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THE ROLE OF CONE BEAM COMPUTED TOMOGRAPHY (CBCT) IN THE ASSESSMENT OF THE PERIAPICAL LESIONS TO OPTIMIZE TREATMENT IN HYPERTENSIVE PATIENTS

PHD THESIS ABSTRACT

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In the overview there is a limited number of images and charts maintaining the numbering from the thesis.

Key words: periapical lesions, cone-beam CT low-dose, periapical radiography, CT low-dose,arterial hypertension.

MOTIVATION AND THE AIMS OF THE PHD THESIS

The management of the periapical lesions on the hypertensive patients implies a firm collaboration between dentists and the cardiologist as well as radiologists who are specialised in the dento-maxilo-facial imaging, since there are some problems that concern the ascertainment of a treatment protocol which requires a functional system of communication between doctors as well as establishing the opportune moment to commence the endodontic treatment depending on the value of the blood pressure.

The computed tomography explorations (CT) represent the method of choice in the urgent assessment of the cranium-facial pathology. In some cases the CT cranium-cerebral explorations contain dental structures as well as the odontal and paradontal pathology (Steinklein et al., 2013). Even if the CT dental examinations are not usually made in the imaging departments, the cranium-cerebral explorations made through computed tomography can have dental structures with odontal and paradontal pathology (Steinklein et al., 2013). This protocol of cranium-cerebral and odonto-paradontal scanning allows the detection of primary dental lesions, secondary impairment of maxillary sinuses and of the soft tissue from proximity, thus requiring the knowledge and the description of these pathological aspects in the final imaging report.

The cone beam computed tomography (CBCT) represents a method of imaging diagnosis which allows fast scanning with high quality imaging reconstructions, with three-dimensional precision and visualisation. Currently there are CBCT systems which offer images with a small FOV, with low doses of radiation, with fine spacial resolution in order to offer the correct endodontic and paradontal diagnosis, alongside guidance on the treatment and the fast and precise post-treatment assessment. The CBCT examination which has become more and more accessible in the last 10 years has enabled its use with the hypertensive patients who have periapical lesions, as well as the assessment of the contribution of this new imaging method in creating a correct and efficient treatment plan which actually constitute one of the aims of this research.

Imaging in endodontics is useful in all the steps of the endodontic treatment, in the pre-operative assessment, allowing the evaluation of the anatomic structures, the estimation of the difficulty of the case and the acknowledgement of the clinical diagnosis. Pre-operatory, the new imaging technology helps determine the duration of work through periapical imaging assessment with the needles on the root canal, it also helps verify gutta-percha cones in the root canals before radicular obturation, as well as in the post-operatory evaluation by visualising the radicular obturation. Post-treatment, CBCT made regularly aims at visualising periapical dynamics, keeping a close eye on the healing in cases of chronic apical pardontitis. Due to its principle of action, CBCT represents an imaging adjuvant in endodontics in contrast with the limitations of bi-dimensional imaging which consisted of bi-dimensional representation of a three-dimensional reality, and the superimposition of the anatomic structures made it difficult to assess the periapical structures.

The main advantage of CBCT represents the fast volumetric acquisition, the superior spacial resolution of C, the advanced multiplaner reconstruction, the bi- and three-dimensional analysis of anatomic structures, emphasising the fine inframilimetric raports between different anatomic structures. Because of the izotropic nature of voxels, it is possible to obtain reconstructions of the CBCT acquisitions in 2D images rotated in nonortogonal sections, panoramic, paraxial , in order to emphasise some particular anatomic elements. Special algorithms and inframilimetric reconstructions can be used to measure the dimensions of the anatomic structures, without distortions or magnifying. CBCT allows visualisation of the complex interrelations between the examined anatomic structures.

However, the density resolution of CBCT is lower than that of CT and of the digital intraoral radiographies. The noise caused by the nonliniar absorption of the X radiations contributes more or less to the degradation of the image. CBCT has the disadvantage of the movement artefacts being greater than the ones caused by metallic structures which distort X radiations represented as dark strips that appear between two dense objects and the artefacts specific to the CBCT system that was used. Taking this limitation into account, our study finds its utility in the assessment of the applicability if this new radiologic diagnosis method in order to diagnose the periapical lesions at the hypertensive patients.

Specialised literature reports in the last years that CBCT has a better diagnosis precision than the periapical radiographies, but the CBCT does not have to replace periapical radiographies used in endodontics, but to augment in particular situations and to emphasise more precisely the anatomic reports, additional root canals, variations of form and morphology of root canals, perforation, apical resorption, location and the aspect of completely or partially treated root canals with a view to applying another treatment. Anastasia Saidi and her collaborators examined radiologically 156 teeth upon which an endodontic treatment was applied through digital periapical radiographies and CBCT. The study showed that the predominance of periapical lesions was considerably greater at CBCT (348%), while through digital periapical radiography the percentage of diagnosis of periapical lesions was 13,8% (Saidi et al., 2015).

Bearing these studies in mind the specific aims throughout this PhD research have been the following:

1. Giving a questionnaire to a group of residents who commonly treat periapical lesions, with the aim of evaluating their knowledge on the bi-dimensional and three-dimensional imaging methods, as well as appreciating the participants' perception on the level of training in modern imaging within the residency programme.
2. Pluri-disciplinary approach on the patients with arterial hypertension, according to the current trends and the modern medical principles concerning the three-dimensional imaging exploration, as well as the specific steps of the endodontic treatment.
3. Comparison of the predominance and the dimension of the periapical lesions among normo and hypertensive patients using cone beam computed tomography (CBCT).
4. The study of the accuracy of the visualisation of the periapical lesions artificially created on a cranium and diagnosed through CBCT explorations and through digital periapical radiographies.
5. Verification and validation of usage of the protocols with a low dose of radiation of computed tomography, without modifying the accuracy of the diagnosis. The principal hypothesis was that low dose protocols lowered with approximately 30-50% can be used in the cranium-facial pathology diagnosis.
6. Validation of some low-dose CBCT protocols for the periapical lesions diagnosis starting from the hypothesis that we can use values of the kilo-voltage similar to the ortopantomographic explorations, of 80Kv and 70kV, preserving the accuracy of the diagnosis.
7. The comparison of the predominance and evaluation of the dimensions of the periapical lesions among hypertensive patients using CBCT explorations compared to digital periapical radiographies.
8. The obtained information could clarify if hypertension represents a modulator factor in the development or acceleration of inflammatory periapical processes.
9. The possibility of reducing the radiation dose through validating low-dose CT/CBCT protocols represents an original aim of our research and at the same time an unexplored territory in our country which is aims at new directions of the applicability of the new protocols.

CHAPTER 6.
THE ANALYSIS OF RADIOLOGICAL KNOWLEDGE OF RESIDENTS THAT HAVE BEEN INVOLVED IN THE TREATMENT OF THE PERIAPICAL LESIONS

Aim of the study

The knowledge of the doctors involved in the treatment of the periapical lesions must include basic notions concerning the indications and interpretation of the imaging methods used, but also the innovations in the field in order to give their patients a minimum degree of radiation at an optimum quality and quantity degree of the obtained information. The evaluation of the degree of knowledge was made through a questionnaire which allowed the examination of a greater variety of aspects and the elicitation of the necessary data through direct questions (Duma, 2011; Scîntee, 1998).

This study was made with the purpose of evaluating the imaging knowledge of the residents as well as their perception on the level of information they received until the present day during their residency programme.

Material and method

We made an opinion questionnaire auto-administered and anonymous (Duma, 2011, Stone, 1993) that was addressed and sent to the residents involved in the complex treatment of the patients with periapical lesions that resort to different methods of imaging exploration. In this questionnaire we followed the evaluation of the knowledge the young doctors concerning the indications, contraindication and the interpretations of the results obtained through these methods. The targeted resident doctors belonged to the following specialisations: general dentistry, endodontics, dento-alveolar surgery and paradontology.

The questionnaire (chapter 6 - questionnaire appendix) contains 15 questions that were analysed by two independent evaluators (specialised teachers with a vast experience in dental and general radiology), with the purpose of increasing the content validity of the questionnaire (Rotariu, 1997; Singly, 1998).

The processing of the information from the data base as well as the statistic analysis was made with the help of the Epi Info 7 programme (Duma, 2003). After counting the same type qualifiers, the Liker medium scale was calculated and the data were compared using the signification test t-Student.

Conclusions

The degree of medical knowledge of the resident doctors in various stages of their training having different specialisations apart from dental medicine concerning the implications of using the modern imaging techniques that use ionised radiations is rarther small.

Our study shows that the resident doctors that are involved in the therapeutic management of periapical lesions know the utility of the CBCT tridimensional imaging in qualitative and quantitative analysis of the data obtained from these methods. The statistic analysis emphasised a low level of interpretation of the CBCT/CT explorations of the patients with periapical lesions by the residents that assessed themselves through this questionnaire.

