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Effects of Dental Factors on Fungal Sinusitis

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Keywords

Maxillary sinusitis · Fungi · Dental caries · Tooth extraction · Dental implantation

Abstract

Objectives: This study aimed to investigate the associations between dental treatments and fungal maxillary sinusitis (FMS). ***Methods:*** We retrospectively reviewed medical charts between July 2014 and March 2019. In total, 100 cases of FMS were included in this study. We also recruited 200 patients as a control group in the same period. Therefore, each of the FMS, chronic rhinosinusitis (CRS), and normal sinus groups consisted of 100 patients. We recorded all endodontic treatments (EDTs), tooth extractions, dental implantations, and apical lesions (ALs). ***Results:*** The FMS group had higher incidences of tooth extraction (49% vs. 11%, respectively) and EDT (29% vs. 16%, respectively) compared to the normal sinus group and fewer ALs compared to the CRS group (6% vs. 24%, respectively). There were significant differences between the CRS and normal sinus groups in the extraction rate (53% vs. 11%, respectively) and frequency of ALs (24% vs. 4%, respectively). The dental implantation prevalence rates were similar across all 3 groups. ***Conclusion:*** The rates of tooth extraction were significantly higher in the FMS and CRS groups compared to the normal sinus group. In addition, of the 3 conditions, FMS was related to EDT, and CRS was related to ALs.

Introduction

Fungal maxillary sinusitis (FMS) is a noninvasive form of fungal rhinosinusitis in which fungal growth in the paranasal sinuses does not invade the mucosa or soft tissue and is not associated with mucin production [1]. FMS presents as a clay or cheese-like material in the sinuses during surgery and is commonly identified via pathological examination or culture of fungus hyphae [2]. Radiologically, micro- and/or macrocalcifications are usually present, and bone or soft tissue destruction is rare [2]. Most fungal balls are found in the maxillary sinus but less

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frequently in the sphenoid, ethmoid, and frontal sinuses [1, 3]. FMS is a very common sinus disease, but its etiology is still unknown.

An early hypothesis for the occurrence of FMS was that fungal growth was promoted by primary chronic rhinosinusitis (CRS) [4]. However, the odontogenic theory was also proposed as an explanation for the occurrence of FMS, which postulates that FMS could occur under the influence of materials used for endodontic treatment (EDT) (e.g., root canal treatments) [5]. It was suggested that minerals in the EDT materials, such as zinc, promote fungal growth [6–8]. In addition to EDT, several dental factors, such as apical lesions (ALs), tooth extraction, and foreign bodies (e.g., dental implants), may cause sinusitis through direct expansion of the infection or by interfering with the mucosal function of the sinus mucosa [9].

There have been few previous studies of the relations of dental factors with FMS. Therefore, we investigated the relationships between various dental factors and FMS in the present study.

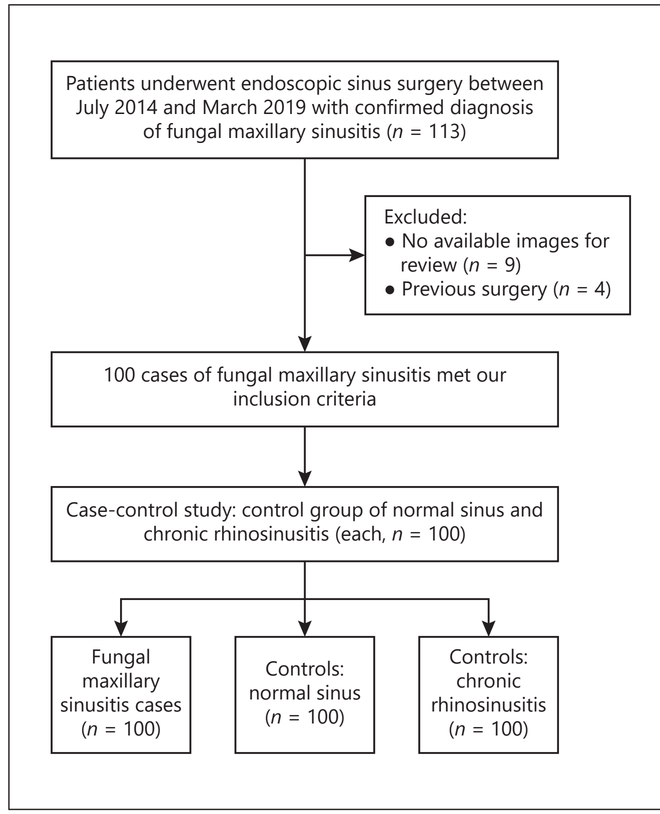

Fig. 1. Flowchart of subject enrollment based on the inclusion and exclusion criteria for the fungal maxillary sinusitis group.

