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·专家论坛·

牙周炎患者种植治疗的临床策略

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【摘要】 牙周炎患者种植修复面临失败及种植体周围炎风险显著升高的挑战，其原因主要涉及牙周致病菌富集及菌群功能失调、宿主免疫失衡，以及吸烟和牙周支持治疗依从性差等因素。此外，牙周炎导致的软硬组织复杂缺损和咬合创伤等，进一步增加了缺失牙种植治疗的复杂性与长期疗效的不确定性。因此，牙周炎患者的种植治疗需构建以“炎症控制—功能重建—长期维护”为核心的系统化管理策略。在牙周炎症得到有效控制和稳定维护的前提下，应综合评估剩余牙列、软硬组织缺损、种植手术方案、修复方式及咬合负荷；必要时通过软硬组织增量技术重建稳定的组织基础，并结合数字化技术实现种植体三维位置、组织支持和力学分布的协调统一，以期实现功能与美学的稳定重建。同时，还需强化风险分层管理、菌斑控制、宿主炎症调控及牙周支持治疗与行为干预，从而提高种植修复的长期稳定性与可预测性。未来，可整合多组学技术、人工智能风险预测、数智化种植技术和新型再生材料的应用，推动牙周炎患者种植修复的个体化精准治疗发展。

【关键词】 牙周炎；　种植体周围炎；　牙种植体；　牙槽骨丧失；　骨重建；　炎症；　牙周支持治疗；　宿主免疫；　菌斑控制；　数智化种植技术

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Clinical strategies for implant therapy in patients with periodontitis

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【Abstract】 Patients with periodontitis face significantly increased risks of implant failure and peri-implantitis. These adverse outcomes are mainly associated with the enrichment of periodontal pathogens and microbial dysbiosis, host immune imbalance, smoking, and poor adherence to supportive periodontal therapy. In addition, complex hard- and soft-tissue defects and occlusal trauma caused by periodontitis further increase the complexity and long-term uncertainty of implant therapy. Therefore, implant treatment in patients with periodontitis should adopt a systematic management strategy centered on “inflammation control, functional reconstruction, and long-term maintenance.” On the premise of periodontal inflammation control and stable maintenance, clinicians should comprehensively evaluate the remaining dentition, hard-tissue and soft-tissue defects, dental implant surgical plan, prosthetic modality, and occlusal load. When necessary, hard-tissue and soft-tissue augmentation procedures should be performed to reconstruct a stable tissue founda-

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tion. Digital technologies should also be integrated to coordinate the three-dimensional implant position, tissue support, and biomechanical load distribution, thereby achieving stable functional and esthetic rehabilitation. Further, risk stratification, plaque control, host inflammatory modulation, supportive periodontal therapy, and behavioral interventions should be reinforced to improve the long-term stability and predictability of implant rehabilitation. In the future, the integration of multi-omics technologies, artificial intelligence-based risk prediction, digital-intelligent implant workflows, and novel regenerative materials may further promote individualized precision therapy.

【Key words】 periodontitis; peri-implantitis; dental implants; alveolar bone loss; bone remodeling; inflammation; supportive periodontal therapy; host immunity; plaque control; digital-intelligent implant technology

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牙周炎是一种由牙菌斑生物膜失调引起的慢性多因素炎症性疾病，是导致成人失牙的首要原因[1]。种植修复是牙周炎患者失牙后，恢复咀嚼功能的主要方案之一[2]。相较于非牙周炎患者，牙周炎患者种植常常面临着风险增高、难度提升、预后较差等临床挑战。然而，目前尚缺乏专门针对牙周炎患者种植治疗的共识与指南。本文结合牛津循证医学中心（Oxford Centre for Evidence-Based Medicine，OCEBM）证据等级标准[3]，针对牙周炎患者牙种植治疗的临床治疗策略进行阐述，以期为提高牙周炎患者种植修复的长期稳定性与可预测性提供参考。

1　牙周炎患者的种植风险与预后

针对牙周炎患者种植预后问题，开展的前瞻性起始队列研究的Meta分析结果显示，随访时间≤5年时，有牙周炎病史的患者的种植体失败风险升高约1.62倍，而随访时间>5年时，失败风险升高至2.26倍。其种植体周围炎发生风险提升4倍，边缘骨丢失平均增加0.75 mm[4]（OCEBM Ⅰ级）。牙周炎患者相对较差的种植预后，与其口腔微生物环境、宿主免疫状态和行为因素等多重因素相关。

