Prevention and Management of Complications in Maxillary Sinus Surgery

Esther Kim, MD, James A. Duncavage, MD*

Maxillary sinus surgery has continued to evolve ever since George Caldwell and Henri Luc described an anterior approach to the maxillary sinus in the late 1800s. Notable changes came in the 1980s with the introduction of endoscopes for use in the para-nasal sinuses. The use of angled endoscopes gave the surgeon views of the middle meatus and maxillary ostium that were previously not possible. The development of the coronal bone window for CT scans, introduced in 1987, also gave sinus surgeons a much-needed diagnostic test for the maxillary sinus.

This article is divided into six sections that are related to six commonly used operations for surgery on the maxillary sinus. The authors discuss maxillary sinoscopy, the Caldwell-Luc procedure, extended middle meatus antrostomy, endoscopic maxillary sinus antrostomy, minimally invasive sinus technique, and balloon sinus procedures. In each of these procedures, the authors discuss potential complications (Table 1) and address prevention and management strategies.

MAXILLARY SINOSCOPY

Maxillary sinoscopy is a surgical technique that allows the surgeon to look inside the maxillary sinus with a telescope and to treat the diseased anterior half of the maxillary

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James Duncavage is a stockholder and serves on the scientific advisory board for Entellus Medical, Inc.
Division of Rhinology, Department of Otolaryngology, Vanderbilt University Medical Center, 7209 Medical Center East, South Tower, 1215 21st Avenue South, Nashville, TN 37232-8605, USA
* Corresponding author.
E-mail address: james.duncavage@vanderbilt.edu

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KEYWORDS

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- Caldwell-Luc
- Maxillary sinoscopy
- Balloon dilatation
sinus. This procedure is often performed in association with an endoscopic endonasal middle meatal approach. For the sinoscopy, the surgeon uses an endoscopic trocar to traverse the canine fossa into the maxillary sinus. During this approach, branches of the infraorbital and anterior superior alveolar nerve (ASAN) may be harmed because of their proximity to the canine fossa. Resultant complications from injury to these nerves include facial pain, dental numbness, and local hypoesthesia. Other notable complications of the sinoscopy procedure include facial swelling and cellulitis. Robinson and Wormald described an ideal point of anterior entry into the sinus at the intersection of the mid-pupillary line and the horizontal line through the floor of the nasal vestibule. Fig. 1 depicts this point. Once this landmark is identified, a trocar is twisted to remove bone of the anterior wall of the maxillary sinus. The trocar should not be hammered into the sinus because of the possibility of fracture of the anterior wall through the branches of the infraorbital nerve and ASAN with resultant facial numbness. Careful attention to these guidelines will diminish the risk for dental numbness and facial hypoesthesia. To decrease postoperative facial emphysema, patients should be instructed to not blow their nose for 24 hours after surgery. Pre- and postoperative antibiotics should also be considered to prevent facial cellulitis as a consequence of dragging the trocar through the facial soft tissues. In the authors’ experience, placing ice over the cheek area postoperatively has reduced the bruising and swelling often associated with this approach.

Caldwell-Luc

Until the mid 1980s, the Caldwell-Luc operation was the main operation used to manage maxillary sinus disease. Currently, it is rare for the sinus surgeon to resort to the Caldwell-Luc operation. The Caldwell-Luc operation is, however, the authors’ mainstay of surgical treatment for failed middle meatus antrostomy maxillary sinus disease. This procedure is the authors’ last-resort operation after exhausting surgical and medical treatments of the diseased sinus, including revision antrostomies, biofilm management, use of culture-directed antibiotics, nasal irrigations, systemic steroids,

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multiple office debridements, and intravenous antibiotics on occasion. When patients state that they are tired of all the treatment, it becomes time to look at other options: the authors offer Caldwell-Luc at this point.