The statistic results confirm the necessity of making some alterations in the curriculum used in residency training. Periods of internship with varying duration depending on the speciality are useful, the residents being trained in the analysis of the anatomy and pathology of the periapical lesions at various groups of patients, normo or hypertensive.

CHAPTER 7.
THE PREVALENCE OF APICAL PERIODONTITIS IN ARTERIAL HYPERTENSION AND NORMOTENSIVE PATIENTS USING CONE-BEAM COMPUTED TOMOGRAPHY. A COMPARATIVE ANALYSIS.

Aim of the study

The purpose of this study was to compare the prevalence and magnitude of periapical lesions in normotensive and hypertensive patients using cone-beam computed tomography (CBCT) and digital periapical radiography.

The acquired information could clarify if hypertension could or could not represent a modulator factor in the development or acceleration of inflammatory processes at a periapical level.

The aims of the study are the following:

1. The assessment of biological data depending on the value of blood pressure.
2. The assessment of the predominance of periapical lesions at hypertensive patients using CBCT.
3. The assessment of the predominance of periapical lesions at normotensive patients using CBCT.
4. The assessment of the dimension of periapical lesions at normotensive patients compared to hypertensive patients using CBCT.
5. The assessment of the biological parameters depending on the value of the oral hygiene index.
6. The assessment of periapical lesions measured with digital periapical radiography depending on the value of the oral hygiene index.
7. The assessment of periapical lesions measured with the help of volumetric computed tomography related to the value of the oral hygiene index.

Material and methods

This retrospective study was conducted within the Faculty of Dental Medicine, UMF GR.Topa Iasi. The study was in line with the Helsinki Declaration (2000), obtaining the written and informed consent of each patient. CBCT purchases were obtained using a ProMax 3D Max (Planmeca, Helsinki, Finland) with a variable FOV. The voxel size was 0.3mm.

CBCT acquisitions of the teeth injured by endodontic lesions of all patients included in th study were analysed, comparing the CBCT images in different plans with the periapical radiographies of the same teeth. Each dental root was individually examined by analyzing CBCT images in the transverse, coronal and paraxial section of the root.

All images of the dental apex were examined for each root in part and analysed the presence or absence of apical periodontitis. A periapical lesion was diagnosed when the dura lamina was detected, and the radiopaque periapical region was greater than ≥0.5mm or approximately double the width of the spinal wall area at the apical level on 1 or more roots on at least 2 CBCT images.

The periapical radiographs analyzed the same parameters for the diagnosis of periapical lesion. The maximum diameter of the lesion was registered.

Statistical analysis was performed using the SPSS software version 25 (IBM, Chicago, United States). The significance level was ascertained at $P<0,05$.

The Pearson correlation analysis and multiple regression analysis (the step method and the Enter method) were used to test the correlation between age, OHI and years of exposure to hypertension before CBCT with the percentage of lesions present and mean lesion size.

132 patients (66 normotensive and 66 hypertensive) were included in the study. Hypertensive patients were asked when they had been diagnosed with HTA (how many years of HTA they had since they had been diagnosed) (tab. 7.1).

The values of the blood pressure of the patients were registered and values from 0-3 were recorded depending on the presence of plaque (Greene J.C. et al., 1964).

Initially, DPR were made based on which the diagnosis of periapical lesions was made, which was subsequently explored through CBCT in order to give a definitive diagnosis to apply the correct treatment plan. After making all the acquisitions, it made the CBCT reconstructions and the necessary measurements for the study. Three-dimensional images were made with the help of MIP (Multi Intensity Projection (fig. 7.1).

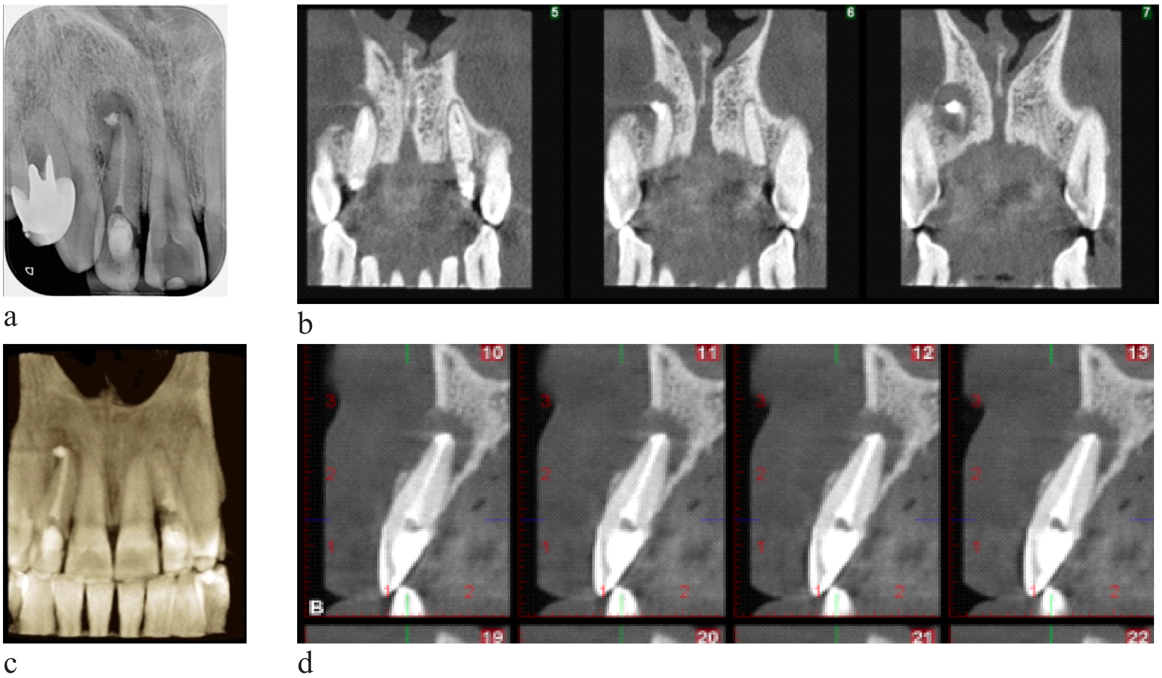


Fig. 7.1. Periapical lesion 1.2. Digital periapical radiography (a); CBCT Coronary reconstruction (b); CBCT 3D Reconstruction (c); CBCT Paraxial reconstructions (d) that emphasise the corono-radicular endodontic treatment with unobtrusive apical overlapping and periapical lesion with destruction of the vestibular margin of the dental cell (personal casuistry)

Results and discussions

This study follows the comparison of the prevalence and the size of the periapical lesions among hypertensive and normotensive patients using CBCT. The statistic tests used to make the differences between samples with hypertensive and normotensive patients.

Independent t-test for periapical radiograph of periapical lesions (PAL-RxPA) and CBCT of periapical lesions (PAL-CBCT), normotensive versus hypertensive

We compared the periapical lesion mean measured through periapical radiography for hypertensive versus normotensive and also the periapical lesion mean measured through CBCT for hypertensive versus normotensive patients (Table 7.2.).

The independent sample t-test has two hypotheses.

H0: μHypertensive = μNormotensive (the independent population means are equal)
H1: μHypertensive ≠ μNormotensive (the independent population means are not equal)
μ - is the mean for the periapical lesions PAL-Rx/PAL-CBCT
The results for the Independent t test are showed in:

Table 7.2. Independent t-test for PAL-RxPA, PAL-CBCT, normotensive versus hypertensive

Hypertensive/Normotensive		N	Mean	Std. Deviation	Std. Error Mean
LPA-RxPA	Hypertensive	66	0.9805	1.38209	0.17012
	Normotensive	66	0.9936	1.27525	0.15697
	Hypertensive	66	2.9059	1.95107	0.24016
LPA-CBCT	Normotensive	66	2.7577	1.79342	0.22075

This table contains descriptive data: mean, std deviation and std error mean for hypertensive, normotensive for each of the continuous variables PAL-RxPA, PAL-CBCT. Levene test for equality of variances showed normal distribution.

For the first variable measured PAL-RxPA: it does not exist significant differences between the periapical lesion mean measured through Periapical Radiography for the hypertensive people versus the normotensive people.

For the second variable measured PAL-CBCT: it does not exist significant differences between the periapical lesion mean measured through CBCT for the hypertensive people versus the normotensive people.

