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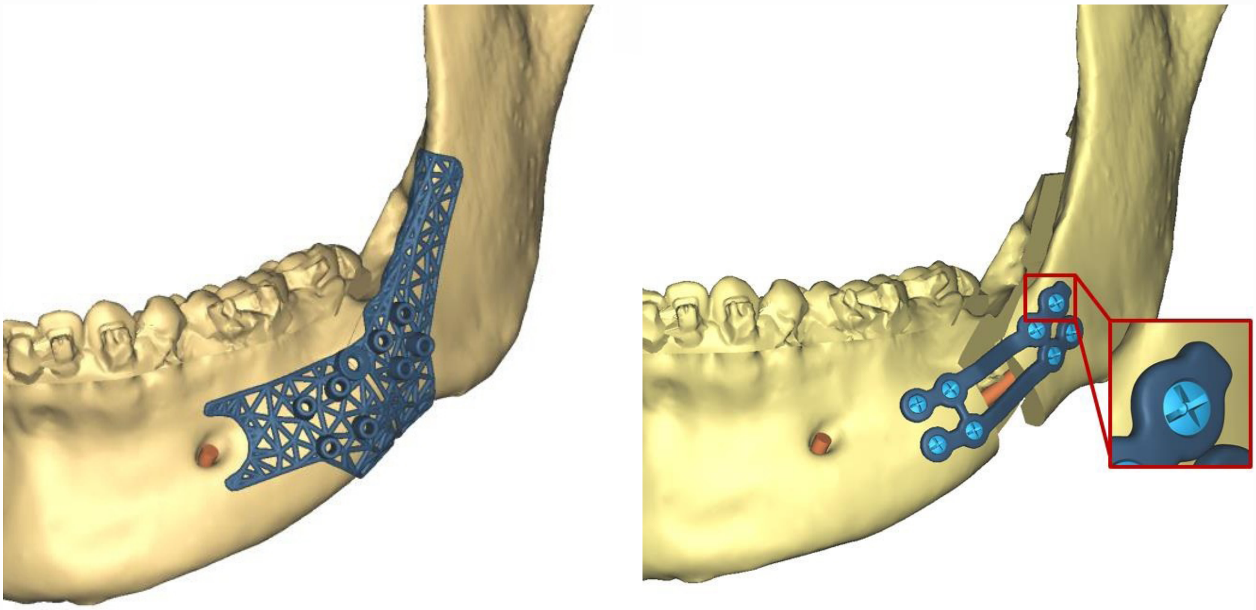

Head and Neck Radiology

Cone Beam Computed Tomography as a State of Art Diagnostic Tool in OMS Diagnostics

One-Stage Implant Surgery

A Type of Technique that can Provide a Long-Term Result

Section Editor
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Journal of ***Diagnostics & Treatment of Oral & Maxillofacial Pathology*** goals to publish the cutting-edge and peer-reviewed articles on work in oral and maxillofacial surgery and neighboring specialties. The journal includes the following topics: implants surgery, head and neck imaging, microvascular and reconstructive surgery, oral and maxillofacial pathology, head and neck surgery/oncology, TMJ lesions/disorders, head and neck trauma, plastic surgery, pharmacology/drugs.

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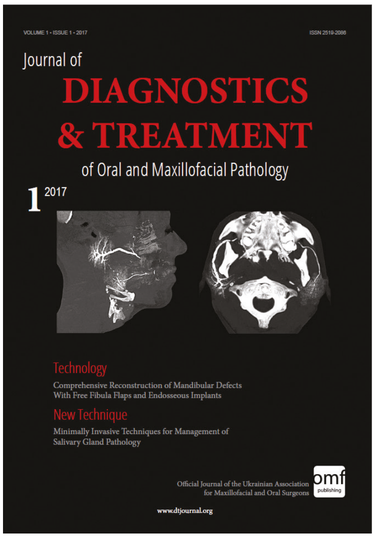

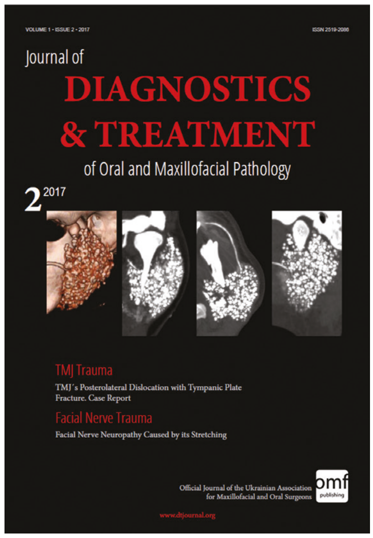

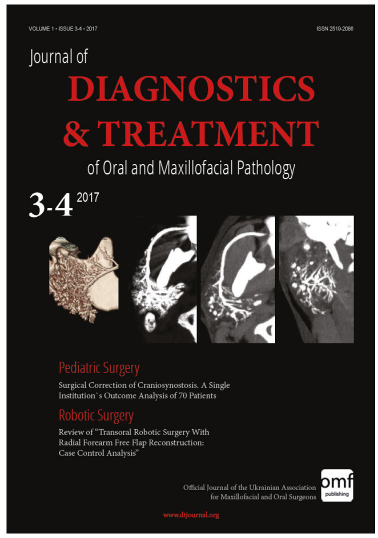

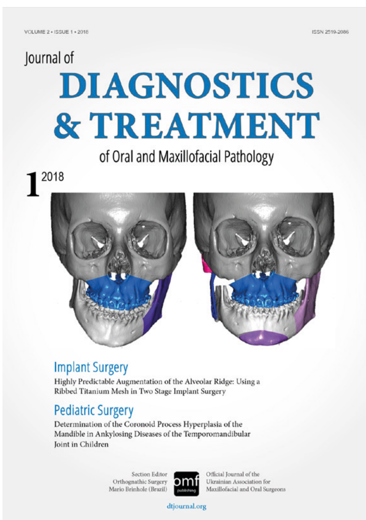

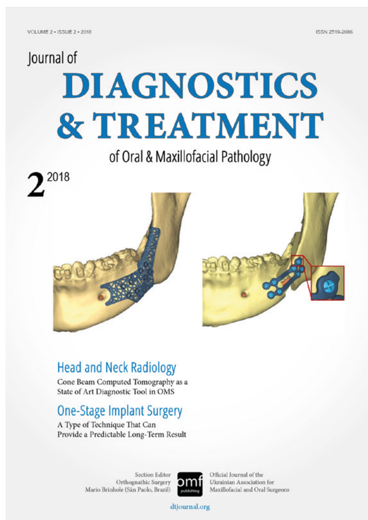

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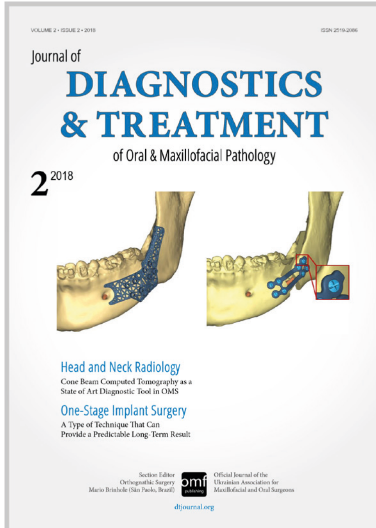

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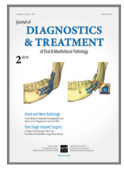

Efficacy of Cone Beam Computed Tomography (CBCT) and Periapical (PA) Radiography in Endodontic Diagnosis and Treatment Planning*

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ABOUT ARTICLE

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Field of view (FOV) in CBCT

ABSTRACT

Aim.
The benefits and limitations of cone beam computed tomography (CBCT) over conventional periapical (PA) radiographs have been studied by many authors since many years ago. The subtle point of negotiation is to understand to what extent the use of CBCT over periapical can have a positive influence on initial radiographic diagnosis in different dental specialties in last recent researches. This article research was achieved by identifying which modality is superior in diagnostic accuracy and outlining what can affect the efficacy of CBCT and PA radiography in the assessment of early periapical lesions, vertical root fractures and bone defects respectively.
Material and Methods.
A retrospective study was conducted with the use of two different electronic databases were search between years 2006–2017, PubMed Central® (PMC), and ProQuest, with a strict inclusion and exclusion criteria. Search was limited to English and articles that compared CBCT to PA radiography with the inclusion of the factors studied. The search strategy included a self made formula for the insertion of keywords into the search engine. Formula was to either enter one radiographic technique followed by the factor being studied, or two radiographic techniques followed by one factor being studied. Articles that appeared in more than one database were considered as duplicates and were only considered once. Two examiners (Hassan Al Basri (HAB) and Mohhamed Fadhul (MF)) searched for the articles on the search engines. HB was assigned to search in PubMed, while MF explored ProQuest. A total of 262 title/abstracts were identified through the data base search engines. Most of the articles were found on PubMed (n = 189) while the other were identified on ProQuest (n = 173). Relevant articles by title/abstract were all recorded and categorized according to the relevance to the factor being studied as shown in the results (n = 107).
Results.
The total number of articles were categorized according to the factor being studied (n = 39) to end up with (n = 15) for periapical lesions, (n = 13) for vertical root fracture and (n = 11) for bone defects. Each category had its own table for analysis and data recording as shown in tables and diagrams. The 13 out of 15 articles concluded that CBCT is superior to PA radiography in, while the rest (n = 2) concluded that no difference was seen between the two modalities in the detection of periapical lesions. 10 out of 13 articles for vertical root fracture and 5 out of 11 in bone defects also concluded that CBCT is superior to PA in the detection of each factor respectively. Pie charts were used to illustrate these differences.
Conclusion.
The main findings of this study demonstrate that with in all three factors studied, the majority of studies emphasized that CBCT was superior to periapical radiography.

Despite the limitations of the review conducted, evidence suggests that cone beam computed tomography is superior to periapical radiography in image quality and diagnostic. However, it can be concluded that the specifications like field of view and voxel size affect the quality of CBCT images and therefore can affect its ability to detect periapical lesions, vertical root fractures and bone defects when compared to periapical radiographs. However, dental clinicians should be cautious with further search regarding the radiation dose of CBCT.

Introduction

In dentistry and oral and maxillofacial surgery, clinical examination with radiographic images is essential to end up with an accurate preoperative diagnosis. Radiography in dentistry has been for many years a building stone not

* This manuscript has not been presented

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only an imaging tool, but a method that aids clinicians in accurate preoperative diagnosis. For several years clinicians have used a two dimensional periapical (PA) radiographs as it provides an acceptable imaging, due to it being cost effectiveness and exposes patients to little radiation. Recently three dimensional images were provided by cone beam computed tomography, which enhanced the level of diagnosis by providing a more accurate representation of the anatomy and enhanced image quality.

The problem with radiology is that it affects diagnosis significantly. Diagnosis in return effects the treatment plan or choice. Likewise, it's very important for radiographic modalities to provide accurate information. Incorrect image assessment can effect or even change treatment decisions. Since CBCT still exposes patient to more radiation, caution should be taken ahead of referral for these images. Only after PA imaging has been taken, CBCT can be indicated as these images will give more details. This raises the question of to what extent is it superior to PA in the diagnosis of periapical lesions, vertical root fractures and bone defects.

The purpose of this study is to identify to what extent CBCT provides more accurate diagnosis (Fig 1) when compared to periapical radiography, and what are the limitations of each modality carried out in the diagnosis of periapical lesions, vertical root fractures and bone defects.

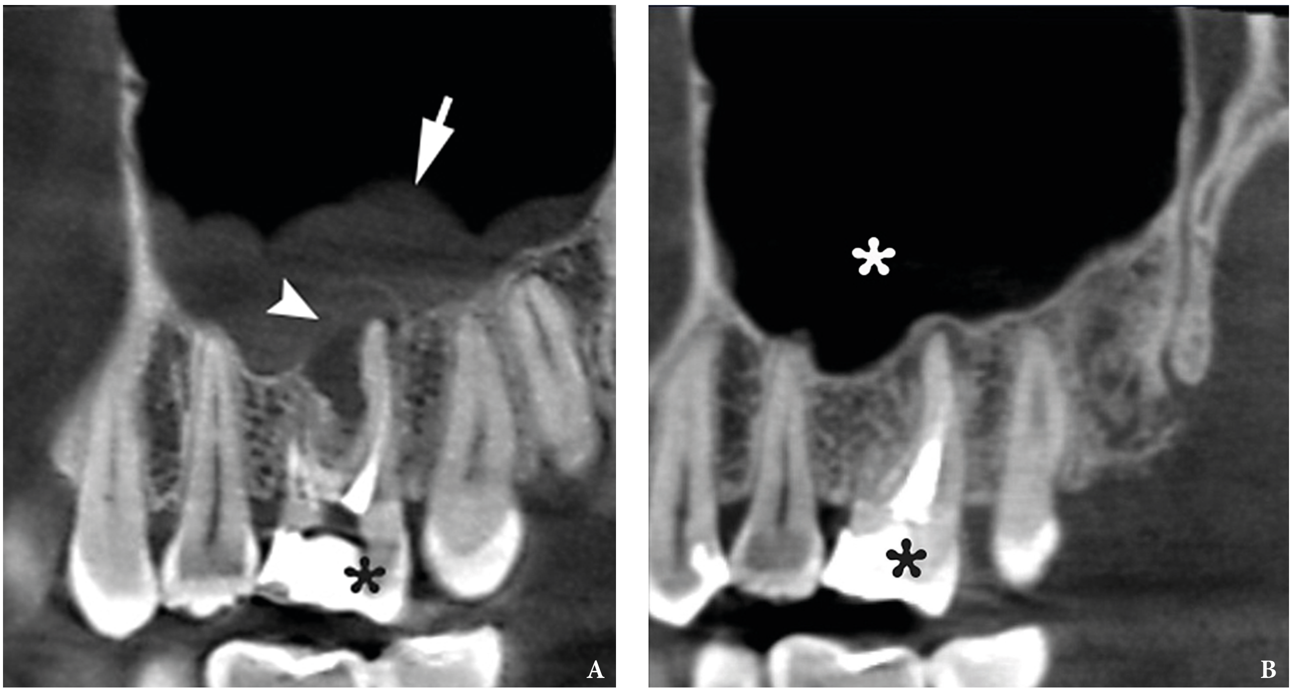

FIGURE 1. A – A sagittal CBCT scan in a 25-year-old lady before endodontic retreatment shows periapical lesion (*arrowhead*) around the apices of a tooth 1.6 (*asterisk*) and chronic maxillary sinusitis (*arrow*). **B** – A 8-month follow-up sagittal CBCT scan shows no signs of periapical lesion around the apices of a tooth 1.6 (*black asterisk*) and no chronic inflammation in the maxillary sinus (*white asterisk*). Images of **Figure 1** are courtesy of Dr. Mariia A. Zimina, Zimina Dental Clinic, Kyiv, Ukraine.

Background Literature

Radiographic imaging has helped many dental practitioners to envision what can't be seen clinically by the naked eye. Radiography has been used in dentistry for many years and has proved to be an imperative diagnostic tool in dental treatment planning (Shah *et al*, 2014) [1]. The dependence of radiography in surgery, endodontics, oral pathology and restorative dentistry remains essential, and in some parts of the world is mandatory by law (van der Sanden *et al*, 2016) [2]. Conventional periapical radiography has been the most commonly used image modality in many clinics, displaying two dimensional images of three dimensional structures (Butaric *et al*, 2010) [3]. However, the quality of their images is very challenging for practitioners, as minute details in these images can be hampered due to image noise and the inability of the radiograph to take three-dimensional images (Uraba *et al*, 2016) [4]. Likewise, recently cone beam conventional computed tomography came to fruition to provide a three-dimensional image of the same structure, providing better image quality and more valuable information to the dental practitioner (Gurtu *et al*, 2014) [5]. While it remains the most commonly used radiographic method in dental practice, the limitations of periapical radiographs are very significant as they are shown to compress a three dimensional anatomy, create geometric anomalies and anatomical noise (Meena *et al*, 2014) [6]. Research has proven that a higher percentage of misdiagnosis occurs in endodontics diagnoses when using conventional periapical radiographs as compared to CBCT which is considered as the standard of care (Peters and Peters, 2012) [7]. When CBCT was first introduced,

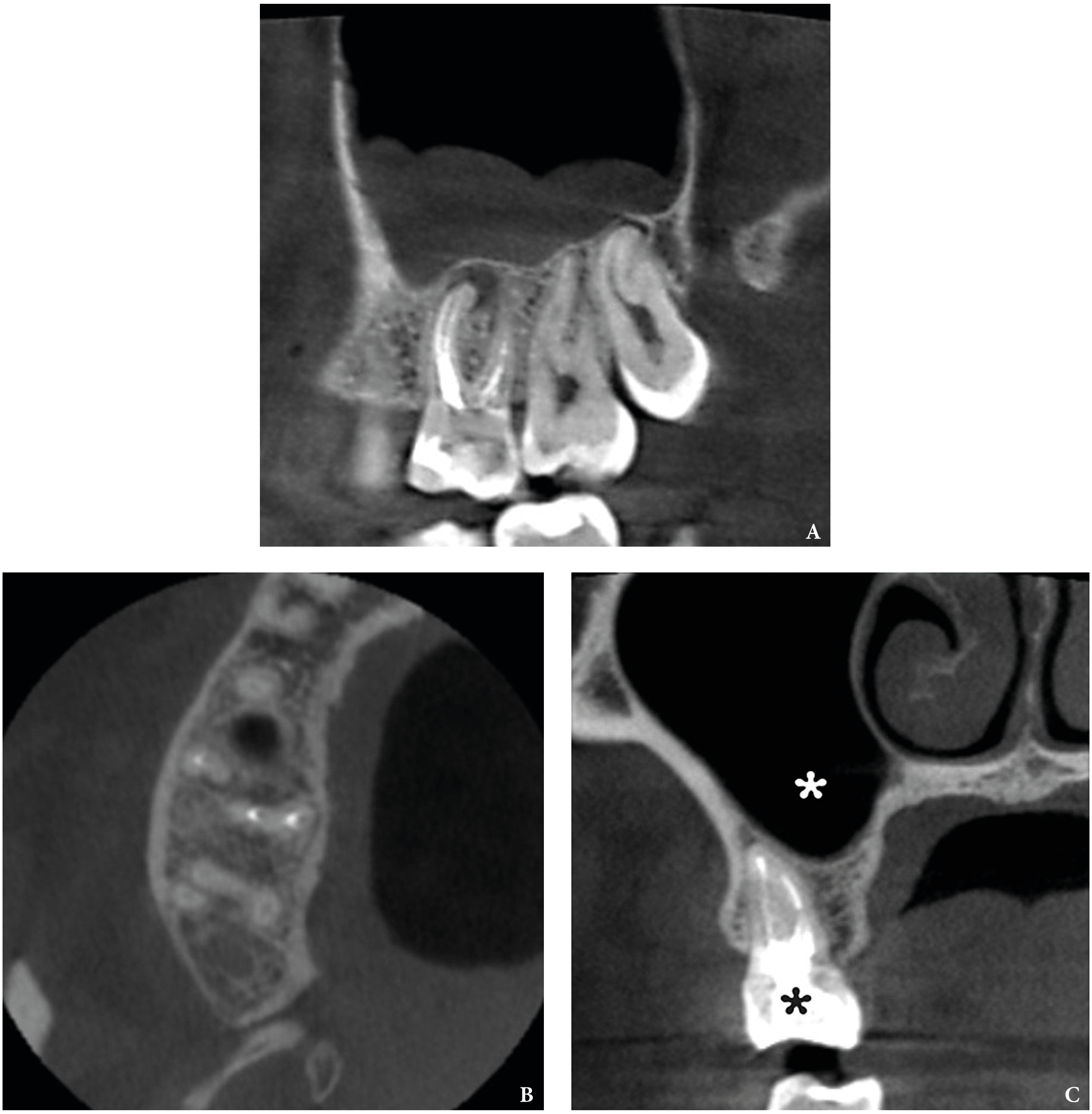

FIGURE 2. (**A**) Another sagittal CBCT scan of the patient from **Figure 1** before endodontic retreatment. An axial (**B**) and coronal (**C**) CBCT scans 8-month after endodontic retreatment of the tooth 1.6 (*black asterisk*) shows no signs of chronic inflammation in the maxilla and maxillary sinus (*white asterisk*). Images of **Figure 2** are courtesy of *Dr. Mariia A. Zimina, Zimina Dental Clinic*;Kyiv, Ukraine.

sectional images were produced, allowing better visualization by means of angles and quality. A study of Mota de Almeida *et al* (2014) [8], proved that the use CBCT has a substantial positive influence on treatment planning in endodontics. Additionally, some authors has also reported CBCT to be more effective than periapical radiographs especially in detecting root canal anatomy. However, others studies have shown that the superior abilities of CBCT were not of significant value especially in detecting the internal anatomy of mandibular incisors (Assadian *et al*, 2016) [9]. While studies have outlined the benefits of CBCT over periapical radiography, a direct comparison to this effectiveness has not been conducted. When CBCT was first introduced, sectional images were produced, allowing better visualization by means of angles and quality. The benefits and limitations of CBCT over conventional periapical radiographs have been studied by many authors. The subtle point of negotiation is to understand to what extent the use of CBCT over periapical can have a positive influence on initial radiographic diagnosis in different dental specialties. This research aims to identify whether the use of CBCT would affect the preliminary diagnosis for different dental cases when compared to periapical images.

Material and Methods

1. SEARCH STRATEGY

The following electronic databases were search between 2006–April 2017: PubMed and ProQuest. To find additional studies a hand selective search was done of the reference lists on the final set of retrieved articles. The search strategy included a self made formula for the insertion of keywords into the search engine. Diagram 1 explains this procedure. These keywords included "Cone Beam Computed Tomography" or "CBCT", "Periapical Radiograph" or "PA", "Digital Radiograph", "Conventional Radiographs", "Periapical Lesions", "Vertical Root Fracture" or "VRF", "Alveolar Bone Loss" and "Bone Defects". The formula was to either enter one radiographic technique followed by the factor being studied, or two radiographic techniques followed by one factor being studied. The diagram presents the formula as such.

