CHAPTER 1

1 Anatomy and Physiology of the Maxillary Sinus

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In this chapter, the reader will review anatomy landmarks of the maxillary sinus. In order to avoid/reduce some surgical complications, it is essential to understand the blood supply, nerve innervations, function, and physiology of the maxillary sinus.

Anatomy of the maxillary sinus

The maxillary sinus is the largest of the four bilateral air-filled cavities in the skull. It is located in the body of the maxilla and is a pyramidal-shaped structure having as its base the medial wall (the lateral nasal wall). This important complex structure will be discussed later in greater detail. The pyramid has three main processes or projections: (1) the alveolar process inferiorly (bounded by the alveolar ridge), (2) the zygomatic recess (bounded by the zygomatic bone), and (3) the infraorbital process pointing superiorly (bounded by the bony floor of the orbit, and below it, the canine fossa). The alveolar and palatine processes form the floor of the maxillary sinus, which after the age of 16 usually lies 1–1.2 cm below the floor of the nasal cavity (Figure 1.1).[1–3]

Usually the maxillary sinus is separated from the roots of the molar dentition by a layer of cancellous bone, although occasionally significant bone volume is absent, allowing the apices of the molar teeth to be very near or project into the floor of the sinus cavity. This can provide a direct pathway for odontogenic infection to spread into the maxillary sinus (Figure 1.2). In such cases, tooth extraction may cause oro-antral fistula formation, with or without infection.

The zygomatic process or projection is largely unremarkable. Occasionally the maxillary sinus may be divided into two or even three separate compartments by bony septa.[4] These can usually be seen clearly on radiographic

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Figure 1.1 Sinus anatomy. The maxillary sinus is the largest air-filled cavity in the skull.

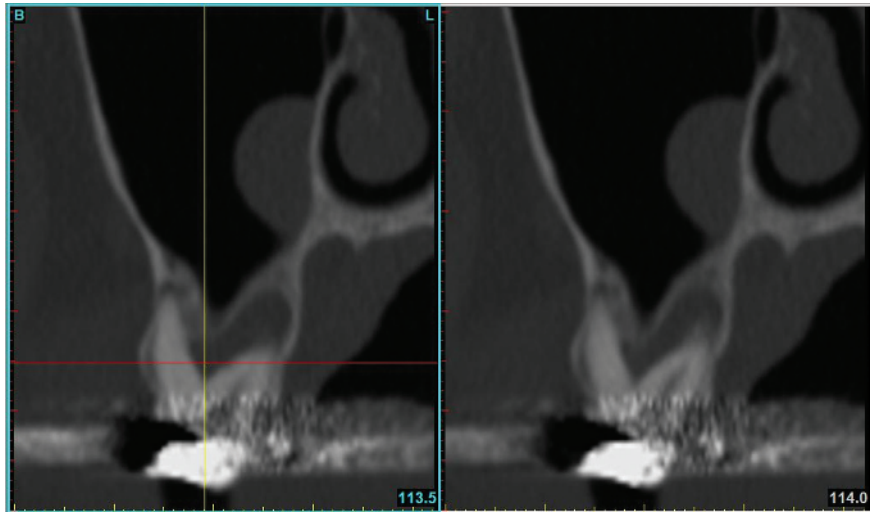

Figure 1.2 Odontogenic infection may create a pathway to spread infection into the maxillary sinus.

examination, as well as by other diagnostic media. The four sinus cavities are all lined with pseudostratified, ciliated, columnar epithelium overlying a layer of periosteum in contact with the bony sinus walls. This bilaminar structure is known as the Schneiderian membrane, and its inner specialized epithelial lining is contiguous with the lining of the nasal cavity through an opening known as the natural ostium. The sinus linings, although similar in structure, are somewhat thinner than the lining of the nasal cavity.[5,6]

