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·临床研究·

不同垂直骨面型骨性Ⅱ类成年女性患者强支抗内收上前牙口咽气道和舌骨位置改变的锥形束CT研究

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【摘要】　目的　探讨不同垂直骨面型骨性Ⅱ类成年女性患者强支抗内收上前牙口咽气道和舌骨位置改变，为正畸临床诊治提供参考。**方法**　本研究已通过单位医学伦理委员会审查批准，并获得患者知情同意。选取60例骨性Ⅱ类成年女性患者，根据下颌平面角将患者分成骨性Ⅱ类均角组和骨性Ⅱ类高角组，两组患者上颌均拔除两侧第一前磨牙强支抗内收上前牙。收集治疗前后的锥形束CT（cone beam CT，CBCT），采用三维测量软件进行测量，分析口咽气道相关指标。**结果**　均角组强支抗内收上前牙治疗前后10个口咽气道测量指标差异没有统计学意义（$P>0.05$），舌骨最高点到过蝶鞍垂直线的距离（perpendicular distance from the highest point of hyoid bone to the vertical line passing through the sella，H-X）值减小（$P<0.05$）；高角组治疗后口咽气道下界面积（oropharyngeal area at the level of the epiglottis tip，OPA-E）、口咽气道下界面前后径（anterior-posterior diameters of the oropharynx at the level ofthe epiglottis tip，E-AP）、口咽气道最小横截面面积（most constricted axial area of the oropharynx，OPA-MCA）、口咽气道最小横截面前后径（anterior-posterior diameters of MCA area of the oropharynx，MCA-AP）较治疗前减小（$P<0.001$），口咽气道体积（oropharyngeal volume，OPV）较治疗前减小（$P<0.05$），舌骨最高点到过蝶鞍水平线的距离（perpendicular distance from the highest point of hyoid bone to the horizontal line passing through the sella，H-Y）和舌骨最高点到会厌基部的距离（highest point of hyoid bone to the epiglottis base，H-Eb）值较治疗前增大（$P<0.05$）。**结论**　均角型骨性Ⅱ类成年女性患者正畸强支抗内收上前牙治疗后口咽气道无改变，骨性Ⅱ类高角型成年女性患者强支抗内收上前牙口咽气道有减小的风险。

【关键词】　口咽气道；　强支抗；　内收；　上前牙；　均角型；　高角型；　骨性Ⅱ类；　锥形束CT
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A cone beam CT study on the changes in oropharyngeal airway parameters and hyoid position in skeletal Class Ⅱ adult female patients with different vertical skeletal types treated with maxillary anterior teeth retraction with maximum anchorage

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【Abstract】 Objective To investigate the changes in oropharyngeal airway parameters and hyoid position in skeletal Class Ⅱ adult female patients with different vertical skeletal types who were treated with maxillary anterior teeth retraction with maximum anchorage, and to provide a reference for orthodontic clinical diagnosis and treatment. **Methods** This study was reviewed and approved by the Medical Ethics Committee, and informed consent was obtained from patients. Sixty adult female patients with skeletal Class Ⅱ were selected and divided into a skeletal Class Ⅱ normodivergent group and a skeletal Class Ⅱ hyperdivergent group based on the patients' mandibular plane angle. In both groups, the bilateral maxillary first premolars were extracted and the maxillary anterior teeth were retracted with maximum anchorage. Cone beam CT(CBCT) images were collected before and after treatment, and three-dimensional measurement software was used to analyze oropharyngeal airway-related parameters. **Results** After retraction of the maxillary anterior teeth with maximum anchorage, the 10 parameters related to the oropharyngeal airway did not exhibit statistically significant differences in the normodivergent group ($P > 0.05$), but the perpendicular distance from the highest point of the hyoid bone to the vertical line passing through the sella (H-X) value decreased ($P < 0.001$). In the hyperdivergent group, the oropharyngeal area at the level of the epiglottis tip (OPA-E), anterior-posterior diameters of the oropharynx at the level of the epiglottis tip (E-AP), most constricted axial area of the oropharynx (OPA-MCA), and anterior-posterior diameters of MCA area of the oropharynx (MCA-AP) decreased after treatment ($P < 0.001$). In addition, the oropharyngeal volume (OPV) decreased after treatment ($P < 0.05$), and the perpendicular distance from the highest point of the hyoid bone to the horizontal line passing through the sella (H-Y) and the highest point of the hyoid bone to the epiglottis base (H-Eb) values increased after treatment ($P < 0.05$). **Conclusion** After retraction of the maxillary anterior teeth with maximum anchorage, there is no change in the oropharyngeal airway in skeletal Class Ⅱ normodivergent female adult patients, while skeletal Class Ⅱ hyperdivergent female adult patients have a risk of reduction in the oropharyngeal airway after maximuim anchorage retraction of the maxillary anterior teeth.

【Key words】 oropharyngeal airway; maximum anchorage; retraction; maxillary anterior teeth; normodivergent; hyperdivergent; skeletal Class Ⅱ; cone beam CT
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美观、稳定和功能一直是正畸治疗的目标，正畸医生不仅关注牙颌结构和外貌的协调和稳定，口颌系统和气道的正常功能也是正畸诊断和治疗计划中不可忽略的部分[1-3]。上气道形状上宽下窄、前后扁平略呈漏斗形，自上而下可分为鼻咽段、口咽段和喉咽段3个部分。口咽段被认为是上气道最狭窄的部位，口咽部塌陷与呼吸道阻塞密切相关[4]。口咽段气道直接与口腔相连，前壁为软腭及舌等软组织，口咽部气道的尺寸与口颌系统相关。拔牙矫治内收前牙的过程中，口咽气道的改变问题一直备受关注。拔牙矫治是否会使得固有口腔体积减小，导致舌头的空间不足，从而可能对气道产生负面影响，目前的研究并没有得出一致的结论[5]。骨性Ⅱ类患者表现为上颌前突或下颌后缩或二者皆有，临床上很常见且治疗难度比较高。国外研究显示骨性Ⅱ类错殆畸形的患者口咽气道体积和气道最小截面积较骨性Ⅰ类和Ⅲ类患者小[6-7]。既往研究也表明骨性Ⅱ类下颌后缩患者颏部发育不足，形态偏薄，颏部矢状向位置偏后，垂直向位置偏上，舌咽气道相对狭窄[8]。拔牙矫治强支抗内收上前牙掩饰性正畸治疗是骨性Ⅱ类成年患者常用的治疗方法之一。本研究选择气道体积最小的骨性Ⅱ类成年患者作为研究对象，以期深入探讨拔牙矫治以及颌面部骨骼形态对口咽气道的影响。为了消除生长、性别和骨骼类型等因素对口咽气道测量的影响，本回顾性研究将需拔除上颌两侧第一前磨牙强支抗内收上前牙的骨性Ⅱ类成年女性患者纳入研究，采用CBCT结合Dolphin imaging三维测量软件，对治疗前后口咽气道的各项指标和舌骨位置进行测量分析，以期为骨