This procedure has been noted to have varying rates of complication and morbidity in the literature. Cutler and Duncavage reviewed 133 Caldwell-Luc procedures with a follow-up of 1 to 6 years. They found a 92% success rate with an average follow-up of 23.5 months. The most common risk for the Caldwell-Luc procedure is the failure of the surgery to cure the infection. Eight percent (n = 3) of subjects in this review did not respond to the surgery. In two of these three cases, failure was caused by trapped mucosa and these cases were successfully salvaged with a repeat Caldwell-Luc procedure. Mild postoperative discomfort was reported in 37% and facial numbness or deformity was identified in 2%.4,5 Defreitas and Lucente published the largest, single institutional review of 670 cases of the Caldwell-Luc operation in 1988. The immediate postoperative complications in 522 subjects were facial swelling in 89% of subjects, cheek discomfort in 33% of subjects, temperature more than 101°F in 12% of subjects, and significant hemorrhage in 3% of subjects. They reported long-term complications of facial asymmetry in 0.7% of subjects, facial numbness or paresthesia in 9.0% of subjects, oral antral fistula in 1.0% of subjects, gingival-labial wound dehiscence in 1.0% of subjects, dacryocystitis in 2.0% of subjects, devitalized dentition in 0.4% of subjects, recurrent sinusitis in 12.0% of subjects, and recurrent polyposis in 5.0% of subjects.6

How do we prevent the previously mentioned complications? The authors recommend using the previously described anatomic landmarks for entry into the maxillary

![Fig. 1. Location of trocar placement for maxillary sinoscopy, Caldwell-Luc, Entellus balloon procedure adapted from Wormald. (Courtesy of Megan Rojas, MA, Nashville, TN; with permission.)](image-url)
sinus to minimize injury to branches of the infraorbital nerve and ASAN. By twisting
the trocar through the canine fossa, one can avoid fracture of surrounding bone. Care must also be taken when elevating the periosteum to avoid injury to the adjacent nerves. The authors do not extend the bone removal lateral to the point of entry to protect the lateral maxillary buttress and to minimize potential facial asymmetry. Bleeding is minimized by the use of the topical clotting agents and, at the end of the procedure, the sinus is filled with hemostatic agents, such as Surgifoam (Ethicon, Inc, Somerville, NJ, USA).

To avoid an oroantral fistula, the authors perform an inferior meatal antrostomy at the time of the Caldwell-Luc procedure to assist with sinus drainage. The placement of this antrostomy is important to not injure the valve of Hasner, and should be directed in the posterior two thirds of the inferior meatus. Patients are seen postoperatively at 1 week to remove and debride crusts that block the middle meatus, which seems to help with postoperative pain and pressure over the maxillary sinus. Wound dehiscence is prevented by closure with absorbable suture using a running, non-locking, horizontal mattress closure.

EXTENDED MIDDLE MEATUS ANTROSTOMY/MEGA-ANTROSTOMY

The extended middle meatus antrostomy was described in 1996 to help manage persistent maxillary sinusitis in patients with a previously placed inferior meatus antrostomy and a surgically reduced inferior turbinate. To correct the postoperative maxillary sinus circular flow that was often present in these patients, the natural maxillary ostium was connected to the inferior meatus antrostomy with removal of the inferior turbinate posterior to the valve of Hasner. Duncavage and Cho reported resolution of sinusitis in all six subjects on whom they first performed this procedure. Cho and Hwang also studied 28 subjects (42 procedures) who underwent a similar procedure for recalcitrant maxillary sinusitis and reported 74% of the subjects with complete or marked resolution of symptoms. They concluded this was a reasonable intermediate salvage procedure for maxillary sinusitis for which radical mucosal exenteration is not desirable.

The authors have identified several possible complications that can be associated with this procedure. The first is exposed bone of the posterior attachment of the inferior turbinate that can lead to crusting. This complication can be easily treated by endoscopic removal of any exposed bone. Another complication is incomplete removal of the posterior inferior turbinate resulting in circular flow around the stump. This complication can be corrected by removing the posterior stump of the remaining inferior turbinate. Bleeding is also a risk, and meticulous hemostasis around the posterior aspect of the inferior turbinate is especially important. Empty nose syndrome or atrophic rhinitis may also occur; it is for this reason that the anterior aspect of the inferior turbinate is meticulously preserved. Injury to the nasolacrimal duct is also a consideration and avoiding the anterior one half of the inferior turbinate will assure the nasolacrimal system from injury.

