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Determining the Causes for Loss of Teeth by Using Preoperative Dental CT Study for the Needs of Dental Implantology

Vladimir Nikolov[1], Teodora Nikolova[2]

[1]Department of Diagnostic Imaging - Military Medical Academy, Sofia
[2]Department of Pediatric Dentistry - Medical University, Varna

Abstract: ***The rapid development of dental implantology in recent years made the use of Dental CT preoperative study a common practice. An important part of the preoperative study is to identify the actual cause for loss of teeth. Inflammatory diseases require thorough rehabilitation prior to surgical procedures for bone augmentation and subsequent implantation. Systemic diseases leading to loss of teeth require systemic treatment. The presence of some of them is contradictory for implants` placement. After analyzing preoperative Dental CT scans of 292 jaws in our retrospective study, we found that in 44% of the cases the cause for tooth loss was apical periodontitis, in 43% - marginal periodontitis or inflammatory processes starting from marginal periodontium, and in the remaining 13 % the cause was one of the listed below: hypodontia, trauma, tumor formation, cyst, fibrous dysplasia or bone leontiasis.***

Keywords: Dental CT, dental implants, causes for tooth loss, jaw tumors, jaw cysts

1. Introduction

Diseases that lead to loss of teeth often result in changes into the residual bone that may directly affect the process of osteointegration of endosteal implants. Their establishment is important for making the most reasonable clinical decisions during treatment and thereby achieving successful implant placement.

Inflammatory Diseases

Many patients, who await placement of dental implants, have lost their tooth/teeth due to some dental infection or its complications. Inflammatory processes, affecting the periapical periodontal space, are classified as different types of periodontitis. In later phases of periapical periodontitis there is bone resorption present, clearly visible after Dental CT examination. The microorganisms do not lead to loss of teeth and atrophy of the alveolar bone by themselves alone. The actual reasons for this are the impaired circulation and venous stasis in the affected region, caused by edematous reactions of the soft tissues usually accompanying inflammation. [2, 7, 9]. On axial Dental CT sections, bone resorption, caused by inflammatory periodontal disease, may have the image of a target, with the radiopaque tip of the root, placed in the center of an osteolytic zone (fig.1, b, c). [5]

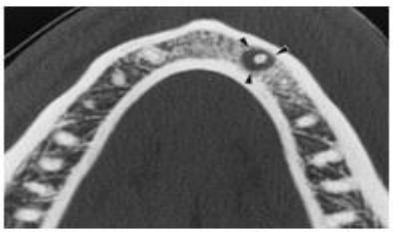


Figure 1 (a): An axial cut at the root level of the left lower canine. We can observe the image of a target, due to the thick radiopaque root in the radiolucent osteolytic zone [5]

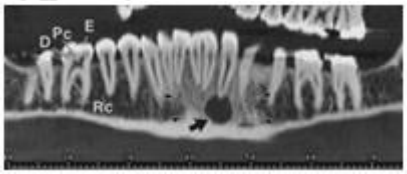


Figure 1 (b): Panoramic reconstruction of the lower jaw of the same patient - reactive osteosclerosis (condensing osteitis) surrounding the osteolytic zone. Dentin - D, enamel - E, radiolucent pulp chamber - Pc and root canals - Rc. [5]

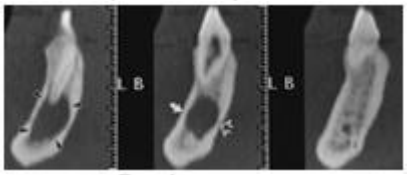


Figure 1 © : Para-axial reconstructions at the same level. Communication of the osteolytic zone with the vestibular (dense arrow) and the lingual (opened translucent arrow) cortical bone of the lower jaw. An additional vascular channel is being present in the frontal region of the lower jaw body [5]

