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Dental assessment of odontogenic maxillary sinusitis, aided by Cone Beam Computed Tomography

Katarzyna Dobroś, Joanna Zarzecka

Department of Conservative Dentistry with Endodontics, Institute of Dentistry, Faculty of Medicine, Jagiellonian University Medical College, Kraków, Poland

Corresponding author: Katarzyna Dobroś, D.D.S.
ul. Montelupich 4, 31-155 Kraków, Poland
Phone: +48 12 424 54 25; E-mail: katarzyna.dobros@uj.edu.pl

Abstract: Objectives: To identify tooth diseases as potential causative factors in the development of maxillary sinus lesions, with the aid of clinical examination combined with Cone Beam Computed Tomography (CBCT), in the patients with persistent sinus-like ailments, unresponsive to routine treatment offered by otolaryngologists.
Materials and Methods: In 44 patients with suspected odontogenic maxillary sinusitis, a dental examination with tooth vitality test was carried out, in conjunction with CBCT. The study involved 29 women and 15 men (age range 19–69 years, mean age 43 (SD = 13.9) years).
Results: In 15 (34.1%) patients the odontogenic lesions were encountered in maxillary sinuses. A total of 33 causative teeth were identified, of which 13 (39%) were after root canal treatment (RCT). Only one of the teeth had a properly reconstructed crown, and only one tooth had the root canals properly filled-in. Most frequently, the lesions in the sinuses were attributed to the inflammation of periapical tissues; the first molar having been established as the most common causative tooth.
Conclusions: A detailed dental examination, pursued in conjunction with CBCT analysis, allow to diagnose odontogenic maxillary lesions. The incidence of long-term ailments originating in the maxillary sinuses should prompt a detailed assessment of the teeth, especially those after RCT.

Keywords: maxillary sinusitis of odontogenic origin, root canal treatment, periapical tissues inflammation, Cone Beam Computed Tomography.

Introduction

Ailments associated with the inflammatory lesions in the sinuses, especially maxillary sinuses, rate among the most common ones in the daily practice of a laryngologist. The most characteristic symptoms of sinusitis are: postnasal drip, facial pain, nasal

obstruction, flowing secretion from the back of the throat, and an impaired sense of smell [1].

Both the location of the teeth in the maxillary bones, and their close proximity to the maxillary sinuses floor, imply that various diseases of the teeth and periapical tissues may affect overall condition of the maxillary sinuses. Persistent, discreet ailments may therefore have their origin in the teeth disease. Computed Tomography (CT) examination is widely regarded as the gold standard in diagnosing maxillary sinus diseases [2]. This examination does not always offer a comprehensive image of the teeth, or dental pathology is left out unreported from the interpretation of sinus CT results [2, 3]. Currently available Cone Beam Computed Tomography (CBCT) examination allows a much more accurate assessment of both the teeth and maxillary sinuses. Leaving out the assessment of the teeth may well result in misdiagnosis, thus delaying the proper one, let alone the actual commencement of any specifically targeted treatment.

A local inflammatory process developing within the mucous membrane is caused by the inflammatory mediators accompanying the teeth and periapical tissues disease. This is facilitated by a specific structure of the maxillary bones, i.e. a functional continuity of the mucous membrane [4]. Swelling of the mucous membrane and its inflammation cause disorders of mucociliary transport [5, 6]. Those disorders and a sinus drainage may be experienced by the patients as, e.g. a flowing secretion from the back of the throat.

Complications resultant from the surgical treatment of the teeth, as the actual cause of lesions developing in the maxillary sinuses, do not pose any diagnostic difficulties, being the most common odontogenic cause [7, 8]. Pulp disease, periapical tissues inflammation, and complications of endodontic treatment are often asymptomatic in character. The diagnosis is therefore based on a thorough clinical examination, combined with radiological diagnosis, most often also aided by CBCT [9, 10].

The study aimed to distinguish various teeth diseases which might be deemed the potential causes of maxillary sinus lesions, through clinical examination aided by CBCT, in the patients with persistent sinus-like ailments, found unresponsive to the treatment offered by otolaryngologists.

Methods

Laryngologists associated in the Regional Dept. of the Society of Otolaryngologists were asked to refer patients with suspected maxillary sinusitis of odontogenic origin to the Dept. of Conservative Dentistry with Endodontics. Patients with the oro-antral communication, or a fistula resultant from improper surgical treatment, were excluded from the study. The additional exclusion criteria were: toothlessness, age under 18 years, pregnancy, general diseases, i.e. confirmed allergy (aspirin asthma), massive

nasal polyps, neoplastic diseases, and autoimmune diseases. In the period spanning June 2014 — Dec. 2016, 44 patients (29 women and 15 men) were referred to the Clinic. All of them furnished an informed written consent to participate in the study protocol. The patients' age ranged 19–69 years, 43 years on average (SD = 13.9).