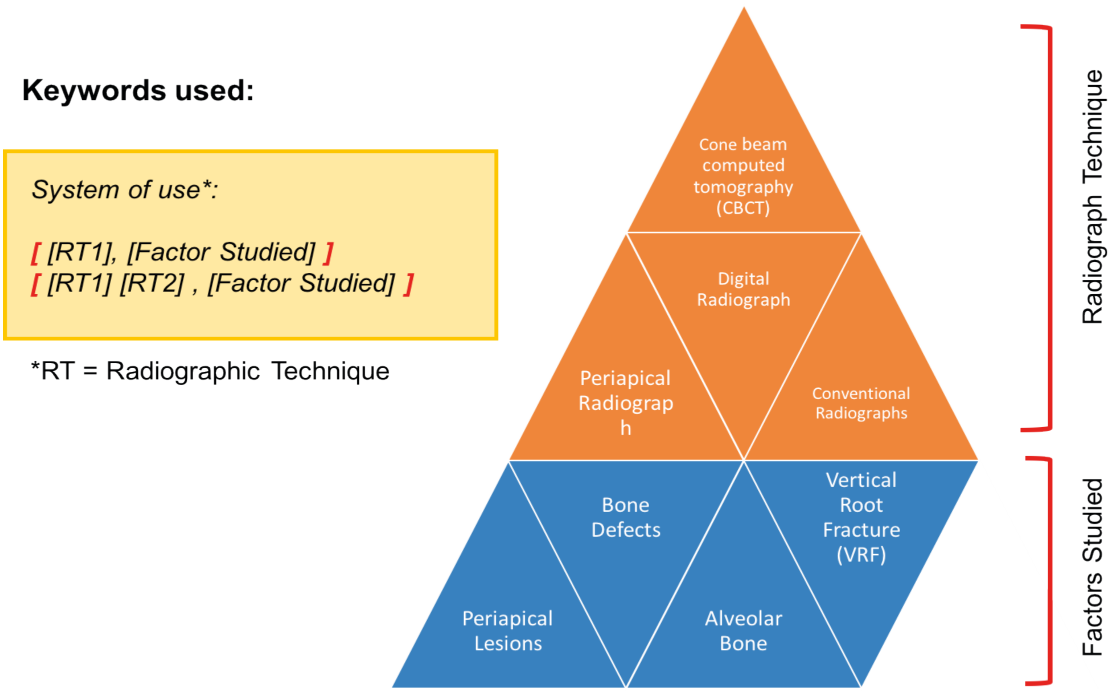

Diagram 1. The diagram above outline the formula used (*yellow box*) to insert the keywords (*pyramid*). The key words consist of two parts, the radiographic techniques (*orange*) and the factors studies (*blue*). Each word was inserted by the use of the formula into the database search engine.

Articles that appeared in more than one database were considered as duplicates and were only considered once. Two examiners (Hassan Al Basri (HAB) and Mohhamed Fadhul (MF)) searched for the articles on the search engines. HB was assigned to search in PubMed, while MF explored ProQuest.

2. INCLUSION AND EXCLUSION CRITERIA

The table bellow (Table 1) outlines the inclusion and exclusion criteria that were used to include and exclude studies as such. In vivo and in vitro studies were included with the exclusion of case reports case studies,

TABLE 1. The Criteria for Included Research

Inclusion Criteria	Exclusion Criteria
Articles from 2006 till 2017	Studies that only reviewed CBCT machines without periapical
English only	Studies outside the factors studied
Abstract that contain one or more of the keywords in the study	Case studies
Interventions: only articles that compared CBCT to periapical radiography (conventional or digital)	Case reports
Outcome measures: only studies that examined periapical lesions, vertical root fracture (VRF) and bone defects.	
Full-text articles only	

review articles, textbooks and editorials respectively. Nevertheless, only studies that compared CBCT to periapical radiography were included. Any studies that compared the modalities outside the factor being studies (periapical lesions, vertical root fracture and bone defects) were excluded. Articles only in English language and full text articles were included.

3. DATA COLLECTION AND PROCESSING

A total of 262 title/abstracts were identified through the data base search engines. Most of the articles were found on PubMed (n = 189) while the other were identified on ProQuest (n = 173). Relevant articles by title/abstract were all recorded bellow and categorized according to the relevance to the factor being studied as shown below (n = 107).

These were then further evaluated according to the inclusion and exclusion criteria by reading the titles/abstracts. After reading some reference lists (n = 6) were added to end up with (n = 39) as the final number of articles reviewed in this study. The Diagram 2 shows the flow process of articles and how they were recruited:

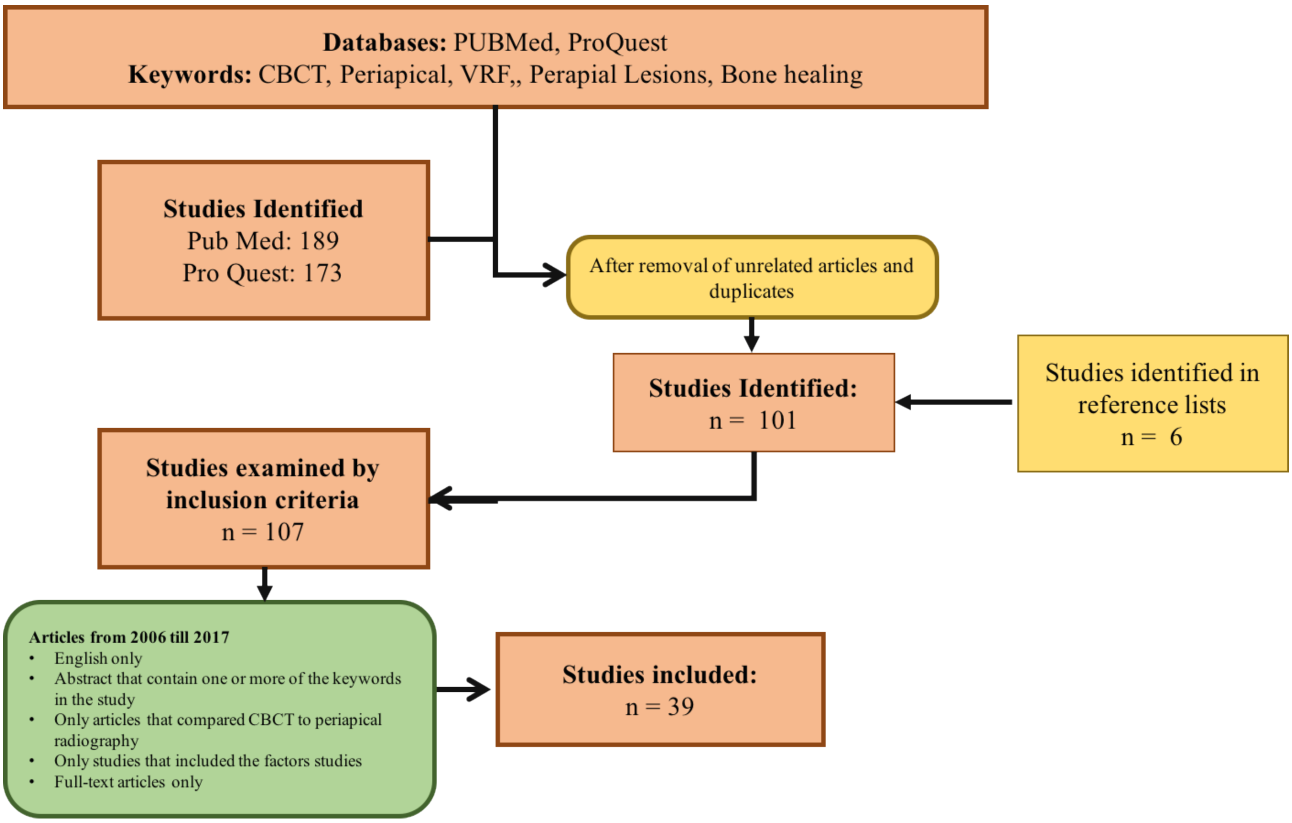

Diagram 2. The diagram is a flow diagram and represent the literature search from the initial time to the final number of articles concluded.

The total number of article (n = 39) were categorized according to the factor being studied to end up with (n = 15) for periapical lesions, (n = 13) for vertical root fracture (Fig 3) and (n = 11) for bone defects. Each category had its own table for analysis and data recording as shown below (Tables 2-4).

Results

The total amount of articles (n = 39) were categorized according to the factor being studied and were classified between *in vivo* and *in vitro* studies. In articles that investigated periapical lesions, the majority of the studied were *in vivo* (n = 11) while the remaining were *in vitro* (n = 4). This was different in the case of articles that investigated vertical root fracture and bone defects were the majority of the studies were *in vitro* studies (n = 12) (n = 10) while the remaining were *in vivo* (n = 1) (n = 1) respectively. The Table 5 summarizes this as outlined.

PART 1: METHODOLOGY

PERIAPICAL LESIONS

The articles in this category had similar methods in data collection; the main changes included the number of sample, observers and the types of machines used. 3 articles have studied induced periapical lesions while 12 examined pathological periapical lesions in real patients. Detailed information on these differences is presented in Table 6.

VERTICAL ROOT FRACTURE

Since the majority if the articles in this factor were *in vitro* studies. The differences included different methods

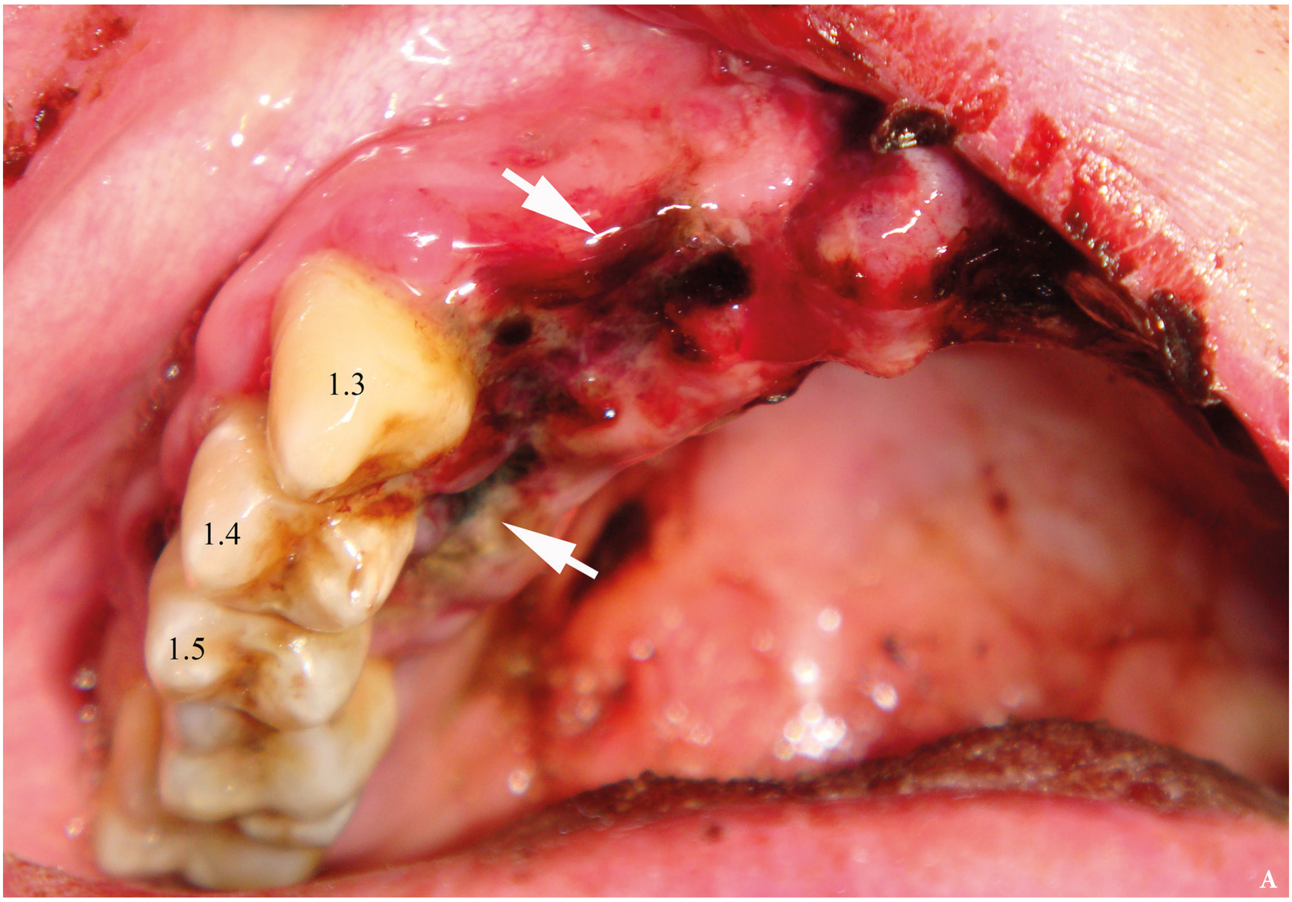

FIGURE 3. An intraoral view (**A**) of a 45-year-old gentleman with a trauma in anamnesis shows ruptured mucosa (*arrows*) from a palatal aspect of the movable teeth 1.3-1.5. That gives a suspicion for a surgeon that the maxillary fracture combines with a roots fracture of the movable teeth. The axial (**B**), coronal (**C**) CBCT scans shows no roots fracture of the teeth 1.3-1.5. The CBCT confirmed only a maxillary fracture (*arrows*) – segmental fracture of the alveolar process. **(Fig 3 continued on next page.)**

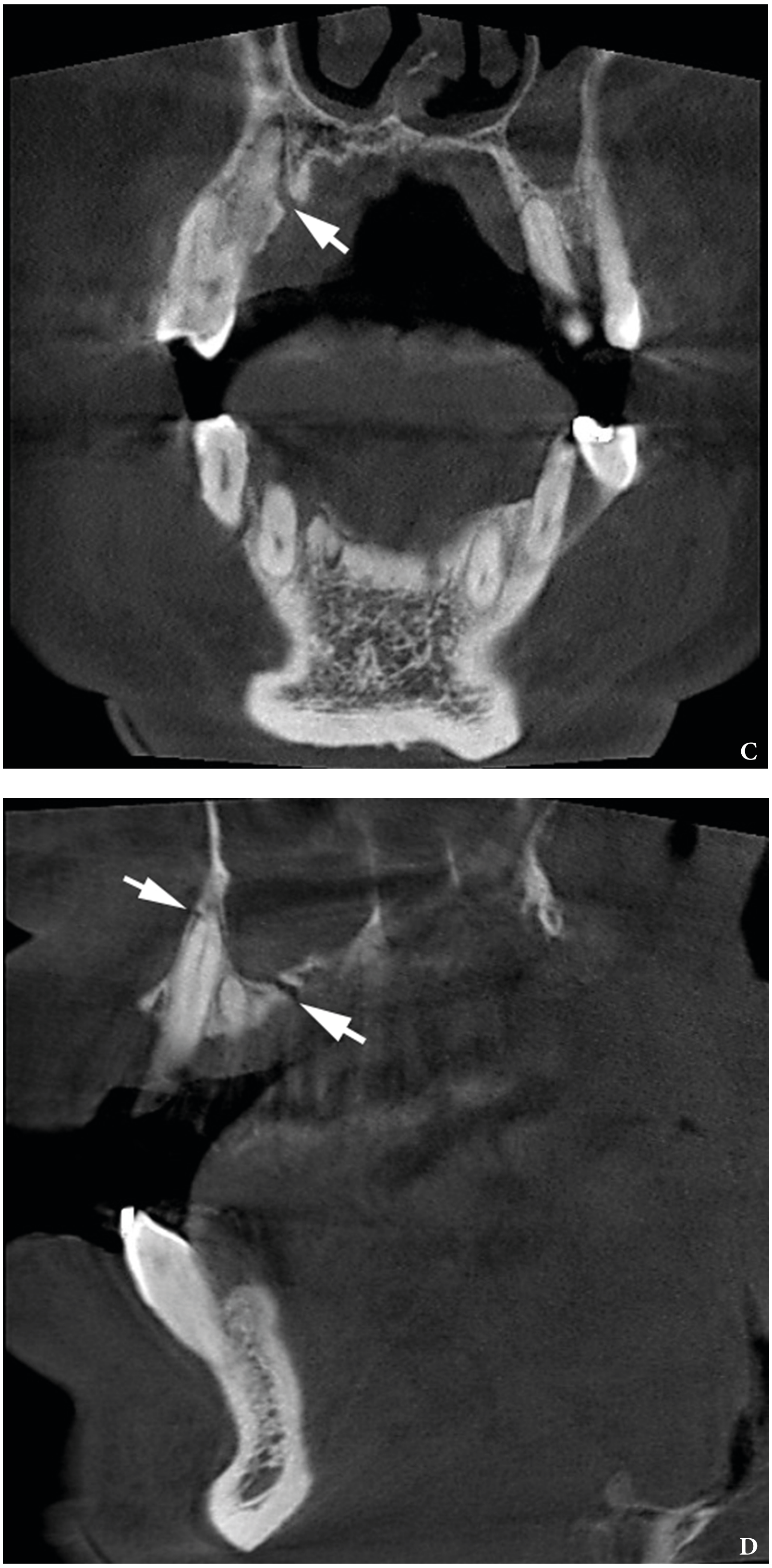

FIGURE 3. (cont'd). A coronal (**C**) and sagittal (**D**) CBCT scans shows no roots fracture of the teeth 1.3-1.5. The CBCT confirmed only a maxillary alveolar fracture (*arrows*). Images of **Figure 3** are courtesy of *Ievgen I. Fesenko, PhD, Assis Prof; Kyiv, Ukraine*.

TABLE 2. The Table Below is a Sample Table of How the Data Was Analyzed for Periapical Lesions Articles

Authors	Year	Study Design	Source of Sample	Type of Lesion	Patient n	Tooth n	Focus	Evaluation Time	Observers	Conclusion

TABLE 3. The Table Below is a Sample Table of How the Data Was Analyzed for Vertical Root Fractures Articles

Authors	Year	Study Design	Source of Sample	Tooth No.	Focus	Method of fractures	Tooth Status	Reference Test	CBCT Specifications	Periapical Specifications	Number of Observers	Conclusion

TABLE 4. The Table Below is a Sample Table of How the Data Was Analyzed for Bone Defects Articles

Authors	Year	Study Design	Source Sample	Number of Teeth	Number of Jaws	Focus	Periapical Specifications	Film Specifications	CBCT Specifications	Bone Status	Reference Test	Number of Observers	Conclusion

TABLE 5. Articles Included in the Study

Factors of Study	*In Vivo* (n)	*In Vitro* (n)	Total Number of Articles (n)
Periapical lesions	11	4	15
Vertical root fractures	1	12	13
Bone healing	1	10	11
Total number (n)			39

of fracture, reference tests, and types of machines as well as the sample number. The status of the tooth (filled/not filled with metallic post) also differed. Details of each respective study are outlined in Table 7.

BONE DEFECTS

In this category of articles, the area of focus differed between studies were 3 articles investigated alveolar bone loss, 5 investigated the efficacy in artificially induce bone defects, 1 examined the peri-implant bone healing and 1 evaluated Regenerative periodontal bone level. The type of machines, sample number, observers' number and bone status also differed and these are all outline in Table 8.

PART 2: WHICH MODALITY IS SUPERIOR?

13 out of 15 articles concluded that CBCT is superior to PA radiography in, while the rest (n = 2) concluded that no difference was seen between the two modalities in the detection of periapical lesions. 10 out out of 13 articles for vertical root fracture and 5 out of 11 in bone defects also concluded that CBCT is superior o PA in the detection of each factor respectively. Pie charts were used to illustrate these differences as shown Diagram 3.

PART 3: LIMITATIONS ADDRESSED

Several articles have mentioned the causes or limitations of CBCT and PA radiography respectively in the identification of periapical lesions, vertical root fractures and bone defects. The numbers of articles that have addressed the limitations are shown in Diagram 3. It can be seen that 9 articles mentioned limitations of PA radiography and 4 articles addressed limitation of CBCT in detection of periapical lesions. In the evaluation of vertical root fracture, 6 articles identified limitations of CBCT compared to PA and 2 articles identified the limitations of PA radiography in examination of the respective category. The limitations addressed for bone defects were less compared to the other categories with only 4 articles identify the limitations for CBCT in evaluating bone and 3 articles have shown the limitations of periapical radiography.

These addressed limitations were tabulated in Tables 9-14. It can be noted that many articles agree that limitations of CBCT are due to its high radiation dose compared to PA and the fact that it require training for the use of system. Nevertheless, it was identified that the specification of CBCT during its use alters its ability to detect lesions when compared to PA radiography. Detailed explain of these differences are tabulated in Tables 9-11.

