniu ze zdjęciami RTG wewnątrzustnymi do detekcji oraz oceny rozległości zmian okołowierzchołkowych przed i w trakcie leczenia. Omówiono dwa przypadki kliniczne.

Słowa kluczowe: tomografia wiązki stożkowej, tomografia wolumetryczna, zmiany okołowierzchołkowe, obrazowanie stomatologiczne

1. Introduction

In dentistry, a precise analysis of dental imaging is very important to make a diagnosis and determine a treatment plan. The imaging possibilities offered by volumetric tomography CBCT in most pathological cases are invaluable compared to traditional X-ray images. CBCT is used in the diagnosis, treatment planning, as well as its monitoring and evaluation of treatment results in such diverse fields of dentistry as implantology, surgery, orthodontics and more often, even in difficult endodontic cases [1–5]. But, of course, quality is connected with higher costs, for example, of purchase of CBCT equipment and its use. The cost of X-ray image is cheaper in comparison with the performance of imaging using Cone Beam Computed Tomography, but in many cases insufficient to detect changes even by an experienced dentist.

2. Cone beam computed tomography

2.1. The principles

CBCT – *cone beam computed tomography* is a compact, faster and safer version of the regular CT. Through the use of a cone shaped X-Ray beam, the size of the scanner, radiation dosage and time needed for scanning are all dramatically reduced. Most CBCT scanners are square like machines with a chair. You will sit upright while a C-arm rotates around your head. Within the arm there is an X-ray source and detector (X-ray receiver), which will make one complete 360° rotation for each scan. While the arm is rotating, it captures multiple images of your head from different angles. These images are then reconstructed to create a 3D image of

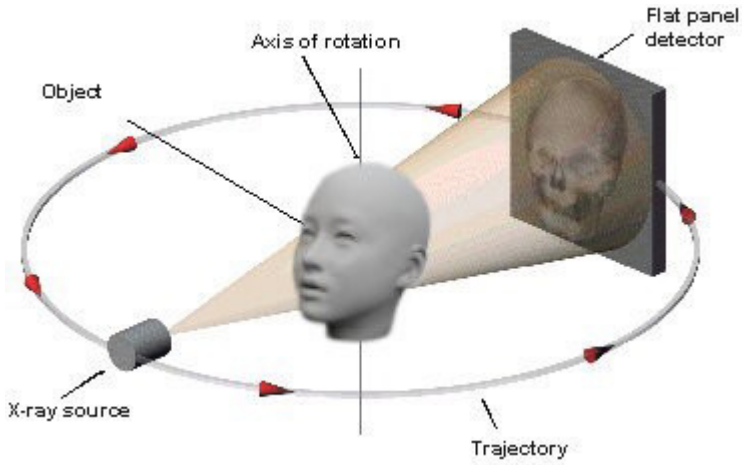

Fig. 1. Principle of CBCT working [7]

your internal anatomy. Some CBCT scanners have you lay down on a table that can move up or down, and slide into and out of the center of a hole, while a gantry makes a 360° rotation. CT imaging of the head can provide clear images not only of soft tissue, but also of bones and blood vessels [6]. To see how CBCT works, go to Fig. 1.

2.2. Application in dental imaging

There is a justified and wide application of volumetric tomography in the diagnostic imaging of teeth diseases of different etiology. Dental imaging focuses on the analysis of the alveolar bone and the surrounding tissues, volumetric tomography in contrast to 2D dental X-ray imaging allows us to view three-dimensional anatomical structures in real size without overlapping and also, in various projections which you can operate on your own [1]. This is the basis for assessing the extent of periapical lesions, which are dependent on both the location of the tooth in dental arches as well as the plain, and the angle at which the sections are analyzed. For example, periapical lesions are usually barely visible in the X-ray image, whereas CBCT imaging gives us a much better image quality, inter alia, thanks to no layers overlapping 3d anatomical structures. Unfortunately, accurate diagnosis of inflammatory changes around the apex of the tooth root is not an easy task. Some cases are complex and often confusing, even for an experienced dentist [8]. In one of the publications [2] it was proved that CBCT examination allows for earlier detection of periapical lesions than intraoral images, up to 38% of periapical lesions and 56% of fistulas detected on 3D imaging was not visible in the intraoral image. The drawback of volumetric tomography can be higher radiation dose than in conventional X-ray, but still it is less than e.g. in a spiral computed tomography. It should be noted that in many cases it is necessary to perform more than one X-ray image and sometimes even that is not enough for proper radiological assessment. Then, the total dose of radiation from the resulting dose of X-ray images exceeds the volumetric imaging dose of radiation from one shot. But on the other hand, the advantage of volumetric tomography is possibility to set the FOV - *field of view* so that the resolution is sufficiently high with radiation dosage which is as low as one can possibly achieve [5]. Depending on treatment plans that relate to maxillo-facial surgery, implantology and endodontics, we choose the most suitable FOV [9]. Comparing CBCT with a regular CT, patients receive a lower effective dose of radiation than that of CT scanners, by adjusting field of view, time scanning and the voxel size. In both cases, the image of hard structures – bones – is very good, but teeth are perfect in CBCT, while in CT just moderate.