In all patients, the number of teeth with caries (D), missing (M), with fillings (F) was determined through clinical examination, allowing for a calculation of the DMFT index [11]. The interview helped to determine whether the teeth were lost due to caries and its complications, or due to other reasons. Assessment of past dental treatment was completed through Dental Treatment Index (DTI) [11].

In all patients CBCT was completed with RayScan Symphony of Ray Co., Ltd. (Korea). All images were assessed under standardized conditions at the same examination workplace using the Xelis Dental — CD Viewer — Dental 3D — Pro. Images were evaluated by a single observer (a specialist in conservative dentistry with endodontics, with 4 years of experience in CBCT diagnosis to his credit).

Lesions in the maxillary sinuses were categorized against the radiological images as: no changes, a thickening of a mucous membrane, cyst. The Periapical and Endodontic Status Scale (PESS) was applied to assess the quality of root canal treatment (RCT), and periapical tissues status. This scale consists of Complex Periapical Index (COPI), and Endodontic Treated Tooth Index (ETTI) (Table 1) [12]. The distance of the root apex from the maxillary sinus floor was described in line with the scale proposed by Lu *et al.* (Table 2) [13].

Table 1. Periapical and Endodontic Status Scale.

Complex Periapical Index	
S (Size of radiolucent lesion)	
S0	
S1	Diameter of small, well-defined radiolucency up to 3 mm
S2	Diameter of small, well-defined radiolucency 3–5 mm
S3	Diameter of small, well-defined radiolucency >5 mm
R (relationship between root and radiolucent lesion)	
R0	No radiolucency, when widening of the periodontal ligament is not exceeding twice the width of the lateral periodontal ligament
R1	Radiolucent lesion appears on one root
R2	Radiolucent lesion appears on more than one root
R3	Radiolucent lesion with furcation involvement

Table 1. Cont.

Complex Periapical Index	
D (Location of damage to bone tissue)	
D0	No radiolucency, when the widening of the periodontal ligament is not exceeding twice the width of the lateral periodontal ligament
D1	Radiolucent around the root
D2	Radiolucency is in contact with essential anatomical structures
D3	Damage sustained by the cortical bone
Endodontically Treated Tooth Index	
L (Length of the root canal filling)	
L1	0–2 mm from radiographic apex
L2	>2 mm from radiographic apex
L3	Overfilling (extrusion of material through the apex)
L4	Filling material visible only in pulp chamber
L5	Filled-in root canal of a surgically treated tooth
H (Homogeneity of the root canal fillings)	
H1	Complete obturation (homogenous appearance of the root canal filling)
H2	Incomplete obturation (voids and porous appearance of the root canal filling)
CS (Coronal seal)	
CS1	Adequate (coronal restoration appears intact radiographically)
CS2	Inadequate (detectable radiographic signs of overhangs, open margins, recurrent caries, or lost coronal restoration)
CF (Complications/failures)	
CF0	No complications
CF1	Root perforations
CF2	Root canal not treated/missed out
CF3	Root resorption
CF4	Root/tooth fracture
CF5	Endodontically treated tooth with radiolucency*

*CF5 has been omitted, for each tooth the COPI is specified

Table 2. Three types of position of the root apex relative to the sinus floor (in the case of multi-root teeth, the apex closest to the sinus floor was recorded).

1	A gap or space between the root tip and the sinus floor
2	The root tip touched the sinus floor
3	The root tip entered the sinus floor

Following a clinical examination, assessment of tooth vitality by thermal test (reaction to ethyl chloride), and an analysis of radiological images of periapical tissues, an odontogenic origin of the lesions in the sinuses was either confirmed, or ruled out. Causal teeth were defined as the ones affected by the pulp diseases, showing any lesions in the periapical tissues, and those after improper RCT.

Patients with the non-odontogenic lesions, and those with no lesions in the sinuses, were sent back to the referring laryngologist. Patients with the odontogenic lesions were referred to dental treatment.