性Ⅱ类成年患者掩饰性正畸治疗提供参考。

1　资料和方法

1.1　研究对象

选择2016年1月—2023年1月在厦门医学院附属口腔医院正畸科就诊的，需拔除上颌两侧第一前磨牙强支抗内收上前牙（上颌磨牙前移量≤拔牙间隙的1/4）的骨性Ⅱ类成年女性患者60例，年龄20～35岁。本项研究为回顾性研究，已获得厦门医学院附属口腔医院医学伦理委员会审查批准（批准号：AF/SQ-02/02.0）。

纳入标准：①女性，年龄20～35岁；②Ⅱ类骨面型：ANB≥4.7°，下颌平面角（SN-GoGn）≥27.3°；③安氏Ⅱ类1分类，上牙列拥挤度小于4 mm；④牙列完整，牙体形态无异常，矫治前牙列完整无缺失（除外第三磨牙）；⑤无明显肥胖或者消瘦，18.5＜身体质量指数（BMI）＜27；⑥健康状态良好，无慢性鼻炎、鼻窦炎、无腺样体和扁桃体肥大等上呼吸道疾病史，夜间无打鼾；⑦无正畸或正颌外科治疗史，无唇腭裂或颅颌面畸形综合征，无颌面部手术外伤史。排除标准：①有重大颌面部外伤史；②有鼻塞、打鼾症状；③锥形束CT（cone beam CT，CBCT）图像不完整或者不清晰，或者术前或术后CBCT材料不全。

1.2　治疗设计

60例患者上颌均设计减数两侧上颌第一前磨牙，微种植支抗内收上前牙（上颌磨牙前移量≤拔牙间隙的1/4），下颌减数两侧下颌第一或者第二前磨牙，下颌支抗不做限制。根据下颌平面角将患者分为两组：骨性Ⅱ类均角组：30例，ANB≥4.7°，37.7°＞SN-MP≥27.3°；骨性Ⅱ类高角组：30例，（ANB≥4.7°，SN-MP≥37.7°）。

采用直丝弓矫治器（0.022英寸×0.028英寸，MBT数据）进行全口唇侧固定治疗，上下颌采用序列镍钛丝排齐整平后，以0.019英寸×0.025英寸不锈钢方丝作为主弓丝关闭间隙。在上颌后牙区植入微种植支抗钉（慈北，中国），滑动法整体内收6个上前牙。

1.3　数据采集

在正畸治疗前（T0）和拆除矫治器后当日（T1），由同一名技师，使用同一台CBCT机（New-Tom VGi，意大利）进行CBCT扫描。患者拍摄时取自然姿势位端坐，眶耳平面与地面平行，光标定位线位于面中部，上下牙列轻咬合于牙尖交错位，平静呼吸，无吞咽、发声及其他任何运动。

1.3.1　图像处理与测量方法　将所采集的CBCT数据转换保存为DICOM（digital imaging and communication in medicine）文件格式，再将转存后的DICOM数据导入三维重建软件Dolphin imaging（version 11.5，Chatsworth，美国）进行重建，根据重建后的三维影像进行测量。在3D编辑中打开影像，在Orientation模块中通过旋转校准平面，确认标志点，利用Axial Plane确认眶耳平面为水平面，利用Mid-Sagittal Plane过鼻根点和颅底点垂直眶耳平面为矢状面。通过Sinus/Airway模块进行气道分段测量，在矢状面切面下，点击Seed Points的Add在气道处添加Seed，再通过添加边界线来限制测量区域，限定Slice airway sensitivity的值为50，点击Update Volume生成气道三维模型。为方便测量通过PNS平面（过PNS点与FH平面平行的平面），会厌平面（过会厌顶与FH平面平行的平面）将气道分为3段：鼻咽段、口咽段、喉咽段，口咽段气道的上界为PNS平面，下界为会厌平面。选择Enable“Minimum Area”，在矢状面的影片利用红色虚线限定区域，点击Find自动生成最小横截面。点击Measure对气道数据进行测量，利用2D Slice Area测量口咽段上下界横截面积与最小横截面积，利用2D Line测量气道各横截面积的左右径与前后径。

1.3.2　测量项目　测量项目包括5个舌骨位置测量指标和10个口咽气道测量指标以及9个牙颌头影测量指标。所有数据测量均在同一台电脑上由研究者本人短时间内测量2次，取平均值。

5个舌骨位置测量指标（图1a）：舌骨最高点到会厌基部的距离（highest point of hyoid bone to the epiglottis base，H-Eb）；舌骨最高点到第三颈椎最前下点的距离（highest point of hyoid bone to the most anterior and inferior point of the third cervical vertebra，H-C3）；舌骨最高点到颏下点的距离（highest point of hyoid bone to the menton，H-Me）；舌骨最高点到过蝶鞍垂直线的距离（perpendicular distance from the highest point of hyoid bone to the vertical line passing through the sella，H-X）；以及舌骨最高点到过蝶鞍水平线的距离（perpendicular distance from the highest point of hyoid bone to the horizontal line passing through the sella，H-Y）。

