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The Use of CBCT Projection for the Schneider Membrane Thickness Analysis

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Abstract

Introduction: *Maxillary sinus is lined with respiratory region mucosa pseudostratified, ciliated epithelium. The Schneider membrane thickness is an important information in diagnosing pathological conditions and planning surgical procedures, e.g. lifting the maxillary sinus floor. To evaluate the condition of paranasal sinuses the radiological diagnosis is used. More and more frequently dental cone beam computed tomography (CBCT) is used.*

Objectives: *The purpose of this investigation was to determine the medium range of the thickness of membrane in patients that frequently attended medical appointments in the Department of Oral Surgery of the Medical University of Warsaw, having undergone the CBCT procedure, and to determine the boundaries of physiological and pathological condition.*

Material and methods: *The analysis of 150 patients CBCT results was performed and 146 patients were qualified to the examination. The medical history was analyzed with particular attention to the symptom characteristic for diseases of paranasal sinuses. The literature of the researchers reviewing the thickness of the sinus mucosa was reviewed and compared with our own results.*

Results: *The average thickness of maxillary sinus mucous membrane in the examined group of patients is 7.8 mm, with 6.83 mm in patients with no symptom of sinus inflammation, and 9.46 mm in patients with at least one symptom. Moreover, the patients with diagnosed recent, recurring or present sinus inflammation, polyps, tonsillar hypertrophy, asthma and Oro-Antral Communication demonstrated a thicker membrane.*

Conclusions: *The literature reports various ranges of physiological thickness of maxillary sinus mucous membrane. Savolainen et al. Defined the pathological thickening as greater than 6 mm, while Phothikhun et al. as exceeding 1 mm. Most often the physiological norm is defined at 2 mm, e.g., Janner et al. In this study the measurements were done, and the results were compared with the*

ones reported in the literature. The majority of examined patients not reporting sinus inflammation the thickness of the maxillary sinus mucous membrane was ≤6 mm. This means that for patients with Schneider membrane thicker than 6 mm the diagnostics should be extended to search for pathologies.

Key words: *cone beam computed tomography, maxillary sinus, mucous membrane, maxillary sinusitis*

Background

Maxillary sinuses (sinus maxillaris) are two twin, pyramid-shaped voids, located in the body of the maxilla.Its walls corresponding to four surfaces of the body of maxilla. In the nasal wall, maxillary hiatus (hiatus maxillaris) that opens into nasal cavity and connects it with maxillary sinus is located. The posterior wall contains alveolar canals and posterior superior alveolar vessels and nerves. The floor is formed by the alveolar process of the maxilla. With a concave shape in the lowest point it corresponds to the roots of the first maxillary molar tooth. The premolar and molar teeth enter with their alveolus top into the sinus floor, whereas the canine alveolar usually heads frontwards. In a case of disappearance of thin osseous cover, teeth roots can come directly in contact with Schneider membrane. Maxillary sinus begins to develop in the fifth month of fetal growth and reaches its maximum size (approx. 24cm^3) at the moment of complete permanent teeth eruption [1]. The sinus has five recesses: frontal recess, superior palatinal recess, inferior palatinal recess, alveolar recess and zygomatic recess [2].

The physiology of maxillary sinuses is closely related to their microanatomy. The mucous lining of the sinus, called Schneider membrane is a pseudostratified, ciliated epithelium. It is the extension of respiratory area of nasal cavity mucous membrane and usually is similar but thinner, paler and containing less glands, goblet cells and cilia [3]. Healthy mucous membrane has thickness of 0.2 to 0.8 mm [4].

The inflammation of maxillary sinus is a disease of the mucous membrane lining with diversified pathophysiology. The following factors can contribute to developing the inflammation: nasal factors, teeth-derived factors, allergic factors, injury-derived factors, blood-derived factors. The inflammation of maxillary sinus is caused primarily by periapical lesions following defective endodontic treatment, complications after dental caries or inflammation of periodontium, complications after extractions such as the Oro-Antral Communication and entrance of the tooth root into the sinus [5].

There are two types of symptoms of the sinonasal inflammation: great and small. To make a diagnosis of paranasal sinuses inflammation it is

necessary to report the presence of at least two symptoms, including at least one great symptom (Tab. 1).

