ODESSA NATIONAL MEDICAL UNIVERSITY

Department of Radiation Diagnostics, Therapy, radiation medicine and Oncology

METHODICAL RECOMMENDATIONS FOR STUDYING THE TOPIC:

"Cone-beam computed tomography in diagnostics. diseases of the maxillofacial region. Dental subtraction CT in dental practice".

(for the 3th year students of the dentistry faculty)

Approved
at the methodical meeting of the department
"27" August 2021
Protocol №1
Head Department ____ Sokolov V.M.

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«Cone-beam computed tomography in the diagnosis of diseases of the maxillofacial region. Dental subtraction CTin dental practice "- 2 years.

1. **Actuality of theme.**

X-ray diagnostics is the most universal diagnostic method, so its teaching is conducted at all medical faculties. In dentistry, the radiological method of research is widely used, so each student must gain knowledge of not only the basics of radiological diagnosis, but also radiological symptoms of pathological conditions of the dental and maxillofacial system, the most common. Dentists strive to provide the highest quality of qualified medical care and use modern scientific advances and the latest diagnostic and treatment technologies to improve the condition of the oral cavity in each of their patients. The dentist must have the knowledge and ability to weigh all the advantages and disadvantages of using radiological examination of the patient in each case to diagnose dental pathology and the risks of exposing the patient to radiation, the consequences of which accumulate from different sources over time. A dentist who knows the history of the disease and can assess all the risks of developing oral diseases is in the best position to make this decision in the interests of each patient. For this reason, guidelines are intended to serve as a resource for the future physician, rather than as a standard of care, requirements or regulations. At present, sufficient practical experience in the use of computed tomography in dentistry has been accumulated. Dentists should refer to the effects of which accumulate from different sources over time. A dentist who knows the history of the disease and can assess all the risks of developing oral diseases is in the best position to make this decision in the interests of each patient. For this reason, guidelines are intended to serve as a resource for the future physician, rather than as a standard of care, requirements or regulations. At present, sufficient practical experience in the use of computed tomography in dentistry has been accumulated. Dentists should refer to the effects of which accumulate from different sources over time. A dentist who knows the history of the disease and can assess all the risks of developing oral diseases is in the best position to make this decision in the interests of each patient. For this reason, guidelines are intended to serve as a resource for the future physician, rather than as a standard of care, requirements or regulations. At present, sufficient practical experience in the use of computed tomography in dentistry has been accumulated. Dentists should refer to and not as a standard of service, requirements or regulations. At present, sufficient practical experience in the use of computed tomography in dentistry has been accumulated. Dentists should refer to and not as a standard of service, requirements or regulations. At present, sufficient practical experience in the use of computed tomography in dentistry has been accumulated. Dentists should refer toCPCT only when they believe that additional diagnostic information will affect the patient's final diagnosis and treatment.

2. Objectives of the lesson:

2.1 General objectives:

1. Get acquainted with the advantages and disadvantages of the method conical computed tomography (CT) in comparison with other methods of radiological research.
2. Have a general idea of the radiation dose that the patient receives during the study.

2.2 Educational:

1. Deontological - to provide information for conversations of students (future doctors) with patients about the potential dangers of ionizing radiation.
2. The guidelines of dentists are to optimize the methods of treatment and research of patients, reduce the impact of radiation and responsible allocation of health resources.
3. Responsibility - to report information that implies the responsibility of a physician who uses ionizing radiation for diagnostic or therapeutic purposes.
4. Legal representations - information on this topic allows the doctor to avoid unfounded accusations of complications during the disease after medical or diagnostic procedures.

2.3. Specific goals:

- know:

1. Features of the methodology CPCT.

2. Indications and contraindications for the use of this method.

3. Mayou have an idea of the methods of mathematical image formation at CPCT.

2.4. Based on theoretical knowledge on the topic:

- master the techniques / be able /:

1. Be able to determine the need for CPCT in a specific clinical case.

2. Be able to justify the appointment in the patient's medical history and fill out referrals for examination.

3. Interpret (evaluate) the findings of the study.

4. Be able to explain to the patient the need for research and explain the results.

3. Materials for classroom independent training (interdisciplinary integration).

Names of previous disciplines	Acquired knowledge and skills
1. Physics.	1. Know the basics of nuclear physics (types of ionizing radiation, units of measurement, dosimetry). 2. Understand the methods of protection against X-rays of patients and staff. 3. Justify the application of the method CPCT.

2. Anatomy	Understand the correspondence of the obtained image to the anatomical structures of the maxillofacial region. Have basic knowledge about the structure of normal tissues, their localization, taking into account the relationship between them.
3. Histology	Describe the structure of different types of cells and tissues, determine the types of tissues, classify tissues.

4. Content of the topic (text or thesis), graph-logical structure of the lesson.

1. Criteria for selecting patients
2. The essence of the CPCT method.
3. Features of scanning.
4. CPCT software and virtual tools.
5. 3-D rederign.