Smaller lesions can occur looking like C-shaped osteolytic zones, covering the root apex **(Fig. 2, 3).** Marginal periodontitis is radiographically manifested by widening of the periodontal spacec lose to the alveolar ridge. It is always combined with periapical changes **(Figure 3).**

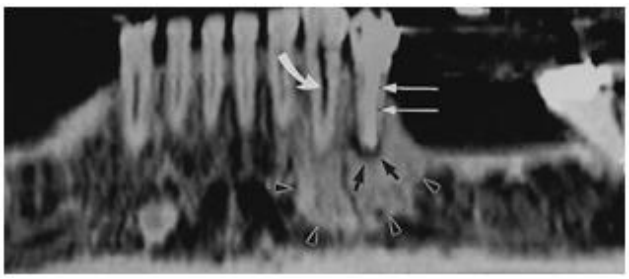


Figure 2: Panoramic reconstruction, obtained by Dental CT. The patient is 52-year-old male with a small periapical

lesion (black arrows), surrounded by a zone of condensing osteitis (arrowheads). There is a radiopaque strip of canal filling material present, compared to the normal radiolucent image of root canals of adjacent teeth (white curved arrow). [5]

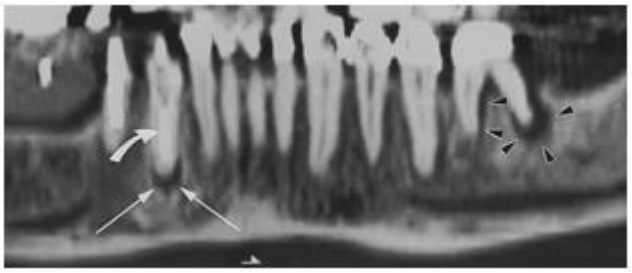


Figure 3: Panoramic reconstruction of lower jaw, obtained by Dental CT, showing advanced marginal (arrow heads) and periapical (straight white arrows) periodontitis. [5]

The portion of bone adjacent to inflammation often reacts to it with osteosclerotic changes, called condensing osteitis **(Fig.1b, 2).** Differential diagnosis between condensing osteitis and osteoblastic bone lesions must be made due to theircommon osteosclerotic appearance. [2]

During preoperative Dental CT studies it was found that patients with dental infections suffered maxillary sinuses complications twice as frequent. [3] A specific accumulation of inflamed soft tissue can be observed right over the root apex of the infected tooth. Axial sections of these areas resemble polyps or retention cysts, but by using Dental CT they can be differentiated and connected with the infected tooth **(Figure 4).**

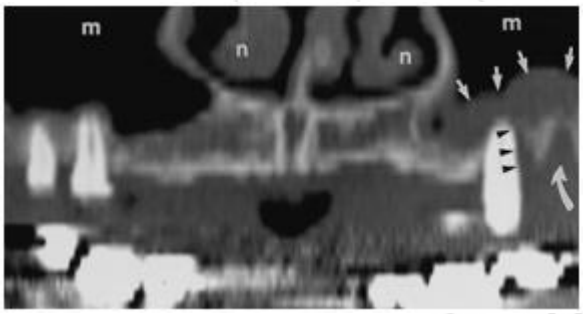


Figure 4: Dental CT panoramic reconstruction, which reveals significant accumulations of inflamed mucosa (small white arrows), centered around the root`s apex of the tooth, suffering apical and marginal periodontal changes. Bone resorption caused by the infection (arrow heads) and an empty post-extraction alveolar socket (curved arrow).M - maxillary sinuses, n - lower nasal conchae. [3]

The images of jaw fractures, obtained by Dental CT, are superior to conventional radiography for the extremely accurate information, concerning location of the fragments, their dislocation and the course of the fracture lines. This is of particular importance for proper diagnostics of vertical root fractures of teeth. [10]

2. Tumor Formations and Cysts

Dental CT is extremely useful for jaw tumor formations and cysts diagnostics, diagnostics of soft tissues of oral cavity floor, epipharynx and pterygoidal pit. It is of particular importance for detecting possible cortical bone defects or communication with the mandibular canal due to the main disease. [6]

Benign tumors and cysts are hardly differentiated from malignant tumor formations using conventional X-ray examination. By using Dental CT we can observe three-dimensional images of the jaws, without strip-like artefacts that can affect the bone image value. This gives the opportunity to obtain information about the state of the cortical jawbone, dimensions and invasion of the lesion into adjacent structures.