1.1　微生物因素

牙周炎患者在种植体植入早期即可出现种植体周牙周相关致病菌富集及群落结构失衡，且这种早期微生态差异与后续炎症表现显著相关[5]。种植体周围炎中的菌群结构与牙周炎高度重叠，且表现为更高的菌群多样性及更丰富的机会致病菌参与[6]。宏基因组测序提示，牙周炎患者的种植体周围菌群的功能处于“预失衡”状态，更易出现菌群功能重编程，尤其是与细菌侵袭相关的通路显著上调，从而影响种植体周围炎的发生发展[7]。值得注意的是，在牙周炎患者中，其口腔微生态长期失衡，这种失衡本身可作为持续性炎症刺激源，诱导宿主免疫反应处于预激或高反应状态，加之种植体周组织对细菌刺激的耐受阈值低于天然牙周组织[8]，使种植体周围组织在后续微生物影响下更易发生过度炎症反应，增加了种植体周围炎等慢性并发症的远期风险[9]。

1.2　宿主免疫因素

牙周炎患者所形成的免疫预激状态主要表现为中性粒细胞功能失衡，辅助性T细胞17（T helper cell 17，Th17）免疫反应增强及巨噬细胞的M1极化。中性粒细胞通过释放弹性蛋白酶和瓜氨酸化组蛋白等机制加剧局部炎症反应和组织降解[10]，还可分泌单核细胞趋化蛋白-1等趋化因子，招募Th17细胞，桥接固有免疫与适应性免疫应答。Th17细胞分泌白细胞介素（interleukin，IL）-17，促进破骨细胞活化和牙槽骨吸收，还能诱导成纤维细胞分泌基质金属蛋白酶（matrix metalloproteinases，MMP）等因子，加速细胞外基质降解和胶原破坏，并驱动骨髓中性粒细胞生成并向牙周组织募集，形成自我维持的炎症放大环路[11-12]。炎症环境下，巨噬细胞向促炎型M1极化，大量释放促炎因子，进一步通过上调核因子κB受体活化因子配体（receptor activator of nuclear factor-kappa B ligand，RANKL）表达，抑制骨保护素（osteoprotegerin，OPG）表达，促进破骨细胞分化与骨吸收倾向，形成“炎症—骨吸收”的恶性循环[13]。这种局部免疫失衡，让种植体周组织面对微生物刺激时，更易出现强烈、持久的炎症，显著增加种植体周围炎的发生风险[14-15]。

除了局部炎症反应，系统疾病也会改变牙周炎患者的炎症反应模式，增加种植体失败风险[16-17]。例如，糖尿病患者等代谢综合征患者常处于慢性低度全身炎症状态[18-19]，一项关于糖尿病患

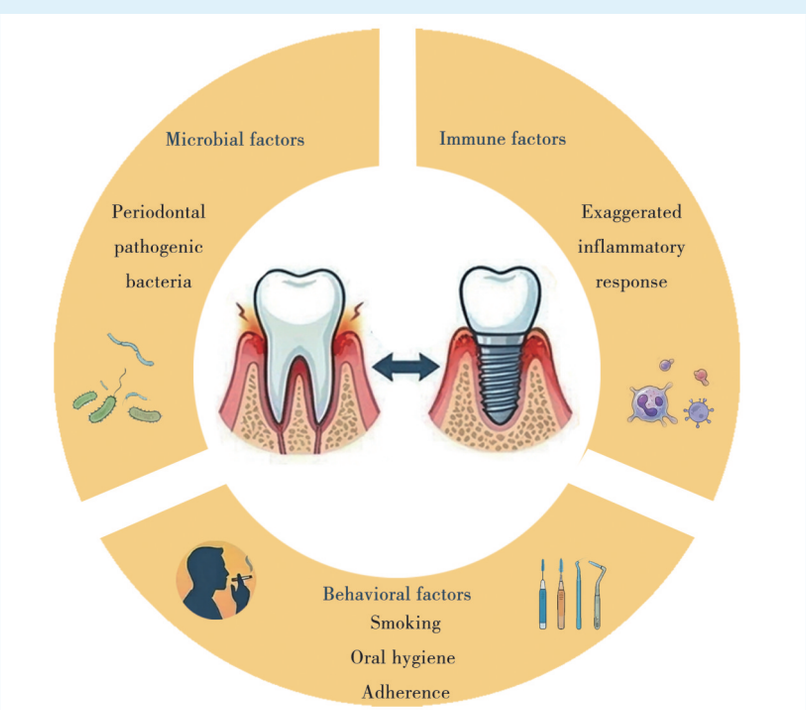
者身体质量指数(body mass index,BMI)对其种植牙预后的回顾性队列研究发现,BMI≥ 30 kg/m^{2}是种植体周围炎的潜在独立风险因素(OCEBM Ⅲ级)[20]。一项针对预后问题,纳入前瞻性队列研究和横断面研究的Meta分析显示,随着糖化血红蛋白水平升高(<6%、6%~8%、>8%),边缘骨丢失呈剂量反应依赖性恶化(OCEBM Ⅱ级)[21],此外,骨质疏松、雌激素缺乏及维生素D代谢异常等因素可降低骨组织再建能力,让局部骨组织对炎症刺激更加敏感,使得牙周组织及种植体周围组织更易出现骨量减少及骨密度下降,进而增加边缘骨丢失风险[22]。

