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Influence of Periapical Lesion Sizes on Different Types of Maxillary Sinus Pathosis using Cone Beam Computed Tomography: A Retrospective Study

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Abstract: **Maxillary sinus (MS) pathosis may have various origins, including odontogenic origin. This study aimed to correlate between MS pathosis and size of periapical lesions (PLs) related to maxillary posterior teeth by evaluating cone-beam computed tomographic (CBCT) images obtained from an archived collection.** ***Methods:*** **The study sample was composed of Maxillary posterior CBCT scans of consecutive patients aged above 18 years having MS pathosis, scans were evaluated retrospectively for the presence of PLs. Sinus pathosis were categorized as mucosal thickening, sinus polyp, antral pseudocyst, nonspecific opacification, periostitis and antral calcification. Periapical radiolucencies were categorized utilizing the CBCT periapical index (CBCTPAI), and the distance between the MS floor and the PL superior border was measured. Data were analyzed at a level of significance set at p<0.05.** ***Results:*** **There was a statistically significant relation between type of MS pathosis and size of PL, mucosal thickening tended to occur more in case of PL with large dimension (score 4 or more), however, sinus polyp tended to occur more in case of PL with small dimension (score 3 or less). There was a high statistically significant difference between the means of PL sizes associated with different types of MS pathosis.**

Keywords: **Cone Beam Computed Tomography, Maxillary sinus pathosis, Odontogenic sinusitis, Periapical lesion.**

1. INTRODUCTION

The bone between the maxillary sinus (MS) and the teeth roots gets thinner in the second premolar and molar area, and the apices of these teeth roots may be situated just below the MS mucosa. A mean distance of about 1.97 mm between the MS floor and the adjoining maxillary posterior teeth roots has been described *(Shahbazian M, Jacobs R, 2012)*.

This close anatomic proximity of the sinus floor to the maxillary posterior teeth root apices offers a potential mechanism for the spread of periapical and periodontal infection to the MS causing inflammatory changes within its mucosal lining and, eventually, the development of odontogenic maxillary sinusitis *[(Lu Y, et al, 2012), (Maillet M, et al, 2011)]*.

Proper interpretation of cone beam computed tomography (CBCT) images of MS is essential before implant planning, diagnosis of lesions in posterior maxilla or extraction of impacted teeth. This process was described as odontogenic sinusitis which accounts for about 10–12 % of all of the maxillary sinusitis cases *[(Brook I, 2006), (Mehra P, Murad H, 2004)]*. The reported rates of prevalence of maxillary sinusitis of odontogenic origin vary, ranging from 10 to 86% *[(Duan X, et al, 2012), (Maillet M, et al, 2011), (Shahbazian M, Jacobs R, 2012), (Ritter L, et al, 2011), (Phothikhun S, et al, 2012)]*.

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The normal sinus mucosa is not apparent on conventional radiographs. However, when the mucosa gets irritated from either an allergic or an infectious process, it may increase in thickness and become evident on CBCT images. Mucosal thickness more than 2 mm is most likely pathological *(Lu Y, et al, 2012).*

A precise diagnosis of odontogenic maxillary sinusitis is important, since the causes and treatments for this disease vary from those for another forms of maxillary sinusitis. If the underlying dental disease is not diagnosed, treatment of odontogenic sinusitis will not be successful *[(Shahbazian M, Jacobs R, 2012), (Legert KG, et al, 2004), (Nair UP, Nair MK, 2010)]*.

CBCT is reliable for the assessment of structures in the maxillofacial region, which includes the MS and periapical alveolar bone changes *[(Lu Y, et al, 2012), (Phothikhun S, et al, 2012), (Brüllmann DD, et al, 2012)]*.

Several studies have evaluated the prevalence of odontogenic MS pathosis using CBCT images *[(Lu Y, et al, 2012), (Maillet M, et al, 2011), (Ritter L, et al, 2011), (Brüllmann DD, et al, 2012)]*. These studies only assessed prevalence of odontogenic sinus lesions, however, up to our knowledge the relationship between the MS pathosis and the periapical lesions (PLs) of the maxillary posterior teeth were not assessed individually. Thus, the aim of our study was to correlate between MS pathosis and size of PLs related to maxillary posterior teeth using CBCT.

