Prevalence of and factors associated with maxillary sinus cyst in a Chinese population

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Abstract

Purpose: This study used cone-beam computed tomography (CBCT) to assess the prevalence of and factors associated with maxillary sinus cysts (MSCs) in a Chinese population.

Methods: A total of 2,571 CBCT scans of 5,000 sinuses were analyzed. MSCs were diagnosed on the basis of imaging features within the maxillary sinus. Sex, age, dental condition, and anatomic condition were assessed. Associations with these factors were evaluated with logistic regression and a generalized estimating equations model.

Results: The prevalence of MSCs was 15.46% at the sinuses level and 23.44% at the patient level. The prevalence of MSCs was higher for men (OR = 1.864, P < 0.001) and for patients with apical lesions (OR = 1.76, P < 0.001), severe bone loss (OR = 1.363, P < 0.05), tooth roots in contact with the sinus floor (OR = 1.68, P < 0.001), and pits or septa on the floor of the maxillary sinus (OR = 1.539, P < 0.001).

Conclusion: This large sample had a high prevalence of MSCs. MSC prevalence was associated with multiple factors, including sex, dental condition, and anatomic condition. Maintenance of healthy dental and periodontal status might help prevent MSCs.

Keywords: cone-beam computed tomography, maxillary sinus cyst, prevalence, related factors

Introduction

The maxillary sinuses are pneumatic cavities within the maxillary bone. They are usually pyramidal in shape, and the base of the pyramid includes the lateral nasal wall and extends to the zygomatic bone at the top [1]. The sinus floor consists of maxillary alveolar bone and part of the hard palate, which is closely related to the oral cavity and maxillary dentition. Common lesions in the maxillary sinus include mucosal thickening, maxillary sinus cyst (MSC), and opacification. Although MSCs rarely cause serious clinical symptoms, they are troubling to many patients and physicians [2-5].

Radiographs are important in diagnosing maxillary sinus lesions; however, evaluation of such lesions is difficult on two-dimensional images [3]. Cone-beam computed tomography (CBCT) —a low-cost, dose-sparing technique— has become the reference standard for maxillary sinus imaging [6-8]. The popularity of CBCT, which displays the maxillary sinus clearly and in three dimensions, has led to its use for analysis of maxillary sinus lesions.

Among sinus lesions, the high prevalence of MSCs (3.6-12.9%) [9,10] and their characteristic features on CBCT have puzzled physicians. MSCs can be classified as retention cysts, mucoceles, and pseudocysts [11]. Although MSCs cannot be diagnosed directly by CBCT imaging, radiographic studies of large samples is an effective means of understanding MSCs. Careful analysis of disease manifestations and related factors can assist in prevention and treatment.
a) On the roof (Fig. 1a);
b) On the floor (Fig. 1b);
c) On the wall near the nasal cavity (Fig. 1c);
d) On other maxillary sinus walls (Fig. 1d).

The widest diameter (in mm) of the MSCs was measured on coronal and axial slices, and the mean of these values was recorded as the final size [15].

Assessment of dental conditions

The dentition from the first premolar to the second molar was recorded and classified as dentate, partially edentulous, or completely edentulous. If teeth (from the first premolar to the second molar) were present, their endodontic and periodontal status was evaluated. The endodontic condition was classified into the following groups (assigning the largest code value whenever applicable):

a) Teeth with no detectable abnormalities;
b) Deep caries with or without treatment(s);
c) Endodontic treatment(s) without visible apical pathology;
d) Apical lesion(s) with or without visible endodontic treatment(s) [12,15].

Periodontal status can be expressed in relation to periodontal bone loss and was classified (assigning the largest code value whenever applicable) as normal to mild (<25% bone loss), moderate (>25 to ≤50% bone loss), or severe (>50% bone loss) [17].

Assessment of anatomic conditions of the maxillary sinus floor

First, the left and right distribution of the maxillary sinus was recorded. Then, the anatomic relationship between the teeth and sinus floor was analyzed individually for each tooth on sagittal and coronal slices and classified as no contact (presence of a measurable layer of bone cortex between the root and floor of the maxillary sinus) or contact (at least one of the tooth roots was in contact with the maxillary sinus floor or protruded into the sinus [1,18]) (Fig. 2a).

The morphology of the sinus floor was evaluated in axial, sagittal, coronal, and reconstructed panoramic images and classified in relation to the absence or presence of pits/septa (a relatively flat floor vs presence of pits or maxillary sinus septa on the floor [19]) (Fig. 2b).

