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Cone Beam Computed Tomographic Study of Mucosal Thickness of Maxillary Sinus Floor

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The purpose of the present study was to determine the mucosal thickness of the maxillary sinus floor. The study included the 3D-cone beam computed tomograms of 53 patients (32 women and 21 men; aged 18-72 years, mean 46,3±13,4). The mucosal thickness was measured on cross-sectional images in its thickest part above the apexes of the molars and premolars, or in the absence of such– above the corresponding position of future dental implants.The average thickness measured was 2,24±3,11 mm, with mucosal thickening in 92,5% of all patients and above 56,3% of all teeth. A significant association was found between the thickness and pathological processes (p=0,002). Highest percentage of changes occurred in the age over 26 years and there is significant association between the thickness and patient's age (p<0,001). Pathology related to the lateral maxillary teeth and maxillary sinus is one of the main factors for mucosal thickening. The preoperative evaluation of the sinus mucosa is essential for the correct planning and prevention of complications in dental implant treatment and maxillary sinus elevation surgery.

Key words: mucosa, maxillary sinus floor, 3D- cone beam computed tomography, maxillary sinus floor elevation

Introduction

During the past two decades dental implants (DI) proved to be a reliable treatment modality in the prosthetic rehabilitation of partially or totally edentulous patients. A restriction for their use in the posterior maxilla is the insufficient residual bone height for implant placement. The reasons for this are due to the continuing alveolar bone resorption which begins immediately after tooth loss, the proximity of the maxillary sinus floor (MSF) and the progression of sinus pneumatization. To provide enough volume of bone for adequate prosthetic support in such cases the sinus floor is grafted with a bone graft or substitute inserted between the elevated maxillary sinus floor membrane (MSFM) and the cranial surface of the inferior sinus wall. A major prerequisite for successful MSF elevation is the healthy sinus with strong MSFM. Sinus pathology of

different origin can complicate or irreversibly compromise the result of the operation. Pathological involvement of the maxillary sinus is often presented as thickening of the mucous membrane. That is why membrane dimensions are used to indicate the presence or absence of disease in the sinus itself or in the vicinity neighboring the implant site.

The thickness of the MSFM, known also as Schneiderian membrane, is variable [4, 5, 10]. Masurements exceeding 2 mm are considered pathology. Factors causing MSFM thickening include, but are not restricted to, infection, allergy, trauma, oncologic conditions, and smoking [3]. It is accepted that the MSFM lying above teeth with periodontal and endodontic lesions shows higher thickness. The situation is well presented above the molars in case of thin bone plate between the dental roots and maxillary sinus floor or in cases having periapical lesions [3,4]. The possibility of inflamatory sinus pathology or a periodontal lesion next to implant and/or graft site to cause supuration or implant failure, thus jeopardasing the treatment and making further surgeries impossible, is high. This turns the preoperative assessment of the condition of the sinus mucosa into a keystone for the planning and prevention of complications in sinus floor elevation surgery. The presence of the pathology aforementioned may shift the treatment plan to such treatment modalities like "All-on-Four", the use of short, zygomatic or pterygomaxillary implants or, something more, can abundon implant treatment at all.

The aim of the present study is to evaluate the thickness of maxillary sinus floor membrane in patients in need of maxillary sinus elevation surgery in conjunction with DI placement and its application in preoperative patient assessment and planning. We also assessed the relationship between periapical pathology and the incidence of mucosal thickening.

Materials and Methods

Patients: Inclusion criteria for the patients consisted of: 1) At least one sided partially or totally edentulous distal maxilla; 2) Need of dental implant treatment; 3) Teeth with and without periapical pathology; 4) Preoperative bilateral 3D-cone beam computed tomography (3D-CBCT) of the maxilla; 5) Clearly visualised maxillary sinus floor. Patients with signs of congenital anomalies, acute sinusitis, and oncologic involvement, as well as patients with history of heavy inflamatory sinus pathology, trauma, preliminary surgery of the distal maxilla and/or the maxillary sinus, were excluded from the study.

