

## ORIGINAL RESEARCH

## Histopathology of maxillary sinus mucosa with odontogenic maxillary sinusitis

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## Abstract

**Objective:** Histopathology of the maxillary sinus mucosa with intractable odontogenic maxillary sinusitis (OMS) was investigated and the role endoscopic sinus surgery (ESS) plays in its pathophysiology was clarified.

**Study Design:** Histopathological analysis of the OMS mucosa.

**Methods:** Surgical specimens were obtained from 20 patients who underwent ESS for intractable OMS. For rigid endoscopic observation of the mucosae, a 70° rigid endoscope 4 mm in diameter with an attached high definition surgical camera was used. Histopathological analyses of the maxillary sinus mucosa were conducted by light and scanning electron microscopy.

**Results:** All the maxillary sinuses were filled, not with viscous, but with purulent secretions. The high-definition camera showed that the maxillary sinus mucosa had gyrus-like appearance. Light microscopic histopathological studies revealed that the surface of the maxillary sinus mucosa was convoluted. Light and scanning electron microscopic histopathological studies revealed that the ciliated cells of the epithelium had not decreased and their goblet cells were not hypertrophic, indicating that the damage of the ciliated columnar epithelium was not severe and they were not injured irreversibly.

**Conclusion:** The ciliated columnar epithelium with intractable OMS was not severely damaged and not irreversibly injured. Hence, the pathophysiology of intractable OMS is one of the reasons why ESS is highly indicated for maxillary sinusitis requiring surgery and the treatment results are exceptionally good when the ventilation and drainage of the maxillary sinus is successfully restored after surgery.

**Level of Evidence:** NA

## KEYWORDS

endoscopic sinus surgery, histopathology, maxillary sinus mucosa, odontogenic maxillary sinusitis, pathophysiology

## 1 | INTRODUCTION

Odontogenic maxillary sinusitis (OMS) is an ancient but underappreciated cause of maxillary sinusitis. It is well known that maxillary dental infection can cause sinusitis and this pathophysiologic condition is called OMS. In the past, untreated dental diseases with endodontic or periodontic lesions of the maxilla accompanied with unilateral opacification of the maxillary sinus was once a common type of OMS.<sup>1,2</sup> However, current pathophysiology and management of OMS have changed.

Regarding the treatment of OMS, endoscopic sinus surgery (ESS) is highly indicated for intractable OMS requiring surgery.<sup>1-5</sup> The treatment results are excellent once the ventilation and drainage of the maxillary sinus is successfully restored after surgery.<sup>1-5</sup> However, optimal timing of surgery and whether intractable OMS patients undergo primary dental treatment, ESS, or both are still unclear. In addition, although previous studies have emphasized dental treatment as the primary treatment modality for OMS, there is recent evidence to suggest that ESS alone may be an effective treatment approach.<sup>1-5</sup>

The purpose of this study is to investigate the histopathology of the maxillary sinus mucosa with intractable OMS and discuss the role ESS plays in the pathophysiology of intractable OMS.

## 2 | MATERIALS AND METHODS

The surgical specimens were obtained from 20 patients who underwent ESS for intractable OMS.

All patients had already had prior root canal treatment (endodontics). This prior dental treatment caused the intractable OMS. The root canal procedures were not sufficient; hence, the root-canal-treated teeth had periapical lesions. In all patients, sinus symptoms outweighed dental symptoms with patients having minimal to absent dental complaints. Sinonasal symptoms of OMS were unilateral and consistent with cardinal symptoms of acute and chronic sinusitis such as purulent anterior rhinorrhea, postnasal drip, facial pressure, and nasal congestion. Five out of the 20 patients had percussion pain in the OMS causative tooth.

Regarding the diagnosis of OMS, evaluation of all patients with unilateral persistent chronic rhinosinusitis included inspection of the maxillary teeth with a cone beam computed tomography (CT) scan for endodontic and periodontic lesions including evidence of periapical lucencies. In addition, the relationships between the apical lesions of the causative teeth and the maxillary sinus were observed using cone beam CT scan to obtain accurate diagnosis. The ESS was performed as a first-line therapy for these cases of symptomatic OMS. Antibiotic administration without dental treatment was performed for the apical lesions of the causative teeth of OMS.

For rigid endoscopic observation of the maxillary sinus mucosa, a 70° rigid endoscope 4 mm in diameter (HOPKINS telescope, 7230CWA, Karl Storz, Germany) with an attached high definition surgical camera (H3-Z Image 1 HD Camera Head, Karl Storz, Germany) was used.