Continuous variables are expressed as mean and standard deviation (SD), or as median (interquartile range, IQR), as appropriate. The Shapiro-Wilk test was used to assess conformity with a normal distribution. The continuous variables were compared between groups with the aid of Analysis of Variance (DMFT) or Kruskal-Wallis test (DTI) for non-normal distribution. Categorical variables were described by respective percentages and compared using Fisher exact test. Due to the nature of (ordinal) variable, the relationship between the frequency of lesions in maxillary sinuses and the distance between the root apex and maxillary sinus floor was assessed by the test of linear trend. Statistical analyses were completed using SPSS 23.0 (SPSS Inc., Chicago, IL, USA). P-values <0.05 were accepted as statistically significant.

The study was endorsed by the University's Bioethical Review Committee (Ref. no. KBET/34/B/2014 and no. 122.6120.141.2015). Imaging diagnostics were financed out of the statutory projects resources (Ref. no. K/ZDS/004589).

Results

As evidenced by a clinical examination, and CBCT analysis of 44 patients, 22 (50%) of them had no odontogenic lesions in the sinuses, whereas 15 (34.1%) had lesions of an odontogenic origin. In the remaining 7 (15.9%) patients, no pathological changes in the sinuses were encountered. There was no evidence that the ailments reported by the patients may have in any way been related to the etiology of the sinus lesions. The median duration of reported ailments was 10 months (Q1 = 4, Q3 = 24). Patients most often complained of headache (50%), flowing secretion from the back of the throat (43.2%), facial pain (43.2%), and nasal obstruction (40.9%).

There were no differences in the general condition of the teeth in patients with no lesions in the sinuses, with the non-odontogenic lesions, and the odontogenic ones. Patients did not differ in terms of the DMFT index and DTI ($p > 0.05$).

A thickening of the mucous membrane in the sinus floor in 12 (80%) patients, and the cysts in 3 (20%) patients with the odontogenic lesions (as evidenced on the CBCT image) were noted. A total of 33 causative teeth were identified. These were mostly molars (16 (48.5%) first molars, and 9 (27.5%) second molars), followed by premolars (3 (9%), first premolars, and 5 (15%) second premolars) (Fig. 1). In 8 patients, it was established that 13 teeth had RCT, including 7 teeth with periapical lesions. Only one of all the teeth under assessment had a properly reconstructed crown, and only one tooth boasted the properly filled-in root canals. In one case the filling material was an extrusion through the apex (L3), one tooth had material in the pulp chamber only (L4). In the remaining 10 cases, the root canals were filed more than 2 mm from the apex (L2). Additionally, a complication in the form of an unfilled canal in the multi-

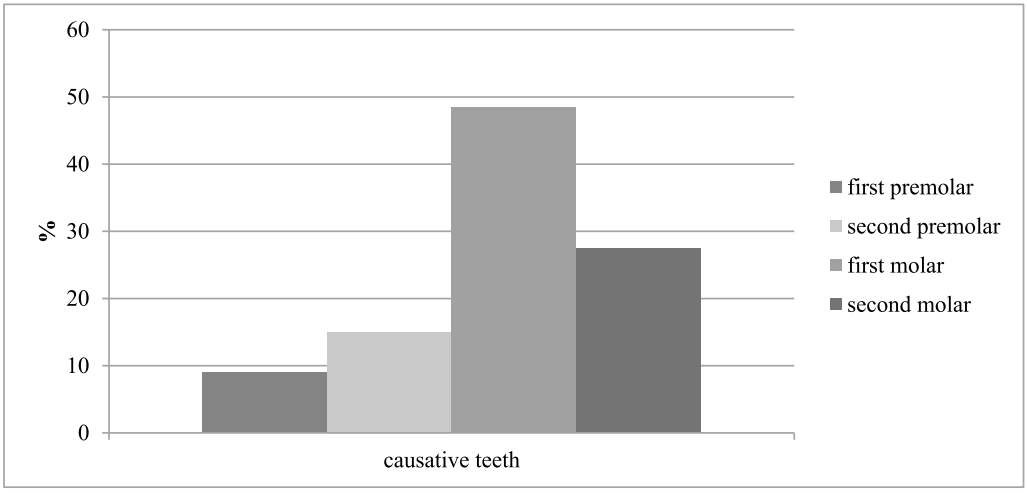

Fig. 1. Percentage share of individual groups of teeth in the development of lesions in the maxillary sinuses.

root tooth was found in 6 teeth (CF 2). With regard to 8 patients, in 5 cases these teeth coexisted with the untreated teeth with periapical lesions (7 teeth) (Fig. 2), and the teeth with pulp diseases (3 teeth). Five patients had the causal teeth with the periapical lesions left untreated, 7 teeth in total (Fig. 3). In two patients, the changes in the sinus were caused by the teeth with pulp diseases (3 teeth) (Fig. 4).