1.3　行为因素

吸烟、口腔卫生维护不足以及患者对牙周支持治疗(supportive periodontal therapy,SPT)的依从性差等行为因素均已被证实与种植体并发症风险显著相关。两项针对预后问题,纳入回顾性队列研究和病例对照研究的Meta分析显示,吸烟者早期种植体失败风险增加约2.59倍[23](OCEBM Ⅱ级),种植体周围炎风险提升约2.27倍,且这种风险在牙周炎患者中得到进一步放大(OCEBM Ⅱ级)[24]。

此外,一项针对治疗获益问题的非随机对照试验发现,相较于接受种植体定期维护治疗者,未接受治疗的患者种植体周围炎发生风险升高2~4.25倍[25-26](OCEBM Ⅲ级)。而且种植体周围炎治疗后维护治疗依从性与牙周炎分级显著相关,提示牙周炎严重程度不仅是生物学风险因素,也可能影响患者长期维护行为[27]。

因此,牙周炎患者较差的种植预后,是微生物失调、免疫失衡及行为因素等共同作用的结果(图1)。其种植治疗不应局限于缺牙修复,而应将风险因素的系统控制贯穿种植前、中、后全流程,以实现更可预测的长期稳定结局。



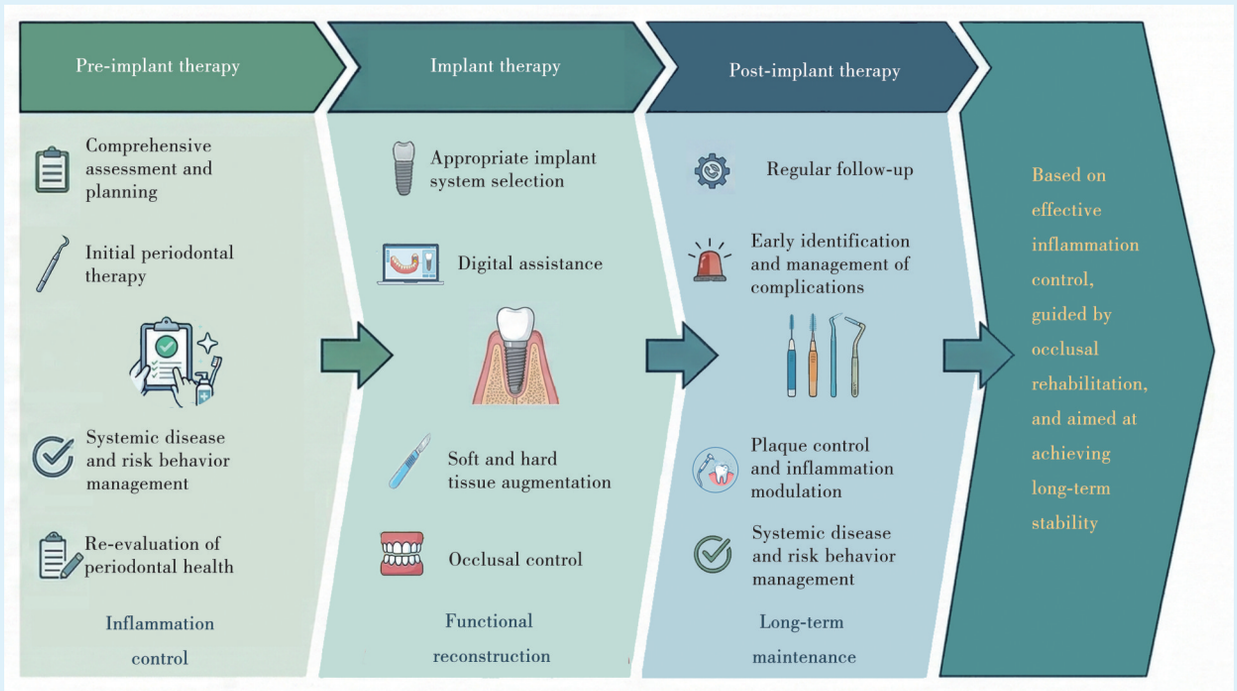
Patients with periodontitis exhibit an increased risk of implant failure and complications. Icons were generated using Google Gemini (Google LLC, Mountain View, CA, USA) and edited in Adobe Photoshop CC (Adobe Inc., San Jose, CA, USA)