4.1. PATIENT SELECTION CRITERIA

4.2. CONICAL-RADIATION COMPUTER TOMOGRAPHY With the introduction of various high technologies in practice, introscopic research methods in medicine have also developed. The real revolution in the worldview was caused by the advent of computed tomography (CT). The first computed tomography was tested in 1974. Later, its creators, engineers Cormack and Hounsville, received the Nobel Prize for this invention, and computed tomography has become one of the most popular methods of radiological diagnostics. What is the advantage of computed tomography compared to other methods of radiodiagnostics? First of all, with standard radiography or, for example, panoramic tomography, the result is a single planar and summation image of the object, and CT scan completely scans the three-dimensional object. Any ordinary picture is taken in real time and then remains a static flat image. It can be viewed on a negatoscope or in a visiograph program, but it is no longer possible to look at an object from a different angle or in a different projection - for this you need to take a new picture. In contrast, in computed tomography, a three-dimensional model restored in computer memory is an exact copy of the entire scanned area, and in the absence of the patient, a specialist can study any object of interest to him at any angle, with on any side, in all planes and at any depth. If the usual radiograph is a summary image, where all sequentially superimposed parts are superimposed on each other, then a fixed computed tomogram of a given area is a slice of tissue. object with a thickness of a millimeter to several millimeters, drawn in any place. In the process of conducting an X-ray examination using any method of imaging, there is inevitably a certain projective distortion of the object in size or configuration, which can lead to errors in the interpretation of the image. In computed tomography, the object is scanned almost "to each other", which eliminates this type of distortion in the process of reconstruction of the three-dimensional image and obtain a fixed slice. Despite the widest range of diagnostic possibilities, until recently, computed tomography as a research method was rarely used in dentistry. This was largely due to the general not too high diagnostic requirements of dentists, sufficiently high radiation exposure and the fact that in most cases, computed tomography reflected the image quality, insufficient for the needs of 25 therapeutic dentistry. However, the development of CT technologies was not only by improving spiral tomographs. At the beginning of the XXI century. a fundamentally new computer tomograph has appeared on the market of diagnostic equipment, intended directly for the examination of the maxillofacial area - a cone-beam computer tomograph. The fundamental difference between specialized dental tomographs and serial and spiral CT scans is, firstly, that in this case, instead of thousands of spectacle detectors, one planar sensor is used for scanning, similar to the panoramic tomograph sensor, and, secondly, that the generated beam oscillates in the form of a cone. The device has no gentry and structurally resembles a pantomograph - a console with a sensor and emitter rotates around the patient's head. During shooting, the emitter works continuously, and information is read from the sensor several times per second, ie in general, a few frames per second. The information is then processed on a computer and a virtual three-dimensional model of the scanned area is restored. After that, the three-dimensional virtual object is "cut" into layers of a certain thickness, and each layer is stored in computer memory as a file in DICOM format. Abroad, tomographic examination of this type is sometimes called Cone Beam Volumetric Tomography (Imaging), ie - cone-beam volume tomography, but the method and equipment, According to the European Academy of DentoMaxilloFacial Radiology and the International Cone Beam Institute, it is called the Cone Beam Computed Tomograph (CVT). - CPCT). Widely used abroad, the term "dental", firstly, in the transcription means dental, and secondly, around the world there is a distinction between areas of interest of specialists on "dental" (dental) and maxillofacial (maxilla-facial). In the first case, the area of interest is limited to the teeth and alveolar part of the jaws, which does not reflect the essence of the purpose of these tomographs, because they can examine the entire maxillofacial area, including paranasal sinuses, skull base, hearing organ, etc. In turn, "three-dimensional" does not mean the tomograph itself (three-dimensional is any object existing in space), but the image, and such an image can be obtained in the same way with any other tomograph (spiral, sequential, magnetic resonance), whose program is equipped with the option of multiplanar reform. Thus, any computed tomography is three-dimensional (3D, Three Dementional), because two-dimensional is a linear tomography. As for the definition of "digital" or "digital" computed tomography, it is clear that any information that exists in the computer is digital, ie non-digital computed tomography can not be, and separately indicate for this reason it is illogical. Assuming that the name of any object can indicate either its technical feature or indicate the area of destination, it can be stated that the equipment of this class is structurally conical-beam and at the same time flat-panel computer tomograph (Flat panel, other tomographs fan collimation and image receiver consisting of thousands of individual point detectors). The term sometimes used abroad is

"Volumetric", ie volumetric, also indicates the technical feature of scanning. According to the purpose of tomographs of this class can be called maxillofacial or orofacial (maxillofacial) computed tomography. However, if we continue the line of names of computer tomographs in general, it turns out that they are all named according to the method of scanning, and not to the field of application - step-by-step CT (Fan-Beam CT), spiral (Spiral CT), cone-beam CT (Cone-Beam CT). Therefore it is not necessary to invent superfluous terms as there is already a logical and generally accepted "cone-beam computed tomography" (KPKT). At present, sufficient practical experience has been gained in the use of CT in dentistry, and the advantage of this method of radiodiagnostics over others is obvious.

<u>FEATURES OF SCANNING</u>Any computer tomograph is a complex consisting of a device for scanning an object and a device for recovering and visualizing the received data, ie from a scanner and a computer. The main functional units of the scanner are the XR generator (X-ray generator) and the image receiver. The image receiver in serial and spiral CTs are point detectors linearly located on the inner surface of the gentry aperture. The radiation generator is also in the center. One line of detectors provides the perception of a thin slice, which ultimately forms a single line of pixels in the image. In sequential tomography, the axial layer is scanned (a slice parallel to or close to the base of the skull), then the gentry is moved, ie the scan step is performed, and the next slice is scanned. Thus, about ' the object is not fully scanned, and the information available between the slices is reconstructed by interpolation, ie obtaining an intermediate value by subtraction based on known proximal data. As a result, the structure of the tissues left between the sections seems to be "invented" by a computer, and small details may not be recognized. The maxillofacial area is replete with small anatomical structures, the visualization of which is of exceptional clinical importance. With this method of scanning, they can remain between the slices, and in their place is reconstructed a certain intermediate formation. In this regard, sequential computed tomography (Fun-beam CT) can not be considered an objective method of examination of the maxillofacial area. Spiral computed tomography works differently: reading information is not consecutive layers, and a single slice (several slices), scanning the object in a spiral. In multislice (multidetector) computed tomography (MSCT), 100% of the information in the area corresponding to the total line width of the detectors (2, 4, 16, 64 and more lines depending on the equipment class) is read in one revolution. When scanning the maxillofacial area, the minimum distance between the turns of the spiral is set (the angle of inclination of the gentry is close to zero), but the resolution of the matrix of the detector spiral CT averages 1 pair of lines per 1 mm, and the voxel size (structural unit) - maximum 0.5 mm. This resolution is insufficient to obtain a quality "picture", such as root canals or differentiation of dentin and enamel. For comparison, the matrix of a modern visiograph provides a final resolution of at least 16 pairs of l / mm. You can significantly improve the image quality by slowing down the movement of the table on the Z axis, but this will significantly increase the radiation load on the patient. In the process of examining the skull on a sequential conventional

