·临床研究·

锥形束CT测量成人上颌前磨牙根尖与上颌窦位置关系及其对即刻种植的影响

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【摘要】 目的 分析上颌前磨牙牙根与上颌窦空间位置关系,为该位点即刻种植时机、方案、术式及种植体选择等提供解剖依据。方法 本研究已通过单位伦理委员会审查批准,并获得患者知情同意。收集2017年1月-2023年3月瑞华口腔门诊部就诊的264例患者(年龄20～65岁)口腔锥形束CT(cone beam CT, CBCT)影像,选取冠状面测量上颌前磨牙根尖到上颌窦下壁的最短距离,对牙根与上颌窦下壁的垂直关系分类,并就双侧、性别及不同年龄组进行比较。结果 上颌前磨牙根尖至上颌窦下壁最短距离:上颌第一前磨牙单根型中位数为7.34 mm,双根型颊根中位数为7.80 mm,腭根中位数为7.36 mm;上颌第二前磨牙单根型中位数为2.56 mm,双根型中颊根中位数为1.73 mm,腭根中位数为1.23 mm。上颌第二前磨牙右侧单根型根尖至上颌窦下壁间最短距离在各年龄组间有统计学差异($P < 0.05$),20～29岁组最小(中位数1.52 mm),≥40岁组最大(中位数4.44 mm)。性别和左右侧对根尖到窦下壁距离的影响无统计学差异($P > 0.05$)。上颌前磨牙根尖与上颌窦垂直关系中,根尖不与上颌窦下壁接触的情况占比最高,垂直关系分类在单根型和双根型间无统计学差异($P > 0.05$)。结论 上颌第一前磨牙根方大多可为即刻种植提供足够高度骨量,较易实现即刻种植;上颌第二前磨牙根方骨量不足常见,需充分利用拔牙窝骨壁或窦底皮质骨实现初期稳定性;根尖与窦下壁垂直关系分型分布受年龄及牙位影响,青年组较其他年龄组更易出现骨高度不足,需谨慎选择即刻种植适应证;牙根数量对牙根与上颌窦垂直关系影响不大,双根型因牙根直径小及根间骨性分隔,可为即刻种植提供更多骨支持。

【关键词】 上颌前磨牙；上颌窦；牙根；锥形束CT；最短距离；牙根数量；垂直关系；即刻种植

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Measurement of the relationship between maxillary premolar roots and the maxillary sinus floor using cone beam CT and analysis of the impact on immediate implantation　LIU Xin[1], DING Ziling[1], YANG Xiaoyu[1], LIU Chufeng[1], LIANG Zhonglang[2], HUANG Leyi[2]. 1. Stomatological Hospital, School of Stomatology, Southern Medical University, Dental Implant Center, Guangzhou 510280, China; 2. Ruihua Dental Clinic, Guangzhou 510315, China

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【Abstract】 Objective To analyze the spatial relationship between the roots of maxillary anterior premolars and the maxillary sinus, thus providing an anatomical basis for timing, planning, surgical approaches, and implant selection at this site. Methods Cone beam CT (CBCT) images were collected from 264 patients (aged 20-65 years) who visited the Ruihua Dental Clinic between January 2017 and March 2023. The minimum distance from the apex of the maxillary anterior premolar roots to the lower wall of the maxillary sinus was measured on the coronal plane. The classification of the vertical relationship between the tooth root and the lower wall of the maxillary sinus was performed, and comparisons were made bilaterally, between genders, and among different age groups. Results The minimum distance (Q_{50}) from the apex of the first maxillary premolar root to the lower wall of the maxillary sinus was 7.34 mm for the single-root type,

