The endoscopic middle meatal maxillary antrostomy is one of the most commonly performed endoscopic procedures. Despite this, at our tertiary institution, we commonly see failed antrostomies requiring revision surgery. Accordingly, we describe in a stepwise fashion strategies helpful in creating a patent and naturally function maxillary antrostomy.

Key Words: Ostium, mucociliary, optimal size, uncinate.

INTRODUCTION
Endoscopic middle meatal maxillary antrostomy was first reintroduced into the English literature by the senior author in the mid 1980s. The concept was based on research demonstrating mucociliary flow through the natural maxillary os. Today, the endoscopic middle meatal antrostomy has become one of the most commonly performed endoscopic sinus procedures. Often considered the most basic and easy portion of endoscopic sinus surgery, our experience in revision endoscopic sinus surgery strongly suggests that this is not the case. Failure to perform a careful antrostomy is a frequent cause of technical failure in endoscopic sinus surgery. In contrast to ethmoid or sphenoid surgery, which have clear and consistent landmarks such as the skull base and lamina papyracea, there are limited identifiable landmarks as to where a natural obstructed maxillary sinus ostium should be located. Accordingly, the goal of this article is to highlight the key intraoperative steps to creating an effective maxillary antrostomy.

IDENTIFYING THE NATURAL OSTIUM
Essential to successful middle meatal antrostomy is inclusion of the natural os. Our experience suggests that the uncinate process becomes involved in the inflammatory reaction early in the disease process. Accordingly, although it is possible to just dilate the maxillary sinus ostium with a balloon, at this point in time we believe that complete removal of the uncinate process is important in firmly established chronic disease. Unfortunately, the anterior margin of the uncinate process attaches to the nasolacrimal duct, a structure not readily visualized during intranasal surgery, and Bolger has previously demonstrated that injury to the nasolacrimal duct during antrostomy is common, although frequently asymptomatic.

Uncinectomy may be completed by any of a variety of different techniques, after which the natural ostium must be visualized. If performed through an initial anterior incision through the uncinate, the ideal landmark is the maxillary line. There are limited identifiable landmarks as to where a natural obstructed maxillary sinus ostium should be located. Accordingly, the goal of this article is to highlight the key intraoperative steps to creating an effective maxillary antrostomy.

Endoscopic Maxillary Antrostomy: Not Just A Simple Procedure
David W. Kennedy, MD; Nithin D. Adappa, MD

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Uncinectomy may be completed by any of a variety of different techniques, after which the natural ostium must be visualized. If performed through an initial anterior incision through the uncinate, the ideal landmark is the maxillary line. The maxillary line is a curvilinear, mucosal eminence projecting from the anterior middle turbinate attachment superiorly extending in a vertical fashion inferiorly to the dorsum of the inferior turbinate. This line correspond intranasally to the junction of the uncinate process and the maxilla. Incising the uncinate just posterior to this line aids in complete removal of the entire process and minimize bleeding as incision into the maxilla is avoided. Once a complete uncinectomy is performed, the natural ostium typically lies under the cut inferior edge of the uncinate process. If not immediately visible, the ostium is best exposed by using a right angle ball-tip probe to displace the residual cut edge of the uncinate medially and inferiorly. The natural ostium can typically be identified at this point with an angled telescope. If the ostium is still not seen, additional retrograde dissection of the uncinate may be necessary. Gentle manipulation of the posterior fontanelle with a ball-tip probe often produces bubbles from the os that can also help in natural ostium identification. The 45° or 70° endoscopes are frequently required to ensure that the natural ostium has, indeed, been opened. Identifying the natural ostium is a critical component in performing a successful maxillary antrostomy. Mucociliary...
recirculation will arise if an ostium is created that does not include the natural ostium, or resulting scar band formation occurs between the natural ostium and surgical ostium (Fig. 1). Once the natural maxillary os is identified and seen to be open, in more minor disease no additional manipulation may be required. If ostial enlargement is necessary it may be possible just to tease out some of the residual uncinate bone that forms part of the medial wall of the maxillary sinus and to reappose the mucosal edges. When more aggressive opening is required, a number of instruments can be used including a variety of through-cutting instruments or curved powered microdebriders. As always, attention should be paid to avoid stripping the mucosa, and exposed bone should be avoided whenever possible because it provide a nidus for persistent inflammation as well as ostial stenosis.