2. PATIENTS & METHODS

Case selection:

This retrospective study was approved by the ethics committee, Faculty of Dentistry, Ain Shams University. Maxillary posterior CBCT scans of consecutive patients aged above 18 years with MS pathosis were collected from the database at the Oral and Maxillofacial Radiology department, Faculty of Dentistry, Ain Shams University, between November 2017 and November 2018. Selected CBCT scans were indicated for impacted teeth or implant planning in the anterior maxilla. CBCT scans of the maxillary posterior teeth of patients having at least second premolar, first and second molars were included in this study.

Patients with one or more maxillary posterior implants, one or more embedded or impacted posterior teeth or with beam hardening artifacts were excluded from this study. Finally, scans of 70 MSs were included.

All CBCT scans were acquired using i-CAT next generation (Imaging sciences International, Hatfield, PA, USA). The images were analyzed using On Demand software (On demand 3D™, Cybermed, Seoul, South Korea).

MS pathosis were classified according to Nunes et al, 2016 into the upcoming groups:

Mucosal thickening *(Figure 1):* { area with soft tissue density, thickness >2 mm, parallel to sinus bone wall}, sinus polyp *(Figure 2)*: { region with soft tissue density forming a fold (an extension) adjacent to thickened MS mucosa}, antral pseudocyst *(Figure 3)*: { region with soft tissue density and no mucosal thickening}, nonspecific opacification { soft tissue density, total or partial *(Figure 4)* homogeneous MS opacification}, periostitis: { new bone may take the form of one or more thin radiopaque lines (laminated) or the line may be thick, adjacent to cortical bone of MS floor, above radiolucent area associated with the tooth apex} and antrolith (antral calcification) { solitary or multiple well-defined radiopaque masses}.

Then maxillary posterior teeth were examined carefully on the cross-sectional and axial images and were classified depending on the dimensions of the PLs according to *Estrela C, et al*:

A 6-point {0–5} scoring system:

- Score 0= intact periapical bone structures.
- Score 1= periapical radiolucency (PR) with the major dimension of 0.5 mm–1.0 mm.
- Score 2= PR with the major dimesnion of 1 mm–2 mm.
- Score 3= PR with the major dimension of 2 mm–4 mm.
- Score 4= PR with the major dimesnion of 4 mm–8 mm.
- Score 5= major dimension >8 mm.

In the present study, size of the PL was calculated by measuring the mesio-distal, bucco-lingual, and vertical dimensions of the lesion and recording the greatest measurement as the lesion size. Axial images were used to measure bucco-lingual and mesio-distal dimensions of the PL, while cross-sectional images were used to measure the vertical dimension of the PL. In cases where buccal and/or palatal cortical border(s) of PL was/were destructed, measurement of the BL dimension was not achievable, and thus score D (cortical destruction) was used to refer for BL dimension and size of the lesion was calculated as the greatest measurement of the mesio-distal and vertical dimensions. The size of PLs related to maxillary posterior teeth was given a score according to CBCT periapical index (CBCTPAI) *(Estrela C, et al, 2008)*. If the patient had more than one PL, the largest was evaluated.

Evaluation of the images:

Two oral radiologists with 16 and 18 years of experience viewed the CBCT images. The observers modified the contrast, magnification, brightness and sharpness for each image for proper visualization and measurement. Images were viewed in the cross-sectional, axial, coronal, and sagittal images. Measurements of PLs were performed on cross-sectional and axial images. Both observers repeated all measurements two weeks later, data were collected and tabulated using Microsoft Excel spreadsheet.