More over the limitations of PA radiography in the detection of periapical lesions, vertical root fractures and bone defect was due to to the image quality affected by noise etc. furthermore, superimposition of structures in the maxillary molar area was also identified as limitation

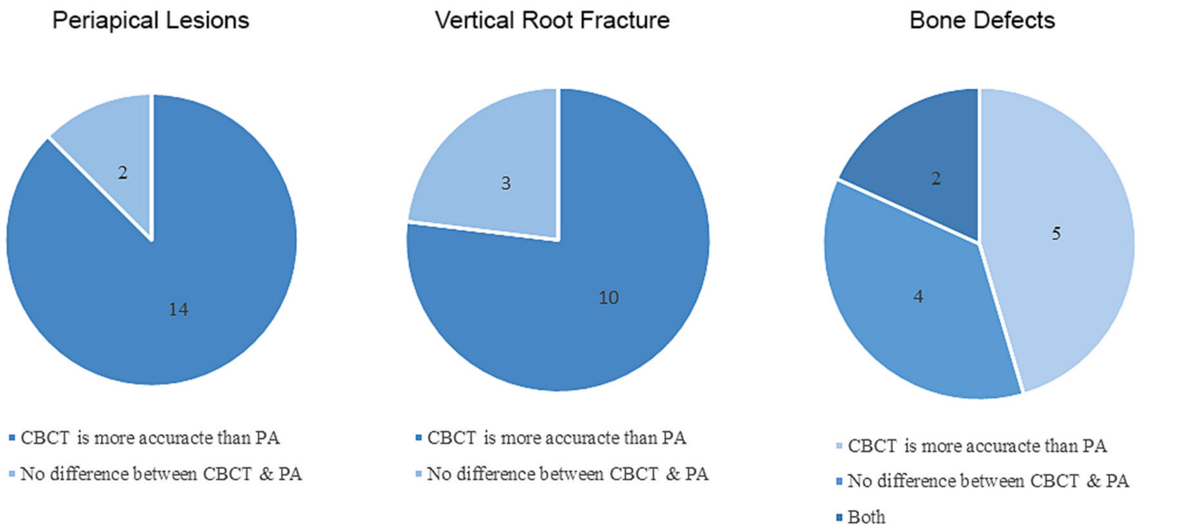

Diagram 3. The diagram illustrated the number of articles that indicated CBCT is superior to PA radiography and the articles that concluded no difference was seen between CBCT and PA radiography for each factor studied.

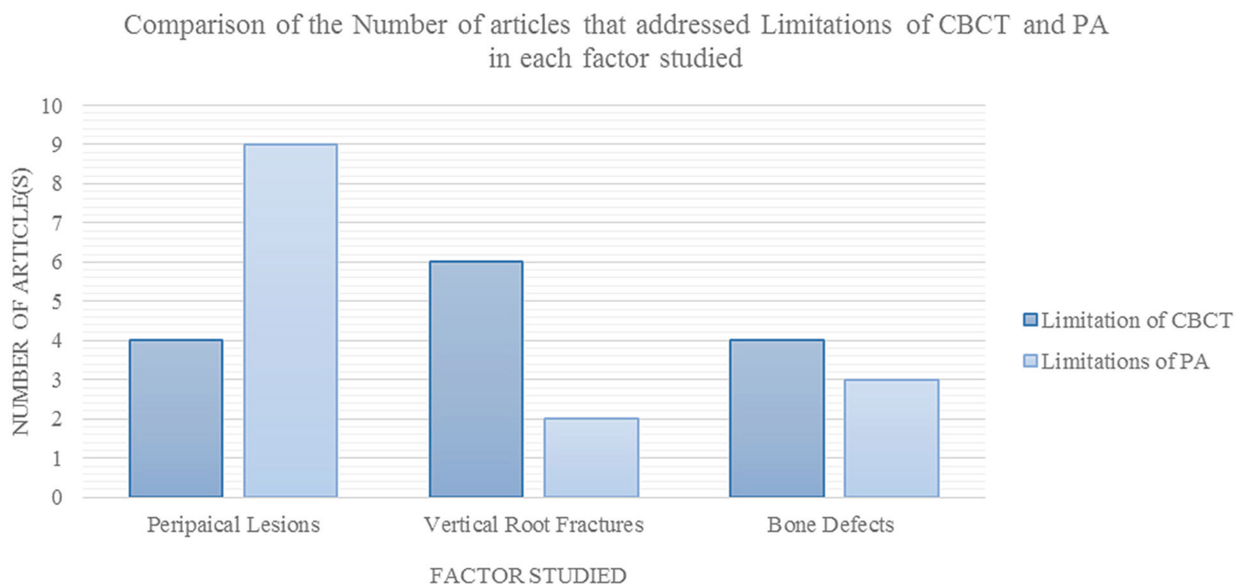

Diagram 4. The graph identifies the number of articles that addressed limitations of CBCT and PA radiography in each factor respectively. The total number of articles for periapical lesions is (n = 15), vertical root fracture (n = 13) and bone defects (n = 11).

of PA. Detailed information about these limitations is outlined in Tables 12-14.

The following tables (Tables 6-14) used to analyze the data with detailed information of the difference in methodology and the limitations of CBCT and periapical radiography as such.

Discussion

This study set out to compare the differences in efficacy between periapical radiography and CBCT in diagnosis of periapical lesions, vertical root fractures and bone defects in current available literature. The main findings of this study demonstrate that with in all three factors studied, the majority of studies emphasized that CBCT was superior to periapical radiography. Twenty-three percent (23%) of all of the studies have shown that there was no difference with regards to the diagnostic capabilities of CBCT and periapical radiography. That can be due the small sample size, the type of study conducted and the type of periapical radiographic modality used. Moreover, only a few studies showed that there was no difference between both modalities. Nevertheless, some limitations are addressed for both radiographic modalities and this may be a contributing factor to our conclusion. The most likely explanation of the negative finding is that the design of the studies can interfere with the conclusion since the studies had different sample size between each other.

TABLE 6. Summary of the Methodology and Conclusion for Articles of Periapical Lesions **(Table 6 continued on next page)**

Authors	Year	Study Design	Source of Sample	Type of Lesion	Patient No.	Tooth No.	Focus	Evaluation Time	Observers	Conclusions
Campello *et al* [10]	2017	*In vitro*	Artificially induced lesions with burs comparing dental radiography (DR)[a] to CBCT	Induced lesions	N/A[b]	11	Presence or absence of	Not indicated	10	CBCT allowed higher accuracy than DPR[c] in detecting simulated lesions for all simulated lesions tested. Endodontists need to be properly trained in interpreting CBCT scans to achieve higher diagnostic accuracy
Kanagasingam *et al* [11]	2017	*In vitro*	Artificially induced lesions with burs comparing DR to CBCT	Induced lesions		67	Presence or absence of	Not indicated	5	All imaging techniques had similar specificity and positive predictive values. Additional parallax views increased the diagnostic accuracy of PR. CBCT had significantly higher diagnostic accuracy in detecting AL[d] compared to PR, using human histopathological findings as a reference standard
Uraba *et al* [4]	2016	*In vivo*	Images were taken from database of the Clinic of Operative Dentistry and Endodontics at the Dental Hospital of Tokyo	Pathological	86	178	Diagnosis	Not indicated	2	1. CBCT exhibited a significantly higher AP detection compared to PR (52% vs. 31%) 2. CBCT shows more accuracy in detecting AL in maxillary molars, canines and incisors groups
Sakhadari *et al* [12]	2016	*In vitro*	Extracted teeth	Induced lesions	45 block	90	Diagnosis	Not indicated	4	1. The results showed that high-resolution CBCT scans had higher diagnostic accuracy than PSP digital radiography for detection of artificially created PA bone lesions 2. Voxel size (field of view) must be taken into account to minimize patient radiation dose
Venskutonis *et al* [13]	2014	*In vivo*	Retrieved from image database from the Department of Oral Diseases, Lithuanian University of Health Sciences from September 2008 – July 2013	Pathological	20	35	Diagnosis	Not indicated	Not indicated	1. CBCT is more accurate compared to DP in detection periapical radiolucency's in endodontically treated teeth 2. More difference is find in examining molar teeth
Saidi *et al* [14]	2014	*In vivo*	Patients were treated, at Endodontic Department of St. Joseph University	Pathological	N/A	156	Follow up healing after endo	Not indicated	2	1. CBCT was more reliable in detecting periapical lesions compared with DR in long-term evaluation of RCT success 2. Prevalence of AP was detecting 34.8% with CBCT compared to 13.8%
van der Borden *et al* [15]	2013	*In vivo*	Image were taken pre operatively and at recall to check the status of the periapical lesion	Pathological	N/A	50 teeth 71 roots	Diagnosis	Not indicated	Not indicated	1. Changes in lesions size after root canal treatment determined with CBCT and PA are different 2. The outcome of RCT with PA can be untrue 3. The findings determined by PA significantly difference from CBCT

[a] *DR – Dental radiography*
[b] *N/A – Not applicable*
[c] *DPR – Dental plane radiography; PR – plane radiography*
[d] *AL – Apical lesions*

TABLE 6. (cont'd). Summary of the Methodology and Conclusion for Articles of Periapical Lesions **(Table 6 continued on next page)**

Authors	Year	Study Design	Source of Sample	Type of Lesion	Patient No.	Tooth No.	Focus	Evaluation Time	Observers	Conclusions
Shahbazian *et al* [16]	2013	*In vivo*	Oral Imaging Center KU Leuven	Pathological	145	537	Detecting AL in posterior maxilla	3 months interval	2	1. PA is not able to visualize pathology in maxillary molar area 2. CBCT can be used to diagnose pathology in posterior maxilla 3. Diagnosing AL with PL is underestimated with 60% missed lesions 4. Due to high radiation dose CBCT should be used only when indicated
Cheung *et al* [17]	2013	*In vivo*	Dental teaching hospital	Pathological		60		Not indicated	1 endodontist, 1 oral radiologist	1. There were substantial disagreements between PA and CBCT for assessing the periapical status of molar teeth, especially for the maxillary arch 2. The findings have implications in periapical diagnosis and for evaluating the outcome of endodontic care
Abella *et al* [18]	2012	*In vivo*	Patients referred to the Department of Endodontucs at Universitat Internacional de Catalunya, Barcelona Spain from January 2011 to March 2012	Pathological	130	138 teeth	Diagnosis	Not indicated	2 examiners	1. The study concluded that 10.4 % of AP lesions were missed by PA radiographs 2. The accuracy of CBCT was significantly higher (p < 0.5)
Davies *et al* [19]	2012	*In vivo*	Refer to part 1 of the study for details	Pathological	99	123	Diagnosis	1 years	Not indicated	1. CBCT shows a lower healing rate compared to PR particularly in molar teeth 2. There was a 14 times increase in failure rate when teeth with no pre operative PA RL were assessed with CBCT compared to PR after 1 year
Balasundaram *et al* [20]	2012	*In vivo*	Patient who reported to the Endodontic Division of the University of Detroit Mercy School of Dentistry with symptoms of periapical lesions. March 2010 to December 2010	Pathological	24	24	Treatment planning	Not indicated	6	1. No difference in the treatment plan between the 2 modalities (PR and CBCT) was found 2. Even though CBCT shows more "information", it doesn't affect the treatment plant when compared to PR
Low *et al* [21]	2008	*In vivo*	The patients were referred to the Department of Oral Surgery and Stomatology in University of Bern, Switzerland	Pathological	45	74	Previously endo treated teeth with signs of AP	Not indicated	1 oral radiologist and 1 endodontist	1. 34% of lesions detected on CBCT were missed by PA in maxillary premolars and molars 2. Lesion expansion into the sinus, sinus membrane thickening, missed canals, and presence of apicomarginal defects were also more frequently seen with CBT than PA
Estrela *et al* [22]	2008	*In vivo*	Databases from the Dental and Radiological Institute of Brasília (IORB, Brasília, DF, Brazil). Exams were obtained between May 2004 and August 2006	Pathological	888	1508	Tooth at pre-op and recall	Not indicated	3	1. Possibility of false-negative diagnosis when using conventional radiography 2. Prevalence of AP was significantly higher with CBCT 3. AP was correctly identified with conventional methods when showed advanced status 4. CBCT was proved to be accurate to identify AP

TABLE 6. (cont'd). Summary of the Methodology and Conclusion for Articles of Periapical Lesions

Authors	Year	Study Design	Source of Sample	Type of Lesion	Patient No.	Tooth No.	Focus	Evaluation Time	Observers	Conclusions
Stavropoulos *et al* [23]	2008	*In vitro*	Pig jaws	Pathological	N/A	N/A	Visibility of a lesion	Not indicated	4	1. The diagnostic accuracy of New Tom 3G was significantly higher than that of intraoral radiographs 2. No difference between digital and conventional was seen

TABLE 7. Summary of the Methodology and Conclusion for Articles of Vertical Root Fracture **(Table 7 continued on next page)**

Authors	Year	Study Design	Source of Sample	Tooth No.	Method of Fractures	Tooth Status	Reference Test	CBCT Specifications	Periapical Specifications	Observers	Conclusions
Bechara *et al* [24]	2013	*In vitro*	Extracted teeth	66	Hammer and attached by methyl acrylate	Endodontically treated tooth	N/A VRF was induced	Picasso Master 3D 17 × 7 cm FOV 0.2 voxel	2 PA were taken at different angles the PSP was controlled by a putty matrix	5	1. CBCT at a small FOV showed more accuracy compared to large FOV 2. PSP and small FOV CBCT show similar results and are greater than large FOV CBCT 3. The study concludes that CBCT should be used when PSP is not enough to detect VRF
Abdinian *et al* [25]	2016	*In vitro*	Extracted teeth	120	Hammer	Non-filled, filled, present with posts	Inspected with magnifier x5	Cranex 3D	3 horizontal angles	2	1. No significant difference was found between the results of CBCT compared to PR in detection of vertical root fracture 2. The study concludes that CBCT should only be used after basic radiology is done
Bechara *et al* [26]	2015	*In vitro*	Extracted teeth	66	Pin tapered with hammer into root	Endodontically treated teeth	A five point scale reviewed by the evaluators	Cranex 3D	PSP plates	5	The accuracy of RF depiction in endodontically treated teeth using 8 cm × 8 cm FOV CBCT was greater than that obtained using one or two PSP plate angulations
Ezzodini Ardakani *et al* [27]	2015	*In vitro*		80	Sharp Chisel and Hammer	RCT Filled	10 × Mangnification Steromicisciope	Planmeca Promax 3D	Conventional	3	1. This study showed that the sensitivity and accuracy of CBCT in detection of vertical root fracture are higher than periapical radiography 2. CBCT can be recommended to be used in detection of vertical root fractures

TABLE 7. (cont'd). Summary of the Methodology and Conclusion for Articles of Vertical Root Fracture **(Table 7 continued on next page)**

Authors	Year	Study Design	Source of Sample	Tooth No.	Method of Fractures	Tooth Status	Reference Test	CBCT Specifications	Periapical Specifications	Observers	Conclusions
Brady *et al* [28]	2014	*In vitro*	Extracted teeth	30	Software: needle inserted into canal to induce fracture	Non-endo treated	Dental Operating Microscope and OCT	2 different CBCT machines: 3D Accuitomo and i-CAT	65 kV 7mA and 0.16 s. Phosphor plate. 10 degrees mesial and distal	3 endodontics and 6 undergraduates	1. CBCT is significantly more accurate in detecting incomplete VRF compared to PA 2. The width of the fracture affects the diagnostic accuracy of CBCT 3. CBCT is more accurate in detecting a fracture of >50 µm rather than <50 µm 4. The resolution is probably the reason for the poor detection
Chavda *et al* [29]	2014	*In vivo*	Unsalvagble teeth from 21 patients	22	NA	Non-endo treated	Dental Operating Microscope at 12.0 × magnification	CBCT 3D AccuitomoF170 small volume (40 mm3) 90 kV, 5.0 mA and 17.5 seconds	Digital Radiograph with sensor woth 66 kV, 7.5 MA at 0.10 seconds	3 Endodontists and 10 undergraduates	1. DR and CBCT have significant limitations in detecting VRF in vivo. 2. CBCT may be useful as an adjunct during clinical examination
Takeshita *et al* [30]	2014	*In vitro*	Extracted teeth	20	Fractured induced by testing machine	Root Canal Filled tooth	Binocular Stereomicroscope	iCAT	Conventional	3	1. CBCT was more accurate than conventional periapical radiography in detecting VRF 2. MPs did not influence the diagnostic accuracy of fractures for either imaging methods 3. The present study used the smallest voxel resolution and FOV, future studies that aim to reduce radiation exposure could examine the influence of the voxel size, FOV, and different CBCT equipment
Jakobson *et al* [31]	2014	*In vitro*	Human teeth	100	Diamond coated steel discs	Tooth endo and with Metallic posts	Light microscope m900 at × 10	CBCT1 (New Tom) CBCT2 (iCAT)	Film and digital Radiographs were taken and compared to CBCT1 and 2	4	1. The presence of metallic posts did not influence the sensitivity of most of the examinations, excluding the CBCT1 system 2. The fracture line orientation may influence VRF detection

TABLE 7. (cont'd). Summary of the Methodology and Conclusion for Articles of Vertical Root Fracture

Authors	Year	Study Design	Source of Sample	Tooth No.	Method of Fractures	Tooth Status	Reference Test	CBCT Specifications	Periapical Specifications	Observers	Conclusions
da Silveira *et al* [32]	2013	*In vitro*	Extracted teeth	60	Stimulated	20 with GP 20 with metallic post 20 No filling	Inspected with magnification	iCAT	3 different angles with digital film	3	1. The radiographic examination with horizontal angle variation should be encouraged as the first complementary approach to assess the presence of VRFs 2. If conventional imaging is not capable to provide adequate information, CBCT can be indicated if a root fracture is strongly suspected 3. The root condition should then guide the voxel resolution choice, selecting 0.3-voxel for not root filled teeth and 0.2-voxel for teeth with filling and/or a post
Kambungton *et al* [33]	2012	*In vitro*	Extracted teeth	60	Induced by a machine system	Endodontically treated teeth	Crack line confirmed with 1% methylene blue solution	Verviewspocs 3D	Digittal intraoral film	3 OMF radiologists	There was no significant difference between intraoral film, high resolution metal oxide semiconductor digital image and CBCT in detecting VRF in mandibular single rooted teeth
Varshosaz *et al* [34]	2010	*In vitro*	Extracted teeth premolars single rooted	90	By a size 45 finger spreader until a sharp crack voice heard	Root canal filled tooth	Stereomicroscopy x20	3D Accuitomo 170; NewTom 3G; VistaScan PSP; CCD sensor	Conventional	2	The 3D Accuitomo 170 was significantly superior to the NewTom 3G, VistaScan PSP, CCD sensor, and conventional film images in the detection of artificially induced vertical root fractures
Tsai *et al* [35]	2012	*In vitro*	Extracted teeth	100	Pin was inserted to induce VRF	Cleaning and shaping no filling	Zackwill/Roell Z020 Universal Testing Machines	Promax 3D		6	CBCT achieves more accurate diagnosis of VRF in comparison to digital radiographs
Metska *et al* [36]	2009	*In vitro*	Extracted teeth	80	Artificially Induced	Filling roots	Stereomicroscope	iCAT	Phosphor plate films	4	1. The sensitivity of CBCT in detecting VRF was significantly higher compared to PR 2. CBCT scans overall significantly more accurate in detecting VRF 3. CBCT accuracy is 0.86 compared to 0.66 in PR 4. The presence of Root Filling did not significantly influence the sensitivity of CBCT but reduced its specificity 5. In PR presence of root filling reduced sensitivity.