Independent t-test for OHI, normotensive versus hypertensive

We want to compare the OHI mean for hypertensive versus normotensive (Table 2.). The independent sample t-test has two hypotheses

H0: μHypertensive = μNormotensive (the independent population means are equal).
H1: μHypertensive ≠ μNormotensive (the independent population means are not equal).
μ - is the mean for the OHI
The results for the Independent t test:

Table 7.4. Independent t-test for OHI, normotensive versus hypertensive

Hypertensive/Normotensive		N	Mean	Std. Deviation	Std. Error Mean
OHI	Hypertensive	66	0.92	0.829	0.102
	Normotensive	66	0.67	0.966	0.119

This table contains descriptive data: mean, std deviation and std error mean for hypertensive, normotensive for the OHI index. Levene test for equality of variances showed normal distribution. Levene test shows a p = 0.103 (a 10.3% probability) meaning that we will accept the null hypothesis.

It does not exist significant differences between the OHI index mean measured for the hypertensive people versus the normotensive people.

Chi Square test results:

This table allows us to understand the distibution within hypertensive and normotensive for a positive or negative diagnostic (Table 7.7.).

There is no difference between normotensive and hypertensive for the positive/negative diagnostic of the periapical lesions explored through periapical radiography.

Table 7.7. Chi Square test

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.000a	1	1.000		
Continuity Correctionb	0.000	1	1.000		
Likelihood Ratio	0.000	1	1.000		
Fisher's Exact Test				1.000	0.577
Linear-by-Linear Association	0.000	1	1.000		
N of Valid Cases	132				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 18.00.

b. Computed only for a 2x2 table

We observed that $\chi(1) = 0.000$, $p = 1.000>0.05$, meaning that there is no statistically significant association between Hypertensive/Normotensive and the periapical lesions explored through periapical radiography. Both hypertensive and normotensive have been equally diagnosed with both positive or negative lesions using periapical radiografy.

Chi Square test used for the percentages of the periapical lesions explored through CBCT for hypertensive versus normotensive people

The chi-square test for independence, also called Pearson's chi-square test or the chi-square test of association, is used to discover if there is a relationship between two categorical variables (Table 4.).

Hypothesis:

Null hypothesis: assumes that there is no association between the two variables.

Alternative hypothesis: assumes that there is an association between the two variables.

Table 7.8. CBCT Hypertensive/Normotensive Cross tabulation

			Hypertensive/Normotensive		
			Hypertensive	Normotensive	Total
BCT	Positive	Count	48	56	104
		Expected Count	52.0	52.0	104.0
		% within Hypertensive/Normotensive	72.7%	84.8%	78.8%
	Negativ	Count	18	10	28

e	Expected Count	14.0	14.0	28.0
	% within Hypertensive /Normotensive	27.3%	15.2%	21.2%
Total	Count	66	66	132
	Expected Count	66.0	66.0	132.0
	% within Hypertensive /Normotensive	100.0%	100.0%	100.0%

This table allows us to understand the distribution within hypertensive and normotensive for a positive or negative diagnostic. As we can see only examaning this table there is a slightly difference between normotensive and hypertensive for the positive/negative diagnostic of the periapical lesions explored through CBCT.

Table 7.10. Results of the Pearson Correlation

Hypertensive/Normotensive			LPA – CBCT	age	OHI
Hypertensive	LPA – CBCT	Pearson Correlation	1	0.044	.735**
		Sig. (2-sides)		0.724	0.000
		N	66	66	66
	age	Pearson Correlation	0.044	1	0.231
		Sig. (2-sides)	0.724		0.062
		N	66	66	66
	OHI	Pearson Correlation	.735**	0.231	1
		Sig. (2-sides)	0.000	0.062	
		N	66	66	66
Normotensive	LPA – CBCT	Pearson Correlation	1	-0.017	.799**
		Sig. (2-sides)		0.892	0.000
		N	66	66	66
	age	Pearson Correlation	-0.017	1	0.062
		Sig. (2-sides)	0.892		0.618
		N	66	66	66
	OHI	Pearson Correlation	.799**	0.062	1
		Sig. (2-sides)	0.000	0.618	
		N	66	66	66

** The correlation is significant at 0.01 levela nivelul 0.01 (2-sides).

We obtained $\chi(1) = 2.901$, $p = 0.089>0.05$ meaning that there is no statistically significant association between hypertensive/normotensive and the periapical lesions explored through CBCT; that is, both hypertensive and normotensive equally have been diagnosed with positive or either negative using CBCT.

The results of this study indicated that the endodontic treatment can be successfully applied at hypertensive patients, although careful investigation of these patients is needed as well as preliminary preparations. The complete case history of arterial hypertension of each patient must be obtained before starting the treatment plan. Adequate screening is essential for these patients. If a patient has a precarious control of the blood pressure, the endodontic treatment will need to be delayed until a medicated stabilisation of the values of the blood pressure will be obtained, according to the indications of the cardiologist.

Another effect of parodontal infection that can explain the association between parodontitis and heart diseases is that the parodontal tissue contains proteins that cross-interact with the heart. Thermic shock protein, which is produces by Tannerella Forsythia and Porphyromonas gingivale is found at approximately 60% of the patients with parodontitis. The resulted antibodies on the thermic shock proteins activated by the parodontal bacteria are eco-reactive with the thermic shock protein which is exposed in the injured endothelium or at the level of ateromatos plaques.

This can set in motion the autoimmune phenomena and can contribute to the formation of artery plaque buildups. Also, there can be common genetic mechanism to provide the connection between parodontitis and heart diseases (Rose et al., 2000).

The important aim of the treatment is to keep a record of the patients with heart diseases and of all the identified risk factors involved:

- Pre-medication should be taken into account to ease anxiety and to make the anodyne more efficient as a stress-reliever.
- Patients should be scheduled in the morning, in the first hours of the morning in short sessions.
- All patients are recommended to have a comfortable position in the dental chair.
- The procedure should take minimum time and the treatment should be terminated as fast as possible to relieve anxiety
- Attention should be paid to the current medication the patients take and to the allergies on any medication, as well as their interaction with other type of medication and their side-effects.

Thus, the prevalence of arterial hypertension on patients with chronic parodontitis has been statistically ascertained with a value of 12,2%. No significant association existed between arterial hypertension and the degree of parodontal damage. The relationship of causality should not be neglected (Shamsuddin et al., 2014).

Conclusions

CBCT is the most widely used imaging technique in modern endodontics that helps endodontics doctors to make a preoperatory diagnosis assessment of periapical lesions, without major differences between medium periapical lesion measured through periapical radiography for hypertensive patients compared to normotensive patients. There is a significant statistical association between hypertensive/normotensive patients and periapical lesions examined through periapical radiographies. There are no significant differences between medium periapical lesion measured with the help of CBCT for hypertensive patients compared to normotensive patients. There are no significant differences between the averages of OHI indices measured through periapical radiographies for hypertensive patients compared to normotensive patients. The study indicates that endodontic treatment can be successfully applied to hypertensive patients, only that careful investigation is needed for these patients as well as preparations in advance. In the light of current research, the management of endodontic lesions at hypertensive patients will be identical with that of normotensive patients.

CBCT preoperatory imaging offers additional information compared to preoperatory digital periapical radiographies which may lead to alteration of the treatment plan.

CHAPTER 8.
THE ASSESSMENT OF PRIAPICAL STRUCTURES THROUGH COMPUTED TOMOGRAPHY PRTOTOCOLS WITH A LOW DOSE OF RADIATION

Aim of the study

Our study's main aim was the ascertainment and validation of low dose radiation protocols, without modifying the diagnosis accuracy. Our main hypothesis was that we can use protocols that reduce with 30-50% the radiation dose to diagnose cranium-facial pathology.

The retrospective study analysed scanned patients in the Radiology department of the Emergency Hospital "Prof. Dr. N. Oblu", Iasi. Our study design had our institutional review board and ethics committee approval; the written informed consent was not needed because the studies were clinically indicated and were performed with a low-radiation dose protocol and total radiation did not increase.

Material and method

We retrospectively analysed patients database between June 2013 and may 2014 in the Radiology department of the Emergency Hospital "Prof. Dr. N. Oblu", Iasi. From 4513 patients who undergo head CT for traumatic cranio-facial injury, we only enrolled 51 patients that respect the inclusion criteria: more than two scans in the same hospitalization interval and one of the scan has to be with low dose protocol and the difference of time between low dose examinations and standard ones was 7 days at the most.

From the study we excluded patients who were wearing dentures and metallic plaques that could produce important artefacts that could have significantly modified the quality of the images, as well as difficult patients who were nervous and uncooperative, whose examinations presented important movement artefacts.

The computed tomography examinations were made using a 16-section CT machine (Toshiba Aquilion 16) capable of producing images at a minimum section of 0.5mm.

The patients were subjected to a dorsal decubitus scan, and in order to obtain scans without movement artefacts fixing devices with sponges made of polyurethane foam and Velcro headband were used enabling a more powerful immobilisation of the cephalic extremity.