tomograph, the patient receives a radiation dose of 1,000-1500 μSv (microsieverts), on the spiral - at least 400 μSv. When scanning the maxillofacial area using a cone-beam tomograph with a voltage of up to 90 kVp, the radiation load is only 30-70 μSv. Beyond the lower limit, this corresponds to the film panoramic tomogram of the dentition (orthopantomogram). For comparison: film radiograph around the nasal sinuses of the nose - 100-200 μSv. As already mentioned, the resolution of the MSCT detector is 1 pair l / mm. In contrast, the KPKT sensor has a resolution of 2–4 pairs of l / mm. Moreover, if during multislice CT almost 100% of information is received in one revolution, then during cone-beam tomography, if a beam corresponding to the width of FOV is used, 100% of information is obtained in half-rotation, and for full rotation all information is collected twice , which provides high accuracy of reconstruction. However, this method of scanning increases the likelihood of dynamic distortion, ie artifacts from the movement of the object, given that recent models of tomographs use scanning technology "half" of the beam: ie uses a beam width slightly larger than the scanning width. moves clockwise. This not only reduces the likelihood of artifacts, but also reduces the radiation load. It should be emphasized that the voxel of the cone-beam tomogram is always isotropic, ie has a cubic shape, and the spiral tomogram in many cases implies the presence of an anisotropic voxel (in the form of a parallelepiped), which has a negative impact on the image quality of oblique reforms. is the most valuable research material for dentists. The size of the voxel in spiral tomography directly depends on the thickness of the cut to be scanned and usually has a size of at least 0.5 mm. The resolution of the cone-beam tomograph sensor does not affect the size of the voxel and it would be a mistake to assume that the smaller the voxel, the higher the resolution of the matrix. The size of the voxel in this case is set during the "cutting" of the three-dimensional model into layers for storage. The size of the voxel plays an important role in the reform of the final image - the smaller the voxel, the clearer, more natural and detailed will be the image on the tomogram. Thus, given that the cone-beam computed tomography matrix has a much higher resolution than the spiral, the radiation load on the patient is less than about 5-10 times, and the imaging program is equipped with specialized tools, it can be argued that the study of maxillary of the facial area by cone-beam tomography compared to sequential and spiral CT is the safest, and the results of the examination in dentistry and ENT practice are the most accurate and reliable. Scanning with a cone-beam tomograph and subsequent reconstruction of the image is a very special way, due to which the CPC is not technically a direct continuation of the line of traditional computed tomography. In essence, the CPC combines the technology of sequential CT and panoramic tomography ("orthopantomograph"). Thousands of point detectors arranged in lines ("rows") in the gentry aperture serve as image receivers in the spiral tomograph. Each of them perceives the signal independently. In a cone beam tomograph, the image receiver is a single flat panel that perceives the image completely, just as it does during a radiograph. Sensors can vary in resolution, structure, and matrix size. The first models of plane-sensor CTs were equipped with a CCD matrix, ie qualitatively the same as that of digital panoramic tomographs ("orthopantomographs").) and most radiovisiographers, but the latest models are already available on the basis of CMOS-matrix. The size of the matrix, ie the area of the working surface, determines the size of the survey area or "field of view" - FOV (field of view). For example, a 7 × 12 cm matrix allows you to scan a three-dimensional space in the form of a cylinder with a diameter of 12 cm and a height of 7 cm. This space completely covers the dentition and periapical tissues from the mandibular canal nose and partially the base of the skull. The size of the sensor in different models of tomographs may differ. For example, some modern panoramic tomographs are equipped with an option limited to CT with a matrix size of 3 × 4 to 5 × 5 cm, which allows you to get a full computed tomography of individual groups of teeth. Apparatus with a large sensor size, such as 15 × 15 cm and above, can scan both the entire maxillofacial area and individual sectors, if the tomograph is equipped with a function to adjust the size of the scanning area. Unlike conventional CT and panoramic tomography, which uses a thin "cutting" beam, during the cone-beam examination, the beam is formed in the form of a cone, as during conventional radiography. During panoramic tomography, the beam is generated continuously, and information is also read continuously. In the process of scanning with a cone-beam tomograph, the beam can also be generated continuously or emitted in the form of pulses, but the reading is always discrete. That is, when rotating the generator around the patient's head, for example, CT series ERC (PAH, PICASSO) reads information 30 times per second. Each image read is a starting frame. This information is then transmitted to a computer, where it is reproduced in reverse order. As a result, a three-dimensional virtual model of the scanned object is reconstructed. Then the restored model is "cut" according to the type of axial sections into information layers, each of which contains spatial information corresponding to an axial layer 0.08-0.3 mm thick. Each layer is converted to the general medical format DICOM (Digital Imaging and Communication in Medicine) and stored on the server in an archived form. While maintaining a complete scan, the amount of memory involved varies and can range from a few tens or hundreds of megabytes to a gigabyte or more, depending on the size of the scan area and the thickness of the layer. So,