TABLE 8. Summary of the Methodology and Conclusion for Articles of Bone Defects **(Table 8 continued on next page)**

Authors	Year	Study Design	Source of Sample	Teeth No.	Jaw No.	Focus	Periapical specifications	CBCT Specifications	Bone Status	Reference Test	Observers	Conclusion
Bayat *et al* [37]	2016	*In vitro*	Seven sheep mandibles	84 (72 artifical defects, 8 natural defects)	7	Artificial periapical bone defects	MINIRAY Soredex Digora Soredex PSP	NewTom Vgi	Drilled bone	Photographs of created defects	3	1. CBCT was superior to digital intraoral radiography for the detection of Grade I furcation involvements, three-wall defects, dehiscence and fenestrations 2. No significant difference was noted between CBCT and digital radiography for the detection of Grades II and III furcation involvements, one-wall, two-wall and trough-like defects
Bardal *et al* [38]	2015	*In vitro*	Five dry mandibles	Edentulous	5	Artificial cacellous bone defects	de Gotzen Film: Soredex-Onion PSP and E-speed Eastman Kodak	Not mentioned	Drilled bone	Not mentioned	2	1. Defects confined to spongy bone can be identified on film and PSP radiographs and CBCT scans 2. However, interpretation of PSP images and CBCT scans needs greater expertise and skills
Bagis *et al* [39]	2015	*In vitro*	Twelve dry jaws (maxilla & mandible)	99	24	Artificial peridontal bone defects	Evolution x3000-2c Digora Soredex PSP	Planmeca Promax	Drilled bone	Periodontal Consultant	2	1. CBCT has the highest diagnostic accuracy for detecting periodontal defects 2. Further studies should be taken with different FOVs and different voxel sizes of the CBCT machines 3. CBCT not recommended if it will not improve diagnosis due to radiation
Takeshita *et al* [40]	2014	*In vitro*	Human teeth and macerated jaws	70	10	Aveolar bone loss	Carestream Health Kodak RVG 6100	iCAT Scanner	Non-induced bone loss	Digital Calliper	2	1. Conventional periapical with Han-Shin film holder was the only method that differed from the controls 2. CBCT had the closest means to the controls
de Faria Vasconcelos *et al* [41]	2012	*In vitro*	Radiogrpahic database	39	N/A	Aveolar bone loss	Spectro 70X Selectronic Kodak Insight	iCAT Scanner	Non-induced bone loss	Dental Radiologist Specialist	3	1. CBCT was superior to digital intraoral radiography for the detection of Grade I furcation involvements, three-wall defects, dehiscence and fenestrations 2. The results showed that there was no significant difference between imaging methods in the identification of pattern of bone loss

TABLE 8. (cont'd). Summary of the Methodology and Conclusion for Articles of Bone Defects

Authors	Year	Study Design	Source of Sample	Teeth No.	Jaw No.	Focus	Periapical specifications	CBCT Specifications	Bone Status	Reference Test	Observers	Conclusion
dos Santos Corpas *et al* [42]	2011	*In vitro*	Ten minipigs	10 implants	10	Peri-implant bone healing	Planmeca Prostyle Intra VistaScan PSP	Accuitomo 3D	N/A	Histological examination	0	1. Minute bone changes during a short-term period can be followed up using digital intra-oral radiography 2. Radiographic fractal analysis did not seem to match histological fractal analysis 3. CBCT was not found to be reliable for bone density measures, but might hold potential with regard to the structural analysis of trabecular bone
Patel *et al* [43]	2009	*In vitro*	Six dry mandibles	10 molars	6	Artificial periapical bone defects	Planmeca Prostyle Intra Schick CDD	Veraviewwpocs	Drilled bone	Microscope and controlled drilling	6	1. With intraoral radiography, external factors such as, anatomical noise and poor irradiation geometry, hinder the detection of periapical lesions 2. CBCT removes external factors and improved detection of the of artificial periapical lesions
Grimard *et al* [44]	2009	*In vivo*	Twenty nine humans (12F, 17M)	35	29	Regenerative periodontal bone level	Air Techniques PSP	Accuitomo 3DX	Non-induced bone loss	Surgical measurements	2	1. Compared to direct surgical measurements, CBVT was significantly more precise and accurate than IRs 2. If supported by further research, CBVT may obviate surgical reentry as a technique for assessing regenerative therapy outcomes
Noujeim *et al* [45]	2009	*In vitro*	Eleven dry hemi-mandible	163 sites M&D	11	Artificial bone defects	Planmeca Prostyle Intra Kodak Insight	Accuitomo 3DX	Drilled bone	Not mentioned	10	Results indicate that the CBCT technique has better accuracy and diagnostic value than periapical films in the detection of interradicular periodontal bone defects
Vandenberghe *et al* [46]	2008	*In vitro*	Human cadaver and dry skull (mandibles)	71	2	Aveolar bone loss	Heliodent DS Schick CDR	iCAT Scanner	Non-induced bone loss	Digital caliper	3	1. CBCT allowed comparable measurements of periodontal bone levels and defects as with intraoral radiography 2. CBCT with 0.4 mm cross-sections demonstrated values closer to the gold standard indicating more accurate assessment of periodontal bone loss 3. Further research is needed to explore these results in vivo with the use of CBCT in periodontal diagnosis

LIMITATIONS OF CBCT

TABLE 9. Limitations of CBCT in Detecting Periapical Lesions Addressed by Various Research Papers

Authors	Year	Study Design	Limitation
Campello *et al* [10]	2017	*In vitro*	CBCT requires proper trained prior to use
Sakhadari *et al* [12]	2016	*In vitro*	Voxel size (field of view) must be taken into account to minimize patient radiation dose
Shahbazian *et al* [16]	2013	*In vivo*	Due to high radiation dose CBCT should be used only when indicated
Balasundaram *et al* [20]	2012	*In vivo*	Even though CBCT shows more "information", it doesn't affect the treatment plant when compared to PR

TABLE 10. Limitations of CBCT in Detecting Vertical Root Fracture Addressed by Various Research Papers

Authors	Year	Study Design	Limitation
Bechara *et al* [24]	2013	*In vitro*	CBCT at a small field of view (FOV) showed more accuracy compared to large FOV
Bechara *et al* [24]	2013	*In vitro*	1. PSP and small FOV CBCT show similar results and are greater than large FOV CBCT 2. The study concludes that CBCT should be used when PSP is not enough to detect VRF
Abdinian *et al* [25]	2016	*In vitro*	1. The study concludes that CBCT should only be used after basic radiology is done
Brady *et al* [28]	2014	*In vitro*	1. The width of the fracture affects the diagnostic accuracy of CBCT 2. CBCT is more accurate in detecting a fracture of >50 μm rather than <50 μm
Jakobson *et al* [31]	2013	*In vitro*	The presence of metallic posts can affect the image when using New Tom
da Silveira *et al* [32]	2013	*In vitro*	The root condition should then guide the voxel resolution choice, selecting 0.3-voxel for not root filled teeth and 0.2-voxel for teeth with filling and/or a post
Metska *et al* [36]	2009	*In vitro*	The presence of root filling did not significantly influence of the CBCT but reduced its specificity

TABLE 11. Limitations of CBCT in Detecting Bone Defects as Addressed by Various Research Papers

Authors	Year	Study Design	Limitation
Bardal *et al* [38]	2015	*In vitro*	Interpretation of CBCT scans needs greater expertise and skills
dos Santos Corpas *et al* [42]	2011	*In vitro*	CBCT was not found to be reliable for bone density measures
Grimard *et al* [44]	2009	*In vivo*	However, CBVT does not provide some of the benefits of reentry surgery such as residual probing depth following regenerative therapy

Such an example is the study by Estrela *et al* (2008) [22], which contained a sample size of 1508 compared to another study by Campello *et al* (2017) [10] only included 11 samples. The study design of the articles included can affect their conclusion, although, this review did not criticize the quality of research included to come up with conclusions. However since this review was based on conclusions of the reviewed articles, this could affect the outcome of the review. From the data collected in the results it is observed that significant key conclusions that were shared between most papers are consistent with other systematic reviews conducted in the same field of study (Bella *et al*, 2012) [47], (Kruse *et al*, 2014) [48]. Studies conducted since 2006 have shown the superiority of CBCT when compared to periapical radiography with regards to the aforementioned factors. On the other hand, while recent studies still support the fact that CBCT is superior, they also outline the technical specification which can influence the diagnostic abilities of CBCT (Bardal *et al*, 2015) [38], (Davies *et al*, 2015) [19], (Shahbazian *et al*, 2013) [16], and Kanagasingam *et al* (2017) [11] suggested that additional parallel views can increase the diagnostic accuracy of PA when comparing to CBCT in the detection of periapical lesions. However, limitations can still occur in the maxillary molar region with PA radiographs. The field of view (FOV) in CBCT had an effect with respect to the specificity and sensibility in detecting

LIMITATIONS OF PERIAPICAL RADIOGRAPHS

TABLE 12. Limitations of Periapical Radiography in Detecting Periapical Lesions Addressed by Various Research Papers

Authors	Year	Type of Study	Limitation Addressed
Uraba *et al* [4]	2016	*In vivo*	CBCT shows more accuracy in detecting AP lesions in maxillary molars, canines and incisors groups
Venskutonis *et al* [13]	2014	*In vivo*	Periapical radiography can give limited information especially in the molar teeth
van der Borden *et al* [15]	2013	*In vivo*	The outcome of RCT with pa can be untrue
Shahbazian *et al* [16]	2013	*In vivo*	PA is not able to visualize pathology in maxillary molar area
Shahbazian *et al* [16]	2013	*In vivo*	Diagnosing AP with PA is underestimated with 60% missed lesions
Cheung *et al* [17]	2013	*In vivo*	There were substantial disagreements between pa and CBCT for assessing the periapical status of molar teeth, especially for the maxillary arch
Low *et al* [21]	2008	*In vivo*	34% of lesions detected on CBCT were missed by pa in maxillary premolars and molars
Estrela *et al* [22]	2008	*In vivo*	Possibility of false-negative diagnosis when using conventional radiography
Estrela *et al* [22]	2008	*In vivo*	PA can only detect lesions at advance state compared to CBCT

TABLE 13. Limitations of Periapical Radiography in Detecting Vertical Root Fracture Addressed by Various Research Papers

Authors	Year	Type of Study	Limitation Addressed
da Silveira *et al* [32]	2013	*In vitro*	The radiographic examination with horizontal angle variation should be encouraged as the first complementary approach to assess the presence of VRF
Metska *et al* [36]	2009	*In vitro*	In PAR presence of root filling reduced sensitivity

TABLE 14. Limitations of Periapical Radiography in Detecting Bone Defects Addressed by Various Research Papers

Authors	Year	Type of Study	Limitation
Bardal *et al* [38]	2015	*In vitro*	Interpretation of PSP images needs greater expertise and skills
dos Santos Corpas *et al* [42]	2011	*In vitro*	Radiographic fractal analysis did not seem to match histological fractal analysis
Patel *et al* [43]	2009	*In vivo*	With intraoral radiography, external factors such as, anatomical noise and poor irradiation geometry, which are not in the clinician's control, hinder the detection of periapical lesions

vertical root fractures. A smaller FOV has shown more accurate detection when compared to larger FOV (Bechara *et al*, 2013) [24]. A few more studies demonstrated that size of the FOV in CBCT alters the ability of detection of VRF in endodontically treated teeth. (Bechara *et al*, 2015) [26], (da Silveira *et al*, 2013) [32]. With regard to bone defects, it was suggested that the use film holders can alter the assessment of alveolar bone loss in PAR, in such a way that it could improve its diagnostic ability (Takeshita *et al*, 2014) [40]. Another point of discussion is the effects of external factors or variables which may influence the ability of diagnosis of the areas in question. With intraoral radiography, external factors such as, anatomical noise and poor irradiation geometry, can hinder the detection of periapical lesions. CBCT removes these external factors and further permits the clinician to select the most relevant views of the area of interest resulting in improved detection of the presence and absence of periapical lesions (Patel *et al,* 2009) [43]. Nevertheless, certain studies also shown that presence and absences of fillings can affects the image quality. Metska *et al* (2009) [36] stated that the presence of root filling has no effect on the efficacy of CBCT. Whereas, da Silveira *et al* (2013) [32] suggested that the presence or absence of fillings guides the voxel to be used. Differences between *in vivo* and *in vitro* studies have a subtle point of negotiation. Even though clinical studies results are consistent with *in vitro* results (both show CBCT is superior to PA). Several studies suggested that PR is not able to detect periapical lesions in the posterior maxilla due to superimposition of the structures where this cannot be assessed in "*in vitro*" studies. (Shahbazian *et al*, 2013) [16], (Cheung *et al*, 2013) [17], (Low *et al*, 2008) [21]. In another study, it concludes with, the orientation of the fracture and how it can influence the ability of detection in both PA and CBCT (Jakobson *et al*, 2014) [31]. Several papers addressed the ease of use and the levels of radiation among these devices.

According to Vandenberghe *et al*, (2008) [46], the use of CBCT should only be used in complex treatment planning such as, periodontal surgeries or implant placements at lower doses and with smaller voxel sizes. Although multiple articles agree that even though CBCT can give an accurate result, clinicians still require more training to easily use and interpret these images (Campello *et al*, 2017) [10], (Bardal *et al*, 2015) [38]. Due to radiation difference between CBCT and PA, literature encourages the use of CBCT only when needed or after the use of PA (Shahbazian *et al*, 2013) [16], (Abdinian *et al*, 2016) [25]. Some authors have stated that the use of CBCT is only permissible if the diagnostic information improves the treatment results due to the extent of radiation (Bagis *et al*, 2015) [39]. The main limitation of this study is that the focus was based on the conclusion of past studies and did not focus in depth on the variation of the design of studies conducted. Although this would not significantly alter our conclusion of the reviewed papers [49-52], it may present as a future complication in such a way that may require more precise analysis. Another major obstacle faced was that this research included a narrow assessment of search engines (only PubMed and ProQuest). With that being said, the portal provided by Ras Al Khaimah Medical and Health Sciences University was not able to retrieve several articles in full-text version, which narrowed our literary records to assess. This study reinforces the recommendation for the use of CBCT in diagnosis of periapical lesions, root fractures and bony defects and should be utilized in treatment planning in most if not all cases. The results are of direct practical relevance in which CBCT will benefit the diagnostic abilities of any dental clinician who had previous training with the use of the device.

Conclusion

Despite the limitations of the review conducted, evidence suggests that cone beam computed tomography is superior to periapical radiography in image quality and diagnostic ability with regards to periapical lesions, vertical root fractures and bone defects. However, it can be concluded that the specifications like field of view and voxel size affect the quality of CBCT images and therefore can affect its ability to detect periapical lesions, vertical root fractures and bone defects when compared to periapical radiographs. However, dental clinicians should be cautious when exposing patient to CBCT due to the higher radiation dose of CBCT. Likewise, it is proposed that the use of PA with some modifications is encouraged before the use of CBCT due to radiation dose.

Future Directions

It is recommended to research the effects of diagnosis on treatment planning by both modalities. Nevertheless, more clinical studies should be conducted when understanding the difference between CBCT and PA in detecting PA lesions due to structures superimposition and it affects. Future studies should investigate how to achieve maximum quality at minimum radiation for the detection of the lesions discussed; Training on the use of cone beam computed tomography should be initiated at early stages of university life due to the requirements and advancements in diagnostic modalities within the dental field.

Ethical Approval

Approval was obtained from the Research and Ethics Committee of the RAK Medical Health Sciences University, Ras Al Khaima, UAE in March 3, 2017 (RAKMHSU-REC-38-2016-UG-D).

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Analysis of Using the Method of Immediate Dental Implantation*

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ABSTRACT

Introduction.
Immediate dental implantation makes it possible to maintain the quantity of jaw bone tissue at the area of the removed teeth. Amount of the inflammatory complications in the post-operative period reduces. Method has minimized quantity of operations and their traumatism. It reduces period of rehabilitation by 4-6 months when using dentures with support for dental implants.
Purpose.
The aim of the work is to analyze the long-term results of immediate dental implantation.
Objects and Methods.
65 patients aged 25-68 years were treated. Patients were included in the study according to the following criteria: 1) one or two implants within a single segment (by using method of immediate dental implantation on the maxilla or mandible) 2) radiation methods of investigation were carried out in dynamics: 1st study before surgery – dental implantation; 2nd through 6 months; 3rd – 12 months after the surgery.
Results.
All implants were osseointegrated. The bone tissue of the jaws is uniformly adhered to the entire surface of the implants, pathological bone resorption was absent.
Conclusions.
Immediate dental implantation is used in clinical situations when the gingival volume is saved, there is no atrophy of the alveolar bone, and oral mucosa isn't thinned. There are no clinical signs of the pathological process in the periapical zone of the removed tooth.

Introduction

Mostly success of the implantation is determined by the correct choice of the implant design, indications and technique of the operative intervention, the period of rehabilitation and the system of preventing complications [1-3]. Against the backdrop of fast and active development of dental implant prosthetics method, one of the significant shortcomings is a need for repeated visits, repeated manipulations (for example, anesthesia), and long duration of the whole treatment. The existing ways to reduce the number of visits and reduce the overall duration of treatment are covered in the modern literature, supported by the scientific justification for indications for the choice of methods of exposure [4-6]. One of the methods is to install the implant immediately after the extraction of the tooth. In such situations, both basal single-stage and classic two-stage intraosseous implants can be used. The implantation of the intraosseous element into the socket of the removed tooth eliminates the need for a long wait for its healing, as well as the repeated administration of an anesthetic and additional visit [7-9].

Usage of the method of one-stage implantation makes it possible to maintain 60-90% of the alveolar bone quantity at the area of the removed teeth. At the same time, without implantation, after tooth extraction, due to resorption and atrophy of bone tissue, after 6-12 months quantity of jaw bone preserved only at 40-50%, and the height of the alveolar bone is reduced by 3-7 mm (Fig 1). Immediately dental implantation reduces amount of inflammatory complications at the post-operative period, minimizes quantity of surgical interventions and their traumatic impact. It allows shortening the time of rehabilitation with the use of orthopedic structures with support for dental implants for 4-6 months [2, 4].

A significant factor in successful treatment, including prosthetic implants, is the state of oral hygiene of the patient [1, 2, 9]. In that regard, oral hygiene is an important

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part of the sanitation of the oral cavity. In the aspect of dental implantation, they become even more important, helping to reduce the risk of complications during the surgical stage and positively affecting the long-term results of treatment [1, 4, 8].

In this regard, before the installation of the implant recommended professional hygiene measures that provide optimal conditions for the operation [3, 4]. However, in determining the indications for dental implantation, some dentists underestimate the patients' performance of the recommended individual hygiene measures.

Many practicing dentists with extensive clinical experience at the same time pay insufficient attention to the oral hygiene of their patients, ignoring this important factor in the complex treatment of partial or complete adentia with non-removable dentures on implants [7, 10].

The aim of the work is to analyze the long-term results of immediate dental implantation method in circumstances of implementation of hygienic measures.

Objects and Methods

65 patients aged 25-68 years were treated. Patients were included in the study according to the following criteria: 1) secondary adentia or indications for the removal of the tooth (teeth) 2) one or two implants within a single segment (by using method of immediate dental implantation on the lower or upper jaw). The exclusion criteria were: 1) pathological process at the periodontium (Figs 2 and 3); 2) comorbidity diseases 3) injuries; 4) operations requiring medical rehabilitation; 5) generalized periodontal diseases.

Therapeutic sanitation was performed before surgery. Patients were trained to individually care of the oral cavity, including the selection of flosses, toothbrush, toothpaste and mouthwash. In the morning, evening after meals all patients have used floss, also they have brushed their teeth with toothpaste, mouthwash, irrigator.

Patients were divided into two groups. First group (33 patients) is included persons on who used the method of immediate two-stage dental implantation. The operation was carried out immediately after tooth extraction under local and regional anesthesia with an injection of "Ultracaine-DC Forte" in a volume of 3.4 ml. Given the anatomical and topographic features of the jaws, the following structures were used: a helical two-stage cylindrical implant, 10 mm, 11.5 mm long, 3.7 mm and 4.5 mm in diameter with a plug.

Immediate one-stage dental implantation (32 people) was carried out with strict adherence to the protocol of this type of rehabilitation of patients with partial secondary adentia. The removal of the destroyed tooth was carried out. The well was minimally prepared, forming a guide channel (Figs 1 and 2). An implant was placed (Figs 3-5). A temporary artificial crown was made.

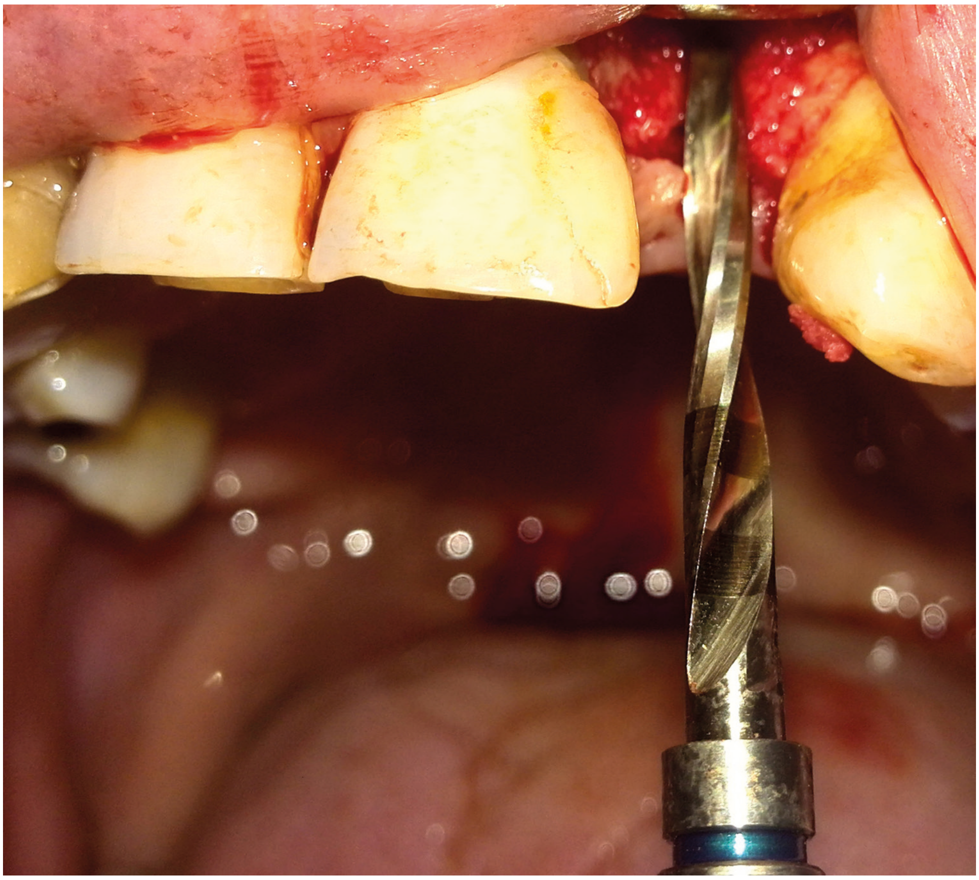

FIGURE 1. Formation of a guide canal on the anterior maxilla.

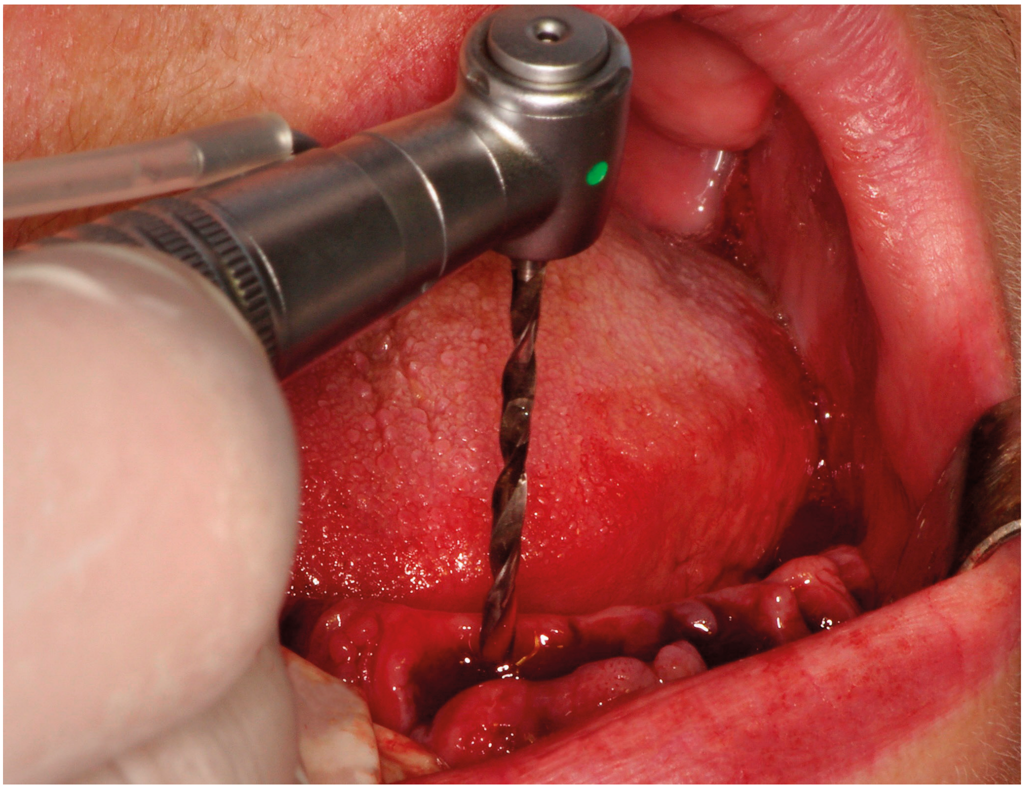

FIGURE 2. Formation of the canal for the implant placement in the alveolus of anterior mandible.