For light microscopy, surgical specimens of the maxillary sinus mucosa were fixed in 10% formalin, dehydrated in graded concentrations of ethanol, and embedded in paraffin. Hematoxylin-eosin stain was used for each section.

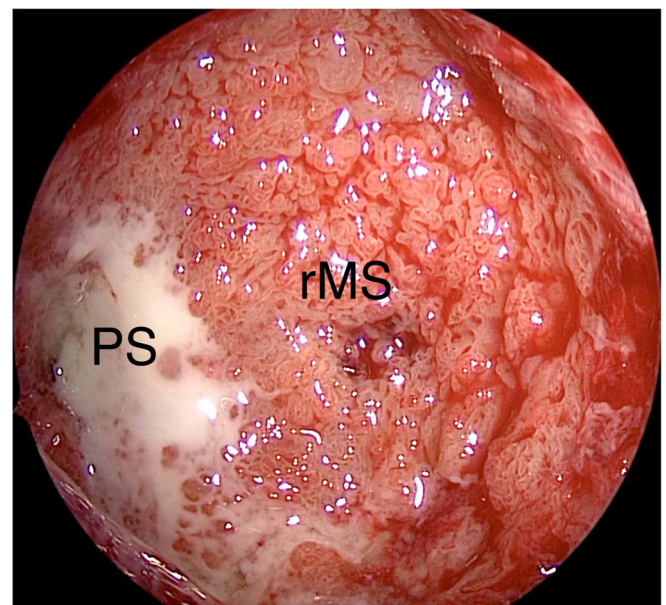
For scanning electron microscopy, the specimens of the maxillary sinus mucosa were fixed in 2.5% glutaraldehyde at 4°C for 2 hours. After rinsing with cacodylate buffer solution, these specimens were washed in physiological saline solution and postfixed in 2% osmium tetroxide with cacodylate buffer solution at 4°C for 2 hours. This was followed by dehydration in a graded series of concentrations of ethanol and dried by the critical point drying method. The specimens were then sputter-coated with gold. Observation was conducted with an S-800 scanning electron microscope (Hitachi High-Technologies Corporation, Tokyo, Japan).

Low-dose macrolide antibiotics were administered orally to all patients for 3 months postoperatively. Resolution of OMS was defined by the absence of inflammation on nasal endoscopy or cone beam CT scans.

## 3 | RESULTS

### 3.1 | Rigid endoscopic findings of the mucosa of the maxillary sinus

All the maxillary sinuses were filled not with viscous but with purulent secretions. A rigid endoscope with an attached high definition surgical camera showed that the maxillary sinus mucosa was gyrus-like in appearance (Figure 1).



**FIGURE 1** A 70° rigid endoscopic view via an enlarged right natural ostium and membranous portion of the maxillary sinus with OMS. The maxillary sinus was filled with purulent secretions. The maxillary sinus mucosa was gyrus-like in appearance. OMS, odontogenic maxillary sinusitis; PS, purulent secretions; rMS, right maxillary sinus



### 3.2 | Light microscopic findings of the maxillary sinus mucosa

Light microscopic histopathological studies revealed that the surfaces of the maxillary sinus mucosa were convoluted (Figure 2) resulting in the gyrus-like mucosal appearance under rigid endoscopy.

The number of ciliated cells of the maxillary sinus epithelium had not decreased and their goblet cells were not hypertrophic (Figure 3), indicating that the damage of the ciliated columnar epithelium was not severe. A great deal of inflammatory cells such as lymphocytes and leukocytes including neutrophils had infiltrated into the epithelium and lamina propria of the maxillary sinus mucosa (Figure 3). Blood vessels were dilated.

As a result, the ciliated columnar epithelium of intractable OMS was not severely damaged and not irreversibly injured.