SOFTWARE AND VIRTUAL TOOLS CT To process the final results of the survey requires processing of the original data. To do this, there are special computer programs that have a number of mandatory options. Currently, there are many general medical DICOM viewers that are not adapted for use in dentistry, as well as specialized dental programs for SCT data processing. In contrast, programs of maxillofacial CPCT are equipped with a number of special options designed specifically for the diagnosis of dental pathologies. 30 Spiral computed tomographs operate with high current and anode voltage (voltage) settings of about 120–140 kV and 100 mA. This provides a fairly high beam load, but allows you to work in multiple visualization modes, corresponding to different ranges of tissue density - lung, bone and soft tissues. The radiation load during cone-beam tomography is much lower due to the fact that the values of current and voltage are many times less - 70-90 kVp and 3-8 mA, respectively. In this regard, as well as taking into account the design features mentioned above and the specifics of the study, work with the image in the program of cone-beam tomography is carried out in the "bone window" mode, which eliminates the possibility of differentiating soft tissues. therefore, some tools used by the CCP were not included with the CCP. To visualize soft tissues and increase the rigidity of the image requires a voltage of 120 kV and special program options, which complicates the widespread use of research in outpatient practice. If we summarize and analyze the data on the technical characteristics of specialized maxillofacial CT, which are currently produced, it becomes clear that the quality of the source material, ie saved DICOM-files, provided equivalent current and voltage, in general, almost no different. Therefore, the ability of the program to best visualize the area under study is of paramount importance to the user. In this case, it means that the program should be equipped with the optimal set of tools that are convenient to work with, and that the final image should be as informative as possible. If we consider the programs of maxillofacial CT from this position, it becomes clear that, despite the external similarities, there are significant differences between them as in the configuration of programs with options adapted to dentistry, and in the principles of operation of individual specialized and general tools. Therefore, some programs, compared to others, may be perceived as incomplete, too simplistic, or, conversely, some functions in practice are perceived as "inconvenient" for use in dentistry. In addition, a very important aspect on the way to achieving optimal results is the ability of the specialist to work with the program, knowledge of dental pathologies and the ability to recognize them on a computed tomogram. Any completed static image, including a radiograph, is two-dimensional (2D) and can be examined in two directions - from left to right and from top to bottom. The third dimension is in-depth research. Thus, the three-dimensional image (3D, Three-Dimensional) means the ability to study the object in length, in width and depth, as well as its visualization in full without projection distortion. This is exactly the opportunity provided by computed tomography. 31 Each CT program has an interface with several working windows and toolbars. The basic interface consists of three or more windows required for the main option - multiplanar reform. MRP-multiplanar reformation - multiplanar or multifaceted reformation (in the literature sometimes there is a transcription "multiplanar reconstruction") means the simultaneous visualization of three restored images (reformats) corresponding to mutually perpendicular sections of three planes, parallel to the plane sagittal (profile, yz plane) and coronal (frontal, transverse, xz plane). The most convenient interface is divided into 4 levels of squares, three of which are MRP-reformats, and the fourth - a three-dimensional model of the scanned object without synchronization of tools with MRP. At the same time, a great achievement in the study is the ability to easily remove (hide) from view the toolbar and the coordinate system line, as well as stretch one of the windows to full screen. Each of the reforms is a thin layer ("slide"), often called a "slice", which carries a certain amount of graphic information. Fixed in any given place and documented section, in fact, is called a tomogram. The selected layer (the visualized slice) of any of the windows can be moved as a plane along a given axis (x, y, z) along the entire length of the object, each window displays a coordinate system in the form of crossed lines that correspond to the position of a layer at the moment (or only on the three-dimensional model, which is less convenient). In the most advanced programs, the MRP option without adjustment is interactive, and by simply capturing the coordinate line or capturing the image itself, it is possible to move not strictly along the x, y, z axes, but also move the entire coordinate system in any order and in any direction. with any spatial inclination of the planes. In the computer tomography programs Ezlmplant, Ez3D 2009, RealScan, OnDemand3D and Xelis Dental, not only the images are interactive, but also the lines of the coordinate system. By capturing the intersection, you can move the center of rotation of the planes, when capturing the proximal part of the line to make their own rotation, and when capturing the middle of the line to increase the thickness of the corresponding layer. At the same time, the results of manipulations are optionally synchronized in all three MRP windows. In some other programs, including those designed for spiral CT, this option exists separately. It is also called MRP, or "oblique" projection, and can be presented in one of the windows without synchronization with the rest, which is much less convenient. In this case, you have to adjust the interactive image to a fixed coordinate. 32 The interactive coordinate system significantly expands the area of use of CT and speeds up the work process. First of all, it is possible for dentists to quickly build an image of any root of the tooth strictly along its vertical axis in all planes, to study the topography of canals and periapical tissues in any direction, rather than on standardized axes, which allows you to visualize the smallest cracks, collaterals, fistulas, etc. throughout. As already mentioned, the initial when restoring the image from the server are axial sections, each of which is an information layer of a certain thickness, stored as a DICOM-file. When restored in the program, these layers seem to overlap again, reconstructing a single three-dimensional model of the object, which has an isotropic spatial resolution. Sagittal and coronal reforms are already obtained as a result of virtual reconstruction from the vertical rows of voxels of the restored model. The visualized slice with the minimum thickness, marked as "0", contains a minimum of volumetric information. Typically, the original layer thickness corresponds to the size of the promissory note of the saved file. In this mode, the smallest details are differentiated, such as root canals, but at the same time the noise level and the impact of various distortions in the thin layer are most pronounced. In addition, the visualization of structures does not always correspond to high quality. To improve the quality of tomograms and optimize the visual perception of the image, there is a function to adjust the thickness of the selected layer. The method of obtaining an image using this option in some programs is denoted by the abbreviation STS (sliding thin, and STSMPR) - "variable layer thickness". When the thickness of the selected layer is increased to 1.0–2.0 mm, much more volumetric information is visualized, noise is smoothed, the image becomes softer and is perceived much easier. This is especially true for sagittal reform. In the Ezlmplant program, the layer thickness can be arbitrarily adjusted from 0.1 mm to 3.0 cm. This makes it possible to obtain not only tomograms, but also zonograms of any area with any angle of inclination of the plane. Zoogram is a tomogram with a large thickness of the selected layer, which gets the whole object, for example, a tooth or a significant part of it - the alveolar process. An example of a zonogram is a regular panoramic tomogram of the dentition (orthopantomogram), which is essentially a panoramic zonogram of the dentition with a layer thickness of 1.0 cm in the front to 1.5-3.0 in the distal. Thus, increasing the thickness of the layer to 1.0-1.5 cm and aligning the planes of the sagittal section along the vertical axis of the tooth, the diagnostician receives an image identical to the intraoral image of the tooth or (depending on the length of the study area) fragment of panoramic zonogram or extraoral image lateral projection. At the same time, there is no projection distortion and shadowing of adjacent bone structures (superposition and interposition), which is typical for conventional images of the maxillofacial area. The function of adjusting the thickness of the selected layer is one of the most important diagnostic tools of the CT program, and failure to fully use this feature can lead to a number of diagnostic errors and inaccuracies, so you should consider several provisions to know how to work with this tool. First, even theoretically, the thickness of the selected layer can not be less than the size of the voxel, because in the construction of the image involved whole voxels, and accordingly, the layer with a minimum thickness carries a minimum of information. Despite the isotropic resolution of the three-dimensional model, when constructing oblique reforms it is impossible to construct an equal layer with a thickness of one voxel - this is the same as on a sheet of notebook in the cell to draw a slash equal to the width of the cell - when counting the number of cells passed the line, involved at least three cells in diameter. Thus, at least three voxels are involved in the construction of the oblique reformat in thickness, but they are located by a ladder, which makes the thickness of the selected layer uneven and the "picture" looks poor. Increasing the thickness of the selected layer will cover more information and make the image more coherent and specific. However, image quality only improves to a certain extent - at some point the summation of the image begins and the quality begins to deteriorate again. So, we can talk about the presence of the optimization threshold, ie the layer thickness that will be optimal for each specific reform and the best for visualizing each specific structure in the program used. That is, for each reformat in each program, the optimal layer thickness should be selected experimentally, which will ensure the best visualization quality and maximum image reliability. For example, in the Ezlmplant program, a layer thickness of 1 mm should be considered optimal for coronal and axial reformations and 2 mm for sagittal reforms during normal imaging. Second, the