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高角Ⅱ类开𬌗患者上下颌前牙根长及中切牙冠根形态的锥形束CT研究

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【摘要】　**目的**　探讨高角Ⅱ类前牙开𬌗患者的上下颌前牙牙根长度及中切牙冠根形态，为临床正畸治疗提供参考。**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。对81例高角Ⅱ类患者（前牙开𬌗40例、正常覆𬌗41例）正畸治疗前的锥形束CT(cone-beam computed tomography，CBCT)图像进行分析，运用Dolphin软件对上下颌前牙的牙根长度以及中切牙冠根形态进行研究，并行统计学分析。**结果**　高角Ⅱ类开𬌗患者(开𬌗组)与高角Ⅱ类正常覆𬌗患者(正常覆𬌗组)的上颌尖牙和侧切牙牙根长度差异无统计学意义，但开𬌗组上颌中切牙(11.12 ± 1.37)mm、下颌中切牙(10.15 ± 1.09)mm、下颌侧切牙(11.27±1.15)mm和下颌尖牙(12.81 ± 1.48)mm的牙根长度均较正常覆𬌗组短且差异均具有统计学意义($P < 0.05$)；另一方面，开𬌗组的上颌中切牙冠根成角(1.10° ± 3.62°)显著小于正常覆𬌗组(4.53° ± 2.30°)($P < 0.01$)，而开𬌗组的下颌中切牙冠根成角与正常覆𬌗组的差异无统计学意义。**结论**　高角Ⅱ类开𬌗患者的上下颌中切牙、下颌侧切牙和下颌尖牙牙根均较高角Ⅱ类正常覆𬌗患者短，高角Ⅱ类开𬌗患者上颌中切牙牙冠长轴相对于牙根长轴偏唇侧，冠根成角较小，利于开𬌗患者的前牙转矩控制或内收移动。

【关键词】　高角；　Ⅱ类错𬌗；　正畸；　前牙开𬌗；　前牙；　牙根长度；　冠根形态；　锥形束CT
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Cone-beam computed tomography study of root length of maxillary and mandibular anterior teeth and central incisor crown-root morphology in high-angle Class Ⅱ open bite patients

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【Abstract】　**Objective**　This study aimed to explore the root length of maxillary and mandibular anterior teeth and central incisor crown-root morphology in patients with high-angle skeletal Class Ⅱ open bite, aiming to provide a reference for clinical treatment. **Methods**　This study was reviewed and approved by the Ethics Committee, and informed consent was obtained from the patients. CBCT images of eighty-one untreated patients (40 anterior open bite patients and 41 normal overbite patients) with high-angle skeletal Class Ⅱ malocclusion were selected before treatment. Dolphin software was used to study the root length of maxillary and mandibular anterior teeth and central incisor crown-root morphology, and the differences between the two groups were analyzed. **Results**　There was no statistical significance in the root length of maxillary lateral incisor and canine between the open bite group and the normal overbite group, significant differences were found in the root length of maxillary central incisor (11.12 ± 1.37) mm、mandibular central inci-

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sor (10.15 ± 1.09) mm, mandibular lateral incisor (11.27 ± 1.15) mm and mandibular canine (12.81 ± 1.48) mm between the open bite group and the normal overbite group ($P < 0.05$). On the other hand, the two groups were significantly different in crown-root morphology of the maxillary central incisor (1.10° ± 3.62° *vs.* 4.53° ± 2.30°, $P < 0.01$) but not in the mandibular central incisor. **Conclusion** The root length of the maxillary central incisor, mandibular central incisor, mandibular lateral incisor, mandibular canine in high-angle Class Ⅱ open bite patients is shorter than that in high-angle Class Ⅱ normal overbite patients, and the long axis of the crown of the maxillary central incisor in high-angle Class Ⅱ open bite patients obviously deviates toward the labial side relative to the long axis of the root. The crown-root angle is smaller, which is beneficial to torque control or adduction movement of the anterior teeth in high-angle Class Ⅱ open bite patients.