Radiological investigations: The 3-DCBCT of all patients was performed with Kodak Carestream 9000 3D machine (Carestream Health, Inc, Rochester, NY) with fixed isotropic field of 0,76 × 0,76 x 0,76 μm (isotropic voxel), image size 17 × 11 cm, maximum exposure of 14 sec. The resulting images were processed with Kodak Carestream Simple Browser Software.

Regions of interest: The regions of interest were defined as the position of the MSF and alveolar ridge of the distal maxilla subjected to DI placement (**Fig 1**). These included edentulous, partially edentulous or dentate alveolar ridges extending from the first premolar to the third molar planned for replacement of failing or already missing teeth with DI. For evaluation of relationship between pathology and the incidence of mucosal thickening were also included teeth without periapical pathology. Teeth with apical root proximity to the nasal cavity instead of the maxillry sinus were excluded from the study (**Fig. 2a and 2b**).

Measurements: The Kodak Carestream Simple Browser Software was used for for evaluation of sinus anatomy and implant planning. The thickest part of the MSFM was measured in millimeters on cross-sectional images with the built-in precise measuring

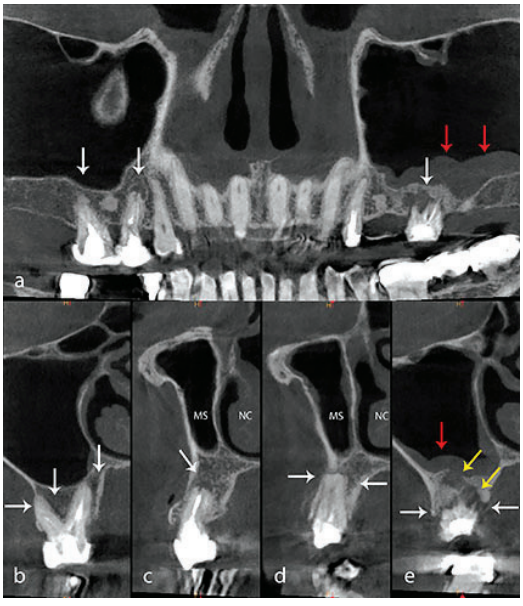
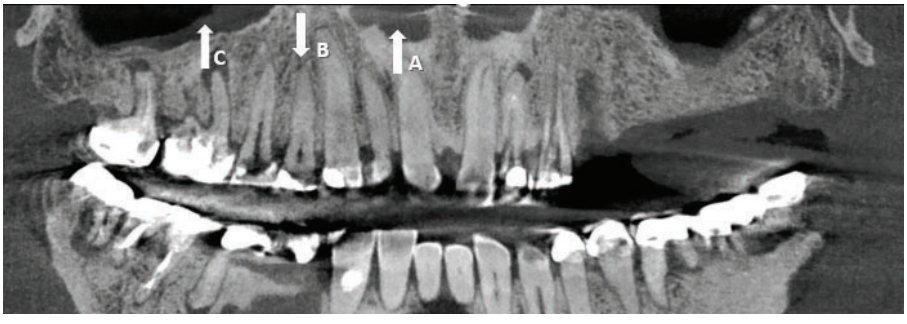


Fig. 1. Region of interest subjected to DI placement- teeth with different types of pathological processes: **a)** Panoramic view of teeth planned for replacement with DI; **b)** Tooth with dehiscence, furcation involvement and periapical lesion; **c)** Tooth with periapical lesion; **d)** Tooth expanded periodontal cleft; **e)** Tooth with periodontitis and alveolar resorption (marked with yellow arrows; with red arrow is marked pathological thickening of sinus mucosa).\

