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·指南与实践·

基于修复体-牙-牙周界面治疗风险评估的美学区复杂冠根折修复策略

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［**摘　要**］ 美学区复杂冠根折指发生于前牙区，牙冠和牙根部同时折断伴牙髓暴露及牙周组织损伤的牙外伤类型。该类损伤以腭侧折裂位置恒定、剩余牙体组织薄弱及侵犯生物学宽度为解剖特征，因此采用修复体-牙-牙周界面治疗风险评估，通过剩余牙本质肩领类型和骨内根长评估抗力风险，结合牙龈及骨形态表型评判牙周风险，基于美观、稳定、微创的治疗原则，初步建立包括安全型、干预型、风险型三种美学区复杂冠根折诊断分型。各分型对应具体的修复和牙周干预策略：安全型患者通过牙冠延长术联合龈壁提升术，减小牙周风险；干预型患者采用外科联合正畸牵引同时解决修复抗力不足与牙周侵犯问题；风险型患者则因残根保存价值有限，建议拔牙后种植修复。上述分型有助于临床医师对该类美学区复杂冠根折进行科学、系统的诊疗决策。

［**关键词**］ 牙外伤；复杂冠根折；修复体-牙-牙周界面关系；诊断分型；风险评估；治疗；综述
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Restorative strategies for complex crown-root fractures in the esthetic zone: a risk assessment based on the restoration-tooth-periodontium interface

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[**Abstract**] Complex crown-root fractures in the esthetic zone refer to a type of dental trauma occurring in the anterior region, characterized by concurrent fractures involving both the crown and root, with associated pulp exposure and periodontal tissue injury. These injuries consistently exhibit critical anatomical features, including a fixed palatal fracture location below the alveolar crest, compromised residual tooth structure, and frequent violation of the biological width. To predict treatment outcomes, a risk assessment framework based on the restoration-tooth-periodontium (RTP) interface was developed. Resistance risk was evaluated by assessing the type of residual dentin ferrule and the length of the root within the alveolar bone, while periodontal risk was assessed according to gingival phenotype and alveolar bone morphology. Based on these risk dimensions and the principles of aesthetics, stability, and minimally invasive treatment, a diagnostic classification system was established, categorizing fractures into three types: favorable, intervention and high-risk. Type-specific management strategies were proposed: for favorable cases, crown lengthening combined with deep margin elevation to reduce periodontal risk is recommended; for intervention cases, orthodontic extrusion or surgical extrusion is applied to simultaneously address ferrule deficiency and biological width violation; for high-risk cases, extraction followed by implant restoration is advised due to limited root preservation value. This classification system translates subjective clinical experience into objective risk stratification, providing a standardized yet individualized framework for multidisciplinary management of complex crown-root fractures in the esthetic zone.

[**Key words**] Dental trauma; Complex crown-root fracture; Restoration-tooth-periodontium interface; Diagnostic classification; Risk assessment; Therapeutic; Review

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[**缩略语**] 修复体–牙–牙周(restoration-tooth-periodontium,RTP);锥形线束计算机断层扫描(cone beam computed tomography,CBCT)

复杂冠根折是美学区常见的牙外伤类型,尤其常见于上中切牙,占全部牙外伤的10%~20%,占全部冠根折的95%以上[1-2]。复杂冠根折指牙冠牙根同时折断,涉及牙釉质、牙本质并伴牙髓暴露。国际牙外伤协会指南中将复杂冠根折作为牙外伤的一类专门疾病[3-6]。由于复杂冠根折剩余牙体组织薄弱,且腭侧断端侵犯生物学宽度,治疗过程中须考虑RTP界面的综合治疗风险,包括牙周健康、牙体组织抗力、修复体边缘设计等多重因素,需要多学科联合介入[7]。