Slowly growing benign tumors often widen the bone and make the cortical jawbone thinner, while rapidly growing malignant lesions usually cause unevenly defined, but with sharp borders, bone defects, which destroy the cortical jawbone, without making it thinner. These changes are easily identified by using Dental CT. [5, 8]. On **Figure 5 (a, b, c)** we observe benign mineralized odontogenic cyst with expansion of bone present, thinning of the cortical bone and displacement of the mandibular canal in caudal direction. Establishing the exact borders of cortical bone, identifying involved teeth and establishing the position of the mandibular canal is crucial for proper surgical planning**.** [4]

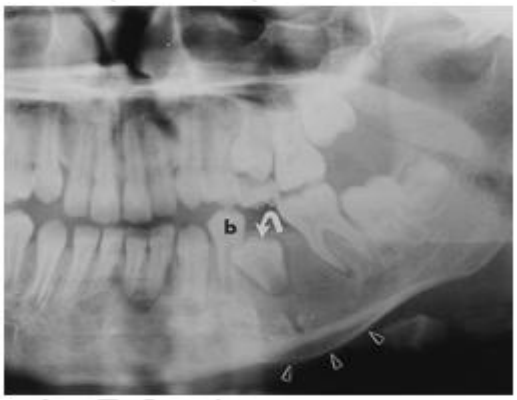


Figure 5: Calcified follicular cyst imaging

(a) Orthopanthomogram of double-contoured cortex (arrowheads) due to bone enlargement. It is impossible to determine whether lingual or buccal cortical bone had been altered. The boundaries of the lesion cannot be well-defined too. The vascular bundle is not visible. Overlaying of the ectopic tooth (arrow) makes it difficult to determine whether there is resorption of the first left premolar present (b). [4]

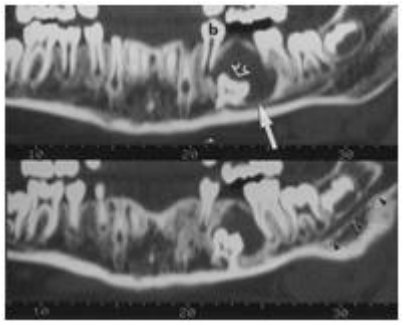


Figure 5(b): Panoramic reconstruction, obtained by Dental CT, allows better representation of the lesion (dense arrow),

the ectopic tooth (open arrow), the mandibular canal (arrowheads), (b) the first left premolar.

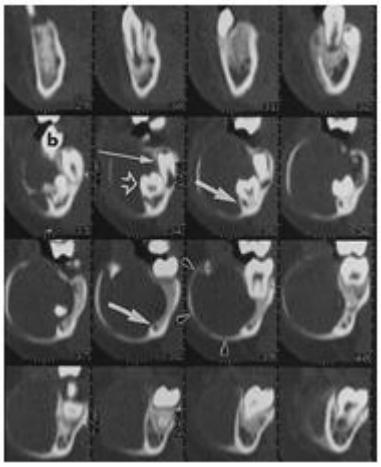


Figure 5 (c): Dental CT para-axial images: expanded vestibular cortical bone (arrowheads), two impacted teeth visible into the volume of the lesion (an open arrow and a thin solid arrow), erupted left first premolar (b), mandibular canal displacement (thick dark arrows) [4]