negative impact of quantum noise on image quality is most pronounced in reformatted images, again with a minimum layer thickness. Increasing the thickness, you can smooth the pattern, remove the "mesh" and visual fragmentation of structures, make the drawing smoother and more concrete. Third, by increasing the layer thickness to a certain threshold, you can offset the impact of many artifacts. Fourth, you can use the STS function to simulate a summary image, which is practically responsible for the quality of a conventional radiograph, which allows you to capture in one layer and visualize on one reformat several objects lying at different depths. For example, foreign bodies in a gunshot wound or overcomplete teeth in different sectors. Because the STS feature is interactive in Ezlmplant, the diagnostician can increase or decrease the layer thickness in real time by moving the mouse. This makes it possible to assess not only the tomogram, but also the correlation of the image available on the slice with the summary image, which is a simple photo and a panoramic zonogram. That is, recognizing any pathology or feature of the structure on the tomogram, the specialist can immediately capture a layer, for example, the entire array of the jaw and understand what it would look like on a normal two-dimensional radiograph. One of the most important and probably the most valuable option for a dentist is the function of arbitrary intersection, or arbitrary "cross-section". If the MPR planes move completely without bending, you can use the cross section to draw an arbitrary slice of any configuration and length. However, the most important thing is that this option means the ability to obtain high-quality panoramic tomograms. The usual panoramic tomogram (orthopantomogram) has a standardized parabola, which corresponds to the average occlusive curve, the trajectory of the focus and the correspondingly selected layer of standard shape in relation to each patient, regardless of its anatomical features. Some specialized dental CT programs also have a specific template for obtaining a panoramic tomogram, which, as with conventional panoramic tomography, has a predetermined shape. However, the Ezlmplant CT scanner program and other programs mentioned above provide a departure from stereotyping and give the specialist complete freedom of action within the scanned three-dimensional space. Using the cross-section function, the specialist can independently draw the course of the section on the axial reform (similar to the focus trajectory) clearly on the apexes or lumens of the canals of the studied jaw, taking into account the inclination of the vertical axes of the frontal group of teeth. The result is a panoramic tomogram, free from any distortions, crossed out according to the best individual course for a particular patient. A normal panoramic tomogram has a certain summation of jaw images and overlapping of neighboring structures, such as the anterior nasal axis, nasal wings, maxillary maxillary processes, hyoid bone, etc., as well as some projective distortion related to technical aspects of photography . All these negative moments are completely eliminated during the reconstruction of the panoramic tomogram in the CT program. Moreover, the length and thickness of the layer can be set to any - from millimeters to visualize root canals and minimal periapical changes, up to 5 mm to assess the condition of teeth and periodontium at the level of spongy substance of interdental septa without summing its profile mass with cortical plates etc. At a layer thickness of 1, 5 cm visualizes the dentition and alveolar jaws to full depth (thickness) like a pantomogram. The primary cross-sectional interface of the Ezlmplant program consists of four windows, which display an axial view with a cross-section course, a panoramic tomogram, a three-dimensional model of the scanned area and a series of cross-sections in a plane perpendicular to the intersection of the panoramic tomogram. Directly in the process of viewing the axial section, it is possible to adjust the course of the intersection by moving the fixed points of the line drawn through the lumens of the root canals. The number of cross-sections that follow a given step (standard, usually 2 mm) of the tomogram course can be set from one to 16 and, moving the cursor on the tomogram, visualize the "slicing" of any selected area. You can also choose any layer thickness - from zero to three centimeters, ie visualize the object in the mode of normal panoramic tomogram (orthopantomogram) and set an arbitrary cross-sectional step at any interval. In addition, you can stretch the panorama to full screen by removing the rest of the windows and toolbars, and use not only the standard mode, but also the projection mode with maximum pixel intensity (MIP) or volume rendering (VR) - visualization mode capacitive model. Ezlmplant is equipped with the functions of an interactive coordinate system and variable layer thickness, which allows the specialist to pre-build the vertical axis of the panorama according to the inclination of the vertical axes of the teeth and thus visualize all groups of teeth simultaneously and completely. using the minimum layer thickness. The screenshot of any part of the tomogram can be saved with the specified extension, exported to any visiography program and used as a separate image. As a result, having made one computer tomogram, the dentist receives high-quality zoograms of dentitions and individual images of teeth, compatible in format with any other programs. One of the most important functions of CT programs is the ability to accurately measure the distance from one point to another. Volumetric scanning during cone-beam tomography theoretically, taking into account the calculation of magnification, occurs without projection distortion and without data loss. Based on this, it can be argued that all measurements can be perceived as relatively reliable. Ezlmplant is equipped with tools for measuring the linear distance between points, the length of the curve and the magnitude of the angle between lines or planes. In addition, if necessary, you can measure not only the distance but also the area of any site on the selected reformat. Using the densitometry function, the optical density of the tissue is measured according to the Hounsville scale. However, the densitometry data obtained on tomograms made with the help of cone-beam tomographs in digital equivalent do not coincide with the data obtained when working with spiral tomograms. This is due to the fact that this type of study is designed to work only in the "bone window", and for the reconstruction of the cone-beam tomography uses a slightly different algorithm (modified Feldkamp-Davis-Kress algorithm), weak tube voltage and other calibration. General medical CT scans are designed to measure the density of reconstructed images obtained with a voltage of 120 kVp and above, so it is impossible to unambiguously compare the data obtained by densitometry of CPC tomograms with standard Hounsville scale, which are characteristic of different body tissues. For example, the density of tooth enamel on the spiral tomogram will correspond to 1,500 HU, and on the conical beam - up to 5,000, but the air will be the same. The data obtained by densitometry are displayed in numbers (NU - CT number, "Haunswild Unit") and in the form of a graph. The results obtained in the figures, as already shown, are very relative, so of particular importance is the graph, which allows you to visually assess the density of the area under study, compared with other structures. Example, when assessing the density of restored bone tissue should be a course of measurement not only through the area under study, but also through healthy tissue in equal measure. Any measurement or object that deserves attention can be provided with a pointer or caption, and a screenshot of the tomogram with notes and edited images is recorded as a separate file in the database. In the future, it can be used as a normal digital image to work in any physiographic program. For the best visualization, you should optimize the image using a graphics editor and zoom function. To build a three-dimensional model, most serial and spiral CT programs use the "shaded surface display" option. This option is used to visualize surfaces based on the choice of pixel threshold values, ie with a given threshold CT number. For example, a section of a certain density corresponding to any anatomical structure is selected, its density is set as a threshold - and all surfaces of the same density and above become opaque. As a result, a three-dimensional model is visualized, similar to a sculpture cast from metal. The SSD option is very convenient for soft tissue research, but has a high error rate when working in the "bone window", and therefore in new versions of programs this option is used less and less. Instead, three-dimensional rendering is provided. VR (volume rendering) - volume rendering, a term that corresponds to the concept of "volume rendering". This is the newest and most reliable option for CT programs, which allows you to get an image and explore a three-dimensional model of the object. In contrast to the SSD function, in this case there is a non-threshold visualization of all voxels involved in image construction, according to their degree of participation and significance within the selected "window" (selected area of the Hounsville scale specialized maxillofacial computed tomographs are designed to work in the "bone window"). To give the object additional realism with the help of tuning, you can achieve a color that matches the actual color of the skeletal bone. If the surface structures (SSD) with a certain limit value in the SKT program bone structures look absolutely smooth and even glossy, with smoothed contours, In Ezlmplant, thanks to the VR function and the high resolution of the sensor, the surface of the bone tissue is not only reproducible in configuration, but also retains a natural texture that transmits the smallest details. Moreover, it is possible to visualize the surface in a certain range of density. This allows the researcher to keep visible only certain structures, such as teeth, without bone tissue or filling material, or, conversely, to fully restore the configuration of soft tissues. PVR (perspective volume rendering) - perspective volume rendering or otherwise - virtual endoscopy (VE) - a variant of the volume rendering option, which allows you to multiply the area under study, while limiting the field of view. Quite difficult to operate option that resembles a computer The use of spiral CT is used to examine organs that are usually examined with an endoscope - blood vessels, bronchi, intestines, extra sinuses, etc. Thanks to the high resolution and unity of the matrix structure, as well as minimizing the pixel size with Ezlmplant virtual endoscopy, it is possible to examine the mandibular, palatal, infraorbital nerves and, most importantly, the root canals of the teeth from the inside. When activating the virtual endoscopy function, the magnified image is perceived as when