### 3.3 | Scanning electron microscopic findings of the maxillary sinus mucosa

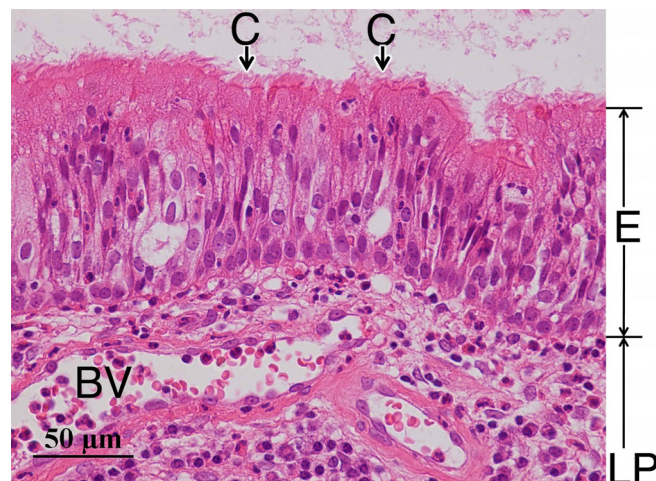
Scanning electron microscopic histopathological study revealed that the ciliated cells of the maxillary sinus epithelium had not decreased and their goblet cells were not hypertrophic (Figure 4), indicating that the damage of the ciliated columnar epithelium was not severe.

As a result, the ciliated columnar epithelium of intractable OMS was not severely damaged and not irreversibly injured.

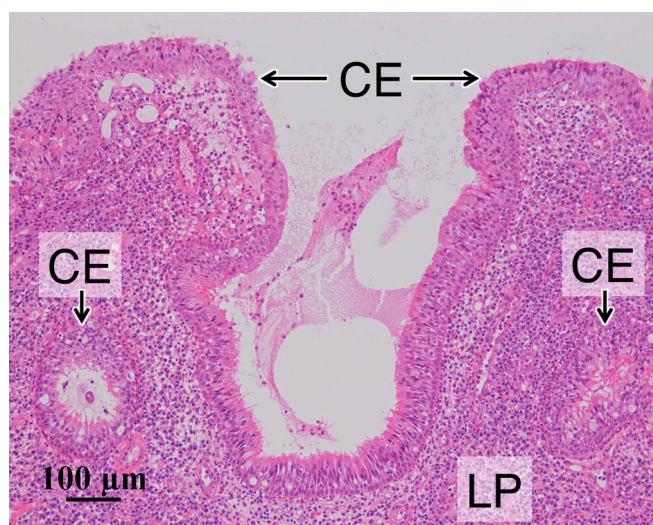
### 3.4 | ESS outcome

In postoperative nasal endoscopy and cone beam CT scans for all patients, the natural ostiums and the membranous portions of the

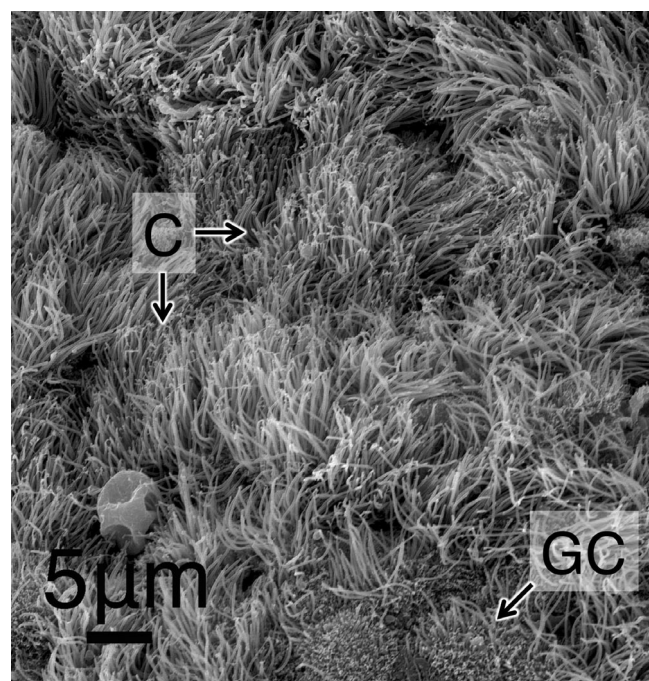
maxillary sinuses were enlarged and the ostiomeatal complexes remained widely open. The ventilation and drainage of all patients' maxillary sinuses seemed to be successfully restored during the



**FIGURE 3** Light microscopic findings of the maxillary sinus mucosa. The ciliated cells of the columnar epithelium had not decreased and their goblet cells were not hypertrophic, indicating that the ciliated columnar epithelium of the intractable OMS was not severely damaged and not irreversibly injured. A great deal of inflammatory cells such as lymphocytes and leukocytes including neutrophils had infiltrated into the epithelium and lamina propria of the maxillary sinus mucosa. Blood vessels were dilated. BV, blood vessel; C, cilia; E, ciliated columnar epithelium; LP, lamina propria of the mucosae; OMS, odontogenic maxillary sinusitis



**FIGURE 2** Light microscopic findings of the maxillary sinus mucosa. Surface of the epithelium of maxillary sinus mucosae was convoluted. CE, convoluted epithelium; LP, lamina propria of the mucosae



**FIGURE 4** Scanning electron microscopic findings of the maxillary sinus mucosa. The ciliated cells of the maxillary sinus epithelium had not decreased, indicating that the damage of the ciliated columnar epithelium was not severe. C, cilia; GC, goblet cell

follow-up period (13-36 months). Sinusitis recurrence after primary ESS for OMS was not imminent.