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7.80 mm for the buccal root of the double-root type, and 7.36 mm for the palatal root. For the second maxillary premolar, the median distance was 2.56 mm for the single root type, 1.73 mm for the buccal root type, and 1.23 mm for the palatal root type. There was a significant difference in the shortest distance from the apex of the right second maxillary premolar single root to the lower wall of the maxillary sinus among the different age groups ($P < 0.05$), with the 20-29-year-old group having the smallest median distance (1.52 mm) and the $\geqslant$ 40-year-old group having the largest (4.44 mm). There was no significant difference in the effect of sex or laterality on distance ($P > 0.05$). The most common vertical relationship between the apex of the maxillary anterior premolar roots and the lower wall of the maxillary sinus was non-contact. There was no significant difference in the vertical relationship classification between the single-root and double-root types ($P > 0.05$). **Conclusion**　Most maxillary first premolar roots can provide sufficient bone height, which makes it easy to achieve immediate implantation. The maxillary second premolar root frequently involves insufficient bone, which is necessary to make full use of the bone wall of the extraction socket or the sinus floor cortical bone to achieve initial stability. The vertical relationship between the premolar root and maxillary sinus was influenced by age and dental position. Younger age groups often exhibit inadequate bone height, and the indication for immediate implantation should be carefully considered. The number of roots does not significantly affect the relationship between the sinus and root; however, double-rooted premolars offer more support for immediate implantation and socket healing due to the small root diameter and bony separation between the roots.

【Key words】　maxillary premolars; maxillary sinus; root; cone beam CT; the shortest distance; the number of roots; vertical relationship; immediate implant

上颌前磨牙位于牙列中部，在微笑发音时有不同程度暴露，属于美学区或美学边缘区，存在即刻种植、即刻修复需求[1-2]；而对于计划行全口种植修复的终末牙列而言，无论是轴向还是倾斜植入，上颌前磨牙区均为优先选择位点[3]。但该位点解剖位置关系邻近上颌窦，受到上颌窦底骨高度影响[4-5]；对于上颌前磨牙即刻种植，需满足拔牙窝周围骨壁完整、颊侧骨壁厚度≥1 mm、颊侧存在2 mm左右跳跃间隙、患牙无急性炎症或脓性渗出、牙龈表型为厚龈型、拔牙位点根方骨量≥3 mm，植入后初期稳定达到35 N·cm[6-7]。若根方骨量不足，可通过利用拔牙窝近远中骨壁夹持及上颌窦皮质骨固位实现初稳时也可考虑即刻种植[8]。本研究对264例成人健康上颌前磨牙行口腔锥形束CT（cone beam CT，CBCT）扫描，选取冠状面测量上颌前磨牙根尖到上颌窦下壁的最短距离，对牙根与上颌窦下壁的垂直位置关系分类，并就双侧、性别及不同年龄组进行比较，总结该区解剖特性，以供临床即刻种植决策参考。

1　资料和方法

1.1　一般资料

本研究经南方医科大学口腔医院伦理委员会批准（2021-YW-28-002），研究对象均签署知情同意书。收集2017年1月−2023年3月瑞华口腔门诊部就诊的264例患者，1 001颗上颌前磨牙CBCT，女性106例（40.2%），男性158例（59.8%），年龄20～69岁。患者按年龄分为青年组（20～29岁）（100例，37.9%），中青年组（30～39岁）（122例，46.2%），中老年组（≥40岁）（42例，15.9%）；上颌第一前磨牙505颗（50.5%），上颌第二前磨牙496颗（49.5%）；第一前磨牙中单根型273颗（27.3%），双根型232颗（23.2%），第二前磨牙单根型452颗（45.1%），双根型44颗（4.4%）。纳入标准：①上颌骨无骨缺损与骨折，无囊肿或肿瘤；②上颌前磨牙牙根完整无吸收，根尖孔发育完成，无严重牙体或牙周疾病，无外伤史；③部分正常𬌗，无明显牙列拥挤，无深覆𬌗和覆盖情况，无正畸治疗史；④无影响骨代谢的全身系统性疾病；⑤CBCT影像清晰。排除标准：①上颌前磨牙区有埋伏牙；②上颌骨和梨状孔占位病变；③CBCT伪影明显或上颌显影模糊。
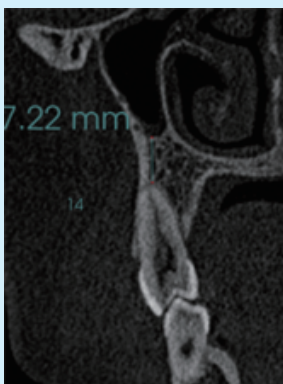
1.2　研究方法

1.2.1　CBCT扫描

患者在标准拍摄姿态下，面部中线与地面垂直，放松站立，眶耳平面与地面平行，固定头位不动。采用CBCT（NEWTOM 3G，CEFLA，意大利）进行口腔颌面部（含上下颌骨）扫

