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·临床研究·

舌系带过短与下颌骨发育受限及下前牙拥挤的相关性研究

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【摘要】　目的　研究舌系带过短与下颌骨矢状向发育受限及下前牙排列异常的关联性，为临床提供参考。**方法**　本研究已通过医院医学伦理委员会批准，选取2024年1月至2025年1月于佛山市禅城区人民医院就诊的7~13岁舌系带过短患者（病例组，n=50）和舌系带正常人群（正常组，n=50）。临床检查舌系带长度并进行Kotlow分型和简化Hazelbaker舌系带功能评估工具（Hazelbaker assessment tool for lingual frenulum function，HATLFF）评分，拍摄头颅侧位片测量ANB角和SNB角以及下颌总长度（Co-Gn），模型分析下前牙拥挤度，对两组数据进行对比分析。Pearson分析舌系带长度、简化HATLFF评分与ANB角、SNB角、Co-Gn和下前牙拥挤度的相关性。受试者工作特征（receiver operating characteristic，ROC）曲线分析舌系带过短对下颌骨发育和下前牙拥挤的诊断价值。**结果**　舌系带过短与下颌骨发育受限和下前牙拥挤显著相关（P<0.05）。病例组舌系带长度、简化HATLFF评分、SNB角和Co-Gn均显著小于正常组，ANB角和下前牙拥挤度均显著大于正常组（P<0.05）。舌系带长度、简化HATLFF评分与ANB角和下前牙拥挤度呈负相关，与SNB角和Co-Gn均呈正相关（P<0.05）。ROC曲线分析显示，简化HATLFF评分、舌系带过短诊断下颌骨发育受限和下前牙拥挤的曲线下面积均大于0.700，具有良好的诊断价值。**结论**　舌系带过短与下颌骨发育受限、下前牙拥挤具有显著相关性。

【关键词】　舌系带过短；　下颌骨发育；　下前牙拥挤；　颌面发育；　HATLFF评分；　头颅侧位片；　牙模
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Correlation study between ankyloglossia and mandibular development and lower anterior crowding

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【Abstract】　Objective　To study the association between ankyloglossia and sagittal mandibular development impairment as well as lower anterior dental crowding, providing a reference for clinical practice. **Methods**　This study was approved by the hospital's Medical Ethics Committee. A total of 100 patients aged 7-13 years were enrolled from January 2024 to January 2025, comprising 50 patients with ankyloglossia (case group) and 50 individuals with a healthy lingual frenulum (normal group). Clinical examination was performed to assess lingual frenulum length, Kotlow classification, and the simplified Hazelbaker assessment tool for lingual frenulum function (HATLFF) score. Cephalometric radio-

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graphs were used to measure the A-point-nasion-B-point (ANB) angle, sella-nasion-B-point (SNB) angle, and mandibular total length (condylion-gnathion [Co-Gn]). Dental cast analysis was conducted to evaluate lower anterior teeth crowding. Data were compared between the two groups. Pearson correlation analysis was used to examine the relationships between the lingual frenulum length, simplified HATLFF score, and cephalometric/dental cast parameters (ANB, SNB, Co-Gn, lower anterior crowding). The diagnostic value of ankyloglossia for mandibular development and lower anterior crowding was analyzed using receiver operating characteristic (ROC) curves. **Results** Ankyloglossia was significantly associated with mandibular development and lower anterior crowding (P<0.05). The case group showed significantly lower values for the lingual frenulum length, simplified HATLFF score, SNB angle, and Co-Gn, while the ANB angle and lower anterior crowding index were significantly higher compared to the normal group (P<0.05). The lingual frenulum length and simplified HATLFF score were negatively correlated with the ANB angle and lower anterior crowding index, and positively correlated with the SNB angle and Co-Gn (P<0.05). ROC curve analysis indicated that the area under the curve (AUC) for the simplified HATLFF score, and ankyloglossia in predicting mandibular development deficiency and lower anterior crowding was greater than 0.700, demonstrating good diagnostic value. **Conclusion** A significant correlation exists between ankyloglossia and both mandibular development deficiency and lower anterior crowding.