On **Figure 6a, b** we observe squamous-cell carcinoma of oral cavity, which had destroyed the cortical jawbone without bone expansion. For patients suffering cancer it is of great importance to diagnose the exact extent of the affected lower jaw bone and the continuity of the mandibular canal prior to mandiblectomy procedure. Surgeons, who support partial mandiblectomy, may use the diagnostic information, obtained byDental CT cuts, and thus to consider vertical mandiblectomy, if the lesion invades even partially into the mandibular canal or diffusely throughout the buccal cortical bone. Axial, para-axial and panoramic reconstructions, obtained by **Dental CT,** are particularly valuable for surgeons. It is important to compare radiographic with clinical findings, due to the extent of the tumor formation, which affects the function of both lower alveolar and mental nerves**.** [5]

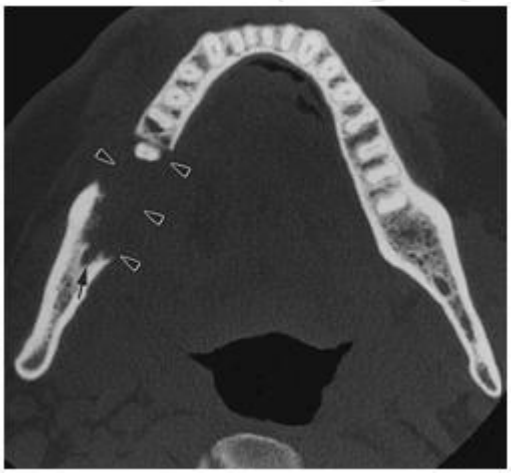


Figure 6(a): Axial CT cut: destruction (arrowheads) of the mandible and its cortex without evidence of bone expansion. The integrity of the mandibular canal (arrow) is also affected by the tumor. [4]

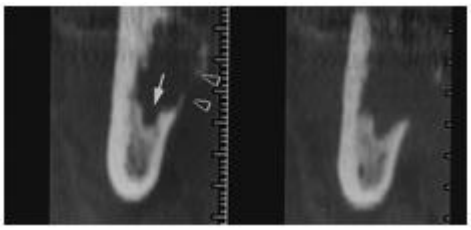


Figure 6(b): Para-axial Dental CT images: cortical bone destruction (arrowheads) and engagement of the upper wall of the mandibular canal. The tumor affects the upper wall of the mandibular canal (arrow). None of the typical for benign lesions symptoms, such as bone expansion and displacement of the mandibular canal, is being present. [4]

In cases of benign lesions, determining the integrity of the lower cortex of mandible helps the surgeon to decide whether it is better to perform bone curettage or resection. Furthermore, knowledge of the interrelationship between the lesion and the roots of teeth is important for deciding which (if any) vital or devitalized tooth must be extracted. [8] The thinnest CT sections and calculations of the images, using bone algorhythm have another advantage too - they can easily visualize small-volume calcifications or slight bone changes, important for the differential diagnosis of the lesion. [1]

It is not always necessary to data scan and visualize soft tissues too (they have higher mAs and standard algorithm for image calculation). Either such type of scan or MRI examination is indicated if there are additional soft-tissue components present. If there are symptoms of oral cavity carcinoma, CT examination of cervical soft tissues is indicated for detecting of possible metastases in the cervical lymph nodes [4].

3. Material and Methods

For the period from 2001 to 2006, 292 jaws of 233 patients were examined, using Dental CTin the Department of Imaging Diagnosis of MMA Sofia, for the purpose of our retrospective study. 143 of the examined jaws are of female and 149 are of male patients, therefore the study is representative for both genders. The jaws were tested on 25 separate criteria and on one combined criterion (age + gender),aiming to create a mathematical model for prediction of the risk level for early compromise of endosteal implants, based on objective information from the preoperative Dental CT study.