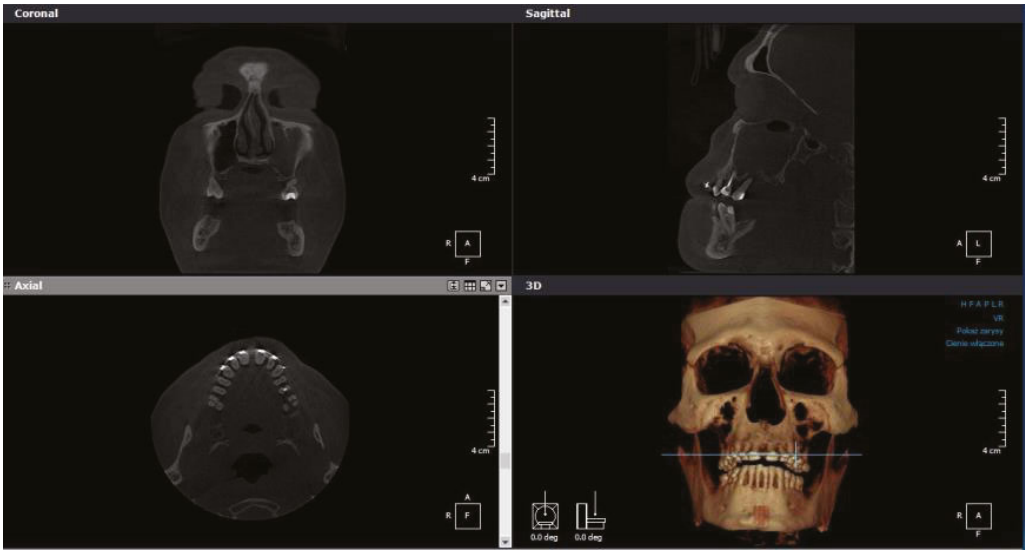

Fig. 2. CBCT. Maxillary sinusitis. Discontinuity of the sinus floor. Left second premolar after RCT with periapical lesion and left first molar with periapical lesion.

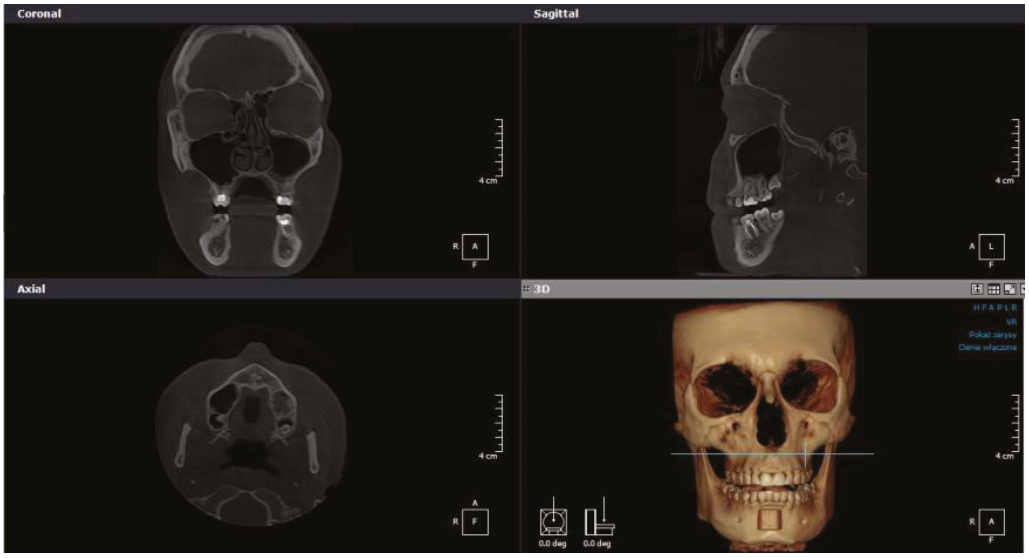

Fig. 3. CBCT. Maxillary sinusitis. Left first molar with periapical lesion.