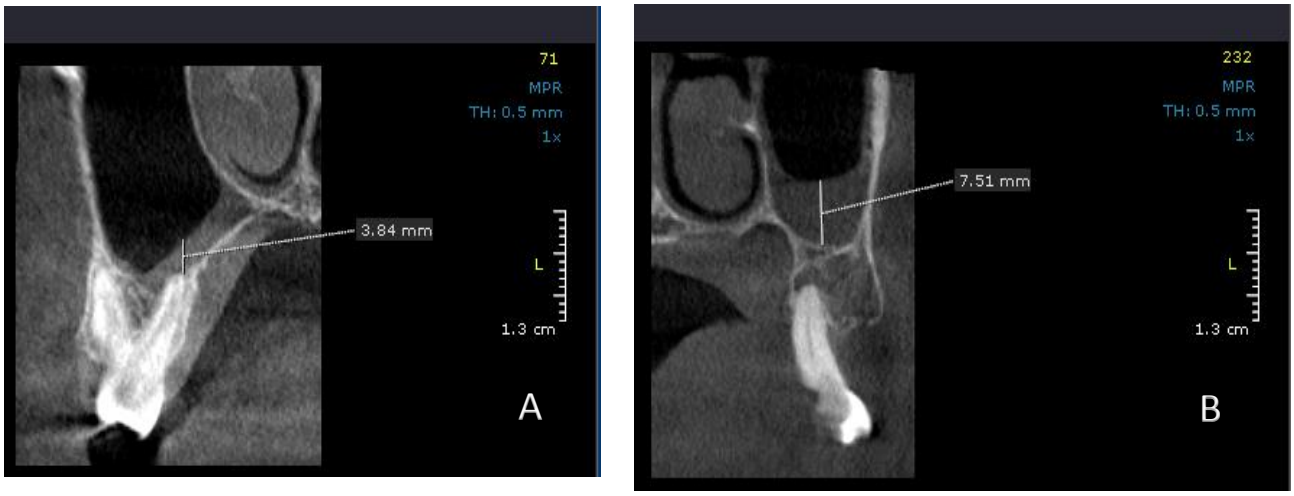

Fig (1): CBCT Cross-sectional images showing mucosal thickening (area with soft tissue density, thickness >2 mm, parallel to sinus bone wall) in absence (A) and presence (B) of PL.

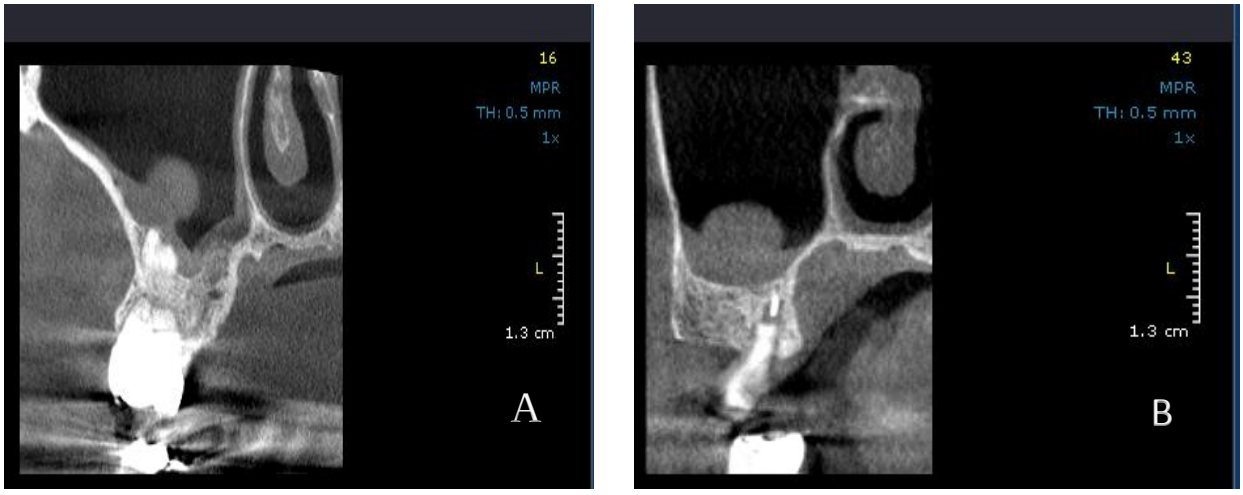

Fig (2): CBCT Cross-sectional image showing MS polyp (region with soft tissue density forming a fold adjacent to thickened MS mucosa) in absence (A) and presence (B) of PL.