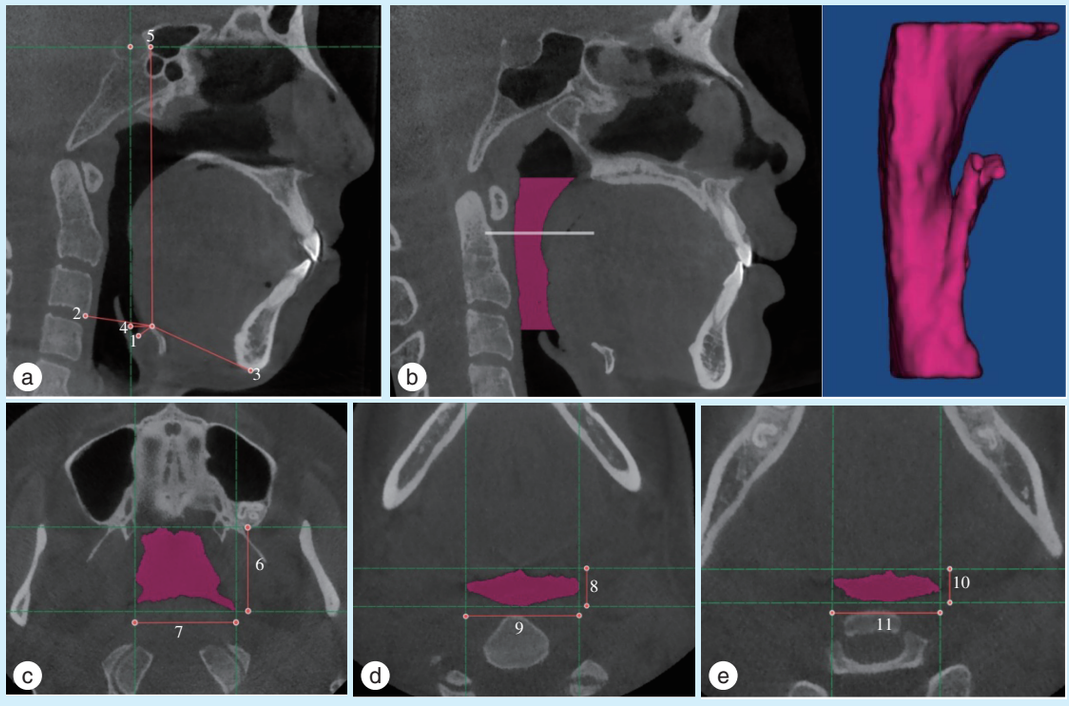
10个口咽气道测量指标：口咽气道体积（oropharyngeal volume，OPV）（图1b），口咽气道上界面积（oropharyngeal area at the level of the PNS plane，

OPA-PNS)(图1c),口咽气道上界面前后径(anterior-posterior diameters of the oropharynx at the level of the PNS plane,PNS-AP),口咽气道上界面左右径(lateraldiameters of the oropharynx at the level of the PNS plane,PNS-Lateral),口咽气道下界面积(oropharyngeal area at the level of the epiglottis tip,OPA-E)(图1d),口咽气道下界面前后径(anterior-posterior diameters of the oropharynx at the level ofthe epiglottis tip,E-AP),口咽气道下界面左右径(lateral diameter of the oropharynx at the level of the PNS plane,E-Lateral),口咽气道最小横截面面积(most constricted axial area of the oropharynx,OPA-MCA)(图1e),口咽气道最小横截面前后径(anterior-posterior diameters of MCA area of the oropharynx,MCA-AP),口咽气道最小横截面左右径(lateral diameters of MCA area of the oropharynx,MCA-lateral)。

9个牙颌头影测量指标:先使用Dolphin image生成头颅侧位片再进行定点测,分别测量SNA角、SNB角、ANB角、下颌平面角SN-MP、上中切牙唇倾度U1-SN、下中切牙唇倾度L1-MP、上下中切牙角U1-L1、U1-X(上中切牙切点至过S点的FH平面垂线的距离)、L1-X(下颌中切牙点至过S点的FH平面垂线的距离)。

1.4　统计学分析

使用SPSS 22.0软件进行统计分析,首先对所有测量指标是否符合正态分布进行了检验。如果数据符合正态分布,组内进行配对样本t检验,组间则进行两独立样本t检验。对于不符合正态分布的数据,采用非参数Wilcoxon秩和检验。当$P<0.05$,则认为差异具有统计学意义。



a: five hyoid bone measurement: H-Eb(1), H-C3(2), H-Me(3), H-X(4), and H-Y(5). b: the volume of the red area is the oropharyngeal volume (OPV), and the white line in the figure is the most restricted axial area of the oropharynx (OPA-MCA) automatically generated by Find. c: the volume of the red area is the oropharyngeal area at the level of the PNS plane (OPA-PNS); anterior-posterior diameters of the oropharynx at the level of the PNS plane (PNS-AP) (6); lateraldiameters of the oropharynx at the level of the PNS plane (PNS-Lateral) (7). d: the volume of the red area is the oropharyngeal area at the level of the epiglottis tip (OPA-E); anterior-posterior diameters of the oropharynx at the level ofthe epiglottis tip (E-AP) (8); lateral diameter of the oropharynx at the level of the epiglottis tip (E-Lateral) (9). e: the volume of the red area is the most constricted axial area of the oropharynx (OPA-MCA); anterior-posterior diameters of MCA area of the oropharynx (MCA-AP) (10); lateral diameter of MCA area of the oropharynx (MCA-Lateral) (11)

Figure 1　Measurements of oropharynx size and hyoid bone position.

图1　口咽气道和舌骨测量指标

2　结　果

2.1　正畸治疗前骨性Ⅱ类均角型和高角型成年女性牙颌指标、口咽气道和舌骨位置比较

如表1所示，正畸治疗前，骨性Ⅱ类高角组SNA、SNB、U1-SN、L1-MP、U1-X较骨性Ⅱ类均角组小，差异有统计学意义（$P<0.05$）；U1-L1、L1-X差异无统计学意义；两组SN-MP、ANB值均符合实验设计；骨性Ⅱ类均角组和高角组10个口咽气道测量指标差异没有统计学意义；H-Eb值均角组比高角组大，差异具有统计学意义（$P<0.001$），其余舌骨位置测量指标差异没有统计学意义。

2.2　治疗后骨性Ⅱ类均角型和高角型成年女性牙颌指标、口咽气道和舌骨位置以及两组牙颌指标改变量比较

如表2所示，强支抗内收上前牙正畸治疗后，骨性Ⅱ类高角组SNA、SNB、U1-SN、L1-MP较骨性Ⅱ类均角组小，差异有统计学意义（$P<0.05$）；骨性Ⅱ类高角组SN-MP较骨性Ⅱ类均角组大，差异有统计学意义（$P<0.001$），符合实验设计。两组ANB、U1-L1、U1-X、L1-X差异无统计学意义；骨性