Table 1. Great and small symptoms of sinusitis

GREAT SYMPTOMS	SMALL SYMPTOMS
Nasal congestion	An unpleasant smell from the mouth
Leakage or retention of purulent discharge in the nose or dripping down the back of the throat	Toothache
Pain/pressure on the face	Headache
Impaired smell	Cough
Fever	Pain/fullness/compression of the ear
Swelling/full face	Fatigue

One of the broadly accepted clinical classification of paranasal sinuses inflammations was proposed by Lund et al., dividing those into acute, recurrent acute and chronic inflammations. The classification is based on the time in which the patient suffers from the disease and it includes also pathophysiologic criteria [8].

Schneider membrane thickness is an important information during the diagnosis of pathologic conditions and during scheduling surgical procedures, e.g. lifting the maxillary sinus floor. To evaluate the condition of paranasal sinuses the radiological diagnosis is used – CT (computed tomography) [9] or CBCT (dental cone beam computed tomography) [10,11], diaphanoscopy [12], endoscopy [13] and fluorescent imaging of near-infrared spectroscopy (NIR) [14]. Radiologic images OPG, CBCT and tooth photography made with the right-angle technique contain the information about the quality and the quantity of the tissues, specifically mineralized tissues. The introduction of Hounsfield scale allows to mathematically analyze tissues with low-mineralization level, e.g. bones are classified as IV type (non-mineralized tissue). The scale fluctuates between -1500 and 3000 units [15]. The results reported by Mah et al. proved the possibility of analyzing grayscale tones in CBCT, with the me-

asurement error of only few percents [15]. Nowadays, the gold standard of imaging in the case of nasal and sinuses mucous membrane inflammation is the computed tomography. However, the CBCT method begins to be used with more and more frequency. The examination conducted with this method, with correctly chosen parameters of exposition and correct patient positioning, provides the information about the extent of disease process and allows to diagnose even the smallest changes in the maxillary sinuses. It also exposes the structure of paranasal sinuses in order to reveal distinct parts in the anatomy [16]. Due to smaller exposure to radiation in comparison with spiral tomography, greater accessibility, shorter examination time and lower costs, in this investigation the thickness of membrane of maxillary sinus was analyzed based on CBCT results.

Objectives

The purpose of this investigation was to determine the medium range of the thickness of membrane and possible factors that could affect the Schneider membrane and cause its thickening. Retrospective examination was conducted on the patients that frequently attended medical appointments in the Department of Oral Surgery of the Medical University of Warsaw, and having undergone the CBCT procedure to make a diagnosis. Available references do not state a clear range, nor the borders between the physiology and pathology of the membrane thickness. The cited authors' results oscillate between 1mm to 6mm.

Material and Methods

The analysis of 150 patients of Department of Oral Surgery's CBCT results was conducted. 146 patients were qualified to the examination, 4 persons did not agree to take part in the investigation. Using the i-CAT Vision program, the measuring of the thickness of maxillary sinus mucous membrane was carried out in the CBCT examination in similar conditions. The measured part was located on the level of premolar teeth and first molar teeth on the right and left side. A questionnaire was conducted among the qualified patients, with special emphasis on symptoms of

sinus inflammation: sinus headache symptom, often described as uncomfortable pressure sensation, headache while bending over, mucus dribbling on the throat back wall.

Additionally, factors that could possibly affect the thickness of mucous membrane were investigated: Oro-Antral Communication, operations of paranasal sinuses, earlier diagnosis of pathology in the sinus area (polyps in maxillary sinus), tonsillar hypertrophy, asthma, sex, age, permanent residence location, smoking (Fig. 1).

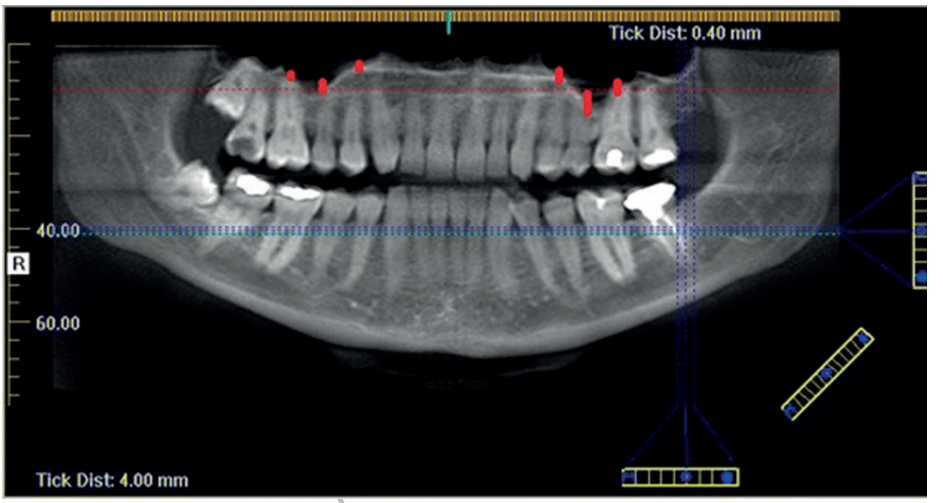

Figure 1 – location of maxillary sinus mucous membrane measurement

Results

As a result of the investigation, two main groups were identified. The first group consisted of patients with no symptom of sinus inflammation. The second group patients with at least one of the symptoms mentioned before.

