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Analysis of post-extraction consequences of posterior maxillary molars on antral sinus in periodontitis patients: A preliminary qualitative two dimensional panoramic study (Prevalence study)

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ABSTRACT

Aim Extraction of the posterior maxillary teeth is the main cause behind maxillary sinus expansion. The aim of the present study was to examine the relationship between extraction of maxillary posterior teeth and sinus expansion in periodontitis patients.
Materials and methods A preliminary cross-sectional study was conducted. Two hundred participants underwent clinical and radiographic examination using panoramic radiograph.
Results Based on the data analysis of the examined sample, no statistical correlation was reported between the maxillary sinus dimensions and age, gender, periodontal condition, alveolar ridge resorption as well as the number of missing teeth.
Conclusions It was concluded that extraction of maxillary posterior teeth, periodontal condition and alveolar ridge resorption could not be considered as risk factors for maxillary sinus pneumutization.

KEYWORDS Maxillary sinus, Missing posterior teeth, Ridge resorption, Sinus pneumtization, Maxillary sinus expansion, Periodontitis

INTRODUCTION

Several studies discussed the qualitative and quantitative post-extraction changes in the alveolar bone (30-50% bone volume) occurring along 3-12 months in all directions. Nearly 23% occurs during the first year followed by lower rates during the second year (11%). The horizontal reductions alone could reach 50% of the total ridge discrepancy (5-7 mm) (1-3). In 2012, Fu et al. (4) reported that horizontal ridge reduction usually occurs before the vertical one and reaches its peak between 6 months and 2 years after extraction. The vertical resorption could exceed the horizontal one, especially on the facial surface, ranging between 0.7-1.5 mm within 4-6 months. Resorption of the facial aspect exceeds that occurring on the palatal one which reduces the total arch length and shifts the center of the ridge to a more palatal position (1, 5).
On the other hand, higher resorption rates could be detected in the molar region in comparison to the esthetic zone and in thin biotype periodontium over the thicker one (1, 6-9). It was also found that the highest prevalence of sinus pneumatization usually accompanies extraction of the second molars (10-12). The presence of maxillary molars could provide adequate resistance against sinus expansion. Even in case of extraction of one or two molars, the remaining teeth preserve the sinus level through transferring the functional forces to the region of the missing tooth. The loss of the posterior maxillary teeth causes stimulation of the osteoclastic activity of the Schneiderian membrane that lines the sinus cavity, causing alveolar bone loss and sinus pneumitization (13, 14). Up till now, this is the most accepted hypothesis that describes the importance of posterior maxillary teeth in preserving dimensions, level and integrity of the maxillary sinus.
In the presence of periodontal diseases, maxillary molars loss has higher rates in comparison with the lower ones (15). Moreover, among maxillary teeth, posterior molars recorded higher prevalence of loss in comparison to premolars and incisors (16). Maxillary sinus pneumutization commonly occurs in periodontitis patients following extraction of posterior molars (17, 18). According to literature, panoramic view and computed tomography are the most common radiographic

techniques used in maxillary sinus evaluation. Although CBCT (Cone beam computed tomography) showed higher accuracy than the panoramic radiograph, the latter technique is the most commonly used. The main disadvantage of the panoramic technique is the production of a 2D image of the jaws and the supporting structures. Only structures included in the focal trough can be clearly visible (19).

Aim

The primary objective of the current qualitative cross-sectional analysis was to report if extracting posterior teeth could develop significant dimensional changes of the maxillary sinus. The secondary objective was to report if the presence of periodontal disease as well as the presence of alveolar bone defects could affect the degree of sinus pneumatization in partially versus fully dentate sites.

MATERIALS AND METHODS

The research question

Based on the available evidence, is extraction of one or more of the maxillary posterior teeth considered as a risk factor for sinus pneumatization?