表1　治疗前骨性Ⅱ类均角型和高角型成年女性牙颌指标、口咽气道和舌骨位置比较

Table 1　Comparison of dental and skeletal parameters, oropharyngeal airway and hyoid bone position between normodivergent group and hyperdivergent group before treatment in adult female patients with skeletal Class Ⅱ　　$\bar{x} \pm s$, n=30

Parameter	Normodivergent group (T0)	Hyperdivergent group (T0)	t	P
SNA/°	85.66 ± 3.598 52	83.006 7 ± 2.873 05	3.156	0.003
SNB/°	79.31 ± 3.270 6	76.303 3 ± 2.965 49	3.730	< 0.001
ANB/°	6.386 7 ± 1.406 08	6.706 7 ± 0.851 75	−1.066	0.291
SN-MP/°	30.816 7 ± 2.916 43	39.836 7 ± 2.424 37	−12.892	< 0.001
U1-SN/°	113.816 7 ± 5.801 79	106.48 ± 6.526 89	4.591	< 0.001
L1-MP/°	104.713 3 ± 5.015 54	101.06 ± 4.615 46	2.936	0.005
U1-L1/°	110.773 3 ± 6.937 75	112.676 7 ± 6.156 06	−1.124	0.266
U1-X/mm	74.061 8 ± 3.737 14	71.618 8 ± 5.471 32	2.020	0.048
L1-X/mm	68.966 7 ± 3.641 23	67.327 4 ± 5.000 71	1.451	0.152
OPV/mm^3	15 034.644 8 ± 2 750.447 7	14 944.933 ± 4 237.084 16	0.097	0.923
OPA-PNS/mm^2	585.064 5 ± 91.219 05	592.780 6 ± 136.415 37	−0.258	0.798
PNS-AP/mm	26.050 1 ± 4.885 78	26.383 7 ± 4.632 21	−0.271	0.787
PNS-Lateral/mm	35.474 3 ± 5.414 83	35.498 1 ± 7.559 27	−0.014	0.989
OPA-E/mm^2	302.420 3 ± 69.504 99	318.652 2 ± 101.709 43	−0.722	0.473
E-AP/mm	14.962 ± 5.132 77	15.676 9 ± 6.142 37	−0.489	0.627
E-Lateral/mm	29.353 7 ± 2.908 78	29.026 3 ± 5.692 85	0.281	0.780
OPA-MCA/mm^2	246.590 1 ± 60.458 21	249.802 9 ± 92.905 89	−0.159	0.874
MCA-AP/mm	14.409 4 ± 5.010 31	13.756 7 ± 3.638 82	0.577	0.566
MCA-lateral/mm	24.608 2 ± 4.486 38	26.787 9 ± 4.884 46	−1.800	0.077
H-Eb/mm	10.342 8 ± 3.280 38	7.804 3 ± 2.359 66	3.441	0.001
H-C3/mm	28.601 8 ± 3.322 6	27.735 ± 3.229 39	1.025	0.310
H-Me/mm	41.832 9 ± 4.818 23	41.994 8 ± 5.865 15	−0.117	0.907
H-X/mm	11.344 7 ± 5.569 14	10.285 4 ± 6.327 14	0.688	0.494
H-Y/mm	94.648 8 ± 8.860 87	91.788 7 ± 4.424 44	1.582	0.119

SNA: angle between sella, nasion and subspinale point A. SNB: angle between sella, nasion and supramentale point B. ANB: angle between subspinale point A and supramentale point B. SN-MP: angle between SN plane and the mandibular plane. U1-SN: angle between upper central incisor and SN plane. L1-MP: angle between lower central incisor and mandibular plane. U1-L1: angle between upper central incisor and lower central incisor. U1-X: perpendicular distance from the upper central incisor incisal edge to the vertical line passing through the sella. L1-X: perpendiular distance from the lower central incisor incisal edge to the vertical line passing through the sella. OPV: oropharyngeal volume. OPA-PNS: oropharyngeal area at the level of the PNS plane. PNS-AP: anterior-posterior diameters of the oropharynx at the level of the PNS plane. PNS-Lateral: lateral diameters of the oropharynx at the level of the PNS plane. OPA-E: oropharyngeal area at the level of the epiglottis tip. E-AP: anterior-posterior diameters of the oropharynx at the level of the epiglottis tip. E-Lateral: lateral diameter of the oropharynx at the level of the epiglottis tip. OPA-MCA: most constricted axial area of the oropharynx. MCA-AP: anterior-posterior diameters of MCA area of the oropharynx. MCA-Lateral: lateral diameters of MCA area of the oropharynx. H-Eb: highest point of hyoid bone to the epiglottis base. H-C3: highest point of hyoid bone to the most anterior and inferior point of the third cervical vertebra. H-Me: highest point of hyoid bone to the menton. H-X: perpendicular distance from the highest point of hyoid bone to the vertical line passing through the sella. H-Y: perpendicular distance from the highest point of hyoid bone to the horizontal line passing through the sella. T0: before orthodontic treatment

表2　治疗后骨性Ⅱ类均角型和高角型成年女性牙颌指标、口咽气道和舌骨位置比较

Table 2　Comparison of dental and skeletal parameters, oropharyngeal airway and hyoid bone position between normodivergent group and hyperdivergent group after treatment in adult female patients with skeletal Class Ⅱ　$\bar{x} \pm s$, n=30