An important part of the study was to determine the cause for loss of teeth. The most common cause for loss of teeth is periapical inflammation with osteolytic changes – present in 125 of the cases. **(Fig. 7)**

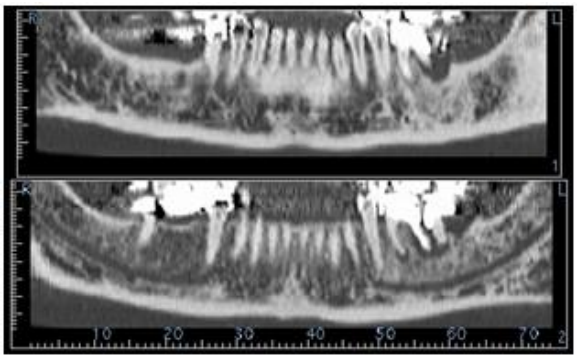


Figure 7: Periapical lesions around the apices of the roots of teeth 36 and 37. Loss of the interdental septum and common cavity formation, involving the distal root of tooth 36 and the mesial root of tooth 37. **(a)** Panoramic reconstructions, obtained by Dental CT. Osteosclerotic condensation of the surrounding trabecular bone, resembling condensing osteitis. Spread of the pathological process against the intact mandibular canal.

Inflammatory changes, affecting the parodontium, are the second most common reason for loss of teeth, being registered in 124 of the cases **(Fig.8).**

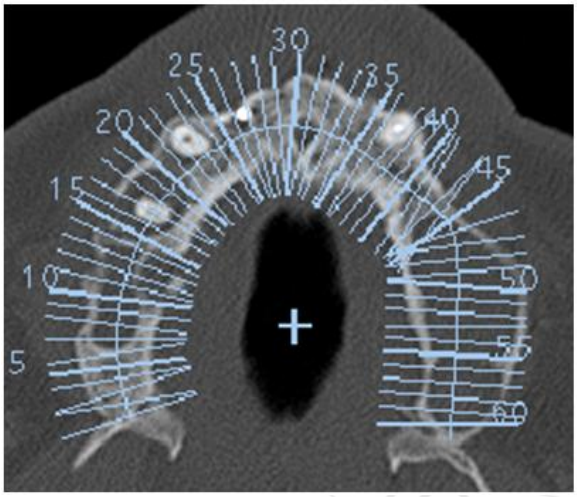
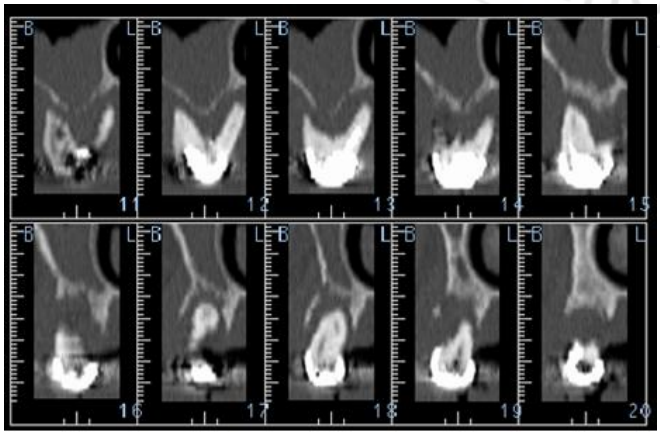
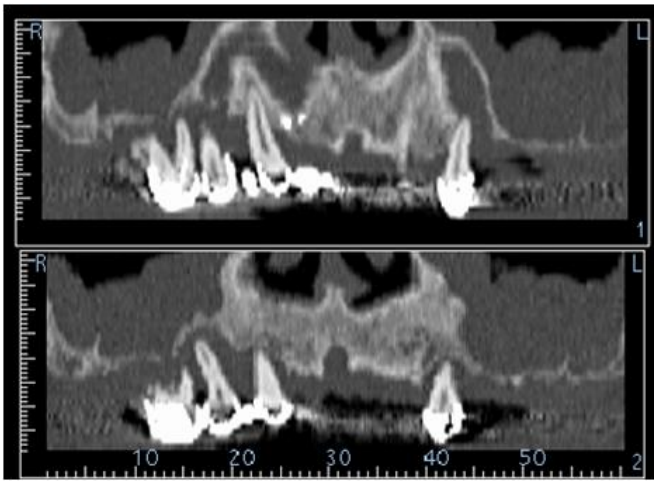


