[DOI]10.12016/j.issn.2096-1456.202440389

·综述·

上颌后牙区牙保存相关上颌窦底提升术的解剖学考量

戢晓，张岚，黄定明
口腔疾病防治全国重点实验室 国家口腔医学中心 国家口腔疾病临床医学研究中心 四川大学华西口腔医院牙体牙髓病科，四川 成都（610041）

【摘要】 显微根尖手术是治疗上颌后牙牙髓根尖周疾病和牙髓源性上颌窦炎的重要方法。然而，由于上颌后牙与上颌窦之间的密切关系，上颌后牙的显微根尖手术面临挑战，术中可能导致上颌窦底黏膜穿孔等并发症。显微根尖手术联合上颌窦底提升术被认为是一种解决方案，即牙保存相关上颌窦底提升术。牙保存相关上颌窦底提升术的评估和设计与局部解剖关系密切相关。本文从上颌后牙、上颌后牙区牙槽嵴和上颌窦三方面系统综述了上颌后牙区显微根尖手术和牙保存相关上颌窦底提升术的解剖学考量。文献回顾结果显示，显微根尖手术中必须切除至少3 mm的根尖，以消除绝大部分的根尖分歧、侧支根管和严重的牙根弯曲。牙槽嵴高度和颊腭侧骨板厚度是评估和设计上颌后牙根尖手术的重要指标。上颌窦底黏膜、上颌窦窦口、上颌后牙与上颌窦底关系、上颌窦分隔、上牙槽后动脉和腭大动脉以及可能存在的上颌窦囊肿是主要的上颌窦相关考量因素。当上颌窦底最低点低于牙根尖、根尖接触或突入上颌窦底，以及根尖周病变与上颌窦底连通时，可以进行牙保存相关上颌窦底提升术。解剖学考量应在上颌后牙区牙保存相关上颌窦底提升术中贯穿始终。未来尚需进一步的研究探讨不同局部解剖关系下牙保存相关上颌窦底提升术的临床设计与难度评估。

【关键词】 牙保存相关上颌窦底提升术；　显微根尖手术；　上颌窦底提升术；　上颌窦；　上颌后牙；　上颌后牙-上颌牙槽骨-上颌窦复合体；　牙髓源性上颌窦炎；　解剖
【中图分类号】 78　**【文献标志码】** A　**【文章编号】** 2096-1456（2025）08-0680-10
【引用著录格式】 戢晓，张岚，黄定明. 上颌后牙区牙保存相关上颌窦底提升术的解剖学考量[J]. 口腔疾病防治, 2025, 33(8): 680-689. doi:10.12016/j.issn.2096-1456.202440389.

微信公众号

Anatomical considerations for natural tooth-related maxillary sinus floor elevation of maxillary posterior teeth

JI Xiao, ZHANG Lan, HUANG Dingming. State Key Laboratory of Oral Diseases & National Center for Stomatology & National Clinical Research Center for Oral Diseases & Department of Conservative Dentistry and Endodontics, West China Hospital of Stomatology, Sichuan University, Chengdu 610041, China
Corresponding author: HUANG Dingming, Email: dingminghuang@163.com

【Abstract】 Endodontic microsurgery is an important treatment for endodontic disease and maxillary sinusitis of endodontic origin of maxillary posterior teeth. However, endodontic microsurgery is challenging due to the close proximity between the maxillary posterior teeth and the maxillary sinus, which may lead to complications of mucosal perforation of the maxillary sinus floor. Endodontic microsurgery combined with maxillary sinus floor elevation is considered as a solution, namely natural tooth-related maxillary sinus floor elevation. The evaluation and design of natural tooth-related maxillary sinus floor elevation are closely related to local anatomic relationships. This article provides a systematic review of the anatomical considerations of endodontic microsurgery, namely natural tooth-related maxillary sinus floor elevation in the maxillary posterior region in terms of maxillary posterior teeth, alveolar ridge of the maxillary posterior region,

【收稿日期】2024-10-14；　**【修回日期】**2024-12-12
【基金项目】四川省科技计划项目（2024NSFSC0593）；四川省干部保健科研课题项目（60022）
【作者简介】戢晓，医师，硕士，Email：jixiao08@126.com
【通信作者】黄定明，教授，博士，Email: dingminghuang@163.com

and maxillary sinus. The literature review showed that a minimum of 3 mm of the root apex must be removed during endodontic microsurgery to eliminate the majority of apical ramification, lateral canals, and severe root curvatures. The height and thickness of alveolar ridge bone are important indicators for evaluating and designing endodontic microsurgery for maxillary posterior teeth. Maxillary sinus floor mucosa, maxillary sinus ostium, the proximity between maxillary posterior teeth and the maxillary sinus floor, maxillary sinus septa, posterior superior alveolar artery, and greater palatine artery, and possible maxillary sinus cysts are the main maxillary sinus-related considerations. When the maxillary sinus floor is below the line between the buccal and palatal roots, when the root apices contact or protrude into the maxillary sinus floor, or when the apical lesion is directly connected to the maxillary sinus mucosa, natural tooth-related maxillary sinus floor elevation is applicable. Anatomical considerations should be emphasized throughout endodontic microsurgery and natural tooth-related maxillary sinus floor elevation in the maxillary posterior region. Further studies are required to investigate the clinical design and difficulty assessment of natural tooth-related maxillary sinus floor elevation in different local anatomical relationships.

【Key words】 natural tooth-related maxillary sinus floor elevation; endodontic microsurgery; maxillary sinus floor elevation; maxillary sinus; maxillary posterior teeth; maxillary tooth-bone-sinus complex; maxillary sinusitis of endodontic origin; anatomy

J Prev Treat Stomatol Dis, 2025, 33(8): 680-689.

【Competing interests】 The authors declare no competing interests.

This study was supported by the grants from Sichuan Science and Technology Program (No. 2024NSFSC0593); Sichuan Province Cadre Health Care Research Project (No. 60022).