描（80 kV、5 mA），重构层厚度0.1 mm，NNT软件重建图像。同一名测量者对所有数据进行2次独立测量取平均值，2次测量间隔超过2周。

1.2.2　选取测量平面　选取与眶耳平面平行的上颌前磨牙最大颊腭向截面为水平面，经过颊腭向牙根最凸点连线与水平面垂直的面为冠状面；通过牙长轴线与水平、冠状面交线交汇点，与水平、冠状面垂直的面为矢状面。牙长轴为牙冠中央窝与根尖点或根分叉点连线，若根尖1/3弯曲，则以

牙冠中央窝与根上2/3根管中心点连线为牙长轴。

1.2.3　上颌前磨牙根尖与上颌窦下壁最短距离测量　测量目标为双侧上颌第一前磨牙与第二前磨牙。选取冠状面，记录上颌前磨牙根尖与上颌窦下壁之间的最短间距。测量中，当上颌窦下壁位置高于牙根尖时，对应测量值记作正数；反之，若上颌窦下壁低于牙根尖，则记为负数；上颌窦下壁与牙根尖触及时测量值为0，示例见图1。测量值精确到0.01 mm。

In the coronal view, during the measurement process, if the floor of the maxillary sinus was located above the apex of the tooth root, the corresponding measurement value was recorded as a positive number. Conversely, if the floor of the maxillary sinus was below the apex of the tooth root, the value was defined as a negative number. In cases where the floor of the maxillary sinus touches the apex of the tooth root, the measured value was marked as 0

Figure 1　Evaluation of the minimal distance between the root apex of maxillary posterior teeth and the maxillary sinus floor in the coronal plane
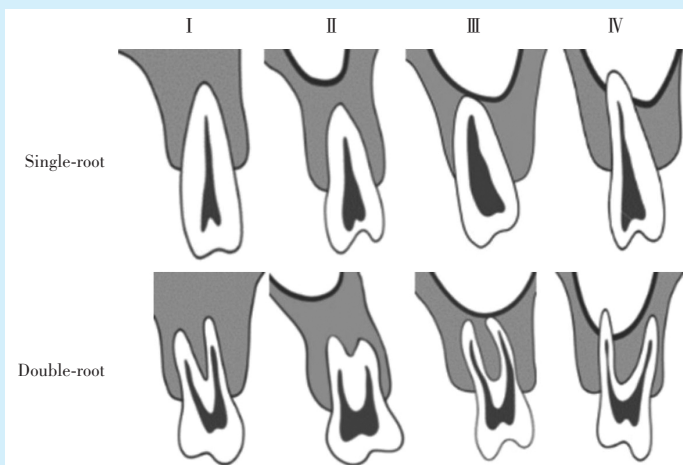
图1　冠状面上颌前磨牙根尖与上颌窦下壁之间的最小间距

1.2.4　上颌前磨牙根尖与上颌窦下壁关系分类

在冠状面分析上颌前磨牙根尖与上颌窦下壁关系。单根或双根型上颌前磨牙根尖与上颌窦下壁的垂直关系分为4型[9-10]（图2）。其中Ⅰ型：根尖上方无上颌窦；Ⅱ型：根尖位于上颌窦下壁下方；Ⅲ型：单根或双根中颊腭间任一根与上颌窦下壁相接，但不进入窦黏膜；Ⅳ型：单根型根尖或双根型颊腭任一根尖穿过上颌窦下壁，黏膜影像连续性不完整。

1.3　统计学分析

SPSS25.0行统计学分析，对所有连续性变量行正态性检验，对于不符合正态分布的连续性资料采取秩和检验，在多组间采取Kruskal-Wallis H检验和Mann-Whitney U多重比较，之后多重比较采取Bonferroni法对检验水准进行校正，用中位数（四分位间距）表示；对计数资料采取卡方检验和Fisher精确检验，多分类有差异时采取卡方分割两两比较，Bonferroni法调整α值，用频数（百分比）表示；

Type Ⅰ: no maxillary sinus above the apex of the root; Type Ⅱ: the apex is located below the maxillary sinus; Type Ⅲ: the apex of a single root or the buccal or palatal root touches the floor of the maxillary sinus without penetrating the sinus membrane; Type Ⅳ: the apex of a single root or the buccal or palatal root extends into the mucosa of the maxillary sinus

