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Endoscopic Management of Maxillary Sinus Diseases of Dentoalveolar Origin

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I. Introduction

The maxillary sinus (MS), first identified by ancient Egyptians, has been well studied, particularly in relation to its structure, vasculature, and relationship with the dentition.^{1,2} The maxillary sinus begins to form during the 10th week of embryonic development as a result of invagination of ethmoid infundibulum mucosa.¹ The sinus continues to enlarge throughout embryonic development and continues ossification up to the 37th week of gestation. Growth progresses throughout childhood until the maxillary sinus reaches its adult size between 18 and 21 years old.³

Anatomically, the alveolar and palatine processes of the maxilla form the floor of the maxillary sinus where the roots of the posterior maxillary dentition lie in close proximity to the floor of the sinus, with the molars having a closer relationship than the premolars.¹ As such, a wide array of maxillary sinus diseases are of dentoalveolar origin.^{4,5} When medical therapy fails to control maxillary sinusitis/inflammation, or in cases of neoplasm, surgery is frequently required. The advancement of endoscopic instruments and intraoperative navigation system has allowed endoscopic approaches using rigid nasal endoscopes to be frequently used to manage maxillary sinus diseases. In this article, we will review the

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minimally invasive endoscopic approaches utilized by Otolaryngologists to manage diseases of the maxillary sinus originating from dentoalveolar pathologies.

II. Maxillary sinusitis

A. Odontogenic Maxillary Sinusitis Episode

1) CASE STUDY—A 49-year-old female presented to otolaryngology clinic complaining of left maxillary sinusitis (facial pain/pressure, purulent drainage and posterior nasal drip with foul smell). She received multiple courses of oral antibiotics (at least 6 months) by her local dentist, who was planning to perform a bone graft to close the bony defect between the maxillary sinus and oral cavity. She had a remote history of nasal surgery (inferior turbinate resection) about 30 years ago for her nasal congestion. On exam, purulence was noted in the left middle meatus, with culture returning as the oral anaerobic bacteria *Streptococcus anginosus*. This was treated with culture-directed antibiotics (clindamycin 300mg qid) for two weeks and saline sinus rinse (240mL) prior to sinus computed tomography (CT) scan (Figure 1A). Based on her CT findings (complete blockage of left maxillary sinus ostium and bony defect), left maxillary endoscopic sinus surgery (opening the maxillary sinus ostium) was recommended to provide an adequate sinus opening for drainage and saline rinse (for irrigation and potential topical drug delivery). The patient wished to avoid any procedure under general anesthesia; therefore, the decision was made to perform in-office balloon sinuplasty of the left maxillary sinus using local anesthesia (topical injection). Upon balloon dilation of the maxillary sinus ostium, thick purulent mucus was expressed. Postoperatively antibiotics were prescribed in addition to saline sinus rinse. The post-procedure sinus CT (Figure 1B) was obtained 6 months after the in-office procedure to confirm the resolution of left maxillary sinusitis. The post-procedure CT scan showed complete resolution of the left maxillary sinus disease and the patient was able to undergo bone grafting for closure of the bony defect. This technique is advantageous for situations where general anesthesia needs to be avoided, or patient preference is to perform in the clinic under topical and local anesthesia. However, many experts agree that this technique should only be utilized in a select cohort of sinusitis patients based on their phenotype, anatomy, and co-morbidities.^{6,7}

2) Scheme: Balloon Sinuplasty (Balloon catheter dilation (BCD) of paranasal sinuses): BCD of the paranasal sinuses was initially introduced in 1993, and approved by the United States (US) Food and Drug Administration (FDA) in 2005.⁸ BCD has the potential advantages of causing less mucosal disruption and distortion of anatomy, less need for postoperative debridement, and faster returning to regular activities as it can be performed awake in the office under local anesthesia.⁹ Several small studies have shown non-inferiority of BCD when compared to traditional functional endoscopic sinus surgery (FESS).¹⁰⁻¹² Complications have been reported from BCD, so this seemingly less invasive procedure is not without risks.¹³ Performing in-office BCD of the maxillary sinus begins with appropriate patient selection and preparation. Indications for BCD are similar to those for standard FESS, and patients should have a trial of medical therapy prior to being considered for BCD. Once the decision has been made to proceed with BCD, thorough review of the patient's CT scan should be performed to identify extent of disease while