上颌后牙、牙槽骨和上颌窦紧密相连，作为一个解剖结构复合体，在血液供应、感觉和空间定位等方面相互关联，发生疾病时极易相互影响，被称为上颌后牙-上颌牙槽骨-上颌窦复合体（maxillary tooth-bone-sinus complex）[1]。由于上颌后牙与上颌窦底（maxillary sinus floor，MSF）关系密切，当上颌后牙发生根尖周炎时，上颌窦也可能被累及，发生牙髓源性上颌窦炎（maxillary sinusitis of endodontic origin，MSEO），其占上颌窦炎总发病率的25%~40%[2-3]。美国牙髓病协会（American Association of Endodontists，AAE）将MSEO定义为继发于牙髓疾病的上颌窦炎，分为三类，包括根尖周炎引起上颌窦底反应性骨生成，骨质膨胀进入上颌窦的牙髓源性上颌窦骨膜炎（periapical osteoperiostitis，PAO），根尖周炎接触上颌窦黏膜引起的牙髓源性上颌窦黏膜炎（periapical mucositis，PAM）和MSEO引起的上颌窦阻塞（sinus obstruction from MSEO）[4]。

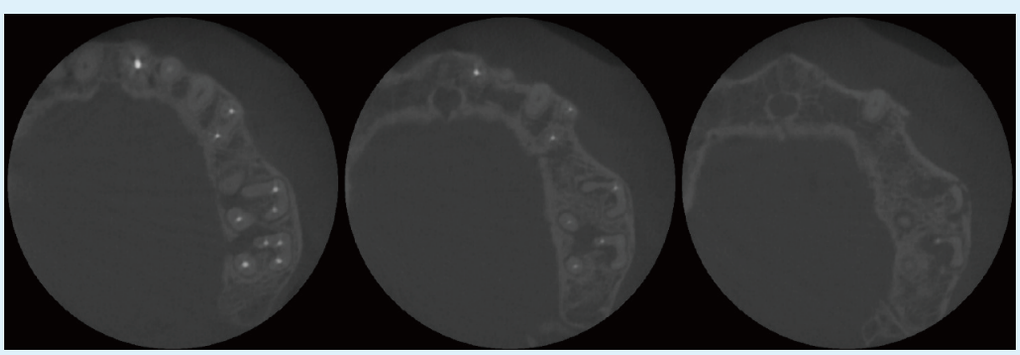
牙髓治疗对于牙髓根尖周病和MSEO是十分关键的[5-7]。对于具有保留价值，经术前评估能够重建根管工作通道的患牙，根管治疗是目前的首选方法[8]。然而，由于上颌后牙根管系统变异多、治疗难度大，超过30%的病例可能出现治疗效果不佳、根尖周病变迁延不愈[9-10]。同时，由于根尖与上颌窦底关系紧密，根管治疗可能对上颌窦黏膜造成影响，甚至可能将根管内感染物、根管锉、牙胶尖等推出根尖孔乃至推入上颌窦内[11]。

对于非手术根管治疗无法进行或疗效不确定的患牙，在与患者充分沟通交流的前提下，可采取显微根尖手术治疗[12]。随着口腔显微镜、口腔数字化技术、生物相容性充填材料的发展，手术治疗的5年成功率可达91.5%，与非手术治疗的预后没有显著差异[13-14]。然而，由于视野和操作空间的受限、上颌后牙复杂的根管系统、上颌后牙牙根与上颌窦底之间的密切关系、上颌窦分隔和上牙槽后动脉的存在等，上颌后牙的显微根尖手术也面临挑战。当患牙牙根接触或突入上颌窦底时，显微根尖手术可能导致上颌窦底穿孔，此时可以行显微根尖手术结合上颌窦底提升术，即牙保存相关上颌窦底提升术（natural tooth-related maxillary sinus floor elevation），目前已有成功病例报道[15-16]。

局部解剖关系的评估与分析对上颌后牙显微根尖手术，特别是牙保存相关上颌窦底提升术具有重要意义。本文将全方面地回顾相关文献，围绕上颌后牙-上颌牙槽骨-上颌窦复合体，对牙保存相关上颌窦底提升术的解剖学考量进行归纳总结，为临床医生进行手术设计和难度评估提供参考。

1　上颌后牙解剖学考量

上颌后牙的解剖非常复杂。术前应用锥形束X射线计算机体层成像设备(cone beam computed tomography,CBCT)仔细观察,术中准确识别,避免遗漏根管引起手术失败。上颌后牙的牙根、根管、根尖孔数目不定,且可能存在副根管、根尖鳍状、根尖三角区、管间交通、C形根管(图1)、根管分叉和侧支根管等[17]。上颌后牙的根管解剖与地理区域、种族、年龄和性别等有关,亚洲人的上颌前磨牙单根管发生率高于其他地区[18]。显微根尖手术中必须切除至少3 mm的根尖,以消除98%的根尖分歧和93%的侧支根管,以及牙根严重弯曲的部分,从而消除大部分残留的微生物和刺激物,有利于完全去除肉芽组织和其他异物[12]。当切除具有多于一个主根管的牙根时,其可能存在峡部组织,含有牙髓或牙髓衍生组织,上颌第一磨牙近颊根峡区发生率约90%,上颌前磨牙约30%,因此需调整根尖倒预备范围以包括峡部区域。当根尖靠近上颌窦底时,可能需要更多的根尖切除量以免伤及上颌窦。当第一或第二磨牙缺失,第三磨牙可以考虑作为功能牙。但第二、第三磨牙位置靠后、牙齿倾斜、根管系统变异大时,显微根尖手术难度较大,解剖风险高,可以考虑进行意向性牙再植术。上颌后牙各牙位的解剖学考量见表1。



Buccal roots of both maxillary first and second molars are fused to form a C-shape

Figure 1　C-shaped root canal of maxillary first molar

图1　上颌第一磨牙C形根管

表1　上颌后牙解剖学考量

Table 1　Anatomical considerations for maxillary posterior teeth

Tooth position	Number of root canals	Lateral canals	Others
First premolar	Double root canals: about 70%[19]	About 50%	The apical third of the root is mostly curved
Second premolar	Single root canal: about 75%	About 50%	The apical third of the root is mostly curved
First molar	The second mesiobuccal canal (MB2): over 60%	About 45%	The mesiobuccal canal is curved and thin
	The third mesiobuccal canal: about 7%-10%[20]	Accessory	MB2 is usually palatally oriented
	The second distobuccal canal: 1.6%-9.5% (1% cases	canal at root bi-	MB2 is associated with secondary dentin[23], which was
	have two or more individual apical foramina[21])	furcation: about	found to be significantly less prevalent in patients under
	C-shaped canal: 1.1%-8.3%[22] (Figure 1)	18%	20 years of age than in patients 20-40 years of age[24]
Second molar	Two or three canals (one or two buccal canals)		The mesiobuccal root of the second molar is close to the
	Double palatal canals: 1.2%-1.6%[25]		distobuccal root of the first canal
Third molar	Complex and unpredictable		Significant buccal and/or distal tilt may be present
	Usually three roots and three canals[26]		
	Up to four roots and six root canals		
	At least one root and one canal		
	C-shaped canal is possible		