UNCINATE TISSUE

The uncinate process often demonstrates osteitis and, if not completely resected, will frequently continue to be a source of persistent disease and postoperative scarring. In severe chronic sinusitis, the bone anteriorly often thickens and makes dissection of the true natural ostium much more difficult. Utilization of a rotating motion with an open back-biting forceps to flip this thickened uncinate process into the nasal cavity is a key step in this situation, and frequently reveals retained and previously unrecognized residual uncinate (Fig. 2).

DISCUSSION

Optimal Antrostomy Shape

For effective mucociliary clearance, the anterior most portion of the sinus must be open. Given the trajectory of the nasolacrimal duct, where the duct runs at an
angle of approximately 110° to the Frankfort horizontal line,\(^5\) the ideal shape of a surgical maxillary antrostomy is pear shaped as the anterior portion is dissected just posterior to the nasolacrimal duct (Fig. 3). Classically, dissection is continued until the “hard bone” of the lacrimal duct is encountered and at this point dissection is generally terminated. However, such an approach may lead to exposure of bone on the posterior aspect of the lacrimal duct. Additionally, both the presence of thickened uncinate, and the fear of nasolacrimal duct injury often lead to a residual anterior lip of bone anteriorly exactly in the region of most critical importance for mucociliary clearance. The use of an image guidance system (IGS) has significantly aided in dissecting this anterior most portion of the antrostomy (Fig. 4).

**Infraorbital Ethmoid Cells**

Infraorbital ethmoid cells, or Haller cells, when present provide an additional challenge. They displace the natural ostium inferiorly and may be involved in the disease process with significant bone neo-osteogenesis and require resection. Unfortunately, ideal instruments are not available at this time for efficient dissection. In these situations, the down-biting forceps turned in a lateral direction, 90° blakesly forceps or the 90° curette may be surgically helpful.

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Fig. 3. Left maxillary antrostomy. Note the pear shape with inclusion of the natural maxillary os (white circle). Additionally, all bone fragments have been removed from mucosal edges to avoid excessive postoperative inflammation. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

Fig. 4. Triplanar computer-assisted image guidance demonstrating a suction tip (green dot with arrow) enables accurate identification of nasolacrimal duct and anterior aspect of maxillary antrostomy dissection. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]
Optimal Antrostomy Size

There is long-standing debate over the optimal size for maxillary antrostomy. The primary concern of large antrostomy is the drying effect on the sinus mucosa that arises from early rabbit models that demonstrated cessation of maxillary mucociliary clearance in the presence of maxillary sinus airflow. It is possible that exposure of the maxillary sinus mucosa to airflow may, as a result of decreased mucociliary clearance, also be a factor in biofilm formation. In any case, the maxillary sinus opening that protrudes into the nasal airflow should be avoided. Thus, when the maxillary sinus protrudes medially posteriorly, either the maxillary sinus is best minimally opened, or the opening should be extended posteriorly to the pterygoid plate, so as to avoid an “air scoop” into the sinus. Recently, there has been an increasing debate regarding the role of nitric oxide (NO) in the maxillary sinus. Phillips et al. published a meta analysis of the literature evaluating NO in the paranasal sinuses. They conclude that currently there are no studies that correlate NO levels with any clinical, biochemical, or pathologic measure of sinus mucosal inflammation. In addition, although NO is bacteriostatic to Staphylococcus aureus in vitro, its actions on other pathogens vary widely from beneficial to detrimental. In addition, although NO appears to be related to ciliary beat frequency, whether this is a cause or effect relationship is unclear. Finally, the meta analysis concludes that at this point, there is evidence that enlarging a maxillary sinus ostia reduces NO concentration, but there is no evidence to demonstrate negative effects of a wide maxillary antrostomy secondary to NO levels.

Mucociliary clearance is most effective with the cilia beating in both directions, so in theory a small antrostomy provides the most effective clearance. On the other hand, concerns with a small antrostomy include postoperative edema, persistent obstruction and scar formation. At the current time, despite much debate, optimal maxillary antrostomy size remains unclear.

CONCLUSIONS

Maxillary antrostomy is frequently believed to be the simplest portion of endoscopic sinus surgery. It is evident that this could not be further from the truth. Maxillary antrostomy is a challenging procedure because of the paucity of landmarks, the critical nature of the anterosuperior portion of the maxillary sinus ostium for mucociliary flow and the potential for significant bone neo-osteogenesis in this region. Using telescopes with significantly deflected angles of view, removal of osteitic bone while minimizing bone exposure and, when necessary, use of image guidance are all important adjuncts to avoiding persistent symptoms and surgical failure.

BIBLIOGRAPHY