Parameter	Normodivergent group (T1)	Hyperdivergent group (T1)	t	P
SNA/°	84.663 3 ± 3.015 19	82.756 7 ± 3.458 69	2.276	0.027
SNB/°	78.63 ± 2.543 98	76.506 7 ± 3.531 62	2.672	0.010
ANB/°	6.066 7 ± 1.220 61	6.256 7 ± 0.968 36	−0.668	0.507
SN-MP/°	30.57 ± 4.162 99	39.206 7 ± 3.128 61	−9.084	< 0.001
U1-SN/°	100.336 7 ± 7.091 25	96.25 ± 6.799 38	2.278	0.026
L1-MP/°	95.843 3 ± 8.054 11	90.21 ± 5.709 78	3.125	0.003
U1-L1/°	133.136 7 ± 6.345 27	134.513 3 ± 6.116 1	−0.856	0.396
U1-X/mm	66.928 8 ± 3.141 61	65.396 1 ± 4.961 71	1.430	0.158
L1-X/mm	64.108 5 ± 3.346 74	62.606 3 ± 4.695 15	1.427	0.159
OPV/mm^3	15 025.066 2 ± 3 799.846 28	13 682.467 2 ± 4 797.154 29	1.202	0.234
OPA-PNS/mm^2	600.846 1 ± 114.917 49	589.659 3 ± 123.566 4	0.363	0.718
PNS-AP/mm	26.598 7 ± 2.891 56	26.213 9 ± 3.936 64	0.431	0.668
PNS-Lateral/mm	35.132 8 ± 6.151 63	34.131 5 ± 4.912 75	0.697	0.489
OPA-E/mm^2	330.117 9 ± 99.319 08	255.309 1 ± 83.370 56	3.160	0.003
E-AP/mm	15.066 3 ± 4.213 58	11.686 4 ± 2.616 71	3.732	< 0.001
E-Lateral/mm	29.217 ± 5.303 49	29.129 4 ± 5.144 88	0.065	0.948
OPA-MCA/mm^2	255.872 5 ± 84.766 45	201.13 1 ± 94.502 14	2.362	0.022
MCA-AP/mm	14.016 1 ± 4.101 78	10.591 4 ± 3.763 94	3.370	0.001
MCA-lateral/mm	25.518 7 ± 7.015 71	26.711 1 ± 4.484 55	−0.784	0.436
H-Eb/mm	9.878 8 ± 3.267 46	9.721 8 ± 3.358 08	0.184	0.855
H-C3/mm	28.930 5 ± 3.959 11	27.470 7 ± 2.923 5	1.625	0.110
H-Me/mm	42.825 3 ± 6.870 92	40.420 5 ± 6.204 13	1.423	0.160
H-X/mm	9.537 8 ± 6.608 14	10.270 2 ± 7.511 57	−0.401	0.690
H-Y/mm	94.834 3 ± 7.089 11	93.003 3 ± 5.523 75	1.116	0.269

SNA: angle between sella, nasion and subspinale point A. SNB: angle between sella, nasion and supramentale point B. ANB: angle between subspinale point A and supramentale point B. SN-MP: angle between SN plane and the mandibular plane. U1-SN: angle between upper central incisor and SN plane. L1-MP: angle between lower central incisor and mandibular plane. U1-L1: angle between upper central incisor and lower central incisor. U1-X: perpendicular distance from the upper central incisor incisal edge to the vertical line passing through the sella. L1-X: perpendiular distance from the lower central incisor incisal edge to the vertical line passing through the sella. OPV: oropharyngeal volume. OPA-PNS: oropharyngeal area at the level of the PNS plane. PNS-AP: anterior-posterior diameters of the oropharynx at the level of the PNS plane. PNS-Lateral: lateral diameters of the oropharynx at the level of the PNS plane. OPA-E: oropharyngeal area at the level of the epiglottis tip. E-AP: anterior-posterior diameters of the oropharynx at the level of the epiglottis tip. E-Lateral: lateral diameter of the oropharynx at the level of the epiglottis tip. OPA-MCA: most constricted axial area of the oropharynx. MCA-AP: anterior-posterior diameters of MCA area of the oropharynx. MCA-Lateral: lateral diameters of MCA area of the oropharynx. H-Eb: highest point of hyoid bone to the epiglottis base. H-C3: highest point of hyoid bone to the most anterior and inferior point of the third cervical vertebra. H-Me: highest point of hyoid bone to the menton. H-X: perpendicular distance from the highest point of hyoid bone to the vertical line passing through the sella. H-Y: perpendicular distance from the highest point of hyoid bone to the horizontal line passing through the sella. T1: the day after removing the orthodontic appliance

Ⅱ类高角组OPA-E、E-AP、OPA-MCA、MCA-AP较均角组小，差异有统计学意义（P < 0.05）；其余口咽气道及舌骨位置测量指标差异没有统计学意义。

如表3所示，均角型和高角型骨性Ⅱ类成年女性患者强支抗内收上前牙正畸治疗后，两组9项牙颌指标改变量均相近，差异没有统计学意义（P > 0.05），提示两组患者上下前牙均实现了大量内收，且内收量较为一致。

2.3　均角型骨性Ⅱ类成年女性患者强支抗内收上前牙后牙颌指标、口咽气道和舌骨位置比较

如表4所示，均角型骨性Ⅱ类成年女性患者强支抗内收上前牙后，U1-SN、L1-MP、U1-L1、U1-X、L1-X较治疗前减少，差异有统计学意义（P < 0.001）。ANB较治疗前减小，差异有统计学意义（P < 0.05）。正畸治疗前后均角组10个口咽气道测量指标差异没有统计学意义（P > 0.05），提示均角型骨性Ⅱ类成年女性患者正畸强支抗内收上前牙治疗后口咽气道无改变；H-X值正畸治疗后较治疗前小，差异具有统计学意义（P < 0.05），其余舌骨位置测量指标差异没有统计学意义，提示均角型骨性Ⅱ类成年女性患者正畸强支抗内收上前牙治疗后舌骨位置较治疗前靠后。

表3　治疗后骨性Ⅱ类均角型和高角型成年女性牙颌指标改变量比较

Table 3　Comparison of the changes in dental and skeletalparameters between normodivergent group and hyperdivergent group after treatment in adult female patients with skeletal Class Ⅱ　$\bar{x} \pm s$, n=30