MB2: the second mesiobuccal canal

2　上颌后牙区牙槽嵴解剖学考量

有研究测量了有牙状态下的牙槽嵴高度,前部(第二前磨牙远中往前的区域)的平均高度为(14.36±3.17)mm,中部(第二前磨牙远中到第二磨

牙远中区域）的平均高度为（9.73 ± 3.29）mm，后部（第二磨牙远中往后的区域）的平均高度为（9.40 ± 4.24）mm[27]。牙槽嵴高度是评估显微根尖手术预后，以及手术中设计开窗位点的重要指标。牙槽骨的高度与牙齿和上颌窦底间的距离也有关。当上颌窦气化程度低，牙槽骨高度较高，就有较充分的空间容纳牙根，根尖与上颌窦底之间可以有较远的距离（图2）。

a: when the degree of maxillary sinus pneumatization is low, the alveolar ridge height is high, and the root apex and the maxillary sinus floor are far apart; b: when the degree of maxillary sinus pneumatization is high, the alveolar ridge height is low, and the root apex and the maxillary sinus floor are close together

Figure 2　Alveolar ridge height in relation to the root apex and maxillary sinus floor

图2　牙槽嵴高度与根尖和上颌窦底关系

研究发现，天然牙存在的情况下，颊侧牙槽骨厚度从第二前磨牙向第二磨牙增加，尤其是上颌磨牙，其外侧为颧突所在位置。最薄的部位是双根第一前磨牙的颊根和第一磨牙的近中颊根，最厚的部位是第二磨牙的近中颊根[28]。腭侧牙槽骨最薄的部位是上颌第一磨牙的腭根，最厚的部位是单根第二前磨牙[29]。骨壁较厚导致显微根尖手术术中需要磨除更多的骨质，去骨容易偏移，根尖定位困难，可能造成上颌窦黏骨膜撕裂穿孔。因此可以使用导板或动态导航引导开窗，以达到微创的治疗效果。同时，颊侧牙槽骨越厚，则对应的前庭沟越浅，影响手术垂直切口的位置和长度。

上颌前磨牙，特别是第一前磨牙的颊根接近颊侧皮质骨板，可能发生根尖开窗[30]。骨开窗可能导致触诊疼痛，因此在手术中切除牙根时应使根尖低于周围骨皮质水平，利于骨组织重建。上颌第一磨牙也可能因骨开窗出现牙根暴露[31]。

3　上颌窦解剖学考量

上颌窦（maxillary sinus）是最大的鼻窦，也是最早发育的鼻窦[8]。在发育期，上颌窦向外下方扩张，上颌窦底向下延伸至上颌牙槽嵴，主要是第二前磨牙、第一和第二磨牙区域，极端情况下甚至可扩展至尖牙牙根[32]。牙齿和上颌窦黏膜间可能仅有菲薄的骨板甚至只有上颌窦黏膜，牙根可能接触甚至突入上颌窦底[33]。

3.1　上颌窦底黏膜

上颌窦的内表面被覆一层薄而光滑的黏膜，被称为施耐德膜（Schneiderian membrane），由骨膜、高度血管化的固有层和一薄层的假复层纤毛柱状上皮组成[34]。生理状态下上颌窦黏膜的厚度约为1 mm，通常认为上颌窦黏膜厚度超过2～3 mm为病理性的增厚[35]。厚龈生物型和上颌窦炎可能导致黏膜增厚，可能增加手术中上颌窦黏膜穿孔风险[36]。一些研究显示吸烟者的黏膜增厚，也有研究显示吸烟者黏膜变薄，但前瞻性研究和系统分析都显示吸烟者上颌窦底提升中穿孔风险增加[37-38]。牙源性囊肿常通过骨质薄弱的区域到达上颌窦，由于骨吸收和炎症，囊肿和上颌窦膜可以紧密粘连在一起，导致手术中分离困难[39]。此外，即使接受了完善治疗，上颌窦底黏膜增厚的恢复可能需要很长时间，因此一般将上颌窦底骨质完整性，而非根尖周病变和上颌窦炎症的愈合作为MSEO治疗成功的标准。

3.2　上颌窦窦口

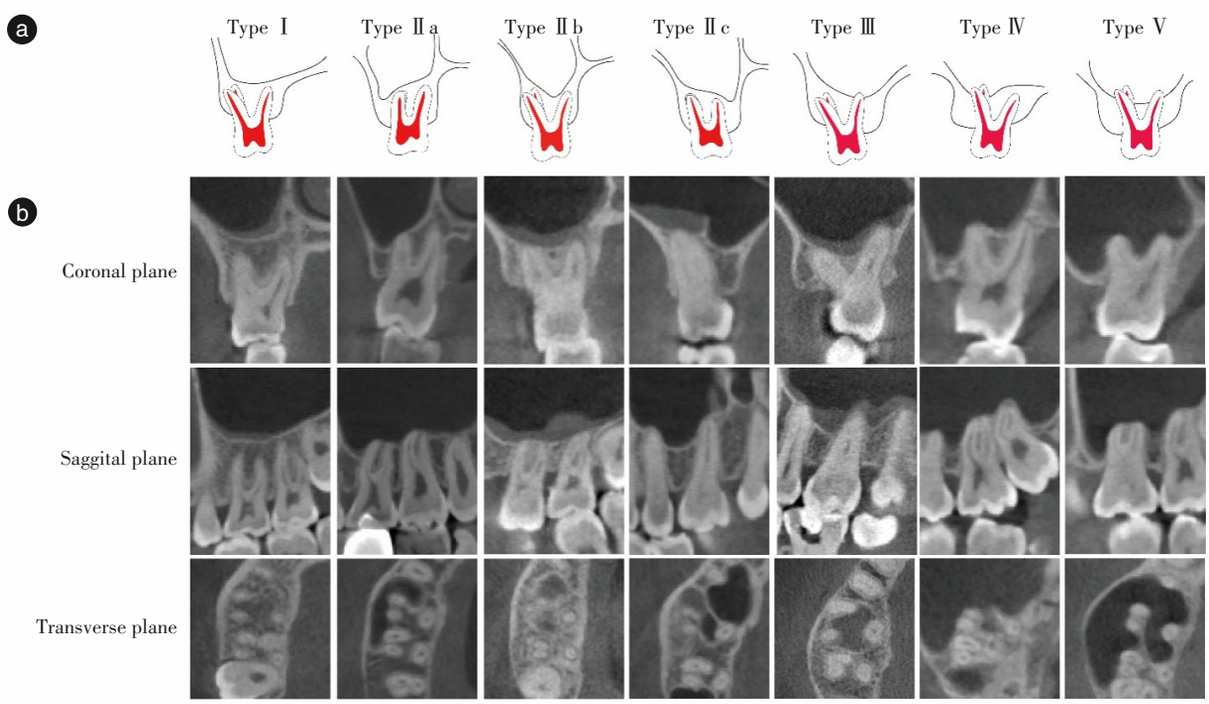
上颌窦窦口位于上颌窦上前1/3，开口于中鼻道，与鼻腔相通。窦口直径约1～4 mm，10%~30%的上颌窦中存在副口。如果MSEO中增厚的黏膜