looking through a magnifying glass, ie the structures inside the channel are displayed with perspective, and flat surfaces with maximum magnification in the center and distortion at the periphery. MIR (maximum intensity projection) - projection of maximum intensity - two-dimensional projection image with visualization of only the most X-ray contrast points. At first glance, this image seems three-dimensional and partially transparent, but in reality it should be perceived as somewhat like a rigid radiograph made in random projection. The pseudo-three-dimensional effect is created due to the fact that the MIR image is interactive and the projection can be changed arbitrarily and dynamically relative to the 38 axis of the observer using rotation tools or mouse. Very convenient option for visualization of retained teeth, odont, dense stones and homogeneous inclusions. The MIR image, like any other, can be viewed in standard negative black and white mode or with different color filters. In Ezlmplant, as in many general medical CT programs, there are fundamentally similar to the MIR functions - mini-MIP and XR-simulation. In the first case, the least dense points are visualized, which correspond to the minimum CT numbers, and in the second - averaged, resulting in a picture resembling a soft three-dimensional radiograph. The mini-MIP function is often used in dentistry, but XR-simulation can be used with great success in orthodontics and ENT practice to compare MPR data with conventional images of additional nasal sinuses. In this case, with the option of a graphic editor (gamma-bright-contrast), the structure of the image that is perceived is brought close to a normal X-ray, then due to the fact that the image itself is interactive, the virtual volume is set to which corresponds to the semi-axial projection relative to the researcher and the virtual light source. The result is an image identical to the image of additional sinuses in the nasolabial fold. Such capabilities of the program are of great scientific value, as they allow a detailed correction between CT data and a standard image without additional exposure of the patient during radiography. All specialized dental CT viewers have a number of options designed to plan implant surgery. Implant dentists were the first to actively use computed tomography in their work, and the first cone-beam tomographs were created just for the needs of implantology. When planning the implantation operation, a panoramic tomogram of the dentition (orthopantomogram), being a two-dimensional image, does not allow to adequately assess the distance to the maxillary sinus, mandibular canal, take into account the spatial inclination of the alveolar jaws, which often leads to errors in the installation of implants, which are also sometimes impossible to recognize by pantomogram. One of the auxiliary functions in the set of tools for planning implant operations is the marking (tracing) of the mandibular canal. To this end, the lumen of the mandibular canal is optimally visualized in all windows of multiplanar reformation and, starting from the mental opening, is traced by setting the points that fix the course. Then the channel is "filled" with the selected color according to the course. The size and density of residual bone varies in all three reforms of multiplanar reform, and based on the obtained data, virtual implant templates are selected and installed. Next, with the help of tuning, you can remove the bone structure and see what will be the spatial ratio of the probable implant and the mandibular canal. The image remains interactive. It can be rotated at any angle and inspected from any angle. The angle of the abutment and the position of the axis of the implant relative to the main loading vector can also be determined in advance by computed tomography. The axis of the implant can be rotated at any angle on any reformat, and the planning procedure itself can also be carried out in the mode of panoramic reconstruction of the image with stepwise intergastric cutting at a given interval. The color of implants and abutments is set by the researcher arbitrarily, a simple choice from the proposed color scale. If on a panoramic tomogram a specialist studies only a two-dimensional object, often made with distortion, then on a computed tomogram the object is displayed in three projections and without distortion, so a more accurate idea of the internal structure of the patient's jaw. In this regard, when planning an implant operation using CT, implantologists often have the opportunity to choose a non-standard or compromise solution. Some experts attach great importance to such a method of examination as measuring the density of bone tissue, and use different methods to obtain results. It should be noted that the data on bone density obtained by working with a panoramic tomogram, do not make practical sense due to the effect of summation in the uneven distribution of solid bone structures and other nuances that relate to the specifics of the survey. At the same time, when working with CT there is no need to measure and calculate the summation density - you can use the method of three-dimensional visualization of the layer, ie simply "cut" a jaw fragment equal to the thickness of the implant using software tools and convert images to VR , and then just "look" and count the number of the largest bone beams that will be in contact with the implant in a particular place. As already mentioned, the X-ray picture on the panoramic tomogram and on the CT images are often very different from each other, and doctors who are accustomed to traditional radiographs, sometimes can not learn for a long time. since it is found that the picture of the "bottom" of the maxillary sinus is provided by the alveolar recess (bay), which occupies not the entire alveolar process, and on the palatal side (ie orally relative to the lumen of the sinus) there is enough bone to implant. At the same time on the panoramic tomogram "implanted" in this place the implant will look as if it is in the lumen of the sinus. All specialized implant planning programs usually offer templates in a variety of configurations, and the more of them, the more impression the user should make. The Ezlmplant program also provides a large set of "implants" from different companies, as well as the available function "implant manager". with which the specialist can independently create an implant template with a given size and configuration. However, it should not be forgotten that the main impact that damages bone tissue and structures surrounding the mandibular canal, maxillary sinus, is manifested in the process of preparation, and the shape of the drill can only be conical or cylindrical. Therefore, from a logical point of view, the shape and configuration of the implant does not matter when planning. Only length and thickness are essential, so it is most logical to use standard cylindrical or conical templates. Of course, in this case we are not talking about implants with memory in the form of subperiosteal and lamellar implants. As already mentioned, the radiation load in cone-beam computed tomography is quite consistent with film panoramic tomography, therefore, control of implant placement can also be performed using CT. When examining 3D VR, in some cases it is necessary to fragment the image, ie to delete some part of it. There are a number of tools for this. The easiest way to fragment an image is to reduce the amount of space you render. To do this, there is an option to limit the "zone of interest" (VOI - Volume of Interest). When it is activated, a transparent cube is built around the three-dimensional model, each of the faces of which is interactive and can be moved along the corresponding axis. Simply capturing any of the faces and shifting it leads to "wiping" the image in the appropriate direction. For example, when a tumor of the mandible is detected, it is possible to leave only the body of the mandible in the area of interest to consider in detail changes in its configuration, and in the presence of a foreign body or concretion to accurately determine the spatial position of the object relative to the nearest anatomical structures. The Draw Mask function allows you to delete part of the image to full depth, while the shape of the object to be removed is set arbitrarily. After activating the function, the fragment selected for "cutting" is outlined in random order, and it is automatically deleted after double-clicking the mouse. The outlined object is covered with a mesh "pattern" before removal, and the researcher can choose to delete this fragment or delete everything else around this fragment. The function of arbitrary fragmentation of the Draw Mask is a very valuable tool for maxillofacial surgeons, because it can be used to "see" the defect that forms after the operation, as well as to remove the undamaged or those which interfere with the viewing of the bone tissue. For periodontists, the function of cubic fragmentation of a three-dimensional model with magnification (3D Zoom Cube) is more relevant. This is a combination of sighting cubic fragmentation and perspective visualization of a given area. When working with this tool, the specialist can enlarge without distortion any fragment of the three-dimensional model and examine this fragment from the reverse side, placing it next to the main image. That is, the structure of bone tissue, for example, in the area of the mandibular incisors can be examined simultaneously from the lingual and vestibular side. In addition, the "cubic 3D zoom", as this feature is sometimes called, is an indispensable tool for examining the structure of the rudiments of teeth in case of suspected enamel hypoplasia or abnormal development of the embryo, for example, after trauma to the baby tooth. As you know, especially difficult is the diagnosis of root fractures without displacement of fragments, longitudinal cracks, as well as the presence of lateral branches of the channel (collaterals). For these purposes, the Ezlmplant program provides an option of arbitrary "oblique cut" - Oblique Slice. It works as follows: the coordinate system is carefully aligned on all axes of the tooth (vertical, vestibulooral and mesiodistal), and the vertical axis of the tooth is selected by the center of rotation of the coordinates. Thus, the researcher gets the opportunity to rotate the entire three-dimensional array of tomograms around a given axis - the vertical axis of the tooth, which remains stationary. In intraoral radiography it is very difficult to design an oblique crack on the plane, which is not parallel to the direction of the beam, so this function is just designed to choose an arbitrary angle of view. When examined on conventional tomographs, the patient is usually given a "layered" printout of all sections, and the doctor is already working with fixed images taken with a certain step in accordance with the specified axes. Ezlmplant also provides this visualization feature. Moreover, the scanning step and the thickness of the layer that stands out can be set arbitrarily - from millimeters to several centimeters.