All of the causative teeth (endodontic-treated teeth, ie, root-canal-treated teeth with apical lesions) were able to be preserved with antibiotic treatment alone. Retreatment or extraction of the OMS causative teeth (endodontic treated teeth) was not necessary.

## 4 | DISCUSSION

Untreated dental diseases with endodontic or periodontic lesions of the maxilla accompanied with unilateral opacification of the maxillary sinus was once a common type of OMS.<sup>1,2</sup> However, current pathophysiology and medical treatment of OMS have changed.

Regarding the etiology, various odontogenic pathologies can cause OMS, including pulpitis, periapical lesions, periodontitis, oroantral fistulas, or foreign bodies in the sinus related to dental treatment.<sup>5-7</sup> However, the presence of periapical lesions is significantly associated with the thickening of the maxillary sinus mucosa and to OMS.<sup>8</sup> In Japan, because of an increase of personal hygiene awareness, it has become rare for untreated dental diseases to cause OMS.<sup>1,2,9,10</sup> Instead, most teeth which cause OMS have already received dental treatment, especially root canal treatment, that is, endodontics.<sup>1,2,8</sup> Apical lesions in incorrectly treated teeth cause pulpal, periapical, or periodontal lesions resulting in otitis and OMS.<sup>1,2,8</sup>

Regarding the diagnosis of OMS, in addition to physical examination, cone beam CT scanning is extremely useful in the diagnosis of OMS.<sup>11-13</sup> The cone beam CT scans are more sensitive and specific than dental radiography in detecting maxillary dental pathology and should be considered even if dental radiography is normal. The relationship between the maxillary sinus and causative teeth can be accurately observed and OMS can be accurately diagnosed using the cone beam CT scans.

Regarding the treatment of OMS, ESS is highly indicated for intractable OMS requiring surgery.<sup>1-5</sup> On the other hand, there is no consensus for the management of causative teeth of OMS.<sup>1-7,9,10</sup> Successful management of OMS involves a combination of medical treatment with dental surgery and/or ESS.<sup>4</sup> Although several studies have emphasized dental surgery as the primary treatment modality for OMS, there is recent evidence to suggest that ESS alone may be an effective treatment approach.<sup>1-5</sup>

From our experience and the results of this study, if the ventilation and drainage of the maxillary sinus is successfully restored after ESS, most of the causative teeth (endodontic treated teeth, ie, root-canal-treated teeth with apical lesions) with minimal to absent symptoms can be preserved with only antibiotic treatment alone.<sup>1,2,9,10</sup> If the burden of OMS is high, primary ESS could be recommended, followed by close dental follow-up and treatment as needed.<sup>1,2,5,9</sup>

In this study, histopathology of the maxillary sinus mucosae with intractable OMS was investigated and the role ESS plays in its pathophysiology was clarified.

## 4.1 | Pathophysiology of the OMS

When odontogenic inflammation such as apical lesion is constantly presented at the floor of the maxillary sinus, the maxillary sinus is exposed to the potential danger of inflammation. Bauer showed that inflammation and infection from tooth roots could spread through the maxillary alveolar bone and sinus mucosa, thereby causing sinus inflammation and infection.<sup>14</sup> Inflammation chains between dental lesions, odontogenic infection, and retardation factors of sinusitis influence OMS.<sup>1,2</sup> And a vicious cycle of inflammation in the closed maxillary sinus results in intractable maxillary sinusitis.<sup>1,2</sup> Regarding the retardation factors on the treatment of sinusitis, mucociliary function, bacteria and virus infections, occlusion of ostiomeatal complex, and a combination of these three factors cause an inflammatory vicious cycle in the closed maxillary sinus and result in intractable OMS.<sup>1,2</sup>

In the case of usual chronic inflammatory maxillary sinusitis, the number of ciliated epithelial cells decreases and goblet cells become hypertrophic and secretions are viscous. Consequently, mucociliary functions of the epithelium of the maxillary sinus mucosae are inhibited.

