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Review Article

Maxillary Sinus Disorders: A Review for the Dental Practitioner

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Abstract

Maxillary sinus and its close proximity to the oral cavity make it a common clinical concern for medical and dental practitioners. For this reason, dentists should be familiar with the anatomy, physiology and pathology of this complex region. Teeth which are protruding into the maxillary sinus can have various dental implications like Implant placement, oroantral fistulae, root displacement into the sinus cavity, and Endo-antral syndrome. The dental practitioner must remain aware of the possibility of odontogenic infections spreading from the teeth into the neighbouring maxillary sinus, producing symptoms of both dental and sinus disease. The purpose of this article is to review the maxillary sinus and its pathologic conditions through different imaging modalities used in dental practice.

Keywords: *Odontogenic Infections; Oroantral Fistulae; Endo-Antral Syndrome*

Introduction

Paranasal sinuses are air filled spaces found within the interior of maxilla, frontal, sphenoid and ethmoid bones. For clinical purposes, the sinuses are divided into two groups, anterior and posterior. The anterior group consisting of the frontal, maxillary, and anterior ethmoid cells open into or near the infundibulum. The posterior group, made up of the posterior ethmoid cells and the sphenoid sinuses, opens above the middle turbinate [1]. The anatomical and clinical significance of the maxillary sinus was first described by Nathaniel Highmore in 1651. Hence, the maxillary sinus is also called as Antrum of Highmore [2].

The purpose of this article is to review the clinical significance of maxillary sinus and its pathologic conditions in dental practice. The dental practitioner must know the basic anatomy, physiology, pathological conditions of the sinus and different imaging modalities to rule out the possibility of odontogenic infections spreading from the teeth into the maxillary sinus, producing symptoms of both dental and sinus disease.

The maxillary sinus is generally larger than the other sinuses and lies in the body of the maxilla [3]. It is pyramidal in shape, with the base forming the lateral wall of the nose and the apex in the zygomatic process of the maxilla. The roof is formed by the floor of the orbit [4]. The anterior wall of sinus corresponds with the canine fossa and separates the sinus from the cheek. The posterior wall lies against the contents of the infratemporal space and pterygomaxillary fossa [1,5].

The floor is formed by lateral hard palate and junction of anterior sinus wall and lateral nasal wall. In the adult, the floor of sinus is approximately 1.0 - 1.25 cm below the level of floor of nasal cavity. From birth to age nine the floor of the sinus is above that of the nasal cavity. At age nine the floor is generally at the level of nasal floor. The floor continues to sink as the maxillary sinus pneumatises. The shape

and configuration of the floor of the maxillary sinus are also extremely variable. The cancellous bone between and above the alveolus can dehisce with increasing age so that the root tips project into the maxillary sinus. They can be covered only by an extremely thin lamella and sinus membrane. The deepest point of maxillary sinus is normally located in the region of molar roots. The mean distance between the mesiobuccal root of second molar and sinus floor is less than 2 mm in most cases. The significance of this wall is related to its relationship to the roots of maxillary teeth and alveolar process. In some instances the sinus extends in to alveolar process between roots of maxillary teeth so that part of socket protrudes into the sinus cavity [6].

According to Underwood, the maxillary sinus floor is frequently divided into three sections:

1. The anterior portion corresponds to the position of the eruption of the deciduous molars (between 8 months and 2 years);
2. The middle portion corresponds to the eruption of the first and second permanent molars (from 5 to 12 years);
3. The posterior, corresponds to the eruption of the third molars (16 to 30 years) [7].

Velasquez-Plata., *et al.* divided the sinus floor as, anterior region, between the mesial aspect and distal aspect of the second premolar root; middle, between distal aspects of second premolar and second molar; and posterior, distal aspect of the root of the second molar [7]. Krennmair., *et al.* divided the maxillary sinus floor into three regions: anterior, corresponds to the premolar area; middle, superior to the first molar; and posterior, in the area of the second molar [8].

According to study conducted by Von Bonsdorff in 1925 on assessments of the distance between the root apices of upper teeth and the floor of the antrum, he found that the roots of second molar were closest to the floor. Paatero also confirmed based on a study conducted on 11 Finnish skulls that the root apices of second molar were in closest proximity to the antral floor, with next in order of frequency the first molar, third molar, second premolar, first premolar and canine [9].