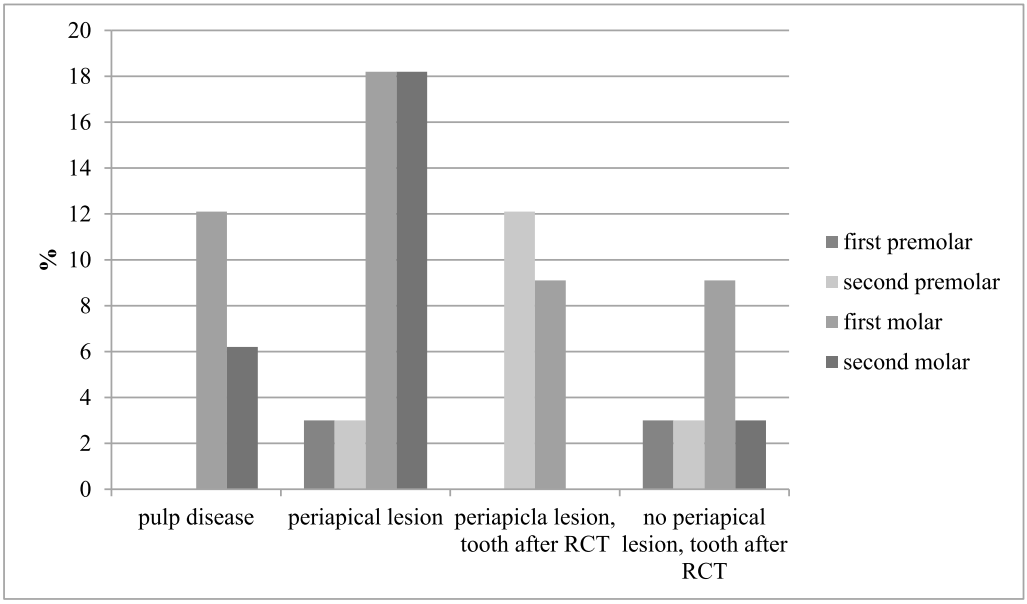

Fig. 4. Odontogenic etiology of the lesions in the maxillary sinuses in the specific groups of teeth.

In this group of 15 patients, in two cases the inflammatory process in the periapical tissues caused the discontinuity of the sinus floor (D3), 5 teeth had the periapical lesions with a diameter in excess of 5 mm (S3). These teeth were not root canal-treated. In the case of the teeth after RCT, the diameter of changes in periapical tissues did not exceed 5 mm, and the continuity of the sinus floor was not interrupted. In the case of the multi-root teeth, some inflammatory changes were usually encountered at more than one root (R2).

It was established that incidence of inflammatory changes in the periapical tissues was associated with the more frequent development of lesions in the maxillary sinuses ($p < 0.05$). Pathological lesions from the sinus were observed more frequently with regard to the root apexes of the first and second molar, and the first premolars in the sinus, or directly at the sinus floor, even though the difference was not statistically significant (Table 3).

All patients with odontogenic lesions were referred to dental treatment. In 14 patients, the causative teeth were referred to RCT, and in one — for extraction, 2 (6.5%) teeth. Eighteen teeth (54.5%) were referred to primary RCT, including 17 molars, and 1 premolar. Another 13 (39%) teeth required secondary RCT, 7 molars and 6 premolars. The patients' overall health condition improved as a result, while one patient, following the endodontic treatment of the causative teeth, required laryngological supervision, and further surgical treatment.

Table 3. Frequency of the incidence of lesions in the maxillary sinuses, and the distance of the root apex from the maxillary sinus floor.

		Tooth										
		Second molar			First molar			Second premolar			First premolar	
Distance from the sinus floor		**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**
Right sinus	No lesion	1 5.00%	16 80.00%	3 15.00%	1 6.25%	9 56.25%	6 37.50%	2 12.50%	12 75.00%	2 12.50%	15 88.24%	2 11.76%
	Mucosal thickening	1 7.14%	7 50.00%	6 42.86%	1 9.09%	5 45.45%	5 45.45%	2 20.00%	7 70.00%	1 10.00%	8 57.14%	6 42.86%
	Cyst	0 0.00%	2 40.00%	3 60.00%	0 0.00%	3 60.00%	2 40.00%	1 20.00%	4 80.00%	0 0.00%	2 66.67%	1 33.33%
p				**0.04**[A]		0.96[A]				0.4[B]	0.1[A]	

