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· 综述 ·

# 错殆畸形患者髁突位置及正畸治疗前后髁突位置变化的CBCT评估

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**【摘要】** 颌系统的功能健康、稳定是口腔正畸治疗的基本目标之一。健康人群的下颌处于牙尖交错位(intercuspal position, ICP)时髁突位置基本位于关节窝的中央, 颞下颌关节功能稳定。错殆畸形患者由于正畸牙齿移动及咬合改变, 可能发生颞下颌关节的相关改建, 特别是髁突位置的改变。传统的髁突位置的评估方法是通过殆架来转移下颌位置, 然后在髁突位置测量仪上进行测量, 但此方法得到的髁突位置变化缺乏一致性。近年来, 锥形束CT(cone beam computed tomography, CBCT)成为正畸治疗检查的首选, CBCT可精准地测量关节间隙, 确定髁突位置的改变。本文对髁突位置的CBCT评估及正畸治疗前后的错殆畸形髁突位置变化的研究进行综述。文献复习结果表明, 不同错殆畸形患者的髁突位置存在差异, 正畸治疗前后髁突位置也可能发生变化, 使用CBCT可以较低的辐射剂量和更高的精确度评价错殆畸形的髁突位置, 有助于进一步研究错殆畸形患者髁突位置变化的机制, 并为患者治疗提供更准确、个性化的指导。

**【关键词】** 髁突位置; 锥形束CT; 正畸治疗; 错殆畸形; 颞下颌关节; 安氏分类; 垂直骨面型; 颞下颌关节紊乱综合征

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**Evaluation of condylar position in patients with malocclusion and changes in condylar position before and after orthodontic treatment using cone beam computed tomography** PAN Yihua, ZHAO Zhihe, LIU Jun. State Key Laboratory of Oral Diseases & National Center for Stomatology & National Clinical Research Center for Oral Diseases & Department of Orthodontics, West China Hospital of Stomatology, Sichuan University, Chengdu 610041, China  
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**【Abstract】** The functional health and stability of the oral and maxillofacial system is one of the basic goals of orthodontic treatment. Currently, it is believed that, in general, the condyle is located in the center of the joint fossa when the mandible is in an intercuspal position (ICP) in healthy normal people. At this time, the function of the temporomandibular joint (TMJ) is stable. Due to orthodontic tooth movement and subsequent occlusal changes, patients with malocclusion may experience related remodeling of the temporomandibular joint, especially changes in the position of the condyle. The position of the mandibular condyle is traditionally evaluated using a condylar position indicator. However, this method lacks consistency in obtaining condylar position changes. In recent years, in the clinical application of orthodontic treatment, cone beam computed tomography (CBCT) has become the first choice for examination. CBCT can accurately measure the interarticular space and determine changes in condylar position. This article reviews the CBCT assessment of condylar position and related research on condylar position changes in patients with malocclusion before and after orthodontic treatment. The literature review results indicate that there are differences in the condylar position of pa-

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tients with different malocclusions, and the condylar position may also change before and after orthodontic treatment. With a lower radiation dose, CBCT has higher accuracy in evaluating the condylar position in patients with malocclusion who undergo orthodontic treatment, thus promoting further study of the mechanism of condylar position changes in patients with malocclusion in the future and providing more accurate and personalized guidance for patient treatment.

**【Key words】** condylar position; cone beam computed tomography; orthodontic treatment; malocclusion; temporomandibular joint; Angle's classification; vertical facial types; temporomandibular joint disorder syndrome

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颞下颌关节是口颌系统的一个重要组成部分,健康人群的下颌处于牙尖交错位(intercuspal position, ICP)时髁突平均位置基本位于关节窝的中央,此时颞下颌关节功能稳定。许多学者认为如果正畸治疗没有使髁突在关节窝内达到正确的位置,可能导致颞下颌关节症状,而髁突在关节窝内达到正确位置可缓解颞下颌关节紊乱病(temporomandibular disorder, TMD)<sup>[1]</sup>。因此了解错殆畸形患者的髁突位置对正畸治疗有重要意义。传统的髁突位置的评估方法是通过殆架来转移下颌位置,然后在髁突位置测量仪上进行测量。但此方法有一定的局限性,它依赖于操作者的熟练度,记录时间长、流程复杂、可重复性不高<sup>[2]</sup>。近年来随着影像学技术的发展,通过锥形束CT(cone beam computed tomography, CBCT)进行髁突位置的研究逐渐增多,本文就错殆畸形髁突位置的CBCT评估,及正畸治疗前后的错殆畸形髁突位置变化的相关研究作一综述。