尽管国际牙外伤协会指南针对复杂冠根折提出了治疗建议,但由于其对患牙保留和拔除的适应证界定不够明确,且推荐的多种治疗方案缺乏分析和优先级排序,导致临床医生尤其是低年资医生在决策时面临困惑[6]。临床上,对于美学区复杂冠根折的诊疗需要正确把握疾病特点,制订个性化的治疗计划,以达成美观、稳定、微创的治疗目标。本文通过分析美学区复杂冠根折的特点,基于RTP界面治疗风险评估形成诊断分型,据此提出修复方案以供同行参考。

1 美学区复杂冠根折的特征

1.1 腭侧折裂位置恒定位于牙槽嵴顶水平或以下

通过对CBCT影像资料分析发现,90%以上的复杂冠根折牙齿腭侧断端位于牙槽嵴顶水平或以下,且与牙位(上中切牙、上侧切牙)无关;在唇侧,折断位置一般位于冠部中下1/3;在近远中

方向，半数以上患牙的至少一侧邻面断端位于龈下[8-9]。腭侧折裂位置相对恒定，主要可能是由上颌骨固有的解剖结构，以及牙外伤时相对恒定的外力方向所致。对上中切牙外伤的有限元分析结果显示，受外力撞击时上中切牙腭侧颈部釉牙本质界处为应力集中区[10]。

1.2　剩余牙体组织薄弱

从剩余牙体组织可否提供未来修复所需的牙本质肩领这一角度来看，主要有以下三种常见的临床类型：Ⅰ型，双侧邻面断面均位于龈上，腭侧位于龈下，剩余牙本质肩领周向角度为180°及以上；Ⅱ型，一侧邻面断面平龈或位于龈下，剩余牙本质肩领周向角度为120°~180°；Ⅲ型，双侧邻面断面平龈（以邻面骨嵴顶最高处记，下同）或位于龈下，剩余牙本质肩领包绕角度为120°及以下。此外，在少数情况下，因外力打击方向的变异，可能出现唇侧断面位于龈下、腭侧断面位于龈上，且双侧邻面断面位置不定的情况，但仍可参照剩余牙本质肩领周向角度进行归类。患牙剩余牙体组织薄弱，不完整的牙本质肩领以及增大的临床冠根比使得修复体具有较大的牙折风险，且存在牙周创伤的可能性[11-12]。

1.3　因侵犯生物学宽度导致局部位点牙周炎

生物学宽度（也称嵴顶上附着组织[15]）是指从龈沟底到牙槽嵴顶之间的距离，主要由结合上皮及牙槽嵴顶上结缔组织附着构成，其平均宽度为2.15~2.30 mm，对牙周抵抗外界因素侵袭具有重要意义[13-14]。侵犯生物学宽度将导致局部位点的牙周炎症，具体可表现为探诊出血、牙槽骨丢失和附着丧失等。侵犯程度可分为三个等级，即结合上皮侵犯、嵴顶上纤维附着侵犯和骨嵴下侵犯，侵犯程度将影响牙周炎的进展程度[16-18]。复杂冠根折患牙腭侧断端位于牙槽嵴顶或以下，为骨嵴下侵犯，是侵犯程度最重的一种情况。

在未进行合适牙周治疗的情况下，局部位点牙周炎在确立后会随时间进展[19]。但是，由于局部位点牙周炎的致病要素主要是腭侧断面的侵犯，致病要素单一，局部位点牙周炎的发生发展可能因致病要素的减弱（如断面暴露修复或者断面良好修复）而逐步稳定，即该类牙周炎可能具有自限性[20]。