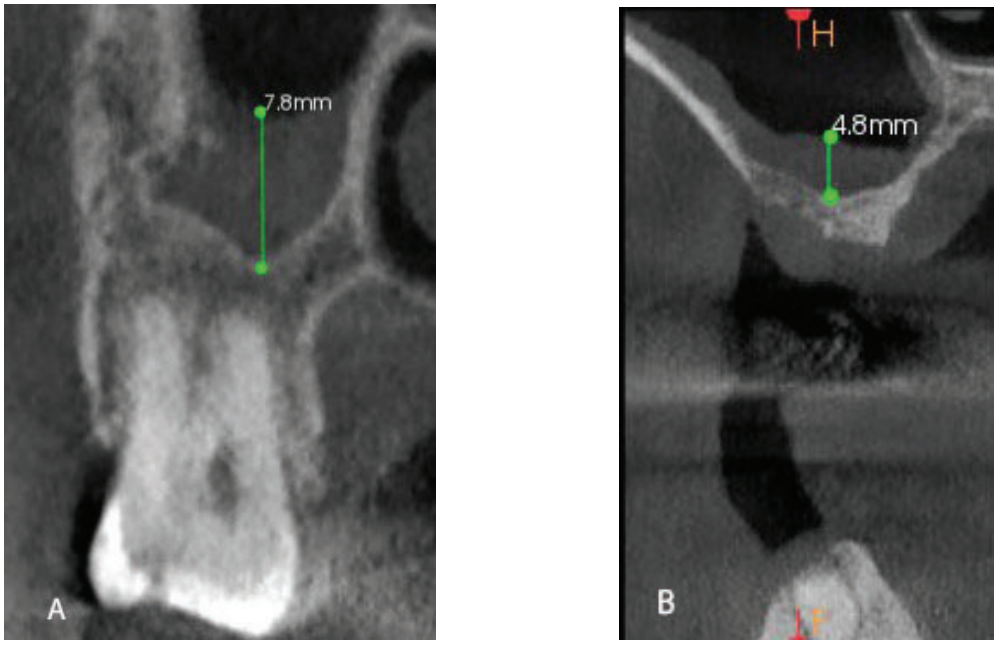


a)

b)

Fig. 2. Relations between dental roots and the floor of the nasal cavity – "missing" data. **a)** Panoramic view – with arrows are marked the nasal cavity (A), a tooth, related to nasal cavity (B), maxillary sinus (C); **b)** Cross-sectional view of the same tooth – with arrow is marked the nasal cavity.

tool in a plane perpendicular to the tangent to the MSF above the root apeces (**Fig. 3a**) and/or corresponding to the planned positions of future DI. Implant positions were planned with the built-in implant library with 4,0 mm in diameter implant projections and positioning the implant shoulders to keep 1,5 mm distance from the necks of the adjacent teeth or 3,0 mm between the shoulders of neighboring implants.



a) Dentate site b) Edentulous site

Fig. 3. Measurements of the thickness of sinus mucosa

Statistics: The data was processed with IBM SPSS Statistics for Windows, Version 19 (IBM CORP, Armonk, NY). For non-parametric data the Mann-Whitney test was used to determine differences in mucosal thickening between sexes and the Chi-square test to evaluate the association of mucosal thickening with age and the presence or absence of MSF pathology. p-value was calculated defined using Fisher'Exact test and statistical significance was set at the $p<0,05$ level. Categorical variables are presented by **n** and **%** values.

Results

The 3D-cone beam computed tomograms of 53 patients (32 women and 21 men; aged 18-72 years, mean 46,3±13,4) nessesitating sinus floor elevation and dental implant treatment were included in the study. The patients were divided into 5 age groups: group 1– under 18 years; group 2 – between 19 and 25 years; group 3 – between 26 and 40 years; group 4 – between 41 and 60 years; group 5 – over 60 years (**Fig. 4**). A total of 424 implant sites and maxillary premolars and molars subjected to replacement with DI were observed.

In reference to pathology the patients were divided in two groups – with and without periapical pathological changes.