Figure 8: A case of 56 year old male patient with severe parodotal disease.**(a)** Para-axial reconstruction scheme



(b) Para-axial images at the level of teeth 15 and 16 show extremely widened periodontal spaces with advanced bone resorption, which involves root furcation region of 16, with destruction of vestibular and palatal cortical bone and formation of an oro-antral fistula, causing chronic odontogenic maxillary sinusitis.



(c) Panoramic reconstructions showing extensively widened periodontal space and severe bone resorption, involving dental roots and oro-antral fistula to the right.

In these cases, the CT signs of active inflammation of the surrounding bone, including an area of osteoporotic changes with thinned bone trabeculae, without affecting the trabecular bonearchitectonics, are of great importance for proper preoperative planning. Osteoporotic changes in alveolar jawbone result in reduced bone density of the trabecular bone below 250 HE. Often there is a disruption of the integrity of lamina dura (limiting the dental alveolar socket from the surrounding trabecular bone), resulting in the presence of separate bone trabeculaeprotruding into the widened periodontal space. The vestibular cortical bone may be thinned until it disappears completely and the roots of teeth get exposed. These changes are typical for the acute phase of inflammation. When the inflammatory process is chronic, there are clues for osteosclerotic condensation of the surrounding bone with thickening of separate bone trabeculae, diminishing the dimensions of bone-marrow spaces due to newly formed bone tissue. We talk about osteosclerotic condensation when the mean trabecular bonedensity value is over 450 HE.

The described above changes are often combined with the presence of bone defects, post-extractionfractures of any of the alveolar socket walls or newly opened oro-antral fistulas. It is important to monitor the presence of osteolytic changes in the area of root furcations and possible resorption of dental roots.

Nowadays, traumatic loss of teeth is more and more common in young adults in active age –represented in 9 of the cases we investigated. It is important to monitor the presence of CT signs ofosteonecrosis of the separated bone fragment (osteosclerotic sealing of the fragment and peripherral bone resorption).

Other relatively common causes for tooth loss are fibrous dysplasia **(Figure 9)**, bone leontiasis **(Figure 10)**, as well as various tumors and cysts of the jaws (**Figure 11,12)**, in which changes in the shape and size of the bone leads to dislocation of teeth, troubled occlusion, destruction of tooth-supporting apparatus and sequential loss of teeth.

Figure 9 (a)

Figure 9 (a) Axial cut at mandibular level. Abnormal bone reconstruction with changed normal shape, size and bone structure and erased visible borders between cortical and trabecular bone. Data for presence of an osteoid accumulation with subsequent calcium deposition in it, without the presence of fibrotic dysplasia.

Figure 9 (b): SSD 3D reconstruction of lower jaw

Figure 10 (a)

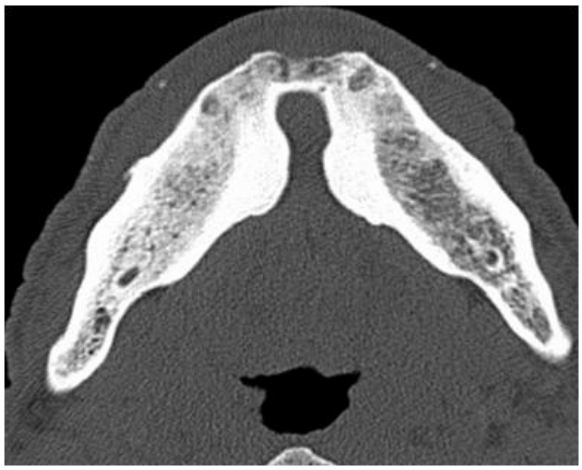


Figure 10 (b)