On the other hand, maxillary sinus mucosa of OMS shows a characteristic histopathology. In this study, histopathological investigation of intractable OMS revealed that the maxillary sinus mucosa appeared gyrus-like in appearance and that the number of ciliated epithelial cells did not decrease, goblet cells were not hypertrophic and the secretions were not viscous but purulent. Zhang et al reported that small papillary protrusions could be seen in the maxillary sinus mucosa of OMS under nasal endoscopy, similar to the morphological behavior, which also presented as papillary folds in the surface of the epithelium.<sup>15</sup> And papillary-like fold mucosa of OMS was covered with intact pseudostratified columnar ciliated epithelium.<sup>15</sup> Raman et al reported that odontogenic chronic rhinosinusitis exhibited increased moderate-severe inflammation compared to chronic rhinosinusitis without nasal polyp, had decreased squamous metaplasia and fibrosis compared to chronic rhinosinusitis with nasal polyp, and exhibited some eosinophilia but to a lesser extent than chronic rhinosinusitis with nasal polyp.<sup>16</sup> Raman et al also reported that odontogenic chronic rhinosinusitis represented an endotype of chronic rhinosinusitis with histopathology more similar to that of chronic rhinosinusitis without nasal polyp.<sup>16</sup>

Hence, from the histopathological point of view, the ciliated columnar epithelium of the intractable OMS was not severely damaged and not irreversibly injured. As a result, mucociliary function of the epithelium will almost certainly recover once the ventilation and drainage of the maxillary sinus is successfully restored. Consequently, regarding the aforementioned three retardation factors on the treatment of OMS, the treatment strategy centers around how to manage the two remaining factors: infections and occlusion of the ostiomeatal complex.

## 4.2 | Current medical treatment of OMS

There is no consensus for the management of causative teeth for OMS. When the causative tooth is extracted, the inflammation chain between dental lesions and maxillary sinusitis will improve. However,

other inflammation chains, such as retardation factors of sinusitis, still exist. The worst situation for the patient is that maxillary sinusitis is not cured even though the tooth has been extracted.

It has been said that successful treatment of OMS first requires management of the odontogenic source and several studies have emphasized dental surgery as the primary treatment modality for OMS. For example, The American Academy of Endodontics published a 2018 position statement on maxillary sinusitis of endodontic origin, suggesting that dental treatment should be performed first, followed by ESS only if needed.<sup>17</sup> However, the management of a previously treated tooth, such as an endodontic treated tooth, that is, root-canal-treated tooth, is challenging.<sup>1,2,9</sup> In addition, as shown in this study in which a large number of inflammatory cells had infiltrated into the maxillary sinus mucosa, intractable OMS which has fallen into a vicious cycle of inflammation in the closed maxillary sinus is difficult to cure using only conservative therapy such as antibiotic administration and dental treatment.<sup>1,2,9</sup> Raman et al reported that the increased inflammation observed in odontogenic chronic rhinosinusitis relative to chronic rhinosinusitis without nasal polyp may help explain why odontogenic chronic rhinosinusitis tends to be refractory to medical and dental therapy.<sup>16</sup>

This study revealed that the maxillary sinus mucosa of OMS shows characteristic histopathology compared with usual chronic inflammatory maxillary sinusitis. The ciliated columnar epithelium of the intractable OMS was not severely damaged and not irreversibly injured. Consequently, mucociliary function of the epithelium will almost certainly recover once the ventilation and drainage of the maxillary sinus is successfully restored after improving the occlusion of the ostiomeatal complex. When the ventilation and drainage of the maxillary sinus is successfully restored after ESS, apical lesions and odontogenic infection will lead to silent chronic lesions using only antibiotic therapy alone and most causative teeth can be preserved.<sup>1,2,9</sup> That is the reason why ESS preceding causative tooth extraction or dental treatment is highly indicated for surgery-requiring intractable OMS. Craig et al support this concept that ESS can be considered first-line therapy for symptomatic OMS, followed by dental treatment when necessary.<sup>5</sup>

## 5 | CONCLUSIONS

Despite increased severe inflammation, the ciliated columnar epithelium of intractable OMS was not severely damaged and not irreversibly injured. Hence, the pathophysiology of intractable OMS is one of the reasons why ESS is highly indicated for surgery-requiring intractable OMS.

The results of the present studies show that the treatment results of intractable OMS are exceptionally good once the ventilation and drainage of the maxillary sinus is successfully restored after surgery and support the concept that ESS can be considered the first-line therapy for intractable OMS caused by root canal treatment (endodontics), followed by dental treatment when necessary.

## CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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