Figure 1　Influencing factors of risk and prognosis of dental implants in patients with periodontitis

图1　牙周炎患者牙种植风险与预后的影响因素

2　牙周炎患者种植治疗的临床策略

除了面临较高的失败风险和并发症,牙周炎所导致的软硬组织破坏以及咬合创伤,使牙周炎患者面临显著的解剖学、矜学与生物学问题的挑战,因此牙周炎患者种植治疗需构建以“炎症控制—功能重建—长期维护”为核心的系统化管理策略(图2)。



Icons were generated using Google Gemini (Google LLC, Mountain View, CA, USA) and edited in Adobe Photoshop CC (Adobe Inc., San Jose, CA, USA)

Figure 2　Clinical treatment strategies for implant therapy in patients with periodontitis

图2　牙周炎患者种植治疗的临床策略

2.1　炎症控制—牙周炎患者开展种植治疗的前提

基于牙周炎患者种植失败的风险因素，欧洲牙周病学联合会S3级临床实践指南建议患者种植前牙周炎必须处于稳定期[28]。笔者建议在规范的牙周基础治疗后需等待4~8周进行再检查，保证全口出血指数<15%，菌斑指数<20%，探诊深度≤4 mm的位点比例≥80%~90%且无>6 mm的深牙周袋。此外，外周血IL-1β、促炎因子（tumor necrosis factor，TNF）-α、IL-6的下降也可作为补充参考[29]。而针对牙周炎患者的种植时机，一项针对治疗获益问题的随机对照试验的Meta分析发现，在严格控制感染和病例筛选（拔牙后剩余牙槽骨高度≥4 mm的位点）条件下，即刻种植在短期修复效果、牙周软组织指标及美学评分具有优势，而延期种植可能有助于牙周组织恢复[30]（OCEBM Ⅰ级）。延期种植时位点已完成软硬组织愈合。但由于牙周炎拔牙后常出现牙槽嵴快速吸收，严重影响种植体植入位置及美学效果[31]。一项针对治疗获益问题，纳入随机对照试验与非随机对照试验的Meta分析发现，在拔除磨牙时通过牙槽嵴保存术可以减少骨吸收[32]（OCEBM Ⅱ级）。而在非磨牙区，一项针对治疗获益问题，纳入随机对照试验与非随机对照试验的Meta分析结果表明牙槽嵴保存术在短期软组织轮廓、黏膜边缘位置及牙槽嵴宽度维持方面显著优于早期种植，并可简化后续种植治疗[33]（OCEBM Ⅱ级）。因此，笔者认为，牙周炎患者的种植时机应基于炎症控制程度、缺牙位点解剖特征及骨缺损范围进行个体化决策。在牙周炎症控制良好的前提下，美学区患牙若局部软硬组织条件允许，即刻种植可有效维持龈乳头高度与软组织轮廓，降低“黑三角”等美学并发症风险。而对于磨牙区，鉴于其多根解剖结构复杂、根分叉病变常见，且牙周炎常伴发大范围水平向及垂直向骨缺损，建议优先在拔牙后实施牙槽嵴保存术以维持牙槽嵴尺寸，待炎症完全消退、软组织充分愈合后再行延期或早期种植。