Study design, settings and participants

For a preliminary cross-sectional study, data were collected from a total number of 200 panoramic radiographs obtained from consecutively enrolled 200 participants. Cairo's population is 25% of the entire population of Egypt. Cairo University is the largest and oldest University in Egypt. Despite the fact that there are various health centers and hospitals, Cairo University's clinics receive almost one million patients per month. The recruited sample was admitted to the periodontology department, faculty of dentistry, Cairo University. Along the period between June 2017 and January 2019, all the examined patients were enrolled in the study according to the eligibility criteria till the needed sample size reached.

Inclusion criteria

Based on the Dental modification of the Cornell Medical Index (20), medically compromised patients or under medical therapy were not excluded. Patients with history of maxillary sinus diseases or surgeries were included. The inclusion criteria permitted the recruitment of patients of both genders with age range >15 years old. The enrolled patients must have at least one extracted maxillary molar in either and /or both sides of the arch with minimal of 3 to 4 months after tooth extraction.

Exclusion criteria

Patients were excluded in case they showed complete bilateral maxillary posterior dentition. Panoramic views with unclear apical extension of the roots or unclear lateral extensions of maxillary sinuses were excluded. Pregnant and lactating women, cancer patients undergoing radiotherapy, sites with mucosal or bony lesions related to the area of interest were also excluded. Patients who underwent sinus lifting proceduresor who received maxillary posterior implants were excluded.

Ethical procedures

Each subject signed an informed written consent form. The experiment's protocol was clearly described to the enrolled patients.

Clinical examination

Patients' history was the first step of clinical examination. For a standardized examination, each patient was asked to fill a written well-structured questionnaire. It was divided into 3 sections including 13 questions to assess; five questions about socio-demographic status, five questions about general medical condition, and the last three questions about oral health condition. It was also written in Arabic, the mother language of the target population and then translated into English language for publishing purposes. Comprehensive examination was conducted by two periodontists at a single appointment. Based upon Seibert classification for alveolar ridge defects (21), diagnosis procedure took place. Out of 284 patients, only 200 patients met the inclusion criteria and accepted to participate in our research.

Variables, assessments, outcomes and data sources

Panoramic radiographs were performed at Oral Radiology department, Faculty of Dentistry, Cairo University using Planmeca Proline XC device (manufactured by Planmeca OY, Finland) set at 68kV and 10 mA with 18 seconds exposure time.

In order to reduce the radiographic errors especially horizontal distortion, reference lines were drawn (Fig. 1) to evaluate the overall sinus dimensional changes as follows.

1 Mesial and distal vertical lines at the lateral boundaries of the sinus.
2 A horizontal line parallel to the lower border of the sinus.
3 A horizontal line adjoining the root tips of maxillary molars.
4- A horizontal line parallel to the interproximal alveolar crest (1.5-2 mm below CEJ).
5 A horizontal line extended between the CEJ of both sides.

Based on these reference lines, the relationship between the maxillary sinus dimensions and 2 main outcomes will be concluded; primary outcome: number of related teeth and secondary outcome: periodontal condition.

Level of the alveolar crest in relation to the CEJ of the adjacent teeth

A horizontal line was drawn to join the CEJ of the

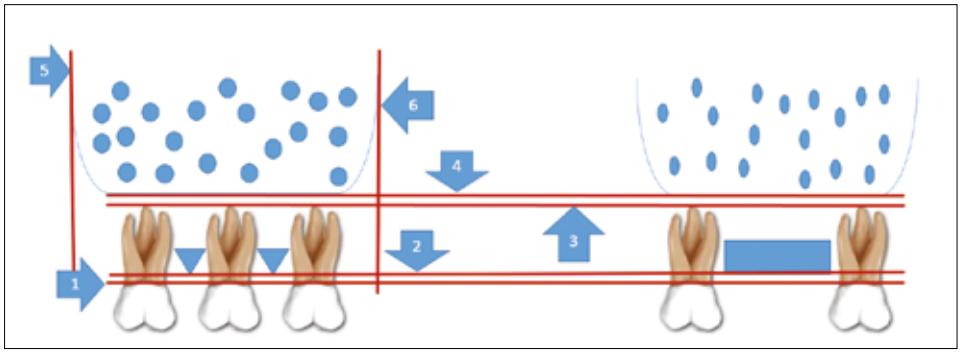

FIG. 1 Reference lines; 1) CEJ horizontal line, 2) Alveolar bone crest horizontal line, 3) Root tips horizontal lines, 4) Inferior border of sinus horizontal line, 5) Distal wall of the sinus vertical line, 6) Mesial wall of the sinus vertical line.