【Key words】 ankyloglossia; mandibular development; lower anterior crowding; craniofacial development; HATLFF score; cephalometric radiograph; dental cast

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舌系带过短是一种常见的先天性口腔发育异常，在新生儿中的发生率约为4.2%~10.7%，其特征为舌系带附着异常导致舌体运动受限，是导致婴幼儿哺乳、发音等功能困难的重要因素之一[1]。近年来，舌系带过短与颌面部发育的关联日益受到关注。研究显示，舌系带过短不仅与错颌畸形存在显著关联[2]，还显著增加下颌切牙拥挤的发生率，严重者甚至阻碍下颌骨正常生长[3]。Sepet等[4]通过定量分析证实，舌系带长度与下颌切牙不规则程度呈显著正相关。这些研究虽已初步揭示了舌系带过短与颌面发育异常的临床关联，但其分析多集中于现象观察与形态测量，尚未深入整合舌系带的形态特征与舌体运动功能进行系统性评估。例如，Beckmann等[5]研究主要基于解剖学观察，未能结合功能维度，缺乏将Kotlow解剖分型与简化Hazelbaker舌系带功能评估（Hazelbaker assessment tool for lingual frenulum function，HATLFF）评分[6]相结合的系统分析，从而限制对舌系带过短与下颌骨发育异常及下前牙拥挤之间关联的深入揭示。据此，本研究联合应用Kotlow分型与简化HATLFF评分，构建形态与功能整合的诊断框架，系统探讨舌系带过短与下颌骨发育受限、下前牙拥挤的关联性，以期为口腔功能与形态发育的交互机制提供新的临床证据。

1　资料和方法

1.1　临床资料

本研究样本量估算以“舌系带过短”作为主要观察指标进行。参考既往研究[7-8]及前期实验数据，预计“舌系带过短”的发生率在4.2%~32.1%。使用PASS 2021软件进行分析，基于两样本率比较公式，在α=0.05（双侧）、检验效能（1−β）=0.80的条件下，每组最小样本量约为32例，选取2024年1月至2025年1月于佛山市禅城区人民医院就诊的7~13岁舌系带过短病例50例，记为病例组。正常组为同期本院7~13岁舌系带正常人群50例。病例组和正常组患者及监护人知情并同意获得医院伦理委员会批准（审批号：伦审2023第031号），并依照《赫尔辛基宣言》制定的伦理准则进行研究。

病例组纳入标准：①年龄7~13岁；②经舌系带过短Kotlow分型方法诊断，系带附着点到舌尖的距离（舌系带长度）<16 mm[9]，见表1；③舌系带功能评估简化HATLFF量表评分≤4分[10]（表2）。

正常组纳入标准：①年龄7~13岁；②舌系带

表1　舌系带过短Kotlow分型方法[11]

Table 1　Kotlow typing method for ankyloglossia[11]

Type	Tongue-tie
Healthy	≥16 mm
Type Ⅰ (mild)	12 mm≤Tongue-tie<16 mm
Type Ⅱ (moderate)	8 mm≤Tongue-tie<11 mm
Type Ⅲ (severe)	3 mm≤Tongue-tie<7 mm
Type Ⅳ (complete)	<3 mm

无解剖及功能异常。

病例组和正常组排除标准：①舌系带成形术史；②拔牙（除第三磨牙）以及正畸治疗史、颌面部外伤；③先天性、系统性和综合征性疾病；④牙周病；⑤骨龄未处于生长发育高峰期，颞下颌关节检查出现明显功能或结构异常（如弹响、疼痛、张口受限、偏斜等）；⑥下颌中切牙不完好，缺失牙，延伸至近远中面的修复体及釉质缺损（除第三磨牙）；⑦畸形牙、多生牙；⑧病例资料不完善。