On the one hand, this way you can create a consistent image that is already familiar to many professionals, such as sequential screening of the maxillary sinuses, and print it on quality paper. But on the other hand, endodontists have the opportunity to get a detailed (with a step of 1 mm along the vertical axis of the tooth), the topography of the root canals. If desired, such a "cut" can be saved as a mini-movie in avi format. and browse outside the program with any player, even on a PDA and phone. The above text describes the most important and popular features of Ezlmplant, Ez3D 2009, RealScan, OnDemand3D, Xelis Dental, etc., but computer tomography software can provide a number of additional and auxiliary tools and options.

5. Materials of methodical providing of employment.

5.1. Tasks for self-examination of the ascending level of knowledge and skills.

1. Know the basics of nuclear physics (types of ionizing radiation, units of measurement, dosimetry).
2. Choose the right materials to protect against the main types of ionizing radiation.
3. Know the structure of the cell, apply knowledge of the mechanism of cell division to explain the effects of ionizing radiation on cells, tissues, organs, etc., classify organisms by types and species.
4. Know the structure of different types of cells and tissues, determine the types of tissues, apply knowledge to explain the effects of ionizing radiation, classify tissues.
5. Know the basic metabolic processes in the human body, determine the mechanisms of action of ionizing radiation and assess their harmful effects, compare the effects of various harmful factors on physiological processes in the body.