making note of any anatomical variants that may affect the ease with which BCD can be performed, such as deviation of the septum, concha bullosa, or silent sinus. Achieving adequate anesthesia is imperative when performing in-office BCD. Numerous local anesthetic protocols have been reported in the literature¹⁴⁻¹⁶, all of which combine topical and infiltrative methods. Typically, we use a combination of 4% tetracaine with oxymetazoline on pledgets placed in the middle meatus and medial to the inferior turbinate, followed by infiltration of 1% lidocaine with 1:100,000 epinephrine along the uncinate process and the middle turbinate (Figure 2A). Following adequate anesthesia, an endoscope is used to visualize the middle meatus. The middle turbinate is gently medialized and the free edge of the uncinate is palpated and gently retracted anteriorly (Figure 2B). The balloon catheter device is then inserted into the infundibulum and the natural ostium is palpated (Figure 2C). The wire device is introduced through the natural ostium and placement is confirmed with transillumination. The wire should easily slide into the maxillary sinus, it is important to not force the wire to avoid injury - particularly to the lamina papyracea. Following confirmation of appropriate position, the balloon device can then be advanced, and inflation may be initiated. Visual confirmation of dilation is evidenced by anterior and medial bulging of the uncinate process and purulent drainage from the maxillary sinus (Figure 2D).¹⁶

B. Fungal Maxillary Sinusitis Episode

1) CASE STUDY—56 year-old-female who had a history of heart transplantation and currently on immunosuppressant therapy presented to otolaryngology clinic with symptoms of recurrent acute sinusitis every 3 months (purulent drainage, facial pain/pressure, and nasal congestion). Sinus CT was obtained after maximal medical therapy (two weeks of oral antibiotics, saline rinse and topical steroid spray), which demonstrated moderate to severe mucosal thickening involving the right maxillary sinus without bony erosive or destructive changes (Figure 3A). However, subtle hyperdense foci were noted within the right maxillary sinus, indicative of likely inspissated superimposed fungal colonization. Based on the CT findings and her immunocompromised status, the decision was made to perform a right endoscopic maxillary antrostomy to clean out the sinus (removing all fungal elements and creating a well-aerated cavity). The patient tolerated the procedure well under general anesthesia with the pathology returning as a fungal mycetoma (fungus ball) (Figure 3B). Odontogenic factors have been reported to increase the risk of developing fungal maxillary sinusitis due to the close relationship between the molar dentition and the maxillary sinus floor, particularly patients undergoing endodontic procedures.¹⁷⁻¹⁹ Tomazic et al. demonstrated that the risk of developing a fungal mycetoma is 2.7-fold higher in patients with odontogenic disease compared to unaffected sinuses.¹⁸ Odontogenic procedures are thought to induce fungal inoculation into the maxillary sinus when the sinus mucosa is penetrated during the procedure.^{19,20} Additionally, materials that contain heavy metals (e.g., zinc), such as root canal sealers, silver cones, or amalgam, may enter the sinus and provide favorable environment for the growth of fungal species.²¹ This patient did have a remote history of dental procedures in her right maxillary molars, although the specific procedural information was not available. Furthermore, any dental procedures that penetrate through the sinus epithelial lining can: 1) cause mucociliary dysfunction, 2) deteriorate the natural drainage of sinus mucus, 3) create an anaerobic environment associated with local tissue

hypoxia, and 4) allow proliferation of fungal species in the maxillary sinus.^{19,20} Therefore, directed endoscopic maxillary antrostomy to enlarge the natural sinus opening (improving ventilation and aeration) and extract the fungus ball is highly effective in managing fungal sinusitis.

2) Scheme: Endoscopic maxillary antrostomy—The endoscopic maxillary antrostomy, introduced in the US in the 1980s, is the initial step in endoscopic sinus surgery and considered by most to be the (relatively) easiest portion of endoscopic sinus surgery. However, failure to understand the anatomy and natural drainage pathway of the maxillary sinus can lead to technical failure and the need for revision surgery. The key in endoscopic maxillary antrostomy surgery is identifying and incorporating the natural ostium of the maxillary sinus into the surgical antrostomy. Identification and complete removal of the uncinate process is the first step in identifying the natural ostium (Figure 4A, 4B).²² Uncinectomy can be performed in an anterior to posterior fashion by incising the uncinate process with a sickle knife just posterior to the maxillary line, a curvilinear mucosal eminence that corresponds to the junction of the uncinate process and the maxilla.²³ Alternatively, the uncinate process may be removed in a posterior to anterior fashion and is the authors' preference as one is less likely to injure or penetrate the lamina papyracea, particularly with hypoplastic maxillary sinuses or cases of very narrow infundibulums. In order to complete this, an angled ball tipped probe is used to reflect the free edge of the uncinate process anteriorly. Cutting instruments can then be used to remove the uncinate process from posterior to its anterior attachment to the lacrimal bone. Switching to a 30, 45, or 70-degree endoscope angled laterally, one can then visualize the natural ostium of the maxillary sinus (Figure 4C).²⁴ Once complete uncinectomy has been performed and the natural ostium of the maxillary sinus is identified, the antrostomy can be enlarged with cutting instruments and incorporated into a posterior fontanelle if present (Figure 4D). Figures (4A-4D) demonstrate the important steps in the completion of the endoscopic maxillary antrostomy.

