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Anatomical Relationship Between The Roots Of Upper Jaw Teeth And The Maxillary Sinus

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Abstract. The proximity of the roots of the maxillary posterior teeth to the floor of the maxillary sinus (sinus maxillaris) represents one of the most clinically significant anatomical relationships in dentistry and oral surgery. This article provides a comprehensive review of the anatomical variations in the relationship between the roots of the upper premolar and molar teeth and the maxillary sinus. The study synthesises findings from anatomical dissection studies, cone-beam computed tomography (CBCT) imaging, and panoramic radiographic analyses to characterise the degree of proximity, the prevalence of root protrusion into the sinus, and the relevant clinical consequences. Evidence indicates that the roots of the maxillary first and second molars most frequently exhibit the closest relationship to the sinus floor, with the palatal root of the first molar demonstrating the highest rate of direct sinus floor contact or protrusion. A thorough understanding of these anatomical relationships is indispensable for the prevention of oroantral communications, the management of periapical infections of odontogenic origin, and the safe planning of dental implant placement in the posterior maxilla.

Keywords: Maxillary sinus, sinus maxillaris, upper jaw teeth, molar roots, oroantral communication, dental anatomy, CBCT, odontogenic sinusitis, maxillary posterior teeth.

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Introduction

The maxillary sinus, or sinus maxillaris, is the largest of the paranasal sinuses and occupies the body of the maxillary bone bilaterally. Its inferior wall - the sinus floor — lies in immediate proximity to the alveolar process of the maxilla, creating an anatomical relationship of profound clinical relevance. The roots of the maxillary posterior teeth, particularly the premolars and molars, may extend to various degrees towards, and sometimes into, the inferior recesses of this sinus. This anatomical arrangement is not static; rather, it is subject to considerable individual variation and is influenced by age-related pneumatisation, tooth eruption patterns, and the degree of alveolar bone resorption.

A thorough knowledge of these anatomical relationships constitutes an essential prerequisite for clinicians engaged in oral and maxillofacial surgery, endodontics, implantology, and periodontology. Failure to appreciate the closeness of molar and premolar roots to the sinus floor can lead to complications including inadvertent root displacement into the sinus during extraction, oroantral fistula formation, and the spread of odontogenic infection to produce sinusitis. Conversely, primary sinus pathology may manifest as toothache referred to the posterior maxillary teeth, underlining the diagnostic significance of this relationship.

Contemporary three-dimensional imaging, particularly cone-beam computed tomography (CBCT), has revolutionised the assessment of this region, enabling precise measurement of the distance between root apices and the sinus floor and the identification of cases in which roots project into the sinus cavity without necessarily perforating the overlying cortical bone. The present article aims to review the existing literature systematically, describe the characteristic anatomical relationships of each tooth type in the maxillary posterior segment, and highlight the clinical implications for daily dental practice.

ANATOMY OF THE MAXILLARY SINUS

The maxillary sinus is a pyramidal, air-filled cavity enclosed within the body of the maxilla. Its base forms the lateral wall of the nasal cavity, while its apex extends towards the zygomatic process of the maxilla. The roof corresponds to the orbital floor, and the anterior wall faces the facial surface of the maxilla.

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The inferior wall, which constitutes the sinus floor, is the most relevant structure in the context of dental root proximity.

At birth, the maxillary sinus is a small rudimentary space, but it undergoes progressive pneumatisation throughout childhood and adolescence, reaching its definitive adult dimensions by approximately 18–20 years of age. In adults, the average volume of the maxillary sinus is approximately 15 mL (range 9.5–20 mL), and its anteroposterior dimension is roughly 34 mm, the vertical height approximately 33 mm, and the width approximately 23 mm. However, significant bilateral and interindividual variation exists.

The sinus floor in dentate individuals typically lies at the level of, or slightly below, the nasal floor. With tooth loss and the consequent resorption of the alveolar process, the sinus floor descends further — a process known as secondary pneumatisation — bringing it into even closer proximity to the residual ridge. The ostium of the maxillary sinus opens into the middle meatus of the nasal cavity via the hiatus semilunaris, and its relatively superior position predisposes the sinus to retention of secretions when mucociliary clearance is impaired.

The sinus floor is not uniformly flat; it commonly presents with recesses that extend between the roots of adjacent teeth. The most prominent of these recesses are the premolar recess (recessus alveolaris anterior), located between the first and second premolars, and the molar recess (recessus alveolaris posterior), located in relation to the molar roots. The presence and depth of these recesses vary considerably among individuals.

