Original Article

Thickening of Schneiderian Membrane Secondary to Periapical Lesions: A Retrospective Radiographic Analysis

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ABSTRACT

Aim: The aim of this study was to investigate the possible correlation between adjacent periapical lesions of maxillary teeth and Schneiderian membrane thickness (SMT). **Materials and Methods:** An analytical study of case-control study design was conducted. From the archives, cone beam computed tomography (CBCT) images of 83 patients with periapical lesion in any of the maxillary posterior teeth were randomly selected as the case group. The normal, contralateral teeth in the same patient were considered in the control group. Eighty-eight teeth were considered in each group, comprising a total sample of 176. For each sample in case group, the distance from the border of the periapical lesion to the cortical bone of the bony floor of the maxillary sinus and SMT were measured. SMT on the contralateral side adjacent to the healthy (control) teeth was also measured. Data were presented in mean ± standard deviation and inferential statistics was performed using independent *t* test and analysis of variance (ANOVA). Later Pearson correlation and multiple linear logistic regression were carried out using Statistical Package for the Social Sciences software program, version 21.0 at 95% confidence interval. **Results:** Teeth with periapical lesion were found to have significantly ($P < 0.001$) increased SMT when compared with that of adjacent to healthy teeth. On the contrary, nonsignificant differences were found in SMT when genders and age groups were compared ($P = 0.295$ and 0.060, respectively). A strong negative correlation was observed between distance of the lesion to the sinus and SMT ($P = 0.003$). **Conclusion:** Neighboring periapical lesions of maxillary teeth are associated with SMT that is worsened when the lesion is close to the sinus.

KEYWORDS: *cone beam computed tomography (CBCT), maxillary sinus, periapical lesions, Schneiderian membrane, thickness*

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INTRODUCTION

One of the challenges in dentistry is to place implants in the posterior maxilla when bone density and alveolar bone dimensions are critical.[1] The Schneiderian membrane (SM) is the mucous membrane lining the interior aspect of the maxillary antral cavity. Histologically, it is comprised of an overlaying periosteum with a delicate layer of a pseudostratified ciliated epithelial lining and a vascularized connective tissue. Schneiderian membrane thickness (SMT) is one of the significant factors to be considered during surgical procedures involving sinus-lifting procedures while placing dental implants in that location.[2] Further, SMT is considered a key anatomic factor influencing sinus membrane perforation and subsequent implant failure, with membranes ≥2 mm to be more resistant

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to perforation during surgical instrumentation and placement of graft material.[3]

According to Kim *et al.* 2006, the mesenchymal stem cells from the maxillary sinus membrane have an ability to form the bone tissue, which plays a significant role in sinus floor elevation surgeries. Apart from this, in sinus-lifting surgery, the choice of a crestal approach or lateral window technique relies on the SMT to avoid perforating the SM.[4,5]

SMT can be determined both histologically and radiographically; in healthy individuals, the average thickness of SM is less than 2 mm radiographically. SMT more than 2 mm is regarded as mucosal thickening.[4] The reasons for thickening of this membrane can be odontogenic, such as periodontal or endodontic pathologies, or allergic conditions with the incidence of sinusitis secondary to odontogenic cause to be reportedly approximately 10%–12%.[6] In advanced periodontitis and endodontic pathologic conditions, the closer the inflammation is to the maxillary antrum, the more is the chance for SM thickening. Advanced periodontal diseases may cause swelling of the maxillary sinus membrane that can be reduced significantly by periodontal therapy.[6,7]

Investigating the relationship between the dental pathosis and the SMT may help to identify the best treatment modalities; however, previous studies that investigated the relationship between dental pathosis and SMT had conflicting results.[8-13] To evaluate the relationship between dental lesions and the thickness of the SM in a reliable way, it is necessary to use accurate methods.

The aim of this study is to explore the effect of periapical radiography (PA) lesions on SM thickening and to explore whether related factors of age, gender, and location of the tooth in the arch are correlated with SM thickening. The research is based on the null hypothesis: there is no relationship between PA dental pathosis and SM thickening.

Materials and Methods

Sample and randomization

A number of images were randomly chosen from a total of 635 cone beam computed tomography (CBCT) images at the Department of Radiology at College of Dentistry, Jouf University. CBCT scans were obtained by Scanora 3D Soredex, Tuusula, Finland) using 6 mA and 89 kVp with a grey scale of 1280 × 1024. The CBCT unit takes a 360º rotation for approximately 20 s. Display of the scans and measurements were carried out with the three-dimensional imaging software on the thin-film-transistor 27-inch monitor (OnDemand 3D, Cybermed Co., Seoul, Korea).