## 1 髁突位置的CBCT量化测量方法

### 1.1 CBCT测量髁突位置的优势

髁突位置,即髁突相对于颞下颌关节窝的位置,是正畸学研究的重点。颞下颌关节的影像学检查有多种手段,包括二维X线检查、计算机辅助断层扫描(computed tomography, CT)、核磁共振(magnetic resonance imaging, MRI)和锥形束CT(CBCT)。CBCT提供了高分辨的三维图像,允许在真实维度中评估和量化面部骨组织,没有显著的放大与变形,提供了更高的解剖精度<sup>[3]</sup>。与二维X线片相比,CBCT对投照技术要求低,能准确记录实际关节间隙尺寸和关节窝中的髁突位置<sup>[4]</sup>。CBCT与CT相比成本更低,辐射剂量更低,采集时间更短<sup>[5]</sup>。与MRI相比,CBCT在显示硬组织成分

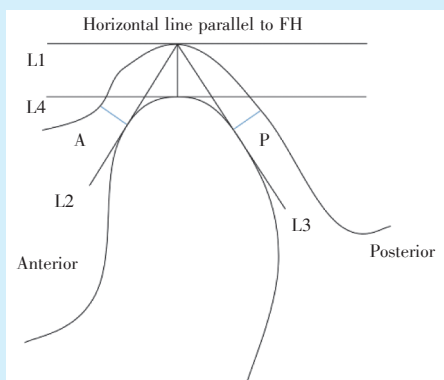
方面具有更高的可用性、更低的成本和更高的精度<sup>[6]</sup>。因此,CBCT在日常正畸中的应用有独特的优势。

### 1.2 髁突位置的CBCT测量方法

髁突位置特殊,主要由髁突与关节凹间的空间位置关系判定,实际上包括矢状面、水平面、和冠状面3个方向的位置关系。目前临床上讨论最多的是髁突的矢状面位置评估方法。颞下颌关节的CBCT图像需要在髁突最大横断面行水平轴校正,使髁突横轴与冠状面平行,然后选取过髁突最大横断面髁突横轴中点的矢状层面进行测量。国际研究常使用Cohlmi法研究髁突位置<sup>[7-8]</sup>:平行于FH平面画L1与关节窝最上点相切,过该切点作髁突前缘的切线L2、后缘的切线L3;前间隙值A为过前缘的切线的切点与关节窝前表面的距离,后间隙值P为过后缘的切线的切点与关节窝后表面的距离;直线4与直线1平行且与髁突的上缘相切,上间隙值为L1上的关节窝最上点与L4上的髁突最上点之间的距离(图1)。通过关节间隙指数(Joint Space Index, JSI)来判定髁突位置<sup>[9]</sup>。JSI是从最窄的前关节间隙和最窄的后关节间隙计算得出的,公式为:  $JSI = (P - A) / (P + A) \times 100$ 。JSI正值代表髁突前位,负值表示髁突后位,零值为髁突中性位。Vargas-Pereira<sup>[10]</sup>认为JSI的正常生理范围是-32.5至21.1,提示生理状态下髁突位置可以存在一定的前后向变化范围。

## 2 错殆畸形的髁突位置

错殆畸形的发生发展可能会影响颞下颌关节的形态与结构,而颞下颌关节的相关变化也可能影响错殆畸形的形成。许多研究显示,与一般人群相比,错殆患者的个体TMD发病率更高<sup>[11]</sup>。错殆畸形的患者往往表现出异常的咬合作用,导



FH: Frankfort horizontal plane; L1: the tangent line passing through the top point of the joint fossa and parallel to the FH plane; L2: the tangent line passing through the top point of the joint fossa as the anterior edge of the condyle; L3: the tangent line passing through the top point of the joint fossa as the posterior edge of the condyle; L4: the tangent line passing through the top point of the condyle and parallel to L1; the anterior joint space A: the distance between the tangent point of L2 passing through the anterior edge of the condyle and the anterior surface of the joint fossa; the posterior joint space P: the distance between the tangent point of L3 passing through the posterior edge of the condyle and the posterior surface of the joint fossa

Figure 1 Cohlmiä method—a common method used for the linear measurement of the sagittal condylar position

图1 矢状向髁突位置的线性测量常用法:Cohlmiä 法

致下颌骨移动时髁突负荷不均匀,因此其髁突位置可能与未出现错殆畸形的患者不同<sup>[12]</sup>。

### 2.1 矢状向分类错殆畸形患者的髁突位置

安氏分类与矢状向骨型分类在正畸学中应用广泛,二者具有内在联系,临床上经常将二者结合综合分析。国内外研究发现安氏Ⅱ类1分类、安氏Ⅰ类和安氏Ⅲ类的错殆患者髁突位置主要是居中和前位,而安氏Ⅱ类2分类错殆患者的髁突位置主要是居中和后位<sup>[13-14]</sup>。