The average mucous membrane thickness in the examined group of patients is 7.8 mm, with 6.83 mm in the first group and 9.46 mm in the second one.

The median of all the patients – 5.3 mm, patients from the first group – 5.05 mm, patients from the second group – 6.55 mm.

Maximum thickness reported in the first group – 26.2 mm, in the second – 38.9 mm.

Minimum thickness in the first group – 0 mm, in the second group – 1 mm.

In the patients with at least one symptom of sinus inflammation diagnosed, the maxillary sinus mucous membrane was 38.5% thicker compared with patients with no symptoms. Patients who reported sinus headache symptom, often described as uncomfortable pressure sensation, had the membrane thicker by 39.7%, headache while bending over – 33.6%, mucus dribbling on the throat back wall – 13.5% (Tab. 2, Tab. 3, Tab. 4, Tab. 5).

Table 2. Impact of history of sinusitis or presence of at least one symptom of sinusitis on the thickness of maxillary sinus mucosa

Sinusitis or suspicion	Number of respondents	Average thickness of the mucosa
No	92	6.83
Yes	54	9.46
Total	146	7.80

Table 3. Impact of sinusitis symptom in the form of spreading sensation in the face to the thickness of the maxillary sinus mucosa

Feeling of spreading face	Number of respondents	Average mucous membrane thickness
Nie	136	7,59
Yes	10	10,60
Total	146	7,80

Table 4. Impact of sinusitis symptom of headache when bending on the thickness of maxillary sinus mucosa

Headache when bending	Number of respondents	Average thickness of the mucosa
No	118	7.43
Yes, rarely or slight	10	8.32
Yes	18	9.93
Total	146	7.80

Table 5. Impact of the discharge dripping down the back of the throat on the thickness of maxillary sinus mucosa

Discharge dripping down the back of the throat	Number of respondents	Average thickness of the mucosa
No	103	7.50
Yes	43	8.51
Total	146	7.80

Table 6. Impact of past, recurring or present sinusitis on the thickness of maxillary sinus mucosa

Sinusitis past/recurrent/ present	Number of respondents	Average thickness of the mucosa
No	128	7.63
Yes	18	9.01
Total	146	7.80

Both the first and the second group consists of most patients with the membrane thickness of 0 mm to 8 mm (Fig. 2). However, 70% of the patients of the first group demonstrated Schneider membrane thickness no bigger than 6 mm. In the second group of the patients in almost 50% the thickness was more than 6 mm (Fig. 3).

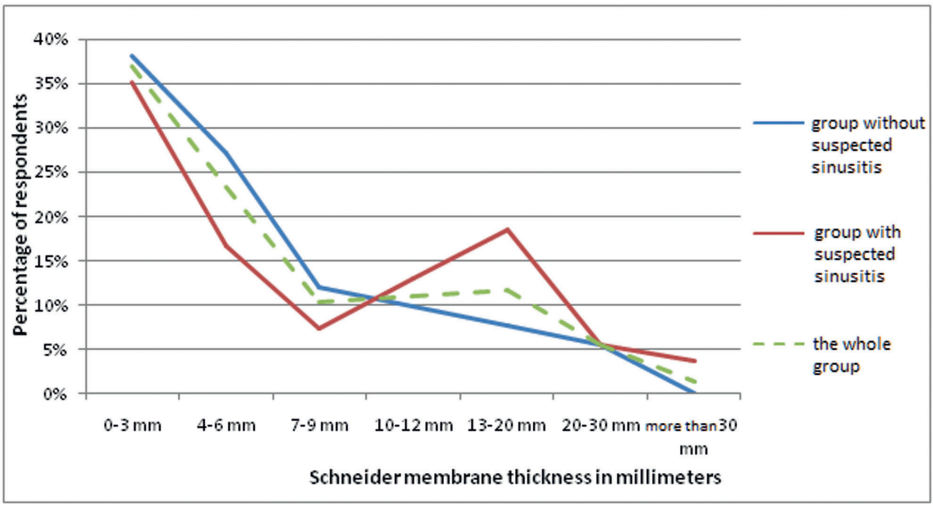

Figure 2. Percentage of the study group presenting a given thickness of Schneider's membrane