Ostium

The natural ostium is located in an anteromedial position in the superior aspect of the medial sinus wall (lateral nasal wall), and its location makes sinus drainage by gravity impossible. It opens into the semilunar hiatus of the nasal cavity and is usually located in the posterior half of the ethmoid infundibulum behind the lower one-third of the uncinate process. The ostium size can vary from 1 to 17 mm and averages 2.4 mm. Because the superior location makes natural drainage impossible, drainage is dependent upon the wave-like motion or "beating" of the hair-like cilia. The ostium is much smaller than the actual bony opening, and mucosa fills most of the space and defines the ostium.[7] On the nasal aspect of the lateral nasal wall, the ostium is hidden behind the uncinate process in 88% of cases. Often there are accessory ostia present, usually located distal to the natural ostium in the area of the posterior fontanelle (Figure 1.3).[8]

The medial sinus wall (lateral nasal wall) is a most significant structure, because the lateral wall presents a series of furrows and projections that can either facilitate maxillary sinus drainage through the ostium or, under certain circumstances, alter or impede sinus drainage. Small swellings of the pathways or the projections resulting from inflammation can be caused by infection, allergic rhinitis, or trauma, leading to impaired sinus drainage. When

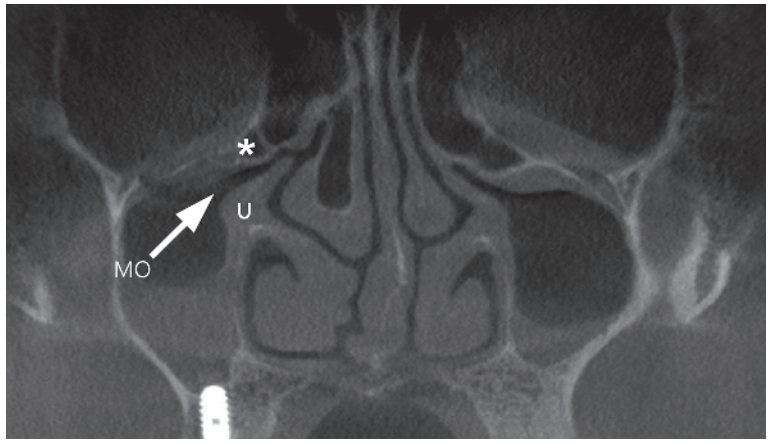

Figure 1.3 The maxillary ostium (MO) enters the infundibulum, which is the space between the uncinate process (U) and the ethmoid bulla (*).

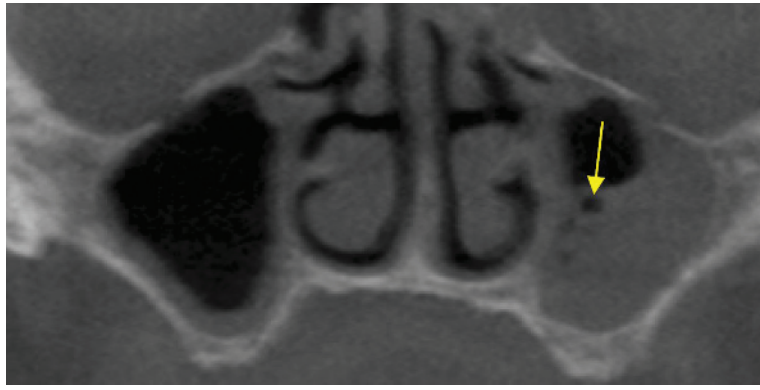

Figure 1.4 Sinus infection. Maxillary sinusitis (mucositis in the right one); note the air inclusions (arrow) suggesting acute sinusitis. (Courtesy of Dr. Massimo De Paoli.)