Figure 2　Vertical relationship between the apex of a single-root maxillary premolar and the apex of a double-root maxillary premolar and the inferior wall of the maxillary sinus

图2　上颌前磨牙根尖与上颌窦下壁垂直关系分类

$P < 0.05$ 为差异具有统计学意义。

2 结果

2.1 上颌前磨牙根尖到上颌窦下壁的最短距离

表1为冠状面上颌窦壁与上颌前磨牙根尖之间的最短距离：第一前磨牙单根型中位数为7.34 mm；双根型中颊根中位数为7.80 mm、腭根中位数为7.36 mm；第二前磨牙单根型中位数为2.56 mm；双根型中颊根中位数为1.73 mm、腭根中位数为1.23 mm。第一前磨牙较第二前磨牙距离上颌窦下壁值更大。上颌窦下壁与前磨牙根尖最短距离在左右两侧差异无统计学意义（$P > 0.05$）。

2.2 不同性别、各年龄组上颌前磨牙根尖到上颌窦下壁的最短距离

不同性别的患者上颌窦下壁与上颌前磨牙根尖的最短距离差异无统计学意义（$P > 0.05$，表2、表3）。在冠状面，上颌第二前磨牙单根型根尖至上颌窦下壁间最短距离在各年龄组间差异具有统计学意义（$P < 0.05$），20～29岁组上颌前磨牙根尖距离上颌窦下壁距离最小，≥40岁组上颌前磨牙根尖距离上颌窦下壁距离最大（表4、表5）。

表1　左右侧上颌前磨牙根尖到上颌窦下壁的最短距离
Table 1　Minimum distance from the maxillary premolars root apices to the maxillary sinus floor on both sides　　$Q_{50}(Q_{25}, Q_{75})$

	First premolar			Second premolar		
	Single-root	Buccal root	Palatal root	Single-root	Buccal root	Palatal root
All	7.34 (2.73, 11.98)	7.80 (4.50, 13.37)	7.36 (3.29, 13.05)	2.56 (0.59, 7.00)	1.73 (0.47, 5.43)	1.23 (0.00, 4.62)
Right	7.52 (3.42, 12.70)	7.64 (4.26, 12.93)	6.89 (2.68, 12.66)	2.35 (0.43, 6.92)	1.56 (0.42, 3.90)	1.23 (0.00, 3.72)
Left	7.08 (2.68, 10.71)	8.91 (4.82, 13.58)	7.64 (4.19, 13.79)	2.86 (0.72, 7.15)	2.05 (0.67, 5.74)	1.40 (0.50, 4.85)
Z	−0.581	−0.846	−0.967	−0.670	−0.516	−0.590
P	0.562	0.398	0.334	0.503	0.606	0.555

表2　不同性别右侧上颌前磨牙根尖与上颌窦下壁的最短距离
Table 2　Minimum distance between the apices of right premolar roots and maxillary sinus in different gender group　　$Q_{50}(Q_{25}, Q_{75})$

Gender	First premolar			Second premolar		
	Single-root	Buccal root	Palatal root	Single-root	Buccal root	Palatal root
Male ($n = 476$)	7.85 (3.37, 12.65)	8.02 (3.50, 13.47)	7.80 (2.45, 12.78)	1.89 (0.56, 6.69)	1.17 (0.44, 2.97)	0.66 (0.00, 1.86)
Female ($n = 316$)	7.48 (3.64, 12.74)	7.32 (4.98, 12.11)	6.59 (3.83, 11.98)	2.84 (0.00, 7.00)	3.72 (0.93, 4.58)	2.74 (0.70, 4.34)
Z	−0.403	−0.342	−0.268	−0.278	−0.684	−0.798
P	0.687	0.732	0.789	0.781	0.494	0.425

表3　不同性别左侧上颌前磨牙根尖与上颌窦下壁的最短距离
Table 3　Minimum distance between the apices of left premolar roots and maxillary sinus in different gender group　　$Q_{50}(Q_{25}, Q_{75})$