The standard examination protocols of the neoro and viscero-cranium including dental apexes used two ways of standard acquisition:

- Sequential scanning with 3, 4, or 6 sections, 250 mA, 1 second rotation time and a voltage of 120 or 130 kV
- Spiral scanning using 16 sections, with a pitch of 0.9.

For low dose protocols the following were used:

- Sequential scanning with 130kV, the potential, with 250 mA, the tube current, and a rotation time of 0.5 seconds, thus obtaining a reduction of the radiation dose with 50%, sequential scanning with 110 kV, the potential, with 250 mA, the tube current, and a rotation time of 0.7 seconds, thus obtaining a reduction of the radiation dose with 34%.
- Spiral scanning with a pitch of 1.5 and a rotation time of 0.7 second, the reduction of the radiation dose being of about 50%.

The qualitative analysis of the images was made over the span of four stages, involving four neuroradiologists with 10, 12, 5 and 6 years of experience (coded in our study with the acronyms MD1, MD2, MD3 and MD4). For the analysis of anatomic and pathologic structures of periapical areas in this study a doctor with a 5 years clinical experience was involved as well as a training course in the diagnosis of dental lesions with the help of CBCT examination (in our study this being know under the acronym D1).

The quality of an image could be quantitatively ascertained by calculating the image contrast, representing the difference between two different structures adjacently situated and by calculating the CNR („contrast to noise ratio"); these calculation and measurements were made in similar areas of interest, for the images with standard dose as well as for those with low doss. The selection of the areas of interest and the following calculations were made by a physicist and another radiologist, neither of them being involved in any stage of the study.

Results and discussions

When the readers evaluated the standard-dose images, they scored as **good quality** approximately 65% of cases (66.7 % reader MD1 and 64,7 % reader MD2), as **acceptable quality** 31.4 % by MD1 and with the same percentage by reader MD2 (Figure 8.3)

Tabel 8.1. The values for medium doses for standard and low dose protocols

	DLP protocol low-dose	DLP standard
Nr	51	51
Medium	459,04	861,09
Std. Dev	57,50	51,21
Median	445,20	858,60
Std. Error	8,05	7,17

A medium reduction of radiation dose was obtained for all 51 cases, with a percentage of approximately 46,68% ($p<0.001$).

The design of our research was based on the comparative study of the computed tomography acquisitions through protocols that used methods of reducing the radiation dose and initial acquisitions obtained through standard protocols. The readers appreciated in 94,11% (47 out of 51 cases) that the images that were obtained through low-dose protocols observe the quality criteria and can be safely interpreted.

Acquisition software of computed tomography devices offer a series of parameters that can be extra accessed and configured compared to standard protocols. Thus changing these parameters will influence the final dose. An easily changed parameter is the tube current, which varies linearly and proportionally with the radiation dose and the rotation speed of the tube varies inversely with the dose; thus the radiation dose could be reduced by half, reducing the values of the current or the scanning speed by 50% (Mullins et al., 2004;Horne et al., 1963; Hon et al., 2013). For the scans through spiral protocol the pitch modification method was used to reduce the radiation dose, which varies inversely with the radiation dose (31).

The radiation doses in our study varied between 54 and 32,6%, thus obtaining an average reduction of approximately 45%. Although there are many low-dose protocols set in the acquisition console we ascertained that the most widely used method by the readers was that which modifies the value of the current (mAs), being used by 75% on the readers. Nonetheless, our study does not emphasise a statistical difference concerning the quality of the images obtained through the two protocols of reducing the radiation dose, which does not explain the difference between the preference of one method over the other.

One explanation could be that the low-dose method which was widely used is found on the protocols available on the acquisition console on a more accessible position and probably the technician or the examining doctor selected the low-dose protocol as their first option.

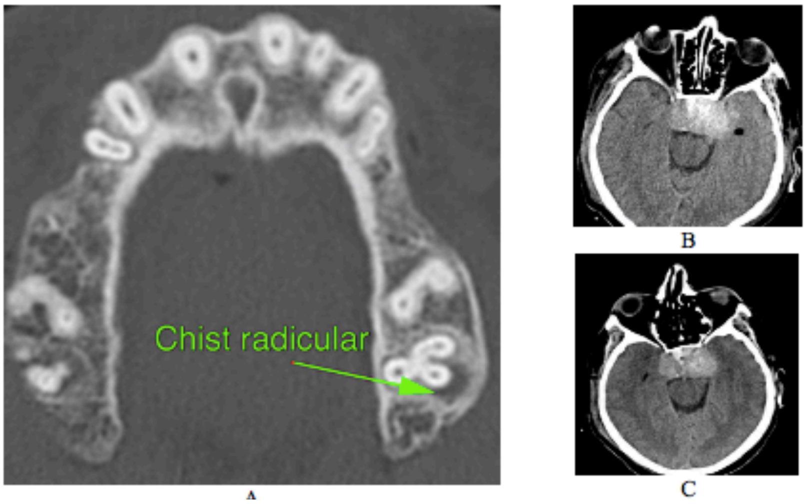


Fig. 8.1. CT axial section through apical region at a patient examined low-dose (A) with a cranio-cerebral injury. B is a low-dose transversal section through the pituitary box and C is obtained through a CT standard protocol.

Conclusions

The computed tomography radiation dose can be reduced using methods which modify the mA and kV parameters, automatic modulation of the pitch or modern reconstruction algorithms, though it is important that they do not modify the final acquisition under the diagnosis threshold in cranio-cerebral traumatic lesions at the patients which concomitantly present periapical lesions.

The statistical results of our study emphasised that although the computed tomography examinations with a low dose of radiation have a lower quality than the standard ones, they do not modify the accuracy of the diagnosis when the reduction is between 30 and 50%; therefore we recommend the use of low-dose protocols especially with children, young people or with those patients with serious conditions that will be CT monitored on the long term.

The interobservant analysis made by the doctors with experience in the evaluation of dental pathology and in sinus and intracerebral complications emphasised that the periapical region can be safely examined through low-dose CT protocols, especially because of the fact that structures it encompasses and the pathological elements have sufficient differences in density, which will not be significantly influenced through the reductions of the radiation dose.

Our results allow us to recommend the use of CT techniques at the patients with injuries and periapical lesions at which point the examination protocols have to include dental apexes to correctly appreciate the intrasinus echo or the eventual dental causes of distance intracerebral causes. For the patients with minor cranio-facial injuries we recommend the use of CBCT, using FOVs of variable dimensions (4x5 mm, 5x5 mm, 8x8 mm) that can be focused only on the traumatised area, managing a visible subsidence of the total dose of radiation.

The reduction of the radiation dose in imaging diagnosis will observe the ALARA principle and it will be a communal responsibility of the attending doctor who is responsible for the justification of the examination, as well as of the radiologist who is responsible for its optimisation.

CHAPTER 9.
THE COMPARATIVE ANALYSIS OF CBCT COMPARED TO DIGITAL PERIAPICAL RADIOGRAPHY ON ARTIFICIALLY GENERATED PERIAPICAL LESIONS

Our main aim of this study was that the artificially generated periapical lesions are more accurately diagnosed through CBCT as compared to the explorations made through digital periapical radiographies.

As for the other **aims** we can mention:

- The comparison of the accuracy of the diagnosis of the endodontics in the artificially generated periapical lesions, using digital periapical radiography and CBCT;
- The assessment of artificially generated periapical lesions and measured with the help of periapical radiography;
- The assessment of artificially generated periapical lesions and measured with the help of volumetric computed tomography.

Material and method
Selection of the cases

For this study we used scans of some dried craniums from the Department of Anatomy from the Dental Medicine Faculty UMF „Grigore T. Popa" Iași and the imaging explorations were made in a radio-imaging dento-maxilo-facial private centre.

Initially we started with 8 craniums but after applying the exclusion and inclusion criteria only 5 dried craniums were selected, thus having 40 teeth that were explored. The teeth used in the studio were whole, having the entire alveolar bone. From the 60 teeth that were initially scanned, 40 teeth were included in the study, 15 maxillary teeth (2 molars first maxilla, 8 incisors, 5 premolars) and 25 mandibular teeth (10 incisors, 5 canines, 6 premolars and 4 molars).

Each dental root was individually examined, radiography images, CBCT in transversal section, coronary and paraxial sections being analysed. Each images of the dental apexes for each root were examined and the presence or the absence of apical paradontitis was also analysed.