1.2　头颅侧位片分析

病例组和正常组头部保持自然头位，头颅X射线机标准头颅侧位片体位（Frankfort平面水平），牙齿自然咬合，标准焦片距150 cm。曝光条件：电压60～80 kV，电流10～20 mA，曝光时间0.5～1.2 s。X线束垂直于头颅矢状面，对准外耳道上方约2 cm。Dolphin Imaging 11.8软件计算上齿槽座点-鼻根点-下齿槽座点（A-point-nasion-B-point，ANB）角和颅底-鼻根点-下齿槽座点（Sella-nasion-B-point，SNB）角以及线性测量下颌总长度（condylion-gnathion，Co-Gn），重复测量3次取平均值，组内相关系数>0.85。观察病例组和正常组是否出现下颌骨发育受限，下颌骨发育受限诊断标准：头颅侧位片显示凸面型，上颌骨位置正常，下颌骨后缩，ANB角>5°[13]，SNB角<78°[14]；磨牙及尖牙均为远中关系，前牙深覆盖>5 mm[15]。

1.3　牙模分析

病例组和正常组制备传统石膏牙模。选择牙模下颌前牙区，使用游标卡尺（精度0.1 mm）测量单颗牙的最大近远中径，即接触点最凸处间距，记录左右两侧尖牙、侧切牙、中切牙的近远中宽度，以上数据之和为下前牙牙冠总宽度（mm）。标记左侧尖牙远中接触点到右侧尖牙远中接触点为测量区间，采用分段测量法，先沿舌侧龈缘弧度测量前段（切牙区），后沿舌侧牙弓轮廓测量后段（尖牙区），将切牙区长度和尖牙区长度相加所得数据为下前牙可用牙弓长度。下前牙拥挤度/mm=下前牙牙冠总宽度-下前牙可用牙弓长度。观察病例组和正常组是否出现下前牙拥挤，下前牙拥挤诊断标准：下前牙拥挤度>1 mm[16]。

1.4　统计学方法

采用SPSS 28.0软件对临床资料进行统计学分析。计量资料组间比较以t检验完成。计数资料组间比较采用χ^2检验。使用GraphPad Prism 8.0软件对计量资料进行Pearson相关性分析，相关系数r趋近于+1表示两个变量正相关，r趋近于-1表示两个变量负相关，r趋近于0表示两个变量无相关性[17]。进行受试者工作特征（receiver operating curve，ROC）曲线分析，计算ROC曲线下面积（area under the ROC curve，AUC），评估舌系带过短对下颌骨发育受限和下前牙拥挤的诊断价值。P<0.05为差异具有统计学意义。

2　结　果

2.1　舌系带过短对下颌骨发育受限和下前牙拥挤的影响

基线两组性别和年龄比较差异无统计学意义

表2　简化HATLFF评分标准[12]

Table 2　Simplified HATLFF scoring rubric[12]

Tongue movement pattern	Tongue movement	Score
Lateralization	None	0
	Body of tongue but not tongue tip	1
	Complete	2
Lift of tongue	Tip stays at alveolar ridge or rises to mid-mouth only with jaw closure	0
	Only edges to mid-mouth	1
	Tip to mid-mouth	2
Extension of tongue	Neither of above, or anterior or mid-tongue humps	0
	Tip over lower gum only	1
	Tip over lower lip	2

HATLFF: Hazelbaker assessment tool for lingual frenulum function

（均P>0.05）。下颌骨发育受限和下前牙拥挤与舌系带过短显著相关，差异具有统计学意义（P<0.05）。病例组舌系带长度、简化HATLFF评分、SNB角和Co-Gn指标显著小于正常组（P<0.05），而病例组ANB角和下前牙拥挤度显著大于正常组（P<0.05）。正常组下颌骨发育受限和下前牙拥挤的占比分别为4.00%和8.00%，而病例组下颌骨发育受限和下前牙拥挤的占比均为44.00%（表3）。

表3　舌系带过短患者与舌系带正常人群各指标比较

Table 3　Comparison of various indicators between patients with ankyloglossia and individuals with healthy lingual frenulum　$\bar{x}\pm s$