III. Odontogenic Cyst Episode

1) CASE STUDY

A 23-year-old female with symptoms of right facial pressure was referred to otolaryngology by an oral surgeon. She has a history of odontogenic keratocyst (OKC) which was surgically removed twice, most recently 3 years prior to this presentation. Other than right facial pressure, she did not report any other sinus symptoms. The preoperative sinus CT scan demonstrated an expansile cystic appearing lesion within the right maxillary alveolar recess, representing an odontogenic cyst (Figure 5A). Multiple endoscopic techniques have been used in the treatment of odontogenic cysts, including maxillary antrostomy, endoscopic mega-antrostomy (modified endoscopic medial maxillectomy), medial maxillary sinus wall transposition, and pre-lacrimal (modified endoscopic denker's) approach.²⁵⁻²⁸ All of these techniques have been used successfully and when reviewing this patient's specific case, a wide maxillary antrostomy (mega-antrostomy) would allow for effective decompression and marsupialization of the lesion without external or transoral approach. Studies have demonstrated that the enucleation and curettage of OKC have been associated with

recurrence, although this may be related to the transoral approach.^{25,29} Marino et al. recently published a case series that no recurrence of OKC was noticed with endoscopic extended maxillary antrostomy.²⁵ During the surgery of this specific patient, once the medial wall of maxillary sinus was removed, the OKC was opened and widely marsupialized into the maxillary sinus (Figure 5B). Therefore, the lesion can continue to drain and avoid cyst reformation.

2) Scheme: Endoscopic Maxillary Mega-antrostomy (Modified Endoscopic Medial Maxillectomy)

Despite aggressive medical therapy and adequate resection of the uncinate process with enlargement of the natural ostium, recalcitrant maxillary sinusitis can occur. Additionally, some diseases affecting the maxillary sinus require wide endoscopic exposure for management. Several techniques have been reported for management of persistent maxillary sinus disease to improve drainage and drug delivery, as well as improving endoscopic exposure. The modified endoscopic medial maxillectomy (MEMM) was first described by Woodworth et al³⁰ in 2006. In 2008, Cho et al.²⁸ described the endoscopic maxillary mega-antrostomy (EMMA). The two techniques are very similar with the exception of more aggressive removal of the inferior turbinate in the MEMM and extension of the antrostomy anterior and inferior to Hasner's valve. In both techniques, a portion of the inferior turbinate is resected and the antrostomy is extended down to the floor of the nose. In the cohort by Cho et al²⁸, 74% of patients reported complete resolution of symptoms, with no revision surgeries required up to 2 years out.²⁸ Figure 6 shows pre- and post-operative CT scans of a patient with refractory chronic sinusitis in cystic fibrosis who underwent EMMA.

Both the MEMM and the EMMA are performed after a standard maxillary antrostomy has already been completed. Next the posterior portion of the inferior turbinate is resected after a curved hemostat is utilized to clamp the inferior turbinate to aid in hemostasis. The turbinate is then resected with endoscopic scissors, including its attachment to the lateral nasal wall. A posterior stump of the turbinate attached to the lateral wall is left and cauterized to avoid bleeding in the region of the sphenopalatine and posterior lateral nasal arteries. The infero-medial wall of the maxillary sinus can then be resected down to the floor of the nose with cutting instruments. Alternatively, a J-curette can be used to puncture the medial wall after which straight through-cutting forceps can be used to remove the remainder of the medial wall. If needed, drilling the inferior aspect with a 15-degree diamond burr can be performed; however, care should be taken to prevent trauma to the greater palatine neurovascular bundle, which may result in palatal numbness.³¹ A medially based nasal floor mucosal flap has also been described to reduce the amount of exposed bone after resection of the medial maxillary wall.³⁰