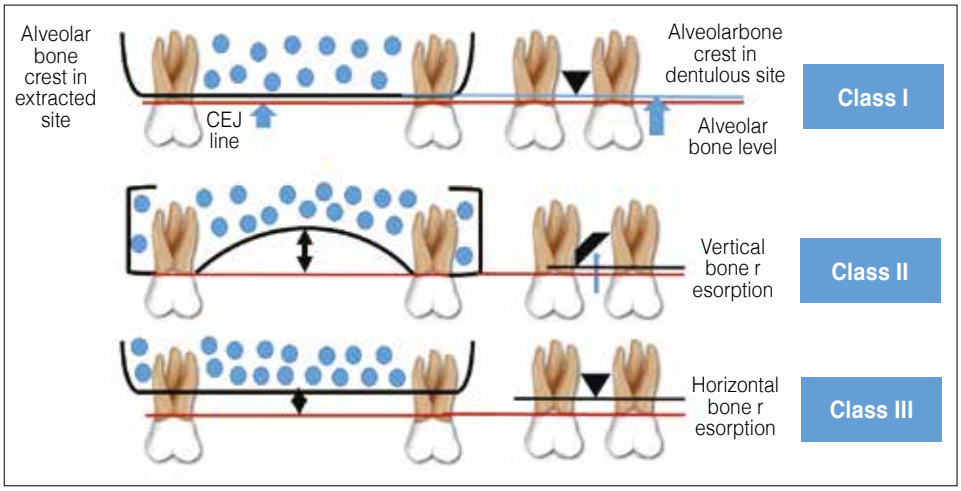

FIG. 2 CEJ and alveolar crest reference lines; Class I: No alveolar bone loss; Class II: Mid crest resorption with intact levels at the CEJs or vertical bone loss; Class III: Horizontal bone loss.

maxillary molars on both sides and another horizontal line was drawn adjoining the alveolar crests parallel to the first one (Fig. 1) to report if there is alveolar bone resorption either in partially edentulous sites or the dentulous sides. Class I: no alveolar bone loss; Class II: no alveolar bone loss at the CEJ but loss at the mid distance away from the adjacent teeth (partially edentulous sides) or vertical bone defects (partially edentulous sites) and Class III: alveolar bone loss at both mid distance and at CEJ of the adjacent teeth either in partially edentulous sites or dentulous ones (Fig. 2).

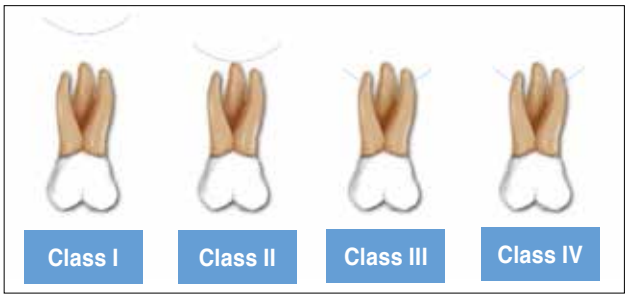

FIG.3 Arabion et al (2015) (22) classification: Type 1: The root was located in distant position from cortical borders of the sinus; Type 2: A close contact between the maxillary root tip and maxillary sinus floor; Type 3: overlapping of the root's shadow into the maxillary sinus without actual penetration into the cavity and Type 4: Root apices protruding into the sinus cavity.

Vertical distance between root tips and inferior border of maxillary sinus

The amount of remaining alveolar bone was qualitatively assessed in accordance to Arabion et al. (2015) (22, who classified the relationship as follows.
Type 1: The root was located in distant position from cortical borders of the sinus.
Type 2: A close contact between the maxillary root tip and maxillary sinus floor.
Type 3: overlapping of the root's shadow into the maxillary sinus without actual penetration into the cavity.
Type 4: Root apices protruding into the sinus cavity (Fig. 3).

