

骨支抗前方牵引矫治生长发育期骨性Ⅲ类错殆畸形的研究进展

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[摘要] 面罩前方牵引装置是矫治生长发育期伴上颌发育不足的骨性Ⅲ类错殆畸形的常用矫治器。近年来,骨支抗前方牵引技术包括骨支抗联合面罩前方牵引和骨支抗联合Ⅲ类颌间牵引的应用显著提高了上颌骨前移的骨性效应,减少了牙齿代偿,能够有效改善面中部凹陷,在替牙列晚期和恒牙列早期的患者中表现出良好的临床效果。此外骨支抗联合Ⅲ类颌间牵引还对控制垂直向高度表现出一定优势。本文对骨支抗前方牵引的类型选择、是否需要联合横向扩弓、治疗时机以及长期疗效等方面的研究进展进行综述,并探讨其未来的发展方向。

[关键词] 骨支抗; 前方牵引; 上颌发育不足; 骨性Ⅲ类错殆畸形

[中图分类号] R783.5 **[文献标志码]** A **[doi]** 10.7518/gjkq.2026008



本文链接

OSID码

Development of bone-anchored maxillary protraction for the orthopedic treatment of class Ⅲ malocclusion in growing patients

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[Abstract] The facemask is the common appliance for the treatment of skeletal class Ⅲ patients with maxillary retrusion. Bone-anchored maxillary protraction (BAMP) appliances have recently been used to overcome the limitations of tooth-borne appliances in the interceptive treatment of class Ⅲ malocclusions. BAMP has demonstrated promising initial results, attributed to its potential to offer great skeletal changes with less unwanted displacement of dentition during the late mixed dentition and early permanent dentition stages. BAMP therapy techniques significantly improve the soft tissue profile, which leads to an improvement of the concave profile. Moreover, BAMP protocol with class Ⅲ elastics has shown certain advantages in controlling vertical skeletal pattern. This work aims to review the research progress in the selection of BAMP protocol, necessity of combining transverse arch expansion, optimal treatment timing, and long-term treatment outcomes and explore its future development.

[Key words] bone anchorage; maxillary protraction; maxillary hypoplasia; skeletal class Ⅲ malocclusion

上颌前方牵引是矫治儿童及青少年伴上颌发育不足的骨性Ⅲ类错殆畸形的有效方法^[1], 传统

牙支抗式面罩前方牵引不可避免会产生上颌切牙唇倾、上颌磨牙近中移动并伸长、下颌切牙舌倾等不利牙性效应,而上颌骨的前移量有限。近年快速发展的骨支抗前方牵引技术(bone-anchored maxillary protraction)^[2-3]通过将微种植体(mini-implants)或微钛板(miniplates)置入颌骨,实现了

[收稿日期] 2024-12-24; **[修回日期]** 2025-03-07

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矫形力的高效传递,显著提升了上颌骨的前移效果,极大地改善了患者的面中部凹陷。这一技术革新不仅避免了传统前方牵引矫治器以牙齿作为支抗而产生的牙性代偿,更能有效地实现上颌骨前移。然而现有研究在骨支抗装置置入位点和牵引方式的选择、是否联合横向扩弓、治疗时机以及长期疗效与潜在风险等方面存在诸多争议。本文拟围绕上述关键争议问题,梳理近年来有关BAMP的循证医学进展与生物力学研究突破,以期为临床决策提供理论依据。

1 骨支抗前方牵引的类型

临床上骨支抗前方牵引的方式通常有两种类型:骨支抗联合面罩前方牵引和骨支抗联合Ⅲ类颌间牵引。前者在上颌特定区域置入微种植体,通过口外前牵引面罩对上颌骨施加向前的牵引力;后者通过在上颌骨后部和下颌骨前部的左右两侧分别置入微种植体,利用口内颌间Ⅲ类牵引前移上颌骨。

1.1 骨支抗联合面罩前方牵引

一般上颌骨有3个常见的骨支抗植入区域,以下是不同植入区域骨支抗联合口外面罩前牵上颌骨的临床研究对比。

1.1.1 梨状孔外缘(鼻外侧壁) 选择上颌前部梨状孔外缘的一个主要原因是施加的牵引力可以尽可能靠近鼻上颌复合体的阻抗中心。上颌骨的鼻外侧壁是实现鼻颊丰满度、眶下区膨隆和改善软组织轮廓的最合适的解剖部位,在此处牵引可达到类似Lefort II型手术的效果^[4]。多项研究^[5-9]评估鼻外侧壁处骨支抗联合面罩前牵引的疗效发现,治疗后患者上颌骨鼻旁区、眶部显著前移。由于上颌前部梨状孔区植入位点距离牙根或恒牙胚较近,存在较大的安全风险,借助锥形束CT在上颌骨前部近上前牙根尖区依据患者骨组织表面形态、骨皮质厚度和牙根分布位置设计置入个性化钛板,可显著降低手术创伤并规避重要解剖结构损伤^[10]。