【Key words】 high-angle; Class Ⅱ malocclusion; orthodontics; anterior open bite; anterior teeth; root length; crown-root morphology; cone-beam computed tomography

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正畸临床中前牙开殆患者，骨性开殆患者的正畸治疗颇具挑战[1]，严重者常需正畸正颌联合治疗，而在正畸代偿治疗中主要利用前牙伸长的钟摆效应或(和)后牙压低的楔形效应，大部分情况下采用拔牙矫治，内收前牙改善咬合关系及侧貌美观[2]，但根外牙根吸收在正畸治疗中屡见不鲜，尤其是拔牙病例[3]，这对于牙根较短的患者而言风险增加。

既往关于牙齿冠根形态的研究表明牙冠长轴与牙根长轴并非位于一条直线上，多数情况下二者之间存在成角情况，即牙冠长轴的延长线与牙根长轴之间存在交角(冠根角的补角，Collum角)[4]。该角度的存在会影响转矩的表达及牙根在牙槽骨中的位置，临床上转矩表达过程中可能出现骨开窗和骨开裂的情况[5]，这将会影响患者的牙周健康及正畸的稳定。

牙根长度及冠根形态的测定对于正畸治疗中预防牙根吸收、骨开窗和骨开裂及转矩表达具有临床指导意义。有学者利用曲面体层片或头颅侧位片测量分析正畸治疗前开殆患者前牙根长和Collum角，但二维影像图片易失真，影响测量的精确性。而CBCT测量结果较为精确[6]，牙根长度测量值与牙根的真实长度接近[7]。此外，尚无针对高角Ⅱ类开殆患者的中切牙冠根形态的研究，因此，本研究通过CBCT对高角Ⅱ类前牙开殆患者与高角Ⅱ类前牙正常覆殆患者的上下颌前牙根长及中切牙冠根形态进行测量分析，以期为正畸治疗中预防牙根吸收、骨开窗和骨开裂及转矩表达提供参考。

1 资料和方法

本研究已获得伦理委员会的批准(批号：重庆医科大学口腔医院2019年伦审(7)号)，并获得患者知情同意。

1.1 研究对象

本实验为回顾性研究，选取于2017年7月至2023年1月到重庆医科大学口腔医院正畸科就诊且拍摄CBCT的81例患者。其中，开殆组含40例高角Ⅱ类前牙开殆患者，男性19例，女性21例，16～30岁，平均(20.8±3.2)岁；正常覆殆组含41例高角Ⅱ类前牙正常覆殆患者，男20例，女21例，16～29岁，平均(21.0 ± 4.1)岁。

高角Ⅱ类开殆组纳入标准：①前牙开殆，至少4个切牙的覆殆≤-0.5 mm；②前颅底平面(SN平面)与下颌平面(MP平面)所成的前下交角(∠SN-MP)≥40°；上牙槽座点(A)-鼻根点(N)-下牙槽座点(B)之间夹角(∠ANB)≥5°；③恒牙殆，前牙牙冠形态规则，牙根未见明显吸收及弯曲；④前牙区排列整齐或仅轻度拥挤；⑤无缺失牙或多生牙。

高角Ⅱ类前牙正常覆殆组纳入标准：①前牙覆殆1～4 mm，覆盖1～4 mm；②③④⑤同开殆组。

排除标准：①前牙区轻度以上拥挤，根尖有暗影；②正畸、正颌治疗史，前牙牙体或修复治疗史；③唇腭裂或全身系统性疾病史；④前牙扭转或倾斜明显；⑤前牙外伤、囊肿或手术史。

1.2 影像学拍摄方法

全部研究对象均经口腔医院同一台CBCT(KaVo Dental Gmb H，美国)拍摄及同一台ProMax全数

字化X线头影测量机（Planmeca公司，芬兰）扫描。设置CBCT拍摄的参数为：分辨率0.4 mm，电压120 kV，电流5 mA；头颅侧位片则为：电压80 kV、电流10 mA。均使研究对象目视前方，后牙咬合，眼耳平面平行于地面并与水平向定位线重合，正中矢状面垂直于地面并与垂直向定位线重合。扫描完成后CBCT影像数据以DICOM格式保存和输出。