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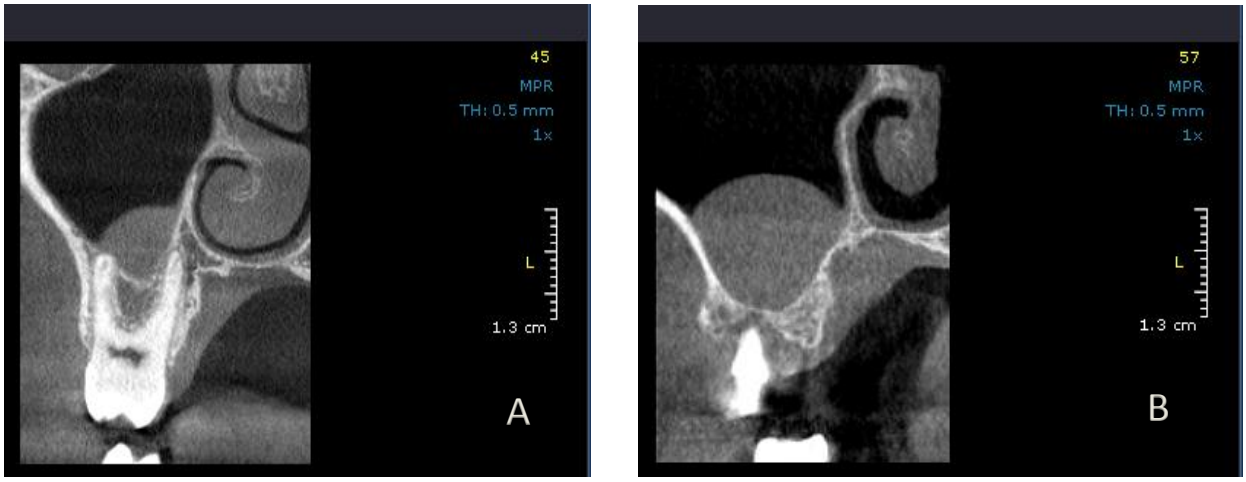

Fig (3): CBCT Cross-sectional image showing antral pseudocyst (region with soft tissue density and no mucosal thickening) in absence (A) and presence (B) of PL.

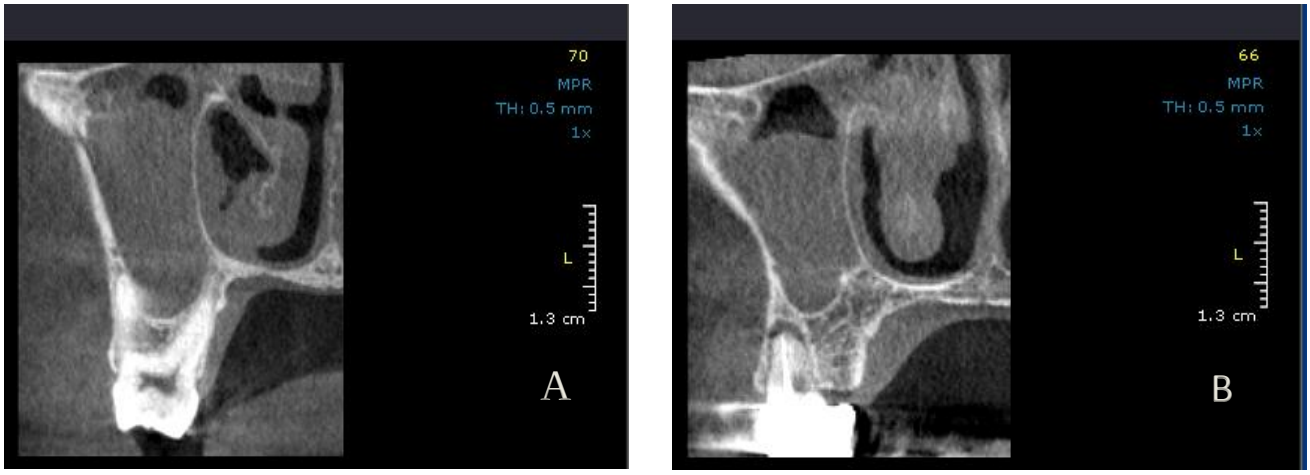

Fig (4): CBCT Cross-sectional image showing non specific opacification (partial homogeneous MS opacification) in absence (A) and presence (B) of PL.

3. RESULTS

The data were statistically analyzed using IBM® SPSS® Statistics Version 17 for Windows. Quantitative variables were described by the mean, standard deviation (**SD**), the range (minimum-maximum), and 95% confidence interval of the mean. The statistical significance of the relation between type of MS pathosis and size of PL were evaluated using the Chi square test. Fisher exact test was used to compare between two types of MS pathosis in relation to size of PL. One way analysis of variance was used for comparing difference between the means of recorded PLs major dimension in three groups or more. Multiple comparisons between the means of PL size associated with different types of MS pathosis were carried out using Bonferroni method. Values of $p<0.05$ were considered statistically significant (**S**) while for $P < 0.01$ were considered highly significant (**HS**).