RELATIONSHIP OF INDIVIDUAL TEETH TO THE MAXILLARY SINUS

Maxillary First Premolar

The maxillary first premolar characteristically presents two roots — a buccal and a palatal root — which diverge apically. The relationship of this tooth to the maxillary sinus varies considerably. In the majority of cases, the root apices of the first premolar are separated from the sinus floor by a layer of cancellous bone measuring 2–5 mm. However, in individuals with pronounced sinus pneumatisation, particularly the anterior premolar recess, the root apices may lie immediately adjacent to, or occasionally protrude into, the sinus. Studies employing CBCT have reported that direct contact between the first premolar root apices and the sinus floor occurs in approximately 5–12% of cases.

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Maxillary Second Premolar

The maxillary second premolar typically presents a single root, which is directed distally and palatally. This tooth occupies an intermediate position in the posterior maxillary segment and its root apex lies, on average, 2–4 mm from the sinus floor. It is involved in sinus-related complications less frequently than the first molar, though its root apex may protrude into the sinus in approximately 10–16% of subjects examined by CBCT. The second premolar is an important landmark when planning the posterior boundary of a sinus lift procedure.

Maxillary First Molar

The maxillary first molar is the tooth most consistently associated with the closest proximity to, and most frequent contact with, the sinus floor. This tooth typically possesses three roots: mesiobuccal, distobuccal, and palatal. Of these, the palatal root is the longest and most prominently positioned relative to the sinus. Multiple CBCT-based studies have demonstrated that the palatal root of the first molar protrudes into the sinus cavity in 30–40% of cases, while the combined prevalence of close proximity (defined as contact or root protrusion) involving at least one of the three roots approaches 50–60%. The bucco-palatal divergence of the roots means that periapical pathology in this tooth may simultaneously involve the sinus floor on multiple sides of the alveolar process.

From a clinical perspective, the first molar is the tooth most frequently implicated in odontogenic maxillary sinusitis, accounting for a substantial proportion of chronic sinusitis cases managed by otorhinolaryngologists with an odontogenic aetiology. Extraction of this tooth carries the highest risk of oroantral communication among all posterior maxillary teeth.

Maxillary Second Molar

The roots of the maxillary second molar are commonly closer together and shorter than those of the first molar. Nevertheless, this tooth maintains a highly significant relationship with the sinus. CBCT analyses indicate that root protrusion into the sinus is present in approximately 20–30% of second molars, with the palatal root again being the most frequently involved. The close proximity of the second molar roots to the sinus floor makes this tooth a critical structure to evaluate when planning posterior maxillary implants or performing periradicular surgery.

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Maxillary Third Molar

The maxillary third molar exhibits the greatest anatomical variability of all posterior maxillary teeth, reflecting its inconstant presence, variable root morphology, and unpredictable eruption. When fully erupted and positioned in the alveolar arch, the third molar may be in close proximity to the posterolateral sinus wall. Root protrusion into the sinus is less common than for the first and second molars but has been documented in approximately 10–20% of cases. Impacted third molars may lie in intimate contact with the posterolateral sinus wall, complicating their surgical removal.

IMAGING MODALITIES FOR ASSESSING ROOT-SINUS RELATIONSHIPS

The accurate assessment of the relationship between dental roots and the maxillary sinus has been substantially advanced by the introduction of three-dimensional imaging techniques. Conventional periapical and panoramic radiographs provide a two-dimensional representation of a three-dimensional structure and are consequently limited by distortion, superimposition, and an inability to evaluate buccolingual dimensions. Panoramic radiography is useful for a preliminary screening of root proximity to the sinus floor but consistently underestimates the true degree of root protrusion, as it projects all structures onto a single plane.

Cone-beam computed tomography (CBCT) offers isotropic three-dimensional imaging at a substantially lower radiation dose than conventional computed tomography and is now regarded as the gold standard for detailed assessment of the maxillary sinus floor and its relationship to the posterior maxillary teeth. CBCT enables direct measurement of the vertical distance between root apices and the sinus floor, evaluation of the integrity of the cortical bone separating the roots from the sinus, and identification of pathological changes in the sinus mucosa associated with periapical disease. Multiplanar reconstructions in the coronal, sagittal, and axial planes permit comprehensive evaluation of all three roots of the maxillary molars individually.