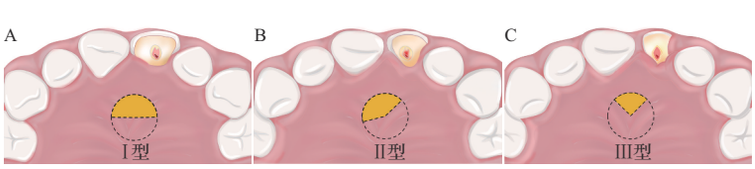
2　基于修复体–牙–牙周界面治疗风险分析的美学区复杂冠根折诊断策略

2.1　美学区复杂冠根折的抗力风险分析

为预测疾病预后，须对其抗力风险进行评估，笔者纳入了剩余牙本质肩领类型和骨内根长两个要素进行抗力风险分级（图2）。

对于美学区复杂冠根折的患牙，其腭侧牙本质肩领缺损会显著减弱桩核修复体的抗折力值，因此能否保留其他三个面的牙本质肩领对于修复体–牙的折断风险预测具有重要意义。研究表明，当冠根折牙齿仍具有唇侧及近远中（180°）肩领时，仍保有一定抗折力；若冠根折牙仅余唇侧肩台，则抗折力明显降低；冠根折牙无肩台则具有最低的疲劳强度和抗折力[21]。对于牙本质肩领Ⅱ和Ⅲ型的复杂冠根折来说，直接行桩核冠修复面临显著增高的根折风险[22-23]。临床上可以通过进行正畸或外科牵引等方法来获得更完整的牙本质肩领，但保留良好的临床冠根比与获取完整的牙本质肩领之间存在矛盾关系[24]。

临床冠根比与修复体–牙的长期牙周稳定具有较强相关性，但在复杂冠根折情况下，骨内根长更能说明剩余牙体在修复后行使功能并维持牙周稳定的潜力。因此，在进行牙体剩余组织分型时，纳入骨内根长作为直观的判定要素。有关骨内根长的安全范围界定，综合考虑了成年人上颌中切牙根长均值、腭侧缺损至牙槽嵴下的实际状况，以及可接受的最大稳定临床冠根比，最终以10 mm骨内根长作为安全界限[25-26]。



A：Ⅰ型，双侧邻面断面均位于龈上，腭侧位于龈下，剩余牙本质肩领周向角度为180°及以上；B：Ⅱ型，一侧邻面断面平龈或位于龈下，剩余牙本质肩领周向角度为>120°~<180°；C：Ⅲ型，双侧邻面断面平龈（以邻面骨嵴顶最高处记，下同）或位于龈下，剩余牙本质肩领包绕角度为120°及以下.

图1　常见美学区复杂冠根折的三种肩领类型

Figure 1　Schematic representation of three residual dentin ferrule types in complex crown-root fractures in the esthetic zone

2.2　美学区复杂冠根折的牙周风险分析

局部位点牙周炎的进展风险与生物学宽度侵犯的范围、

深度,局部菌斑累积,修复体边缘设计,牙周表型,局部和全身因素等相关[27-29]。由于局部位点牙周炎显著影响患牙预后,需要对局部位点牙周炎进展风险进行正确预测。牙周表型对预测牙周炎的进展风险具有重要意义,厚牙周表型可抵御外界干扰,实现牙周的长期稳定[30-32]。

牙周表型主要有两部分组成,牙龈表型和骨形态表型。笔者纳入这两个要素进行牙周风险分级(图2)。牙龈表型主要与角化龈宽度、黏膜厚度等指标相关,可通过CBCT测量[31, 33]。在分界标准上,角化龈宽度通常以5.0 mm为界,黏膜厚度则通常以1.0 mm为界,且两者存在正相关关系[34-38]。骨形态表型与唇侧牙槽骨骨板厚度相关,通常的分界标准为0.5 mm[15, 36, 39]。此外,骨形态表型在预测拔牙后的骨吸收量时具有重要意义[40-41]。研究显示,天然牙中牙龈表型与骨形态表型没有确切的关联性,可能出现交叉型;而种植体中交叉型普遍存在[42-43]。