Index	Normal group (n=50)	Case group (n=50)	t/χ^2	P
Sex [n (%)]			1.461	0.227
Male	25(50.00)	31(62.00)		
Female	25(50.00)	19(38.00)		
Age/ years	10.28±1.80	10.32±1.95	−0.107	0.514
Tongue-tie/mm	17.03±0.63	9.01±4.18	13.439	<0.001
Simplified HATLFF score	6.00±0.00	3.32±0.84	22.461	<0.001
Mandibular retrognathia [n (%)]			21.930	<0.001
Yes	2(4.00)	22(44.00)		
No	48(96.00)	28(56.00)		
ANB Angle/°	2.17±1.35	4.84±1.59	−9.070	<0.001
SNB Angle/°	80.01±1.27	77.29±2.38	7.131	<0.001
Co-Gn/mm	93.60±6.97	86.26±7.92	4.920	<0.001
Lower anterior crowding [n (%)]			16.840	<0.001
Yes	4(8.00)	22(44.00)		
No	46(92.00)	28(56.00)		
Crowding degree of lower anterior teeth/mm	0.64±0.65	2.59±2.48	−5.359	<0.001

HATLFF: Hazelbaker assessment tool for lingual frenulum function. ANB: A-point-nasion-B-point. SNB: sella-nasion-B-point. Co-Gn: condylion-gnathion. Normal group: individuals with healthy lingual frenulum. Case group: patients with ankyloglossia

其中，Kotlow分型Ⅰ型（轻度）舌系带长度、简化HATLFF评分和SNB角显著小于正常组（均P<0.05），ANB角显著大于正常（P<0.05），两组Co-Gn和下前牙拥挤度比较差异无统计学意义（均P>0.05）；Ⅱ型（中度）舌系带长度、简化HATLFF评分、SNB角和Co-Gn显著小于Ⅰ型（轻度）（均P<0.05），ANB角和下前牙拥挤度显著大于Ⅰ型（轻度）（均P<0.05）；Ⅲ型（重度）舌系带长度、HATLFF评分、SNB角和Co-Gn显著小于Ⅱ型（中度）（均P<0.05），ANB角和下前牙拥挤度显著大于Ⅱ型（中度）（均P<0.05）；Ⅳ型（完全）舌系带长度和简化HATLFF评分显著小于Ⅲ型（重度）（均P<0.05），下前牙拥挤度显著大于Ⅲ型（重度）（均P<0.05），两组ANB角、SNB角和Co-Gn比较差异无统计学意义（均P>0.05）。随着Kotlow分型严重程度增加（Ⅰ型→Ⅳ型），下颌骨发育受限（SNB角和Co-Gn值递减，ANB角递增）及下前牙拥挤度逐渐加重，提示舌系带过短的严重程度可能与颅颌面畸形呈正相关（表4）。