阻塞上颌窦开口，应先治疗上颌窦炎，使上颌窦通气良好，引流通畅，然后再进行显微根尖手术，必要时还应联合进行上颌窦底提升术。

3.3　上颌后牙与上颌窦底关系

上颌前磨牙的根尖通常位于上颌窦底的颊侧，手术相对安全。如果上颌前磨牙的颊腭根分叉度较大，腭根位置较深，通常需要将开窗向近中延伸，或扩大颊根的切除长度，以便实现更好的视野和操作空间[40]。

上颌磨牙的根尖更靠近上颌窦，以上颌第二磨牙近颊根为最，上颌后牙根尖可能直接接触或突入上颌窦底[41]。CBCT研究显示35.9%的上颌后牙牙根接近上颌窦底，14.3%的牙根伸入上颌窦[42]。本课题组结合之前的研究[43]，提出了一种基于CBCT的上颌后牙-上颌牙槽骨-上颌窦复合体解剖关系改进分类(图3)。因此，直接进行显微根尖手术可能导致上颌窦底穿孔，其发生率为10.4%～50.0%[44]。根尖周病变如穿通上颌窦底，即发生牙髓源性上颌窦黏膜炎，会增加手术中上颌窦暴露的可能性。但对于牙髓源性上颌窦骨膜炎，根尖病变引起上颌窦底骨膜扩张，上颌窦底膨隆，从牙根尖被抬起，此时手术导致穿孔风险较低。但有研究认为，即使在上颌后牙显微根尖手术中发生了上颌窦黏膜的穿孔，手术的预后也没有改变[45]。



a: diagram, b: CBCT examples; Type I: all roots do not contact or protrude into the maxillary sinus floor, and the highest point of all roots is lower than the lowest point of the maxillary sinus floor; Type Ⅱa: all roots do not contact or protrude into the maxillary sinus floor, but maxillary sinus nadir is on the buccal side of all roots; Type Ⅱb: all roots do not contact or protrude into the maxillary sinus floor, but maxillary sinus nadir is between the roots; Type Ⅱc: all roots do not contact or protrude into the maxillary sinus floor, but maxillary sinus nadir is on the palatal side of all roots; Type Ⅲ: one root contacts or protrudes into the maxillary sinus floor; Type Ⅳ: two roots contact or protrude into the maxillary sinus floor; Type Ⅴ: three roots contact or protrude into the maxillary sinus floor

Figure 3　An improved classification of anatomical relationship in the maxillary tooth-bone-sinus complex

图3　上颌后牙-上颌牙槽骨-上颌窦复合体解剖关系改进分类

因此，当根尖靠近上颌窦底时，牙保存相关上颌窦底提升术是一种可行的方案[46-47]。颊侧翻瓣难度较小，大血管少，手术视野好，尤其当患牙根分叉区域骨质破坏较重时，能相对较好地确定腭根根尖位置[48]。通过上颌窦外侧壁开孔，仔细剥离并抬高黏膜，可以为手术提供足够的操作空间和良好的视野，同时也降低了上颌窦底黏膜损伤和穿孔的风险，保证了显微手术的安全性和有效性[15]。通过使用生物材料，根尖和上颌窦底之间的垂直距离也会增加，这可以预防未来拔牙导致

口腔上颌窦交通(oroantral communications, OAC),也为将来可能的种植手术奠定良好的生物学基础[49-50]。

显微根尖手术中的上颌窦底提升与种植中的不同,上颌窦黏膜通常处于炎症、感染而非健康状态,且患牙牙根突入上颌窦底可能导致窦底骨变得卷曲而非圆滑。因此,对于牙保存相关上颌窦底提升术,术前的影像学评估,特别是CBCT分析是十分必要的[51-52]。当根尖突入上颌窦底的距离越大,突入的根尖越多,上颌窦底提升的难度越大。颊腭根夹角和上颌窦底形成的角度也与手术难度有关,夹角越小,剥离上颌窦底黏膜就越困难,手术难度增加。当上颌窦底提升过于困难时,可以考虑将非手术治疗和显微根尖手术治疗相结合,如颊根的手术治疗结合腭根的根管治疗[16],或在导板引导或动态导航下进行显微根尖手术[53-55]以提高治疗效果,最大限度地减少手术并发症。

其他避免上颌窦底穿孔的方案还包括经上颌窦入路和腭侧入路进行显微根尖手术。然而,经窦入路需要主动穿透上颌窦黏膜,导致出血较多、视野不佳,而且同样存在上颌窦穿孔的风险[56]。腭侧入路更适合仅需要对腭根进行干预的病例[57],但视野和操作空间有限,技术敏感性高,且有损伤腭大神经血管束的风险。

3.4　上颌窦分隔

上颌窦骨壁的骨皮质可能向窦腔内突起,28.1%的骨性突起高度超过2.5 mm,被称为上颌窦分隔(sinus septum, sinus septa)[58]。上颌窦分隔最常见于上颌第一磨牙和第二磨牙之间[59],分隔处黏膜纤薄,剥离黏膜的难度增加,穿孔的风险增加[60]。但上颌窦分隔降低了上颌窦底提升部位与临近骨壁的距离,对上颌窦内成骨有积极的意义。上颌窦分隔还可以为手术中放置的可吸收膜提供支撑。

3.5　上牙槽后动脉和腭大动脉

上牙槽后动脉(posterior superior alveolar artery, PSAA)供应上颌窦侧壁和上颌窦黏膜。28.9%的PSAA行走于窦外侧壁黏膜与骨壁之间,63.6%的PSAA行走于窦外侧骨壁中,7.5%的PSAA行走于窦外侧壁骨板外侧[61]。血管位于牙槽嵴顶上方10~20 mm,平均距离16.4 mm[62],其直径与颊侧骨壁厚度呈正相关[63]。上颌窦底提升术中侧壁开窗设计时应避让该血管,防止损伤引起大出血。