Statistical analysis

Descriptive analysis of the data is presented first as distributions, frequencies, percentages, means, and standard deviations. The chi-square test was used to compare the significance of categorical independent variables (such as sex) at the patient level. Analysis of variance was used to compare the diameters of MSCs at different sites. To account for a possible patient clustering effect, univariate logistic regression using a generalized estimating equation (GEE) model was used to evaluate all factors potentially associated with MSC prevalence. Significant factors in univariate analysis were included in multivariate logistic regression analysis using a GEE model. The results were interpreted as estimated odds ratios (ORs) with 95% confidence intervals (CIs).

Intra-observer reliability was determined by intra-class correlation coefficients. A P value of <0.05 was considered to indicate statistical significance. Statistical analyses were performed with SPSS (Version 26.0, IBM Corp., Armonk, NY, USA).

Results

Population and CBCT imaging details

CBCT images from 2,571 individuals were evaluated: 1,416 (55.08%) from women and 1,155 (44.92%) from men. Age ranged from 18 to 85 years (mean, 41.77 ± 15.34 years). MSCs were detected in 603 (23.44%)...
patients (mean age, 42.58 ± 15.44 years). The prevalence of MSCs was 28.83% in men and 19.07% in women (P < 0.001).

The 2,429 patients with bilateral maxillary sinuses and the remaining patients with unilateral maxillary sinuses were included in this study. The main reason for exclusion was detection of implants in the maxillary posterior region. Ultimately, 5,000 maxillary sinuses were included in the analysis.

At the sinus level, 798 MSCs were found in 738 (15.46%) sinuses; 54 sinuses contained multiple cysts, and as many as four MSCs were found in a sinus. The mean diameter of MSCs was 12.97 ± 5.96 mm. Regarding MSC site, more than three-quarters (612/766.9%) of MSCs were located on the maxillary sinus floor (mean size, 13.88 ± 6.07 mm), whose mean diameter was significantly greater than in the other groups (P < 0.05); 97 (12.16%) MSCs were detected on the wall near the nasal cavity (mean diameter, 9.71 ± 4.26 mm), and the remaining 27 (3.38%) were located on the roof (mean diameter, 10.52 ± 3.45 mm) (Fig. 3).

**Intra-observer repeatability**

Intra-class correlation coefficients for the size of MSCs were 0.974 for coronal slices and 0.959 for axial slices, which indicates excellent intra-observer repeatability.

**Demographic factors and MSCs**

In total, 5,000 sinuses were evaluated: 2,233 in men and 2,767 in women (Table 1). Notably, 428 sinuses in men had MSCs (prevalence, 19.17%), whereas 310 sinuses (11.20%) in women had MSCs. The results of univariate logistic regression analysis indicated that MSC prevalence did not significantly differ by age group.

**Dental conditions and MSCs**

In the 5,000 maxillary posterior regions adjacent to the maxillary sinus, 138 were in completely edentulous patients (Table 2). Univariate logistic regression analysis showed that dentition conditions did not significantly affect MSC prevalence. Analysis of endodontic conditions showed that 877 regions had at least one tooth with apical lesions and that the prevalence of MSCs was 21.09%. Univariate logistic regression analysis indicated that patients with apical lesions had a higher risk of MSCs (OR = 1.8, P < 0.001). Among the maxillary posterior regions adjacent to the maxillary sinus, 1,501 (30.87%) had severe periodontal bone loss in at least one tooth. Severe periodontal bone loss in the maxillary posterior region was associated with higher prevalence of MSCs in the corresponding maxillary sinus (OR = 1.309, P < 0.05). Moderate bone loss was associated with lower prevalence of MSCs (OR = 0.772, P < 0.05) in univariate logistic regression analysis.

### Table 1

| Variables | n   | Presence (%) | Univariate logistic regression analysis |
|-----------|-----|--------------|----------------------------------------|
| Sex       |     |              | OR (95% CI) P value                     |
| Female    | 2,767 | 310 (11.20%) | 1                                      |
| Male      | 2,233 | 428 (19.17%) | 1.878 (1.579-2.234) <0.001             |
| Age group (y) |     |              |                                        |
| 18-35     | 2,020 | 279 (13.81%) | 1                                      |
| 36-50     | 1,348 | 197 (14.61%) | 1.064 (0.854-1.325) 0.58               |
| 51-85     | 1,632 | 262 (16.05%) | 1.197 (0.978-1.464) 0.081              |