IV. Benign Tumor Episode

1) CASE STUDY

This is a 63-year-old male who initially presented at Otolaryngology clinic with complaints of rhinorrhea, left nasal congestion with intermittent bloody secretions, and diminished sense of smell. Nasal endoscopy demonstrated a mass originating from the middle meatus

(lateral to the middle turbinate). The preoperative sinus CT and magnetic resonance imaging (MRI) scans showed heterogeneously enhancing tumor expanding the left maxillary sinus and extending into the nasal cavity and upward into the ethmoid cells and inferior aspect of the left frontal sinus, suggestive of a slow-growing tumor (Figure 7). The biopsy demonstrated a solid type of ameloblastoma (follicular, plexiform and acanthomatous pattern). In order to endoscopically remove this benign tumor with adequate resection margin along the attachment site, the decision was made to perform the extended maxillary antrostomy combining endoscopic maxillary mega-antrostomy (modified medial endoscopic maxillectomy) and pre-lacrimal approach (see below). During the surgery, the tumor was attached to the posterior wall of maxillary sinus which was removed using endoscopic drills and with the addition of the pre-lacrimal approach complete resection was able to be achieved without the need for external approaches in clearing the adequate margins (at least 1cm). The patient tolerated the procedure well and remained tumor-free in his recent 4-year follow up.

2) Scheme: Pre-lacrimal approach to the maxillary sinus

Despite the above-mentioned extended approaches to the maxillary sinus, there are still areas that remain difficult to access, particularly when approaching tumors of the anterior or antero-lateral walls the maxillary sinus. A transseptal approach has been described to improve exposure³², however this has largely been supplanted by pre-lacrimal approaches. Morrissey et al³³ described a modification to the pre-lacrimal approach that was initially reported by Zhou et al³⁴ in 2013. This technique allows improved access to the anterior and antero-lateral walls of the maxillary sinus and is primarily used for tumor resection as opposed to management of CRS. Figure 8A-F shows intra-operative photos of the pre-lacrimal approach for treatment of an ameloblastoma. It is important to consider the feasibility of achieving adequate margin status when planning for endoscopic resection, and surgeons should not compromise oncologic principles during attempts to complete endoscopic resection.

The technique described by Morrissey et al³³ begins with uncinectomy and maxillary antrostomy. Although not required for the pre-lacrimal approach, the authors advocate for improved ease of surveillance post operatively. A mucosal incision is then made along the lateral nasal wall above the level of the inferior turbinate and carried antero-inferiorly in a curvilinear fashion anterior to the inferior turbinate and into the pyriform aperture. The mucoperiosteum is then elevated to expose the bone of the inferior turbinate and its lateral attachment. A horizontal osteotomy is then performed at the inferior edge of the pyriform aperture, followed by a vertical osteotomy extending superiorly and ultimately connecting to another horizontal osteotomy at the level of the maxillary ostium until the nasolacrimal duct (NLD) is exposed. Alternatively, as depicted, powered drills can be utilized to remove this pre-lacrimal bone. The NLD is then retracted medially to allow for a final osteotomy of the posterior bone of the duct that allows removal of the head of the inferior turbinate and bone around the nasolacrimal duct providing access to the maxillary sinus. Once the procedure has been concluded, the inferior turbinate is lateralized and the mucosal incision is sutured.

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Additionally, modified peri-lacrimal approaches have been described by multiple surgeon.^{35,36} In one of these modified approaches, an incision is initiated above the axilla of the middle turbinate and continued anteriorly to the piriform aperture. The lateral nasal wall mucosa is elevated and the NLD is elevated superiorly. The lacrimal bone is then removed with cutting instruments and the flap is elevated until it can be tucked posteriorly. The inferior portion of the bone below the NLD system is then drilled and opened. Care should be taken to avoid injury to the medial superior alveolar nerve to prevent numbness of the teeth.

V. Complications of Endoscopic Maxillary Sinus Surgery

With endoscopic surgical techniques, it is critical for the endoscopic surgeon to have thorough knowledge of the anatomy and be capable of recognizing and managing potential complications. The majority of complications with maxillary sinus surgery are bleeding, orbital penetration, and nasolacrimal duct injury.³⁷ Bleeding complications from isolated maxillary sinus surgery are relatively rare. Mucosal bleeding can typically be controlled with adequate preoperative injection of local anesthesia with epinephrine and topical administration of vasoconstrictive agents during the surgery. Total intravenous anesthesia has also been reported to improve intraoperative visualization with no adverse effects on hemodynamic parameters.³⁸ Named vascular structures are not frequently encountered with endoscopic approaches to the maxillary sinus; however, the greater palatine neurovascular bundle and posterior lateral nasal branches of the sphenopalatine artery may be injured with extended posterior and inferior dissection of the medial maxillary wall.³⁹ Therefore, once exposed, these arteries should be well controlled before finishing the surgery in order to avoid major postoperative bleeding.