The study was ethically approved by the ethical committee of Jouf University (reference number 34–32). This radiographic study was performed according to principles of Helsinki Declaration (9th version, 2013).

The selected images met the following inclusion criteria: patients older than 18 years of age and presence of a periapical, pulpal, or periodontal lesion related to a premolar or molar maxillary tooth at one side of the arch, with sound corresponding tooth at the contralateral side to serve as control.

The exclusion criteria of the study consisted of CBCT images of completely edentulous subjects in the maxilla, patients with implants in the maxilla, a history of an acute trauma to the maxillary sinus, suspected cysts in the posterior maxilla, patients who received bone grafts in the posterior maxilla, history of sinusitis or allergic disease, or patients with no control healthy tooth on the opposite side.

Measurements and reliability

All measurements were performed following a standardized method that was published elsewhere.[8] Distance from border of periapical lesions to adjacent cortical bone plate of the sinus floor was measured [Figure 1]. Thickness of the SM was measured at three different locations opposite to the PA lesion and the average distance was recorded. Intra-examiner reliability was evaluated by repeating measurements of 10 cases. The value of κ was calculated to be 0.89, which was judged as a good agreement. Inter-examiner reliability was measured by having an experienced radiologist to do the measurement again for the same 10 images. The value of κ was found to be approximately 0.87 indicating satisfactory agreement.

Statistical analysis

Images were randomly chosen using Statistical Package for the Social Sciences (SPSS) software program, version 21.0 (IBM Corp., Armonk, NY, USA). Periapical lesions were considered as cases. Comparison between different groups with ratio data was carried out using: *t* test and analysis of variance (ANOVA). Correlations between ratio data were carried out using Pearson correlation. Multiple linear regression analysis was carried out with a stepwise method to explore relationship of membrane thickness with other different variables.

Results

A total of 83 patients (83 CBCT images) were included in the study. There were 78 teeth with one periapical

lesion each and five teeth with two lesions each, resulting in a total of 88 lesions. A total of 88 healthy teeth in the corresponding contralateral side were included. Thirty patients (34.1%) were females and 53 patients (65.9%) were males. Mean age of the study sample was 44.8 ± 13.6 years. Mean age of females was 43.2 ± 14.1 years and for males was 45.6 ± 13.5 years [Table 1].

In 50% of cases with periapical pathology (n = 44), there was an associated membrane thickening. SMT adjacent to radiolucent periapical lesions was measured to be 0–8 mm. Membrane thickness at control side (with no associated periapical radiolucency) was measured to be 0–5 mm. Distance of the radiolucent periapical lesion to the floor of the sinus was measured to be 1–6 mm with the majority being 3 mm (n = 29, 33%). Average membrane thickness adjacent to periapical lesions (2.45 ± 2.58) was significantly higher than that adjacent to healthy teeth on control side (0.78 ± 1.29) (P < 0.001) [Figure 2].

Figure 1: Cropped coronal section of cone beam computed tomography showing periapical lesion associated with right maxillary first molar. Section also shows Schneiderian membrane thickness adjacent to the periapical lesion

No significant differences were found in SMT adjacent to periapical lesions when genders or age groups were compared [Table 2].

Most of the teeth affected with periapical lesions were first molar teeth (n = 42, 47.7%), followed by second molars (n = 17, 19.3%), first premolars (n = 15, 17%), and second premolar (n = 14, 15.9%). Results also indicated no significant differences in membrane thickness when the location in the arch of related tooth (i.e., teeth: #4, #5, #6, or #7) was considered [Table 3].

Regression analysis of membrane thickness as dependent variable, with a stepwise method with variables of age, gender, location in the arch, and distance from sinus, excluded all variables except distance between lesion and sinus [Table 4].

Regression analysis also indicated that Pearson correlation (r = –0.286) between membrane thickness and distance between periapical lesion and sinus was found to be significant (P = 0.007) [Table 5]. R^2 was

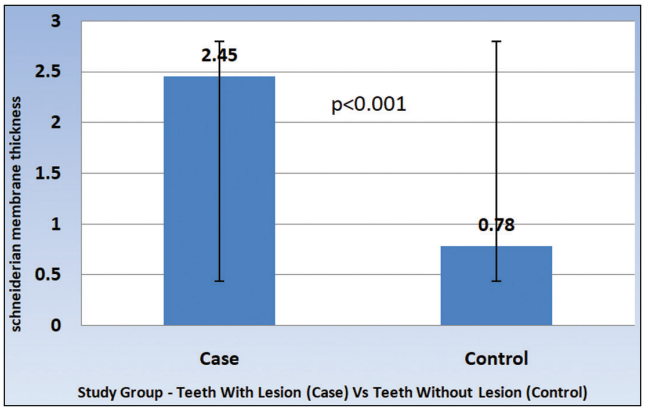

Figure 2: Comparative evaluation of average membrane thickness between the study groups