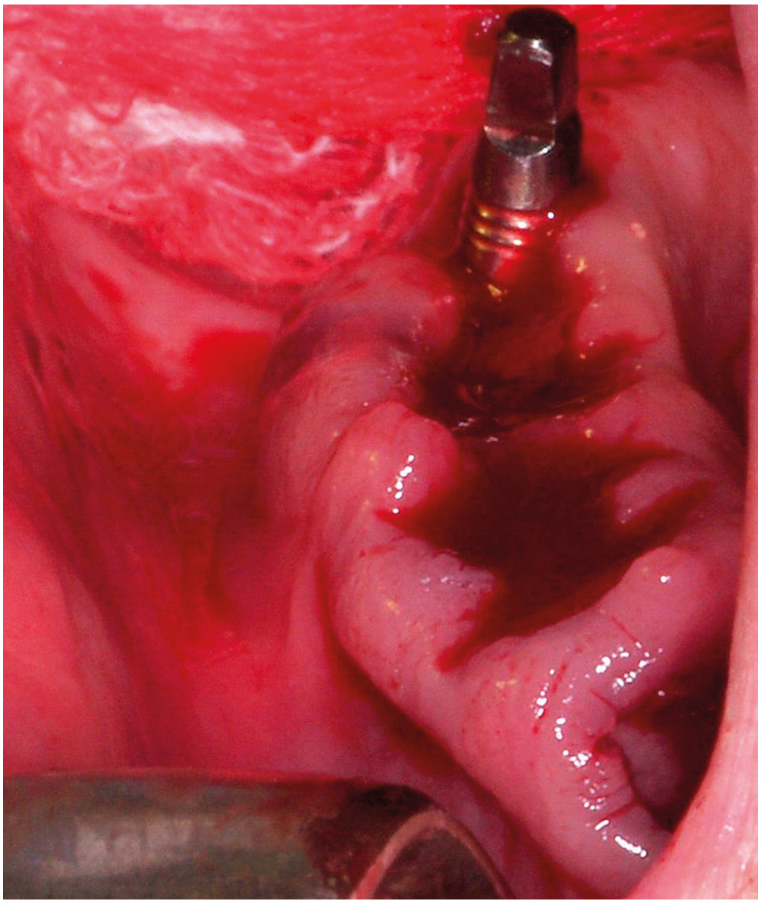

FIGURE 3. An implant is placed in the area of the removed tooth.

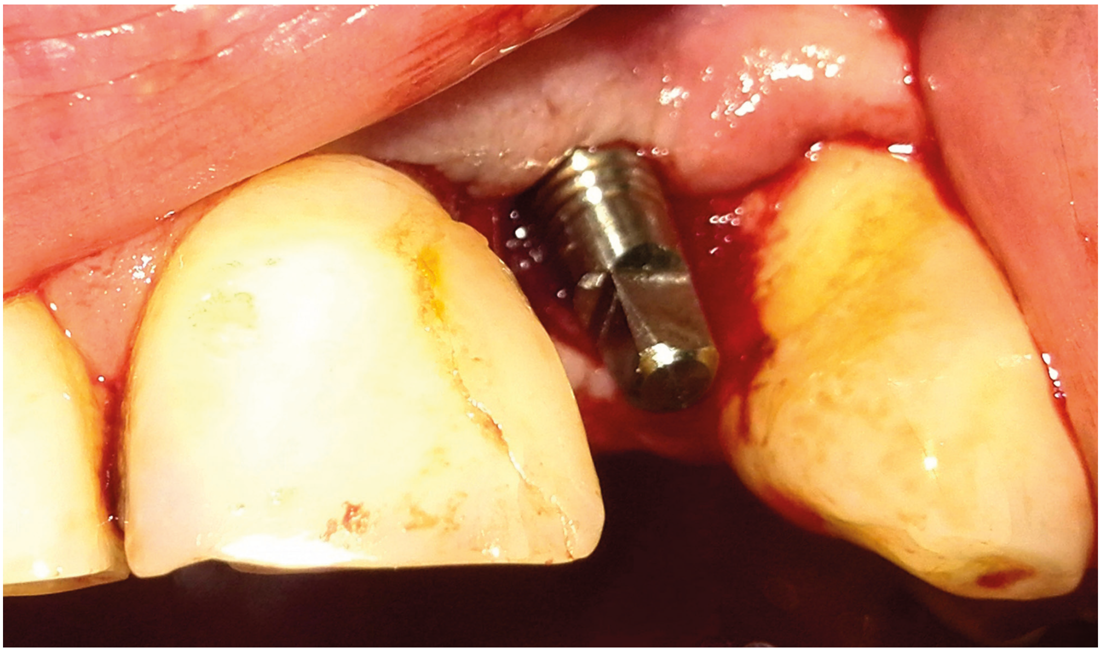

FIGURE 4. A monolithic implant is inserted into the tooth socket.

FIGURE 5. Immediate and delayed methods of dental implants placement are used in combination.

Before the surgery, the characteristics and structure of the bone tissue, the proximity of the maxillary sinus (on the maxilla), the localization of the mandibular canal were evaluated on the basis of the results of radiological methods (cone-beam computed tomography (CBCT) of the jaws or panoramic radiography). In the following, with the aim of dynamic evaluation of the implant's osseointegration, the radiation methods of the study were carried out at the following times: after 6 months; 12 months after the surgery.

As a criterion for assessing the condition of the implant, the performance indicator (PFI) was used, which was examined after 6 and

12 months after the intervention. At the same time, the quality of implant placement in bone, the level of adherence of bone tissue to the surface of the implant, the presence of horizontal or vertical resorption were noted. Controlled the functional state, distribution of load on the implant, occlusive load during chewing.

After the manufacture of the permanent metal-ceramic crown, the esthetic state of the artificial crown, its color and shape, the degree of erosion, discoloration, and the chipped crown were evaluated. Then the patients were measured the depth of the gingival groove or gingival pocket. The probing was performed at several points in the region of each implant and the arithmetic mean value was calculated.

An important role was given to the state of hygiene, the presence of plaque in the area of the implant, which increases the risk of local inflammation in the form of mucositis and peri-implantitis.

Evaluation of dental status was carried out using: a simplified Green-Vermillion index (OHI-S, Green, Vermillion, 1964); gingival index (GI, Loe, Silness, 1963); papillary-marginal-alveolar index (PMA, in the modification of Parma, 1960); the periodontal index (CPITN, WHO, 1960); the intensity of caries index (Klein, Palmer, 1937).

Results and Discussion

Before the operation, oral hygiene in both groups was good or satisfactory (OHI-S = 0.6). The intensity of gum inflammation, according to the interpretation of GI index, corresponded to a light gingivitis (1.0). The average number of sextants with gingival hemorrhage (CPITN "1") ranged from 0.3 to 0.4.

The results of the postoperative examination (7-14 days) showed that in 55% of cases, patients experienced mild soreness, in 45% – localized pain. The presence of soft tissue edema in the implant placement area was observed in 75% of cases, in 25% – edema in the area of implant and alveolar process mucosa.

In 75% cases, regional mucous hyperemia of the dental papilla was recorded, in 25% – marginal hyperemia with bleeding during probing. An objective examination established that in 100% of cases the mobility of the implants was not noted.

X-ray was taken to determine the state of bone structures, and their relationship to the implant (Fig 6).

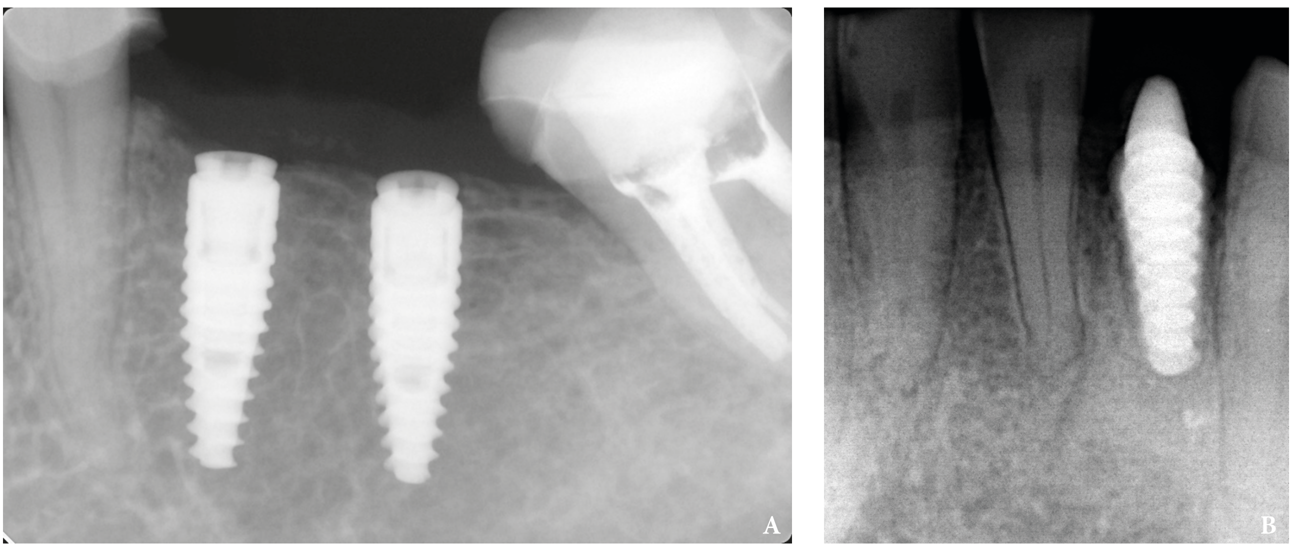

FIGURE 6. Quality of bone around the implants in the region of molars (**A**) and frontal teeth (**B**).

The main criteria for assessing the state of the dental implant in the long term were the following parameters: the degree of mobility of the implant; presence of bone tissue damage; degree and rate of bone atrophy; the condition of the mucosa adjacent to the implant; the depth of the pocket between the implant and the mucosa; quality of implant application to adjacent teeth; functional load efficiency; the ratio of the implant and the anatomical structures.

When examining patients 3 months after surgery, a subjective assessment of pain was made; clinically determined presence of soft tissue edema, inflammatory phenomena in the implant placement area, bleeding of the gingival mucosa during probing, the mobility of the implant was controlled, the presence of dental plaque was determined (Figs 14, 15).

When conducting radial methods of investigation, the degree of engraftment of the implant in the bone tissue was determined (orthopantomography, dental X-ray or cone-beam computer tomography). Criteria for X-ray diagnosis were the following indicators: bone tissue densely attached to the surface of the implant; absence of bone tissue in the area of the implant for two turns of thread; horizontal resorption of bone tissue by 1/2 the length of the implant; vertical unilateral resorption of bone tissue.

In the control period 3-4 months after the operation, the patients had no pain, no inflammatory phenomena were observed, the implants were immovable, the bone tissue fit tightly over the entire surface of the implant, oral hygiene was satisfactory on average in the OHI-S index, signs of mucositis and peri-implantitis was not revealed.

In one case of two-stage implantation, osseointegration did not occur, on the X-ray the vertical and horizontal resorption of bone tissue was recorded, the pronounced mobility of the implant, edema and hyperemia of the tissues of the gum and mucous membrane was clinically determined (Fig 7). The implant was removed.

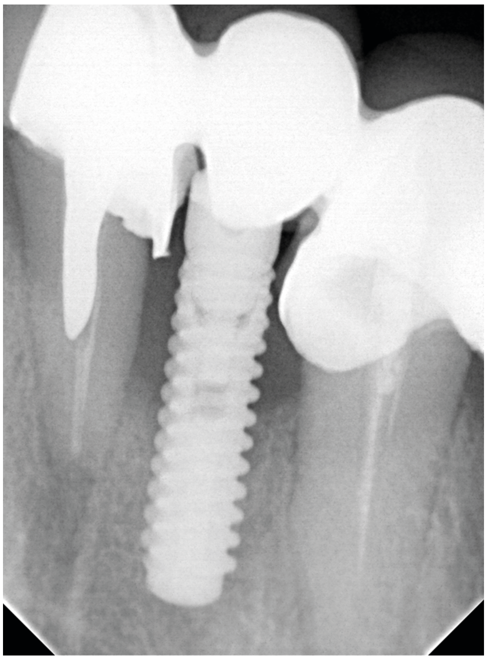

FIGURE 7. Resorption (*arrowheads*) of the alveolar bone around the implant.

Evaluation of the quality criteria for the installation of dental implants through 6 months showed that in a two-stage operation in the long-term, the patients had no pain, no inflammatory phenomena were observed, the implants were immobile, the bone tissue fit tightly over the entire surface of the implant.

In a one-step operation, pain sensations and inflammatory phenomena were also not observed, the implants were immovable, and the bone tissue is adhered tightly over the entire surface of the implant (Figs 8 and 9).

Oral hygiene in patients with a two-stage and one-stage implantation after the placement of the metal-ceramic crowns for intraosseous implants remained good (OHI-S = 0.6) or satisfactory (OHI-S = 1.6). The intensity of gingiva inflammation, according to the interpretation of GI index indicators, corresponded to a light gingivitis (1.0). The average number of sextants with gingival hemorrhage (CPITN "1") was 0.6.

Estimation of the aesthetic state of the prostheses testified that the color and shape of the artificial crowns were not violated; the orthopedic supraconstructions were retained, fixed, the occlusion was optimal.

Thus, the analysis of the condition of the prosthesis during the observation period from 3 months to 1 year after the operation showed that the frequency of complaints about the removal of the implant as a result of the absence of osseointegration was 1.5% of the cases.

The results of clinical studies showed that the installation of implants directly into the dental holes immediately after their removal is a minimally invasive method of surgical treatment, allowing to significantly reducing the duration of the operating period.

Conclusions

Modern methods of dental implant prosthetics have a

FIGURE 8. Inflammation of the gingiva around the implants on the mandible is absent.

FIGURE 9. Postsurgical panoramic radiograph shows the direction of the implants positions and the surrounded bony tissue of the mandible after placement of non-removable denture.

wide range of technical means (tools, devices, materials) that make it possible to expand the indications for their use. Worthy of attention are methods that reduce the invasiveness of ongoing surgical interventions. These include the surgical implant placement directly into the socket of the removed teeth in one visit, without repeated operations on the alveolar process and the gum. Prosthetics on the implant allow us to use high-quality materials for the lining of prostheses, first of all, high-grade ceramic masses.

High efficiency of complex treatment is ensured by well-coordinated work of highly qualified specialists: surgeon, prosthodontist, therapeutist and dental technician.

After the prosthodontics treatment, there is dynamical monitoring of the patients.

Immediate dental implantation is used in clinical situations when the gingival volume is saved, there is no atrophy of the alveolar bone, oral mucosa isn't thinned. There are no clinical signs of the pathological process in the periapical zone of the removed tooth.

Method of a single-stage implantation is used under the same conditions, if the patient wishes to conduct all the manipulations per one visit.

Usage of individually selected hygiene products by patients with intraosseous implants is an indispensable clause to keep in a good hygienic status oral cavity and preventing possible complications of the treatment.

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Features of Computed Tomography Assessment in Maxillofacial Surgery*

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ABSTRACT

Summary.
Purpose of the article is to present the anatomy of the facial skeleton of healthy people at images of multislice computed tomography (MSCT) [1]. The analysis of multislice computed tomography scans were used upon the investigation. Based on the results of multislice computed tomograms a normal anatomy of the facial bones presented. Using the multislice computer tomography makes possible to effectively diagnose degenerative, inflammatory and neoplastic processes of the facial bones.

Introduction

The implementation of multislice computed tomography (*synonym*: multidetector computed tomography) [1] into oral and maxillofacial surgery and head and neck surgery is a major achievement of modern medicine and, first of all, maxillofacial and head and neck radiology [2, 3]. The emergence of this method of investigation is the result of a modern scientific and technological revolution. Computed tomography is a fundamentally new, noninvasive diagnostic method that allows one to visualize the relationship of individual organs and tissues in normal and under different pathological conditions, based on the use of the principle of mathematical modeling of an X-ray image, followed by construction using a computer, according to the data obtained, images of horizontal "slices" of parts of the human body on the display screen. This type of research has opened up broad prospects for diagnosis. Currently, it is increasingly being used in diseases of the maxillofacial region and neck [4, 5].

The first official report on the use of a new type of radiographic study, called transaxial computed tomography, was made by Hounsfield and Ambrose in April 19, 1972 at the annual congress of the British Institute of Radiology. In the same year, the first publication of the authors on this method of research appeared. The highest recognition of the value of a fundamentally new type of survey for all of humanity is the award in 1979 of the Nobel Prize for Physiology or Medicine English electrical engineer Godfrey Hounsfield (Great Britain) and American physicist Allan Mcleod Cormack (USA) for the introduction of computed tomography in medical practice. Diagnosis using a computed tomography is based on the detection of direct radiologic symptoms, i.e. the localization, shape and size of the pathological focus is determined. Indirect signs, caused by the germination of the tumor in the surrounding soft tissues, lymph nodes, large vessels also have significance.

Advantages of computed tomography are its harmlessness, safety, the speed of obtaining information, the absence of contraindications, the availability of use not only in a hospital environment, but also upon examination of a patient in small private clinics.

In our opinion, CT scan in patients with osteomyelitis and posttraumatic changes of facial bones, diseases of the maxillary sinuses, tumors and tumor-like formations of the maxillofacial region and neck, as well as many other diseases of the face and neck is a prerequisite for establishing an accurate diagnosis and implementation of the correct treatment [6-10]. Also, using the digital imaging and communications in medicine (DICOM) images of the CT scans and loading them into special software helps became routine practice in the 3D planning

* This manuscript has not been presented

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of the surgeries and 3D printing [12-14]. Ignoring this method of research in a complex examination of patients can be considered a medical error [15-23].

Discussion

In this article, we will present the multislice CT scans of the facial skeleton of healthy persons.

In order to make it easier for us to understand the anatomy of the bones of the facial skeleton in CT images, we recall the clinical anatomy of these bones, and then we will compare them with the images that we obtained on spiral computer tomograms.

The mandible (lower jaw) (Figs 1 and 2), is an unpaired and movable bone of the skull, has a horseshoe shape and develops from the 1st branchial arch.

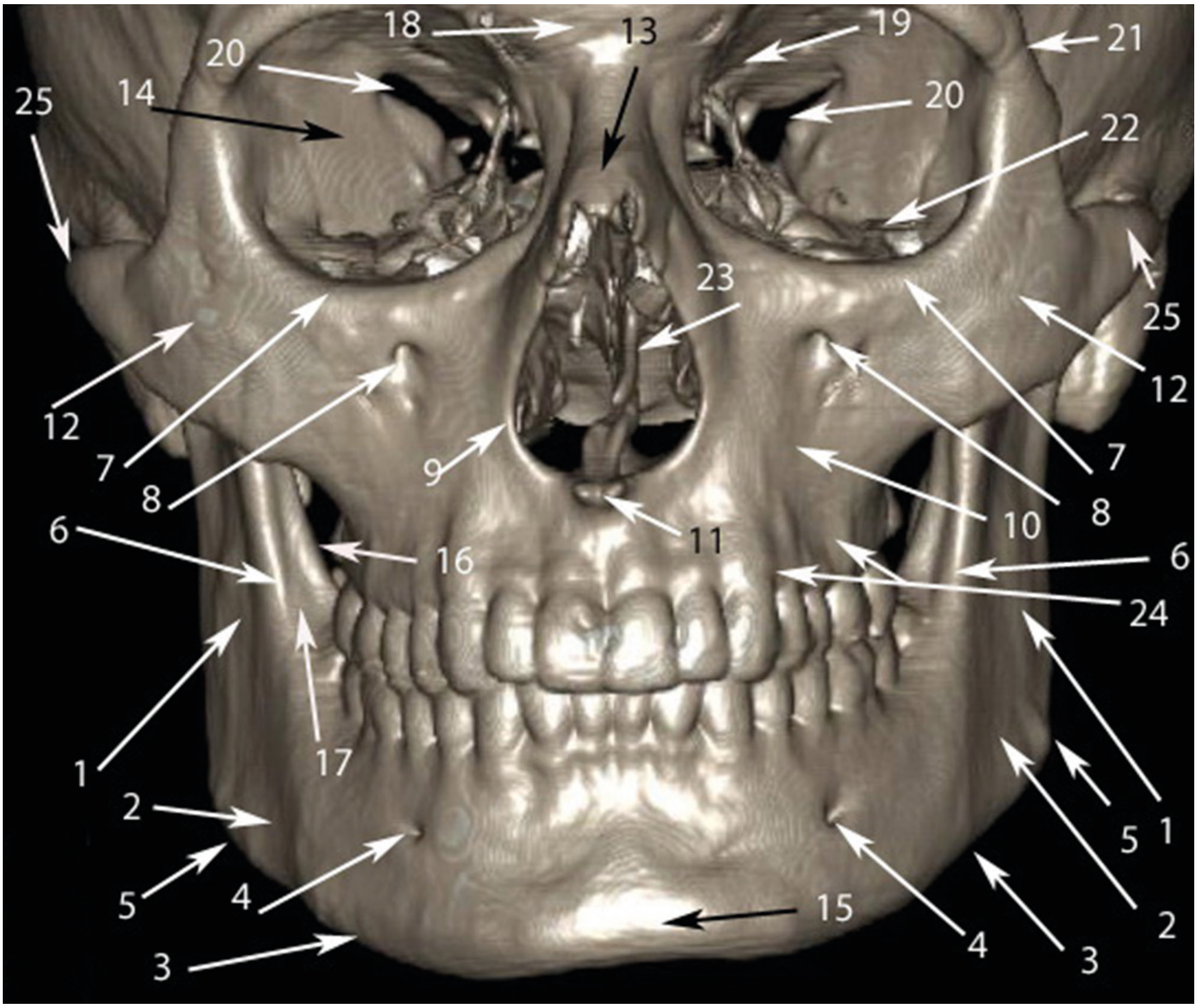

FIGURE 1. Facial bones on the 3D scan (frontal view) of multislice computed tomography. *Numbers* with *arrows* denote the following anatomical structures: 1 – mandibular ramus; 2 – masseteric tuberosity; 3 – the body of the mandible; 4 – mental foramen; 5 – angulus mandibulae; 6 – linea obliqua externa; 7 – infraorbital rim; 8 – infraorbital foramen; 9 – nasal aperture; 10 – canine fossa; 11 – anterior nasal spine; 12 – zygomatic bone; 13 – nasal bone; 14 – orbit; 15 – mental spine; 16 – internal blique line; 18 – glabella (an anatomical landmark on the frontal bone); 19 – optic canal; 20 – superior orbital fissure; 21 – zigomaticofrontal suture; 22 – inferior orbital fissure; 23 – nasal septum; 24 – juga alveolaria elevations of the alveolar processes; 25 – zygomatic arch.