The rate of orbital injury during endoscopic sinus surgery is reported to be less than 0.5%.³⁷ However, orbital injury during endoscopic sinus surgery can have severe visual consequences (Figure 9). The thin roof of the maxillary sinus separates the sinus from the orbit superiorly. Additionally, the lamina papyracea, is intimately associated with the uncinate process and is at risk of being violated when performing uncinectomy (the first step in opening the maxillary sinus during endoscopic sinus surgery). Disruption of the bony framework of the orbit increases the risk of injury to 1) extraocular muscles, 2) oculomotor nerve, and 3) ophthalmic vessels (which could lead to blindness and orbital hematoma, more commonly during endoscopic ethmoidectomy than maxillary antrostomy). By carefully reviewing the preoperative imaging to recognize anatomical variants and identifying anatomical landmarks during the surgery, surgeons can avoid iatrogenic injury to the orbital contents. BCD of the maxillary sinus is not without risk either. A recent review found 211 adverse events associated with BCD between 2008-2018 with 30 patients having orbital complications, 26% of which required decompression with lateral canthotomy.⁴⁰

The nasolacrimal duct courses along the antero-medial aspect of the maxillary sinus and is thus at risk when approaching the maxillary sinus endoscopically. It has been reported that up to 20% of nasolacrimal ducts have bony dehiscence. Additionally, previous reports have suggested occult injury to the nasolacrimal duct in 15% of a cohort of patients undergoing endoscopic sinus surgery, however, in long term follow up, none of these patients developed

symptomatic sequelae.⁴¹ If epiphora develops it will usually present within the first two weeks following injury, but may resolve spontaneously after post-operative inflammation subsides.⁴² Cases that do not resolve spontaneously may require dacryocystorhinostomy (DCR) if the obstruction is proven to be within the nasolacrimal duct.⁴¹

Mucus recirculation is another problem caused by inadequate maxillary sinus surgery. Cilia within the maxillary sinus naturally propel mucus toward the natural ostium where it is subsequently swept toward the nasopharynx where it can be swallowed.⁴³ When there is an accessory ostium or surgical antrostomy that fails to connect with the natural ostium, recirculation may occur. This may result in symptoms of sinus pressure, nasal congestion, or recurrent sinusitis.⁴⁴ Correction of this is relatively straightforward and involves connecting the natural ostium with the surgically created antrostomy.⁴⁴ For this reason, the importance of adequate antrostomy during the initial surgery should not be underscored as recirculation can result in significant morbidity and ultimately subject the patient to revision surgical intervention.

VI. Conclusions

Endoscopic surgery on the maxillary sinus has experienced significant advances in technique and approaches since the maxillary antrostomy was introduced in the 1980s. Disease processes that previously required open surgical approaches to the maxillary sinus can now be treated endoscopically while preserving form and function of the sinus without injuring maxillary sinus mucosa or disrupting normal mucociliary clearance. Understanding the techniques described previously will allow surgeons to appropriately plan treatment strategies for patients with a variety of maxillary sinus diseases from dentoalveolar origin.

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References

1. Iwanaga J, Wilson C, Lachkar S, Tomaszewski KA, Walocha JA, Tubbs RS. Clinical anatomy of the maxillary sinus: application to sinus floor augmentation. *Anat Cell Biol* 2019; 52:17–24. [PubMed: 30984447]
2. Mavrodi A, Paraskevas G. Evolution of the paranasal sinuses' anatomy through the ages. *Anat Cell Biol* 2013; 46:235–238. [PubMed: 24386595]
3. Nuñez-Castruita A, López-Serna N, Guzmán-López S. Prenatal development of the maxillary sinus: a perspective for paranasal sinus surgery. *Otolaryngol Head Neck Surg* 2012; 146:997–1003. [PubMed: 22267494]
4. Bell GW, Joshi BB, Macleod RI. Maxillary sinus disease: diagnosis and treatment. *Br Dent J* 2011; 210:113–118. [PubMed: 21311531]
5. Kim SM. Definition and management of odontogenic maxillary sinusitis. *Maxillofac Plast Reconstr Surg* 2019; 41:13. [PubMed: 30989083]
6. Piccirillo JF, Payne SC, Rosenfeld RM et al. Clinical Consensus Statement: Balloon Dilatation of the Sinuses. *Otolaryngol Head Neck Surg* 2018; 158:203–214. [PubMed: 29389303]