2.2　功能重建—牙周炎患者种植修复的目标

2.2.1　全口评估与整体方案设计　对于牙周炎患者的种植修复治疗，应系统性地开展“评估—拔除—重建”流程，准确判断每颗松动牙的保留价值。对于判定为无保留价值的牙，应有计划地予以拔除，而非姑息保留，避免进一步的骨丧失，损害未

来种植位点的解剖条件[34]。在此之后，基于为患者恢复长期稳定的咬合功能，并兼顾功能、美学和可清洁性，进行整体性的种植方案设计，包括：①根据剩余牙列的分布和咬合关系，确定种植体的数量、位置和角度，尽量最小化悬臂长度、采用双侧平衡与群体功能设计，避免单侧咬合过载[35]；②考虑通过正畸联合牙周再生手术改善剩余牙齿的稳定性和功能[36]；③设计过渡性修复体以维持咀嚼功能和美学，同时为种植修复创造有利条件。对于需要全口重建的患者，根据可用骨量、患者全身状况和经济条件等，选择种植体支持的固定修复或覆盖义齿[37]。

2.2.2　种植系统的选择　目前缺乏针对牙周炎患者种植体设计选择的高质量临床研究。牙周炎可因长期炎症破坏出现牙槽骨吸收和骨结构改变，部分病例可能伴有局部骨密度或骨质量下降。基于体外有限元分析的系统评价[38]，笔者建议，对于此类患者，在骨宽度允许的情况下，应优先考虑大直径、较深螺纹、较小或优化螺距以及锥形/骨挤压型的种植体，可增加骨—种植体接触面积和机械嵌合，以获得充分初期稳定性。一项针对治疗获益问题，纳入随机对照试验与非随机对照试验的Meta分析结果显示，长度≤8 mm短种植体或≤6 mm的超短种植体可用于垂直骨量不足的后牙区，减少治疗复杂度[39-40]（OCEBM Ⅱ级）。但需注意，短种植体由于骨接触面积减少，冠根比异常，承受咬合力时应力集中更明显。一项针对预后问题，纳入病例对照研究的系统评价显示，小直径短种植体更容易发生种植体折裂等机械并发症，且在伴有咬合力异常和副功能运动的牙周炎患者中风险更高[41]（OCEBM Ⅳ级）。

其次，钛种植体仍为首选材料，其长期临床证据充分且表面改性技术成熟；氧化锆种植体虽显示良好生物相容性，但长期随访数据仍相对有限[42]。钛种植体表面特性是影响骨整合和长期稳定性的关键因素。中等至高粗糙度表面可促进成骨细胞附着和分化。但在牙周病史患者中，一项针对治疗获益问题，纳入随机对照试验与非随机对照试验的Meta分析结果显示，机械加工表面与中粗糙表面种植体在存活率和边缘骨丢失方面无显著差异[43]（OCEBM Ⅱ级）。亲水性改性表面在体外研究中被证实可通过调控巨噬细胞M2型极化，下调促炎因子TNF-α、IL-1β和IL-6的分泌，间接调控RANKL/OPG信号轴[44]。一项针对治疗获益问题，纳入随机对照试验与非随机对照试验的Meta分析结果显示，亲水性改性表面可加速骨整合、缩短暴露于细菌污染环境的时间窗口，有助于增加早期稳定性[45]（OCEBM Ⅱ级），但另一项针对治疗获益问题，仅纳入了随机对照试验的Meta分析发现，其长期预后方面优势有限[46]（OCEBM Ⅰ级）。此外，纳米结构、生物活性及功能化修饰等表面改性种植体，均能在一定程度上调节“炎症—成骨”失衡状态，改善骨结合的效果，但临床证据仍有限[47]。

最后，在种植体连接方式方面，与传统平台匹配设计相比，平台转换设计通过将微间隙向内迁移，减少炎症对骨嵴的直接刺激，一项针对治疗获益问题，纳入随机对照试验的Meta分析结果显示，在负载后1年及更长期随访中均表现出更少的边缘骨丢失[48]（OCEBM Ⅰ级），所以在牙周炎人群中具有更高的临床推荐价值。

因此，在牙周炎患者中，种植体选择应结合合理的宏观几何设计，考虑选用亲水处理等表面优化的钛种植体确保初期稳定性，推荐选用平台转换连接设计，有利于维持边缘骨水平并降低种植体周围炎发生风险。