ENDOSCOPIC MIDDLE MEATAL ANTROSTOMY

Kennedy and colleagues introduced the middle meatal antrostomy as a better surgical approach to the maxillary sinus in the mid 1980s. Proof that the mucociliary clearance through the natural os persisted despite inferior meatal antrostomies led to the development of this procedure. Kennedy argued that careful enlargement of the natural os was the key to treatment of this sinus. The endoscopic middle meatal antrostomy is one of the most common endoscopic sinus procedures sinus surgeons
perform today. The maxillary sinus is often misunderstood and a mere surgical opening is not enough; it must include the natural os. The surgery can be performed in various ways but the key steps of the procedure include removal of the uncinate process, identification of the natural os, and enlargement of the ostium. This procedure can be accomplished through a variety of instruments, including biting instruments and powered microdebriders. The patency of the middle meatal antrostomy in the original Kennedy study was reported to be 98%. In a more recent study that involved 90 antrostomies, 84 (93.5%) remained patent after 18 to 30 months. The size of the antrostomy does not appear to affect the outcome of symptoms or chronic maxillary sinusitis.

Scarring in a postoperative setting is commonly seen and can easily be revised in the office. It is often the result of a circular injury to the ostium. Care must be taken when dissecting the natural os to leave the anterior superior aspect of the antrostomy intact. Scarring can also result in circular flow when the scar tissue separates the natural ostium from the surgical antrostomy. A missed natural ostium is also another cause for circular flow. Whether the scar tissue forms or a missed ostium is the cause for the circular flow, Albu discovered that this finding has the strongest correlation in persistent postoperative symptoms. Similarly, the accessory os should be included in the enlargement to prevent circular flow. Fig. 2 is a pictorial sequence of circular flow in the setting of missed natural ostia. One can follow the air bubble to see the flow pattern.

Several complications can occur intraoperatively. Injury to the nasolacrimal duct can occur with excessive dissection anteriorly, most commonly with a back biter. The nasolacrimal sac lies 8.8 mm above the insertion of the middle turbinate and drops about 11 mm inferiorly where it then becomes the nasolacrimal duct. It is closest to the maxillary os at the midpoint of the maxillary line, which is described as a curvilinear line from the middle turbinate attachment to the roof of the inferior turbinate. The initial management of this complication is by observation. If postoperative epiphora is persistent, ophthalmologic consultation and subsequent operative treatment may be needed, including a dacryocystorhinostomy. Orbital penetration during uncinectomy is a potential complication and is especially important in the setting of hypoplastic maxillary sinus surgery. The uncinate may often be adherent to the medial orbital wall in some situations, and care must be taken to dissect the uncinate away before removal is attempted. Using a sickle knife to perform an uncinectomy would be inappropriate in the example of a severely atelectatic, retracted uncinate. Entering the maxillary sinus inferiorly first and then following the contour of the orbit is the safest technique to avoid orbital penetration. Even less common is injury to the infraorbital nerve. A dehiscent nerve will be evident on coronal CT scan and when this anatomic variation occurs, care must be taken to not injure the nerve by avoiding aggressive dissection within the sinus.

During endoscopic sinus surgery, the middle turbinate is often preserved. In the setting of preservation, it can become destabilized and cause scarring of the middle

Fig. 2. Circular flow of maxillary sinus as a result of missing natural os, following the bubbles will give the reader the direction of movement.
meatus. To prevent this, a spacer must be placed postoperatively or care must be taken to prevent lateralization with either the Bolger technique, excoriating the medial surface of the turbinate and septum, or suture technique. If scarring results, often simple office revision is all that is necessary, but operative revisions are not uncommon.

**BALLOON PROCEDURES**

Balloon technology has become a relevant tool in sinus surgery. It has enabled sinus surgeons to address treatment of the maxillary sinus while avoiding some of the surgical pitfalls previously mentioned. There are two products that are able to address the maxillary sinus. Each product has shown efficacy in treatment of chronic rhinosinusitis of the maxillary sinus.