Materials and Methods

Study Population

This study and the retrospective chart review were approved by the institutional review board of our hospital (Approval No. KC20RISI0758). We retrospectively reviewed all patients who underwent endoscopic sinus surgery between July 2014 and March 2019. FMS patients with radiologically confirmed unilateral disease that was further verified via histopathological identification of fungal hyphae were enrolled [2]. Among the 113 patients initially included in the study, 13 were excluded due to a lack of appropriate images for evaluation in this study (i.e., paranasal CT) (n = 9) or previous surgery (n = 4). Finally, 100 patients with FMS met our inclusion criteria (Fig. 1). We also enrolled a further 200 patients treated in the same period, 100 with normal sinuses and 100 with CRS, for comparison in reference to the designs of previous studies [6, 10]. Both groups' subjects were sequentially selected at the same period of the study. The normal sinus group consisted of patients who had undergone transsphenoidal pituitary surgery and whose sinuses appeared to be normal. The CRS group consisted of patients with or without polyps and with unilateral sinusitis as revealed by CT. FMS patients and allergic fungal sinusitis patients were excluded from the CRS group. In all groups, we excluded patients undergoing revision sinus or nasal surgery and those with bilateral sinus disease, trauma, or other sinus diseases (e.g., benign or malignant neoplasms).

Data Collection

We reviewed and extracted demographic data and the patients' medical history and reviewed CT scans to check for the EDT, AL, extraction, and dental implantation (DI) status. We focused only on the second premolar and the first and second molars because these are the teeth most commonly associated with maxillary sinus disease [9]. Paranasal CT consisted of a 0.6-mm-thick axial projection and reconstruction as a 1-mm-thick coronal image. Prior EDT was identified when white hyperdense spots were evident in the tooth canals (Fig. 2a) [10]. The locations of missing extracted teeth were marked on the CT images (Fig. 2b) [10]. DIs were identified on axial images (Fig. 2c). An AL was defined as radiolucent opacification near a tooth root, reflecting either an AL per se or apical periodontitis (Fig. 2d) [9]. We counted all affected teeth on only the ipsilateral side of the diseased sinus. In patients with normal sinuses, both sinuses were disease free, and we therefore used computer-based randomization software to select the side for inclusion in the analyses. Two reviewers (M.B. and I.H.L.) independently performed a CT review, and if the results of the 2 reviewers were different, the decision was made together with a third reviewer (D.H.K.).

Statistical Analysis

Numerical variables are expressed as mean ± standard deviation. Student's t test was used to compare patient ages and the numbers of affected teeth. The χ^2 and Fisher's exact tests were used to compare categorical variables. In all analyses, $p < 0.05$ was taken to indicate statistical significance. Statistical analyses were performed using SPSS software (ver. 24.0; IBM Corp., Armonk, NY, USA).