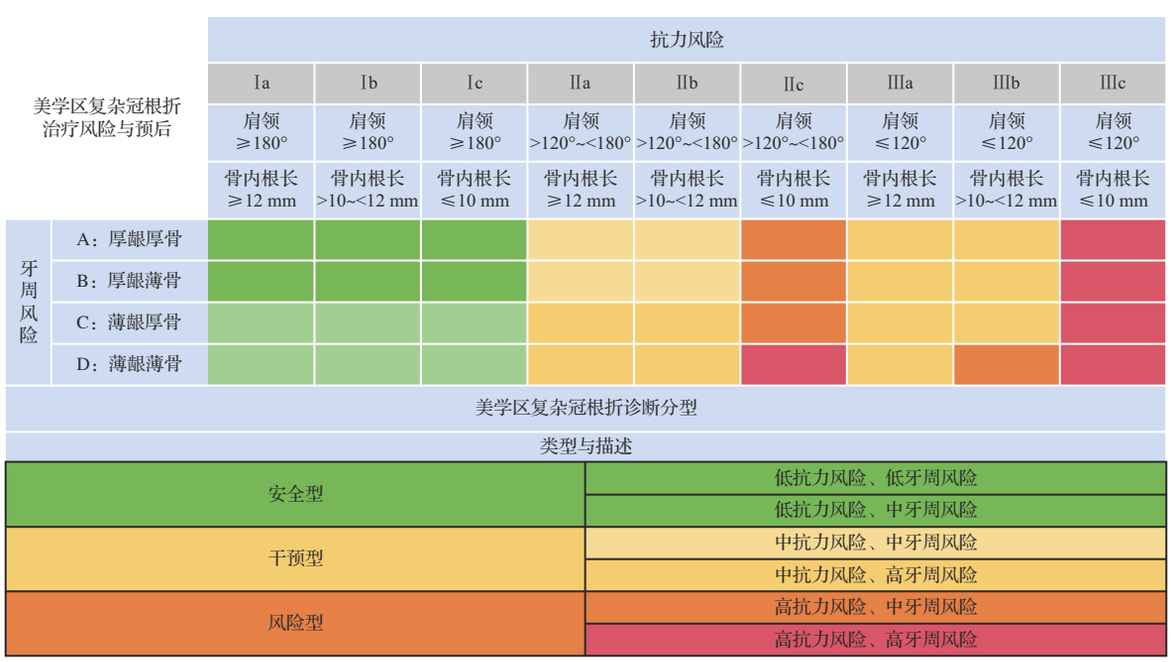
2.3　美学区复杂冠根折的诊断分型

诊断分型的目的是正确判断疾病治疗风险和预后。作为RTP界面最主要的治疗风险,抗力风险和牙周风险是影响复杂冠根折预后的核心要素,因此作为诊断分型的主要依据。美学区冠根折的诊断分型如图2所示。其中,安全型(绿色系)具有低牙体风险及中低牙周风险,主要应考虑局部位点牙周炎的影响;干预型(黄色系)具有中牙体风险及中高牙周风险,应综合解决牙本质肩领问题与局部位点牙周炎问题;风险型(橙色系)具有高牙体风险及中高牙周风险,难以在牙体与牙周间获得平衡。

3　基于美学区复杂冠根折诊断分型的治疗策略

3.1　治疗目标及原则

美学区复杂冠根折诊疗的整体目标为美观、稳定和微创,同时应尽可能保留天然牙[44-45]。对整体目标的理解可分解为两个方面:复杂冠根折修复治疗的目标是使得修复体–牙存在可接受的抗力、固位,并仍具有良好的牙周支持能力,使得修复体–牙可长期行使良好功能并稳定存续;复杂冠根折牙周治疗的目标是使得局部位点牙周炎处于“炎症性稳定”的状态,即牙周炎确立但并不明显进展[17, 46]。因此,在制订美学区复杂冠根折的诊疗方案时,应始终将RTP界面关系放在诊疗的出发点,以重塑协调的三者关系作为诊疗成



骨内根长指唇侧牙槽嵴顶水平至根尖处距离,建议通过锥形线束计算机断层扫描数据测量. 厚龈:角化龈宽度5.0 mm及以上且黏膜厚度1.0 mm及以上;薄龈:角化龈宽度5.0 mm以下或黏膜厚度1.0 mm以下;薄骨:唇侧骨板0.5 mm以下;厚骨:唇侧骨板0.5 mm及以上.