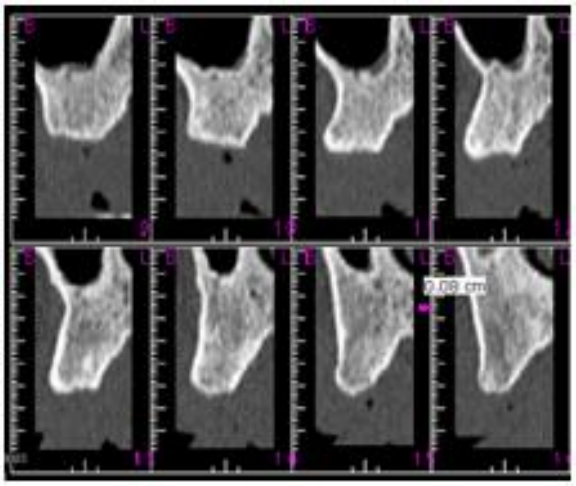


Figure 10: Complete maxillary and mandibular tooth loss of patient suffering bone leontiasis.

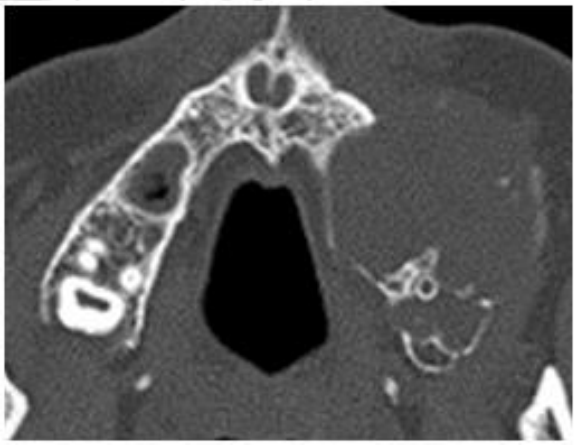


Figure 11 (a):

Figure 11 A 16 year old female patient with multi-localyzedadamantinoma.

(a) Axial cut at the level of the maxillary alveolar ridge. A soft-tissue lesion, causing extensive osteolysis and disturbing the integrity of lamina dura of the post-extraction alveolar socket of tooth 28. Bone expansion, affecting the left maxillary sinus, with data for bone destruction and granulous calcifications in the soft tissue tumor mass.

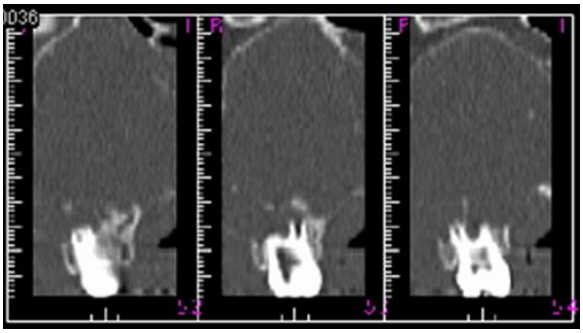


Figure 11 (b):

Fig. 11(b) Para-axial reconstructions at the level of tooth 27, showing expanded and destroyed bone at the level of the left maxillary sinus floor and extensive osteolytic changes in the root furcation area of 27 and the vestibular cortical bone at the same level. There is resorption of dental roots present and visible widening of the residual root canals, most likely due to the same pathological process.