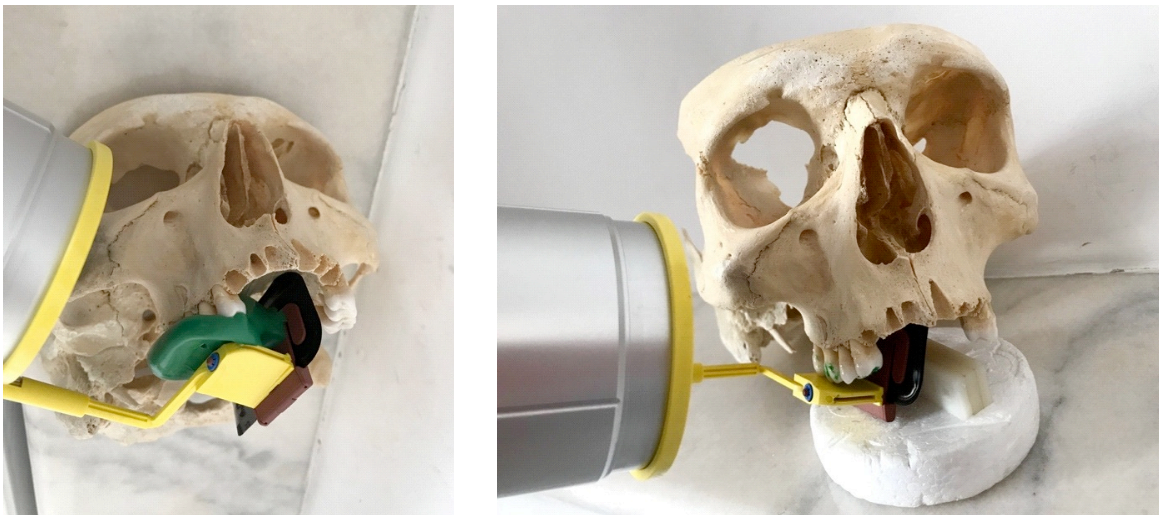
A periapical lesion was diagnosed when the lamina dura was interrupted and in the periapical region the radio-transparency was greater or equal to 2mm or approximately the double of the width of the space of the periodontal ligament at apical leve (Abella et al., 2012; Zhang et al., 2015), on one or more roots in at least 2 plans of the CBCT images. Thus the inclusion and exclusion criteria were determined.

The inclusion criterion in the study was the following: whole teeth, with the apexes in the whole alveolar teeth with a thickness of minimum 5mm.

After the exclusion from the study of the selected teeth periapical radiographies and CBCT scans were made for each tooth, before introducing the artificially generated periapical lesions.

The digital periapical radiographies were obtained using the system of ExpressTM imagistic plates (Instrumentarium Dental, Tuusula, Finlanda) and a digital appliance with X rays with 70kVp and 8mA (XDent X70, XDent Dental Equipment, Ribeirão Preto, São Paulo, Brazilia). The digital periapical radiographies were taken using the beam collimation technique, using a positioning instrument developed in order to hold the digital sensor (the instruments: XPC RINN®, RINN Corporation, Elgin, Illinois, SUA).

In order to allow the reproducibility of the position of the sensor and of the parallel incidence of the X rays, the stabilisation parameters were made using condensation impression materials (ZetaplusTM, Zhermack SpA, Badia Polesine, Roma, Italia) (fig. 9.3).



Stabilisation parameters, positioning instruments, X rays cylinder and the cranium in the position to perform the digital periapical radiographies

For the CBCT scans the following settings were made: 90 kVp, 10 mA, FOV 5 cm × 5 cm and the size of the voxel of 0,4 mm (Fig. 9.4).

Fig. 9.4 The position of the cranium in the posture to make the CBCT acquisition

The teeth that were included in the study were explored through digital periapical radiographies and CBCT to evaluate the initial situation. Subsequently, these were carefully extracted using elevators and extraction forceps so that the apex of the teeth or the cell would not be damaged.

After the extraction they were visually inspected. The teeth were carefully positioned in the alveolar process and a new CBCT scan was made to confirm that the teeth were completely adapted to the cell.

The teeth that could not be adequately repositioned and that had a radiotransparent lag between the apex and the adjacent alveolar bone were also excluded from the study (fig. 9.5). The bone defects that were artificially created were generated around the top of the teeth included in the study with the help of an extra-hard drill of different sizes, the diameter growing continuously-0.5mm, 1.0mm, 1.6mm. In the case of the pluriradicular teeth we opted for only one artificial lesion thus: for the maxillary molars the drilling occurred at the level of the apex of the palatine root, for the mandibular molars the drilling occurred at the level of the apex of the distal root, for the biradicular premolars we chose randomly choosing the root with the greatest periapical bone volume.

The exploration of the teeth before and after the positioning in the cell

After each bone defect was simulated, periapical radiographies and CBCT were made. In order to generate the same manifestations, stabilisation guides made from impression materials (Express STD, 3M ESPE) were used.

The images generated after all the CBCT scans and periapical radiographies were selected and evaluated by a radiologist doctor and an endodontist. The digital periapical radiographies were viewed using CliniView (Instrumentarium Dental, Tuusula, Finlanda) and the CBCT scans were viewed using the imaging software CS 3D (Carestream Health, Rochester, NY, SUA). Thus, only an image in sagittal position was selected, this being the clearest image. In case there is disagreement between them, a third opinion was asked, that of an implantologist After the images were selected, they were analysed by 5 different endodontists offering for each image one of the three possible answers: presents lesion, missing lesion, I am not sure. In case a lesion was present it was measured in mm. The comparison between DPR and CBCT was made using the chi-square test. All the statistics tests were performed using SPSS 19.0 version (IBM Corp., Armonk, NY, SUA). The level of significance was established at 5%.

Protocols and measurements

For the drilling with a diameter of 0.5mm

For the artificially generated bone defects with the help of an extra-hard drill of 0.5mm in the periapical radiography we registered minimum values of 0.1mm and maximum values of 0.42mm of the artificially generated periapical lesions, thus reaching an average of 0.23mm and the standard deviation of 0.09mm.

For the artificially generated bone defects with the help of an extra-hard drill of 0.5mm in CBCT we registered minimum values of 0.4mm and maximum values of 0.55mm of the artificially generated periapical lesions, thus reaching an average of 0.5mm and the standard deviation of 0.03mm.

For the drilling with a diameter of 1mm

For the artificially generated bone defects with the help of an extra-hard drill of 1mm in the periapical radiography we registered minimum values of 0.21mm and maximum values of 0.95mm of the artificially generated periapical lesions, thus reaching an average of 0.5mm and the standard deviation of 0.15mm.

For the artificially generated bone defects with the help of an extra-hard drill of 1mm in CBCT (standard protocol 90Kv) we registered minimum values of 0.9mm and maximum values of 1.1mm of the artificially generated periapical lesions, thus reaching an average of 0.98mm and the standard deviation of 0.05mm.

For the drilling with a diameter of 1.6mm

For the artificially generated bone defects with the help of an extra-hard drill of 1.6mm in the periapical radiography we registered minimum values of 0.5mm and maximum values of 1.8mm of the artificially generated periapical lesions, thus reaching an average of 0.95mm and the standard deviation of 0.28mm.

For the artificially generated bone defects with the help of an extra-hard drill of 1.6mm in CBCT (standard protocol 90Kv) we registered minimum values of 1.5mm and maximum values of 1.65mm of the artificially generated periapical lesions, thus reaching an average of 1.59mm and the standard deviation of 0.04mm.

Results and discussions

Recent meta-analysis that concern aspects about the diagnosis precision of CBCT and digital periapical radiography showed that periapical radiographies (both conventional and digital) have a better diagnosis precision when it comes to identifying the artificially generated periapical lesions, compared to the CBCT imaging which showed excellent precision (Leonardi Dutra K et al.,2016).

The ascertainment of this study is in accordance with those of the recent meta-analysis, as well as with the the data from Kanagasingam and co., who, using hispathological data, concluded that CBCT has a significantly better diagnosis accuracy (Hadley et al.,2008). Paula-Silva FW and her collaborators made a study on bodies and emphasised that the roots which seemed to be whole on conventional periapical radiographies, actually had an obvious inflammation hyspathologically speaking. Comparing the hyspathological evaluation of these teeth with the digital periapical radiographies and CBCT acquisitions, the periapical radiographies managed to detect the periapical lesions only in 22% of the cases, whereas CBCT the failure ratio was only 9% (Paula-Silva FW et. al., 2009).

Thus, the American Association of Endodontics and the American Academy of Oral and Maxilo-Facial Radiology acknowledged that CBCT be used as auxiliary in bidimensional imaging especially when evaluating and treating complex cases (Special Committee et al., 2015). Green and co. Observed that the roots that seemed healthy on the periapical radiographies, had apical parodontitis conformed hystologically as well as through CBCT (Green et. al., 1997).

Conclusions

CBCT was more reliable that the digital periapical radiography in detecting mandible and maxillary teeth on dry skull, this being an advantage especially for pluriradicular teeth.

CBCT allowed a greater accuracy than the DPR in detecting the lesions simulated for all the tested simulated lesions.