图2　美学区复杂冠根折诊断分型

Figure 2　Diagnostic classification of complex crown-root fractures in the esthetic zone

功评价的核心依据[47]。

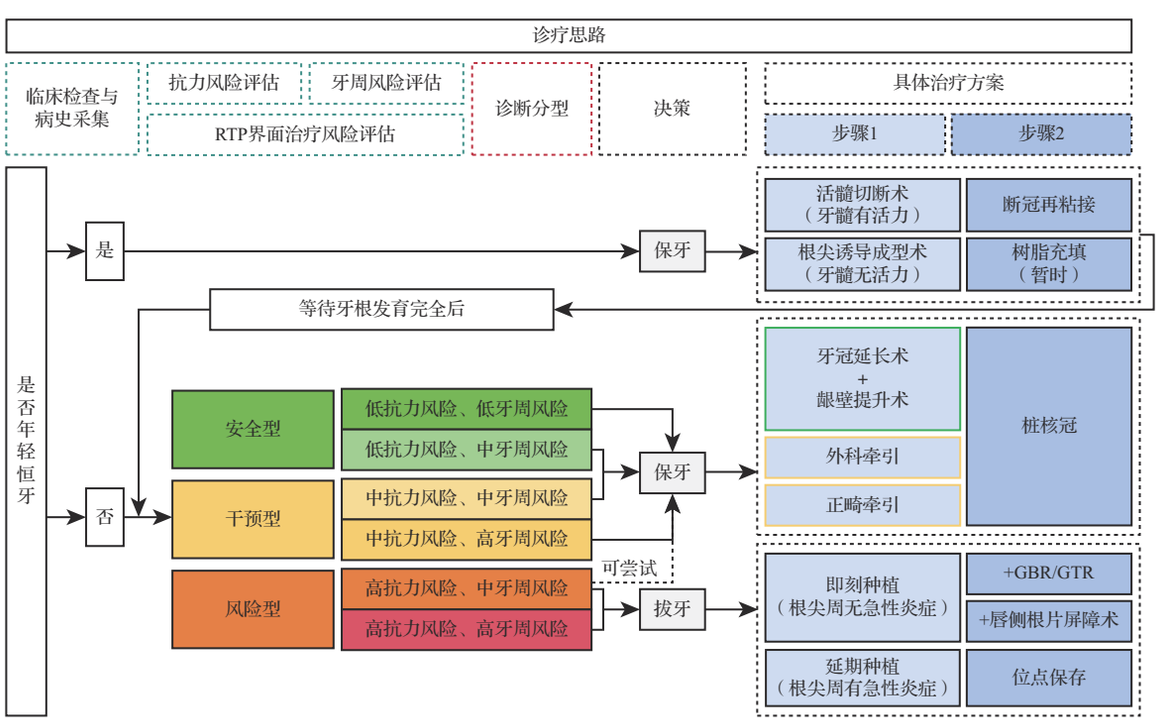
图3为美学区复杂冠根折临床诊疗路径。原则上，首要是通过评估剩余牙体组织正确认识修复风险，并探寻修复体整体强度与牙周支持能力的平衡；再通过牙周表型预测局部位点牙周炎进展风险，并制订合适的牙周应对方案，需要同时考虑当下牙齿抗折状态和未来牙周稳定状态。另外，从微创治疗的角度出发，由于创伤性露髓通常不伴有慢性感染，因此并非所有复杂冠根折伴牙髓暴露的患者都必须行根管治疗。对于牙根尚未完全形成的年轻恒牙，活髓切断术是可行且有效的选择；而对于牙根已发育完成的恒牙，根管治疗的目的是为植入桩核创造条件[48-50]。