2.2.3　骨与软组织的功能重建　牙周炎的长期进展可导致牙槽骨呈现复杂、多样且不规则的形态学缺损，也导致局部软组织退缩与角化龈丧失，从而显著增加种植手术的技术难度和并发症风险[49-50]。针对牙周炎患者复杂的软硬组织缺损，应适时开展软硬组织增量技术。

2.2.3.1　骨增量技术　骨增量技术是为了恢复种植体的三维支撑基础，常包括引导骨再生术（guided bone regeneration，GBR）、自体骨块重建技术以及上颌窦提升术等。

GBR是目前临床应用广泛且循证依据充分的骨增量方法之一，一项针对治疗获益问题，开展的病例系列研究显示，GBR能有效增加（4.0±1.5）mm的牙槽骨宽度，并维持良好的边缘骨稳定性及软组织健康[51]（OCEBM Ⅳ级）（ClinicalTrials.gov registration：NCT03028922）。近年来，新型材料通过增强屏障膜稳定性，延长屏障功能持续时间[52]，以及改善骨替代材料体积稳定性及吸收率[53]，进一步提升了GBR的骨增量效果。

一项针对治疗获益问题，开展的病例系列研究显示，对于垂直骨缺损≥4 mm或空间维持困难的病例，自体骨块移植较单纯GBR具有更强的三维

结构支撑能力，并能有效促进成骨细胞迁移，促进血管化及骨再生，实现显著的垂直及水平骨增量[54]（OCEBM Ⅳ级）。一项针对治疗获益问题，开展的随机对照试验结果显示，结合计算机辅助设计与制作（computer-aided design/computer-aided manufacturing，CAD/CAM）个性化钛网的应用，可进一步增强空间维持能力，实现垂直及水平骨增量[55]（OCEBM Ⅱ级）（ClinicalTrials.gov registration：NCT04257097）。

此外，在上颌后牙区，上颌窦底提升术是重要的骨增量手段。但长期慢性牙周炎症可能影响窦腔软组织的结构与微环境，从而潜在地影响上颌窦底提升术的愈合质量和并发症风险[56]。一项针对治疗获益问题，仅纳入随机对照试验的Meta分析结果表明，在临床中，可采用生物活性骨替代材料[57]（OCEBM Ⅰ级）及生物制剂辅助以促进骨再生效果[58]；一项针对治疗获益问题，开展的非随机对照试验显示，在经牙槽嵴入路（内提升）中结合骨致密化技术，以增强骨量及初期稳定性[59]（OCEBM Ⅲ级）；对于需行外侧开窗的病例，一项针对治疗获益问题，开展的病例系列研究表明，可通过微创手术策略在减少创伤的同时维持良好的骨增量效果，适用于全身状况较差或伴复杂牙周炎的患者[60]（OCEBM Ⅳ级）。

然而，在牙周炎背景下，无论采用GBR、自体骨块移植还是上颌窦底提升术，均面临共同的生物学与临床挑战。牙周炎患者常处于持续或易复发的低度炎症状态，这种宿主免疫失衡可干扰移植骨的血管化过程及新骨形成，进而增加骨吸收及重建失败的风险。同时，牙周炎相关的软组织退缩与角化龈不足，使得术区软组织封闭能力下降，而骨增量手术对软组织张力控制及初期稳定性要求较高，一旦创口关闭不良，易发生切口裂开及移植材料暴露，从而显著影响再生效果。所以，在牙周炎患者实施骨增量与种植治疗时，应以进入稳定的SPT阶段为前提，根据骨缺损情况及软组织条件，依据GBR“PASS”原则，即创口一期愈合、血管化、空间维持与血凝块/种植体稳定，并制定个体化手术策略，以实现在风险可控前提下的骨重建及长期种植体稳定。

2.2.3.2　软组织管理　一项针对预后问题，纳入前瞻性队列研究、回顾性队列研究和横断面研究的Meta分析表明，种植体周围角化黏膜宽度<2 mm会导致黏膜活动度增加，刷牙时软组织不适，患者自我菌斑控制效率降低，与种植体不良预后显著相关[61]（OCEBM Ⅱ级）。此外，一项针对预后问题，开展的回顾性队列研究表明，薄龈生物型患者在种植体负荷后第1年表现出更显著的边缘骨丢失和牙龈退缩，且探诊深度显著增加[62]（OCEBM Ⅲ级）。因此，对于具有牙周炎病史且软组织表型不佳的患者，应考虑进行软组织增量，增加黏膜厚度至1.8~2.0 mm并获得单侧≥2.0 mm的角化龈宽度，有助于建立稳定的生物学封闭，降低黏膜退缩及种植体周围炎风险，从而促进长期的美学稳定性和菌斑控制能力[63-65]。