2.2　舌系带过短与下颌骨发育受限和下前牙拥挤的相关性

舌系带过短与ANB角和下前牙拥挤度呈负相关，与SNB角和Co-Gn呈正相关（P<0.05）（图1）。

舌系带过短患者简化HATLFF评分与ANB角和下前牙拥挤度呈负相关，与SNB角和Co-Gn呈正相关（P<0.05）（图2）。

2.3　舌系带过短对下颌骨发育受限和下前牙拥挤的诊断价值

简化HATLFF评分和舌系带过短诊断下颌骨发育受限和下前牙拥挤的曲线下面积均大于0.700，说明准确度较好，具有良好的诊断价值（表5、图3）。

3　讨　论

3.1　舌系带过短是下颌骨发育受限、牙列发育异常的重要风险因素

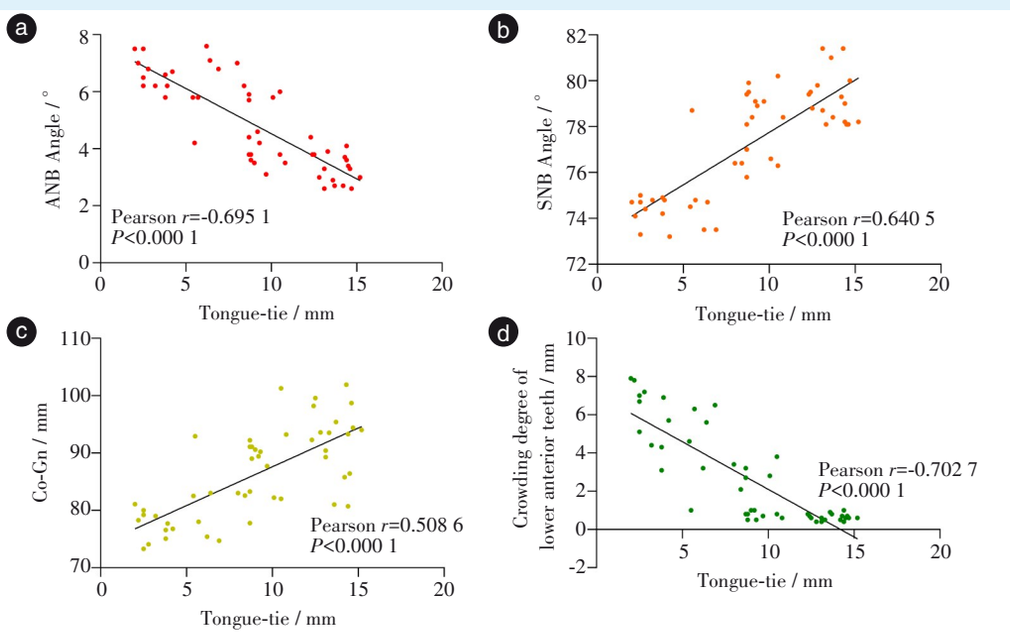
舌系带过短作为常见的口腔发育异常，其与颅颌面形态发育的关系逐渐受到学界关注。舌系

表4　舌系带过短Kotlow分型对颌骨和牙列的影响

Table 4　Effects of Kotlow type for ankyloglossia on jawbone and dentition　$\bar{x}\pm s$

Kotlow type	n	Tongue-tie/ mm	Simplified HATLFF score	ANB angle /°	SNB ANgle/°	Co-Gn/mm	Crowding degree of lower anterior teeth/mm
Healthy	50	17.03±0.63	6.00±0.00	2.17±1.35	80.01±1.27	93.60±6.97	0.64±0.65
Type I (mild)	17	13.71±0.90①	4.00±0.00①	3.34±0.56①	79.26±1.14①	92.26±6.09	0.64±0.17
Type Ⅱ (moderate)	16	9.19±0.83②	3.50±0.73②	4.68±1.22②	78.09±1.46②	87.92±5.80②	1.59±1.18②
Type Ⅲ (severe)	11	5.00±1.26③	2.73±0.65③	6.25±0.89③	74.69±1.47③	79.25±5.30③	4.69±1.77③
Type Ⅳ (complete)	6	2.42±0.28④	2.00±0.00④	6.92±0.53	74.37±0.61	77.67±3.22	6.95±1.02④
F		973.300	394.300	49.810	59.420	18.620	101.700
P		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

HATLFF: Hazelbaker assessment tool for lingual frenulum function. ANB: A-point-nasion-B-point. SNB: sella-nasion-B-point. Co-Gn: condylion-gnathion. ①Compared with healthy, P<0.05. ②Compared with type I, P<0.05. ③Compared with type Ⅱ, P<0.05. ④Compared with type Ⅲ, P<0.05



ANB: A-point-nasion-B-point. SNB: sella-nasion-B-point. Co-Gn: condylion-gnathion. a: the correlation between tongue-tie and the ANB angle. b: the correlation between tongue-tie and the SNB angle. c: the correlation between tongue-tie and Co-Gn. d: the correlation between tongue-tie and lower anterior crowding