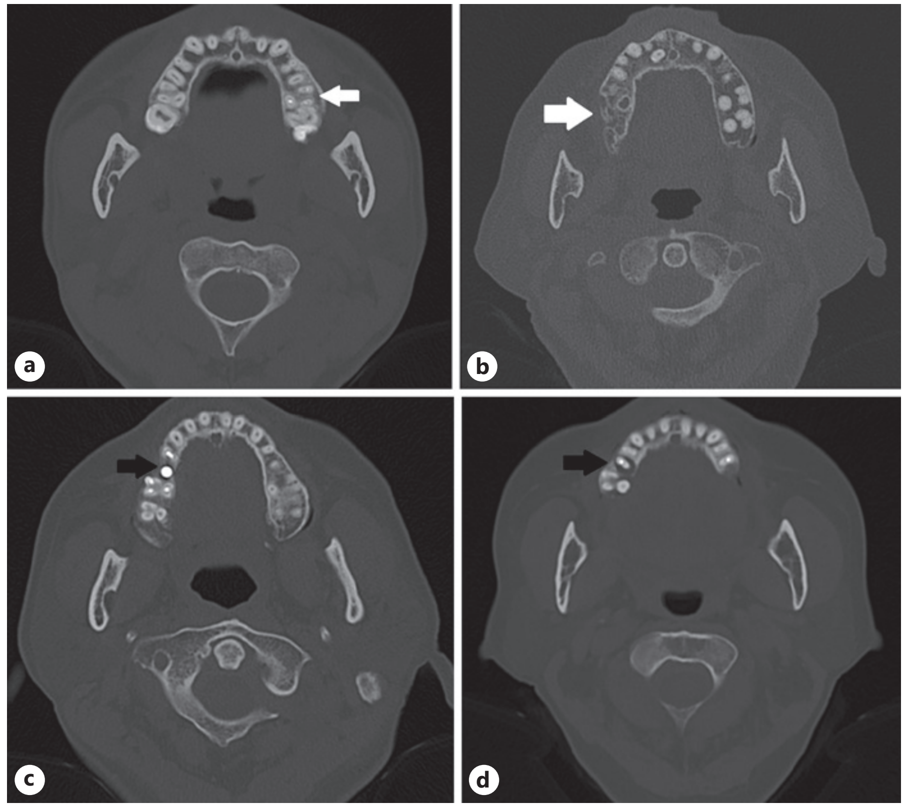

Fig. 2. Axial computed tomography scans for examining various dental factors. **a** Endodontic treatment material. Note the white hyperdense spots in the roots of the left first molar (white arrow). **b** Tooth extraction. The first and second right molars are missing (white arrow). Adults usually have 8 teeth in each half of the upper jaw. **c** Dental implant (black arrow). **d** Apical lesion. Radiolucent opacification is evident near the root of the second premolar (black arrow).

Table 1. Patient demographic data of the 3 groups

	Fungal maxillary sinusitis (n = 100)	Normal sinus (n = 100)	Chronic rhinosinusitis group (n = 100)
Age, years	61±12*, †	52±16	50±17
Proportion of females, %	76*, †	55	54
Smoking history, %	8	4	3
Hypertension, %	36†	25	19
Diabetes mellitus, %	18†	10	6
Asthma, %	2	0	1

* $p < 0.05$ compared to the normal group. † $p < 0.05$ compared to the chronic rhinosinusitis group (χ^2 test).

Results

The proportion of females was higher and patients were older in the FMS group than in the normal sinus and CRS groups. Compared to CRS, FMS showed a stronger association with diabetes mellitus (18% of cases; $p < 0.001$) and hypertension (36% of cases; $p < 0.001$) (Table 1). The mean number of teeth exhibiting dental factors was significantly higher in the FMS group than in the normal sinus group (1.42 ± 1.12 vs. 0.56 ± 0.92, respectively; $p < 0.001$). Median number of the affected teeth was 0 and 1 for normal and FMS groups, respectively. The number of affected teeth was similar in the FMS and CRS groups (1.42 ± 1.12 vs. 1.47 ± 1.07, respectively; $p = 0.747$). A median of 2 teeth exhibited dental factors in the CRS group (Fig. 3).

We found that the FMS patients had undergone more extractions than the patients with normal sinuses (49% vs. 11%, respectively; $p < 0.001$). In addition, 29% of the FMS patients had received EDT compared to 16% of the individuals in the normal sinus group ($p = 0.028$) (Table 2). The FMS group exhibited significantly fewer ALs

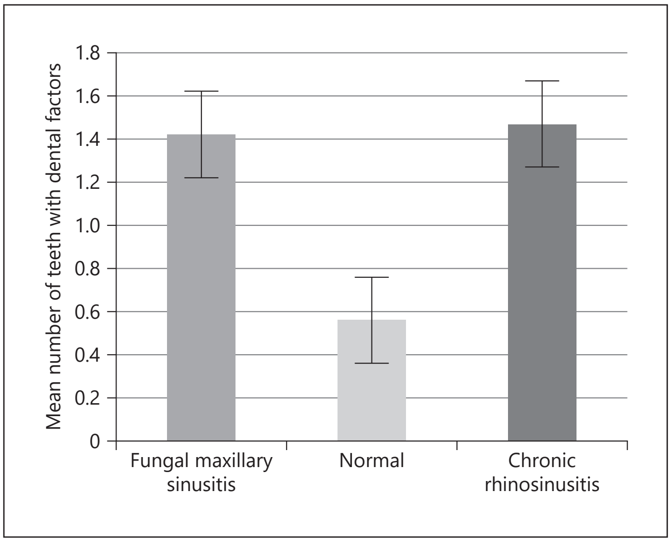

Fig. 3. Mean number of teeth corresponding to the status of each dental factor in the fungal maxillary sinusitis, normal sinus, and chronic rhinosinusitis groups.

than did the CRS group (6% vs. 24%, respectively; $p < 0.001$). Other factors, including the EDT rate, were similar between the 2 groups (Table 3). More CRS patients had undergone tooth extractions and had ALs in comparison with the normal sinus group (53% vs. 11%, respectively; $p < 0.001$, and 24% vs. 4%, respectively; $p < 0.001$). The EDT rates were similar in both groups (23% vs. 16%, respectively; $p = 0.212$). The DI rates were similar across all 3 groups.

Table 2. Comparison of dental factors between the fungal maxillary sinusitis and normal sinus groups

	Fungal maxillary sinusitis (*n* = 100)	Normal sinus (*n* = 100)	*p* value*
Extractions	49	11	**<0.001**
Endodontic treatments	29	16	**0.028**
Apical lesions	6	4	0.516
Dental implants	14	8	0.175

* $p < 0.05$ (χ^2 test).