Endodontics have to be trained accordingly in interpreting the CBCT scans in order to obtain a greater precision of the diagnosis. In endodontics, for the pluriradicular teeth, CBCT is an important instrument in the separate evaluation of each root, eliminating the limitation of diagnosis made by the overlapping of the roots or of other anatomic structures over the apexes of the investigated roots, as in the case of DPR.

CHAPTER 10
THE POSSIBILITY TO REDUCE THE RADIOATION DOSE THROUGH CBCT LOW-DOSE PROTOCOLS IN THE EXPLORATION OF ARTIFICIALLY GENERATED PERIAPICAL LESIONS

The aims of the study

Our study had as its **main aim** the validation of some CBCT low-dose protocols in the diagnosis of periapical lesions. Our hypothesis was that we can use protocols that reduce the radiation dose with values between 80Kv and 70kV, thus maintaining an optimal level of diagnosis.

The obtained information can thus concretise in a series of **auxiliary aims** derived from the main aim as follows:

1. The assessment of periapical lesions measured with the help of CBCT (computer tomografiei volumetrice).
2. The assessment of periapical lesions measured with the help of periapical radiography.
3. The comparison of the diagnosis precision of endodontics who have been previously trained in the detection of artificially generated periapical lesions using CBCT and DPR.
4. The assessment of the sizes of artificially generated periapical lesions through two low-dose protocols of 80Kv and 70kV.
5. The assessment of the diagnosis precision with various doses of radiation of CBCT and FOV in the diagnosis of simulated periapical lesions.
6. The comparison of the diagnosis accuracy of DPR with that of CBCT with a view to detecting the artificially generated periapical bone defects on dried craniums.

Materials and methods

For this study we used scans of some dried craniums from the Department of Anatomy from the Dental Medicine Faculty UMF „Grigore T. Popa" Iași and the imaging explorations were made in a radio-imaging dento-maxilo-facial private centre. The initial batch of craniums was 8, but after applying the inclusion and the exclusion criteria only 5 cranium were selected, thus obtaining 40 teeth. These were analysed by 3 doctors, a radiologist, an endodontics doctor and a dentist, each having 10 years of experience.

Inclusion criteria: in the study there were: whole odontal and parodontal teeth, with intact cell.

The exclusion criteria focused on the teeth with periapical lesions, teeth with injuries, teeth whose cell was not intact, with the injured vestibular or oral bone cortical.

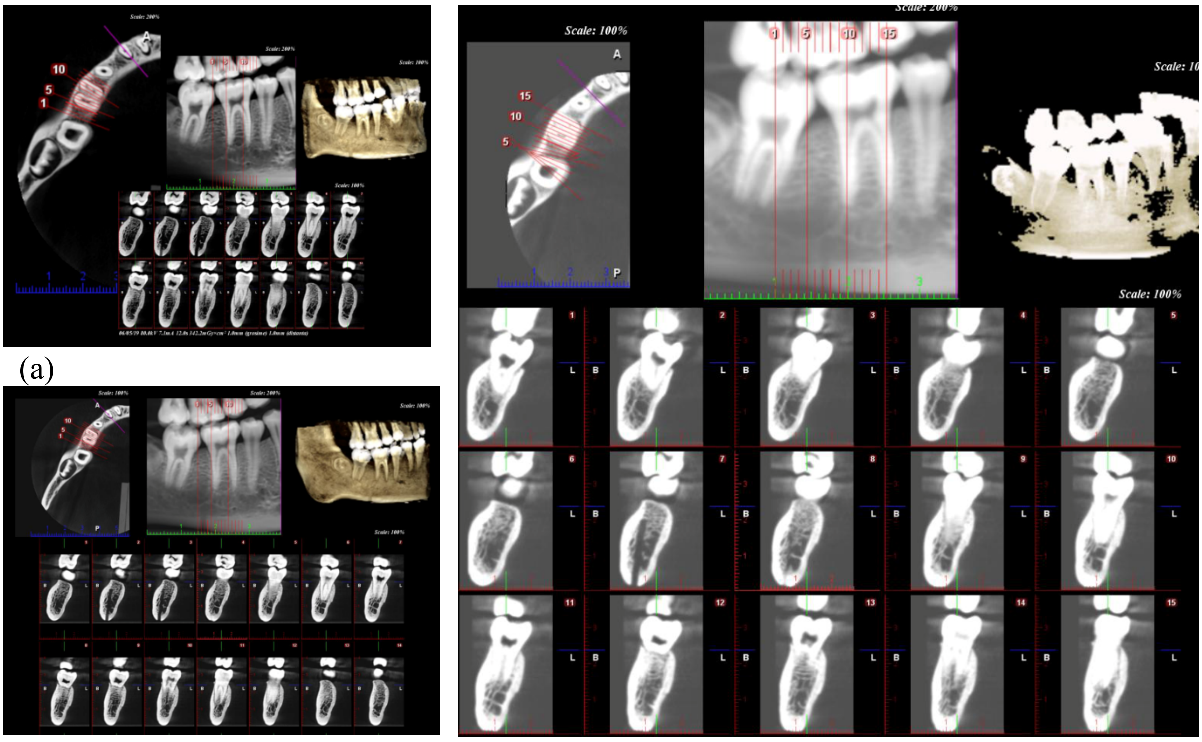
Each dental root was individually examined , analysing radiography images, CBCT in sagittal, coronary and paraxial section of the root. Each images of the dental apexes for each root were examined and the presence or the absence of apical paradontitis was also analysed.

A periapical lesion was diagnosed when the lamina dura was interrupted and in the periapical region the radio-transparency was greater or equal to 1.5mm or approximately the double of the width of the space of the periodontal ligament at apical leve (Abella et al., 2012; Zhang et al., 2015), on one or more roots in at leaast 2 plans of the CBCT images.

Imaging examinations

After the inclusion of the selected teeth DPR and CBCT scans were performed for each tooth, before creating the artificial periapical lesions. Thus we used 5 dried craniums on which were created simulated periapical lesions, progressively magnified with the help of 3 spherical drills of various sizes. In the study 40 radiologically explored teeth were included, thus having 160 CBCT acquisitions of the initial situation and also after each drilling.

For the initial CBCT scans the following settings were used: 90 kVp, 10 mA and a scanning time of 24 seconds, small FOV (5 cm × 5 cm) and the size of the voxel of 0,1 mm. Subsequently, after each artificially generated periapical lesion, two more low-dose protocols were exposed: low-dose 1 (80kV) and low-dose 2 (70kV).



(b) (c)

Fig.10.2. Initial explorations of 46. CBCT protocol 90kV (a); CBCT protocol 80kV (b) and CBCT protocol 70kV (c)

After the CBCT acquisitions of the initial situation, the teeth were carefully extracted to avoid damaging the teeth and the alveolar process. The teeth were carefully positioned in the alveolar process and a new CBCT scan was made to confirm that the teeth were completely adapted to the cells.The teeth that could not be adequately repositioned and that had a radiotransparent lag between the apex and the adjacent alveolar bone were also excluded from the study (fig. 10.1).

The bone defects that were artificially created were generated around the top of the teeth included in the study with the help of an extra-hard drill of different sizes, the diameter growing continuously-0.5mm, 1.0mm, 1.6mm.After each bone defect was simulated, periapical radiographies and CBCT were made. In order to generate the same manifestations, stabilisation guides made from impression materials (Express STD, 3M ESPE) were used. In the case of the pluriradicular teeth we opted for only one artificial lesion thus: for the maxillary molars the drilling occurred at the level of the apex of the palatine root, for the mandibular molars the drilling occurred at the level of the apex of the distal root, for the biradicular premolars we chose randomly choosing the root with the greatest periapical bone volume.

The images obtained after the CBCT scans were selected and assessed by a radiologist, an endodontist and a dentist, agreeing for each image on one of three possible answers: the lesion is present, the lesion is absent, uncertain, offering values of the identified radiotransparencies.

For the **initial explorations** stage (explorations made before artificially generated periapical lesions) we do not have any lesion detected through periapical radiography or CBCT, through standard and low-dose protocols.

For the drilling with a diameter of 0.5mm

For the artificially generated bone defects (fig. 10.4) with the help of an extra-hard drill of 0.5mm in the CBCT acquisitions (standard protocol - 90kV) we registered minimum values of 0.4mm and maximum values of 0.55mm of the artificial periapical lesions, thus reaching an average of 0.5mm and the standard deviation of 0.03mm.

For the artificially generated bone defects with the help of an extra-hard drill of 0.5mm in CBCT (low-dose 1-80kV) we registered minimum values of 0.3mm and maximum values of 0.65mm of the artificial periapical lesions, thus reaching an average of 0.48mm and the standard deviation of 0.08mm.

For the artificially generated bone defects with the help of an extra-hard drill of 0.5mm in CBCT (low-dose 2-70kV) we registered minimum values of 0.15mm and maximum values of 0.4mm of the artificial periapical lesions, thus reaching an average of 0.27mm and the standard deviation of 0.1mm.