1.3　测量平面获取及数据测量

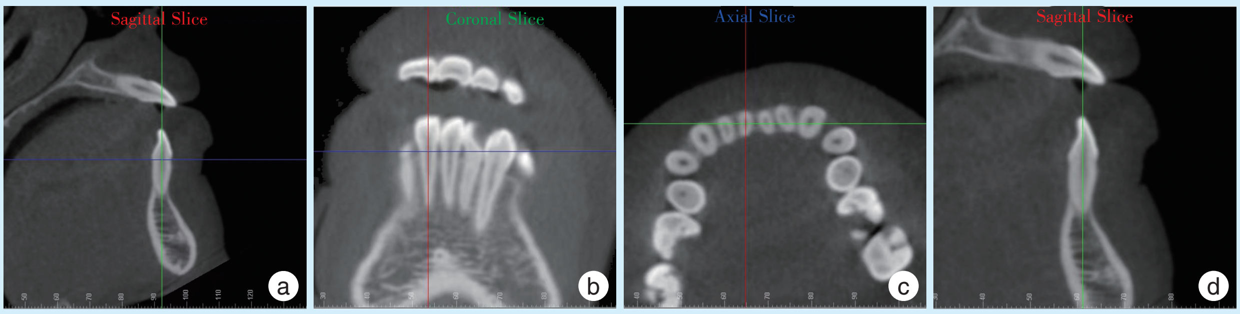
本研究运用Dolphin 3D Imaging软件（Dolphin Imaging and Management Solutions，Chatsworth，CA，美国）对牙齿进行测量，导入CBCT数据后行三维定位，最终的测量平面定位于牙齿的正中矢状面（最大唇舌向截面），如图1所示。将测量平面放大一定程度，连接根尖点和唇舌侧釉牙骨质（enamelo-cemental junction，CEJ）连线的中点作为测量的牙根长度，以牙根长轴与牙冠长轴延长线的交角作为Collum角，测量上下颌前牙的牙根长度及中切牙的Collum角，如图2所示。

全部的CBCT测量工作要求在一段连续的时间内由同一人完成，并在两周后复测，对前后两次测量值进行组内相关系数（inta-class correlation，ICC）分析，当ICC值≥0.75时，取平均值作为最终测量值；否则重新测量。

1.4　统计学方法

所有的数据分析均在SPSS 23.0软件上进行，对两组的牙根长度及Collum角数据先行正态分布和方差齐性检验，牙根长度的测量值均满足正态分布及方差齐性，对两组牙根长度进行两独立样本 t 检验；Collum角为非正态分布，采用非参数检验。

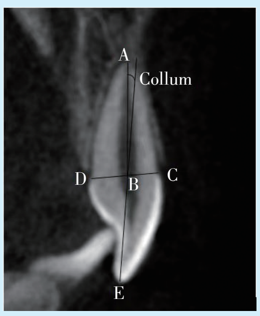
采用两独立样本 t 检验对比两组中的患者年龄，采用卡方检验分析性别分布，结果两组中的年龄性别之间无统计学差异。此外，比较左右侧同



a: sagittal plane. b: coronal plane. c: axial plane. d: to ensure the accuracy of the measurement, the enlarged and adjusted sagittal plane served as the measurement plane. Three different colored lines represent different planes. Blue: axial plane. Red: sagittal plane. Green: coronal plane. As shown in the figure, on the sagittal plane, the blue line passes through the midpoint of the CEJ line on the labial and lingual sides; on the coronal plane, the blue line passes through the CEJ line and rotates the image on the axis plane to ensure that the intersection line between the green line and the measured tooth is minimized. On the coronal plane, the red line passes through the midpoint of the incisal margin and the apical point; and on the axial plane, the green line passes through the midpoint of the CEJ and the apical. CEJ: enamelo-cemental junction

Figure 1　Three-dimensional location of root length

图1　牙根长度的三维定位



Point A is the apical point, point B is the midpoint of the CEJ, point C is the CEJ of labial side, point D is the CEJ of lingual side, point E is incisal margin, and AB line is the long axis of the root (root length), and EB line is the long axis of the crown, the Collum angle is the intersection angle of AB and EB extension lines. CEJ: enamelo-cemental junction

Figure 2　Diagram of root length and Collum angle measurement

图2　牙根长度及Collum角测量示意图

名牙的根长及Collum角，差异无统计学意义，故合并左右侧同名牙的根长和Collum角作为最终的统计数据，即开𬌗组各牙位样本量为80，正常覆𬌗组为82。$P < 0.05$ 为差异有统计学意义。

2 结　果

2.1 开𬌗组与正常覆𬌗组上下颌前牙牙根长度的比较

开𬌗组上颌尖牙和侧切牙的牙根长度虽比正常覆𬌗组短，但差异无统计学意义。开𬌗组上下颌中切牙、下颌侧切牙和下颌尖牙的牙根长度较正常覆𬌗组短且差异均具有统计学意义，提示前牙开𬌗患者的上下颌中切牙、下颌侧切牙和尖牙牙根长度较正常覆𬌗组短（表1）。