Regarding intra and inter-observer agreement of measurements, ICC (Intraclass correlation coefficient) was used, a value of one corresponds to perfect agreement and a value of zero corresponds to no agreement. Regarding the size of PL the intra-observer reliability was excellent (ICC=0.90) and the inter-observer reliability was very good (ICC=0.83). Concerning the distance between MS floor and superior border of PL, both the intra and inter-observer reliability was excellent [(ICC=0.92) and (ICC=0.90) respectively].

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Our results showed a statistically significant relation between type of MS pathosis and size of PL according to Chi squared test, however, this test was not appropriate since many readings had zero frequency so two types were compared considering score 3 or less against 4 or more by applying Fisher Exact test. It was found that mucosal thickening tended to occur more in case of PL with large dimension (score 4 or more), however, sinus polyp tended to occur more in case of PL with small dimension (score 3 or less) with high statistically significant difference.

Frequency of different types of MS pathosis associated with PLs, with their corresponding mean value of major PL dimensions was recorded [Table (1)]. One way analysis of variance revealed that there was a high statistically significant difference between the means of PL major dimensions (sizes) associated with different types of MS pathosis.

Comparing the means of PL size associated with different types of MS pathosis; our results showed that there was a high statistically significant difference between the means of PL size associated with mucosal thickening and sinus polyp, i.e mean of PL size associated with mucosal thickening was greater than that associated with sinus polyp [by 2.65] with high statistical significance. On the other hand there was no statistically significant difference between the means of PL size associated with non specific opacification (partial) and mucosal thickening as well as between the means of PL size associated with non specific opacification (partial) and sinus polyp [Table (2)].

Table (1): Descriptive statistics of the size of PL [by major dimension] associated with different types of MS pathosis.

	N	Mean	SD	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Mucosal thickening	24	6.70	1.27	6.17	7.24	4.43	8.79
Sinus polyp	5	4.05	2.24	1.27	6.83	1.91	7.74
Antral pseudocyst	1	7.40	.	.	.	7.40	7.40
Non specific opacification Partial	3	6.38	2.02	1.37	11.39	4.05	7.60

Table (2): Multiple Comparisons Bonferroni Method.

		Mean Difference	P Value	95% Confidence Interval		
				Lower Bound	Upper Bound	
Mucosal thickening	**Sinus polyp**	2.65	0.00348	0.78	4.52	**P< 0.01**
Non specific opacification Partial	**Mucosal thickening**	0.32	1.00000	-2.01	2.65	**P> 0.05**
Non specific opacification Partial	**Sinus polyp**	-2.33	0.12487	-5.11	0.45	**P> 0.05**

P < 0.01 Highly significant

P > 0.05 Non significant

4. DISCUSSION

MS may show abnormalities such as mucosal thickening, polyps, antral pseudocysts, antrolith and opacification. There is no agreement about how thick the mucosal lining of the sinus should be to be considered as mucosal thickening, a range of values from 2-6 mm was considered as mucosal thickening in different studies *[(Rege IC, et al, 2012), (Bornstein MM, et al, 2012)]*. Location of MS is of great dental importance due to its close proximity to root apices of maxillary posterior teeth, thus, sometimes the extraction of these teeth may cause oroantral fistula, also the placement of an implant in this area may lead to injury of sinus floor if there were no sufficient bone height.

As a result of the close anatomic proximity of upper posterior teeth to floor of sinus with an average distance of 1.97 mm *[(Lu Y, et al, 2012), (Maillet M, et al, 2011)]*, and bone thickness between sinus floor and tooth roots which gets thinner in second premolar and molar area to the extent that apices of upper posterior teeth may be situated just under the sinus mucosa *(Shahbazian M, Jacobs R, 2012)*, hence, spreading of dental diseases into the antrum may occur *(Kasikcioglu A, Gulsahi A, 2016)* and odontogenic MS pathosis may be suggested.

Mucosal thickening, polyps, retention cysts, sinusitis and luminal opacification can be observed in the MS in relation to tooth periapical infection *[(Ritter L, et al, 2011), (Phothikhun S, et al, 2012), (Brüllmann DD, et al, 2012), (Vallo J, et al, 2010)]*. Conversely, tooth roots which are near or situated in the sinus may also be affected by MS infections *(Kasikcioglu A, Gulsahi A, 2016)*. And so the aim of our study was to correlate between MS pathosis and PLs related to maxillary posterior teeth using CBCT.