Gender	First premolar			Second premolar		
	Single-root	Buccal root	Palatal root	Single-root	Buccal root	Palatal root
Male ($n = 476$)	7.50 (3.47, 10.76)	7.07 (4.24, 13.62)	7.14 (3.32, 14.02)	2.90 (0.90, 6.90)	2.11 (0.95, 5.49)	1.20 (0.77, 4.93)
Female ($n = 316$)	6.12 (2.20, 10.29)	9.02 (6.00, 13.44)	7.96 (5.50, 13.11)	2.67 (0.11, 7.16)	1.40 (0.50, 6.04)	2.70 (0.50, 4.62)
Z	−0.758	−1.184	−1.19	−1.081	−0.222	−0.222
P	0.449	0.236	0.234	0.280	0.824	0.824

表4　不同年龄组右侧上颌前磨牙与上颌窦下壁的最短距离
Table 4　Minimum distance between the apices of right premolar roots and maxillary sinus in different age group　　$Q_{50}(Q_{25}, Q_{75})$

Age/year	First premolar			Second premolar		
	Single-root	Buccal root	Palatal root	Single-root	Buccal root	Palatal root
20-29 ($n = 300$)	6.42 (2.04, 9.51)	6.99 (2.88, 12.51)	6.42 (3.22, 12.80)	1.52 (0.00, 5.06)	1.53 (0.39, 2.53)	0.47 (0.00, 2.29)
30-39 ($n = 366$)	8.28 (4.35, 13.59)	7.98 (4.31, 12.31)	7.37 (2.30, 11.97)	2.83 (0.68, 7.65)[a]	0.84 (0.23, 3.81)	1.23 (0.19, 3.23)
≥ 40 ($n = 126$)	11.12 (2.56, 13.83)	8.91 (5.36, 16.96)	9.00 (4.93, 16.65)	4.44 (1.00, 8.94)[ab]	8.64 (6.03, 11.25)	5.74 (3.90, 7.58)
H	4.492	1.444	0.972	9.308	2.246	2.303
P	0.106	0.486	0.615	0.010	0.325	0.316

a: *vs*. 20-29 year-old group, $P < 0.05$; b: *vs*. 30-39 year-old group, $P < 0.05$

表 5 不同年龄组左侧上颌前磨牙与上颌窦壁的最短距离

Table 5 Minimum distance between the apices of left premolar roots and maxillary sinus in different age group Q_{50} (Q_{25}, Q_{75})

Age/year	First premolar			Second premolar		
	Single-root	Buccal root	Palatal root	Single-root	Buccal root	Palatal root
20-29 (n = 300)	5.16 (2.00, 9.97)	6.92 (4.72, 10.71)	6.29 (4.35, 10.87)	1.83 (0.00, 5.35)	1.69 (0.00, 4.47)	5.16 (2.00, 9.97)
30-39 (n = 366)	7.96 (3.69, 11.63)	10.14 (4.67, 14.92)	9.88 (3.29, 14.33)	2.89 (0.89, 9.06)	2.11 (0.73, 8.19)	7.96 (3.69, 11.63)
≥ 40 (n = 126)	7.55 (2.44, 9.99)	10.65 (5.76, 15.92)	9.93 (4.14, 15.72)	3.27 (1.43, 6.54)	4.16 (2.73, 9.02)	7.55 (2.44, 9.99)
H	4.838	2.643	1.639	5.833	2.161	4.838
P	0.089	0.267	0.441	0.054	0.339	0.089

2.3 上颌窦下壁与上颌前磨牙根尖垂直关系的类型

表 6 为上颌前磨牙根尖与上颌窦下壁的垂直关系类型。上颌窦与上颌第一前磨牙根尖垂直关系为 Ⅱ 类型频数最高，Ⅳ 类型频数最低。Ⅱ 型 > Ⅰ 型 > Ⅲ 型 > Ⅳ 型，在上颌第二前磨牙中，Ⅱ 类型占比最高为（77.02%），其次为 Ⅲ 型（16.73%）、Ⅳ 型

（5.44%）、Ⅰ 型（0.81%）。以上结果说明上颌窦窦腔范围达到上颌前磨牙根尖上方概率高，但根尖进入上颌窦的概率低。单根组和双根组之间分型的差异性分析结果显示左右侧第一、第二前磨牙上的单根组和双根组之间的垂直关系分型上差异均无统计学意义（P > 0.05）。

表 6 两侧上颌前磨牙根尖与上颌窦下壁的垂直关系的分类占比

Table 6 Classification and proportional description of the vertical relationship between the apices of the anterior maxillary premolars and the inferior wall of the maxillary sinus n (%)