In the mandible distinguish the horizontal part or body, corpus mandibulae and branch, ramus of the mandible. These two parts converge at an angle, angulus mandibulae. The mandibular body consists of the upper part, pars alveolaris, and the base of the lower jaw, the basis mandibulae. In the upper part there are dental alveoli, alveoli dentales with septa alveolaria. Dental alveoli on the external surface of the lower jaw correspond to the alveolar elevations, juga alveolaria. In the anterior part of the body there is a thickening – the chin elevation, protuberantia mentalis, and at the level of the projection of the roots between the first and second small molars is the chin aperture, foramen mentale – the exit of the mandibular nerve of canalis mandibulae. A little below the chin aperture begins the external oblique line, linea obliqua externa. She goes up and back, gradually moving to the front edge of the branch of the jaw. Behind the oblique line, the outer surface of the lower jaw is smooth, but closer to its corner, chewing tuberosity is noticeable, tuberositas masseterica is the place of attachment of the actual chewing muscle. The inner surface of the body of the lower jaw is smoother. On the middle line there are two protruding bone spines (the spine can be bifurcated) – the chin spines, spina mentalis – the sites of the tendon attachment m. Genioglossi. On the sides of the spina mentalis, oval-shaped flat pits are noted, fossae digastricae are the places of attachment of the digastric muscle. Above and lateral from them are still visible fovea, fovea sublingualis – the place of abutment of the hyoid gland. Between the two pits, a convex line of attachment of the

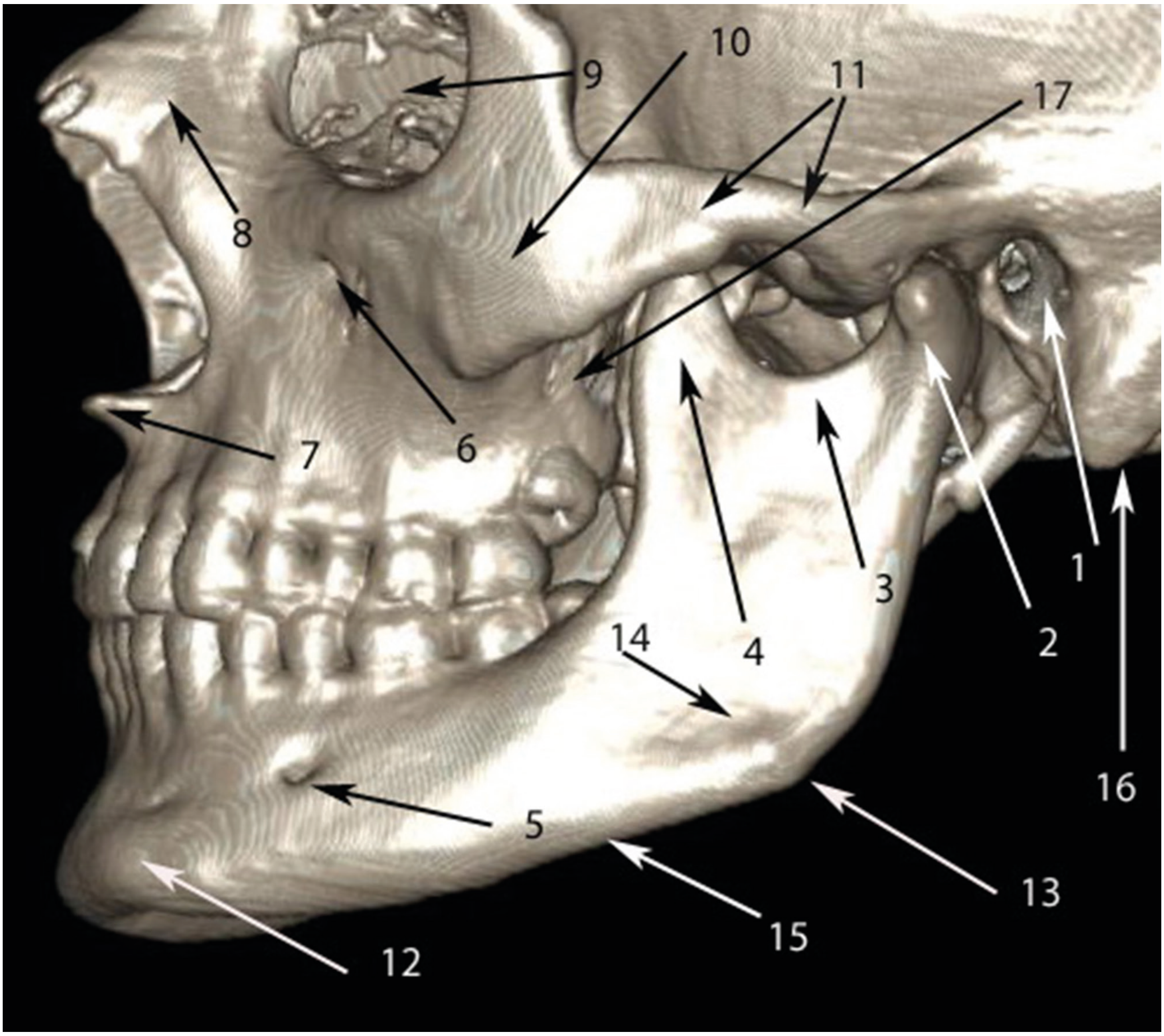

FIGURE 2. Facial bones on the 3D scan (lateral view) of multislice computed tomography. *Number*s with *arrows* denote the following anatomical structures: 1 – external auditory meatus; 2 – processus condylaris; 3 – incisura mandibulae; 4 – processus coronoideus; 5 – mental foramen; 6 – infraorbital foramen; 7 – anterior nasal spine; 8 – nasal bone; 9 – orbit; 10 – zygomatic bone; 11 – zygomatic arch (formed by the temporal process of the zygomatic bone and the zygomatic process of the temporal bone); 12 – mental spine; 13 – angle of mandible; 14 – masseteric tuberosity; 15 – left mandibular body; 16 – mastoid process; 17 – maxillary tuberosity.

maxillo-hyoid muscle begins, linea mylohyoidea. This line goes to the branch of the lower jaw and Y – figuratively diverges into the bony ridges, which are sent to the coronary and condylar processes. The outer cushion of the jaw is called linea obliqua externa, and the inner jaw is linea obliqua interna. Somewhat higher and in front of the osseous tongue of the jaw, at the point of convergence of the two bony cords (coming from the coronary and condylar processes) there is a flattened bony elevation – torus mandibulae.

The jaw branch, ramus mandibulae, on the inner surface has a hole, foramen mandibulae leading to the mandibular canal (canalis mandibulae). The inner edge of the hole acts as a tongue - lingula mandibulae, where lig. sphenomandibulare is attached. The branch of the jaw has two processes: processus coronoideus (coronoid process) and processus condylaris (muscular process). Between the two processes there is a tenderloin, incisura mandibulae. The condylar process has a caput mandibulae and a collum mandibulae; in front on the neck is a fovea, fovea pterygoidea (attachment site of m.pterygoideus lateralis).

The maxilla (upper jaw) is represented by two maxillary bones. The maxillary bone consists of a body and four processes (Figs 1 and 2). The body, corpus maxilla, contains a large maxillary sinus (sinus maxilla), which opens with a hole (hiatus maxillaris) into the nasal cavity in the middle nasal passage. The front surface (facies anterior) below passes into the alveolar process, where there are a number of elevations (juga alveolaria) corresponding to the position of the roots of the teeth. Above these elevations is the canine fossa (fossa canina).

The anterior surface of the maxillary is delimited from the orbit by the infraorbital margin (margo infraorbitalis), beneath which is the infraorbital foramen (foramen infraorbitalis). The medial border of the anterior surface is the nasal incision (incisura nasalis). The subfamily surface (facies infratemporalis) is separated from the anterior surface by the zygomatic process and carries a tuber maxilla and a large palatine fissure (sulcus palatinus major). The nasal surface (facies nasalis) below passes into the upper surface of the palatine process. On it there is a crest of the inferior nasal shell (crista conchalis).

Behind the frontal process is a tear sulcus (sulcus lacrimalis), which passes into the nasolacrimal canal (canalis nasolacrimalis), which communicates the lower nasal passage with the orbit. The hole leading to sinus maxillaris opens in the middle nasal passage. The facial surface (facies orbitalis) in the region of the posterior margin has an infraorbital furrow (sulcus infraorbitalis), which in front turns into canalis infraorbitalis opening on the anterior surface of the maxillary by a hole (foramen infraorbitale). Under this hole is the fossa canina.

Appendices of the maxillary are represented by: frontal – processus frontalis; Alveolar – processus alveolaris (its lower edge – arcus alveolaris has dental cells, alveoli dentalis, which are separated by septa, septa interalveolaria); Palatine – processus palatinus (forms the skeleton of the palate, palatum osseum, in the anterior part there is a incisive canal, canalis incisivus, as well as the incisive sutura, sutura incisiva, separating the incisal bone that has merged with the maxillary bone); zygomaticus – processus zigomaticus.

Zygomatic bone is a paired and strongest of facial bones. It has 3 surfaces and 2 processes. The lateral surface, facies lateralis has the form of a four-pointed star and slightly protrudes into a hillock. The glabrous surface, facies orbitalis, participates in the formation of the orbital walls. Facies temporalis (temporal surface) faces the temporal fossa. The frontal process, processus frontalis, connects with the zygomatic process of the frontal and large wing of the sphenoid bone. The temporal process connecting with the zygomatic process of the temporal bone forms a zygomatic arch.

Anatomical features of the bones of the facial skeleton in 3-D images are presented in Figures 1 and 2. The x-ray and facial bone bones in horizontal, frontal and sagittal sections in images of spiral CT are represented in Figures 3, 4 and 5.

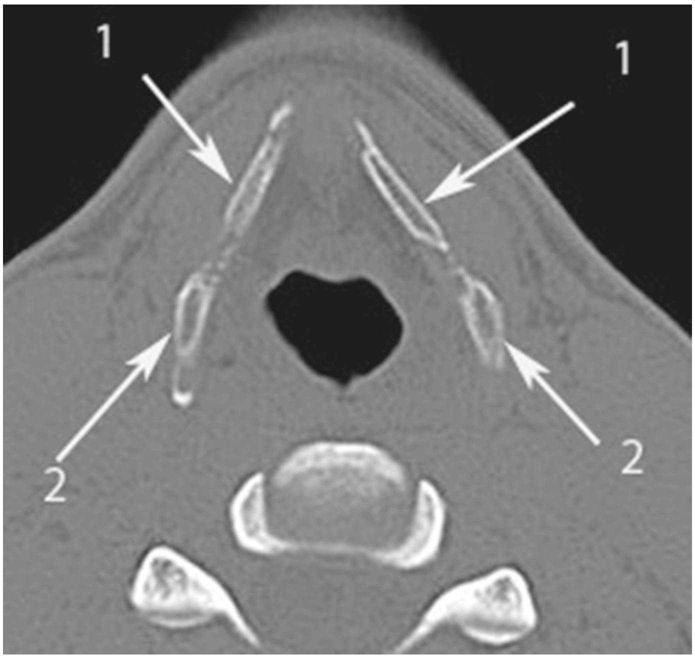

FIGURE 3. Axial CT scan at the level of hyoid bone. *Numbers* with *arrows* denote the following anatomical structures: 1 – the lateral borders of the greater horns of hyoid bone; 2 – the greater horns.

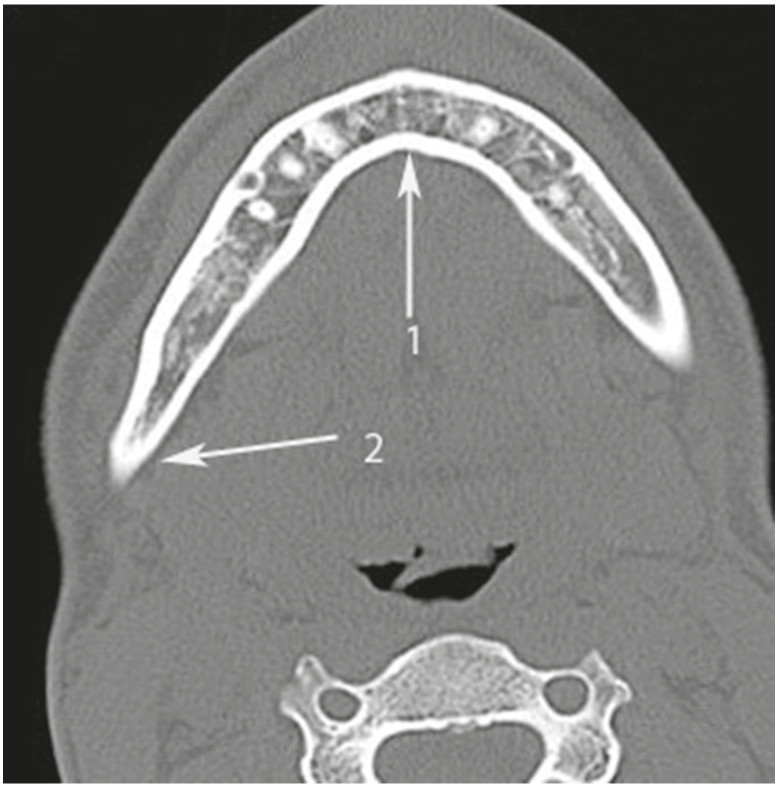

FIGURE 4. Axial CT scan at the level of the lower border of mandible. *Numbers* with *arrows* denote the following anatomical structures: 1 – the mandibular symphysis; 2 – the right mandibular ramus.

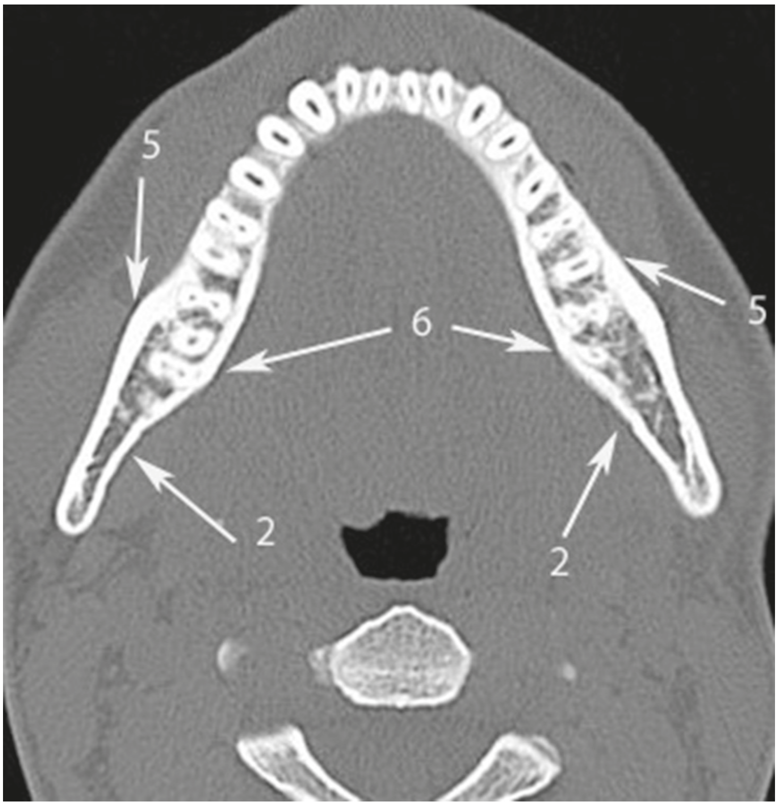

FIGURE 5. Axial CT scan at the level of the teeth at the mandible. *Numbers* with *arrows* denote the following anatomical structures: 2 – the right mandibular ramus; 5 – external oblique ridge (Latin: linea obliqua externa); 6 – mylohyoid line (Latin: linea mylohyoidea).

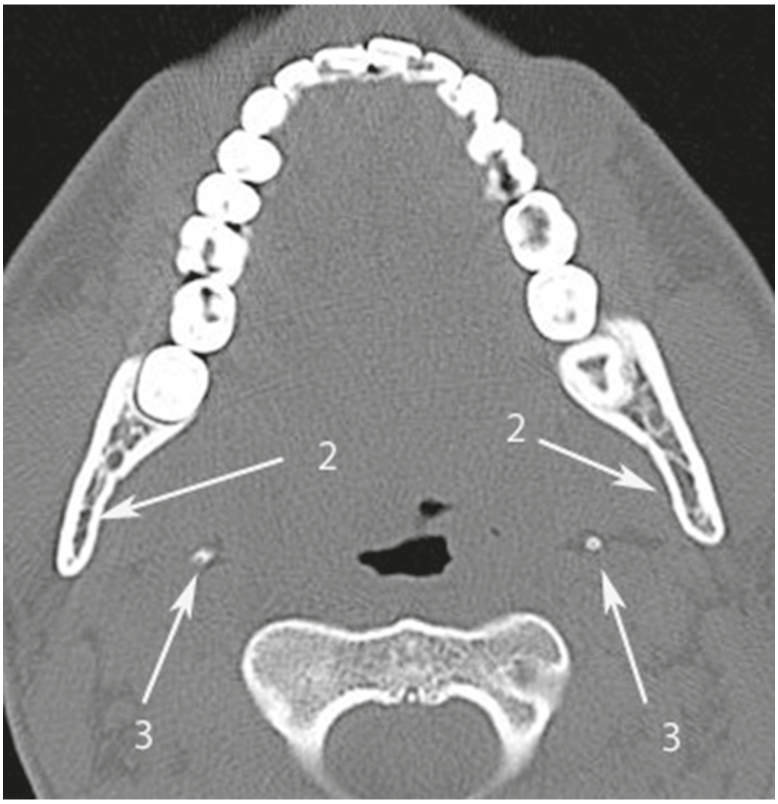

FIGURE 6. Axial CT scan at the level of the teeth crowns of the mandible. *Numbers* with *arrows* denote the following anatomical structures: 2 – inner surfaces of the mandibular rami; 3 – styloid processes of the temporal bones.

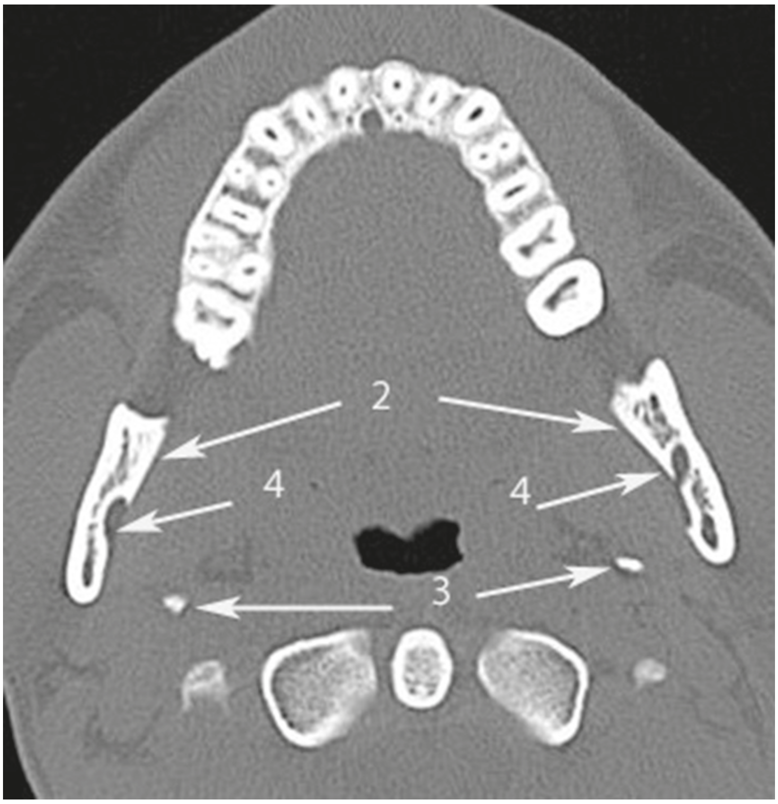

FIGURE 7. Axial CT scan at the level of the maxillary teeth. *Numbers* with *arrows* denote the following anatomical structures: 2 – inner surfaces of the mandibular rami; 3 – styloid processes of the temporal bones; 4 – mandibular foramen.