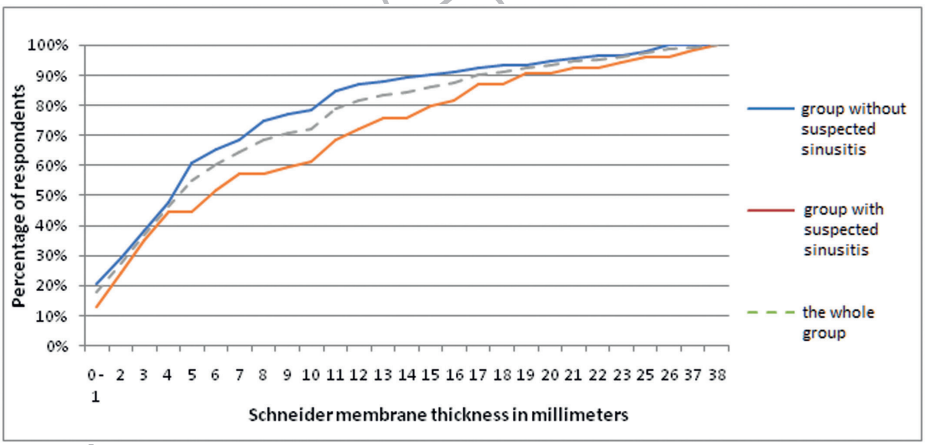

Figure 3. Percentage of patients with Schneider membrane thickness equal or smaller than the given value

The patients with diagnosis of recent, recurring or present sinus inflammation demonstrated the membrane thicker by approx. 1.4 mm on average compared with patients with no inflammation recorded (Tab. 6).

The patients with complications after extraction in form of Oro-Antral Communication demonstrated the membrane thicker by 4.1 mm on average than patients with no complications (Tab. 7).

Table 7. Impact of the complications after extractions in the form of oro-antral communication on the thickness of maxillary sinus mucosa

Complex extractions, oro-antral communication	Number of respondents	Average thickness of the mucosa
No	135	7.49
Yes	11	11.58
Total	146	7.80

The patients with polyps in maxillary sinus demonstrated the membrane thicker by 5.3 mm compared with patients with no polyps diagnosed (Tab. 8).

Table 8. Impact of polyps in the maxillary sinus on the thickness of maxillary sinus mucosa

Polyp	Number of respondents	Average thickness of the mucosa
No	141	7.62
Yes	5	12.88
Total	146	7.80

The examination reports also show that people with tonsillar hypertrophy demonstrated the membrane thicker by 45.6% compared with people with no hypertrophy (Tab. 9).

Table 9. Impact of tonsil hypertrophy on the thickness of maxillary sinus mucosa

Tonsil hypertrophy	Number of respondents	Average thickness of the mucosa
No	126	7,58
Deleted	11	7,64
Yes	9	11,04
Total	146	7,80

Patients with asthma had the Schneider membrane thicker by 1.3 mm than people without this disease (Tab. 10).

Table 10. Impact of asthma on the thickness of maxillary sinus mucosa

Asthma	Number of respondents	Average thickness of the mucosa
No	134	7.69
Yes	12	8.99
Total	146	7.80

Polyp	Number of respondents	Average thickness of the mucosa
No	141	7.62
Yes	5	12.88
Total	146	7.80

The investigation showed no significant correlation between sex and smoking and the Schneider membrane thickness.

The patients from the first group did not demonstrate connection between the thickness and the sex of the patient. In the second group, men had the membrane thicker by 2.41 mm on average (Tab. 11).

Table 11. Impact of gender on the thickness of maxillary sinus mucosa

	Number of respondents		Average mucous membrane thickness
F	All respondents	89	7,29
M		57	8,59
Total amount		**146**	**7,80**
F	Group 1	54	5,83
M		38	8,24
Total amount		**92**	**6,83**
F	Group 2	35	9,54
M		19	9,30
Total amount		**54**	**9,46**

Smokers demonstrated slightly thinner membrane than non-smokers (Tab. 12).