Acclarent Inc uses balloon technology that introduces a balloon catheter over a wire through an angled sheath. The sheaths are specific to each sinus: 70° for frontal, 110° for maxillary, and 0° for sphenoid. The wire is either used under fluoroscopy or a lighted wire can be used. The initial clinical evaluation to confirm safety and efficacy of sinusplasty in the paranasal sinuses (CLEAR) study reported a patency of 113 out of 124 (91%) maxillary ostia. It was non-patent in 1 (1%) and indeterminate in 10 (8%).

The most common complication of this technology is failure to pass the catheter. In the CLEAR study, prior scar tissue was the cause in six subjects, anatomic restrictions in four subjects, and polyps in one subject. The study did not delineate the failure by sinus. The wire can be malpositioned and miss the natural os. As a result, dilatation of the accessory os, submucosal passage of the balloon, and orbital penetration can occur. Fig. 3 shows the guidewire appropriately coiled into the maxillary sinus. The wire must be fully visualized coiling in the maxillary sinus to be assured correct placement. Rotation of the sheath medially and caudally also improves the correct trajectory of the wire. One way to reduce this malpositioning is to use a lighted guidewire (Luma, Acclarent Inc, Menlo Park, CA, USA). Fig. 4 shows the maxillary sinus with the Relieve Luma catheter. Device failure has also been described and may be easily addressed with replacement. Non-patency of the balloon-dilated ostia required revision in 7 out of 195 (3.6%) of the sinuses. The CLEAR study at 2 years did not specify which sinuses required revision. The PatiENT Registry reported a 2.4% revision rate.

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**Fig. 3.** Fluoroscopy view of the left maxillary sinus with the guidewire appropriately coiled in the maxillary sinus. (Courtesy of Acclarent, Inc, Menlo Park, CA; with permission.)
Entellus Medical uses a balloon to dilate the maxillary os through a transantral approach. A side-cutting trocar is placed through the maxillary sinus. A 0.5 mm fiber-optic telescope is passed through a dual lumen sheath where a 5.0 mm or 7.0 mm balloon is passed through the second lumen. Once the natural os is identified, the balloon is directed into the ostium and ethmoid infundibulum and dilated to 12 atmospheres of pressure.

Complications of this procedure are similar to a maxillary sinoscopy described earlier. These complications include facial numbness, tooth numbness, facial swelling, and oroantral fistula. Soft-tissue infections can occur in the cheek as a result, seeding the cheek upon trocar placement or removal. This complication can be managed by premedicating patients with antibiotics before the procedure. Failure to identify the maxillary os is a potential complication. The balloon remodeling antrostomy therapy (BREATHE) study reported a two (3.4%) failures in identifying the natural os. Fig. 5 shows the view of the natural os during a transantral approach (Entellus Medical). This result is likely to occur when placement of the trocar is not lateral enough. In the authors’ experience, careful placement of the trocar allows for a good trajectory for the balloon catheter. Also in the BREATHE 1 study, two (3.4%) subjects had tooth numbness and one (1.7%) subject had facial numbness. In all, the rate of adverse incidents was quite low.

Fig. 4. Lighted guidewire in the maxillary sinus. (Courtesy of Acclarent, Inc, Menlo Park, CA; with permission.)

Fig. 5. View of the maxillary ostia during transantral approach, arrow is pointing to the os. Note that the view is of limited clarity. (Entellus procedure.)
MINIMALLY INVASIVE SINUS TECHNIQUE

Minimally invasive sinus technique was first described by Setliff and was described as surgery that maintains landmarks and spaces. It involves complete removal of the uncinate process and exposing the inferior aspect of the agger nasi, which allows for visualization of the maxillary sinus ostium but is not manipulated. Because the ostium is not enlarged, some feel that ventilation is not enough to treat the diseased sinus. Scarring in 2% of cases was the most common complication of the middle meatus. Failure of the procedure regardless of cause can be managed with endoscopic middle meatal antrostomy. Catalano reported a 5.9% revision rate but did not report a revision procedure.

To conclude, maxillary sinus surgery can greatly improve patients’ symptoms and disease process. The authors encourage the surgeon to take great care in ensuring sound surgical principles. Understanding the potential areas in which surgery can fail will help tremendously in preventing complications.

REFERENCES