Table 1: Sample characteristics

Variable	No. of patients examined (n)	No. of teeth examined with lesions (n)	No. of teeth examined without lesions (n)
Sample size	83	88	88
		N (%)	Mean ± SD
Gender	Female	30 (36.14)	43.2 ± 14.1
	Male	58 (69.87)	45.6 ± 13.5

SD = standard deviation

Table 2: Comparison of Schneiderian membrane thickness adjacent to periapical lesions according to gender and age

Variable		*N**	Mean	SD	SEM	*P* Value
Gender	Female	30	2.066	2.347	0.428	0.293
	Male	58	2.655	2.685	0.352	
Age groups	≥50 years	33	3.121	2.666	0.464	0.060
	<50 years	55	2.054	2.460	0.331	

SD = standard deviation, SEM = standard error of mean

*The number of periapical lesions (total of 88) in the 83 subjects

Table 3: Schneiderian membrane thickness in relation to region in the arch

Region in the arch	*N**	Mean	SD	SEM	95% CI for mean		Min	Max	*P* Value
					Lower bound	Upper bound			
First premolar	15	1.6	2.4	0.62	0.279	2.920	0	6	0.416
Second premolar	14	3.2	2.6	0.70	1.692	4.736	0	6	
First molar	42	2.5	2.5	0.39	1.720	3.279	0	6	
Second molar	17	2.5	2.9	0.70	0.992	3.948	0	8	
Total	88	2.5	2.6	0.27	1.908	3.000	0	8	

SD = standard deviation, SEM = standard error of mean, CI = confidence interval

*The number of periapical lesions (total of 88) in the 83 subjects

Table 4: Correlation matrix of dependent and independent variables (*n* = 88)

Variables*	SMT	Age	Gender	Tooth position	Distance from sinus
	Pearson correlation coefficient (*P* value)				
SMT	1.000	–	–	–	–
Age	0.171 (0.056)	1.000	–	–	–
Gender	0.109 (0.156)	0.083 (0.220)	1.000	–	–
Tooth position	0.070 (0.259)	–0.003 (0.490)	0.292 (0.003)	1.000	–
Distance from sinus	**–0.286 (0.003)**[a]	0.019 (0.429)	–0.234 (0.014)[b]	–0.499 (0.000)[c]	1.000

SMT = Schneiderian membrane thickness

*Excluded variables: age, gender, and tooth number

[a]$P < 0.01$

[b]$P < 0.05$

[a]$P < 0.001$

Table 5: Results of analysis of variance (ANOVA) showing significance level of the model

	Sum of squares	Df	Mean square	*F*	*P* Value
Regression	47.121	1	47.121	7.636	0.007[a]
Residual	530.697	86	6.171		
Total	577.818	87			

Df = degree of freedom

[a]$P < 0.01$

Table 6: Coefficients related to regression model with membrane thickness as the dependent variable

Model	Unstandardized coefficients		*R*[a]	R^2	Standardized coefficients	*t*	Sig.	95% Confidence interval for *B*	
	B	Std. error			β			Lower bound	Upper bound
Const.	4.304	0.720				5.98	0.000[b]	2.873	5.734
Distance from sinus	–0.559	0.202	0.241	0.672	–0.286	–2.763	0.007[c]	–0.961	–0.157

[a]$P < 0.05$

[b]$P < 0.01$

[a]$P < 0.001$

found to be 0.082, showing that only 8.2% of the variance in membrane thickness can be accounted for by variation in distance of the lesion to the membrane.

Table 6 shows coefficients of the regression model. The model predicts that when distance from the lesion to the sinus is 0 mm, membrane thickness is expected to be 4.304 mm, and with each incremental increase in the distance from the lesion to the sinus by 1 mm, membrane thickness is expected to decrease by 0.559 mm.

