Introduction

In light of the theory that mucus flow is directed centripetally toward the natural maxillary ostium, endoscopic sinus surgery has been employed to treat chronic rhinosinusitis for nearly 40 years. Technology has made a historic breakthrough in the surgical treatment of chronic rhinosinusitis. However, many patients still suffer continuously from this disease, despite maximal medical therapy and endoscopic sinus surgery. Management of refractory chronic rhinosinusitis is difficult because pathophysiology is not clear, despite many factors considered related to it. In any case, incorrect operational procedure may be one cause of this phenomenon. Nowadays, another milestone of endoscopic sinus surgery is recognition of the need to preserve the natural structure and function of the nasal cavity and paranasal sinus as much as possible in the course of surgery.

To improve the effect of surgical treatment of chronic rhinosinusitis, it is necessary to strengthen basic scientific research regarding the nasal cavity and paranasal sinus. In this study, we applied nasal endoscopy to observe transport through the maxillary ostia in the ethmoid infundibulum.

Material and methods

Patients

Five hundred and twelve patients suffering from chronic rhinitis or rhinosinusitis (n = 235 women and n = 277 men; 13 to 76 years of age, mean age 48.2 years) were recruited for this study. Medical therapy had been or was to be used to treat these patients. Patients had no surgical history of nasal cavity and paranasal sinus, and their middle meatus (especially their semilunar hiatuses) were all wide enough that the maxillary ostia could be observed with transnasal endoscopy.

Method: Transnasal observation of 512 patients in a supine or seated position was conducted with 0- and 70-degree nasal endoscopes. Drainage pathways of mucopurulence at the natural maxillary ostia were observed. A dye test was also performed in 53 patients to clearly observe real-time transport of activated carbon in the ethmoid infundibulum.

Results: Among 914 ethmoid infundibula, mucopurulence and activated carbon were transported out of 31 and 53 natural maxillary ostia, respectively. All ethmoid infundibula drained at the inferior edges of the ostium, despite patients’ supine or seated positions. Fourteen cases of mucopurulence and 17 cases of activated carbon flowed circularly in the ethmoid infundibulum. The flow of activated carbon from the natural ostium to the nasopharynx could also be observed simultaneously or solely. However, there were 6 ostia through which no activated carbon flowed back into or drained out of the sinus, despite flow from the natural ostium to the nasopharynx or circular flow.

Conclusions: The drainage pathway of the maxillary ostium is its inferior edge. The accessory ostium is only necessary to promote circular flow. Mucopurulence or activated carbon, which flowed circularly in the ethmoid infundibulum, can also be gradually transported to the nasopharynx. Revision surgery may not be necessary for all patients with circular chronic maxillary sinuses.
Nasal endoscopy

All patients were seated at first, and 0- and 70-degree nasal endoscopes were applied to observe the flow pattern of mucopurulence through the maxillary ostia in the ethmoid infundibula. Next, patients in whom mucopurulence was clearly observed to be draining from the maxillary ostia were asked to adopt a supine position; these patients were re-examined after lying in a supine position for two minutes.

Dye test

Patients were supine, and regular surface anaesthesia was administered. Activated carbon was placed in the top of a catheter for intravascular interventional therapy. The top of the tube was placed into the maxillary sinus via its ostium with the assistance of a 70-degree transnasal endoscope. The end of the tube was joined to a syringe. Air was pushed out of the syringe to propel the activated carbon into the maxillary sinus. After the application of activated carbon, patients were allowed sit upright. Transport of activated carbon was observed at the ostia of the maxillary sinuses, especially the drainage pathway where the dye drained out of the natural maxillary ostium, mostly every two minutes. Meanwhile, each patient was observed in the supine position at least once. Total experimental time was 20-60 minutes.

Results

There were 914 maxillary ostia that could be clearly observed. Mucopurulence was clearly observed draining from 31 ostia. Even when patients were supine or seated, draining tracks were all located in the range of the inferior edge of the maxillary ostia (Figure 1). Activated carbon was observed draining from the inferior edges of the ostium in all 53 tested maxillary sinuses, whether patients were in a supine or seated position (Figure 2).

Circular flow of mucopurulence was observed in 14 ethmoid infundibula. However, maxillary sinuses were all not full of mucopurulence, and the circular flow was only exhibited to be a ring between the natural and accessory ostia (Figure 3). Out of 53 dye tests, circular flow of activated carbon was observed in 17 ethmoid infundibula and the flow of activated carbon directed to the nasopharynx could be observed solely or simultaneously (Figure 4) during the experiment. No activated carbon drained out of or into 6 ostia, although a flow of activated carbon was observed directing to the nasopharynx during the experiment (Figure 2).

Discussion

Surgical enlargement of the natural maxillary ostium is only in its
Transport through the maxillary ostium

beginning stages. This surgery is intended to restore ventilation and drainage of the maxillary sinus even when the maxillary ostium is enlarged into the anterior nasal fontanelle or circularly enlarged. However, there has never been a theory about whether a special drainage pathway from the natural maxillary ostium exists, and the ostium can be enlarged in different patterns. The regenerating mucous membrane is deciliated and dysfunctional. Additionally, postoperative drainage generally does not follow a physiologic pathway, and may even lose its ability to transport out of the ostium and just flow circularly within the sinus. As a result, mucopurulence is retained in some postoperative maxillary sinuses despite patency of the surgical ostium. This phenomenon implies that the drainage pathway of the maxillary sinus may have been destroyed during endoscopic sinus surgery, and the damage may therefore be irreversible. In this study, drainage of mucopurulence and activated carbon were all shown to flow via the inferior edges of the natural maxillary ostia. Reserving the inferior edge of the natural maxillary ostium during endoscopic sinus surgery should maintain the physiologic drainage pathway of the sinus as a complete and continuous system; this could be the key to eliminating mucous stasis in postoperative maxillary sinuses.

Natural and accessory ostia of the maxillary sinus may coexist in the ethmoid infundibulum, and recirculation would be possible if there was secretory flow. In this study, mucopurulence returns to 14 maxillary sinuses, and activated carbon returns to 17 maxillary sinuses, via the ostia. Moreover, no activated carbon drained out of or into 6 ostia, even though the flow of activated carbon was observed directing to the nasopharynx. The natural ostium is the position where the maxillary sinus can actively drain mucopurulence or activated carbon. The ostium through which no activated carbon drained out of or into the maxillary sinus may be considered an accessory ostium. Therefore, circular flow may not occur; even if the accessory ostium exists, it is only a necessary but not a sufficient condition for the presence of circular flow.

In this study, a dye test was used to clearly observe real-time transport through the maxillary ostium. The experiment demonstrated that the transport of activated carbon from the natural ostium to the nasopharynx flows in several sub-tracks. Recirculation occurred when the accessory ostium was located in the pathway of one or more sub-track(s); otherwise, recirculation would not occur despite the presence of an accessory maxillary ostium in the ethmoid...
infundibulum. In any case, whether circular flow occurred or not, the flow of activated carbon from the natural ostium to the nasopharynx was demonstrated in all cases (Figures 2,4). This phenomenon implies that the activated carbon which had been put into the maxillary sinus should have been transported gradually to the nasopharynx, but the drainage time should be longer in circular flow sinuses than in sinuses that lack circular flow. In turn, this hypothesis suggests that in circular chronic maxillary sinus, continuous mucopurulence may result from persistent inflammation of the maxillary sinus, and circular flow may not be the real cause of persistent inflammation. If this hypothesis is true, revision endoscopic sinus surgery may not be necessary for all patients with circular chronic maxillary sinuses.

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References