2005年Liu等^[11]提出使用经缝牵张成骨术(trans-sutural distraction osteogenesis, TSDO)治疗重度面中部发育不全,通过梨状孔侧缘置入牵引钩配合口外面罩行前方牵引,在4例青少年患者(含3例唇腭裂患者)实现了平均8 mm的面中部前移量,该技术对未完全钙化的颅面骨缝施加拉力以促进骨生长,避免了传统截骨式牵张成骨

(distraction osteogenesis, DO)的创伤风险。为进一步优化力学效应,2015年Tong等^[12]改良了经缝牵引装置系统,采用颅外固定牵张成骨器(rigid external distractor, RED),以颅骨为支抗,联合镍钛记忆合金弹簧施加牵引力,可避免面罩牵引反作用于颞部而引起的下颌骨顺时针旋转。该项技术目前已广泛应用于生长发育期上颌发育不足的唇腭裂患者^[13]。对于较严重的面中部发育不全患者,也可以在青春发育期进行TSDO从而获得较满意的疗效。

1.1.2 颧牙槽嵴区 上颌颧牙槽嵴区因其骨质厚密的解剖特性成为正畸骨支抗植入的理想位点。Cha等^[14]在8岁患者的双侧颧牙槽嵴区置入钛板,通过每侧2.94~3.92 N的面罩牵引力实现A点(上牙槽座点)8.1 mm的矢状向前移。Ge等^[15]在骨性Ⅲ类患者的同区域植入微种植体,发现每侧1.96~2.45 N的小牵引力即可获得与传统面罩前牵引相当的上颌骨前移效果,且有效规避了上颌切牙唇倾的不良作用。该研究表明植入颧牙槽嵴的微种植体可作为上颌骨前方牵引的稳定支抗来源,兼具微创性以及椅旁操作的便捷性。

1.1.3 上腭部 上腭部被覆不易感染的角化黏膜,具有良好的骨质条件,此外接触牙根或损伤其他重要解剖结构的可能性相当小。充足的可用空间使得临床医生可以选择更大直径的种植体,且无需翻瓣手术、成功率高^[16]。Elsaharty等^[17]采用贴近腭部形态的C形钛板配合微种植钉实施前牵引,使7~9岁患者的上颌骨长度(Co-A)平均增长(2.60±0.75) mm,但该装置因缺乏扩弓功能难以应对合并牙弓狭窄的病例。Wilmes等^[18]研发的Hybrid-Hyrax扩弓器通过在腭中缝两侧植入微种植体,在实现骨性扩弓的同时提供强支抗,有效防止前牵引过程中的牙弓前移。值得注意的是,虽然Ngan等^[19]发现该装置与传统Hyrax联合面罩前牵引的上颌前移量的差异无统计学意义,但Choi等^[16]通过使用11~13 mm长螺钉穿透双层骨皮质,成功获得2.55 mm的A点矢状向前移量,是对照组牙支抗前方牵引效果(1.12 mm)的2倍,其认为微种植体的植入深度影响上颌骨前移的效果。

1.2 骨支抗Ⅲ类颌间牵引

de Clerck等^[20-21]将颌间弹性牵引施加在生长发育期骨性Ⅲ类患者口内位于上颌颧牙槽嵴和下颌侧切牙与尖牙间的微钛板上,使用适度的连续牵引力(初始单侧0.98 N逐步增至2.45 N)实现了A

点平均5.2 mm的矢状向前移,且避免了下颌骨的顺时针旋转。在此基础上,Manhães等^[22]针对12岁恒牙早期的骨性Ⅲ类高角患者,利用Hybrid-Hyrax扩弓器与下颌骨前部的微型螺钉进行Ⅲ类颌间牵引以前移上颌骨,上颌骨有效长度(Co-A)增加4.5 mm,反殆解除,下颌平面角减小,软组织容貌改善。不容忽视的是,相关研究^[23]提示颌间牵引治疗后,颞下颌关节窝的前壁骨质增生、后壁骨质吸收,与髁突的向后移位密切相关。故对于有颞下颌关节退行性病变潜在风险的患者需严格把控适应症。