3.2　具体治疗方案

3.2.1　安全型（绿色系）　对于安全型而言，如外伤后保留有完整的断冠，断冠再粘接是一种保守、简单和美观的治疗方法。这项技术的优势在于可以搭配使用活髓切断、根尖诱导成型等牙髓治疗手段，因此对于恒牙根尖未完全形成的年轻患者尤其适合，可视为一种半永久或永久的修复方案[51]。在断冠再粘接的具体技术细节上，通过各种斜面设计、钉洞设计、植入纤维桩等方式，有助于增强整体抗折强度[52]。研究表明，对折断牙釉质进行超轮廓与牙本质内沟制备可以增强粘接强度[53]。利用患牙髓腔空间置入树脂纤维条带也具有增强粘接和抗力的作用[54]。

在牙周方面，由于美学区复杂冠根折的腭侧断端位于骨嵴下，经典牙冠延长术所需的较大去骨量可导致冠根比显著恶化以及患牙、邻牙的牙周膜严重弱化。联合采用牙冠延长术及龈壁提升术可以再定位腭侧断端，可减轻牙周刺激并改善修复体边缘的应力分布[55-57]。这种联合手术的要点是，应至少完成2 mm去骨，使得断端侵犯减低到结合上皮层面，在此基础上再进行龈壁提升术[16, 55]。临床及组织学研究表明，断端位于结合上皮侵犯时，龈壁提升术可以显著降低患牙菌斑评分、牙龈出血评分和探诊深度，使得牙周恢复至“炎症性稳定”状态[58]。并且，龈壁提升不影响间接修复体疲劳性能、抗断裂性、失效模式，且避免了修复体边缘对牙周可能产生的刺激[55]。

当然，如通过合理处置牙龈轮廓可清晰获取断端边缘，亦可采用间接修复体与断端对接的形式来直接恢复缺损。值得注意的是，龈下对接部分应避免使用高金或饰面瓷，且尽量抛光。



具体治疗方案中的治疗框外框线颜色代表适用的诊断分型. RTP：修复体–牙–牙周；GBR：引导骨再生术；GTR：引导组织再生术.

图3　美学区复杂冠根折临床诊疗路径图

Figure 3　Clinical decision pathway for the management of complex crown-root fractures in the esthetic zone.

3.2.2 干预型(黄色系) 在骨内根长足够(≥12 mm)的条件下,可通过正畸牵引、外科牵引等方法,以牺牲临床冠根比的代价来获得更好的牙本质肩领环绕角度,并同时解决生物学宽度侵犯问题。在牙周方面,如患牙具厚牙周表型,直接的牙周治疗方案如牙冠延长和龈壁提升是可行的;但如合并薄牙周表型,则应考虑间接的牙周治疗方案如正畸/外科牵引,以尽可能减少生物学宽度的侵犯。

外科牵引则指的是通过无创拔牙系统,向牙根施加冠向牵引力后,将牙根整体拔出,并把牙根再定位于牙槽窝内新的位点。相比正畸牵引,外科牵引更加快速,对牵引量的把握也相对容易控制。一项研究表明,在牵引量为2.5~5.0 mm下,外科牵引总体成功率在90%以上[59]。作为一种牙槽外科手术,外科牵引的常见并发症是牙根吸收和根骨固连,同时有部分患者会出现牙槽骨吸收[60]。

正畸牵引是一种更温和的方法,但需要较长的时间。需要注意的是,在牵引过程中,由于对牙周组织施加张力,同时也会引起患牙牙周附属组织的延伸,这种延伸量为牙根牵引量的60%~80%[61]。为减少这种牙龈的冠向延伸,可以配合使用牙槽嵴上纤维环切术,以获得理想的软硬组织轮廓外形及腭侧断面的充分暴露[24]。