7. Cingi C, Bayar Muluk N, Lee JT. Current indications for balloon sinuplasty. *Curr Opin Otolaryngol Head Neck Surg* 2019; 27:7–13. [PubMed: 30507684]
8. Ference EH, Graber M, Conley D et al. Operative utilization of balloon versus traditional endoscopic sinus surgery. *Laryngoscope* 2015; 125:49–56. [PubMed: 25180840]
9. Jensen BT, Holbrook EH, Chen PG, Luong AU, Marino MJ, Yao WC. The intraoperative accuracy of maxillary balloon dilation: a blinded trial. *Int Forum Allergy Rhinol* 2019; 9:452–457. [PubMed: 30629822]
10. Levy JM, Marino MJ, McCoul ED. Paranasal Sinus Balloon Catheter Dilation for Treatment of Chronic Rhinosinusitis: A Systematic Review and Meta-analysis. *Otolaryngol Head Neck Surg* 2016; 154:33–40. [PubMed: 26519456]
11. Bikhazi N, Light J, Truitt T, Schwartz M, Cutler J, Investigators RS. Standalone balloon dilation versus sinus surgery for chronic rhinosinusitis: a prospective, multicenter, randomized, controlled trial with 1-year follow-up. *Am J Rhinol Allergy* 2014; 28:323–329. [PubMed: 24823902]
12. Cutler J, Bikhazi N, Light J, Truitt T, Schwartz M, Investigators RS. Standalone balloon dilation versus sinus surgery for chronic rhinosinusitis: a prospective, multicenter, randomized, controlled trial. *Am J Rhinol Allergy* 2013; 27:416–422. [PubMed: 23920419]
13. Alam ES, Hadley JA, Justice JM, Casiano RR. Significant orbital and intracranial complications from balloon sinus dilation as a stand-alone and powered dissector-assisted procedure. *Laryngoscope* 2018; 128:2455–2459. [PubMed: 30194706]
14. Lee JT, DelGaudio J, Orlandi RR. Practice Patterns in Office-Based Rhinology: Survey of the American Rhinologic Society. *Am J Rhinol Allergy* 2019; 33:26–35. [PubMed: 30306790]
15. Sillers MJ, Melroy CT. In-office functional endoscopic sinus surgery for chronic rhinosinusitis utilizing balloon catheter dilation technology. *Curr Opin Otolaryngol Head Neck Surg* 2013; 21:17–22. [PubMed: 23222121]
16. Silvers SL. Practical techniques in office-based balloon sinus dilation. *Operative Techniques in Otolaryngology-Head and Neck Surgery* 2014; 25:206–212.
17. Matjaz R, Jernej P, Mirela KR. Sinus maxillaris mycetoma of odontogenic origin: case report. *Braz Dent J* 2004; 15:248–250. [PubMed: 15798832]
18. Tomazic PV, Dostal E, Magyar Met al. Potential correlations of dentogenic factors to the development of clinically verified fungus balls: A retrospective computed tomography-based analysis. *Laryngoscope* 2016; 126:39–43. [PubMed: 26199048]
19. Torul D, Yuceer E, Sumer M, Gun S. Maxillary sinus aspergilloma of odontogenic origin: Report of 2 cases with cone-beam computed tomographic findings and review of the literature. *Imaging Sci Dent* 2018; 48:139–145. [PubMed: 29963486]
20. Burnham R, Bridle C. Aspergillosis of the maxillary sinus secondary to a foreign body (amalgam) in the maxillary antrum. *Br J Oral Maxillofac Surg* 2009; 47:313–315. [PubMed: 19250722]
21. Urs AB, Singh H, Nunia K, Mohanty S, Gupta S. Post endodontic Aspergillosis in an immunocompetent individual. *J Clin Exp Dent* 2015; 7:e535–539. [PubMed: 26535103]
22. Kennedy DW, Zinreich SJ, Shaalan H, Kuhn F, Naclerio R, Loch E. Endoscopic middle meatal antrostomy: theory, technique, and patency. *Laryngoscope* 1987; 97:1–9.
23. Kennedy DW, Adappa ND. Endoscopic maxillary antrostomy: not just a simple procedure. *Laryngoscope* 2011; 121:2142–2145. [PubMed: 21796640]
24. Chiu AG, Palmer JN. Maxillary Antrostomy In: Chiu AG, Palmer JN, Adappa ND, eds. *Atlas of Endoscopic Sinus and Skull Base Surgery*: Elsevier, Inc, 2019:41–50.
25. Marino MJ, Luong A, Yao WC, Citardi MJ. Management of odontogenic cysts by endonasal endoscopic techniques: A systematic review and case series. *Am J Rhinol Allergy* 2018; 32:40–45. [PubMed: 29336289]
26. Maxfield AZ, Chen TT, Scopel TF et al. Transnasal endoscopic medial maxillary sinus wall transposition with preservation of structures. *Laryngoscope* 2016; 126:1504–1509. [PubMed: 26692367]
27. Costa ML, Psaltis AJ, Nayak JV, Hwang PH. Long-term outcomes of endoscopic maxillary mega-antrostomy for refractory chronic maxillary sinusitis. *Int Forum Allergy Rhinol* 2015; 5:60–65. [PubMed: 25312656]