3. Periapical lesion – clinical case

The research was conducted in dental clinic "NZOZ SPS Dentist" in Cracow using CBCT scanner Gendex, model GXCB-500 and GXDP-700, and intraoral X-ray system Gendex - Oralix 65S. The patients were tested through dental X-ray and CBCT, in an initial test when symptoms of the inflammation of the periapical tissue were noticed and a repeat test carried out a while after treatment.

The surface area of the periapical lesion was selected 10 times in an intraoral X-ray image, the values were averaged and standard deviation was calculated. In 3D imaging the projection was set as close as possible to view on the tooth in an intraoral X-ray image and the surface area of the periapical lesion was also selected 10 times, the values were averaged and standard deviation was calculated. The mean values of surface area of the periapical lesion visible in the intraoral X-ray image and volumetric imaging were compared.

The software used for analysis of intraoral images was Fiji Is Just ImageJ 1.48a and for 3D scans – Onis 2.4 Free Edition. Function, which allows for the selection of irregularly shaped surface area was crucial in choosing suitable software.

3.1. Case 1

A 35 year old male during the first examination. Tooth 46. The second complex examinations were done after the treatment – 2 and a half year later. Periapical lesion did not heal after 2,5 years.

Figure 2 and Table 1 show periapical lesions measurements on an intraoral X-ray image before the treatment and Figure 3 and Table 2 on 3D imaging.

Fig. 2. Intraoral X-ray image of tooth 46 – before the treatment with marked periapical lesions (case 1)

Table 1. Results of the measurement of the surface area of the periapical lesions in intraoral X-ray image of tooth 46 – before the treatment (case 1)

MEASUREMENT	SURFACE AREA OF PERIAPICAL LESION [mm^2]	
1	3,4	5,3
2	3,8	5,1
3	4,1	5,1
4	4,3	5,5
5	3,3	5,3
6	3,5	5,2
7	4,2	5,0
8	3,6	5,2
9	3,8	5,4

10	3,5	5,0
Average value:	3,8	5,2
Standard deviation:	0,35	0,17
Sum of 2 average values:	9,0	

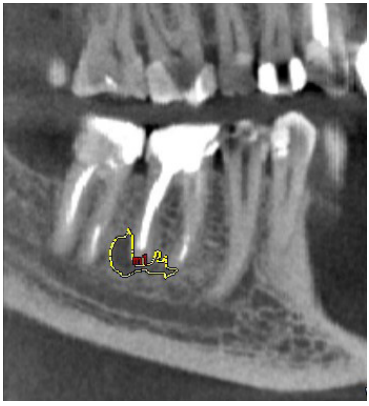

Fig. 3. View from CBCT on tooth 46 before healing period (case 1)

Table 2. Results of the measurement of the surface area of the periapical lesions in CBCT imaging of tooth 46 – before the period of healing (case 1)

MEASUREMENT	SURFACE AREA OF PERIAPICAL LESION [mm^2]
1	21,4
2	21,0
3	22,8
4	21,2
5	20,5
6	20,5
7	20,9
8	22,4
9	21,7
10	21,6
Average value:	21,4
Standard deviation: 0,76	

Comparing the average value of the surface area of the visible periapical lesions in the intraoral X-ray image with the 3D scan, this inflammation is visibile over 2 times better in 3D imaging in the first stage of treatment.

Figure 4 below and Table 3 show measurements in 2D images after 2,5 years of treatment and in CBCT, see Figure 5 and Table 4.