Parameter	Normodivergent group (T0-T1)	Hyperdivergent group (T0-T1)	t	p
SNA/°	0.996 67 ± 2.983 92	0.25 ± 2.133 27	1.115	0.269
SNB/°	0.68 ± 3.039 67	−0.203 33 ± 2.221 76	1.285	0.204
ANB/°	0.32 ± 0.722 73	0.45 ± 0.489 02	−0.816	0.418
SN-MP/°	0.246 67 ± 3.578 55	0.63 ± 1.390 15	−0.547	0.587
U1-SN/°	13.48 ± 8.403 83	10.23 ± 5.040 40	1.817	0.074
L1-MP/°	8.87 ± 5.738 93	10.85 ± 6.899 31	−1.208	0.232
U1-L1/°	−22.363 33 ± 8.018 15	−21.836 67 ± 8.218 80	−0.251	0.803
U1-X/mm	7.132 97 ± 1.854 87	6.222 67 ± 2.997 80	1.414	0.163
L1-X/mm	4.858 13 ± 1.955 05	4.721 07 ± 2.694 11	0.226	0.822

SNA: angle between sella, nasion and subspinale point A. SNB: angle between sella, nasion and supramentale point B. ANB: angle between subspinale point A and supramentale point B. SN-MP: angle between SN plane and the mandibular plane. U1-SN: angle between upper central incisor and SN plane. L1-MP: angle between lower central incisor and mandibular plane. U1-L1: angle between upper central incisor and lower central incisor. U1-X: perpendicular distance from the upper central incisor incisal edge to the vertical line passing through the sella. L1-X: perpendiular distance from the lower central incisor incisal edge to the vertical line passing through the sella. T0: before orthodontic treatment; T1: the day after removing the orthodontic appliance

2.4　高角型骨性Ⅱ类成年女性患者强支抗内收上前牙后牙颌指标、口咽气道和舌骨位置比较

如表5所示，高角型骨性Ⅱ类成年女性患者强支抗内收上前牙后，ANB、U1-SN、L1-MP、U1-L1、U1-X、L1-X较治疗前减少，差异有统计学意义（$P<0.001$）；SN-MP较治疗前减少差异有统计学意义（$P<0.05$），提示下颌平面治疗后实现了少量逆旋；OPA-E、E-AP、OPA-MCA、MCA-AP较治疗前减少（$P<0.001$）；OPV较治疗前减少（$P<0.05$），提示高角型骨性Ⅱ类成年女性患者正畸强支抗内收上前牙治疗后口咽气道体积、口咽气道下界面积、口咽气道下界前后径、口咽气道最小横截面面积、口咽气道最小横截面前后径均减少；H-Y和H-Eb值较治疗前增加，差异具有统计学意义（$P<0.05$），提示高角型骨性Ⅱ类成年女性患者强支抗内收上前牙后舌骨位置较治疗前靠前靠下。

3　讨　论

在口腔医学科学研究领域，颌面部骨骼形态与口咽气道之间的关系一直备受正畸医生关注[9-11]。不同矢状骨面型与上气道容积的关系一直是研究的热点[12-14]。有研究表明，从Ⅲ类到Ⅰ类再到Ⅱ类骨面型，上气道的平均截面积逐渐减小，而高度逐渐增大，这表明上气道形态从Ⅲ类、Ⅰ类向Ⅱ类转变时，呈现出逐渐变狭长的趋势[7, 15]。同时上气道容积也呈现出从Ⅱ类到Ⅰ类再到Ⅲ类逐渐增大的趋势[16]。刘媛等[17]研究发现下颌骨矢状向发育不足的年轻成年人群上气道口咽部明显较正常人群和上颌骨矢状向发育不足者狭窄，而上颌骨矢状向发育不足对上气道口咽部大小无显著影响。口咽部和喉咽部的气道尺寸也受到颌面部垂直骨面型类型的影响，其中高角患者（垂直生长型）的数值最低[18]。但本研究结果显示正畸治疗前骨性Ⅱ类均角组和高角组口咽气道测量指标差异没有统计学意义。国外研究也表明，高角组鼻咽段气道体积比均角及高角组小，低角组口咽气道体积较均角组和高角组大，但均角组和高角组口咽气道体积差异没有统计学意义[19]。

关于骨性Ⅱ类高角患者拔牙矫治后上气道的改变尚存争议[20-21]。邢珂等[22]的研究指出对于骨性Ⅱ类高角患者，尤其是前牙较为舌倾的患者，正畸医生应同时密切关注其颅颈姿势和气道，警惕睡眠呼吸暂停综合征的发生。一项2023年的国外研究表明拔牙正畸治疗会影响上呼吸道的尺寸和舌骨的位置，最大支抗内收前牙会减少呼吸道的尺寸，而中等支抗会增加呼吸道的尺寸[23]。而2024年一项关于成人Ⅰ类双颌前突患者拔除上下前磨牙最大支抗内收前牙的CBCT研究显示，治疗后气道体积、横截面积以及舌骨位置均没有显著改变[24]。目前关于不同垂直骨面型拔牙矫治后气道改变的研究数量较少。Guo等[25]研究结果发现骨性Ⅱ类高角型患者拔除第一前磨牙矫治不会对口咽部大小或舌骨位置产生负面影响。有研究发现拔除前磨牙正畸治疗后下颌发生逆时针旋转，

表4　均角型骨性Ⅱ类成年女性患者正畸强支抗内收上前牙后牙颌指标、口咽气道和舌骨位置改变

Table 4　Changes in the dental and skeletal parameters, oropharyngeal airway and hyoid bone position after maximum retraction of the maxillary anterior teeth in skeletal Class Ⅱ adult female patients with normodivergent　$\bar{x} \pm s$, n=30