Table 12. Impact of smoking on the thickness of maxillary sinus mucosa

Cigarettes	Number of respondents	Average thickness of the mucosa
No	108	7.86
Yes	38	7.63
Total	146	7.80

The research included also investigating the impact of permanent residence location on the thickness of the Schneider membrane, taking into consideration the population of the town or city. However, in the group of 146 patients, 113 persons lived in Warsaw. This issue is continuously investigated, taking into account more diversified patient groups, including residents from towns of various localization, infrastructure development level and air contamination level.

The biggest medium thickness of alveolar bone mucous membrane was recorded in age groups of 25-30 and 65-70 years. In order to confirm these results, the research should be widened by adding the same number of persons to each age group (Fig. 4).

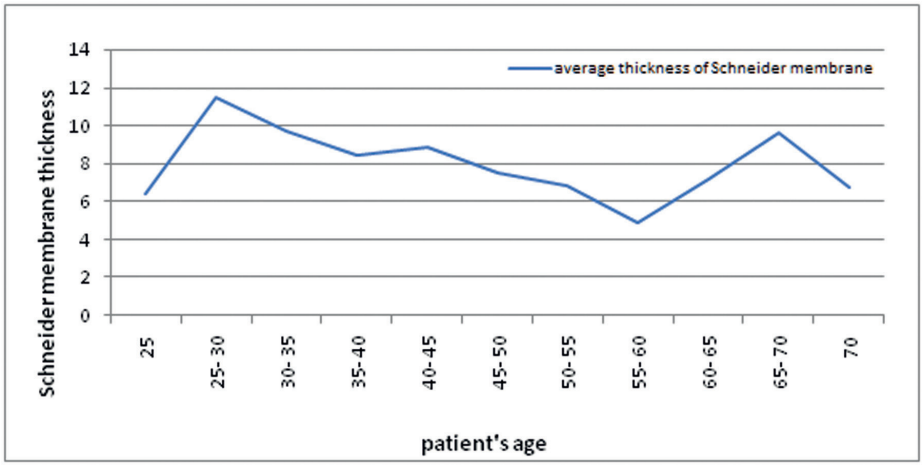

Figure 4. Average Schneider membrane thickness in various age groups.

Discussion

The literature reports various ranges of physiological thickness of the maxillary sinus mucous membrane thickness, from 1 mm to 6 mm: Savolainen et al. defined pathological thickness as greater than 6 mm [17]. Vallo affirms that physiological Schneider wall thickness should measure from 3 mm to 6 mm [18]. Phothikhun et al. stated that pathological thickening is greater than 1 mm [19], so did White [20]. Other authors, such as Janner et al. [21] and Rak KM [22] define the limit of physiological thickness of mucous membrane at approx. 2 mm.

For the majority of patients who took part in the examination and did not report any symptoms of sinus inflammation, the average thickness of maxillary sinus mucous membrane was equal or smaller than 6 mm. This result corresponds to Savolainen et al. observations published in *Radiological findings in the maxillary sinuses of symptomless young men* [17]. It means that patients who report the Schneider membrane thickness greater than 6 mm should be examined in search for pathological changes.

In addition, greater thickness of Schneider membrane was noted in patients who reported symptoms or undergoing sinus inflammation and

alsotonsillar hypertrophy, polyps in the maxillary sinus, asthma and Oro--Antral Communication.

According to Kryst, the definition of sinus inflammation includes a group of medical conditions which all have one feature in common: the presence of inflammatory process in sinonasal mucous membrane [2]. This research showed that patients with diagnosed sinus inflammation (recent, past, present or recurring), demonstrated maxillary sinus mucous membrane thicker by approx. 1.4 mm on average than healthy patients. Also Hryniewicz points out that, proven in a radiologic examination, sinonasal mucous membrane thickening allows to diagnose acute sinonasal inflammation. Responsivity of this method equals 76% [6].

This investigation confirms that patients who had reported tonsillar hypertrophy, demonstrated Schneider membrane thicker by 3.5 mm on average. This fact has its explanation described in the research by Hryniewicz, who states that throat adenoid hypertrophy is a factor that increases the possibility of suffering from development and recurrence of sinus inflammation [6]. In this investigation, the patients with the presence of polyps in maxillary sinus had Schneider membrane thicker by 5.3 mm compared with patients without polyps. According to Maria Zaleska--Krecicka, polyps develop from inflammatory or allergic changes of mucous membrane. The most common localizations of polyps are maxillary sinuses, ethmoid sinuses and middle nasal cavity. The polyp derives from mucous membrane edema, then proliferation of submucosa and cumulation of liquids [23]. Fokkens et al. in his publication confirms that chronic rhinosinusitis with nasal polyps is described as a subgroup of chronic rhinosinusitis. What is more, chronic rhinosinusitis, with or without polyps, are commonly treated as one disease type, as they are almost impossible to distinguish [24]. In our investigation, 5 patients of 146 were diagnosed with polyps, which is approx. 3.5% of patients. It confirms the observation of Fokkens et al., who stated that polyps affect 4% of population. Furthermore, he described the correlation between polyp presence, chronic nasal and sinonasal mucous membrane inflammation, acute bronchial asthma and aspirin intolerance, called “Samter’s triad”, aspirin-induced asthma or

