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口腔颌面部软组织缺损的血管化皮瓣游离移植修复技术应用现状与展望

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摘　要

口腔颌面部软组织缺损是常见的临床问题，通常由外伤、手术切除口腔黏膜病变及良恶性肿瘤等原因引起。缺损的存在不仅对口腔功能产生负面影响，同时也对患者的美观和心理产生诸多困扰。本文旨在综述口腔颌面部软组织缺损的愈合机制及各种自体组织移植修复方法，通过对不同修复策略的优缺点的比较，为临床治疗提供指导，以期为该领域的研究者和临床医生提供有效的参考。

关键词

软组织缺损，伤口愈合，自体组织移植，皮瓣移植

Current Status and Prospect of Vascularized Flap Free Graft Repair Technology for Oral and Maxillofacial Soft Tissue Defects

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Abstract

Oral and maxillofacial soft tissue defects are common clinical problems, usually caused by trauma,

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surgical resection of oral mucosal lesions, and benign and malignant tumors. The existence of defects not only has a negative impact on oral function, but also causes many problems to the aesthetics and psychology of patients. The purpose of this article is to review the healing mechanism of oral and maxillofacial soft tissue defects and various autologous tissue transplantation repair methods, and to provide guidance for clinical treatment by comparing the advantages and disadvantages of different repair strategies, in order to provide an effective reference for researchers and clinicians in this field.

Keywords

Soft Tissue Defects, Wound Healing, Autologous Tissue Transplantation, Flap Transplantation

1. 引言

口腔颌面部软组织缺损是指口腔颌面部软组织的部分或整体缺损，常见于颌面部外伤、口腔黏膜病变切除术后、口腔恶性肿瘤切除术后等。口腔颌面部的功能特征至关重要，咀嚼、吞咽、言语等都是人类生理功能的重要组成部分[1]，其功能完整性不仅直接影响着患者的营养摄入和生活质量，还可能对患者的人际交往和社会心理适应能力产生消极影响。因此，颌面外科医生在进行软组织重建时，应增强对于重建的感知，必须全面考虑如何恢复这些功能，而不仅是单纯的闭合缺损，以期寻求更好的功能结果和美学效果[2]。因此，在软组织缺损的修复过程中，如何在解剖形态恢复和生理功能重建之间建立动态平衡，成为了当今外科医生丞待解决的重要课题，然而，软组织缺损修复的临床效果往往与所选择的修复方式密切相关，不同的修复方法有各自的适应证、优缺点，因此医生需对患者进行系统评估，如缺损范围、毗邻结构特征及患者的功能需要，从而制定个体化、精准的修复策略。

本文将深入探讨口腔颌面部软组织创口的愈合机制以及软组织缺损的各类血管化皮瓣游离移植修复技术的选择，旨在为相关领域的研究人员和临床医师提供坚实的理论支持，并为实际应用提供明确的指导。同时，我们还将展望未来的研究方向，探索适合于口腔颌面部软组织缺损修复的新方法。我们的目标是全面提高修复效果，提升患者的生活质量，使其能够更好地参与社会活动、恢复正常生活。

2. 伤口愈合机制

伤口愈合是一个复杂且动态的生理过程，主要分为止血期、炎症期、增殖期和组织重塑期四个相互关联的生物学阶段[3]，这四个阶段有序进行，且相互重叠[4]。组织受到损伤后数分钟内即发生血管收缩和血小板活化，形成含有血小板、胶原蛋白和各种蛋白质(如纤维蛋白、凝血酶和纤维连接蛋白)的血凝块，实现初步止血。损伤后 1 至 4 天，血管通透性增加，各种细胞因子和生长因子释放引发炎症反应[5]，以中性粒细胞浸润为特点，通过吞噬作用清除坏死组织，防止和对抗细菌入侵，这一阶段由白细胞、单核细胞、巨噬细胞等介导[6]。随后进入增殖期，持续时间通常为受伤后第 3 天至 2 周，此期伤口开始收缩及愈合，新生血管生成和结缔组织形成[6]。此外，成纤维细胞会形成胶原基质来填充伤口边缘和缺损的组织空隙[7]，促进创口愈合。重塑期是伤口愈合的最后阶段，通常可能持续数月。在重塑过程中，不断更新胶原蛋白以建立新组织的抗拉强度和弹性[6]，最终实现组织机械性能的恢复。