Parameter	Normodivergent group (T0)	Normodivergent group (T1)	t	p
SNA/°	85.66 ± 3.598 52	84.663 3 ± 3.015 19	1.829	0.078
SNB/°	79.31 ± 3.270 6	78.63 ± 2.543 98	1.225	0.23
ANB/°	6.3867 ± 1.406 08	6.066 7 ± 1.220 61	2.425	0.022
SN-MP/°	30.816 7 ± 2.916 43	30.57 ± 4.162 99	0.378	0.709
U1-SN/°	113.816 7 ± 5.801 79	100.336 7 ± 7.091 25	8.786	< 0.001
L1-MP/°	104.713 3 ± 5.015 54	95.843 3 ± 8.054 11	8.466	< 0.001
U1-L1/°	110.773 3 ± 6.937 75	133.136 7 ± 6.345 27	−15.276	< 0.001
U1-X/mm	74.061 8 ± 3.737 14	66.928 8 ± 3.141 61	21.063	< 0.001
L1-X/mm	68.966 7 ± 3.641 23	64.108 5 ± 3.346 74	13.61	< 0.001
OPV/mm^3	15 034.644 8 ± 2 750.447 7	15 025.066 2 ± 3 799.846 28	0.019	0.985
OPA-PNS/mm^2	585.064 5 ± 91.219 05	600.846 1 ± 114.917 49	−1.436	0.162
PNS-AP/mm	26.050 1 ± 4.885 78	26.598 7 ± 2.891 56	−0.751	0.459
PNS-Lateral/mm	35.474 3 ± 5.414 83	35.132 8 ± 6.151 63	0.678	0.503
OPA-E/mm^2	302.420 3 ± 69.504 99	330.117 9 ± 99.319 08	−1.689	0.102
E-AP/mm	14.96 2 ± 5.132 77	15.066 3 ± 4.213 58	−0.09	0.929
E-Lateral/mm	29.353 7 ± 2.908 78	29.217 ± 5.303 49	0.172	0.864
OPA-MCA/mm^2	246.590 1 ± 60.458 21	255.872 5 ± 84.766 45	−0.646	0.524
MCA-AP/mm	14.409 4 ± 5.010 31	14.016 1 ± 4.101 78	0.386	0.703
MCA-lateral/mm	24.608 2 ± 4.486 38	25.518 7 ± 7.015 71	−0.685	0.499
H-Eb/mm	10.342 8 ± 3.280 38	9.878 8 ± 3.267 46	0.632	0.532
H-C3/mm	28.601 8 ± 3.322 6	28.930 5 ± 3.959 11	−0.738	0.466
H-Me/mm	41.832 9 ± 4.818 23	42.825 3 ± 6.870 92	−0.914	0.369
H-X/mm	11.344 7 ± 5.569 14	9.537 8 ± 6.608 14	2.188	0.037
H-Y/mm	94.648 8 ± 8.860 87	94.834 3 ± 7.089 11	−0.196	0.846

SNA: angle between sella, nasion and subspinale point A. SNB: angle between sella, nasion and supramentale point B. ANB: angle between subspinale point A and supramentale point B. SN-MP: angle between SN plane and the mandibular plane. U1-SN: angle between upper central incisor and SN plane. L1-MP: angle between lower central incisor and mandibular plane. U1-L1: angle between upper central incisor and lower central incisor. U1-X: perpendicular distance from the upper central incisor incisal edge to the vertical line passing through the sella. L1-X: perpendiular distance from the lower central incisor incisal edge to the vertical line passing through the sella. OPV: oropharyngeal volume. OPA-PNS: oropharyngeal area at the level of the PNS plane. PNS-AP: anterior-posterior diameters of the oropharynx at the level of the PNS plane. PNS-Lateral: lateral diameters of the oropharynx at the level of the PNS plane. OPA-E: oropharyngeal area at the level of the epiglottis tip. E-AP: anterior-posterior diameters of the oropharynx at the level of the epiglottis tip. E-Lateral: lateral diameter of the oropharynx at the level of the epiglottis tip. OPA-MCA: most constricted axial area of the oropharynx. MCA-AP: anterior-posterior diameters of MCA area of the oropharynx. MCA-Lateral: lateral diameters of MCA area of the oropharynx. H-Eb: highest point of hyoid bone to the epiglottis base. H-C3: highest point of hyoid bone to the most anterior and inferior point of the third cervical vertebra. H-Me: highest point of hyoid bone to the menton. H-X: perpendicular distance from the highest point of hyoid bone to the vertical line passing through the sella. H-Y: perpendicular distance from the highest point of hyoid bone to the horizontal line passing through the sella. T0: before orthodontic treatment; T1: the day after removing the orthodontic appliance

患者上气道最小横截面积增大[26-27]。但以上研究与本研究支抗设计不同，上颌支抗设计均不是强支抗。本研究将骨性Ⅱ类成年女性患者分为均角组和高角组，上颌拔除第一前磨牙并采用强支抗内收上前牙，结果显示两组患者治疗后上下前牙均实现了大量内收，上下前牙唇倾度减少，两组患者上下前牙内收量没有统计学差异，骨性Ⅱ类均角型患者强支抗内收上前牙后口咽气道无改变，而骨性Ⅱ类高角型患者强支抗内收上前牙治疗后口咽气道体积、口咽气道下界面积、口咽气道下界前后径、口咽气道最小横截面面积、口咽气道最小横截面前后径均减少，气道的左右径治疗前后没有显著差异。正畸治疗前骨性Ⅱ类高角组牙颌指标较均角组小但两组口咽气道测量指标差异没有统计学意义，治疗后两组患者上下前牙内收量一致，但治疗后两组口咽气道改变却不同。推断可能原因是骨性Ⅱ类高角患者上下颌较骨性Ⅱ类均角患者后缩，为了获得良好的面型需要更为直立的上下前牙位置，骨性Ⅱ类高角患者上下前牙大量内收直立后固有口腔的体积减小，固有口腔的体积减小到一定限度后可能导致舌体空间不足，进而对气道产生负面影响[28]。提示骨性Ⅱ类高患

表5　高角型骨性Ⅱ类成年女性患者正畸强支抗内收上前牙后牙颌指标、口咽气道和舌骨位置改变

Table 5　Changes in the dental and skeletal parameters, oropharyngeal airway and hyoid bone position after maximum retraction of the maxillary anterior teeth in skeletal Class Ⅱ adult female patients with hyperdivergent　$\bar{x} \pm s$, n=30