In our study, we used CBCT for examining the MS and detection of PLs in accordance with several authors *[(Nunes CA, et al, 2016), (Kasikcioglu A, Gulsahi A, 2016), (Maillet M, et al, 2011), (Goller-Bulut D, et al, 2015), (Rege IC, et al, 2012), (Low KM, et al, 2008), (Khorshidi H, et al, 2016), (Luz J, et al, 2018)]*, counter to usage of computed tomography by Guerra-Pereira et al *(Guerra-Pereira I, et al, 2015).* CBCT is considered reliable and accurate for the assessment of structures in the maxillofacial area, including the MS and PLs *[(Lu Y, et al, 2012), (Phothikhun S, et al, 2012), (Brüllmann DD, et al, 2012)]*. It provides an accurate assessment of maxillary bone around root apices of posterior teeth without the superimposition resulted from teeth and the surrounding structures *[(Kilic C, et al, 2010), (Ardakani FE, et al, 2015)]* and allows measuring the size of the PL and determining its exact location in relation to the sinus and other structures.

The use of CBCT enabled analyses of 3D volume and examination of MS in all the orthogonal planes in order to detect sinus pathosis and determine its type. The advantages of CBCT scanning over the CT (for example; low cost, less radiation dose and less metal artifacts) may justify its use in MS imaging *(Shanbhag S, et al, 2013)*.

We chose CBCT scans that showed sinus pathosis, patients over 18 years old were selected to ensure complete MS development, also certain abnormalities such as opacification and mucosal thickening are common findings in early childhood which don't indicate sinus disease *(Rege IC, et al, 2012)*.

Patients with missing second premolar, first and second molars were excluded to avoid sinus pneumatization *(Sharan A, Madjar D, 2008)*, also patients having impacted and embedded teeth were excluded to avoid other factors that may affect sinus floor. CBCT scans that were showing one or more implants in the maxillary posterior area or those that showed beam hardening artifacts in this area were excluded from the study for proper visualization and evaluation of this region and to avoid faulty determination of lesion measurements *[(Lu Y, et al, 2012), (Rege IC, et al, 2012), (Maillet M, et al, 2011)]*.

MS abnormalities that were observed on CBCT scans in this study were classified according to *(Nunes CA, et al, 2016)* into mucosal thickening, sinus polyp, antral pseudocyst, opacification (partial and total), periostitis and antrolith. We considered mucosal thickening to be greater than 2 mm, similarly some previous studies considered same value for mucosal thickening *[(Janner SF, et al, 2011), (Shanbhag S, et al, 2013), (Lu Y, et al, 2012)]*, however, Nunes et al and Rege et al recorded mucosal thickening when the mucosa was greater than 3 mm thick *[(Nunes CA, et al, 2016), (Rege IC, et al, 2012)]*. Studies done by Low et al and Obayashi et al considered membrane thickening to have occurred only when the thickness was greater than 4 mm *[(Low KM, et al, 2008), (Obayashi N, et al, 2004)]*.

On CBCT images PL appears as a radiolucent region associated with the apex of tooth which shows thickness of at least double that of the periodontal ligament *(Low KM, et al, 2008)* or only as a radiolucent region surrounding the apex of tooth suggestive of bone destruction and undetectable or irregular lamina dura *(Rege IC, et al, 2012)*. In this study, CBCTPAI has been utilized to identify PL size using CBCT based on scores defined according to the dimension of the radiolucent region. Its use is advantageous in the determination of PL size because of measuring the lesion in three anatomic planes of reference on the 3D image provided by CBCT imaging yielding a more precise analysis of the size of PL *(Estrela C, et al, 2008)*.

Concerning the relation between "type of MS pathosis" and "size of the PL", in the present study, there was a high statistically significant difference between the means of PL major dimension (size) associated with different types of MS pathosis. Our results showed that mucosal thickening tends to occur more in case of PL with large dimension (score 4 or more) than in case of PL with small dimension (score 3 or less), however, sinus polyp tends to occur more in case of PL with small dimension (score 3 or less) than in case of PL with large dimension (score 4 or more) with high statistically significant difference. In contrast, Nunes et al found that there were no significant differences between CBCTPAI scores 1, 2, 3, and 4 (different PL sizes) and the absence or presence of MS changes, although, when the PL dimension was greater than 8 mm, all MSs showed abnormalities (Nunes CA, et al, 2016).