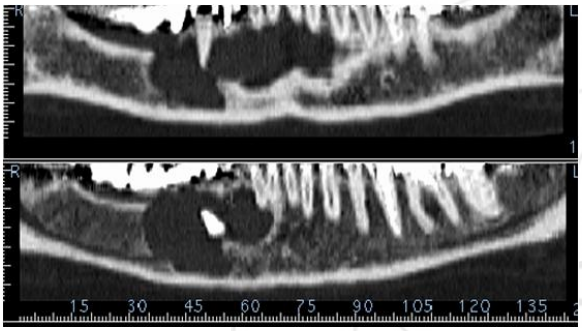


Figure 12 (a):

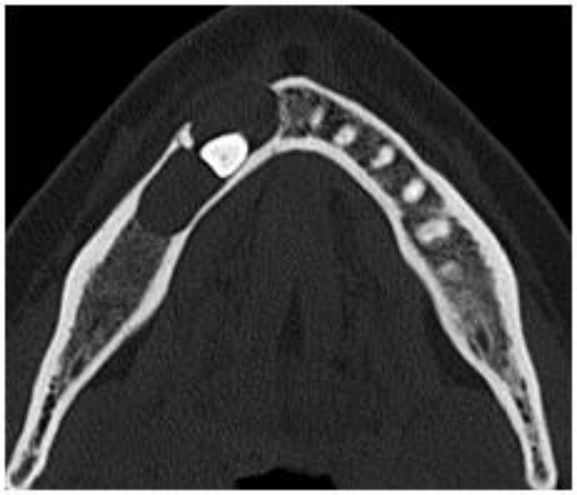
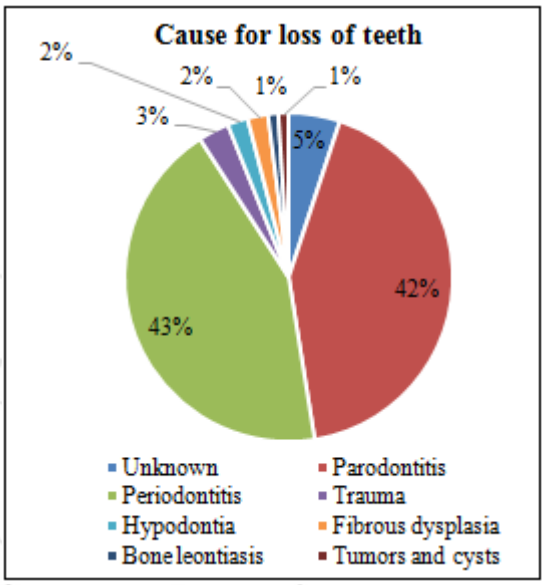


Figure 12 (b):

Figure 12a, b Impacted tooth 43 with a large-sized follicular cyst, which involves its crown. The cyst makes cortical bone thinner, without destructing it, causing slight deformation of the body of the jaw.

In 6 of the examined patients, the reason for the study was the diminished number of tooth germs, called hypodontia. In these cases it is significant to determine the distance between the roots of the adjacent to the missing germ teeth. It is also important to determine the vestibulo-lingual jawbone size, which is being significantly reduced in most cases.

Causes for tooth loss	*Number of cases*	*Percentage*
Unknown	13	4.5
Marginal periodontitis	124	42.5
Apical periodontitis	125	42.8
Trauma	9	3.1
Hypodontia	6	2
Fibrous dysplasia	5	1,7
Bone leontiasis	3	1
Tumors and cysts	2	0,7



In many cases the preoperative CT study provides opportunities to determine the nature of the disease that has led to tooth loss. This information is valuable for dental implantologists and helps them construct a proper treatment plan. Being aware of the main disease, caused the loss of teeth, is often of major importance for successful placement of endosteal implants.

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Author Profile

Nikolov Vladimir received Master degree in Medicine from Medical universityof Varna, 1987, Clinical fellowship in Radiology at Military Medical Academy of Sofia fortheperiod 1990-1992. Specialization in Radiology, 1992. For the period 1999-2017 worksat CT and MRI Clinicsof Military Medical Academy, Sofia. Specialinterestsinmaxillo-facialdiagnostics. 2017 - PhDinRadiologyfrom Military Medical Academy, Sofia.