腭侧入路手术中必须考虑腭大动脉。腭大动脉和腭前神经从上颌第二磨牙远中的腭大孔穿出并向前延伸。86%的腭大孔正对第三磨牙,13%的腭大孔在第二和第三磨牙之间,1%的情况正对第二磨牙,从腭大孔中央到硬腭正中矢状平面平均距离是16 mm。腭大动脉的主要分支距尖牙区腭侧龈缘下约12 mm,距第二磨牙区腭侧龈缘下14 mm。此外,腭穹隆越浅,腭大动脉越靠近腭侧龈缘[64]。因此,腭侧切口不能接近牙槽突和上腭隆突交界处,应避免远中的垂直松解切口。腭大动脉损伤后局部加压止血效果不佳,可能需要结扎颈外动脉[26]。在腭侧翻瓣以治疗第一磨牙腭根时,腭大动脉和腭前神经可能包含在瓣中,但这一般不会出现问题。

3.6　上颌窦囊肿

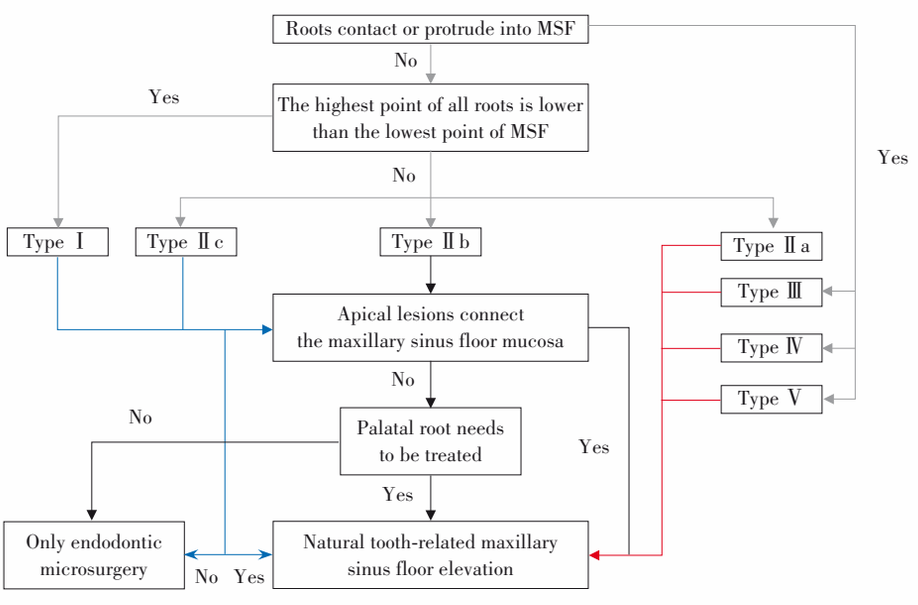
上颌窦囊肿的患病率与牙槽骨吸收、牙根与上颌窦底接触、上颌窦底凹陷和上颌窦分隔有关[65],对牙保存相关上颌窦底提升术有一定影响。对上颌窦囊肿分为三种类型:黏液囊肿、潴留囊肿和假性囊肿[66]。黏液囊肿较为少见,内壁较厚,有时可能涉及骨质破坏,一般认为在完整摘除前是上颌窦底提升的绝对禁忌证。潴留囊肿和假性囊肿一般不影响上颌窦底提升,但需警惕提升导致囊肿向顶部移位导致窦口堵塞,或提升导致囊肿破裂,发生上颌窦炎、骨增量材料弥散、感染等[67-68]。上颌窦囊肿对上颌窦底提升的影响存在争议,目前主要的治疗策略包括不处理囊肿,直接行上颌窦底提升;抽吸或摘除囊肿,同期行上颌窦底提升;以及摘除囊肿,择期行上颌窦底提升[69]。需要根据病例实际选择合适的治疗方案。

上颌窦囊肿多采用手术治疗,术式包括上颌窦根治术(Caldwell-Luc手术)和内镜鼻窦手术等。上颌窦根治术经唇龈切口凿开上颌窦前壁,去除病变黏膜,但并发症较多,近年由于鼻内窥镜技术的发展,应用已逐渐减少[39]。内镜鼻窦手术的分类较为复杂,其中功能性鼻内镜手术(functional endoscopic sinus surgery, FESS)是上颌窦病变的首选手术方法,旨在准确定位病变,准确去除病变,保留鼻窦黏膜,恢复纤毛黏液传输功能,形成一个包含自然开口的窦腔[70]。应根据术前CT及鼻内镜检查结果,精确分析上颌窦局部解剖关系及病变情况,制定个体化的手术方案。

4　总　结

上颌后牙根尖与上颌窦底之间的密切关系可

能对显微根尖手术，特别是牙保存相关上颌窦底提升术产生重要影响。因此应通过临床检查和影像学检查进行详细的评估（图4），CBCT是评估上颌窦及其周围解剖结构的重要工具。当患牙所有根尖低于上颌窦底最低点且有一定距离时，手术难度较低，不需要进行上颌窦底提升；当上颌窦底最低点低于牙根尖、根尖接触或突入上颌窦底，以及根尖周病变与上颌窦底连通时，手术易导致上颌窦底穿孔，需要在进行上颌窦底提升的前提下进行显微根尖手术。但对于MSEO引起的上颌窦阻塞，或上颌窦内同时存在脓液蓄积、囊肿（特别是黏液囊肿）或肿瘤的病例，应当先进行耳鼻喉科治疗，待上颌窦病变治疗结束后再考虑择期行口腔手术的必要性。未来尚需进一步研究探讨不同局部解剖关系下牙保存相关上颌窦底提升术的临床设计与难度评估。



MSF: maxillary sinus floor

Figure 4　Flowchart of evaluation on natural tooth-related maxillary sinus floor elevation

图4　牙保存相关上颌窦底提升术评估流程图

【Author contributions】 Ji X completed the literature search and wrote the manuscript. Zhang L, Huang DM conceptualized and reviewed the article. All authors read and approved the final manuscript as submitted.

参考文献

[1] Zhang J, Liu L, Yang L, et al. Diagnosis of odontogenic maxillary sinusitis by cone-beam computed tomography: a critical review[J]. J Endod, 2023, 49(11): 1445-1456. doi: 10.1016/j.joen.2023.08.014.

[2] Sakir M, Ercalik Yalcinkaya S. Associations between periapical health of maxillary molars and mucosal thickening of maxillary sinuses in cone-beam computed tomographic images: a retrospective study[J]. J Endod, 2020, 46(3): 397-403. doi: 10.1016/j.joen.2019.12.004.

[3] Yassin-Kassab A, Bhargava P, Tibbetts RJ, et al. Comparison of bacterial maxillary sinus cultures between odontogenic sinusitis and chronic rhinosinusitis[J]. Int Forum Allergy Rhinol, 2021, 11(1): 40-47. doi: 10.1002/alr.22627.