The maxillary sinus is the first sinus to develop. At approximately the 70th day of gestation, rudimentary uncinate ridge develops. Shortly thereafter, just posterior and superior to this ridge in the middle meatus, a mucosal bud slowly burrows laterally into the maxilla. The evagination is located in the central part of the middle meatus, termed the infundibulum [9]. From this primordial dimple, the evagination expands so that a cavity measuring 7 x 4 x 4 mm in the maxilla [10]. The average dimensions of the maxillary sinus of the adult are 40 x 26 x 28 mm with an average volume of 15 ml [2].

The maxillary sinus is lined with a respiratory mucosa similar to that of the nose and other paranasal sinuses. It consists of a mucoperiosteum with 3 layers: an epithelial covering, a lamina propria, and periosteum. The maxillary sinus membrane varies in thickness, but is generally 0.3 to 0.8 mm. The epithelial lining is a single layer of pseudo stratified columnar ciliated epithelium (Schneiderian membrane) with few blood vessels and is thicker than that of the other paranasal sinuses [9].

The maxillary sinus possesses rich anastomoses and receives its arterial supply from the infraorbital, sphenopalatine, posterior lateral nasal, facial, pterygopalatine, greater palatine, and posterior superior alveolar arteries. The veins accompany the arteries, and drain anteriorly via cavernous plexus in to the facial vein and in posterior via the pterygoid plexus to the internal jugular vein. The lymphatic drainage is through the infraorbital foramen or through the ostium and then to submandibular and deep cervical lymph nodes [10].

The innervations of the sinus are of particular interest from a diagnostic standpoint. Nerve supply is from the maxillary division of the trigeminal nerve, with branches coming directly from the posterior, middle and anterior superior alveolar nerves, infraorbital nerve and the anterior palatine nerve. The posterior wall of the sinus receives its nerve supply from the posterior and middle superior alveolar nerves, whilst the anterior wall is supplied by the anterior superior nerve. These nerves travel enclosed in the wall of the sinus innervating the related teeth. It could, thus, be difficult to distinguish pain of dental origin from that of sinus origin [9].

The Functions of Maxillary Sinus:

1. **Humidification and warming of inspired air:** The extensive vascular and secretory systems of the nasal cavity and paranasal sinuses serve to warm and humidity ambient air in preparation for access to the lower airways.
2. **Aiding nasal cavity immune defence and production of nitric oxide**: Goblet cell produces glycoproteins which enhances viscosity and elasticity of the sinonasal mucosa in response to irritation. Turbulent airflow forces all inspired air to contact mucosal surfaces so that smaller particles stick to the mucus.
3. **Lightening the skull bones**: This theory suggests that paranasal sinuses reduce the weight of the skull.
4. **Imparting resonance to the voice**: It has been suggested that maxillary sinus impart resonance to the voice during speech.
5. **Shock absorber function**: Negus proposed that paranasal sinuses could play a role in absorbing shock and protecting the sense organs from the effects of shock.
6. **Aiding facial growth:** Proetz proposed that the human frontal and maxillary sinuses were designed to assist forward and downward growth of the face.
7. **Floatation device:** Hardy and Evan's suggested that paranasal sinuses could act like a floatation device. This helps in maintaining the nose above the level of water while swimming [11].

Diagnostic Imaging of maxillary sinus

Imaging Modalities of maxillary sinus are, conventional plain radiography includes periapical, occlusal, panoramic and facial views. Facial Views includes Waters, Caldwell, Lateral, Submentovertical views. Other diagnostic modalities to study the paranasal sinuses are CT, MRI, CBCT, Ultrasonography, Positron Emission Tomography, Radionuclide bone scans with Technetium 99m and Gallium citrate scans.

Conventional Plain Radiography is the imaging modality of choice in the evaluation of the paranasal sinuses. A variety of radiological signs can be recognised from alterations in the interfaces and contrasts among bone, soft tissue, and air [11]. On periapical radiographs, the borders of the maxillary sinus appear as a thin, delicate tenuous radiopaque line. In the absence of disease it appears continuous, but on close examination it can be seen to have small interruptions in its smoothness or density [2].