For the drilling with a diameter of 1mm

For the artificially generated bone defects with the help of an extra-hard drill of 1mm in the CBCT acquisitions (standard protocol - 90kV) we registered minimum values of 0.9mm and maximum values of 1.1mm of the artificial periapical lesions, thus reaching an average of 0.98mm and the standard deviation of 0.05mm.

For the artificially generated bone defects with the help of an extra-hard drill of 1mm in CBCT (low-dose 1-80kV) we registered minimum values of 0.9mm and maximum values of 1.15mm of the artificial periapical lesions, thus reaching an average of 1mm and the standard deviation of 0.06mm.

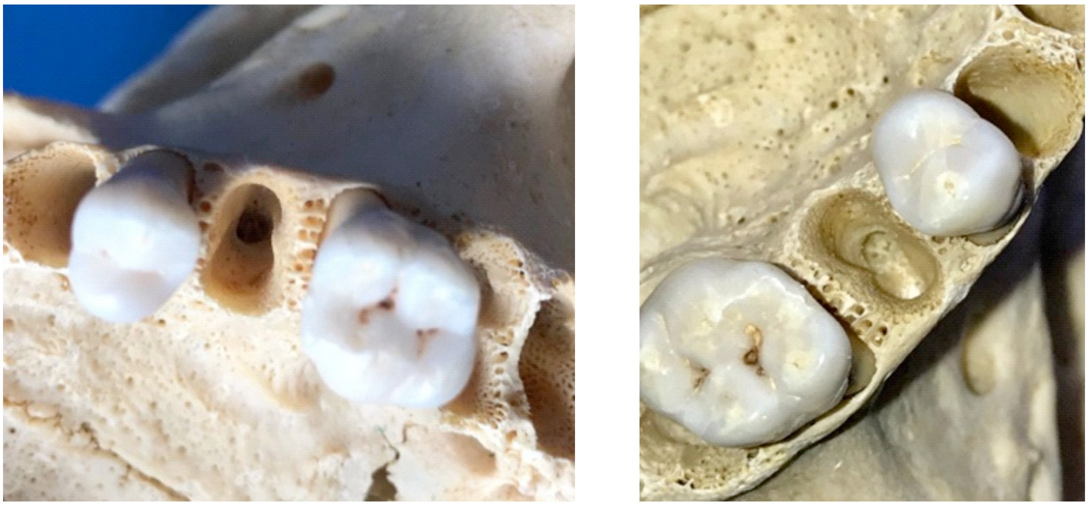
For the artificially generated bone defects with the help of an extra-hard drill of 1mm in CBCT (low-dose 2-70kV) we registered minimum values of 0.5mm and maximum values of 1mm of the artificial periapical lesions, thus reaching an average of 0.68mm and the standard deviation of 0.13mm.

For the drilling with a diameter of 1.6mm

For the artificially generated bone defects with the help of an extra-hard drill of 1.6mm in the CBCT acquisitions (standard protocol - 90kV) we registered minimum values of 1.5mm and maximum values of 1.65mm of the artificial periapical lesions, thus reaching an average of 1.59mm and the standard deviation of 0.04mm.

For the artificially generated bone defects with the help of an extra-hard drill of 1.6mm in CBCT (low-dose 1-80kV) we registered minimum values of 1.4mm and maximum values of 1.7mm of the artificial periapical lesions, thus reaching an average of 1.56mm and the standard deviation of 0.08mm.

For the artificially generated bone defects with the help of an extra-hard drill of 1.6mm in CBCT (low-dose 2-70kV) we registered minimum values of 1.25mm and maximum values of 1.75mm of the artificial periapical lesions, thus reaching an average of 1.5mm and the standard deviation of 0.15mm.



The drilling of the artificially generated bone defects at the level of the apex of the palatine root of 2.5

Conclusions

Due to the fact that CBCT is widely used in the dental and maxilo-facial imaging it is important that the users as well as the practitioners to understand the basic concepts of this imaging technique.

We could conclude that CBCT with the low-dose 1 protocol was more reliable in detecting the artificially generated periapical lesions in the mandible and maxilla in an ex vivo model independent of the size of the lesion as compared to the lowe-dose 2 protocol (70kV). This advantage was more obvious in the maxilla, in the mono-radicular teeth as well as in the pluri-radicular teeth.

CBCT allows the examiner to select the most relevant images of the area of interest which leads to a better detection of presence or the absence of the artificial periapical lesions.

Our research shows that many of the endodontics lesions obtained from the analysis of the CBCT images did not match with their presence on the low-dose 2 CBCT acquisitions. Therefore, the use of low-dose 2 CBCT protocols has obvious limits which can be overcome through examinations with doses suitable to the region and the scanned volume.

In order to make a 3D examination, it is essential that the radiation dose be kept "at the lowest possible level in order to obtain reasonable images" and that FOV is limited only to the area of interest.

A difference between the standard CBCT acquisitions and the low-dose ones in detecting the periapical lesions. However, this difference was significant only for the control group, where there were more false positive diagnostics. The size of the FOV did not emphasise any difference in the application of the diagnosis.

Thus, if the CBCT examination was chosen as an instrument for the diagnosis of the periapical lesions, adapting the FOV to obtain a smaller dose of radiation for the patients should always be taken into account. Moreover, due to the emergence of false positive results, the CBCT examination should be complementary to a clinical examination in order to ascertain a correct diagnosis and an adequate treatment strategy (Hedesiu et al., 2012).

Consequently, CBCT remains an important imaging exploration that should use adequate exploration of the potential of the system (correct FOV settings, adequate mAs, kVpi and the selection of the definition parameters) in accordance with the ALARA concept (the lowest acceptable dose so as to apply a correct diagnosis).

CHAPTER 11.
THE COMPARATIVE ANALYSIS OF THE EXPLORATIONS OF THE PERIAPICAL LESIONS THROUGH DPR AND CBCT ON HYPERTENSIVE PATIENTS

The aims of the study

Our study had as its main aim the comparison of the prevalence and the assessment of the sizes of the periapical lesions among hypertensive patients using CBCT as compared to DPR. The obtained information can thus be concretised in a series of auxiliary aims derived from the main aim as follows. These could clarify if arterial hypertension does represent or not a modulating factor in the development or the acceleration of the inflammatory processes at the periapical level, taking into consideration the plurifactorial context of the evaluation with a variability of the individual parameters of the patients included in the study, from the degree of personal hygiene, to age, the seniority of the arterial hypertension and to other particularities of the cases.

The aims of the study are as follows:

- The assessment of hypertension as a modulating factor in the development or the acceleration of the inflammatory processes at the periapical level.
- The assessment of the biological parameters depending on the value of blood pressure.
- The assessment of the prevalence of periapical lesions at hypertensive patients using CBCT.
- The assessment of the prevalence of periapical lesions at normotensive patients using CBCT.
- The assessment of the size of periapical lesions at normotensive patients as compared to hypertensive patients using CBCT.
- The assessment of the biological parameters depending on oral hygiene index.
- The assessment of periapical lesions measured with the help of DPR depending on the value of the oral hygiene index.
- The assessment of the periapical lesions measured with the help of CBCT correlated with the the value of the oral hygiene index.

Materials and methods

The selection of the patients

This study was a retrospective one which included patients from Department of Endodontics from the Dental Medicine Faculty UMF „Grigore T. Popa" Iași and the radiological explorations from a radio-imaging dento-maxilo-facial private centre. A written and informed agreement was obtained from each patient.

The initial batch of patients was 200, but after applying the inclusion and exclusion criteria, only 66 hypertensive patients were included in the study.

We registered the values of the blood pressure of the patients and recorded the number of years from the time the patients were diagnosed with arterial hypertension, depending on the classification of the values of the blood pressure. The oral hygiene index OHI was also registered and recorded values from 0-3 depending on the presence of plaque (Greene et al., 1964).

The OHI index - 0 the absence of plaque, 1 over-gum plaque in 1/3n of the tooth's cervix, 2- plaque on 1/3 middle part of the corona, 3- plaque in 1/3 incisival of the corona

Imaging examinations

DPR were made based on which the periapical lesion diagnosis was applied. Subsequently these were explored through CBCT in order to apply a definitive diagnosis so as to ascertain a correct plan of treatment.

Thus, the inclusion and the exclusion criteria were ascertained. The modern digital radiographic imaging has introduced relevant improvements in endodontics. In endodontics the quality of the image is very important because it facilitates the correct interpretation of the anatomy, of the endodontic pathology, the detection of the possible canal curves, as well as the post-operatory evaluation and the long term result of the endodontic treatment (Versteeg et al., 1997; Lo Giudice et al., 2016).