结缔组织移植是增加黏膜厚度与改善长期稳定性的金标准，一项针对治疗获益问题，开展的随机对照试验显示，结缔组织移植平均可增加黏膜厚度1 mm[66]（OCEBM Ⅱ级）（ClinicalTrials.gov registration：NCT05458271），而游离龈移植术是角化龈增宽的金标准，一项针对治疗获益问题，纳入随机对照试验与非随机对照试验的Meta分析结果显示，游离龈移植可使角化龈平均增宽2.74 mm[67]（OCEBM Ⅱ级）。但传统软组织移植，多采用自体组织，存在开辟第二术区、组织可用量有限、手术时间长、技术敏感性高、并发症发生率高等缺陷，目前研究发现富血小板纤维蛋白、异种胶原基质、脱细胞真皮基质可在一定程度上替代自体移植，减少供区创伤并获得软组织增量效果[68]。此外，对于上颌前牙美学区条带状游离龈移植联合异种胶原基质能更有效改善颜色与质地匹配，特别适用于高笑线、薄型软组织表型及美学要求高的患者[64]。

2.2.4　数字化技术赋能精准功能重建　在牙周炎患者中，由于牙槽骨呈现不规则吸收、骨壁缺损及嵴顶形态不对称，传统自由手植入更易产生空间偏差，尤其在骨量有限或邻近重要解剖结构时风险增加。数字化辅助种植，如静态导板技术[69-70]和动态导航系统[71-72]对于实现理想三维定位和提高长期可预测性具有重要临床意义[73]。此外，种植机器人技术逐步应用于临床，其通过数字化规划与高精度执行，实现更稳定的路径控制与重复性，尤其在严重骨吸收、多单位种植修复或邻近重要解剖结构的疑难病例中优势明显[74]。

2.2.5　咬合的设计与控制　咬合创伤与种植体边缘骨丢失呈正相关，并在炎症状态下加速骨破坏[75]。因此，合理的咬合设计以及在临床维护中重复进行咬合检查与调整是维护种植体健康的必

要步骤[76]。术后需调整牙齿咬合主功能区，减弱牙齿近远中向移位的分离，有助于维持种植修复体的邻面接触[77]。此外，一项针对治疗获益问题，开展的非随机对照试验显示，相较于传统强调的正中轻咬合，更应确保在侧方运动和前伸运动中，种植修复体不产生早接触和不利的引导力[78]（OCEBM Ⅲ级），以减轻修复体的功能性负担，从而提高种植体稳定性和长期成功率[79]。

综上，笔者强调牙周炎患者种植修复的核心目标应由单纯缺牙修复转向功能重建。应以牙周炎症控制和稳定维护为前提，综合评估剩余牙列、软硬组织条件、种植手术方案、修复方式及咬合负荷，结合数字化手段实现种植体三维位置、组织支持和力学分布的协调统一。只有在构建充足稳定的软硬组织支持以及合理的生物力学负荷条件基础上，才能有效降低种植体周围炎的发生风险，并实现长期可维持的口颌功能重建。

2.3　长期维护—牙周炎患者种植成功的保障

牙周炎患者接受种植治疗后，牙周支持治疗是维持组织健康、降低并发症风险的核心策略，能显著降低种植体周围炎的发生率，提高种植体存活率[80]。基于个体风险制定的支持性维护计划可更有效改善探诊深度、出血等临床指标，并有助于抑制骨丢失与炎症进展[81]。

2.3.1　并发症早期识别与管理　目前，多种基于循证医学证据的种植体周围炎预测工具被开发，其通过整合牙周炎易感性、探诊深度及吸烟史等关键危险因素，为临床提供了可量化的术前风险分层框架[82-83]。机器学习模型亦展现出优异的预测效能[84]。美国骨结合学会和美国牙周病学会联合专家共识指出，种植体周围炎的预防应遵循风险分层和持续维护原则[85]。笔者推荐，对于高风险因素的患者，应实施风险导向的SPT，3~4个月复查1次；而对于低风险且组织稳定者，可在持续评估基础上适当延长维护间隔。常规复查可通过探诊出血、探诊深度和影像学检查进行监测[86]。结合种植体周围龈沟液中的生物标志物，如IL-1β、皮质醇[87]以及活化基质金属蛋白酶-8[88]（ClinicalTrials.gov registration：NCT05711407）进行动态监测，可提高早期诊断及风险评估的敏感性。