### Table 2

| Variables | n   | Presence (%) | Univariate logistic regression analysis |
|-----------|-----|--------------|----------------------------------------|
| Status of dentition (from first premolar to second molar) |     |              | OR (95% CI) P value                     |
| Dentate   | 3,739 | 537 (14.36%) | 1                                      |
| Partially edentulous | 1,123 | 177 (15.76%) | 1.117 (0.931-1.34) 0.235               |
| Completely edentulous | 138  | 24 (17.39%)  | 1.21 (0.735-1.99) 0.453                |
| Endodontic conditions |     |              |                                        |
| Health teeth with no abnormalities detected | 3,108 | 402 (12.93%) | 1                                      |
| Deep cavities with or without treatments | 544  | 82 (15.07%)  | 1.195 (0.924-1.545) 0.175              |
| Endodontic treatments without visible apical pathology | 333  | 45 (13.51%)  | 1.052 (0.755-1.463) 0.765              |
| Apical lesions with or without visible endodontic treatments | 877  | 185 (21.09%) | 1.484-2.183 0.001                     |
| Periodontal status |     |              |                                        |
| Normal to mild, ≤25% bone loss | 1,127 | 168 (14.91%) | 1                                      |
| Moderate, >25 to ≤50% bone loss | 2,234 | 266 (11.91%) | 0.772 (0.627-0.95) 0.015               |
| Severe, >50% bone loss | 1,501 | 280 (18.65%) | 1.309 (1.026-1.614) 0.022              |

n, number of sinuses; OR, odds ratio; CI, confidence interval.
Anatomic conditions and MSCs

There was no significant difference in MSC prevalence between left and right sinuses. Most sinuses were in contact with or had been penetrated by at least one tooth root (Table 3). Pits or maxillary sinus septa on the floor were found in 2,863 sinuses. Univariate logistic regression analysis showed that when tooth roots were in contact with the sinus floor or protruded into the maxillary sinus, MSCs were 1.571 times as likely, as compared to sinuses with no root contact or protrusion (P < 0.001). The risk of MSCs was higher when pits or septa were present on the floor of the maxillary sinus (OR = 1.774, P < 0.001).

Multivariate logistic regression analysis using a GEE model for factors potentially related to MSCs

MSCs were positively associated with male sex (OR = 1.864, P < 0.001), apical lesions (OR = 1.76, P < 0.001), severe bone loss (OR = 1.363, P = 0.02), tooth roots in contact with the sinus floor (OR = 1.68, P < 0.001), and presence of pits or septa on the maxillary sinus floor (OR = 1.539, P < 0.001) (Table 4).

Multivariate logistic regression analysis using a GEE model for factors potentially related to MSCs at different sites

Presence of an MSC on the floor of the maxillary sinus was significantly associated with male sex (OR = 1.85, P < 0.001), apical lesions (OR = 1.982, P < 0.001), severe bone loss (OR = 1.777, P < 0.001), tooth roots in contact with the sinus floor (OR = 1.96, P < 0.001), and pits or septa on the floor of the maxillary sinus (OR = 1.568, P < 0.001) (Table 5). Factors associated with an MSC on the wall near the nasal cavity were male sex (OR = 2.285, P = 0.001) and age 51 to 85 years (OR = 3.131, P = 0.016).

Table 3 Results of univariate logistic regression analysis of patient anatomic characteristics

| Variables                        | n   | Presence (%) | OR (95% CI)       | P value    |
|----------------------------------|-----|--------------|-------------------|------------|
| Sinus side                       |     |              |                   |            |
| Right                            | 2,507 | 374 (14.92%) | 1                 |            |
| Left                             | 2,493 | 364 (14.60%) | 0.976 (0.851-1.119) | 0.727      |
| Anatomic relationship between teeth and sinus floor |     |              |                   |            |
| No contact                       | 2,474 | 291 (11.76%) | 1                 |            |
| Contact                          | 2,526 | 447 (17.70%) | 1.571 (1.333-1.836) | <0.001     |
| Morphology of sinus floor        |     |              |                   |            |
| No pits or septa                 | 2,137 | 224 (10.48%) | 1                 |            |
| Pits or septa                    | 2,863 | 514 (17.95%) | 1.774 (1.486-2.118) | <0.001     |

n, number of sinuses; OR, odds ratio; CI, confidence interval

Table 4 Results of multivariate logistic regression analysis of factors potentially related to MSC prevalence