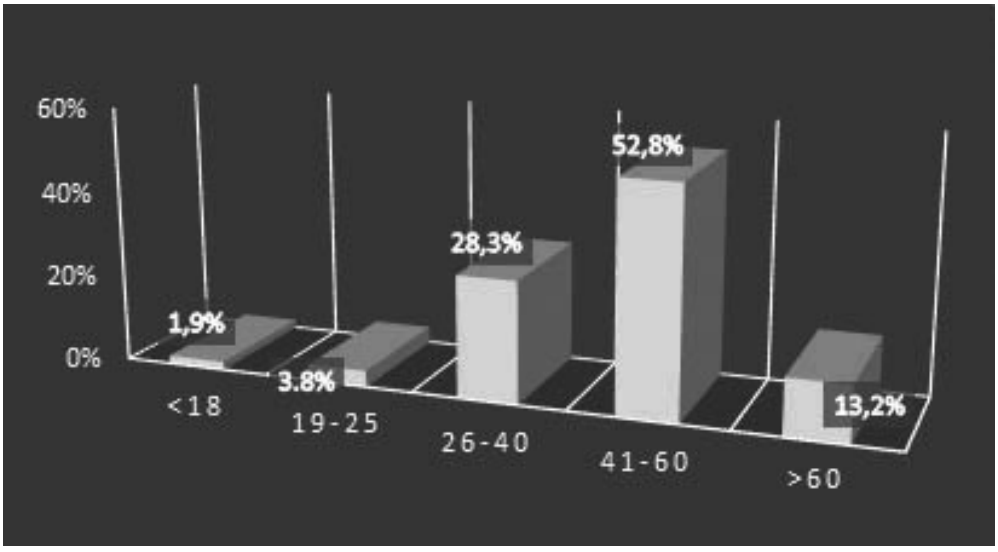


Fig. 4. Distribution of patients in age group

Patients were also divided in two groups according to incidence of mucosal thickening – with and without mucosal thickening.

The Schneiderian membrane thickness ranged between 0 and 15,90 mm, average 2,24±3,11 mm. Mucosal thickening was found in 92,5% of all patients and above 56,3% of all teeth (**Table 1**). The mucosal thickness was divided into 5 groups according to the classification of Goller-Bulut et al. [4]:

Table 1. Frequency of the mucosal thickness

		Frequency	**Percent %**	**Valid Percent %**
Thickness	**yes**	215	50,7%	56,3%
	no	167	39,4%	43,7%
	Total	382	90,1%	100,0%
Missing		42	9,9%	
Total		424	100,0%	

Class 1. 0 mm
Class 2. 0-2 mm
Class 3. 2-4 mm
Class 4. 4-10 mm
Class 5. More than 10 mm (**Fig. 5**)

Fifty nine precent of all cases were distributed in Group 1 and Group 2 with mucosal thickening up to 2 mm. In these pateints the MSFM was classified as normal (**Fig. 6**).

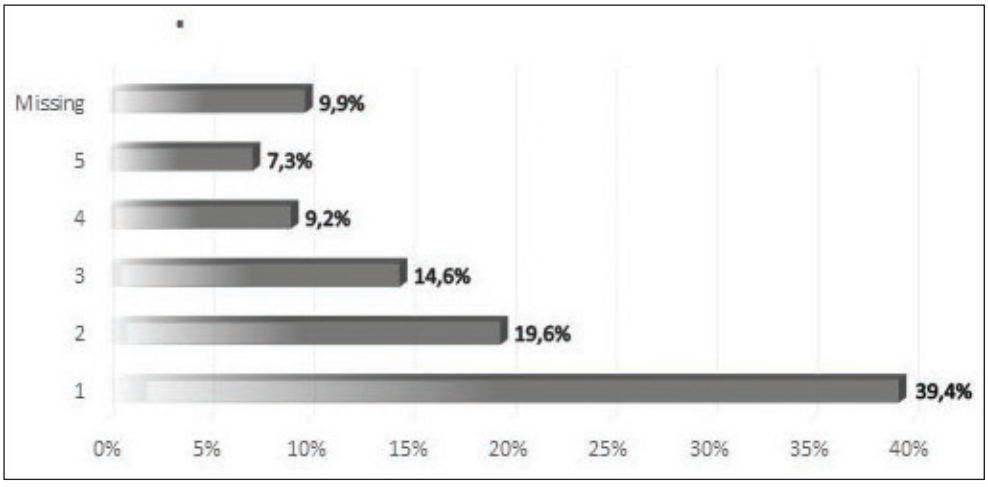


Fig. 5. Distribution of the mucosal thickness due to classes.