2.3.2　菌斑控制与炎症调节　有效的菌斑生物膜控制是预防和控制种植体周围炎的基础性措施[89]。菌斑导向治疗（guided biofilm therapy，GBT）作为一种标准化的生物膜管理方案在牙周与种植体维护中逐渐受到关注[90]。其综合了菌斑染色、甘氨酸或赤藓糖醇喷砂[91-92]（ClinicalTrials.gov registration：NCT05801315）、手工/超声清洁等步骤，以系统化程序有效清除菌斑生物膜，控制炎症[93]。光动力疗法等辅助生物膜干预技术作为机械清洁的补充，能改善种植体周围的炎症指标，提示多模式生物膜清除策略具有潜在的应用前景[94]。此外，宿主调节治疗作为一种针对炎症级联反应上游调控的策略，通过抑制过度激活的中性粒细胞，调节Th17细胞免疫平衡和巨噬细胞极化，改善宿主免疫炎症反应，在牙周炎中已得到较为充分的研究[95]。然而，其在种植体周围炎中的临床应用中，仅有小样本临床证据提示其可改善种植体周围炎临床指标[96]，未来需要更多高质量临床研究加以验证。

2.3.3　行为因素的管控　行为因素是影响种植体周围长期稳定的重要可干预因素，其管理应贯穿于种植治疗全过程。戒烟是首要措施，长期戒烟可能使风险趋近于非吸烟者[97]。因此，可结合行为治疗、尼古丁替代及药物辅助（如伐尼克兰）开展系统化戒烟干预。此外，应针对糖尿病、代谢综合征及骨代谢异常等共病开展综合管理，要求患者积极到相关临床科室进行疾病监测与用药调整，从而优化种植治疗预后、降低生物学并发症风险[98]。同时，采用“演示—回授”模式强化口腔卫生指导[99]，帮助患者掌握使用软毛或电动牙刷进行机械清洁，并结合牙间刷、冲牙器及单束刷等辅助工具[100]开展有效自我菌斑控制，并鼓励患者借助手机口腔卫生管理软件[101]和移动端人工智能辅助技术[102]（ClinicalTrials. gov registration：NCT06083649）提升依从性与长期维护效果。

因此，笔者建议种植修复完成后，应以风险导向的牙周支持治疗为核心，开展对种植体周围疾病的早期识别和动态管理。同时，通过规范化菌斑控制、炎症调节、戒烟和全身共病管理，提高患者自我维护能力和长期依从性。只有将专业维护与患者行为管理相结合，才能在牙周炎易感背景下持续降低种植体周围炎和种植失败风险，保障种植修复的长期稳定。

3　总结与展望

综上所述，牙周炎患者种植体失败及种植体周围炎风险增加，其种植修复是一项“炎症控制—功能重建—长期维护”的系统工程。因此，需通过

系统的牙周炎症控制与稳定维护、科学的种植方案设计、合理的材料与技术选择以及长期规范的维护管理，在可控风险范围内实现患者功能与美学的重建。未来研究应整合宏基因组学、免疫组学及代谢组学等多组学数据，深入解析牙周炎与种植体周围炎的共性与差异机制。同时，积极开发人工智能与大数据的风险分层系统，基于多中心验证、动态风险监测及精准检测技术的融合，实现高风险人群的精准识别与决策支持，推动风险评估从静态筛查向个体化全程管理演进。利用数智化种植技术、功能化种植体表面改性材料和软硬组织再生材料，进一步优化复杂软硬组织缺损的修复策略，推动牙周炎患者种植治疗向更安全、可预测及个体化方向发展。

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【Data availability statement】 Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

【Generative AI statement】 The icons in Figure 1, Figure 2 were generated using Google Gemini (Google LLC, Mountain View, CA, USA) and subsequently edited in Adobe Photoshop CC (Adobe Inc., San Jose, CA, USA). The authors take full responsibility for the content of the generated material, including the originality, accuracy, and its compliance with ethical and copyright standards, and confirm that the work does not plagiarize or infringe upon any copyright. No other generative AI technologies were used.

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