The inferior border level of the maxillary sinus

The first line was drawn adjoining the inferior boundaries of the right and left maxillary sinuses. A qualitative scoring system was developed to evaluate the level of the inferior border of the maxillary sinus as follows.
Grade I: both sinuses at the same level.
Grade II: the inferior border of one side is coronal to the other side.
Grade III: the inferior border of one side is apical to the other side (Fig. 4).

The mesio-distal (M-D) extension of the maxillary sinus boundaries

Two vertical lines extending from the mesial and distal

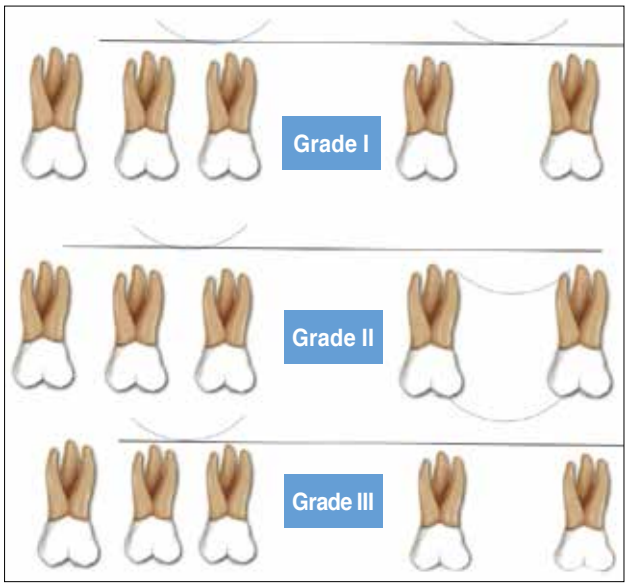

FIG. 4 Inferior border of sinus; Grade I: both sinuses at the same level; Grade II: the inferior border of one side is coronal to the other side and Grade III: the inferior border of one side is apical to the other side.

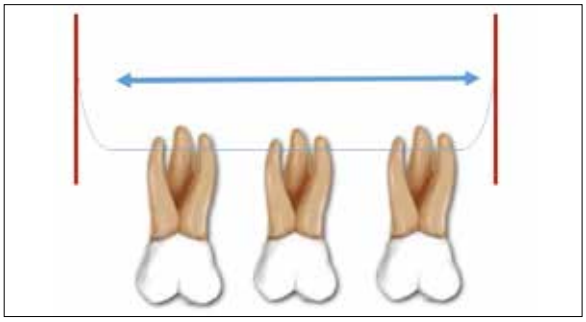

FIG. 5 M-D extension of maxillary sinus.

borders of maxillary sinuses were drawn downwards to the corresponding tooth (Fig. 5); Grade I: maxillary sinus extends between second premolar and first molar, Grade II: maxillary sinus extends between second premolar and second molar, Grade III: maxillary sinus extends between second premolar and third molar, and Grade IV: maxillary sinus extends between second premolar and maxillary tuberosity.

The number of missing teeth

The number of missing maxillary molars were classified as:
1) one tooth missing;
2) two teeth missing;
3) three teeth missing.

Statistical analysis

A descriptive statistical analysis was performed using Minitab version 17.1.0 for Microsoft 2013. Data were statistically described in terms of number of cases and percentages. The data normality was examined by Anderson-Darling Normality Test. The Pearson correlation coefficient was used for the data analysis. The positive correlation occurs when an increase in one variable increases the value in another. The negative correlation occurs when an increase in one variable decreases the value of another. The value of zero indicates that there is no association between the 2 variables. P-values <0.05 indicated statistically significant values.