Table 3. Comparison of dental factors between the fungal maxillary sinusitis and unilateral chronic rhinosinusitis groups

	Fungal maxillary sinusitis (*n* = 100)	Chronic rhinosinusitis (*n* = 100)	*p* value*
Extractions	49	53	0.572
Endodontic treatments	29	23	0.333
Apical lesions	6	24	**<0.001**
Dental implants	14	10	0.384

* $p < 0.05$ (χ^2 test).

Discussion

The odontogenic theory of FMS is widely accepted, but its pathogenesis has not been well explained [11]. Previous studies have focused on the role root canal materials play in facilitating fungal sinus growth [6, 10]. It has been reported that 30%–40% of cases of chronic maxillary sinusitis have dental causes, such as ALs and tooth extraction [9]. In this respect, previous studies indicated higher incidences of extraction and EDT in patients with FMS compared to normal controls (100% vs. 76.1%, respectively) [6]. Manipulation of the sinus mucosa during dental procedures has been proposed as one of the main predisposing factors for FMS, as it may promote primary saprophytic colonization [12]. Our results also showed that FMS was associated with a higher EDT rate compared to normal sinuses. In addition, tooth extraction was more common in the FMS group than in the normal sinus group. It has been reported that the upper tooth root reaches the maxillary sinus mucosa or separates from the mucous membrane with only a thin bone cover, causing sinusitis through direct expansion of the infection or by interfering with mucosal cleaning [9]. Our results were consistent with these findings in that the CRS group had more ALs than the other groups.

EDT and extraction have been reported to be associated with the development of FMS. A previous study reported that 89.2% of the patients in the FMS group had undergone EDT compared to 36.9% in the normal control group ($p < 0.001$) [6]. Another article reported that the FMS group exhibited an EDT rate of 36.3% compared to 16.1% in the CRS group ($p < 0.001$), and the extraction rates were similar in both groups ($p = 0.719$) [10]. These differences in the results may have been because we enrolled only patients with unilateral sinusitis in both the FMS and CRS groups to ensure uniformity of the data, whereas the previous study included bilateral CRS in the CRS group. In addition, there have been reports of the occurrence of FMS after tooth extraction, consistent with our findings [13, 14]. Taken together with these observations, our findings suggest that the development of FMS may reflect manipulation of the sinus mucosa during tooth extraction and dental procedures such as EDT.

Our findings suggest that development of both FMS and chronic maxillary sinusitis reflects manipulation of the sinus mucosa during dental procedures; both groups exhibited significantly more dental factors than the normal control group [9]. This finding suggests that FMS is of mixed origin. The principal predisposing factor is sinus mucosal manipulation during a dental procedure; this facilitates primary saprophytic colonization [12]. Thus, the EDT material may not play any role.

The main strength of our study was that we compared 3 groups and selected patients with unilateral CRS as the CRS control group for homogenization of the data. In addition, although EDTs have been evaluated in many previous studies, we investigated several additional dental factors. Nevertheless, this study had some limitations. First, this is a retrospective study, and therefore causal relationships could not be determined. We found that FMS was associated with a significant number of dental factors. However, the factor that initiates the onset of FMS remains unknown. Second, we did not match patient ages among the groups, as this was difficult when enrolling patients with unilateral sinusitis, which is less common than bilateral sinusitis. Additionally, manual selection of unilateral sinusitis cases from the medical records could lead to selection bias, although we intended to choose only patients who underwent surgery in the same period with other groups.

Conclusion

The FMS group had significantly higher rates of EDT compared to the other groups. Rates of tooth extraction were higher in the FMS and CRS groups compared to the normal sinus group, and the CRS group had a higher incidence of ALs with unilateral maxillary opacification.

Statement of Ethics

This clinical trial was approved by the Institutional Review Board of the Seoul St. Mary's Hospital (KC20RISI0758). All investigators conducted this study in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients before recruitment.

Conflict of Interest Statement

The authors declare that there are no competing interests.

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There were no funding sources for this study.

Author Contributions

Mohammed Basurrah contributed to study conception and design, acquisition of data, analysis and interpretation of data, drafting the article and revisions, and final approval of the article; Do Hyun Kim contributed to study conception and design, acquisition of data, analysis and interpretation of data, drafting the article and revisions, and final approval of the article; Il Hwan Lee contributed to study conception and design, analysis and interpretation of data, drafting the article and revisions, and final approval of the article; Sung Won Kim contributed to study conception and design, analysis and interpretation of data, drafting the article and revisions, and final approval of the article; Soo Whan Kim contributed to study conception and design, acquisition of data, analysis and interpretation of data, drafting the article and revisions, and final approval of the article.

Data Availability Statement

The data that support the findings of this study are openly available in "figshare" at https://doi.org/10.6084/m9.figshare.14994270.v1.

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