Elnagar等^[24]和Willmann等^[25]对骨支抗联合面罩前牵引和骨支抗联合Ⅲ类牵引的疗效进行了比较,结果显示:两者均能促进上颌骨前移,有效矫治Ⅲ类颌间关系,改善面中部凹陷,而Ⅲ类牵引在控制垂直高度方面优势明显,还能避免面罩颞兜对下前牙的舌向作用力。这使其成为高角患者的首选治疗方法。此外一项比较了5种不同前牵引方式的网状Meta分析^[26]显示骨支抗联合Ⅲ类牵引在控制牙性代偿和垂直高度上效果最好,支持上述结果。

2 骨支抗前方牵引的牵引部位和角度

三维有限元分析是一种有效的研究不同牵引力方向对颅颌面骨骼的生物力学效应的方法^[27],骨支抗前方牵引的三维有限元研究显示不同牵引部位与牵引角度对颌骨的运动模式具有不同影响。

就牵引部位而言,在颞下嵴与鼻外侧壁区与咬合平面行前下30°牵引的对比研究^[28]显示,前者能产生更高的上颌骨缝应力值并引发鼻颌复合体逆时针旋转,而鼻外侧区可降低旋转趋势,实现上颌骨前部整体平移及中部扩张。进一步研究指出在颞牙槽嵴区与咬合平面呈20°角牵引能实现颅上颌复合体平移^[29];而腭部骨支抗因应力分布范围更广,可产生更强的向前位移效果^[30]。针对牵引角度的选择,研究^[31]表明应根据临床特征进行差异化设计:在上颌骨前部牵引时,深覆殆患者推荐与Frankfort平面呈0°~30°牵引,正常覆殆适用40°牵引,开殆倾向者宜采用50°~60°。Shyagali等^[32]三维评估了骨支抗Ⅲ类颌间牵引联合上颌横向扩弓和后牙殆垫的效果,结果显示前牵引治疗后上颌骨和下颌骨以逆时针旋转向后移位,并提出此种治疗模式更适用于骨性Ⅲ类高角患者。而

Ⅲ类牵引的生物力学效应随牵引角度的增大而衰减,建议尽可能减小与咬合平面夹角以提高上颌骨骨性前移的效果^[33]。

由于有限元模型、骨支抗放置位置、参考平面的选择以及分析指标的不同,既往研究在上颌前方牵引的结果上呈现出差异性。在临床运用过程中,应依据患者骨支抗的具体位置以及垂直骨面型来确定上颌骨牵引的方式。

3 骨支抗前方牵引是否需要联合横向扩弓

在文献中有一个普遍观点,即无论是否存在牙弓横向发育不足,均通过上颌快速扩弓(rapid maxillary expansion, RME)松解上颌骨的周围骨缝以促进前方牵引,但近年来多项研究^[34-35]提示伴或不伴上颌扩弓,均可达成上颌骨的前移。Miranda等^[36]比较了是否联合扩弓进行骨支抗Ⅲ类牵引的临床疗效,结果显示单纯颌间牵引能获得更显著的上颌骨前移量。此外, Park等^[37]学者运用三维有限元分析法对微种植体辅助上颌快速扩弓(micro-implant assisted rapid palatal expansion, MARPE)对前方牵引所产生的作用展开了对比研究,研究结果显示:MARPE组模型应力主要集中在微种植体植入的腭中缝区域,能有效地打开腭中缝,但上颌骨的前移幅度却不如单纯面罩前牵引。由此可见,RME促进上颌前方牵引的效果尚未能获得足够肯定的证据。

2005年, Liou^[38]引入了在上颌前牵引的同时进行交替快速上颌扩弓和缩弓(alternate rapid maxillary expansions and constrictions, Alt-RAMEC)的方案,其基本原理是进一步分离环上颌骨缝,促进上颌骨向前平移。该方案的疗效最初在腭裂患者中得到证明。Liou等^[39]观察到经Alt-RAMEC/面罩治疗后A点平均前移5.8 mm,约为RME/面罩组的2倍。2020年的一项Meta分析^[40]表明:Alt-RAMEC/面罩在改善矢状向关系方面可获得与骨支抗前方牵引相似的效果。Kathem等^[41]将Alt-RAMEC与骨支抗牵引装置联合使用有效地纠正了青少年Ⅲ类患者的矢状向差异,成功实现上颌骨前移达8 mm。Ergul等^[42]研究得出相似结论,但另外指出前方牵引的支抗比选择扩弓方法(RME或Alt-RAMEC)更为关键。Alt-RAMEC配合骨支抗前方牵引似乎可以短时间内改善颌骨矢状向关系、获得明显的软硬组织改变,但由于当前研究缺乏