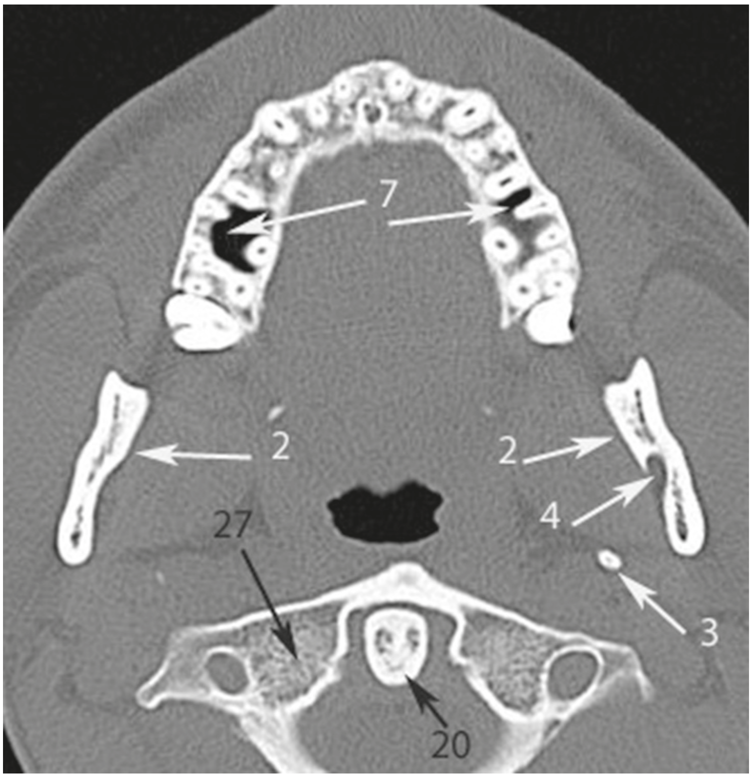

FIGURE 8. Axial CT scan at the level of inferior wall of the maxillary sinus. *Numbers* with *arrows* denote the following anatomical structures: 2 – inner surfaces of the mandibular rami; 3 – styloid processes of the temporal bones; 4 – mandibular foramen; 7 – the bottom of the maxillary sinus; 20 – odontoid process (dens) of the axis (is a second cervical vertebra (C2)); 27 – atlas (is a first cervical vertebra (C1)).

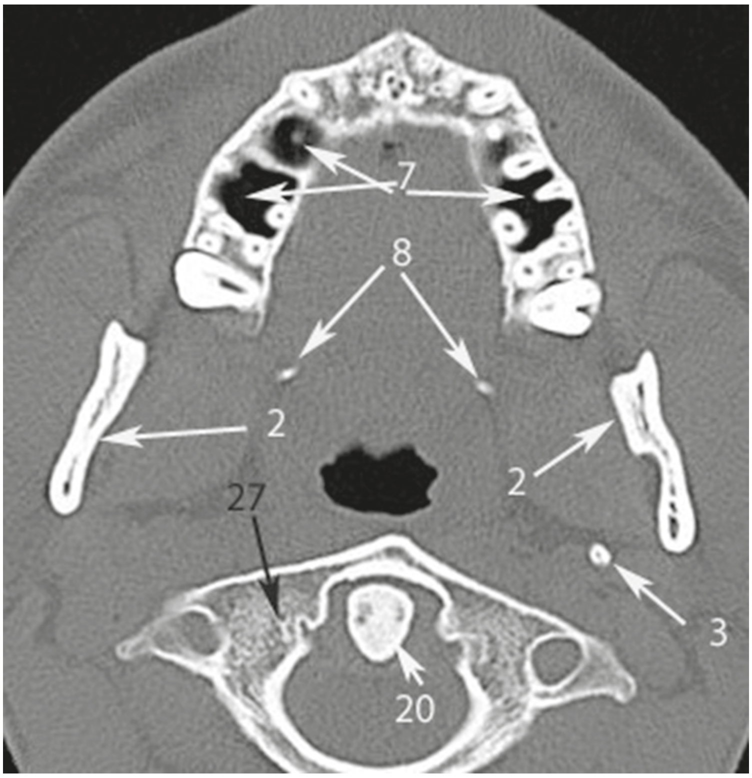

FIGURE 9. Axial CT scan at the lower third of the maxillary sinus. *Numbers* with *arrows* denote the following anatomical structures: 2 – inner surfaces of the mandibular rami; 3 – styloid process of the temporal bone; 7 – maxillary sinus; 8 – the pterygoid hamulus; 20 – odontoid process (dens) of the axis (is a second cervical vertebra (C2)); 27 – atlas (is a first cervical vertebra (C1)).

FIGURE 10. Axial CT scan at the middle third of the maxillary sinus. *Numbers* with *arrows* denote the following anatomical structures: 2 – inner surfaces of the mandibular rami; 3 – styloid process of the temporal bone; 9 – maxillary sinus; 10 – sphenoid; 11 – apices of the teeth roots located in the maxillary sinus; 17 – the hard palate; 20 – odontoid process (dens) of the axis (is a second cervical vertebra (C2));

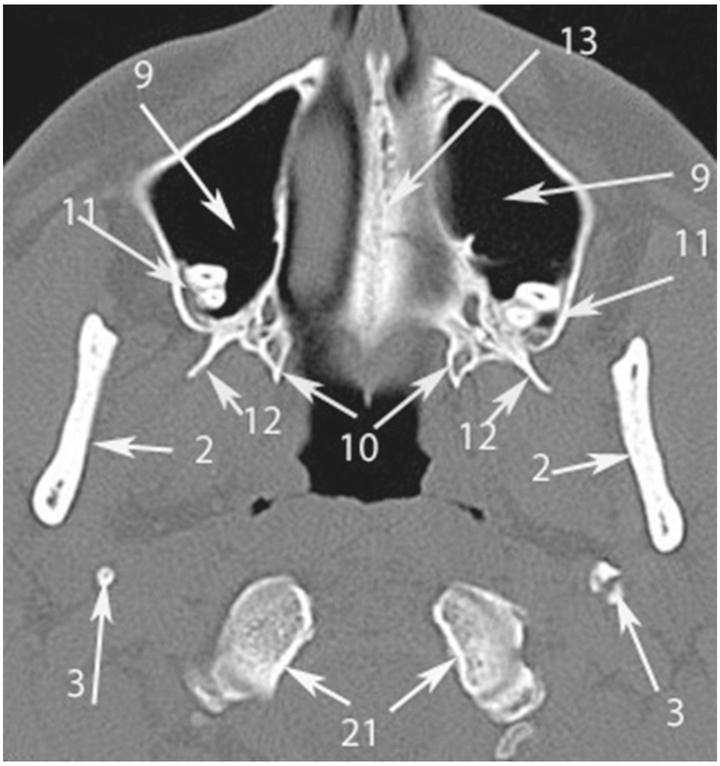

FIGURE 11. Axial CT scan at the middle third of the maxillary sinus. *Numbers* with *arrows* denote the following anatomical structures: 2 – inner surfaces of the mandibular rami; 3 – styloid process of the temporal bone; 9 – maxillary sinus; 10 – medial pterygoid plate of the sphenoid; 11 – apices of the teeth roots located in the maxillary sinus; 12 – lateral pterygoid plate of the sphenoid; 13 – nasal septum; 17 – the hard palate; 21 – cervical vertebrae.

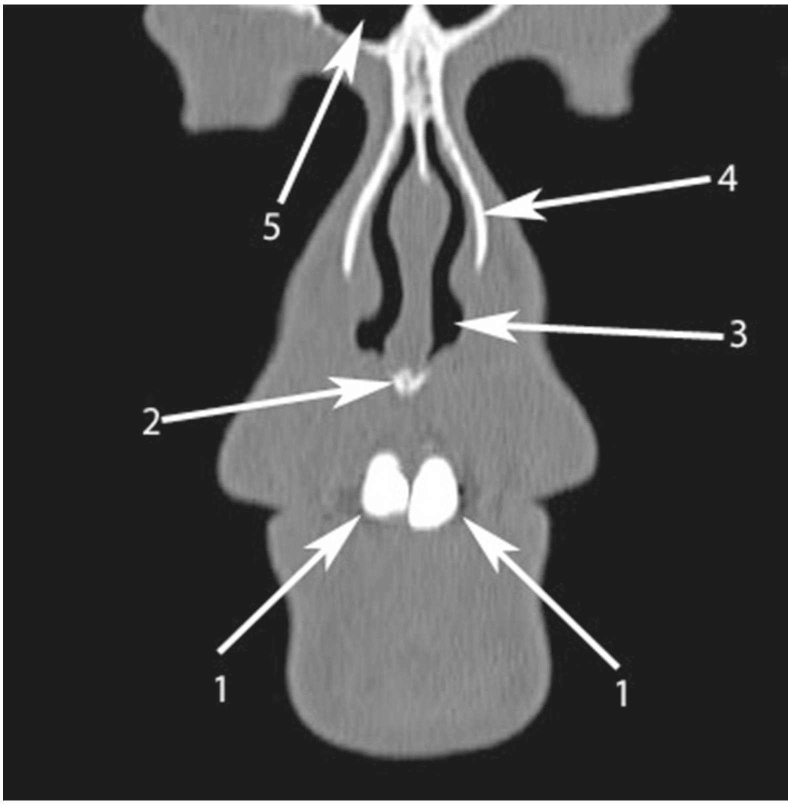

FIGURE 12. Coronal CT scan at the level of central incisors. *Numbers* with *arrows* denote the following anatomical structures: 1 – central incisors; 2 – anterior nasal spine; 3 – nasal cavity; 4 – frontal process of the maxillary bone; 5 – frontal sinus.

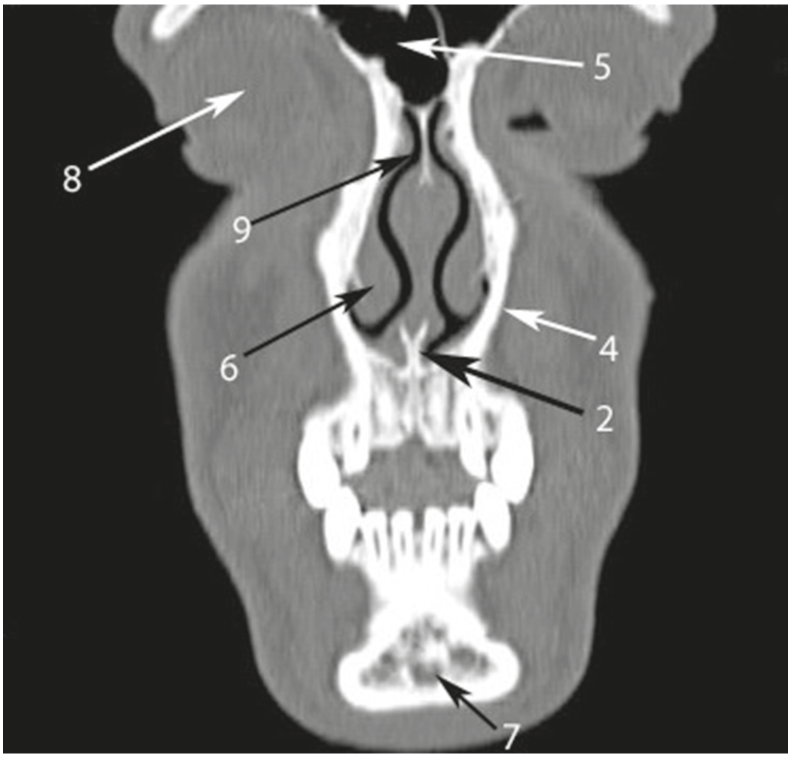

FIGURE 13. Coronal CT scan at the level of canines. *Numbers* with *arrows* denote the following anatomical structures: 2 – anterior nasal spine; 3 – nasal cavity; 4 – frontal process of the maxillary bone; 5 – frontal sinus; 6 – inferior nasal concha; 7 – mandibular symphysis; 8 – orbita; 9 – perpendicular plate of the ethmoid bone.

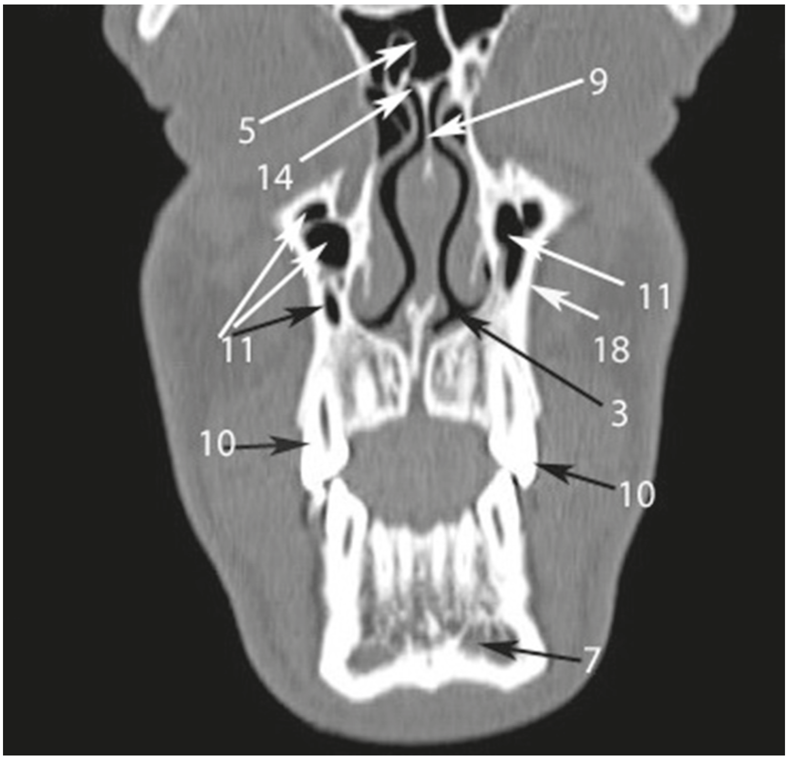

FIGURE 14. Coronal CT scan at the level of canines. *Numbers* with *arrows* denote the following anatomical structures: 3 – nasal cavity; 5 – frontal sinus; 7 – mandibular symphysis; 9 – perpendicular plate of the ethmoid bone; 10 – maxillary canines; 11 – maxillary sinus; 14 – nasal spine of the frontal bone; 18 – the outer cortical plate of the maxilla.

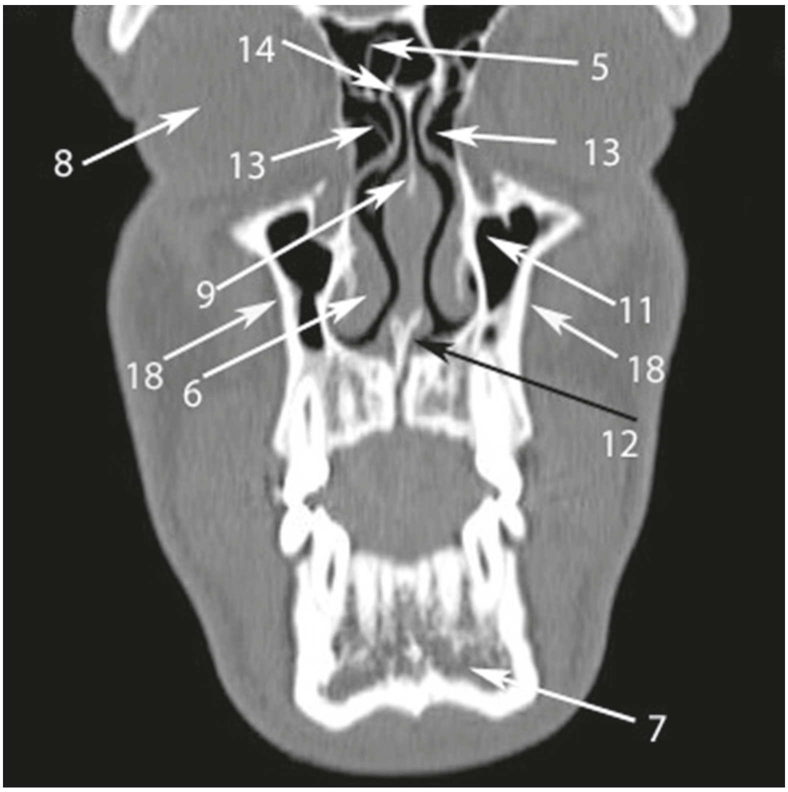

FIGURE 15. Another coronal CT scan at the level of canines. *Numbers* with *arrows* denote the following anatomical structures: 5 – frontal sinus; 6 – inferior nasal concha; 7 – left mandibular symphysis; 8 – orbit; 9 – perpendicular plate of the ethmoid bone; 10 – maxillary canines; 11 – maxillary sinus; 12 – vomer; 13 – ethmoidal air cells (Latin: cellulae ethmoidalis); 14 – nasal spine of the frontal bone; 18 – the outer cortical plate of the maxilla.

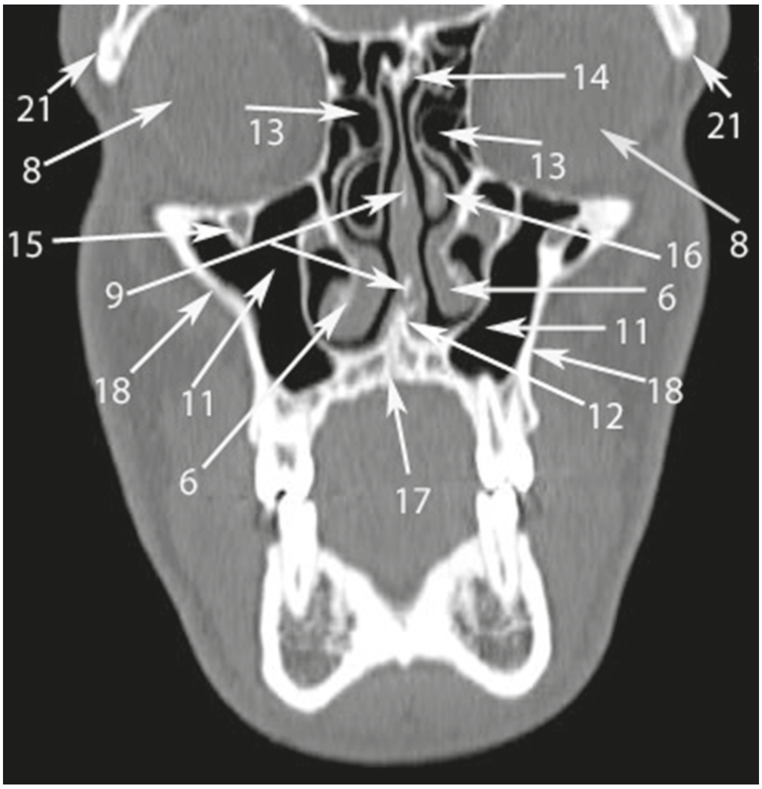

FIGURE 16. Coronal CT scan at the level of 1st premolars. *Numbers* with *arrows* denote the following anatomical structures: 6 – inferior nasal concha; 8 – orbit; 9 – perpendicular plate of the ethmoid bone; 11 – maxillary sinus; 12 – vomer; 13 – ethmoidal air cells (Latin: cellulae ethmoidalis); 14 – nasal spine of the frontal bone; 15 – infraorbital canal; 16 – middle nasal concha; 17 – hard palate (palatine process of the maxilla); 18 – the outer cortical plate of the maxilla; 21 – zygomatic process of the frontal bone.

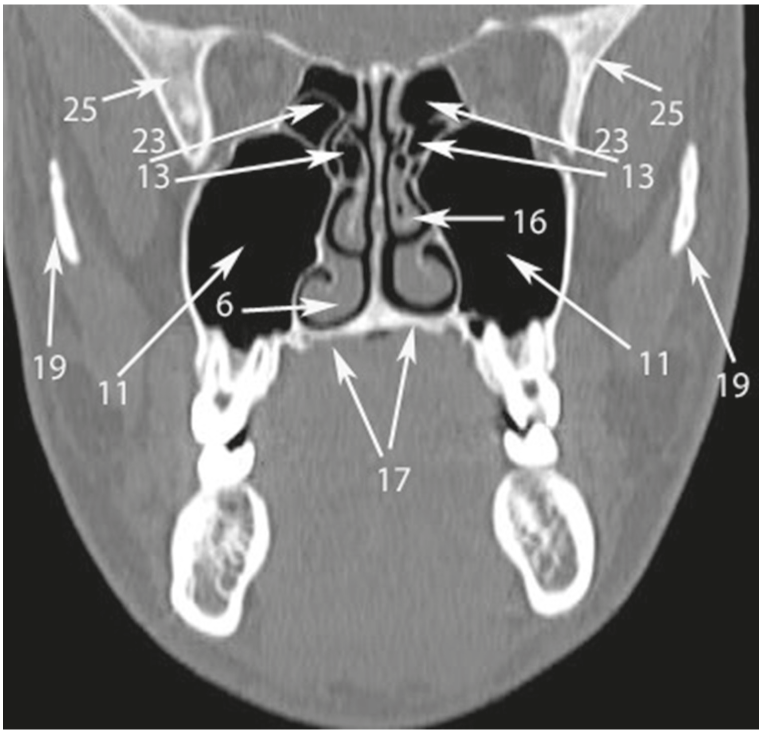

FIGURE 17. Coronal CT scan at the level of 1st molars. *Numbers* with *arrows* denote the following anatomical structures: 6 – inferior nasal concha; 11 – maxillary sinus; 13 – ethmoidal air cells (Latin: cellulae ethmoidalis); 16 – middle nasal concha; 17 – hard palate (palatine process of the maxilla); 19 – zygomatic bone; 21 – zygomatic process of the frontal bone; 23 – sphenoid sinus; 25 – greater wing of the sphenoid bone.