Occlusal, lateral occlusal radiographs are especially valuable for demonstrating a root fragment in the sinus cavity [1]. In panoramic radiography the maxillary sinus is visualised with the standard technique. In the panoramic projection of maxillary sinus, the body of zygomatic bone and temporal process of zygomatic bone, which is anterior half of zygomatic arch, will almost invariably be superimposed on the sinus.

Specialized skull views like the occipito-mental or Water's projection is the primary view to observe the maxillary and anterior ethmoid sinuses. First described by Waters and Waldron in 1915, taken at varying angles (15°, 30° and 35°) a comparison of internal anatomy, bony continuity and defects, as well as sinus pathology or foreign objects is possible [13]. Other images that may be included are the submentovertex, posteroanterior and lateral skull views.

CT is considered the best imaging modality for the evaluation of paranasal sinuses. CT clearly depicts the fine bony anatomy compare to conventional imaging [13]. It is primarily indicated in recurrent disease despite medical therapy, suspicion of ethmoid or sphenoid disease, or to assist in the identification of anatomic abnormalities or evaluation of patients who have developed a complication from sinusitis such as abscess formation [14].

MRI imaging of the paranasal sinuses is a complementary imaging technique to CT. MRI plays an important role in the evaluation of intracranial and intraorbital complications of sinusitis [12].

A-mode ultrasound is a safe, quick, non-invasive technique that has been introduced as a diagnostic screening tool for sinus pathology. In normal sinus scans an initial reflected echo is seen at the probe/skin interface and the second echo at the bone/air interface. With mucosal thickening an echo will be obtained from the mucosa/air interface as well as the bone/mucosa interface. A back wall echo is obtained when fluid or a large polyp carries ultrasound to the posterior bony wall, which reflects an echo. The accuracy of ultrasound in detecting fluid has been well documented [2].

CBCT provides high definition, three dimensional digital data on precise anatomical information of all oral and maxillofacial structures at reduced cost and less radiation to patient, in comparison to traditional imaging systems like Orthopantomography, which are limited by distortion, magnification changes, restricted clarity, lack of accuracy in measurements and not allowing for 3D modelling.

Positron Emission Tomography (PET) performed in tandem with CT or MRI, may be value in the initial workup of certain malignancies involving the sinuses, and is also an excellent tool in the assessment of response to therapy and in screening for recurrence [16]. Radionuclide bone scan Technetium 99m (Tc^{99m}) methylene diphosphonate depict osteoblastic activity in Pagets disease. Gallium scans used in combination with bone scans for the diagnosis of osteomyelitis [17].

Discussion

The floor of maxillary sinus is curved rather than flat and is formed by the lower third of the medial wall and the buccoalveolar wall of the maxilla. The distance from the sinus floor to the root tips of the teeth is longest for the first premolar and shortest for the second molar distobuccal root tip. The first and second molar roots are most commonly in close proximity to the inferior wall of the maxillary sinus [5].

Lesions of the maxillary sinus may remain clinically asymptomatic, particularly when localized in the inferior portion of the antrum. When the free flow of fluid and gas through the ostium is blocked, pressure within the sinus increases and there is potential for considerable pain and discomfort. Pain from the maxilla may be referred to the face, eye, nose and oral cavity. Facial symptoms may include unilateral paresthesia, anaesthesia, and midface fullness. There can be a change in vision, diplopia, altered eyeball position, and epiphora. Nasal symptoms may include epistaxis, allergic rhinitis and postnasal drip. Intra-orally, in addition to tooth pain and sensitivity, paresthesia or anaesthesia of the gingiva and mucosa as well as a feeling of alveolar expansion or malocclusion may be experienced [18].

Maxillary sinusitis of dental origin

Sinusitis is usually an extension of a nasal infection. The spread of pulpal disease beyond the confines of the dental supporting tissues into the maxillary sinus was termed as Endo-antral syndrome (EAS) by Selden. Periapical infection of maxillary first premolar, first and second molars are most likely to be responsible for direct spread of oral infection to the sinus [2,4].