		Vertical relationship				Total	χ^2	P
		Type Ⅰ	Type Ⅱ	Type Ⅲ	Type Ⅳ			
Right first premolar	Single-root	13 (9.56)	115 (84.56)	5 (3.68)	3 (2.20)	136	2.632	0.414
	Double-root	10 (8.62)	100 (86.21)	6 (5.17)	0 (0)	116		
Right second premolar	Single-root	2 (0.89)	170 (75.89)	37 (16.52)	15 (6.70)	224	2.614	0.473
	Double-root	0 (0)	12 (70.59)	5 (29.41)	0 (0)	17		
Left first premolar	Single-root	16 (11.68)	116 (84.67)	3 (2.19)	2 (1.46)	137	0.471	0.939
	Double-root	6 (5.17)	106 (91.38)	3 (2.59)	1 (0.86)	116		
Left second premolar	Single-root	2 (0.88)	179 (78.51)	36 (15.79)	11 (4.82)	228	3.742	0.287
	Double-root	0 (0)	21 (77.78)	5 (18.52)	1 (3.70)	27		

Type Ⅰ -Type Ⅳ classification is shown in Figure 2. Type Ⅰ: there is no maxillary sinus above the apex of the root; Type Ⅱ: the apex is located below the maxillary sinus; Type Ⅲ: the apex of a single-root or the buccal or palatal root touches the floor of the maxillary sinus without penetrating the sinus membrane; Type Ⅳ: the apex of a single-root or the buccal or palatal root extends into the mucosa of the maxillary sinus

3 讨 论

3.1 上颌前磨牙根尖与上颌窦下壁距离、位置关系及对种植时机的建议

上颌前磨牙处于牙弓中部，骨宽度较前牙相对充足，骨高度较磨牙相对充足，可获得较高的即刻种植成功率[11]。前磨牙区种植后良好的初期稳定性受牙根形态及根方骨量影响。Von Arx 等[12]测量双根型第一前磨牙颊根与上颌窦下壁的距离为（8.28 ± 6.27）mm、腭根为（7.17 ± 6.14）mm。第二前磨牙颊根为（3.28 ± 3.17）mm，腭根为 3.69 ± 4.51 mm。本研究结果趋势与其基本一致。第一前磨牙单根型根尖窦底距 7.34 mm，双根型中颊根为 7.80 mm，腭根为 7.36 mm；第二前磨牙单根

型为 2.56 mm，双根型中颊根为 1.73 mm，腭根为 1.23 mm。由此可见上颌第一前磨牙根方大多可为即刻种植提供足够高度的骨量，较易实现即刻种植甚至即刻修复；但上颌第二前磨牙根方可利用骨量有限，若需即刻种植建议利用拔牙窝近远中壁增加骨接触面积，利用近远中骨壁的夹持及穿上颌窦底皮质骨操作增加种植体周骨接触面积及骨密度，实现更好的初期稳定性和早期骨接触。

Oishi 等[9]研究上颌前磨牙根尖与上颌窦下壁关系分型与本研究相似，他们通过对 301 例患者分析发现第一前磨牙 Ⅱ 型（65.4%）> Ⅰ 型（15.1%）> Ⅲ 型（12.8%）> Ⅳ 型（6.7%）。第二前磨牙，Ⅱ 型（39.0%）> Ⅳ 型（35.3%）> Ⅲ 型（24.2%）> Ⅰ 型

（1.5%）。而 Regnstrand 等[13]发现，上颌第二前磨牙位置关系中，Ⅲ型（牙根与窦壁接触不穿通）占比最高。这可能与人种差异、年龄构成和社会生活因素等有关。当根尖与上颌窦下壁间垂直关系为Ⅰ型（根尖上方无上颌窦）或Ⅱ型（根尖与上颌窦有一定距离），满足可用骨高度 ≥ 3 ~ 5 mm 时，符合即刻种植所需骨高度，建议首选标准直径（≥ 4 mm），长度≥10 mm 的种植体；对垂直关系Ⅱ分型，可用骨高度 < 3 mm，若能利用腭侧骨壁，或拔牙窝近远中骨壁夹持获得约 5 mm 有效骨接触也可实现可预期的即刻种植；当前述条件均难以实现，但可通过突破根方上颌窦底皮质骨，提升约 3 mm，获得种植体周有效骨接触面时也可行即刻种植。但需注意，偏腭侧时，最好为Ⅰ ~ Ⅲ类骨质，角度 < 10°[14]。对于不植骨上颌窦底提升，可联合应用血小板浓缩制品以促进骨形成[15]。根尖上方无可用牙槽骨的Ⅲ/Ⅳ型，建议延期种植，可考虑拔牙位点保存，减少缺牙后剩余骨高度丧失[16]。