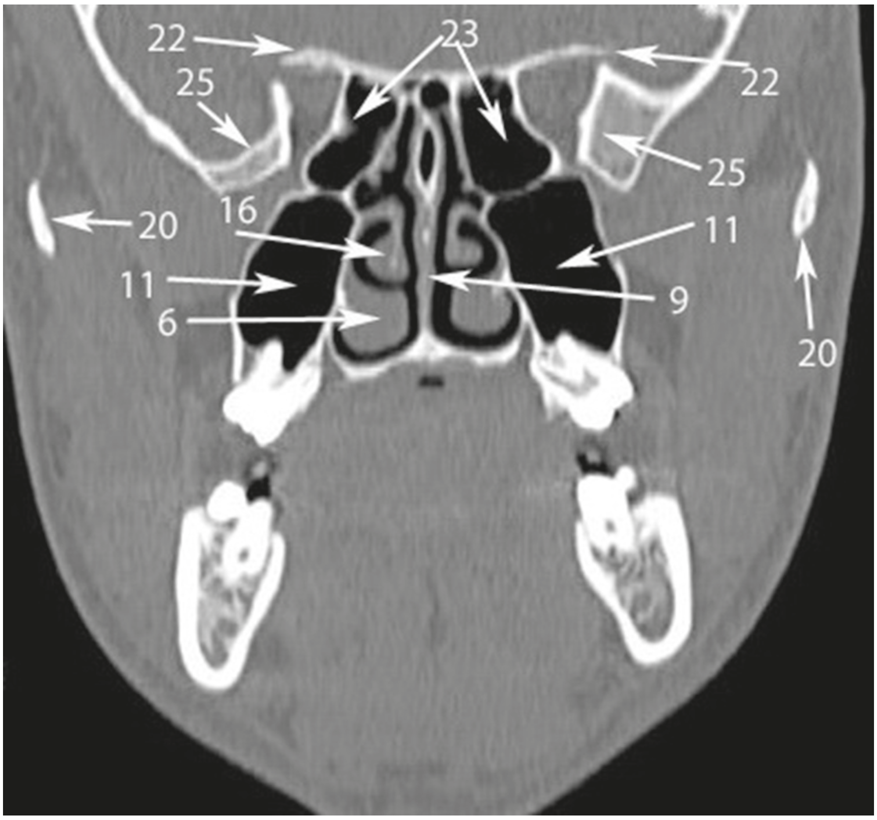

FIGURE 18. Coronal CT scan at the level of 2nd molars. *Numbers* with *arrows* denote the following anatomical structures: 6 – inferior nasal concha; 9 – perpendicular plate of the ethmoid bone; 11 – maxillary sinus; 16 – middle nasal concha; 20 – temporal process of the zygomatic bone (forms a zygomatic arch together with the zygomatic process of the temporal bone); 23 – sphenoid sinus; 22 – lesser wings of the sphenoid bone; 23 – sphenoid sinus; 25 – greater wing of the sphenoid bone.

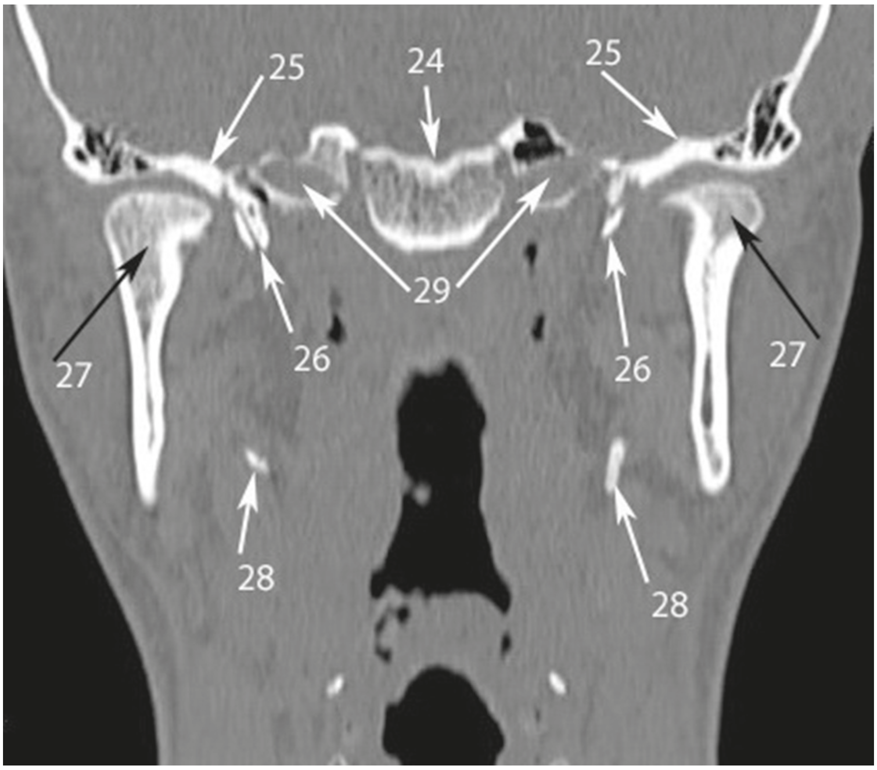

FIGURE 19. Coronal CT scan at the level of condylar processes. *Numbers* with *arrows* denote the following anatomical structures: 24 – basilar part of the occipital bone; 25 – greater wing of the sphenoid bone; 26 – pterygoid process of the sphenoid bone; 27 – condylar process of the mandible; 28 – styloid process of the temporal bone; 29 – carotid canal of temporal bone.

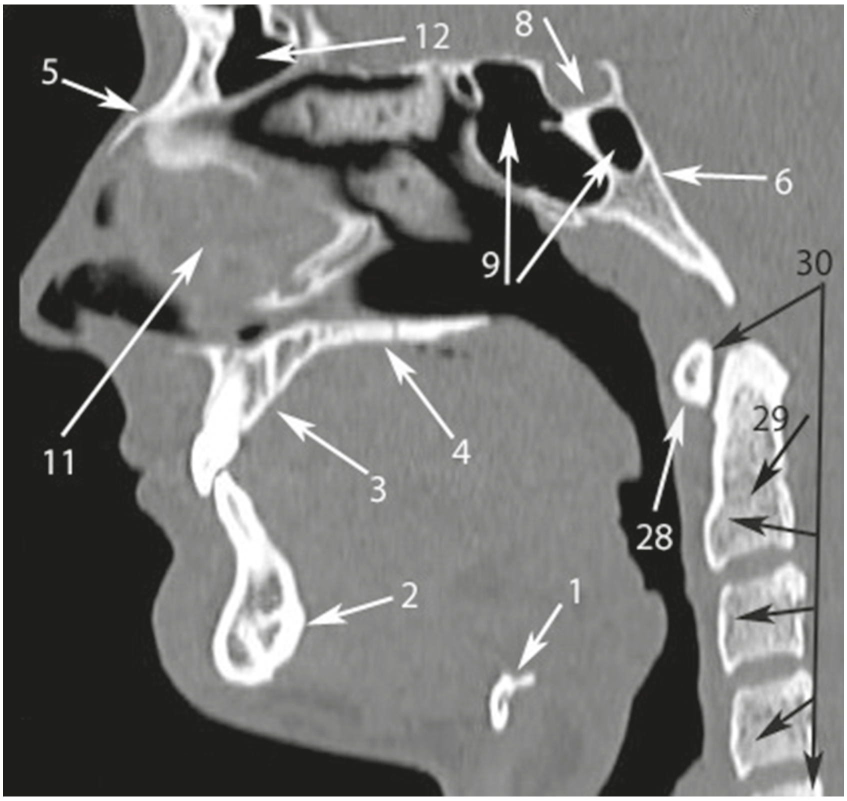

FIGURE 20. Sagittal CT scan at the level of central incisors. *Numbers* with *arrows* denote the following anatomical structures: 1 – hyoid bone; 2 – mandible; 3 – maxilla; 4 – hard palate; 5 – nasal bones; 6 – sphenoid bone; 8 – sella turcica (hypophyseal fossa of sphenoid bone); 9 – sphenoid sinus; 11 – nasal septum; 12 – frontal sinus; 28 – atlas (is a first cervical vertebra, C1); 29 – axis (is a second cervical vertebra (C2)); 30 – cervical vertebrae.

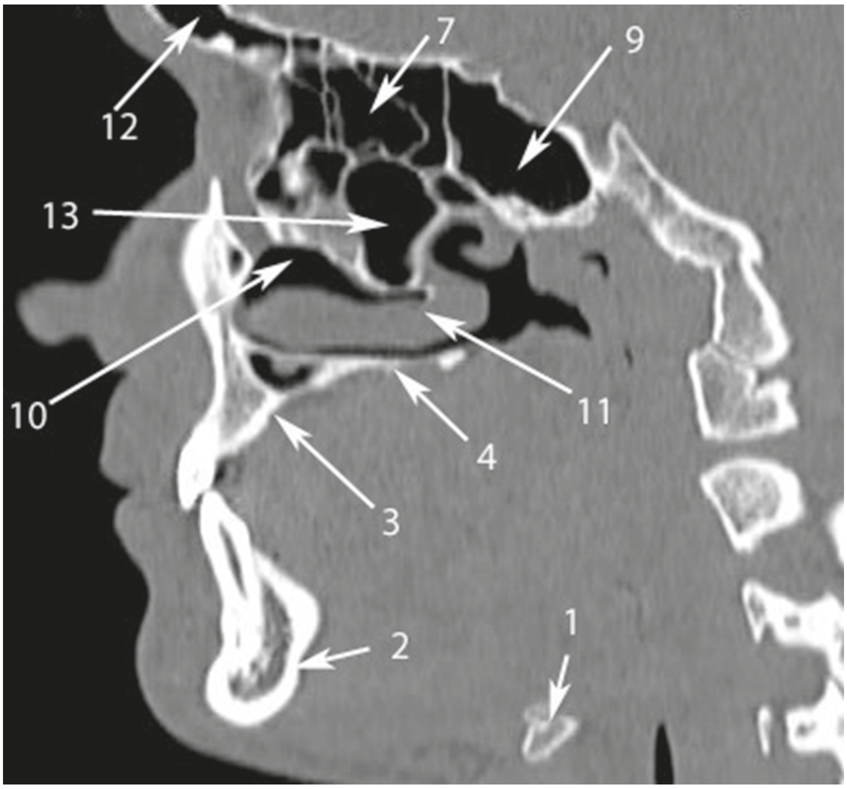

FIGURE 21. Sagittal CT scan at the level of canines. *Numbers* with *arrows* denote the following anatomical structures: 1 – hyoid bone; 2 – mandible; 3 – maxilla; 4 – hard palate; 7 – cells of the ethmoid sinus; 9 – sphenoid sinus; 10 – nasal cavity; 11 – nasal septum; 12 – frontal sinus; 13 – maxillary sinus.

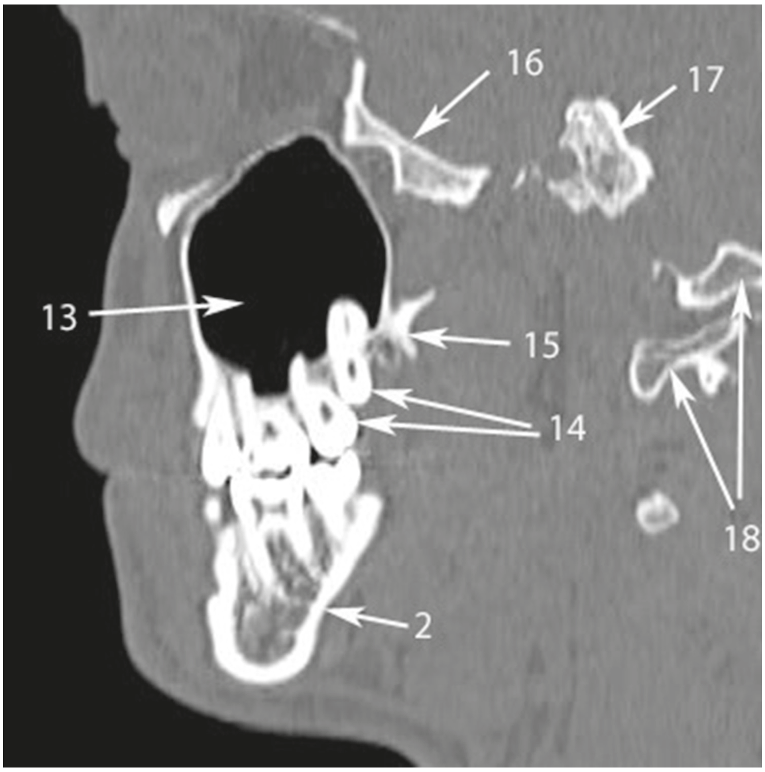

FIGURE 22. Sagittal CT scan at the level of maxillary molars. *Numbers* with *arrows* denote the following anatomical structures: 2 – mandible; 13 – maxillary sinus; 14 – upper molars; 15 – pterygoid process; 16 – sphenoid bone; 17 – occipital bone; 18 – cervical vertebrae.

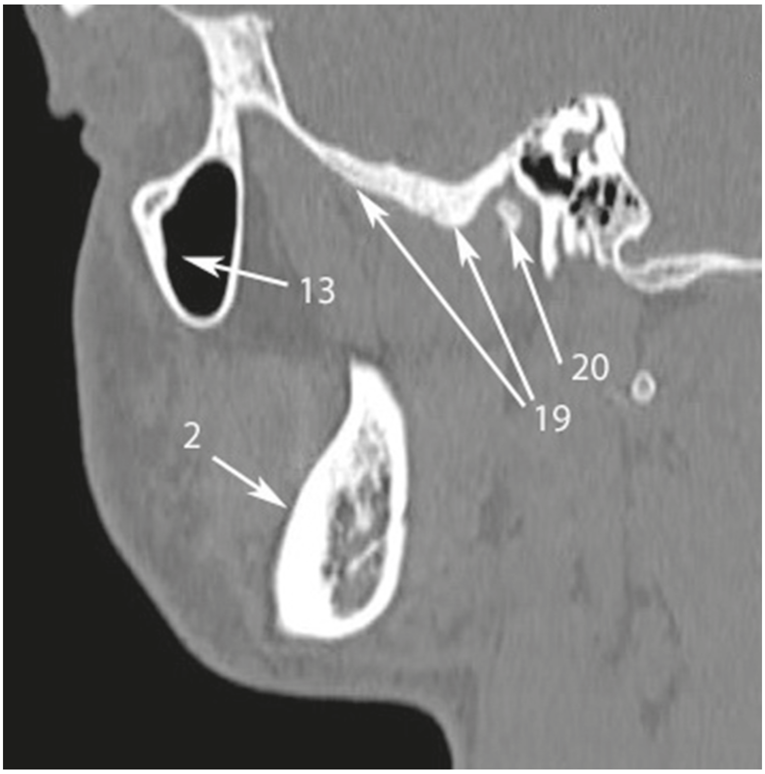

FIGURE 23. Sagittal CT scan at the level of angle of the madible. *Numbers* with *arrows* denote the following anatomical structures: 2 – mandible; 13 – maxillary sinus; 19 – greater wing of the sphenoid bone; 20 – mandibular condyle.

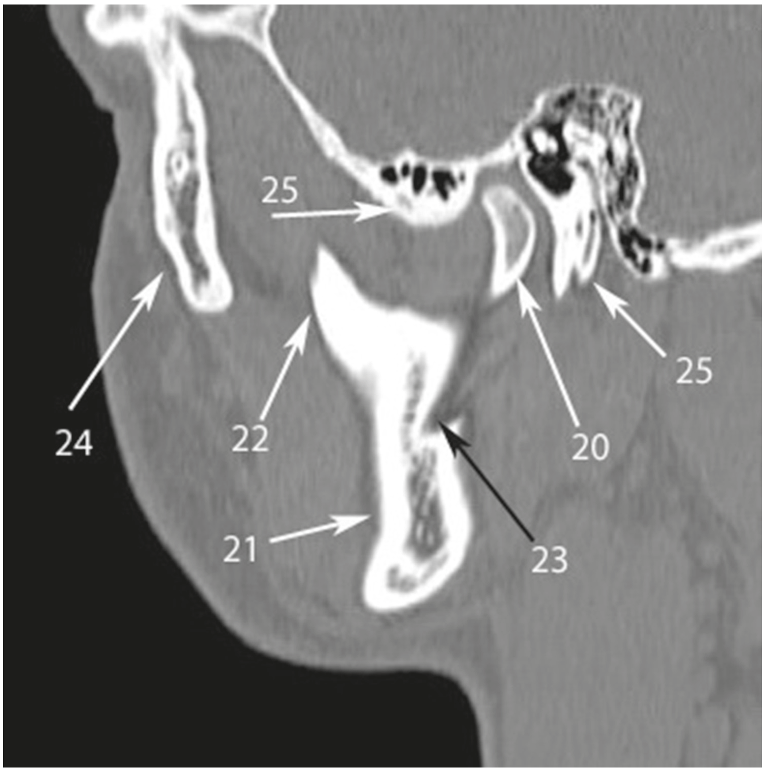

FIGURE 24. Sagittal CT scan at the level of mandibular foramen. *Numbers* with *arrows* denote the following anatomical structures: 20 – mandibular condyle; 21 – ramus of the mandible; 22 – coronoid process; 23 – the beginning of the mandibular canal (near the mandibular foramen); 24 – zygomatic bone; 25 – temporal bone.

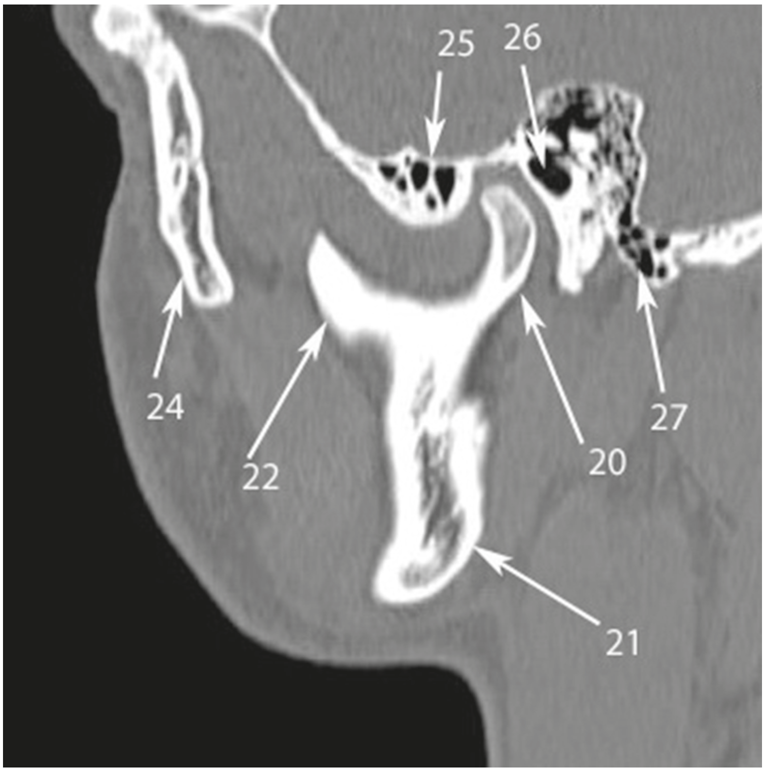

FIGURE 25. Sagittal CT scan at the level of mandibular ramus. Numbers with arrows denote the following anatomical structures: 20 – mandibular condyle; 21 – ramus of the mandible; 22 – coronoid process; 23 – the beginning of the mandibular canal (near the mandibular foramen); 24 – zygomatic bone; 25 – temporal bone.

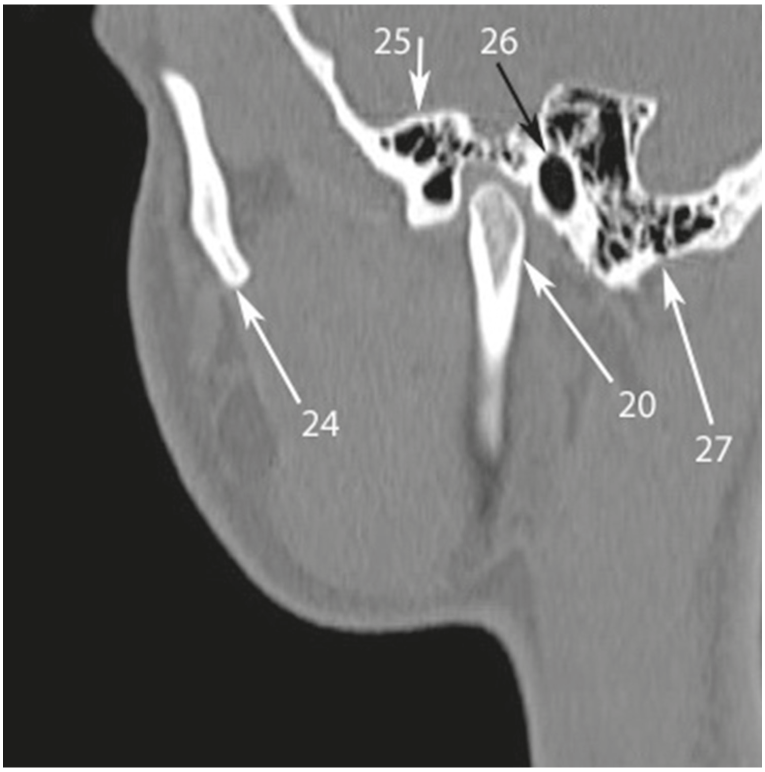

FIGURE 26. Sagittal CT scan at the level of mandibular condyle. *Numbers* with *arrows* denote the following anatomical structures: 20 – mandibular condyle; 24 – zygomatic bone; 25 – temporal bone; 26 – external auditory canal; 27 – cells of the mastoid process of the temporal bone.

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Role of Authors

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