Fig. 6. Normal mucosa (marked with an arrow)

In 31,6% of the sites thickening was accompanied by periodontal lesions (**Table 2**), and in 69,40% of all cases having pathology the pathological changes presented with mucosal thickening (**Fig. 7**).

There was a significant association between the thickness and periodontal pathology, p=0,002 (**Table 3**).

The incidence of mucosal thickening increased significantly in the age over 26 years with highest percentage of frequency over 60 years (66,7%) (**Fig. 8**).

The association between the mucosal thickness and age is statistically significant, p<0,001 (**Table 4**).

Table 2. Relationship between the mucosal thickening and pathology

		Pathology	
		no	**yes**
Thickness	**yes**	68,4%	31,6%
	no	82,0%	18,0%
Total		74,3%	25,7%

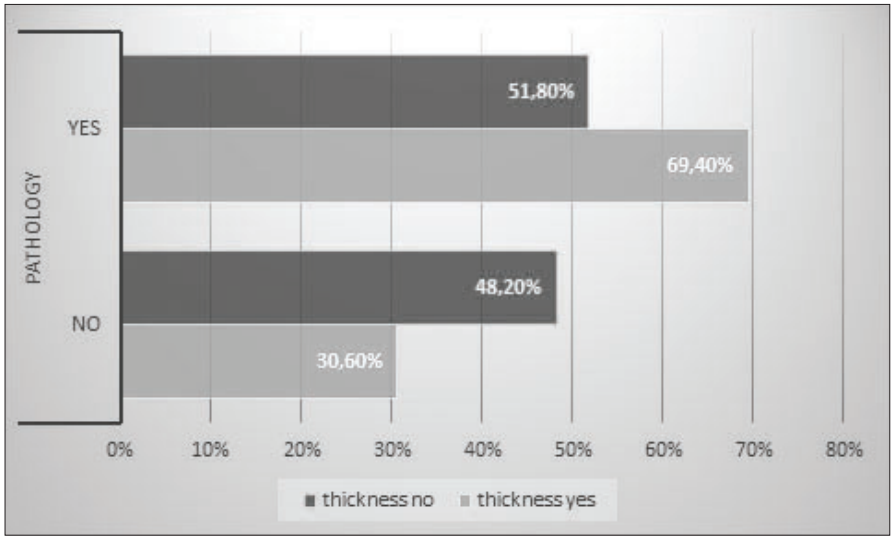


Fig. 7. Mucosal thickening in case of periapical pathology

Table 3. Association between the mucosal thickening and pathology

		Thickness
Pathology	**p value**	p=0,002
	N of Valid Cases	382

There is statistically significant difference between males and females (p=0,008). Thickness of the sinus mucosa is higher in males. The calculated average in males is 2,95±3,66 mm and in females – 1,81±2,64 mm (**Table 5**). But there is no statistically significant association between gender and incidence of mucosal thickening (p=0,07) (**Table 6**).