[4] Tataryn RW, Lewis MJ, Horalek ML, et al. Maxillary Sinusitis of Endodontic Origin. American Association of Endodontists Position Statement[Z/OL]. [2024-12-12]. https://www.aae.org/specialty/wp-content/uploads/sites/2/2018/04/AAE_PositionStatement_MaxillarySinusitis.pdf.

[5] Siqueira JF Jr, Lenzi R, Hernández S, et al. Effects of endodontic infections on the maxillary sinus: a case series of treatment outcome[J]. J Endod, 2021, 47(7): 1166-1176. doi: 10.1016/j.joen.2021.04.002.

[6] Craig JR, Poetker DM, Aksoy U, et al. Diagnosing odontogenic sinusitis: an international multidisciplinary consensus statement[J]. Int Forum Allergy Rhinol, 2021, 11(8): 1235-1248. doi: 10.1002/alr.22777.

[7] Craig JR, Tataryn RW, Aghaloo TL, et al. Management of odontogenic sinusitis: multidisciplinary consensus statement[J]. Int

Forum Allergy Rhinol, 2020, 10(7): 901-912. doi: 10.1002/alr.22598.

[8] Lin J, Wang C, Wang X, et al. Expert consensus on odontogenic maxillary sinusitis multi-disciplinary treatment[J]. Int J Oral Sci, 2024, 16(1): 11. doi: 10.1038/s41368-024-00278-z.

[9] Tibúrcio-Machado CS, Michelon C, Zanatta FB, et al. The global prevalence of apical periodontitis: a systematic review and meta-analysis[J]. Int Endod J, 2021, 54(5): 712-735. doi: 10.1111/iej.13467.

[10] Meirinhos J, Martins JNR, Pereira B, et al. Prevalence of apical periodontitis and its association with previous root canal treatment, root canal filling length and type of coronal restoration - a cross-sectional study[J]. Int Endod J, 2020, 53(4): 573-584. doi: 10.1111/iej.13256.

[11] Yanık D, Nalbantoğlu AM, Er K. Sinus membrane thickness of healthy endodontically treated maxillary molars[J]. Clin Oral Investig, 2024, 28(8): 418. doi: 10.1007/s00784-024-05815-y.

[12] Setzer FC, Kratchman SI. Present status and future directions: surgical endodontics[J]. Int Endod J, 2022, 55(Suppl 4): 1020-1058. doi: 10.1111/iej.13783.

[13] Floratos S, Kim S. Modern endodontic microsurgery concepts: a clinical update[J]. Dent Clin North Am, 2017, 61(1): 81-91. doi: 10.1016/j.cden.2016.08.007.

[14] 黄湘雅, 蔡艳玲, 韦曦. 显微根尖手术的全周期管理[J]. 口腔疾病防治, 2021, 29(10): 649-655. doi: 10.12016/j.issn.2096-1456.2021.10.001.
Huang XY, Cai YL, Wei X. Full-cycle management of endodontic microsurgery[J]. J Prev Treat Stomatol Dis, 2021, 29(10): 649-655. doi: 10.12016/j.issn.2096-1456.2021.10.001.

[15] Silberman JJ, Moldauer BI, Torres J, et al. Palatal root surgery of a maxillary molar using a piezosurgery transantral approach with simultaneous sinus lift grafting: a case report[J]. Int Endod J, 2021, 54(3): 464-475. doi: 10.1111/iej.13423.

[16] Azim AA, Wang HH, Serebro M. Selective retreatment and sinus lift: an alternative approach to surgically manage the palatal roots of maxillary molars[J]. J Endod, 2021, 47(4): 648-657. doi: 10.1016/j.joen.2020.08.028.

[17] Ahmed HMA, Neelakantan P, Dummer PMH. A new system for classifying accessory canal morphology[J]. Int Endod J, 2018, 51(2): 164-176. doi: 10.1111/iej.12800.

[18] Martins JNR, Versiani MAl. Worldwide assessment of the root and root canal characteristics of maxillary premolars – a multi-center cone-beam computed tomography cross-sectional study with meta-analysis[J]. J Endod, 2024, 50(1): 31-54. doi: 10.1016/j.joen.2023.10.009.

[19] Liu X, Gao M, Bai Q, et al. Evaluation of palatal furcation groove and root canal anatomy of maxillary first premolar: a CBCT and micro-CT study[J]. Biomed Res Int, 2021, 2021: 8862956. doi: 10.1155/2021/8862956.

[20] Ordinola-Zapata R, Martins JNR, Plascencia H, et al. The MB3 canal in maxillary molars: a micro-CT study[J]. Clin Oral Investig, 2020, 24(11): 4109-4121. doi: 10.1007/s00784-020-03284-7.

[21] 李嘉宁, 张倩霞, 周子超, 等. 上颌第一磨牙解剖结构的锥形束CT研究[J]. 空军军医大学学报, 2024, 15(10): 1092-1098. doi: 10.13276/j.issn.2097-1656.2024.10.003.
Li JN, Zhang QX, Zhou ZC, et al. A cone beam CT study of the anatomical structure of the maxillary first molar[J]. J Air Force Med Univ, 2024, 15(10): 1092-1098. doi: 10.13276/j.issn.2097-1656.2024.10.003.

[22] Liu M, Huang Y, Wu Y, et al. Nonsurgical endodontic retreatment of C-shaped maxillary molars: case reports and review of literature [J]. BMC Oral Health, 2024, 24(1): 1401. doi: 10.1186/s12903-024-05155-z.

[23] Studebaker B, Hollender L, Mancl L, et al. The incidence of second mesiobuccal canals located in maxillary molars with the aid of cone-beam computed tomography[J]. J Endod, 2018, 44(4): 565-570. doi: 10.1016/j.joen.2017.08.026.

[24] Peters OA. The Guidebook to Molar Endodontics[M]. Berlin Heidelberg: Springer-Verlag, 2017.

[25] Matsumoto K, Imai Y, Hirose H, et al. A case report of root canal retreatment of a four-rooted maxillary second molar[J]. J Dent Sci, 2023, 18(1): 461-463. doi: 10.1016/j.jds.2022.08.033.

[26] Louis H, Berman, Hargreaves KM. Cohen's Pathways of the Pulp, 12th Editor[M]. Amsterdam: Elsevier, 2021.

[27] Demirkol M, Demirkol N. The effects of posterior alveolar bone height on the height of maxillary sinus septa[J]. Surg Radiol Anat, 2019, 41(9): 1003-1009. doi: 10.1007/s00276-019-02271-2.