Samter's syndrome. Fokkens points out that 7-15% of asthmatics suffer from nasal polyps. In this investigation, in the group of 12 asthmatics, polyps were diagnosed in 2 persons, which makes 16,7%.

This investigation proved that asthmatics demonstrate thicker Schneider membrane, what is confirmed in Satoshi Hamada et al. observations, described in the article *Radiographic Evidence of Sinonasal Inflammation in Asthma-chronic Obstructive Pulmonary Disease Overlap Syndrome: an Underrecognized*. Satoshi Hamada proved that the frequency of presence of radiologic symptoms of sinus inflammation among people with asthma, ACO and COPD equaled respectively 95.5%, 72.2% and 60%. Patients suffering from ACO and COPD were diagnosed with mild radiologic symptoms, while average to severe symptoms were reported in the cases of people with asthma [25]. E. J. Peters et al. in his research *Sinus computed tomography scan and markers of inflammation in vocal cord dysfunction and asthma* proved the correlation between asthma and sinus disorders in 1/3 of patients [26]. Also M. Bresciani et al. in the publication Rhinosinusitis in severe asthma [27] presented a connection between chronic sinus inflammation and asthma.

This investigation did not prove a direct correlation between smoking and maxillary sinus mucous membrane thickening. However, the publication Microbiology of acute and chronic maxillary sinusitis in smokers and nonsmokers [28] proved that the amount of bacteria causing chronic mucous membrane inflammation and smoking are related. Smokers demonstrated a much higher number of those pathogens. Smoking can directly affect the thickness of maxillary sinus mucous membrane. It is also important to point out that smoking can worsen the condition of people with asthma, what in consequence can lead to thickening of sinus mucous membrane [29].

In order to confirm the relation between sex and mucous membrane thickness it would be necessary to research a wider group of patients. In this investigation, the group of not healthy patients did not demonstrate any connection between Schneider membrane thickness and sex, whereas in the group of healthy patients men showed a thicker membrane

by 2.41 mm on average. This fact can also be noted in the publication by Vogiatzi T et al., *Incidence of anatomical variations and disease of the maxillary sinuses as identified by cone beam computed tomography; a systematic review*, where one of the conclusions is that men usually demonstrate higher frequency of pathological changes in maxillary sinus, including the thicker mucous membrane [30].

The research on the impact of air contamination on Schneider membrane thickness is being carried out currently (Fig. 5).

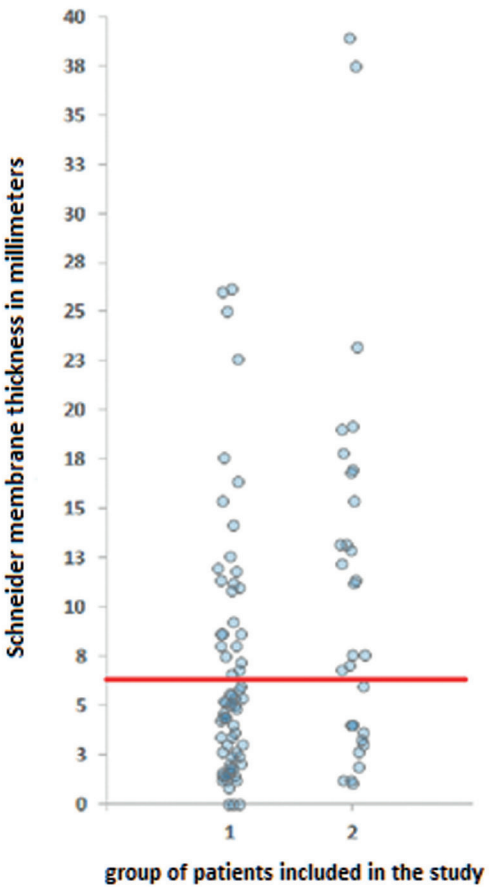

Figure 5. Schneider membrane thickness and suspicion of sinus inflammation

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