RESULTS

A total of 200 participants with different age and gender completed the study. The patients' ages were categorized into 3 ranges; Range 1 (<20 years), Range 2 (20-40 years), and Range 3 (>40 years). The mean age of the participants was 37.065±11.286 (p value <0.005). The minimal value was 18 years while the maximum value was 70 years. Class 2 (20-40 years) recorded the largest category (119 patients; 59.5%) while Class 1 (<20 years) recorded the smallest category (8 patients; 4%). Using Grubbs' test for outlier testing, no outlier at the 5% level of significance was detected.

In the sample 128 (64%) out of 200 patients were females while only 72 (36%) were males (Fig. 6). The male:female ratio showed a statistically significant difference in favor to females (p<0.005). Using Grubbs' test for outlier testing, no outlier at the 5% level of significance was detected.

Correlations

In this section, the relationship between the sinus dimensions (through reference lines) and age, gender, number of involved teeth and periodontal condition was analysed.

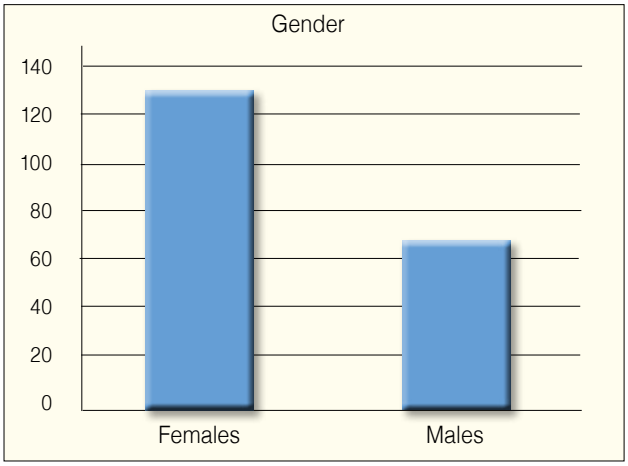

FIG. 6 Bar chart representing patients' gender.

The level of the inferior border of the maxillary sinus

Eighty percent of participants were classified as grade I (160 patients). While only 1% of the enrolled sample was classified as grade III and 19% was classified as grade II.

A statistical significance was reported in relation to the age range (p-value=0.000) and number of involved teeth (p-value=0.000) while a non statistical relationship was reported with gender (p-value = 0.131), periodontal condition (p-value=0.255) and alveolar ridge deficiency (p-value=0.225).

The value of the Pearson correlation coefficient (r=0.000) indicated that there was no relationship with the periodontal condition as well as the degree of ridge deficiency. A positive coefficient (r=0.183) revealed an inverse relationship with the number of missing teeth.

The mesio-distal extension of the maxillary sinus boundaries

Hundred and eighty patients were classified as grade IV (90%), while 18 patients were classified as grade III (9%). Only 1 patient was classified as grade I and another one classified as grade II. There is a non-statistically significant difference between the mesio-distal extension of the maxillary sinus and the age range (p-value=0.933), the number of missing teeth (p-value=0.899) and periodontal condition (p-value=0.008). A statistically significant relationship was found with degree of ridge resoprtion (p-value=0.000). The value of the Pearson correlation coefficient (r=0.000) indicated that there was no relationship between the mesio-distal extension of the maxillary sinus and age. An inverse Pearson relationship was reported with age (r= -0.103), periodontal condition (r= -0.188) and degree of ridge deficiency (r= -0.132).

Vertical distance between root tips and inferior border

Eighty five patients were categorized as type 2 (42.5%) While 79 patients were categorized as type 3 (39.5%). Thirty six patients were classified as type 1. No patients were recorded as type 4.

There was a non statistically significant difference between the vertical extension of the maxillary sinus and age range (p-value=0.936) as well as the periodontal condition (p-value= 0.998). While a statistically significant relationship was reported with gender (p-value= 0.000), number of missing teeth (p-value= 0.000) and degree of ridge deficiency (p-value= 0.000). There was no relationship (r= 0.000) with periodontal diseases, age range as well as the degree of ridge deficiency. A negative Pearson relationship was reported with number of missing teeth (r= -0116).