However, studies made by Lu et al and Goller-Bulut et al showed similar results to our study where a positive correlation between the incidence and severity of sinus mucosal thickening with the degree of apical periodontitis was found; the prevalence of mucosal thickening of the MS increased dramatically with the size of PL. This may be due to invasion of the sinus by bacteria and toxins present in apical lesions directly via the porous maxillary bone or indirectly through blood and lymph vessels *[(Sheikhi M, et al, 2014), (Jung YH, Cho BH, 2012)]*, thus infecting the mucosa of the antrum. An increase in the amount of bacteria and toxins leads to an increase in the severity of PL and so increases the likelihood of mucosal thickening of MS. However, when the PL size was limited, the prevalence rate of MS mucosal thickening appeared to be unaffected *[(Lu Y, et al, 2012), (Goller-Bulut D, et al, 2015)*].

5. CONCLUSIONS

Our study concluded that a positive correlation between type of MS pathosis and size of PL was found, thus the size of a PL influenced the type of sinus abnormality.

REFERENCES

[1] Ardakani FE, Razavi SH, Tabrizizadeh M. Diagnostic value of cone-beam computed tomography and periapical radiography in detection of vertical root fracture. Iranian endodontic journal. 2015;10(2):122.

[2] Bornstein MM, Wasmer J, Sendi P, Janner SF, Buser D, Von Arx T. Characteristics and dimensions of the Schneiderian membrane and apical bone in maxillary molars referred for apical surgery: a comparative radiographic analysis using limited cone beam computed tomography. Journal of endodontics. 2012 Jan 1;38(1):51-7.

[3] Brook I. Sinusitis of odontogenic origin. Otolaryngology-Head and Neck Surgery. 2006 Sep 1;135(3):349-55.

[4] Brüllmann DD, Schmidtmann I, Hornstein S, Schulze RK. Correlation of cone beam computed tomography (CBCT) findings in the maxillary sinus with dental diagnoses: a retrospective cross-sectional study. Clinical oral investigations. 2012 Aug 1;16(4):1023-9.

[5] Chanavaz M. Maxillary sinus: anatomy, physiology, surgery, and bone grafting related to implantology--eleven years of surgical experience (1979-1990). The Journal of oral implantology. 1990;16(3):199-209.

[6] Estrela C, Bueno MR, Azevedo BC, Azevedo JR, Pécora JD. A new periapical index based on cone beam computed tomography. Journal of endodontics. 2008 Nov 1;34(11):1325-31.

[7] Goller-Bulut D, Sekerci AE, Köse E, Sisman Y. Cone beam computed tomographic analysis of maxillary premolars and molars to detect the relationship between periapical and marginal bone loss and mucosal thickness of maxillary sinus. Medicina oral, patologia oral y cirugia bucal. 2015 Sep;20(5):e572-9.

[8] Guerra-Pereira I, Vaz P, Faria-Almeida R, Braga AC, Felino A. CT maxillary sinus evaluation-A retrospective cohort study. Medicina oral, patologia oral y cirugia bucal. 2015 Jul;20(4):e419-26.

[9] Janner SF, Caversaccio MD, Dubach P, Sendi P, Buser D, Bornstein MM. Characteristics and dimensions of the Schneiderian membrane: a radiographic analysis using cone beam computed tomography in patients referred for dental implant surgery in the posterior maxilla. Clinical oral implants research. 2011 Dec;22(12):1446-53.

[10] Jung YH, Cho BH. Assessment of the relationship between the maxillary molars and adjacent structures using cone beam computed tomography. Imaging science in dentistry. 2012 Dec 1;42(4):219-24.

[11] Kasikcioglu A, Gulsahi A. Relationship between maxillary sinus pathologies and maxillary posterior tooth periapical pathologies. Oral Radiology. 2016 Sep 1;32(3):180-6.

[12] Khorshidi H, Shahidi S, Ghapanchi J, Raoofi S, Paknahad M, Khajeh Daloiee N, Zamani A. The Association Between Maxillary Sinus Mucosal Thickening and Periapical Radiolucency Using Cone-Beam Computed Tomography Scanning: A Retrospective Study. Journal of Dentomaxillofacial. 2016 Oct 15;5(3):5-10.