5.2. The information necessary for the formation of knowledge and skills can be found in textbooks:

-main (basic):

1. Radiology (radiation diagnostics and radiation therapy). Kyiv, Book Plus, 2018. -721 p.
2. Radiology (radiation diagnostics and radiation therapy). Test tasks. Part 1. Kyiv, Book Plus. 2015. -104 p.
3. Radiology (radiation diagnostics and radiation therapy). Test tasks. Part 2. Kyiv, Book Plus. 2015. -168 p.
4. Radiology (radiation diagnostics and radiation therapy). Test tasks. Part 3. Kyiv, Book Plus. 2015. -248 p.
5. GB Prots, VP Pyurik, Yu. I. Solodzhuk and others. // Ukrainian Dental Almanac. - 2016. - № 3 - Vol. 2. - P. 87–92.

-Auxiliary:

1. Abdelkarim A. Three-dimensional imaging for indirect-direct bonding could expose patients to unnecessary radiation. Am J Orthod Dentofacial Orthop. 2017Jan; 151 (1): 6. doi: 10.1016 / j.ajodo.2016.10.006. PubMed PMID: 28024783. Никберг И.И. Ionizing radiation and human health. K. Health, 1989, p. 6-13.
2. Educational edition Center for testing the professional competence of specialists with higher education in the fields of "Medicine" and "Pharmacy". Collection of test tasks for passing the license exam: Step 3. Dentistry. Kyiv. Center for testing the professional competence of specialists with higher education in the fields of "Medicine" and "Pharmacy" (in Ukrainian) 2018. - 24 p.
3. Possibilities of modern x-ray examination methods for diagnostics of hidden dental caries of approximal localization / I. I. Sokolova, S. I. German, TV Tomilina et all // Wiadomości Lekarskie. - Vol. LXXII, N 7. - 2019. - P. 1258–1265. (Scopus).
4. Radiographic studies in dentistry: recommendations for the selection of patients and limiting radiation exposure. Educational and methodical manual for interns in the specialty "Dentistry" and dentists / Sokolova II, Udovychenko NM, Herman SI and others. // Kharkiv KhNMU, 2020, p.4-37.
5. https://fmza.ru/upload/medialibrary/cc1/sz_stomatologiya_2018.pdf

5.3.Orienting map for independent work with literature on the topic «Cone-beam computed tomography in the diagnosis of diseases of the maxillofacial region. Dental subtraction CTin dental practice».

№	**Task**	**Instructions for the task**	**Independent records of students**
1.	Indicate the main stages of CT development.	Make a short synopsis.	
2.	Prepare written answers about the components of CT.	Clearly understand the components of the device. Prepare to visit the CT room.	
3.	Learn to distinguish metel artifacts from the Internet.	Explain what CT artifacts are and their origins.	

6. Materials for self-control over the quality of training.

Questions for self-control.

1. Name the main components of the CT device.
2. Explain in your own words how to get a three-dimensional image.
3. How is information stored on digital media?

4. What are the indications and contraindications to CPCT? Prove your opinion.
5. What is the role of CT in planning endodontic treatment?
6. What is the frontal, axial and sagittal plane of the CT scan?
7. DICOM standard of medical research in dental practice.
8. Density windows in CT. Voxel. MPR and MIP reconstruction.
9. Leading symptoms in the study of caries of occlusal and proximal surfaces.
10. Why are there "metal" artifacts in the formation of CT images in dental practice?
11. Give methereal assessment of the root canal system of the tooth.
12. What is osteoporosis?
13. What are the features of bone tissue based on density assessment? How it affects further treatment planning.
14. How does CPCT study assess the hard tissues of the tooth and periapical structures?
15. What is the importance of studying the relationships of adjacent structures?

7. Practical work (tasks) performed in class:

1. Draw in a workbook a diagram of the division of the cell and the cell itself. Give an explanation.
2. Draw a diagram of water radiolysis in a workbook. Give an explanation.
3. Draw tables in the workbook with the basic units of radioactivity. Give an explanation.
4. Draw schematic principles of operation of basic devices for radiometry. Give an explanation.
5. Draw schematic principles of the main devices for dosimetry. Give an explanation.
6. Draw schematic principles of anti-inflammatory action of ionizing radiation. Give an explanation.
7. Draw schematic principles of antitumor action of ionizing radiation. Give an explanation

8. **Topic of the next lesson:**"Radiation research methods and radiation normal radiation anatomy. Radiation signs of diseases of the teeth and jaws.

9. **Tasks for UDRS and NDRS on the topic of the next lesson:**

Normal tooth image (shadow of enamel cover and dentin crown, enlightenment of the tooth cavity and root canal, lateral parts of the periodontal space, image of the interdental septum). Signs of teeth of the upper and lower jaws. Evaluation of adjacent teeth.Children's dentition. The turn of teeth change is normal. Development of the jaw in the X-ray image.System consideration algorithm:

1) determine the type of radiograph;
2) assess the quality of the radiograph on the basis of: contour, structure, separate image and the correct size of the teeth;
3) find out whether the upper or lower jaw is removed;
4) what exactly are the teeth;
5) identify pathological changes in the following sequence: tooth crown, tooth cavity, root canals; root surface, periodontal fissure, compact hole plate, surrounding bone tissue.

Methodical recommendations were __________ as. Katerina DOIKOVA