Parameter	Hyperdivergent group (T0)	Hyperdivergent group (T1)	t	P
SNA/°	83.006 7 ± 2.873 05	82.756 7 ± 3.458 69	0.642	0.526
SNB/°	76.303 3 ± 2.965 49	76.506 7 ± 3.531 62	−0.501	0.62
ANB/°	6.706 7 ± 0.851 75	6.256 7 ± 0.968 36	5.04	< 0.001
SN-MP/°	39.836 7 ± 2.424 37	39.206 7 ± 3.128 61	2.482	0.019
U1-SN/°	106.48 ± 6.526 89	96.25 ± 6.799 38	11.117	< 0.001
L1-MP/°	101.06 ± 4.615 46	90.21 ± 5.709 78	8.614	< 0.001
U1-L1/°	112.676 7 ± 6.156 06	134.513 3 ± 6.116 1	−14.553	< 0.001
U1-X/mm	71.618 8 ± 5.471 32	65.396 1 ± 4.961 71	11.369	< 0.001
L1-X/mm	67.327 4 ± 5.000 71	62.606 3 ± 4.695 15	9.598	< 0.001
OPV/mm^3	14 944.933 ± 4 237.084 16	13 682.467 2 ± 4 797.154 29	3.374	0.002
OPA-PNS/mm^2	592.780 6 ± 136.415 37	589.659 3 ± 123.566 4	0.441	0.663
PNS-AP/mm	26.383 7 ± 4.632 21	26.213 9 ± 3.936 64	0.19	0.85
PNS-Lateral/mm	35.498 1 ± 7.559 27	34.131 5 ± 4.912 75	1.752	0.09
OPA-E/mm^2	318.652 2 ± 101.709 43	255.309 1 ± 83.370 56	4.204	< 0.001
E-AP/mm	15.676 9 ± 6.142 37	11.686 4 ± 2.616 71	4.019	< 0.001
E-Lateral/mm	29.026 3 ± 5.692 85	29.129 4 ± 5.144 88	−0.085	0.933
OPA-MCA/mm^2	249.802 9 ± 92.905 89	201.131 ± 94.502 14	4.749	< 0.001
MCA-AP/mm	13.756 7 ± 3.638 82	10.591 4 ± 3.763 94	5.287	< 0.001
MCA-lateral/mm	26.787 9 ± 4.884 46	26.711 1 ± 4.484 55	0.11	0.913
H-Eb/mm	7.804 3 ± 2.359 66	9.721 8 ± 3.358 08	−4.445	< 0.001
H-C3/mm	27.735 ± 3.229 39	27.470 7 ± 2.923 5	0.814	0.422
H-Me/mm	41.994 8 ± 5.865 15	40.420 5 ± 6.204 13	2.003	0.055
H-X/mm	10.285 4 ± 6.327 14	10.270 2 ± 7.511 57	0.019	0.985
H-Y/mm	91.788 7 ± 4.424 44	93.003 3 ± 5.523 75	−2.338	0.026

SNA: angle between sella, nasion and subspinale point A. SNB: angle between sella, nasion and supramentale point B. ANB: angle between subspinale point A and supramentale point B. SN-MP: angle between SN plane and the mandibular plane. U1-SN: angle between upper central incisor and SN plane. L1-MP: angle between lower central incisor and mandibular plane. U1-L1: angle between upper central incisor and lower central incisor. U1-X: perpendicular distance from the upper central incisor incisal edge to the vertical line passing through the sella. L1-X: perpendiular distance from the lower central incisor incisal edge to the vertical line passing through the sella. OPV: oropharyngeal volume. OPA-PNS: oropharyngeal area at the level of the PNS plane. PNS-AP: anterior-posterior diameters of the oropharynx at the level of the PNS plane. PNS-Lateral: lateral diameters of the oropharynx at the level of the PNS plane. OPA-E: oropharyngeal area at the level of the epiglottis tip. E-AP: anterior-posterior diameters of the oropharynx at the level of the epiglottis tip. E-Lateral: lateral diameter of the oropharynx at the level of the epiglottis tip. OPA-MCA: most constricted axial area of the oropharynx. MCA-AP: anterior-posterior diameters of MCA area of the oropharynx. MCA-Lateral: lateral diameters of MCA area of the oropharynx. H-Eb: highest point of hyoid bone to the epiglottis base. H-C3: highest point of hyoid bone to the most anterior and inferior point of the third cervical vertebra. H-Me: highest point of hyoid bone to the menton. H-X: perpendicular distance from the highest point of hyoid bone to the vertical line passing through the sella. H-Y: perpendicular distance from the highest point of hyoid bone to the horizontal line passing through the sella. T0: before orthodontic treatment; T1: the day after removing the orthodontic appliance

者强支抗内收上前牙时口咽气道有减小的风险。对于成年骨性Ⅱ类高角患者特别是伴下颌后缩的患者采用掩饰性正畸治疗时需警惕对口咽气道的负面影响，必要时采取折中的治疗方案或者正畸正颌联合治疗[29-30]。一项回顾性研究也将Ⅱ类患者分为均角不拔牙组、均角拔牙组以及高角拔牙组，使用侧位片来评估患者的气道间隙和舌骨位置，同时使用问卷评估患者睡眠质量和阻塞性睡眠呼吸暂停风险，研究结果显示在高角拔牙组气道减少最明显，与本研究结果一致，但三组的睡眠质量都很高，OSA风险都很低，组间没有显著差异[31]。提示影像学上的改变不一定会引发功能改变，仍需要进行治疗前后的功能分析进一步明确拔牙矫治对上气道功能的影响[32-33]。

本研究也存在一些局限性。首先，气道受患者体重影响，本研究仅仅在病例纳入时对体重指数进行了限制，未对治疗前后体重变化进行记录，无法排除患者体重变化对气道的影响[34-35]。其次，头部姿势和舌体位置被证明会影响上气道的体积，是三维放射图像采集过程中的混淆变量，本研究对拍摄头位进行了规范，但忽略了患者的舌体位置可能产生的影响[36-37]。同时本研究采Dolphin

Imaging三维建模及测量，未来基于人工智能的全自动测气道建模和测量会更快更准确[38]。

综上，本研究通过对比均角型和高角型骨性Ⅱ类成年女性患者强支抗内收上前牙后口咽气道的改变，发现骨性Ⅱ类均角型患者强支抗内收上前牙口咽气道改变没有显著性，而骨性Ⅱ类高角型患者强支抗内收上前牙口咽气道有减小的风险，提示成年骨性Ⅱ类高角患者特别是伴有下颌后缩患者采用掩饰性正畸治疗时需警惕对口咽气道的负面影响。

【Author contributions】 Shen JX designed the study, conceptualized and wrote the article. Chen ZZ collected and analyzed the data. Lin YH directed the data collection and revised the article. Su JJ designed the study, guided and critically reviewed the article structures. Huang WX revised the article. All authors read and approved the final manuscript as submitted.

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