CLINICAL IMPLICATIONS

Oroantral Communication and Fistula

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Oroantral communication (OAC) occurs when the barrier between the oral cavity and the maxillary sinus is disrupted, most commonly during the extraction of maxillary posterior teeth whose roots are in close proximity to, or project into, the sinus floor. When left untreated, OAC may become epithelialised to form an oroantral fistula (OAF), providing a permanent pathway for the contamination of the sinus with oral microorganisms. The reported incidence of OAC following maxillary molar extraction ranges from 0.31% to 4.7%, with the first molar carrying the highest risk. Awareness of the preoperative CBCT findings can prompt clinicians to modify their surgical approach — for instance, by sectioning multi-rooted teeth before elevation — thereby reducing the risk of iatrogenic sinus perforation.

Odontogenic Maxillary Sinusitis

Odontogenic sinusitis accounts for approximately 10–12% of all cases of maxillary sinusitis and is caused by the spread of periapical or periodontal infection from the posterior maxillary teeth into the adjacent sinus. The maxillary first molar, by virtue of its intimate relationship with the sinus floor, is the tooth most commonly implicated. Clinicians should be alert to unilateral maxillary sinusitis in a patient with concurrent dental pathology in the posterior maxilla, as definitive resolution of the sinusitis requires elimination of the dental source in addition to any necessary endoscopic sinus surgery.

Dental Implantology and Sinus Augmentation

The posterior maxilla frequently presents insufficient vertical bone height for the placement of standard-length dental implants, owing to the combined effects of alveolar bone resorption following tooth loss and secondary sinus pneumatisation. Sinus floor elevation, performed either via a lateral window approach (Caldwell-Luc modification) or a transcrestal (osteotome) technique, is a well-established surgical procedure that creates the necessary bone volume. Detailed knowledge of the sinus dimensions, the position of septal ridges within the sinus (Underwoodsepta), and the available residual bone height — all assessed by CBCT — is essential for surgical planning. Inadvertent perforation of the Schneiderian membrane during sinus augmentation is a recognised complication whose risk is influenced by the local anatomical configuration.

Endodontic Considerations

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In endodontic practice, the proximity of the maxillary posterior roots to the sinus floor is relevant in several contexts. Extrusion of irrigant or obturating material beyond the root apex may result in sinus contamination, provoking acute or chronic sinusitis. Periradicular surgery on teeth whose apices project into the sinus requires meticulous technique to avoid mucosal perforation and to manage any mucosal thickening encountered intraoperatively. Conversely, sinus pathology — including mucous retention cysts and mucoceles — may produce radiographic changes around the root apices that can mimic periapical disease, necessitating careful differential diagnosis.

ANATOMICAL VARIATIONS AND FACTORS INFLUENCING ROOT-SINUS PROXIMITY

The degree of proximity between the maxillary posterior roots and the sinus floor is influenced by multiple anatomical and demographic variables. Age is a significant factor: progressive sinus pneumatisation over the lifetime reduces the thickness of the bone separating the root apices from the sinus. In edentulous patients, the process is particularly marked, and the ridge crest may lie only millimetres from the sinus floor.

The presence of Underwood's septa — bony ridges projecting from the sinus floor, encountered in approximately 28–37% of individuals — can influence the pattern of root-sinus contact and also constitutes a surgical hazard during lateral window sinus lift procedures. The number, height, and orientation of these septa are highly variable and can only be reliably evaluated by CBCT.

Root morphology also plays a role: teeth with unusually long roots, pronounced root divergence, or root dilaceration are more likely to be in close contact with the sinus. The number of roots is relevant: three-rooted maxillary first premolars, though rare, carry a higher risk of sinus proximity than the more common two-rooted form. Ethnicity and gender have been proposed as additional variables, though the evidence is not conclusive.

CONCLUSION

The anatomical relationship between the roots of the upper jaw teeth and the maxillary sinus is a subject of central importance to clinical dentistry and oral surgery. The maxillary first molar roots, particularly the palatal root, maintain the closest and most clinically consequential relationship with the sinus floor, with

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direct contact or protrusion documented in a substantial proportion of the population. The maxillary second molar and, to a lesser extent, the second premolar also present significant proximity to the sinus.

The advancement of CBCT imaging has markedly improved the ability of clinicians to characterise these relationships preoperatively, enabling more precise surgical planning and a reduction in procedure-related complications such as oroantral communication, odontogenic sinusitis, and membrane perforation during sinus augmentation. An integrated understanding of the morphometric variability of the sinus floor, the individual root anatomy, and the influence of age-related pneumatisation is indispensable for the safe and effective management of the posterior maxilla.

Future research should focus on the development of standardised classification systems for root-sinus proximity that can be applied consistently across CBCT studies, thereby facilitating meta-analytic synthesis of prevalence data and the establishment of evidence-based clinical guidelines.

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