2.1.1 骨性Ⅰ类、安氏Ⅰ类错殆 大部分骨性Ⅰ类、安氏Ⅰ类错殆患者髁突位置处于中位和前位<sup>[15]</sup>。Pullinger等<sup>[16]</sup>认为,髁突位于关节窝中位或前移位能较好地维持关节盘的稳定。

2.1.2 骨性Ⅱ类、安氏Ⅱ类1分类错殆 骨性Ⅱ类、安氏Ⅱ类1分类错殆患者髁突位置主要为前移位和中位,且前移位更多<sup>[13]</sup>。有研究显示骨性Ⅱ类、安氏Ⅱ类1分类错殆患者在生长发育高峰前髁突位置居后位较多,生长发育高峰后髁突位置居前位较多<sup>[17]</sup>。可能是Ⅱ类1分类深覆盖患者通过前伸下颌来行使前牙切道功能,此功能运动模式导致髁突位于前位者多。

2.1.3 骨性Ⅱ类、安氏Ⅱ类2分类错殆 骨性Ⅱ类、安氏Ⅱ类2分类错殆的髁突位置靠后,此类患者更易患TMD<sup>[18]</sup>。有学者认为此类错殆的髁突位置可能与前牙深覆殆有关,上颌前牙内倾造成的咬合干扰可能导致下颌功能性的后退,可能是其髁突位置靠后的原因,提示可以通过打开咬合进行Ⅱ类2分类患者错殆畸形的治疗<sup>[19]</sup>,使上下颌骨的关系得到改善。

2.1.4 骨性Ⅲ类、安氏Ⅲ类错殆 Ⅲ类患者关节髁突位于关节窝偏前位,关节上间隙小于安氏Ⅰ

类患者<sup>[13-14]</sup>。这可能是Ⅲ类错殆患者存在前牙反殆造成的咬合干扰,常导致下颌位置有功能性的前移,因此髁突位置偏前位。

### 2.2 下颌偏斜

下颌偏斜也是患者寻求正畸治疗的原因之一,其病因可能是骨性因素,也可能为是功能性因素。长期功能性的髁突移位最终会导致骨性的改建,有研究提出可根据下颌骨长度的对称性来区分偏颌患者,并发现下颌骨长度对称的偏颌患者偏斜侧髁突后移,对侧髁突前移,而下颌骨长度不对称患者组双侧髁突位置基本无差异<sup>[20]</sup>。Lv等<sup>[21]</sup>研究发现,骨性Ⅱ类伴下颌偏斜的患者,双侧髁突间隙基本无差异,但存在偏斜组髁突后间隙明显小于双侧对称组。Chen等<sup>[22]</sup>观察到单侧磨牙缺失的幼鼠下颌长期功能移位导致最终双侧髁突的变化。上述研究表明,在功能性偏颌时进行正畸治疗的干预,可能改建髁突位置,从而改善偏颌畸形。

### 2.3 垂直骨面型分类错殆畸形患者的髁突位置

2.3.1 低角错殆畸形 低角患者的髁突位置可能在矢状向的任意位置,前部、上部、后部关节间隙都有可能变窄<sup>[23]</sup>。Lin等<sup>[24]</sup>研究发现,Ⅱ类错殆低角型患者的髁突向下移位。也有研究显示,与均角组相比,低角组的髁突位置无明显矢状向变化<sup>[23]</sup>。

2.3.2 高角错殆畸形 高角患者最常见的是后关节间隙变窄和上关节间隙变窄<sup>[7, 25]</sup>。也有研究发现与均角组和低角组相比,高角患者的前关节间隙更大<sup>[26]</sup>。Lin等<sup>[24]</sup>发现,Ⅱ类错殆高角型患者的髁突向前、向上移位。与Ⅱ类低角相比,Ⅱ类高角的髁突前位更多,前关节间隙缩小,后关节间隙增



加,提示Ⅱ类高角病人可能更易发生TMD<sup>[15]</sup>。Chen等<sup>[27]</sup>发现与骨性Ⅰ类均角相比,Ⅲ类错殆高角型患者的髁突前、上、后间隙均变小,但前后位置变化无统计学意义。与矢状向分析相似的是,不同的研究结果存在较大的差异,有研究认为垂直向骨型与髁突位置间无相关性<sup>[28]</sup>。

### 3 正畸治疗对髁突位置的影响

正畸治疗调整错殆畸形患者的咬合关系时,需要维持正常的髁突位置,或者诱导髁突向稳定的方向移动,避免异常髁突位置的错殆畸形正畸治疗后髁突位置进一步异常。根据正畸治疗前的髁突位置,设计治疗方案,调整咬合,引导下颌向前或向后移动,使髁突在颞下颌关节窝内重建,减轻颞下颌关节不适的症状,提高舒适性和远期疗效<sup>[18]</sup>。