| Variables                        | B   | SE     | Wald χ² | OR (95%CI)       | P value    |
|----------------------------------|-----|--------|---------|-------------------|------------|
| Males                            | 0.622 | 0.0841 | 54.797  | 1.864 (1.382-2.197) | <0.001     |
| Endodontic conditions            |     |        |         |                   |            |
| Apical lesion(s) with or without visible endodontic treatment(s); | 0.565 | 0.1097 | 26.536  | 1.76 (1.419-2.182)  | <0.001     |
| Periodontal status               |     |        |         |                   |            |
| Severe, >50% bone loss           | 0.31 | 0.1249 | 6.147   | 1.363 (1.067-1.741) | 0.02       |
| Teeth roots in contact with sinus floor | 0.519 | 0.1064 | 23.791  | 1.68 (1.364-2.069)  | <0.001     |
| Pits or septa on sinus floor     | 0.431 | 0.1032 | 17.442  | 1.539 (1.257-1.883) | <0.001     |
| Severe, >50% bone loss           |     |        |         |                   |            |
| Teeth roots in contact with sinus floor | -2.828 | 0.1359 | 432.973 | 0.059 (0.045-0.077) | <0.001     |

B, regression coefficient; SE, standard error; OR, odds ratio; CI, confidence interval

Table 5 Results of multivariate logistic regression analysis of factors potentially related to prevalence of MSCs on the sinus floor

| Variables                        | B   | SE     | Wald χ² | OR (95%CI)       | P value    |
|----------------------------------|-----|--------|---------|-------------------|------------|
| Males                            | 0.615 | 0.0998 | 37.991  | 1.85 (1.521-2.249) | <0.001     |
| Endodontic conditions            |     |        |         |                   |            |
| Apical lesion(s) with or without visible endodontic treatment(s); | 0.684 | 0.1247 | 30.072  | 1.982 (1.552-2.53)  | <0.001     |
| Periodontal status               |     |        |         |                   |            |
| Severe, >50% bone loss           | 0.575 | 0.1466 | 15.372  | 1.777 (1.333-2.368) | <0.001     |
| Teeth roots in contact with sinus floor | 0.673 | 0.1212 | 30.817  | 1.96 (1.545-2.485)  | <0.001     |
| Pits or septa on sinus floor     | 0.45 | 0.1189 | 14.298  | 1.568 (1.242-1.979) | <0.001     |
| Severe, >50% bone loss           |     |        |         |                   |            |
| Teeth roots in contact with sinus floor | -3.378 | 0.1626 | 431.598 | 0.034 (0.025-0.047) | <0.001     |

B, regression coefficient; SE, standard error; OR, odds ratio; CI, confidence interval

Discussion

Analysis of consecutive CBCT scans of 5,000 maxillary sinuses showed a relatively high prevalence of MSCs. Factors associated with presence of MSCs included individual factors, dentition, dental conditions, and anatomic conditions. Moreover, this study was able to accurately classify MSC sites and analyze MSCs in relation to site.

This study revealed a high prevalence of MSCs (15.46% at the sinus level, 23.44% at the patient level). Studies using CT or CBCT reported MSC prevalences of 3.6% and 12.9% at the sinus level [2,5,12,15] and 12.4% and 22% at the patient level [2,15,20]. This discrepancy among studies may be due to differences in indications for CBCT scans and ethnic differences among the studied populations. Moreover, sample size affects statistical accuracy. Yeung et al. [15] reported that mucous retention cysts were found in 32 of 156 CBCT scans analyzed. Each additional case would increase prevalence by 0.6%.

In this study, 76.69% of MSCs were located on the sinus floor, which contradicts a previous study reporting that most (53.6%) MSCs were located on the sinus walls and that 17.8% were present on the roof and only 28.6% were on the floor [15]. This discrepancy is attributable to the fact that MSCs located on the walls and floor of the maxillary sinus in the present study were described as “located on the maxillary sinus floor.” MSCs on the sinus floor had a mean diameter of 13.88 ± 6.07 mm, which is larger than previously reported values [15]. Again, ethnic differences among the populations studied may explain this discrepancy.