有效对照组,上述结论尚有待更多高质量的临床随机对照研究进一步验证。

对于上颌骨宽度正常的骨性Ⅲ类错殆患者,联合扩弓治疗并不是必要的。值得注意的是上颌骨发育不全是Ⅲ类错殆畸形的重要病因,上颌发育不全不仅影响前后维度,还影响垂直和横向维度。因此,当上颌牙弓宽度发育不足时,上颌扩弓与骨支抗前方牵引仍需同步进行^[43]。

4 骨支抗前方牵引的治疗时机

骨支抗前方牵引的治疗时机需综合考虑颌骨发育特征及患者依从性。对于10岁以下低龄患者,由于牙槽骨高度不足^[44-45]、颌骨密度较低,易出现微种植体稳定性欠佳,加之配合度管理困难,通常不建议实施该疗法^[21]。近期众多临床研究^[6-7,9,14,46-51]已成功地将在骨支抗前方牵引应用于替牙列晚期及恒牙列早期(CS3期)。在此阶段进行治疗可达到在利用剩余生长潜力前移上颌骨的同时,降低矫治后下颌骨追赶性生长带来的复发可能性^[52]。此外置入的微种植体还可作为后期牙齿矫正的支抗来源,而建立尖窝相对的完善咬合关系也有利于矫治效果的稳定^[53]。

5 骨支抗前方牵引的长期疗效

目前关于骨支抗前方牵引长期疗效的研究相对较少,现有研究对其长期稳定性均表示肯定。Lee等^[7]对上颌发育不足的骨性Ⅲ类患者的长期疗效进行评估,追踪观察至18岁,结果显示面罩前方牵引治疗结束,在过青春生长期后骨支抗组的颌间关系维持得更好,表现出比传统组更有利的牙列骨骼变化和更高的临床成功率。Jang等^[9]对行鼻侧壁微钛板前牵引治疗的17例患者追踪6.8年后发现,前方牵引后面中部的饱满度在青春期后也得到维持。Meazzini等^[51]使用骨支抗Ⅲ类牵引联合Alt-RAMEC获得上颌骨平均向前移动5.4 mm,在超过6年的随访观察后也未见明显复发。

现有研究^[54-56]在评估Ⅲ类错殆畸形治疗稳定性中提出治疗结束后下颌骨生长的量和方向是Ⅲ类错殆患者能否成功治疗的主要关键。为有效防止复发,在正畸治疗过程中实施适度的过矫治策略十分必要,这一举措旨在为下颌骨后续的生理性生长预留充足空间。此外基于个体生长发育的差

异性,临床上还应根据患者颌骨的剩余生长潜力选择合适的个性化保持措施。

6 小结与展望

随着骨支抗的引入,临床医生对骨支抗前方牵引的认知和应用不断深入,上颌前方牵引的有效年龄范围已经从乳牙列、早期混合牙列期扩大到年轻恒牙列期。对于错过传统面罩前方牵引治疗时机或治疗不成功的患者,骨支抗前方牵引仍是一种有效的方法,其在增加骨性效应、减少牙性代偿方面相比传统牙支抗前方牵引具有显著优势^[57]。此外骨支抗联合Ⅲ类颌间牵引无需复杂头帽装置,可实现24 h持续牵引,并且能更好地控制垂直向高度,为生长发育期骨性Ⅲ类高角复杂病例提供了有效治疗方案。

当代数字化技术不断发展,BAMP的发展呈现精准化、微创化的特点,通过数字化印模、3D打印和动态力学模拟,可在锥形束CT指导下实现个性化钛板及导板的设计^[58-59]。由于需要进行侵入性手术,以及存在如微种植体松动等不良作用,提高骨支抗前方牵引的安全性和稳定性是未来研究的挑战。目前关于交替快速上颌扩弓和缩弓能否增强前牵引效果的结论存在争议,骨支抗前方牵引的长期疗效也仍需进一步观察研究。另外,关于骨支抗前方牵引的矫治时机以及实施的具体方式还需要通过丰富的临床实践来进行更深入的验证。

利益冲突声明:作者声明本文无利益冲突。

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(本文编辑 吴爱华)