The level of the alveolar crest in relation to the CEJ of the adjacent teeth (Degree of ridge deficiency)

Based on the level of the alveolar bone in relation to the CEJ, ninety four patients were classified as class I (47%), while 32 patients were classified as class II (16%). Seventy-four patients were classified as class III (37%). There was a statistical significant relationship between the level of alveolar crest and the number of missed teeth (p-value= 0.000), age range (p-value=0.001) as well as the periodontal condition (p-value=0.000). On the other hand, there was a non-statistical significant relationship between the level of alveolar crest and the level of the inferior border (p-value=0.225),

According to Pearson correlation coefficient, it indicated a weak relationship with the number of missed teeth (r= 0.253) and age range (r=0.239), as well as moderate relationship with the periodontal condition (r=0.540).

The number of missed maxillary molars

Hundred and fifteen patients (57.5 %) were categorized as class 1 with only one molar missing while 67 patients (32%) were classified as grade 2 with two molars missing. Only 21 patients (10.5%) was classified as grade 3 with three molars missing.

A statistical significant relationship between the number of the missed teeth and age range (p-value=0.000), degree of ridge deficiency (p-value=0.000). On the other hand, there was a non-statistical significant difference between gender (p-value=0.899). According to Pearson correlation coefficient, it indicated non-linear relationship with the gender (r=0.000), weak relationship with the alveolar ridge deficiency (r=0.253) and age range (r=0.239).

Periodontal condition

According to the latest classification in 2018, the enrolled participants were categorized into periodontitis and non-periodontitis patients. Only 81 patients (40.5%) of the enrolled sample were diagnosed as non-periodontitis patients while 119 patients (59.5%) were diagnosed as periodontitis.

A statistical significant relationship between the periodontal status and age (p-value=0.001), degree of alveolar ridge deficiency (p-value=0.000). On the other hand, there was a non-statistically significant difference between the periodontal status and the level of the inferior border of the maxillary sinus (p-value=0.255), the vertical relation between the inferior border and the root tips (p-value=0.998).

Pearson correlation coefficient indicated non-linear relationship with gender (r=0.000), positive relationship with number of teeth (r= 0.112) degree of ridge deficiency (r=0.540) and age range (r=0.239).

DISCUSSION

According to the literature, the phenomenon of sinus pneumtization and its relationship to the presence of the maxillary posterior teeth has been previously discussed (15-18). Our study aimed to analyze if extracting