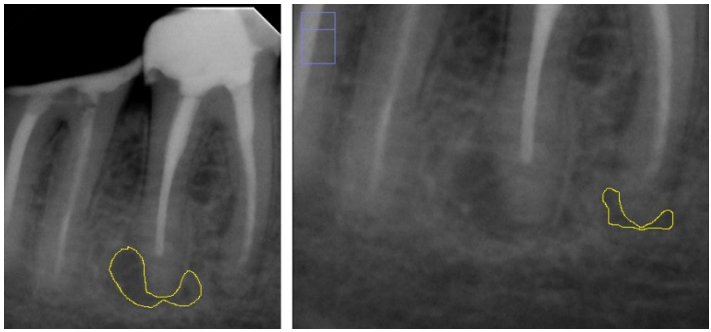

Fig. 4. Intraoral X-ray image of tooth 46 – during the treatment with marked periapical lesions (case 1)

Table 3. Results of the measurement of the surface area of the periapical lesions in intraoral X-ray image of tooth 46 – during treatment (case 1)

MEASUREMENT	SURFACE AREA OF PERIAPICAL LESION [mm^2]	
1	12,1	2,0
2	11,3	1,7
3	10,5	2,0
4	10,7	2,0
5	11,8	2,1
6	12,3	2,2
7	12,3	2,5
8	11,4	2,0
9	11,5	2,4
10	11,2	2,4
Average value:	11,5	2,1
Standard deviation: 0,62 0,25		
Sum of 2 average values:	13,6	

Fig. 5. View from CBCT on tooth 46 during treatment (case 1)

Table 4. Results of the measurement of the surface area of the periapical lesions in CBCT imaging of tooth 46 – during treatment (case 1)

MEASUREMENT	SURFACE AREA OF PERIAPICAL LESION [mm²]
1	20,5
2	22,0
3	21,1
4	20,5
5	22,6
6	19,9
7	20,2
8	22,6
9	20,7
10	20,5
Average value:	21,1
Standard deviation: 0,99	

Comparing the average value of the surface area of the visible periapical lesions in the intraoral X-ray image with the 3D scan, this inflammation is still visibile over 2 times better in 3D imaging after 2 and half year of treatment.

3.2. Case 2

A 50 year old male during the first examination. Tooth 11. The extraction of the tooth was done after more than a month of re-treatment, and after the next 8 months the patient got an implant. Figure 6 and Table 5 show periapical lesions measurements in an intraoral X-ray image before the treatment and Figure 7 and Table 6 in 3D imaging.

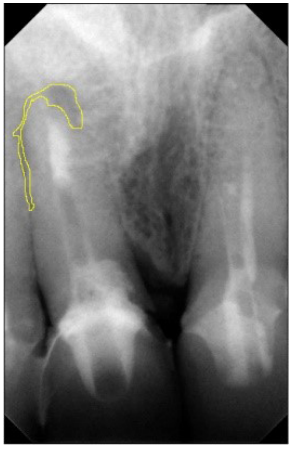

Fig. 6. Intraoral X-ray image of tooth 11 - before the treatment with marked periapical lesions (case 2)

Table 5. Results of the measurement of the surface area of the periapical lesions in intraoral X-ray image of tooth 11 – before the treatment (case 2)

MEASUREMENT	SURFACE AREA OF PERIAPICAL LESION [mm²]
1	7,2
2	7,7
3	7,0
4	7,1
5	7,6
6	7,9
7	7,8
8	8,0
9	7,6
10	7,5
Average value:	7,5
Standard deviation: 0,34	

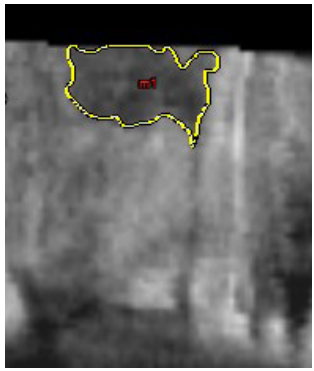

Fig. 7. CBCT image of tooth 11 – before the treatment with marked periapical lesions (case 2)

Table 6. Results of the measurement of the surface area of the periapical lesions in CBCT image of tooth 11 – before the treatment (case 2)

MEASUREMENT	SURFACE AREA OF PERIAPICAL LESION [mm²]
1	33,1
2	34,8
3	32,7
4	32,1
5	33,3
6	32,2
7	33,9
8	32,6

9	33,7
10	37,5
Average value:	33,6
Standard deviation: 1,60	

The surface area of periapical lesions visible in 3D imaging is more than 4 times bigger than in the 2D intraoral image. In volumetric imaging, due to the fact that there is no overlapping of anatomical structures and due to the ability to view the image from different angles, periapical lesion is very clearly visible.

4. Conclusion

Application of Cone Beam Computed Tomography in dental imaging is very useful in detection and assessment of periapical lesions. Volumetric tomography in contrast to X-ray allows us to view three-dimensional anatomical structures in real size without overlapping. This is the basis for assessing the extent of periapical lesions. Volumetric tomography is an excellent technique for dental use in endodontics and implantology.

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