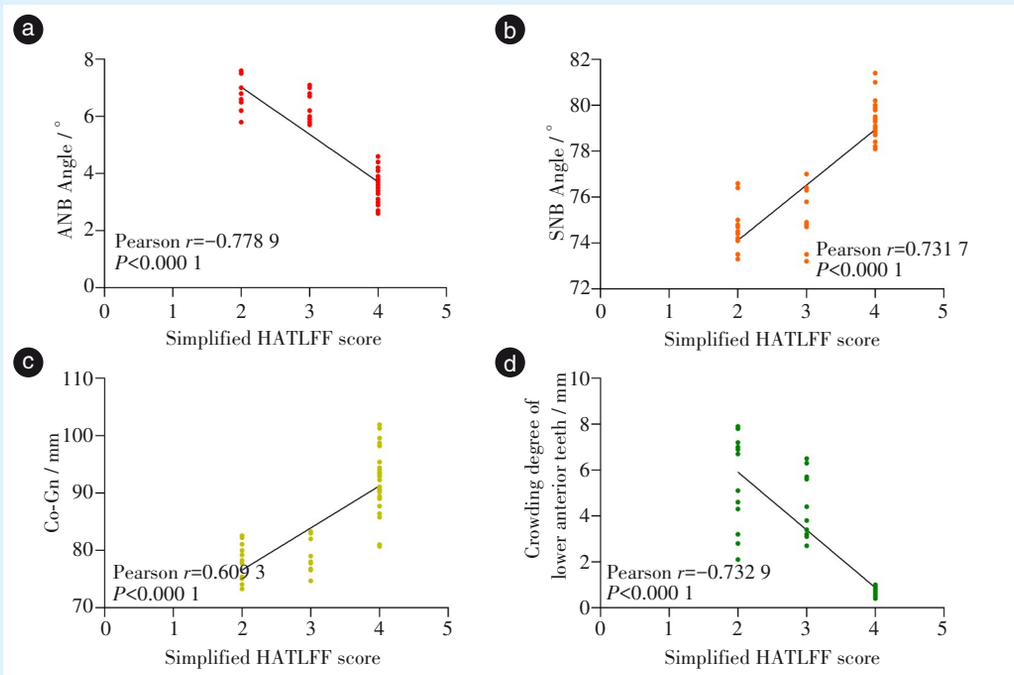
Figure 1　The correlation between ankyloglossia and mandibular development as well as lower anterior crowding

图1　舌系带过短与下颌骨发育受限和下前牙拥挤的相关性

带作为连接舌腹与口底的动态筋膜结构，不仅涉及腺体导管解剖，更通过悬吊颏舌肌维持舌体位置与运动自由度[18]。Sawai等[19]研究指出，舌系带在胎儿期可限制颊、唇与舌的运动，维持骨骼与软组织间的平衡；其过短可能进一步导致下颌与牙齿发育异常[20]。本研究通过Kotlow分型和简化HATLFF评分证实舌系带过短患者下颌骨发育受限（下颌骨体长度不足或下颌后缩）及下前牙拥挤占比显著高于正常人群，提示舌系带过短是影响下颌骨发育及下前牙排列的重要风险因素。进一步研究发现，下颌骨发育受限与下前牙拥挤度与Kotlow分型密切相关，随着分型加重（由Ⅰ型至Ⅳ型），SNB角与Co-Gn逐渐减小，ANB角则递增，下前牙拥挤度亦呈梯度加重，表明舌系带限制程度与下颌骨发育受限及牙列紊乱密切相关，与既往研究结果一致[21-22]。

3.2　舌系带形态功能与颌面发育的相关性

为进一步量化舌系带形态功能与颌面发育指标之间的关系，本研究进行Pearson相关分析，结果显示舌系带长度、简化HATLFF评分（舌系带功能



HATLFF: Hazelbaker assessment tool for lingual frenulum function. ANB: A-point-nasion-B-point. SNB: sella-nasion-B-point. Co-Gn: condylion-gnathion. a: the correlation between the simplified HATLFF score and the ANB angle. b: the correlation between the simplified HATLFF score and SNB angle. c: the correlation between the simplified HATLFF score and Co-Gn. d: the correlation between the simplified HATLFF score and lower anterior crowding

Figure 2　The correlation between simplified HATLFF score and mandibular development as well as lower anterior crowding in patients with ankyloglossia

图2　舌系带过短患者简化HATLFF评分与下颌骨发育受限和下前牙拥挤的相关性

表5　舌系带过短对下颌骨发育受限及下前牙拥挤的诊断价值分析

Table 5　Analysis of the diagnostic value of ankyloglossia for mandibular development and lower anterior crowding