maxillary molars could affect maxillary sinus expansion in periodontitis patients via panoramic assessment.
Panoramic radiograph is not commonly used in maxillary sinus assessment due to its 2 dimensional imaging which could not efficiently evaluate; the horizontal ridge deficiency, sinus diseases, apical extension of the sinus and the actual invasion of the root tips inside the sinus cavity.
Notwithstanding the latter limitations, we preferred to use panoramic radiographs over CBCT in our study due to several reasons; part of the routine examination (23), cost effectiveness, easiness to be interpreted by non-radiologists, low radiation doses in comparison to CBCT and high availability (24). Furthermore, the outcomes related to the vertical parameters could be easily examined with minimal distortion in comparison to the horizontal dimension (23, 24). Therefore, in order to compensate for panoramic distortion, fixed reference lines were drawn with the help of anatomic landmarks as CEJ, boundaries of the maxillary sinus itself, maxillary tuberosity and the root tips of the maxillary posterior teeth (25).
The dimension of the maxillary sinus is genetically related to the skeleton's size, the genetic background, the patient's age and the type of breathing (if oral or nasal breather) (26). It was found that the maxillary sinuses are of smaller dimensions in oral breathers. Our results were in accordance with Yuki et al. (2011) (27) that there is no statistically significant differences between the volume of the maxillary sinus at the dentulous and the partially edentulous sides. It was found that periodontal disease could only thicken the mucoasal lining of the maxillary sinus. Low grade long-term inflammation could have a stimulatory effect of bone laydown.
On the other hand, our results did not agree with those of several studies that supported the maxillary sinus expansion could occur following maxillary posterior teeth extraction, namely those by Yoshinobu & Hiroko (1997) (28) and Takahisa (2002) (29). Yoshinobu & Hiroko (1997) (28) explained that by the presence of cancellous bone in the basal part of the maxillary sinus which could facilitate the expansion phenomenon. Takahashi et al. (2016) (29) reported that the volume of the maxillary sinus can be reduced by the effect of aging process as well as extraction of maxillary posterior teeth.
The main age range participating in our experiment was of middle age between 20 and 40 years old (80%). Most of participants were females (64%). In accordance to Ariji et al. (1994) (26) and Gulec et al. (2019) (30), our results did not find a relationship between gender as well as the patient's age (above 20 years) and the overall dimensional changes of the maxillary sinus.
Fracture or loss of the inferior boundary of the sinus, the presence of an apical pathology (31), reduced density of the alveolar bone, root projection into the sinus cavity, roots surrounded by curved sinus floor and multiple adjacent teeth extractions could be one of the main causative factors behind expansion of the inferior border of the sinus in a coronal direction.
Following teeth extraction, the inferior border of the maxillary sinus usually undergoes remodeling as well as sinus expansion especially in case of low bone density due to the reduced bone resistance, but this is not an absolute event. The remodeling process could change the shape of the sinus floor, but there is no evidence supporting its effect on sinus expansion (32).
The level of the inferior border seemed too difficult to be changed above the age of 20 years. Eighty percent of our participants reported bilateral symmetry of the inferior border level in partially edentulous and dentulous sites. In accordance to Ariji et al (1994) (26), periodontal condition and alveolar ridge resorption rate showed no correlation with the inferior border position. Ninety percent of sinuses extended between second premolars and maxillary tuberosity. The M-D extension of the maxillary sinus showed no correlation with age and negative correlation with the number of missing teeth, periodontal condition and degree of ridge deficiency. In accordance with Ren et al. (2015) (33) and Yildirim et al (2019) (34), our results revealed that there was no relationship between the periodontal condition and the extension of the maxillary sinus either coronally or mesio-distally.
Forty-two percent of participants reported type II (root tips at the inferior border of sinus with no penetration). No relationship was reported with age and periodontal condition. The number of missing teeth as well as degree of ridge resorption showed an intimate relationship with the vertical distance. Eberhardt et al. (1992) (10) and Arabion et al. (2015) (22) reported that the distance between the root tips of the maxillary first molar and the sinus floor is more than the distance at the second and third molars.
Forty-seven percent showed no alveolar ridge deficiency (Class I). Positive correlation was reported with age, number of missed teeth and periodontal condition. Only 57.5% of participants reported one tooth missing. The number of missing teeth showed increased with age, degree of ridge deficiency and periodontal condition due to the reduced periodontal support which accelerates the incidence of teeth loss.

CONCLUSION

The results of the present study emphasized the following.
Extraction of posterior maxillary molars, degree of ridge resorption, periodontal diseases, age or gender could not be considered as a risk factor for maxillary sinus pneumutization.
Teeth extraction is only a risk factor for the alveolar ridge resorption.
The use of panoramic radiographs showed to be adequate for qualitative diagnosis of the maxillary sinuses but not

for quantitative assessment.
Aging is not considered as risk factor for sinus expansion. Maxillary sinus expansion is quite limited above the age of 20 years.
The presence of posterior teeth could not guarantee preserving the level of the inferior border.
Periodontitis or long-term periodontal disease is not a risk factor for maxillary sinus pneumutization.
Based on the results of the present study, we recommended to examine the patients using quantitative technique as CBCT to report the differences of the volume of the maxillary sinus between the intact and extracted sides.

Ethics approval and consent to participate

Both the ethical approval as well as the written consent form were approved by the National ethics committee.

Availability of data and materials

The data that support the findings of this study are available from faculty of Dentistry-Cairo University but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of faculty of Dentistry-Cairo University.

Competing interests

None.

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Authors' contributions

The manuscript has been read and approved by all authors; NY, KS, who have contributed to prepare each step of the manuscript; experiment, writing and analysis. NY: Writing, methodology, corresponding author, samples collection, funding; KS: Data analysis, revision and editing of manuscript, and funding.

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