		Tooth										
		Second molar			First molar			Second premolar			First premolar	
Distance from the sinus floor		**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**
Left sinus	No lesion	0 0.00%	11 78.57%	3 21.43%	0 0.00%	8 80.00%	2 20.00%	0 0.00%	10 90.91%	1 9.09%	10 62.50%	6 37.50%
	Mucosal thickening	1 5.26%	11 57.89%	7 36.84%	2 11.11%	6 33.33%	10 55.56%	5 33.33%	9 60.00%	1 6.67%	11 68.75%	5 31.25%
	Cyst	0 0.00%	1 33.33%	2 66.67%	0 0.00%	3 60.00%	2 40.00%	0 0.00%	3 60.00%	2 40.00%	2 66.67%	1 33.33%
p				0.3[A]		0.19[B]			0.059[A]		0.99[B]	

A — p value from linear trend;
B — p value from fisher exact test;
$p < 0.05$

Discussion

Review of literature by Hauman *et al.* indicates that the first reports on the spread of infection from the teeth to the sinuses appeared in 1943 [14]. The author refers to the study of human corpses by Bauer, whereby the inflammatory changes in the sinuses in close proximity of the teeth with pulp inflammation were established through histopathological examination. The spread of dental infections through the tissues surrounding the tooth to the maxillary sinuses was referred to as the Endo-antral syndrome (EAS) by Selden in the 1970s [15–17]. The symptoms characteristic of EAS are: (i) pulp disease in the tooth in which the root apex is close to the maxillary sinus, (ii) periapical radiolucency in the root apex area of the teeth affected by a pulp disease, (iii) radiologically visible loss of the lamina dura defining the inferior border of the maxillary sinus over the teeth affected by a pulp disease (iv) localized thickening of the sinus mucosa above the apex of the causative tooth, (v) varying degrees of radiopacity of the surrounding sinus space [17].

In the material under study, the most frequent cause of the lesions developing in the maxillary sinuses were the teeth with inflammation in the periapical tissues. This is corroborated by a study by Lu *et al.* who, having retrospectively analysed the CBCT images, indicated that periapical lesions increased the risk of inflammatory lesions in the maxillary sinus [13], with Brullmann *et al.* having arrived at the similar conclusions. They also argued that the teeth after RCT may cause a reaction from the mucous membrane of the maxillary sinus floor, although they did not evaluate the actual quality of this treatment [18]. Czarnecka *et al.*, when studying the patients with chronic maxillary sinusitis of odontogenic origin, diagnosed 48.9% teeth with improper RCT [19]. In our own material, 13 causative teeth were treated endodontically, although a single tooth only had a properly reconstructed crown, and a single one only had the root canals properly filled-in. The teeth with the filling material in the pulp chamber only, or the ones with unfilled root canals, or missed-out root canals are a potential source of infection [20]. In these cases, the root canal system had not been adequately disinfected, and there were some unfilled spaces left behind which might be prone to being infested with bacteria in the form of a biofilm [21]. In line with the findings of the meta-analysis carried out by Gillen *et al.*, a properly restored crown, and the properly filled-in root canals were crucial for therapeutic success [22]. Crown micro-leakage, or any bacteria casually left behind in the root canals are conducive to the spread of infection.

It is essential to emphasise the potential for the development of odontogenic lesions in the maxillary sinuses caused by the teeth with pulp diseases. Such teeth were identified in 5 patients, even though did not reveal any clinical symptoms or changes in the radiological images. In those cases, a clinical examination proved the

only effective diagnostic means, though. Diagnosing the teeth affected by the pulp diseases is particularly difficult, as they are often asymptomatic.

There was no correlation between the thickness of the maxillary sinus floor and the incidence of lesions in the sinuses in the material under study. Similar results were obtained by Lu *et al.* [13].

A specific bone structure of the maxillary sinus floor is conducive to the spread of a disease. Occasionally, the sinus may be separated from the roots of the teeth by the Schneidarian membrane only [4]. Swelling of the mucous membrane, damage to the structure of cilia, accumulation of mucus, and changes in its density may be instrumental in the impaired transport of this secretion, consequently accounting for its flow down the back of the throat [5]. Admittedly, this calls for some further, more in-depth investigation, so as to add more credence to our preliminary findings.

One of the limitations of our study consists in the small number of patients referred to our department by the otolaryngologist, in the period when the study was actually conducted.

Conclusions

Detailed dental examination, aided by CBCT analysis, allowed to have the dental cause of various sinus diseases effectively identified. Incidence of inflammatory lesions in the periapical tissues was associated with more frequent development of lesions in the maxillary sinuses, also in the improperly filled-in root canals; the teeth affected by the pulp diseases the likely causative factors. Long-term ailments originating in the maxillary sinuses, especially where the RCT teeth are encountered, should prompt a thorough assessment of all teeth.

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