28. Cho DY, Hwang PH. Results of endoscopic maxillary mega-antrostomy in recalcitrant maxillary sinusitis. *Am J Rhinol* 2008; 22:658–662. [PubMed: 19178809]
29. Leung YY, Lau SL, Tsoi KY, Ma HL, Ng CL. Results of the treatment of keratocystic odontogenic tumours using enucleation and treatment of the residual bony defect with Carnoy's solution. *Int J Oral Maxillofac Surg* 2016; 45:1154–1158. [PubMed: 26922497]
30. Woodworth BA, Parker RO, Schlosser RJ. Modified endoscopic medial maxillectomy for chronic maxillary sinusitis. *Am J Rhinol* 2006; 20:317–319. [PubMed: 16871936]
31. Woodworth BA, Grayson JW. Modified Medial Maxillectomy for Recalcitrant Maxillary Sinusitis In: Chiu AG, Palmer JN, Adappa ND, eds. *Atlas of Endoscopic Sinus and Skull Base Surgery*: Elsevier, Inc, 2019:123–132.
32. Harvey RJ, Sheehan PO, Debnath NI, Schlosser RJ. Transseptal approach for extended endoscopic resections of the maxilla and infratemporal fossa. *Am J Rhinol Allergy* 2009; 23:426–432. [PubMed: 19671261]
33. Morrissey DK, Wormald PJ, Psaltis AJ. Prelacrimal approach to the maxillary sinus. *Int Forum Allergy Rhinol* 2016; 6:214–218. [PubMed: 26346189]
34. Zhou B, Han DM, Cui SJ, Huang Q, Wang CS. Intranasal endoscopic prelacrimal recess approach to maxillary sinus. *Chin Med J (Engl)* 2013; 126:1276–1280. [PubMed: 23557558]
35. Suzuki M, Nakamura Y, Yokota M, Ozaki S, Murakami S. Modified transnasal endoscopic medial maxillectomy through prelacrimal duct approach. *Laryngoscope* 2017; 127:2205–2209. [PubMed: 28295338]
36. He S, Bakst RL, Guo T, Sun J. A combination of modified transnasal endoscopic maxillectomy via transnasal prelacrimal recess approach with or without radiotherapy for selected sinonasal malignancies. *Eur Arch Otorhinolaryngol* 2015; 272:2933–2938. [PubMed: 25145643]
37. Svider PF, Baredes S, Eloy JA. Pitfalls in Sinus Surgery: An Overview of Complications. *Otolaryngol Clin North Am* 2015; 48:725–737. [PubMed: 26117302]
38. Lu VM, Phan K, Oh LJ. Total intravenous versus inhalational anesthesia in endoscopic sinus surgery: A meta-analysis. *Laryngoscope* 2019.
39. Campbell RG, Solares CA, Mason EC, Prevedello DM, Carrau RL. Endoscopic Endonasal Landmarks to the Greater Palatine Canal: A Radiographic Study. *J Neurol Surg B Skull Base* 2018; 79:325–329. [PubMed: 30009111]
40. Hur K, Ge M, Kim J, Ference EH. Adverse Events Associated with Balloon Sinuplasty: A MAUDE Database Analysis. *Otolaryngol Head Neck Surg* 2019:194599819884902.
41. Cohen NA, Antunes MB, Morgenstern KE. Prevention and management of lacrimal duct injury. *Otolaryngol Clin North Am* 2010; 43:781–788. [PubMed: 20599082]
42. Ali MJ, Nayak JV, Vaezaefshar R, Li G, Psaltis AJ. Anatomic relationship of nasolacrimal duct and major lateral wall landmarks: cadaveric study with surgical implications. *Int Forum Allergy Rhinol* 2014; 4:684–688. [PubMed: 24845875]
43. Chung SK, Cho DY, Dhong HJ. Computed tomogram findings of mucous recirculation between the natural and accessory ostia of the maxillary sinus. *Am J Rhinol* 2002; 16:265–268. [PubMed: 12422971]
44. DelGaudio JM, Ochsner MC. Office surgery for paranasal sinus recirculation. *Int Forum Allergy Rhinol* 2015; 5:326–328. [PubMed: 25611335]