2.2 开𬌗组与正常覆𬌗组上下颌中切牙Collum角的比较

开𬌗组上颌中切牙的Collum角明显小于正常覆𬌗组（$P < 0.05$），提示开𬌗组上颌中切牙的牙冠长轴虽然位于牙根长轴腭侧但较正常覆𬌗组稍偏唇侧，而下颌中切牙Collum角与正常覆𬌗组差异无统计学意义（表2）。

表1　开𬌗组与正常覆𬌗组间上下颌前牙牙根长度的比较

Table 1　Comparison of root length of maxillary and mandibular anterior teeth between open bite group and normal overbite group

$\bar{x} \pm s$, mm

Tooth position	Open bite group (n = 80)	Normal overbite group (n = 82)	P	t
Maxillary canine	13.98 ± 1.69	14.21 ± 1.86	0.431	−0.789
Maxillary lateral incisor	11.59 ± 1.36	11.76 ± 1.13	0.381	−0.879
Maxillary central incisor	11.12 ± 1.37	11.69 ± 1.60	0.017	−2.411
Mandibular canine	12.81 ± 1.48	13.29 ± 1.50	0.041	−2.058
Mandibular lateral incisor	11.27 ± 1.15	11.83 ± 1.05	0.002	−3.226
Mandibular central incisor	10.15 ± 1.09	10.70 ± 0.99	0.001	−3.328

n: bilaterally homonymous teeth

表2　开𬌗组与正常覆𬌗组上下颌中切牙Collum角的比较

Table 2　Comparison of Collum angle of maxillary and mandibular center incisor between open bite group and normal overbite group

$\bar{x} \pm s$, °

Tooth position	Open bite group (n = 80)	Normal overbite group (n = 82)	P	t
Maxillary central incisor	1.10 ± 3.62	3.31 ± 4.21	0.001	−3.547
Mandibular central incisor	4.53 ± 2.30	4.26 ± 2.87	0.513	0.656

n: bilaterally homonymous teeth

3 讨　论

牙根吸收在正畸治疗不能完全规避，短根牙齿发生牙根吸收的风险及程度均更大[8]，在此之前，Harris[8]、Arntsen等[9]研究显示开𬌗患者上颌中切牙的牙根长度均比正常覆𬌗患者及深覆𬌗患者短，且差异具有统计学意义。同样，Choi等[10]发现开𬌗患者上颌侧切牙和下颌切牙的牙根长度均显著短于正常覆𬌗患者及深覆𬌗患者。此前笔者曾研究开𬌗患者与正常覆𬌗患者的上下前牙根长对比，结果显示开𬌗患者的上下前牙根长均较正常覆𬌗组短，且差异均具有统计学意义[11]。而本研究对开𬌗患者进一步限制为高角Ⅱ类前牙开𬌗患者，正常覆𬌗组亦为高角Ⅱ类正常覆𬌗患者，结果显示仅下颌前牙及上颌中切牙的根长均较前牙正常覆𬌗者短且差异具有统计学意义，而上颌侧切牙和尖牙虽然根长较正常覆𬌗组短但却无统计学差异，造成这一结果的原因可能研究对象的选择不同有关，本次研究仅涉及高角Ⅱ类患者，而此前的研究对象并未在矢状向和垂直向上进行限制。本研究显示高角Ⅱ类开𬌗患者下颌前牙及上颌中切牙的根长均较短且差异具有统计学意义，这对于正畸治疗而言需要提高警惕，一方面牙根较短会改变冠根比例，影响牙齿的阻抗中心进而影响牙齿的移动方式；另一方面该类患者的矫治多涉及前牙的内收和转矩控制，而这两种牙齿移动方式恰恰会增加牙根吸收的风险[12]。临床中应关注前牙牙根长度，更多利用“楔形效应”逆旋下颌，纠正前牙开𬌗，避免前牙根尖区的应力集中，尽可能预防牙根的吸收，保留更多的牙根组织。