但无论采纳何种技术,最终矫治目标是使腭侧断端至少平龈,并保证近远中邻面、唇侧具有理想的牙本质肩领。

3.2.3 风险型(橙色系) 由于同时面临较大的牙体和牙周风险,临床医生应仔细考量各种因素,慎重考虑是否保留患牙,拔牙后种植修复可能是更好的解决办法。

拔除患牙时需要特别注意拔牙后唇侧牙槽骨吸收问题,薄龈薄骨牙周型拔牙后将面临最明显的骨吸收和轮廓塌陷[40, 62]。对于一些无法保留患牙的情况,在剩余骨条件或牙龈条件一般的情况下,可以先对残根进行正畸牵引,以达成软硬组织增量效果,再考虑进行种植修复。

很多学者就如何维持美学区组织轮廓进行了研究,包括使用即刻种植同期植骨,即刻种植联合软组织移植等,这些方法部分解决了软硬组织缺损的修复问题[63-64]。但美学区的种植难处在于组织轮廓的过增量或塌陷均影响美观,而在术后短期内,增量通常伴随不确切程度的吸收,因此软硬组织移植在把握"适度"上尤其困难。此外,在植入后的数年里,很多研究表明种植体周围组织的进一步吸收和塌陷是无法完全避免的,且薄牙周表型的植体周骨吸收更为显著,这让美学区组织轮廓的预期变得更为困难[65-68]。

唇侧根片屏障术由Hürzeler等[69]于2010年首次提出,其核心理念是,在拔牙的同时保留部分牙根(唇侧根片),维持唇侧束状骨板–牙周韧带的血供和结构完整性,从而避免拔牙导致的唇侧骨板生理性吸收。相较于增量技术,该技术从效果上说更是一种保存技术,其保持了原有的复合体结构,并由此提供美学预期[70]。唇侧根片屏障术尤其适用于薄龈薄骨牙周型的拔牙患者,提供相比增量技术更为优异的轮廓维持效果[71-72]。然而,作为一种技术难度较高的手术,唇侧根片屏障术的效果很大程度上取决于术者对适应证的正确选择以及正确且精准的手术操作。

3.3 对未成年患者的特殊考量

对于美学区复杂冠根折的未成年患者,诊疗原则是"保留优先于拔除"。临床诊疗需尝试达成三个目标:在生物学上,最大化利用牙根发育潜力,激活颌骨生长;在美学上,通过过渡性修复维持社交外观;在功能上,以间隙保存换取未来修复的有利条件。

对于尚在牙根发育阶段根尖孔未闭合的年轻恒牙,首选活髓保存,甚至在外伤后数日内仍可尝试进行活髓切断保存[6, 73]。建议仅在牙髓明确坏死的情况下考虑去除感染的牙髓组织。对于断端位于龈下3 mm内的患牙,可考虑在正畸牵引的条件下行断冠再粘接或树脂修复,待成年后永久修复;对于牙根剩余骨内长度为5 mm及以下的情况,可考虑牙根保留术,以维持骨发育及保存骨量。

4 结 语

本文建立了以RTP界面治疗风险为核心的美学区复杂冠根折诊断分型方法,实现了主观临床经验向客观风险分级转化,为复杂病例诊断和治疗路径的标准化、个性化提供了科学依据,特别在美学区保牙决策、风险预警和多学科沟通等方面体现了临床价值。该分型体系指导下的治疗策略更贴近疾病本质和组织生理,能帮助临床

医生在决策时较好地平衡修复体、牙、牙周三者关系,有效弥补了国际牙外伤协会等现有指南对于具体适应症和决策逻辑的不足,同时为个体化治疗方案的制订和团队协作提供了清晰框架。

但本方法仍存在局限:其分型体系未设定具体的风险阈值,治疗建议的长期临床效果尚待前瞻性验证。此外,诸如外科牵引、断冠再粘接等技术方案高度依赖术者的技巧,未成年患者等特殊人群亦面临发育与修复策略平衡等挑战。未来应进一步细化分型定量标准,积累多中心长期随访数据,推动多学科协同诊疗模式在美学区复杂冠根折领域的持续优化。

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数据可用性　本研究未生成任何新数据集,所有分析数据均已公开,并已在文中明确标引

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医学伦理　本研究不涉及人体或动物实验

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