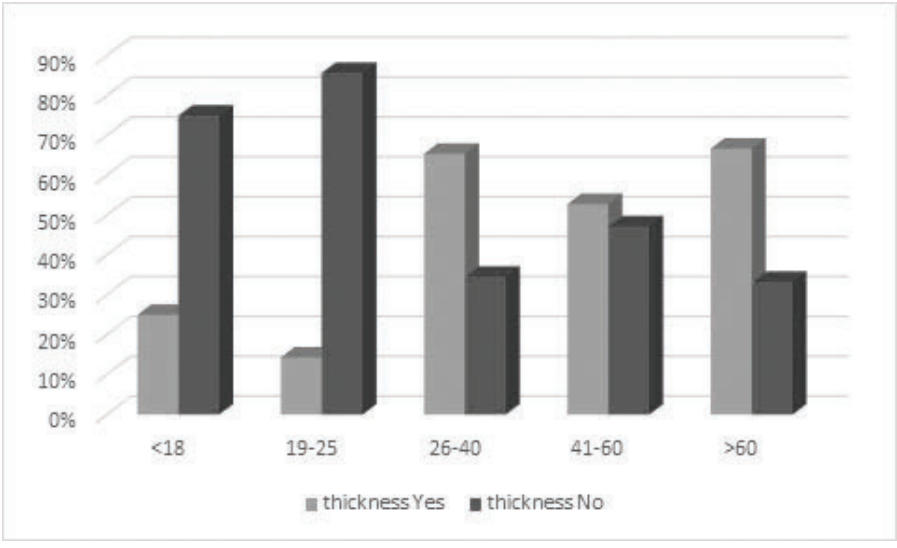


Fig. 8. Relationship between the mucosal thickness and age

Table 4. Association between the mucosal thickness and age

		Thickness
Age	**p value**	p<0,001
	N of Valid Cases	382

Table 5. Mucosal thickness according to the gender

Gender	N	Mean	SD	SEM	Median	IQR	Min	Max	p
M	143	2,95	3,66	0,31	1,60	3,90	0,00	12,40	p=0,008
F	239	1,81	2,64	0,17	1,10	2,60	0,00	15,90	

Table 6. Association between gender and incidence of mucosal thickening

			Gender		Assossiation
			M	**F**	**p**
Thickening of sinus mucosa	**no**	N	54	114	p=0,07
		%	32,1%	67,9%	
	yes	N	89	125	
		%	41,6%	58,4%	

Discussion

The Schneiderian membrane's thickening is with high percentage of occurrence. The proximity of the MS floor to the roots of the superior molars and premolars determines the influence of the periapical pathological processes on the sinus mucosa. The thickening of the mucous membrane predisposes to a greater incidence of its perforations in the MS floor elevation surgery [13].

The normal mucosa is about 1 mm thick and over than 2 mm [5] is considered pathological. Lu Y et al. [6] found that, for sinusitis, the thickness of the sinus membrane is greater than 2 mm. Therefore it is considered to be an indicator of presence of sinusitis and is assumed as a pathological condition. In the present study, mucosal thickening was found in more than the half of all measured positions. This frequency is significantly higher than the results reported by other studies [2, 4, 9] but is similar to the percentage found by Shanbhag S et al. [11] and Nurbakhsh B et al. [7].The measured average mucosal thickness is similar to the established thickness in previous studies [4, 5, 9].

Janner et al. [5] found that there is a correlation between sinus membrane thickening and the presence of sinus or periapical pathology. The results of the present study proved the significant relations between the mucosal thickness and the periapical pathological processes. Therefore the pathology appears as a main factor for thickening of Schneiderian membrane. These results are supported by other authors [1, 3, 4, 8, 10].

The frequency of the mucosal thickening increases with progressing of the age and there is significant association between these two indices. We found highest percentage of changes in the age group over 60 years and in the age over 25 years it increases considerably. These results are also confirmed by the study of Lu Yet al. [6] and Goller-Bulut et al. [4]. These researches determined highest percentage (51,2%) of mucosal thickening at the age of 41-60 years. The results are similar to those in our research (52,8%) for the same age group.

In their studies, Sheikhi et al. [12] and Goller-Bulut et al [4] proved that periapical pathological processes as well as greater incidence of mucosal thickening are more common in males. The results in our study confirm that the thickness of the sinus mucosa is higher in males, but there is no statistically significant association between the gender and incidence of mucosal thickening.

Conclusion

Within the limitation of this study it was show that the mucosal thickening of the MS's floor is a condition with high percentage of occurrence. The present study confirmed that there is significant correlation between thickness of the sinus mucosa and age. Periodontal pathology proved to be critical factor for thickening of the Schneiderian membrane. The preoperative evaluation of the mucosal thickness is essential for the correct planning in dental implant treatment and maxillary sinus elevation surgery.

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