Discussion

A thorough knowledge of the anatomy of maxillary antrum and its anatomical variations is necessary for precise and successful surgical treatment in the posterior aspect of the upper jaw by preventing potential complications.[14,15] This study was conducted in a geographic region known for the high prevalence of advanced carious lesions and retained roots with the inevitable need for extractions and replacement of teeth by advanced restorative solutions such as implants.[16] Despite the aforementioned fact, to the best of our search, no studies have been published studying the relationship of Schneiderian membrane with the periapical region on Saudi population, especially in the northern region. Another rationale for choosing the current population for the study was also an attempt made toward having a homogenous sample, as the race can be one of the confounding variables. Unfortunately, it is also well established that dental patients in this area develop periapical lesions at a high prevalence and at a relatively young age.[17] Further, recent studies reported the high prevalence of certain maxillary sinus-related changes such as pneumatization,[18] which could also be a contributing factor to the anticipated complications in surgeries involving the upper jaw. This study also outscores previous studies,[2,8] which were conducted on different population, by recruiting same patient for case as well as control. By doing so, the potential influence of crucial confounding factors such as medical status and bone quality of the participants was nullified. Preoperative evaluation and assessment of the SMT is essential to plan the surgical therapies in the close vicinity of the membrane, such as a sinus lifting, which enhances the chances of perforation of the SM or any other related complications.[19]

Various conventional and advanced radiographic imaging methods were used to evaluate the SMT; these techniques include magnetic resonance imaging, multislice computed tomography, and conventional PA. CBCT is an advanced imaging technique and has been commonly used nowadays while placing dental implants, maxillofacial surgical procedures, orthodontic treatment, and evaluation of periodontal treatment planning.[20] It has been reported that the results of hard tissue evaluation with the CBCT technique are comparable to those carried out when using CT and conventional radiographic techniques. Moreover, CBCT images are effective in revealing the etiology and relationship between odontogenic pathologic lesions and sinus involvement.[12,15]

Considering these benefits, CBCT was used in this study to evaluate the radiographic thickness of the SM and the relationship between changes in SMT and periapical pathologies.

Comparing the thickness of the membrane between the two genders, we did not find any significant difference similar to the some studies,[8] whereas other researchers found that males have thicker membranes than females.[2,21-24] Variations between different studies regarding gender differences can be explained by the influence of other confounders that could play a role such as ethnicity and environmental factors.

In this study, no statistically significant difference was found between SMT and age. This finding was similar to several previous studies,[2,21,22,25] which confirms that SMT is not correlated to age; however, it is correlated to inflammatory lesions in close proximity to the sinus. Compared to average SMT of less <1 mm adjacent to healthy teeth, the average SMT associated with adjacent PA lesions was approximately 2.5 mm, which is considered a thickened SM. Similar to the results of this study, various authors noted that the presence of periapical infection resulted in an increase in SMT. Previous literature reported that the presence of periapical infection resulted in an increase in the thickness of the mucosa in 38.1%–83.2% of cases.[9-12] This correlation was confirmed by Eggmann *et al.*[26] who reported in their systematic review that periapical lesions in the maxillary posterior aspect, but not periodontal pathology, are correlated with SMT. Further, Dagassan-Berndt *et al.*[27] noted that although clinical signs of periodontal destruction were not associated with SMT in dentulous individuals, periapical pathologies and the distance from root tips to the maxillary antrum showed a significant correlation.

However, Khorramdel *et al.*[8] observed a significant correlation between periapical as well as periodontal pathologies and SMT. In this study we found a correlation between the distance from sinus and thickening of SM with a cutoff point of 2.9 mm. Furthermore, a significant relationship was found between the thickness of the SM and the distance between the floor of the maxillary antrum and the apex

of the roots.[8] Similarly, Hsu *et al.*[4] observed in their study that decreased distance between the infection and floor of maxillary antrum leads to thickening of SM.

This is confirmed by the results of the regression analysis conducted in this study and these points out to the importance of the distance of the lesion from the sinus. As the distance increases, membrane thickness decreases. This shows that membrane thickening is mediated by the inflammatory process within the periapical lesion.

Conclusion

Thickness of SM is directly correlated with periapical pathologies. As distance is decreased, this correlation becomes more significant. More research is necessary to investigate the influence of other significant local and systemic cofounders such as pneumatization and nutritional status.

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Conflicts of interest

There are no conflicts of interest.

Author contributions

Dr. Mohammed G. Sghaireen was involved in study conception, data collection, data acquisition and analysis, data interpretation, manuscript writing and other roles. He is the sole author of this manuscript.

Ethical policy and institutional review board statement

The study was ethically approved by the ethical Committee of Jouf University (reference number 34–32). This radiographic study was performed according to Principles of Helsinki Declaration (9th version, 2013).

Patient declaration of consent

The current study involving human participants was reviewed and approved by the ethical board at Jouf University (reference number 34–32). Written informed consent for participation was taken for this study in accordance with the national legislation and the institutional requirements. The data collected from this research is solely for the research and educational purposes.

Data availability statement

The data set used in the current study will be made available on request from Dr. M. G. Sghaireen; dr.mohammed.sghaireen@jodent.org.

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