normal sinus drainage becomes altered or obstructed, this can lead to chronic sinusitis (Figure 1.4). The medial sinus wall remains relatively smooth during development, while the nasal side (lateral nasal wall) develops a series of projections and outgrowths into the nasal cavity. The lateral nasal wall develops as the medial wall of the maxillary sinus and includes portions of the ethmoid, the maxillary, the palatine, the lachrymal, the medial pterygoid plate of the sphenoid, the nasal, and the inferior turbinate bones. The lateral nasal wall gives rise to the following structures that become part of the ostiomeatal complex (OMC), a name given to the structures forming the projections of the lateral wall and their respective furrows, meatuses, and hiatuses, which become the drainage pathways from the sinuses.[9]

Microscopic anatomy

The microscopic anatomy of the sinuses reveals four basic cell types: namely, pseudostratified ciliated columnar epithelium, nonciliated columnar cells, goblet cells, and basal cells (Figure 1.5). The ciliated cells are by far the most prevalent cell type, and each cell has from 50 to 200 cilia. These cilia have been found to wave or "beat" at a rate of 700–800 times per minute and are capable of moving mucous at a rate of 9 mm per minute. They move mucous and serous secretions toward the ostium, and, due to its superior location, must overcome gravity in order to do so. Nonciliated cells are characterized by the presence of microvilli, which may serve to increase the surface area, helping to warm and humidify incoming air. The goblet cells produce glycoproteins that are responsible for the viscosity and elasticity of mucous. The function of the basal cells is unknown, but some speculate they may serve as a stem cell for differentiation. The maxillary sinus has the greatest concentration of goblet cells, although all of the sinuses have a paucity of goblet cells and submucosal cells compared to the nasal cavity.[10]

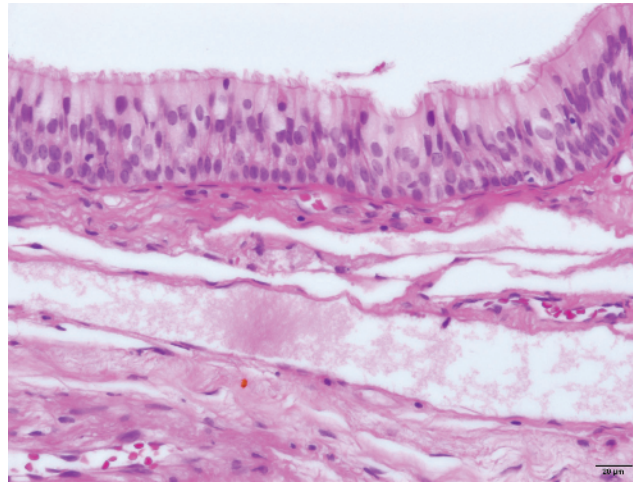

Figure 1.5 The microscopic anatomy of the sinuses reveals four basic cell types: pseudostratafied ciliated columnar epithelium, nonciliated columnar cells, goblet cells, and basal cells. (Used with permission from Prof. Chun-Pin Chiang.)

Nerves and blood vessels

Sensory innervation of the maxillary sinus is supplied by the maxillary division on the trigeminal nerve (V-2) and its branches (Figure 1.6): the posterior superior alveolar nerve, anterior superior alveolar nerve, infraorbital nerve, and greater palatine nerve. The middle superior alveolar nerve contributes to secondary mucosal innervation. The natural ostium receives its innervation via the greater palatine nerve, and the infundibulum is supplied by the anterior ethmoidal branch of V-1. The mucous membranes receive their postganglionic parasympathetic innervation for mucous secretion from the greater petrosal nerve (a branch of the facial nerve). Secretomotor fibers originate in the nervus intermedius, synapse at the pterygopalatine ganglion, and are carried piggyback to the sinus mucosa along with the sensory branches of V-2. Vasoconstrictor branches originate from the sympathetic carotid plexus.[11,12]

The blood supply to the maxillary sinus is supplied by branches of the internal maxillary artery (Figure 1.7): the infraorbital orbital artery runs with the infraorbital nerve in the floor of the orbit, the lateral branches of the sphenopalatine and greater palatine arteries, and in the floor of the sinus, the posterior, middle, and anterior superior alveolar arteries. Venous drainage runs anteriorly into the facial vein and posteriorly into the maxillary vein, jugular vein, and dural sinus system.[13]