The digital periapical radiographies were obtained using the system of ExpressTM imagistic plates (Instrumentarium Dental, Tuusula, Finlanda) and a digital appliance with X rays with 70kVp and 8mA (XDent X70, XDent Dental Equipment, Ribeirão Preto, São Paulo, Brazil). The digital periapical radiographies were taken using the beam collimation technique, using a positioning instrument developed in order to hold the digital sensor (the instruments: XPC RINN®, RINN Corporation, Elgin, Illinois, SUA). The ex vivo and in vivo studies confirm the fact that bi-dimensional radiology presents obvious limits in the diagnosis of periapical lesions (Jorge et al., 2008).

CBCT acquisitions were obtained using a ProMax 3D Max (Planmeca, Helsinki, Finland) in a private radiodiagnostic clinic. The scan was made with a FOV of 40X40 with the following exposure parameters 90KV, 12mA, 12 seconds and the size of the voxels 0.4x0.4x0.4 mm. With the help of the ROMEXIS software 3.0.1 (Planmeca OY, Helsinki, Finland) the acquisitions could be visualised and the reconstructions made (fig 11.1A). The CBCT acquisitions of all the teeth of the patients were analysed as well as the periapical radiographies of the same teeth. Teeth from CBCT acquisitions were analysed and the teeth with injuries, with dental apexes in contact with the maxillary sinus, mandibular canal, nasal membrane, teeth with penetrations and dehiscences included teeth, internal or external desorption at the apical level, with artefacts were excluded.

Each dental root was individually examined, radiography images, CBCT in sagittal section, coronary and paraxial sections being analysed. Each images of the dental apexes for each root were examined and the presence or the absence of apical paradontitis was also analysed.

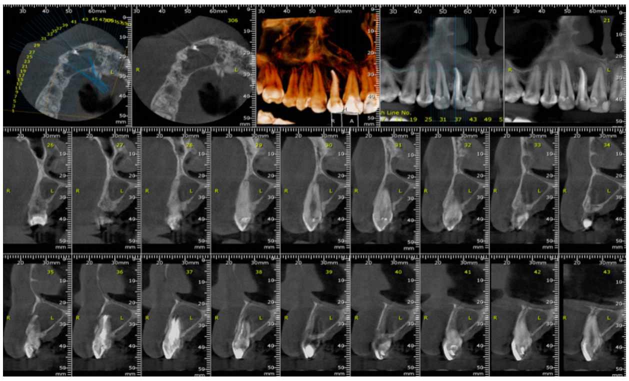
A periapical lesion was diagnosed when the lamina dura was interrupted and in the periapical region the radio-transparency was greater or equal to 1,5mm or approximately the double of the width of the space of the periodontal ligament at apical level (Abella et al., 2012; Zhang et al., 2015), on one or more roots in at least 2 plans of the CBCT images. Thus the inclusion and exclusion criteria were determined.

On the periapical radiographies the same parameters were analysed as for the diagnosis of the periapical lesions. The maximum diameter of the lesion was registered. In case there are more lesions at the level of the apexes of the same tooth, the largest periapical lesion was selected.

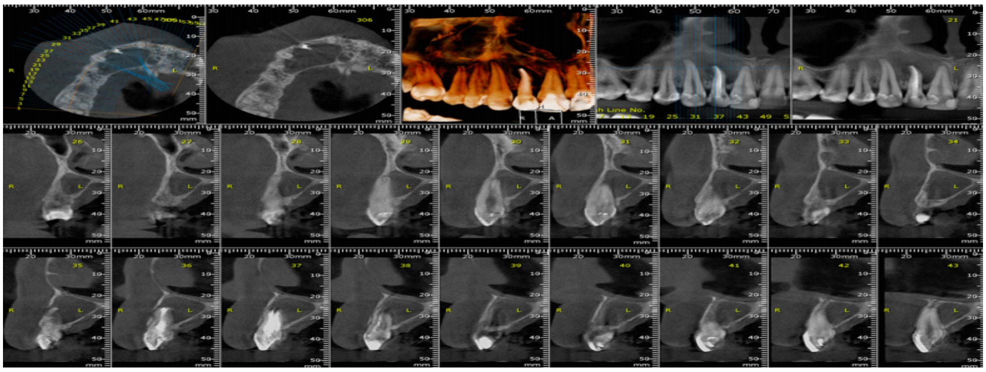
Two examiners interpreted the images independently and reached a consensus in case of a disagreement, by mutual agreement ascertaining a similar value of the periapical lesion. The presence of a periapical radiotransparency was considered to be a periapical lesion at the level of that tooth, and in the cases where several periapical radiotransparencies were present at the same tooth level, radiotransparency with the largest diameter was selected. The teeth were treated endodontically.

Statistical analysis was performed using the SPSS software version 25 (IBM, Chicago, United States).

Parametric data was expressed as mean and standard deviation (SD). The significance level was set at $P < 0.05$. The Pearson correlation analysis and multiple regression analysis were used to test the correlation between age, the OHI index and the number of years the patients were exposed to arterial hypertension.



A **B**



C

The evaluation of the periapical lesion 1.2 through DPR (A) and through CBCT panoramic reformatting (B) and paraxial sections (C)

Our results show that in many cases the bone lesions associated to the periapical areas can be present but undetectable on periapical radiography. These data are in accordance with the information provided by other studies from specialised literature (White et al., 2008).

According to a study where apical lesions were artificially created on human maxilla, the conventional periapical radiographies were successful in apical detection, with a greater accuracy than when the cortical bone was involved (Westphalen et al., 2004). Actually, nowadays researchers agree that periapical radiographies have a limited capacity of diagnosing periapical lesions and that they should not be used for scientific research due to the low sensibility and to the limited accuracy of this radiological method (Winslow et al., 2008).

Conclusions

CBCT can be considered a reference method (golden standard) in endodontics due to its finesse and accuracy of the details that overcome the accuracy of DPR in detecting the periapical lesions in an incipient stage.

CBCT has a better diagnostic accuracy than DPR because the spacial resolution is superior to that of the periapical radiography exam. The images obtained through DPR were less sensible in detecting the periapical lesions. The quality of the images obtained through CBCT offers the possibility of early identifying some periapical lesions that could not be diagnosed through DPR.

The endodontic treatment could be successfully applied at hypertensive patients, only that tri-dimensional imaging investigations of the periapical lesions are needed in order to make the endodontic treatment more efficient.

ORIGINALITY AND PERSPECTIVES OPENED BY THE DOCTORAL STUDIES

The present research brings important elements of novelty for the current study of knowledge in the area of medical imaging.

The original aspects of the studies made in this PhD research can be organised in three different directions, depending on the perspective from which the research endeavour was analysed. Thus, the innovative character can be found at the level of the approached subject, at the level of methodology and of course, at the level of the results that were obtained.

As for the theme of the studies, it develops an area which was very little explored because of of its niche position meaning the imaging exploration and investigation of the periapical lesions at hypertensive patients. In literature there is currently a limited number of studies made on the association between the two pathologies and relatively little data on the way of optimal exploration of these kind of patients, associating cardiac comorbidities, in our case being arterial hypertension.

Although CBCT represents an investigation technique accepted as the golden standard in multiple categories of oral pathologies, it was insufficiently studies in the context of arterial hypertension. For this reason, this research brings important data that clarify the role of CBCT in the exploration of these kind of patients.

As for the methodology that was used, CBCT represents one of the most modern and novel methods of imaging investigation, offering acquisitions as precise as those obtained through classical tomography, but with the advantage of lower doses of radiations.

Another original methodological element is the creating of experimental designs based on artificially generated periapical lesions through drilling in the bone substance, which allow a correct standardised assessment of the diagnosis accuracy of the studied methods.

Based on the results that were obtained, the research brings valuable information concerning the practical applicability of CBCT in the diagnosis of periapical lesions at hypertensive patients.

This method proved not only its superiority over the DPR offering the possibility of making low-dose protocols that keep the qualitative advantage over other imaging methods, at the same time limiting the inconveniences of ionised radiations exposure.

Low-dose protocols that this study validated represent useful tools in clinical practice and can be successfully used in imaging diagnosis of periapical lesions at hypertensive patients.

Also, based on the results, our research signals the need for additional information and awareness of the medical personnel concerning the applicability, the risk and the benefits of three-dimensional imaging investigation methods in periapical pathology.

As for future perspectives, this research opens the direction of investigating the role of CBCT and of low-dose protocols in other dental pathologies such as dental injuries, internal and external radicular resorption, the management and monitoring of the post-operatory evolution and non-surgery management of periapical lesions, the management of failure of the endodontic treatment as well as in the ascertainment of the implant treatment plan.

Another important direction of study would be the extension of the research on the association of other comorbidities, that the current studies have exposed in order to avoid biased results but which complete the usual clinical tableau of the patient with dental problems.

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