Key Points:

1. A wide array of maxillary sinus diseases are from dentoalveolar origin due to anatomical proximity.
2. Advancement of endoscopic instruments and intraoperative navigation systems, have allowed a significant number of maxillary sinus disorders to be managed through endoscopic surgical approaches without a need for open (external) or transoral approaches.
3. Multiple endoscopic techniques have been used in the treatment of maxillary sinus diseases from dentoalveolar origin including balloon sinuplasty, maxillary antrostomy, endoscopic maxillary mega-antrostomy (modified endoscopic medial maxillectomy), endoscopic medial maxillectomy, pre-lacrimal approach to the maxillary sinus (modified endoscopic Denker's approach), and the endoscopic Caldwell-Luc approach.

Figure 1.

Odontogenic Maxillary Sinusitis

A. Coronal CT scan showing complete opacification of unilateral left maxillary sinus with loss of bone, representing oroantral fistula

B. Post-procedure sinus CT (6 months after the balloon sinuplasty): Complete resolution of the left maxillary sinusitis

Figure 2.

Balloon Sinuplasty (Balloon Catheter Dilation, BCD) of Maxillary Sinus

A. Local anesthesia: Infiltration of 1% lidocaine with 1:100,000 epinephrine along the uncinate process and the middle turbinate

B. Palpation of the natural ostium of the maxillary sinus with the BCD device

C. After confirmation of placement with transillumination the balloon is advanced, and the sheath is retracted. Upon inflation of the balloon device the uncinate process is seen bulging medially.

D. Purulent secretions are expressed from the maxillary sinus during ostial dilation.

Figure 3.

Fungal Maxillary Sinusitis

A. Sinus CT: Complete opacification of right maxillary sinus with subtle foci of hyperdensity, indicating inspissated superimposed fungal colonization

B. Intraoperative view of fungal ball (mycetoma) within the maxillary sinus

Figure 4.

Endoscopic Maxillary Antrostomy (Right)

- A. Identification of the space behind the uncinate process (infundibulum) using a seeker
- B. Complete removal of the uncinate process using 90-degree grasping forceps
- C. Identification and enlargement of the natural ostium of the maxillary sinus
- D. Completion of endoscopic maxillary antrostomy (right)

Figure 5.

Odontogenic Cyst

A. An expansile cystic appearing lesion (asterisk) within the right maxillary alveolar recess, representing an odontogenic cyst

B. Intraoperative view of Odontogenic Keratocyst (asterisk), which was opened and widely marsupialized into the maxillary sinus

Figure 6.

Pre & Post Sinus CT Scan after Endoscopic Maxillary Mega-Antrostomy (EMMA)

A. Coronal CT scan demonstrating recalcitrant bilateral maxillary sinusitis despite prior maxillary antrostomy in a CF patient

B. Post-operative coronal CT scan following EMMA and demonstrating nasalization of the maxillary sinuses

Figure 7.

Ameloblastoma (originating from Left Maxillary sinus)

A. Coronal Sinus CT: Extensive mass-like opacification of the left maxillary sinus with expansion and extension into left nasal cavity

B. Coronal T1 contrast enhanced MRI: Heterogeneously enhancing tumor expanding the left maxillary sinus and extending into the nasal passages

Figure 8.

Pre-Lacrimal Approach to the Maxillary Sinus

- A. Mucosal incision along the superior edge of the inferior turbinate turning inferiorly at the anterior head
- B. The mucosa is reflected down exposing the anterior bone of the inferior turbinate and the ridge of the piriform aperture where the drilling will be performed.
- C. Axial CT scan with red circle outlining the bone removed to complete the pre-lacrimal approach.
- D. A powered drill was used to remove the bone.
- E. Exposure of the maxillary sinus through the pre-lacrimal window
- F. The mucosal incision is sutured at the end of the procedure.

Figure 9.
Orbital Complication. A coronal sinus CT image showing a lamina papyracea defect after endoscopic sinus surgery, resulted in medial rectus injury.