[13] Kilic C, Kamburoglu K, Yuksel SP, Ozen T. An assessment of the relationship between the maxillary sinus floor and the maxillary posterior teeth root tips using dental cone-beam computerized tomography. European journal of dentistry. 2010 Oct;4(4):462-7.

[14] Legert KG, Zimmerman M, Stierna P. Sinusitis of odontogenic origin: pathophysiological implications of early treatment. Acta oto-laryngologica. 2004 Aug 1;124(6):655-63.

[15] Low KM, Dula K, Bürgin W, von Arx T. Comparison of periapical radiography and limited cone-beam tomography in posterior maxillary teeth referred for apical surgery. Journal of Endodontics. 2008 May 1;34(5):557-62.

[16] Lu Y, Liu Z, Zhang L, Zhou X, Zheng Q, Duan X, Zheng G, Wang H, Huang D. Associations between maxillary sinus mucosal thickening and apical periodontitis using cone-beam computed tomography scanning: a retrospective study. Journal of endodontics. 2012 Aug 1;38(8):1069-74.

[17] Luz J, Greutmann D, Wiedemeier D, Rostetter C, Rücker M, Stadlinger B. 3D-evaluation of the maxillary sinus in cone-beam computed tomography. International journal of implant dentistry. 2018 Dec;4(1):17.

[18] Maillet M, Bowles WR, McClanahan SL, John MT, Ahmad M. Cone-beam computed tomography evaluation of maxillary sinusitis. Journal of endodontics. 2011 Jun 1;37(6):753-7.

[19] Mehra P, Murad H. Maxillary sinus disease of odontogenic origin. Otolaryngologic Clinics of North America. 2004 Apr 1;37(2):347-64.

[20] Nair UP, Nair MK. Maxillary sinusitis of odontogenic origin: cone-beam volumetric computerized tomography–aided diagnosis. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2010 Dec 1;110(6):e53-7.

[21] Nunes CA, Guedes OA, Alencar AH, Peters OA, Estrela CR, Estrela C. Evaluation of periapical lesions and their association with maxillary sinus abnormalities on cone-beam computed tomographic images. Journal of endodontics. 2016 Jan 1;42(1):42-6.

[22] Obayashi N, Ariji Y, Goto M, Izumi M, Naitoh M, Kurita K, Shimozato K, Ariji E. Spread of odontogenic infection originating in the maxillary teeth: computerized tomographic assessment. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2004 Aug 1;98(2):223-31.

[23] Phothikhun S, Suphanantachat S, Chuenchompoonut V, Nisapakultorn K. Cone-beam computed tomographic evidence of the association between periodontal bone loss and mucosal thickening of the maxillary sinus. Journal of periodontology. 2012 May;83(5):557-64.

[24] Rege IC, Sousa TO, Leles CR, Mendonça EF. Occurrence of maxillary sinus abnormalities detected by cone beam CT in asymptomatic patients. BMC oral health. 2012 Dec;12(1):30.

[25] Ritter L, Lutz J, Neugebauer J, Scheer M, Dreiseidler T, Zinser MJ, Rothamel D, Mischkowski RA. Prevalence of pathologic findings in the maxillary sinus in cone-beam computerized tomography. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2011 May 1;111(5):634-40.

[26] Shahbazian M, Jacobs R. Diagnostic value of 2D and 3D imaging in odontogenic maxillary sinusitis: a review of literature. Journal of oral rehabilitation. 2012 Apr;39(4):294-300.

[27] Shanbhag S, Karnik P, Shirke P, Shanbhag V. Association between periapical lesions and maxillary sinus mucosal thickening: a retrospective cone-beam computed tomographic study. Journal of endodontics. 2013 Jul 1;39(7):853-7.

[28] Sharan A, Madjar D. Maxillary sinus pneumatization following extractions: a radiographic study. International Journal of Oral & Maxillofacial Implants. 2008 Jan 1;23(1).

[29] Sheikhi M, Pozve NJ, Khorrami L. Using cone beam computed tomography to detect the relationship between the periodontal bone loss and mucosal thickening of the maxillary sinus. Dental research journal. 2014 Jul;11(4):495-501.

[30] Vallo J, Suominen-Taipale L, Huumonen S, Soikkonen K, Norblad A. Prevalence of mucosal abnormalities of the maxillary sinus and their relationship to dental disease in panoramic radiography: results from the Health 2000 Health Examination Survey. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2010 Mar 1;109(3):e80-7.