To the present authors’ knowledge, only a few studies have analyzed the characteristics of MSCs on CBCT images. Previous reports found no significant association of the presence of mucous retention cysts with endodontic or periodontal status [12,15]. Moreover, young patients (age 10-35 years) were more likely than older patients to have MSCs [12], which was not the case in the present study. Nevertheless, past findings must be con...
sidered cautiously, as the number of MSCs and cases with endodontic or periodontal pathologies were small in previous studies [12,15]. In this study, the prevalence of MSCs was significantly higher in men than in women. In P. R. China, the smoking rate is significantly higher among males (51.4%) than among females (4.1%) [21], as is the prevalence of periodontitis [22]. Analysis of dental conditions showed that the higher prevalence of MSCs was associated with apical lesions and severe periodontal bone loss. Moreover, when tooth roots were in contact with sinus floor or protruded into the maxillary sinus, there was a greater chance of MSCs, which was consistent the results of previous report [18]. These findings can be explained as follows. Apical lesions develop when collagenase, lysosomal enzymes, toxins, and other bacterial virulence factors promote bacterial invasion and tissue destruction of apical bone after pulp necrosis. Periapical infections may spread to the maxillary sinus and cause inflammation [23,24]. Severe periodontal bone loss may bring periodontitis-related bacteria and their inflammatory products closer to the maxillary sinus. A local increase in the level of pathogenic bacteria, their products, and inflammatory cytokines can spread to the sinus from maxillary bone, or pathogens may reach the sinus indirectly through blood and lymphatic vessels [25]. The sinus floor acts as a barrier that rarely allows direct penetration of dental infections into the sinus [3]. However, when tooth roots are in contact with the sinus floor or protrude into the maxillary sinus, infections may more easily infiltrate the sinus. Normal maxillary sinus mucosa adheres to sinus bone. When pits or septa are present on the floor of the sinus, the corresponding mucosa is no longer flat. When there is a septum, the mucosa at the top of the septum may be weak. Such mucosa is more susceptible to various stimuli that lead to formation of correspond- ing lesions. Once inflammation has affected the mucosa, if there are pits or septa on the floor of the maxillary sinus, inflammatory secretion readily accumulates locally and is difficult to drain, which may increase the risk of mucosal lesions. Retention cysts are caused by seromucous gland obstruction that results in a ductal epithelium-lined cystic structure filled with mucin [26]. Retention cysts are commonly seen around the ostium, because the seromucous gland is usually present in this area [27]. Mucoceles (also known as true cysts) are lesions that develop from extravsations of mucus into the surrounding soft tissues [28,29]. Imaging of mucoceles reveals that they are spherical, opaque, affected the sinus, and expand into adjacent structures [30]. Pseudocysts are an accumulation of inflammatory exudates, without epithelial lining [26]. They generally occur on the floor of the maxillary sinus and range from a small, dome-shaped mass to a large lesion filling the entire sinus cavity [30]. When lesions were classified with the above classification, the present imaging findings confirmed that the prevalence of pseudocysts was much higher than the prevalences of the other two types of MSCs. The present results indicate that homogeneous, dome-shaped opacities with sharply demarcated lateral borders on the floor of maxillary sinus should be diagnosed as pseudocysts. In this study, MSCs on the floor of the sinus were more affected by odontogenic factors. This largely depends on anatomic location; the mucosa of the maxillary sinus floor is closest to the oral cavity and tooth roots. This was also consistent with pseudocyst development [27]. For MSCs on the wall near the nasal cavity, prevalence was significantly higher in men than in women. This sinus wall is adjacent to the nasal cavity and is more susceptible to irritation from the nasal cavity. The higher prevalence of smoking among Chinese men than among women may explain this result. The higher prevalence in older patients may be attributable to the fact that nasal function is diminished in older adults [31], thus affecting the maxillary sinus mucosa on the wall near the nasal cavity. The present results showed that MSC prevalence was associated with multiple factors, including sex, dental condition, and anatomic condition. Sex is a nonmodifiable factor and thus has no role in MSC prevention. However, regular physical examination, early discovery, and early treatment are recommended. The natural anatomic condition of the maxillary sinus, which is usually regarded as unchangeable, can be altered by sinus floor elevation (SFE). Keeping the maxillary sinus floor as flat as possible after SFE can prevent MSCs. This study has some limitations. It was a retrospective analysis of consecutive CBCT images collected at a stomatology hospital. Clinical interpretation of the results is limited by the lack of data on patient histories and follow-up. Other medical conditions, such as pre-existing chronic sinusitis and systemic conditions, were not considered. Further studies using CBCT images to evaluate patients with MSCs and their natural course are expected. In conclusion, the prevalence of MSCs was relatively high. Multiple conditions were associated with MSC prevalence, including presence on the floor of the maxillary sinus, sex, dental conditions, and anatomic conditions. Maintenance of healthy dental and periodontal status can help prevent MSCs. Acknowledgments This work was supported by the Health Department of Zhejiang Province Fund (Grant No. 2018KY499), the Natural Science Foundation of Zhejiang Province (Grant No. LQ19H140006), and the National Natural Science Foundation of China (Grant No. 81901051). 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