本研究同时分析了高角Ⅱ类患者上下中切牙

的冠根形态，结果显示无论是开𬌗组还是正常覆𬌗组，中切牙牙冠长轴和牙根长轴均并非位于同一直线上，而是牙冠偏向于牙根舌腭侧，这与国内外学者的研究一致[5, 13]。另一方面，既往研究表明，安氏Ⅱ类2分类错𬌗的上颌中切牙冠根成角现象最为明显[14]；此外，骨性Ⅲ类错𬌗中下切牙的冠根成角亦较大[15]。但本研究中开𬌗组的上颌中切牙冠根成角的角度较正常覆𬌗组小且差异具有统计学意义，这意味着高角Ⅱ类开𬌗患者的牙根长轴和牙冠长轴更接近于同一直线上，这对于正畸临床治疗无疑是有利的。

众所周知，转矩控制在正畸治疗中至关重要，在维持覆𬌗覆盖及咬合关系中起着关键作用[5, 16]，一定程度上决定了正畸治疗的成功与否。在直丝弓矫正技术中，转矩的表达一方面可通过托槽上预加的转矩数值结合方丝得以表达，另一方面得益于牙齿具有正常的冠根形态[17]。理想状态下，转矩充分表达的同时牙根应位于牙槽骨中央，这利于牙根和牙周的健康及正畸效果的稳定。然而正畸中不难发现，当牙冠转矩控制较好时，CBCT图像上却显示牙根已经接近骨皮质甚至已穿破骨皮质，尤其多见于安氏Ⅱ类2分类错𬌗畸形的上颌中切牙以及骨性Ⅲ类错𬌗下切牙的术前去代偿，因这两种错𬌗类型切牙的冠根成角尤为明显[13-14]，一定程度上易造成牙根吸收、骨开窗、骨开裂等情况，引起牙龈退缩、牙齿敏感，甚至牙齿的松动脱落。而本研究结果显示高角Ⅱ类开𬌗患者上颌中切牙冠根成角较小，对于临床治疗而言意味着当上颌中切牙牙冠转矩表达充分时，牙根位置更接近牙槽骨中央，一方面，可一定程度减少骨开窗骨开裂或牙根吸收的风险，利于牙根和周围牙周组织的健康；另一方面，牙根在松质骨中的移动更为安全且高效稳定，符合正畸治疗追求的健康、高效及稳定。

关于冠根成角的原因，目前尚无定论，相较于先天原因，学者们更倾向于后天环境的影响[18]。在牙齿萌出和建𬌗过程中，牙齿会受到舌向力（舌头）及唇侧力（唇颊）的影响，这些力的存在可能会对牙齿的形态产生改变[19]。对于安氏Ⅱ类2分类错𬌗的上颌中切牙冠根成角明显的原因，学者们认为，由于该类患者下唇肌张力较大，且下唇覆盖上切牙唇面位置较高，长期的舌向肌力改变了牙冠的萌出方向，使牙冠更为直立，而牙根萌出方向不变，致使冠根成角较大[5]。同理，开𬌗患者普遍存在异常的舌吞咽习惯，在吞咽时，开𬌗患者常将舌头伸至上下前牙之间，用以封闭口腔前部完成吞咽动作，每日上千次的吞咽会对切牙牙冠产生频繁的唇向力，而这是否会导致切牙牙冠萌出方向较正常覆𬌗者更偏唇侧，目前尚未见相关报道。

另一方面，已知先天因素及后天环境均可影响牙根的形态，常见的如遗传因素、系统性疾病、医源性因素（如放/化疗）[20-22]，以及可能的性别因素等（男性的牙根长度长于女性）[23]。事实上，形成特定牙根大小和形状的功能环境可能会对牙根的长期完整性造成损害[8]。正如此前探讨的影响开𬌗患者牙根较短的原因，除了可能与咬合功能低下有关之外，也可能与异常舌习惯息息相关[11]，异常的舌习惯会对前牙产生侧向力，一旦超过牙齿的生理承受限度便可引发牙根吸收，这可见于牙根发育期或根尖形成之后[8]。

综上所述，本研究通过CBCT对高角Ⅱ类开𬌗患者的上下前牙根长及中切牙冠根形态进行测量分析，发现开𬌗组除上颌尖牙和侧切牙的牙根长度与正常覆𬌗组之间无明显差异外，其他前牙根长均较短且存在显著性差异，上下颌切牙根长较短可能与其咬合功能低下及异常吞咽有关。此外，相较于高角Ⅱ类前牙正常覆𬌗患者，高角Ⅱ类开𬌗患者上颌中切牙冠根成角较小且差异具有统计学意义，这利于正畸治疗中的转矩控制，即转矩表达充足的同时牙根更直立于牙槽骨中，符合正畸追求的健康、平衡、稳定、美观。

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