#### 3.1 儿童功能矫形治疗对髁突位置的影响

功能矫形矫治能治疗部分早期骨型错殆,使髁突在关节窝内发生较大移位。对安氏Ⅱ类的功能矫治,黄鑫琪等<sup>[29]</sup>Meta分析表明,Herbst功能矫治器的戴入可使髁突位置发生明显的前下移位,但停戴后髁突位置基本回到治疗前;Twin-Block的戴入也会使髁突向前下移位,治疗结束后1周髁突位置恢复至关节窝中位,治疗结束后1年髁突位可能有前移趋势。

对于安氏Ⅲ类的功能矫治,Hugh等<sup>[30]</sup>对Ⅲ类主动骨缝牵引器对颞下颌关节的短期影响进行了研究,发现患者经治疗髁突向后移动,治疗后关节前间隙增加,关节后间隙减小,髁突位由前移变为相对居中。相关功能矫形的髁突位置的长期随访暂时缺乏,这也是未来正畸学需要持续关注的重要问题。

#### 3.2 固定矫治、无托槽隐形矫治对髁突位置的影响

在固定矫治中,颌间牵引是一种常见的调整下颌位置的手段。研究表明,安氏Ⅱ类2分类患者正畸治疗后髁突位置有明显的前下移位<sup>[9]</sup>。固定矫正使用Ⅱ类牵引可能使关节窝内的髁突位置发生变化<sup>[31]</sup>。Danilova等<sup>[32]</sup>研究显示,伴TMD的Ⅱ类2分类患者进行正畸治疗后,双侧髁突向前移动至髁突中心位置,可有效预防正畸期间TMD症状。颞下颌的功能性紊乱不易在临床观察到,可能存在神经肌肉代偿。髁突位置的变化可能代表着颞下颌关节有功能性的紊乱,需要正畸医生注意。王超然等<sup>[33]</sup>用CBCT分析安氏Ⅲ类错殆畸形患者

治疗前后的髁突位置变化,Ⅲ类牵引正畸治疗后,髁突位置向后、向上移动,这与Ⅲ类牵引的有限元模拟分析的结果一致。

无托槽隐形矫治器技术是一种殆垫矫治器,使用时对髁突位置可能会产生一定的影响。Lin等<sup>[34]</sup>在使用隐适美治疗Ⅱ类错殆畸形患者时发现,髁突向前移位,下颌骨向后向下旋转,可能由于Ⅱ类牵引产生垂直向下颌磨牙的伸长和下颌位置前移。无托槽隐形矫治对髁突位置变化影响的研究尚不充足,可关注后续相关的研究。

#### 3.3 咬合板治疗对髁突位置的影响

正畸治疗中可能会使用到咬合板,特别是诊断伴有TMD的患者。Taut等<sup>[35]</sup>发现使用咬合板联合运动疗法治疗TMD时,髁突有向前移动的趋势,关节间隙指数增加。Derwich等<sup>[36]</sup>认为,JSI增加 $\geq 5$ 可认为是咬合板成功治疗TMD的指标。咬合板可改变下颌骨的位置,使咬合关系符合理想咬合关系<sup>[37]</sup>。

#### 3.4 正畸-正颌联合治疗对髁突位置的影响

正畸-正颌联合治疗可以治疗严重的骨性牙颌面畸形,但术后可能出现髁突移位及髁突进行性吸收,髁突位置的变化可能导致颞颌关节出现TMD症状<sup>[38]</sup>。因此,正颌手术对髁突位置的影响也是一个研究热点<sup>[39]</sup>。Podčernina等<sup>[40]</sup>对Ⅲ类患者正颌手术后的髁突位置进行了CBCT评估,发现上颌单颌和双颌手术组在术前、术后或1年随访时的髁突位置无显著差异。髁突移位常被认为是导致术后复发的因素之一,术后位移值的差异以及恢复到原始位置的运动可能与软组织和肌肉的张力和适应有关。正颌术前对髁突位置进行影像学评估,在髁突稳定的情况下进行正颌手术,可有效降低髁突吸收的风险。

总之,错殆畸形患者的髁突位置与制定正畸治疗方案紧密相关。使用CBCT可以较低的辐射剂量和更高的精确度在正畸中评价错殆畸形的髁突位置。髁突在下颌关节盘的帮助下维持与关节窝的连接,当存在TMD时,在条件允许时可拍摄MRI,可以更全面了解颞下颌关节内的情况,包括盘突关系。CBCT影像学检查也有其局限性,如正中关系位不等于最大牙尖交错位时,它无法记录两种咬合状态的差异,不能全面地展示关节的功能状态;但其检查直观、精确、易掌握,方便将错殆畸形的髁突位置纳入正畸治疗方案的制定。

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