Lymphatic drainage is accomplished through a network of lymphatic connections over the pterygopalatine plexus to the eustachian tube and nasopharynx. The primary lymphatic receptacles of the paranasal sinuses are the lateral cervical and retropharyngeal lymph nodes.[12]

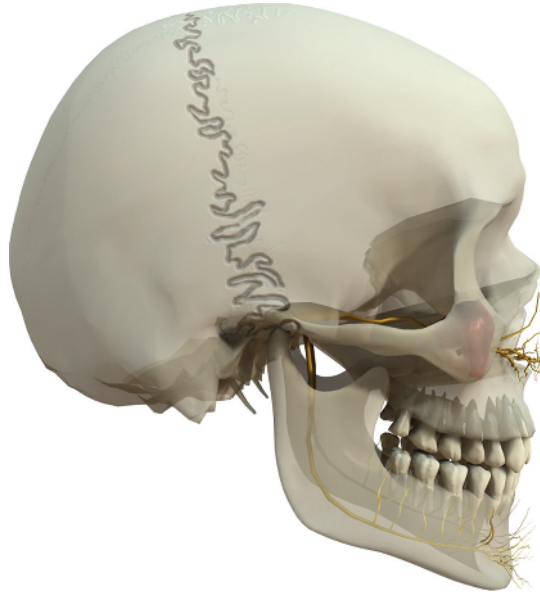

Figure 1.6 Sensory innervation of the maxillary sinus.

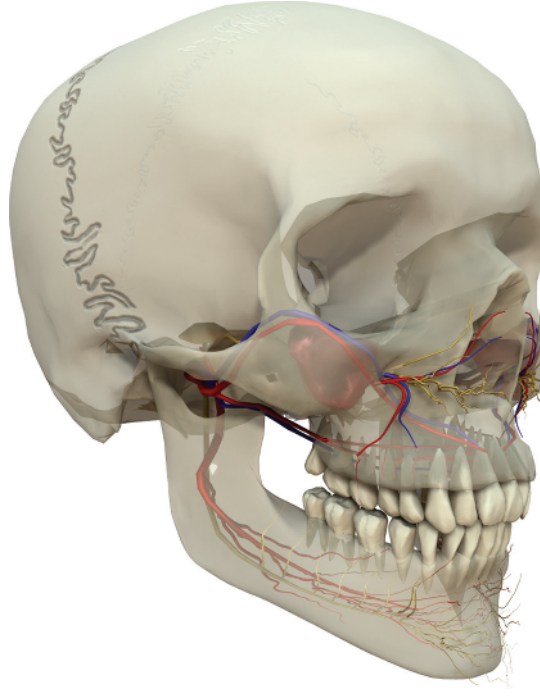

Figure 1.7 The blood supply to the maxillary sinus.

Function and physiology of the maxillary sinus[1,14]

- Humidifying and warming inspired air
- Regulation of intranasal pressure
- Increasing surface area for olfaction
- Lightening of the skull mass
- Resonance
- Absorbing shock, helping to lessen brain trauma
- Contributing to facial growth
- Mucociliary propulsion of mucous and serous secretions toward the ostium

Pathophysiology of the maxillary sinus

Chronic or persistent maxillary sinusitis is a pathologic condition that must be recognized and treated before any anticipated sinus elevation procedure prior to bone grafting. The etiologic elements underlying a chronic (or acute) sinusitis can be (1) disruption in the mucociliary flow patterns, causing stagnation and failure of normal drainage through the ostium, (2) viral or bacterial infection of the upper respiratory tract, or (3) inflammatory swelling and blockage of the ostiomeatal pathways due to allergic reaction and/or infection.[15] As with most disease processes, etiologies are usually multifactorial. In cases of chronic or acute sinusitis, referral to an appropriate ENT physician is essential.

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