3.2　上颌前磨牙区种植近远中向及颊腭向解剖关系要点

因第一前磨牙处于牙弓转角处，尖牙的唇腭向及近远中向倾斜对其都主要体现在近远中向影响。通过 CBCT 影像分析尖牙倾斜角度及根尖位置，设计前磨牙种植体轴向，顺应尖牙牙根倾斜角度，合理避让，可较好地控制尖牙牙根与种植体间距离，实现对周围健康组织的保护。例如将植体稍向远中倾斜避让尖牙牙根[17]；选用锥形种植体[18]，通过缩小种植体尖端直径避开邻牙牙根；通过数字化手段，利用导板或导航精准植入等。这些方法亦可用于避让前磨牙根方颊腭向倒凹，此倒凹常存在于尖牙牙槽突后方，若无法避让，种植时在颊舌向穿通尖牙窝致骨开窗骨开裂，可考虑对凹陷区采用引导性骨组织再生术，或者偏腭侧植入、调整种植体轴向（角度 < 10°）等方法，或将以上方法组合使用实现最佳临床效果。

3.3　上颌前磨牙牙根与上颌窦壁关系的增龄性改变

本研究右侧单根型第二前磨牙20 ~ 29 岁年龄组上颌窦距离根尖平均距离最近；≥ 40 岁组较其他年龄组根尖离颌窦最远。该趋势与吴兴胜等[19]研究一致，其对293例不同年龄组上颌窦气化的比较中发现，青年群体上颌窦气化程度高于其他年龄组，年龄越大，气化量越低。上颌窦底功能刺激主要受咀嚼力及呼吸影响。一方面，咀嚼食物精

细化及饮食结构改变，咀嚼力减小，应力刺激下的垂直骨增量减少；另一方面，青年群体肺活量大，呼吸时上颌窦内压力变化大，扩张性压力作用大于收缩性牵引力作用导致窦壁持续缓慢吸收，窦腔不断扩大，因此20 ~ 29 岁年龄组人群根尖与上颌窦距离更近。上颌窦较大时，前磨牙和磨牙根接触突出到上颌窦内[20]，拔牙后因破骨细胞激活，气化加重，上颌窦底进一步向牙槽骨方向扩展[21]，需利用 CBCT 等手段，谨慎评估，以减少穿孔。

3.4　上颌前磨牙区在上颌牙列缺失中的重要性

研究表明，上颌无牙颌种植中无论尖圆形、方圆形或卵圆形牙弓，理想的最少种植体位点均应包括第二前磨牙区[3]。Sagat 等[22]运用三维有限元分析修复体牙弓形态与种植体位置对修复体（12 颗牙并含悬臂结构）的受力影响，发现在修复体前部或后部加载后，应力分布最好的上颌6枚或8枚种植体位置均包括上颌第一、第二前磨牙。当上颌牙列缺失，无法在磨牙区植入可即刻负重的种植体时，可在前磨牙区近远中向倾斜种植（角度 ≤ 30°），利用上颌前磨牙上方，上颌窦前下壁间的骨量，植入长度 ≥ 12 mm，直径 ≥ 4 mm 的植体，从而获得足够的骨接触面积和初期稳定性，提高即刻修复可能性[23]。

综上所述，本研究发现上颌第一前磨牙根方大多可为即刻种植提供足够高度骨量，较易实现即刻种植。但上颌第二前磨牙，若需即刻种植建议利用近远中拔牙窝壁增加骨接触面积或穿上颌窦底骨壁增加皮质骨固位，以实现更好初期稳定性和更大初期骨接触面积。根尖与窦下壁垂直关系分型分布受年龄及牙位影响，青年组较其他年龄组更易出现骨高度不足，需谨慎选择即刻种植。牙根数量对牙根与上颌窦垂直关系影响不大，双根型因牙根直径小及根间骨性分隔，可为即刻种植提供更多骨支持。

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