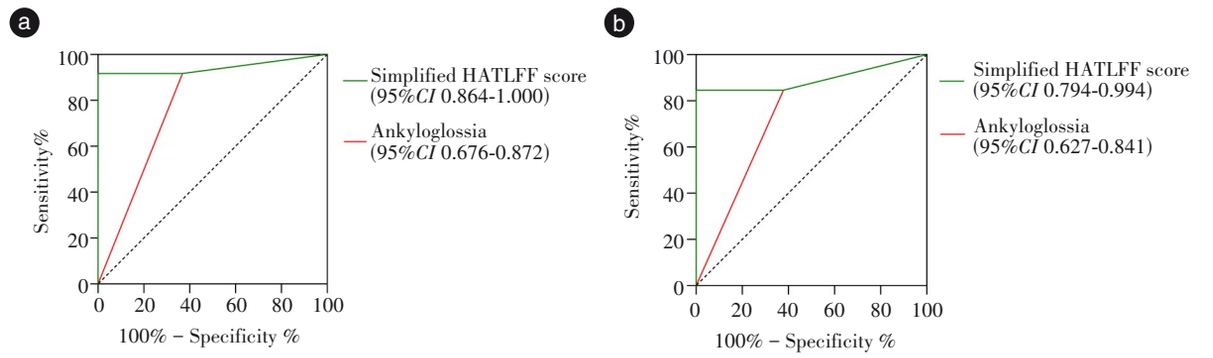
Index	Diagnostic value for mandibular development			Diagnostic value for lower anterior crowding		
	AUC (95%*CI*)	Sensitivity(%)	Specificity (%)	AUC(95%*CI*)	Sensitivity(%)	Specificity(%)
Simplified HATLFF score	0.943(0.864-1.000)	91.67	100.00	0.894(0.794-0.994)	84.62	100.00
Ankyloglossia	0.774(0.676-0.872)	91.67	63.16	0.734(0.627-0.841)	84.62	62.16

HATLFF: Hazelbaker assessment tool for lingual frenulum function. AUC: area under the receiver operating characteristic curve. *CI*: confidence interval

性评估指标)与ANB角和下前牙拥挤度呈负相关,与SNB角和Co-Gn呈正相关。提示舌系带越短或功能越差,颌骨不调及下前牙拥挤越严重,推测舌系带长度和功能可作为预测下颌发育和牙列稳定性的潜在指标。Biswas等[23]研究报道,舌系带过长可能与Ⅲ类错颌及下颌前突相关,进一步说明舌系带形态异常对颌骨发育的广泛影响。舌系带异常可干扰唇、舌、颊运动,导致牙位与颌位异常[24],并对牙周组织与咬合关系产生系统性损害[25]。

3.3　构建形态-功能整合评估体系具有高诊断效能与临床价值

本研究将解剖学指标(舌系带长度)与功能性指标(简化HATLFF评分)相结合,建立了具有高诊断效能的评估体系。ROC分析显示,简化HATLFF评分和舌系带过短,对下颌骨发育受限和下前牙拥挤的检出敏感度均超过84%,且曲线下面积均>0.700,具有良好的诊断价值。这一发现为临床早期筛查提供了可靠的量化工具。咬合平面的方向是牙齿排列的基础[26],错颌畸形患者中下前牙拥



HATLFF: Hazelbaker assessment tool for lingual frenulum function. ROC: receiver operating curve. a: ROC curve for diagnosing mandibular development with ankyloglossia. b: the ROC curve for diagnosing lower anterior crowding with ankyloglossia

Figure 3　The diagnostic value of ankyloglossia for mandibular development and lower anterior crowding

图3　舌系带过短对下颌骨发育受限和下前牙拥挤的诊断价值

挤复发的概率极高[27]。因此，早期识别并干预由舌系带异常导致的风险因素，对于阻断发育性畸形、提升长期治疗效果稳定性具有重要意义。

综上所述，舌系带过短与下颌骨发育受限及下前牙拥挤显著相关。

【Author contributions】 Chen HJ, Song J served as the principal investigators, overseeing the overall study design, protocol development, ethical application, progress and quality supervision, and final review. Among them, Chen HJ was also responsible for data cleaning and measurement. Tu CH and Mo ZF were responsible for data collection and statistical analysis. All authors read and approved the final manuscript submitted.

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