[28] Liao WC, Chang SH, Chang HH, et al. An analysis of the relevance and proximity between maxillary posterior root apices to the maxillary sinus and the buccal cortical bone plate[J]. J Dent Sci, 2024, 19(4): 1972-1982. doi: 10.1016/j.jds.2024.07.019.

[29] Lavasani SA, Tyler C, Roach SH, et al. Cone-beam computed tomography: anatomic analysis of maxillary posterior teeth-impact on endodontic microsurgery[J]. J Endod, 2016, 42(6): 890-895. doi: 10.1016/j.joen.2016.03.002.

[30] Nalbantoğlu AM, Yanık D. Evaluation of facial alveolar bone thickness and fenestration of the maxillary premolars[J]. Arch Oral Biol, 2022, 142: 105522. doi: 10.1016/j.archoralbio.2022.105522.

[31] Ferrari CH, de Carvalho LS, Rocha CT, et al. Correlation between tooth position parameters and apical fenestration: a cone-beam computed tomography study[J]. Methods Protoc, 2024, 7(1): 14. doi: 10.3390/mps7010014.

[32] Qin Y, Shu G, Xu T. Evaluation of the relationship between maxillary sinus wall and maxillary canines and posterior teeth using cone-beam computed tomography[J]. Med Sci Monit, 2020, 26: e925384. doi: 10.12659/MSM.925384.

[33] Lee S, Fernandez J, Mirjalili SA, et al. Pediatric paranasal sinuses-development, growth, pathology, & functional endoscopic sinus surgery[J]. Clin Anat, 2022, 35(6): 745-761. doi: 10.1002/ca.23888.

[34] 孙明新, 宋东哲, 黄定明. 上颌窦对上颌后牙显微根尖手术的影响[J]. 口腔疾病防治, 2022, 30(2): 140-147. doi: 10.12016/j.issn.2096-1456.2022.02.011.
Sun MX, Song DZ, Huang DM. The influence of the maxillary sinus on maxillary posterior tooth endodontic microsurgery[J]. J Prev Treat Stomatol Dis, 2022, 30(2): 140-147. doi: 10.12016/j.

issn.2096-1456.2022.02.011.

[35] Whyte A, Boeddinghaus R. Imaging of odontogenic sinusitis[J]. Clin Radiol, 2019, 74(7): 503-516. doi: 10.1016/j.crad.2019.02.012.

[36] Oliveira-Santos N, Beersingh AH, Felizardo HMA, et al. Association between maxillary sinus floor perforation by dental implants and mucosal thickening: a cone-beam computed tomography study [J]. J Dent, 2024, 144: 104963. doi: 10.1016/j.jdent.2024.104963.

[37] Nemati M, Khodaverdi N, Hosn Centenero SA, et al. Which factors affect the risk of membrane perforation in lateral window maxillary sinus elevation? A prospective cohort study[J]. J Craniomaxillofac Surg, 2023, 51(7/8): 427-432. doi: 10.1016/j.jcms.2023.06.010.

[38] Wang X, Ma S, Lin L, et al. Association between smoking and schneiderian membrane perforation during maxillary sinus floor augmentation: a systematic review and meta-analysis[J]. Clin Implant Dent Relat Res, 2023, 25(1): 166-176. doi: 10.1111/cid.13146.

[39] Gang N, JiaMin C, Ye W, et al. Comparing the efficacy of sinus irrigation with traditional Caldwell-Luc procedure following odontogenic cyst surgery involving the maxillary sinus[J]. Sci Rep, 2021, 11(1): 18136. doi: 10.1038/s41598-021-97477-z.

[40] Syngcuk K, Kratchman S. Microsurgery in Endodontics [M]. Hobken: John Wiley & Sons, 2018.

[41] Wang S, Wang X, Jiang J, et al. Relationship between the surgical access line of maxillary posterior teeth and the maxillary sinus floor[J]. J Endod, 2022, 48(4): 509-515. doi: 10.1016/j.joen.2022.01.014.

[42] Pagin O, Centurion BS, Rubira-Bullen IR, et al. Maxillary sinus and posterior teeth: accessing close relationship by cone-beam computed tomographic scanning in a Brazilian population[J]. J Endod, 2013, 39(6): 748-751. doi: 10.1016/j.joen.2013.01.014.

[43] Robaian A, Alqhtani NR, Alghomlas ZI, et al. Vertical relationships between the divergence angle of maxillary molar roots and the maxillary sinus floor: a cone-beam computed tomography (CBCT) study[J]. Saudi Dent J, 2021, 33(8): 958-964. doi: 10.1016/j.sdentj.2021.08.004.

[44] von Arx T, Käch S, Suter VGA, et al. Perforation of the maxillary sinus floor during apical surgery of maxillary molars: a retrospective analysis using cone beam computed tomography[J]. Aust Endod J, 2020, 46(2): 176-183. doi: 10.1111/aej.12413.

[45] Taschieri S, Morandi B, Giovarruscio M, et al. Microsurgical endodontic treatment of the upper molar teeth and their relationship with the maxillary sinus: a retrospective multicentric clinical study [J]. BMC Oral Health, 2021, 21(1): 252. doi: 10.1186/s12903-021-01610-3.

[46] 黄定明, 张岚, 满毅. 牙保存相关上颌窦底提升术的生物学基础[J]. 国际口腔医学杂志, 2023, 50(3): 251-262. doi: 10.7518/gjkq.2023048.
Huang DM, Zhang L, Man Y. Biologic bases of nature tooth-related maxillary sinus floor elevation[J]. Int J Stomatol, 2023, 50(3): 251-262. doi: 10.7518/gjkq.2023048.

[47] 谭学莲, 满毅, 黄定明. 牙保存相关上颌窦底提升术的临床应用[J]. 国际口腔医学杂志, 2024, 51(4): 381-391. doi: 10.7518/gjkq.2024071.
Tan XL, Man Y, Huang DM. Clinical applications of natural tooth-related maxillary sinus floor elevation[J]. Int J Stomatol, 2024, 51(4): 381-391. doi: 10.7518/gjkq.2024071.

[48] 李佳桐, 傅裕杰, 满毅, 等. 上颌磨牙根尖周囊肿致上颌窦底骨板破坏行显微手术1例[J]. 口腔医学研究, 2021, 37(7): 671-672. doi: 10.13701/j.cnki.kqyxyj.2021.07.020.
Li JT, Fu YJ, Man Y, et al. Endodontic microsurgery for destruction of maxillary sinus floor caused by maxillary molar with apical cyst: a case report[J]. J Oral Sci Res, 2021, 37(7): 671-672. doi: 10.13701/j.cnki.kqyxyj.2021.07.020.