Oro-antral fistula

Oroantral fistula is an abnormal communication between the maxillary sinus and the oral cavity and may be the result of several different pathologic processes. Most commonly, it can occurs after dental extraction, massive trauma to the face, surgery to the maxillary sinus, osteomyelitis of maxilla, gumma involving the palate, infected upper implant dentures, neoplasm, Paget's disease, and iatrogenic injury [18].

Partial maxillectomy, surgical treatment of large maxillary cysts, Caldwell-Luc operation, malignant tumors of maxillary sinus, Wegener's Granulomatosis and Lymphosarcoma are also leads to oro-antral communication in order of frequency, after removal of the first, second, and third molars, as well as the premolars, a fistula may occur. The risk of the occurrence of oroantral communication in children and adolescents is less because of the smaller volume of the sinus [5].

Teeth or roots in the maxillary sinus

Unerupted upper third molar, the roots of which are in proximity to the maxillary sinus, conically rooted upper second premolar are the most common displaced teeth into the sinus cavity, entire teeth, portions of teeth and other foreign bodies may also be driven in to antrum following severe facial trauma [5].

Foreign bodies including food particles, peas, nuts, cotton wool, chewing gum, dental packs and dressings, pieces of impression materials. Root canal instrument, fillings and broken blade of extraction forceps has also been discovered from the antral cavity. Displaced root tips or foreign bodies are usually removed because of their propensity to cause antral infection or it might act as nidus for rhinolith formations [5].

Antrolith

The antrolith was referred by Bowerman (1969) as the complete or partial encrustations of an antral foreign body usually of endogenous or occasionally exogenous origin. It is a hard calcareous structure with a rough irregular surface consisting of a central nucleus upon which are gradually deposited mineral salts, especially calcium phosphate and carbonate and magnesium. Synonyms are antral stones, antral calculi, antroliths, antral rhinoliths, and maxillary rhinoliths [5].

Cysts, odontogenic and nonodontogenic tumors

Any cyst of the maxilla, odontogenic and nonodontogenic, may slowly expand and grow into the maxillary sinus. The two most common cysts to involve the sinus are the radicular and the dentigerous cysts [5].

In benign tumours Ameloblastoma, Pindborg tumor, Calcifying odontogenic cyst, compound and complex odontoma, Cementomas, Adenomatoid odontogenic tumour etc. Ameloblastoma, Fibromyxoma, Hemangioma, Lymphangioma, Neurofibroma and salivary tumours can cause destruction of antral borders. Malignant lesions are Malignant Ameloblastoma, Primary intraosseous carcinoma, Carcinoma arising from odontogenic epithelium or cysts. Odontogenic sarcomas like Ameloblastic fibro sarcoma, Ameloblastic odontosarcoma can involve maxillary sinus. Fibrous Dysplasia, Paget's disease and Ossifying fibroma, Cherubism are the rare bony dysplasia of the jaws, they often encroach upon the maxillary sinus [5].

Fractures of maxillary sinus walls

Floor of maxillary sinus is probably the most common area of the sinus to be fractured. In case of very large antra the floor is thinner than the normal and more likely to fracture as a result of force applied during extraction of any upper tooth from the canine to the third molar. The maxillary tuberosity region is the most common site of fracture in the floor of maxillary sinus [5].

Implant

Maxillary sinus provides a challenge in implant dentistry because of the reduced bone volume, which is due to alveolar bone resorption and pneumatization of the sinus cavity. Several ways to avoid the sinus cavity is to use a short implant, tilt the implant mesially or distally, use a long zygomatic implant, and/or shorten the dental arch with premolar occlusion [19].

Philip Boyne is the first to report the elevation of the maxillary sinus floor for pre-prosthetic reasons. The maxillary sinus was augmented prior to a tuberosity reduction to increase the inter-arch distance and create a more symmetric maxillary arch for denture prosthesis [20].

Conclusion

The maxillary sinus is an air-filled space in the maxilla. Due to anatomical complexities, it is difficult to evaluate the relation between the root apices of maxillary posterior teeth and the floor of maxillary sinus which is essential for diagnosis of sinus pathology, understanding the path of dental infection and planning of dental treatment.

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