[49] 杨雪超, 李文芝. 血浆基质在牙髓根尖周病治疗中的应用[J]. 口腔疾病防治, 2024, 32(2): 81-88. doi: 10.12016/j.issn.2096-1456.2024.02.001.
Yang XC, Li WZ. The applications of the plasma matrix in the treatments of dental pulp and periapical diseases[J]. J Prev Treat Stomatol Dis, 2024, 32(2): 81-88. doi: 10.12016/j.issn.2096-1456.2024.02.001.

[50] Wu DT, Munguia-Lopez JG, Cho YW, et al. Polymeric scaffolds for dental, oral, and craniofacial regenerative medicine[J]. Molecules, 2021, 26(22): 7043. doi: 10.3390/molecules26227043.

[51] Cotti E, Schirru E. Present status and future directions: imaging techniques for the detection of periapical lesions[J]. Int Endod J, 2022, 55(Suppl 4): 1085-1099. doi: 10.1111/iej.13828.

[52] Connert T, Weiger R, Krastl G. Present status and future directions - guided endodontics[J]. Int Endod J, 2022, 55(Suppl 4): 995-1002. doi: 10.1111/iej.13687.

[53] Villa-Machado PA, Restrepo-Restrepo FA, Tobón-Arroyave SI. Dynamically guided transantral piezoelectric endodontic microsurgery: a case report with technical considerations[J]. Int Endod J, 2024, 57(4): 490-500. doi: 10.1111/iej.14026.

[54] Chen C, Qin L, Zhang R, et al. Comparison of accuracy and operation time in robotic, dynamic, and static-assisted endodontic microsurgery: an *in vitro* study[J]. J Endod, 2024, 50(10): 1448-1454. doi: 10.1016/j.joen.2024.05.018.

[55] Wei X, Du Y, Zhou X, et al. Expert consensus on digital guided therapy for endodontic diseases[J]. Int J Oral Sci, 2023, 15(1): 54. doi: 10.1038/s41368-023-00261-0.

[56] Zhang T, He Z, Tian H. Association between periodontal status and degree of maxillary sinus mucosal thickening: a retrospective CBCT study[J]. BMC Oral Health, 2021, 21(1): 392. doi: 10.1186/s12903-021-01737-3.

[57] Lee SH, Cho SY, Kim DH, et al. Clinical outcomes after apical surgery on the palatal root of the maxillary first molar using a palatal approach[J]. J Endod, 2020, 46(4): 464-470. doi: 10.1016/j.joen.2020.01.005.

[58] 张广勇. 基于CBCT的上颌后牙区与种植相关解剖结构的测量分析[D]. 大连: 大连医科大学, 2023.
Zhang GY. Measurement and analysis of implant related anatomic structures in maxillary posterior region based on CBCT[D]. Dalian: Dalian Medical University, 2023.

[59] 卡地里亚·吐尔逊江, 丁成芳, 王玲. 上颌窦分隔发生率及特征的锥形束CT研究[J]. 口腔医学研究, 2024, 40(3): 259-264. doi:

10.13701/j.cnki.kqyxyj.2024.03.013.
Kadiliya·TUERXUNJIANG, Ding CF, Wang L. Cone-beam CT study on incidence and characteristics of maxillary sinus division [J]. J Oral Sci Res, 2024, 40(3): 259-264. doi: 10.13701/j.cnki.kqyxyj.2024.03.013.

[60] Shao Q, Li J, Pu R, et al. Risk factors for sinus membrane perforation during lateral window maxillary sinus floor elevation surgery: a retrospective study[J]. Clin Implant Dent Relat Res, 2021, 23(6): 812-820. doi: 10.1111/cid.13052.

[61] Tofangchiha M, Hematzadeh S, Vali ME, et al. Anatomical localization of posterior superior alveolar artery: a retrospective study by cone-beam computed tomography[J]. Dent Med Probl, 2022, 59(3): 407-412. doi: 10.17219/dmp/145894.

[62] Hayek E, Nasseh I, Hadchiti W, et al. Location of posterosuperior alveolar artery and correlation with maxillary sinus anatomy[J]. Int J Periodontics Restorative Dent, 2015, 35(4): e60-5. doi: 10.11607/prd.2172.

[63] Duruel O, Ataman-Duruel ET, Töztüm MD, et al. The radiological evaluation of posterior superior alveolar artery topography by using computed tomography[J]. Clin Implant Dent Relat Res, 2019, 21(4): 644-648. doi: 10.1111/cid.12794.

[64] Herman L, Font K, Soldatos N, et al. The surgical anatomy of the greater palatine artery: a human cadaver study[J]. Int J Periodontics Restorative Dent, 2022, 42(2): 233-241. doi: 10.11607/prd.4945.

[65] Ren L, Chen C, Li N, et al. Prevalence of and factors associated with maxillary sinus cyst in a Chinese population[J]. J Oral Sci, 2022, 64(1): 22-27. doi: 10.2334/josnusd.21-0217.

[66] 容明灯, 周腾飞. 上颌窦黏膜病变对上颌窦底提升术的影响及治疗对策[J]. 口腔疾病防治, 2020, 28(9): 551-561. doi: 10.12016/j.issn.2096-1456.2020.09.002.
Rong MD, Zhou TF. Clinical guidelines for maxillary sinus floor elevation with sinus membrane lesions[J]. J Prev Treat Stomatol Dis, 2020, 28(9): 551-561. doi: 10.12016/j. issn. 2096-1456. 2020.09.002.

[67] Anitua E, Alkhraisat MH, Torre A, et al. Are mucous retention cysts and pseudocysts in the maxillary sinus a risk factor for dental implants? A systematic review[J]. Med Oral Patol Oral Cir Bucal, 2021, 26(3): e276-e283. doi: 10.4317/medoral.24155.

[68] Lee IH, Kim DH, Kim SW, et al. An anatomic study on the maxillary sinus mucosal thickness and the distance between the maxillary sinus ostium and sinus floor for the maxillary sinus augmentation[J]. Medicina(Kaunas), 2020, 56(9): 470. doi: 10.3390/medicina56090470.

[69] Testori T, Scaini R, Deflorian M, et al. Mucosal cyst aspiration in conjunction with maxillary sinus elevation: a clinical cohort study [J]. Clin Implant Dent Relat Res, 2024, 26(3): 564-570. doi: 10.1111/cid.13315.

[70] Fokkens WJ, Lund VJ, Hopkins C, et al. European position paper on rhinosinusitis and nasal polyps 2020[J]. Rhinology, 2020, 58(Suppl S29): 1-464. doi: 10.4193/Rhin20.600.

（编辑　张琳）

官网