创口愈合方式直接影响临床修复方式的选择，在临床上，外科医生最期望能通过缝合等使伤口边缘

紧密贴合来实现伤口封闭愈合，这种情况通常见于无明显组织缺损或缺损少、创缘平整、创缘张力指数小、创口无明显感染等情况[8]。当创口微环境满足一期愈合条件时，通过精确缝合可引导修复过程直接进入增殖期，从而缩短愈合周期至 7~14 天。在这一过程中，伤口边缘通过血小板聚集、凝血、组织生长因子的释放及纤维细胞的迁移和增殖形成血凝块，随后逐渐被新生成的组织替代，因此其愈合过程相对较快。然而，口腔中对于此种愈合方式的适应征非常局限，仅适用于孤立于唇、硬腭、颊黏膜、口底、舌侧缘等[9]较为整齐或创伤较小的创口。当缺损跨越口腔亚单位时，如口底－舌部联合缺损，若仍使用直接缝合的方式，形成的瘢痕易导致功能缺陷[10]。对于缺损范围小于 50%的舌部缺损，直接缝合后舌活动、言语等方面的功能较皮瓣重建术后更好[11]；Merdan 等人[12]通过部分舌切除术后采用直接缝合或皮瓣重建的研究对比，发现当舌部缺损范围大于 50%时，选择直接缝合技术对于患者舌体活动、言语、吞咽功能的恢复有较大影响。

在口腔颌面外科的诊疗中，相当一部分患者的创面是无法直接拉拢缝合的[13] [14]，如口腔颌面部严重损伤(外伤、实体瘤切除等造成的大面积组织缺损)等，此时，使用各种移植物来覆盖保护创面成为必要选择，临床上常用的有自体移植、同种移植、异体移植及各类生物材料等。本综述着重分析血管化游离皮瓣移植技术的适应证与术式选择原则。

3. 自体移植

自体移植是指将一块健康组织移植到缺损部位，其来源于患者自身组织，如皮肤、肌肉等，其优点是取自患者自身，排异风险较低、组织相容性高、血供丰富，愈合效果通常较好[15] [16]；自体移植通过再生和修复机制促进愈合，自体组织中含有丰富的干细胞和生长因子，可以促进组织再生，移植物中的血管、细胞和生长因子有助于提供营养，促进细胞增殖与再生。但其具有供区发病率的风险[17]，可能导致取材部位的疼痛、肿胀、瘢痕甚至功能障碍；此外，还会导致手术时间延长，需要进行取材处理。

由于口腔颌面部恶性肿瘤切除而导致软组织缺损的患者，通常在手术切除后还需辅助放疗、化疗或免疫治疗，从而有发生相关的颌骨坏死的风险，Toshinari 等人[18]的研究表明皮瓣移植可以为发生药物相关性颌骨坏死而暴露的骨骼提供机械化稳定和血管化良好的覆盖，从而促进其良好的愈合。然而，Kos 等人[19]的研究指出，虽然相对罕见，但在第一次肿瘤切除重建后，用于口内重建的皮瓣上有可能出现继发性肿瘤或新的原发性肿瘤，目前仍然没有解释导致这种情况发生的潜在机制。

3.1. 前臂桡侧游离皮瓣

前臂桡侧游离皮瓣(Radial Forearm Free Flap, RFFF)于 1983 年首次应用于口腔内软组织缺损重建[20]，其供养动脉是桡动脉。RFFF 具有薄且柔韧、不带肌肉、解剖恒定、血管蒂长、制备容易、存活率较高的优点[21] [22]，其血管口径与头颈部受区血管口径相近，血管蒂长，便于吻合血管，该皮瓣被广泛应用于头颈部组织缺损修复重建中，尤其是口腔中小软组织缺损的修复重建中，如舌体、颊粘膜等，并成为主力皮瓣。RFFF 在应用时，口腔内原发灶的切除和 RFFF 的制备可由两组人员同时进行，从而节约手术时间。

但 RFFF 具有自身局限性，术后静脉血栓形成是 RFFF 最显著的并发症[23]；其次，其制备需要牺牲知名血管桡动脉；外观影响也是其劣势之一[24]，前臂处于人体暴露部位，大多数情况下不能直接拉拢缝合，常需从腹壁、上臂内侧等部位切取薄层皮片修复 RFFF 制备后的缺损区域，从而导致该区域瘢痕明显，但研究表明可以通过使用适当的方法来获得供体部位美容效果的改善，如猪胶原膜[25]、脱细胞基质[26]、自体脂肪移植[27]、局部或远处全层皮肤移植[28]等。此外，植皮若失败还会导致肌腱暴露甚至于影响腕部功能，常有麻木、活动异常等并发症[29]的发生。Jie Liu 等人[30]进行的关于 RFFF 长期供体发

病率的研究表明，RFFF 切取后，术后平均腕关节活动度较术前明显降低，这可能是由于术后早期疼痛、肿胀限制活动，术后平均约 12 个月恢复正常，腕关节功能障碍如握力、尖端捏、手掌捏等在术后 24 个月仍有一定程度的功能不全，这与 Riecke 等人[31]的研究结果一致。锻炼配合物理治疗可在一定程度改善腕关节功能障碍，促进功能恢复[30]。

3.2. 大腿前外侧皮瓣

大腿前外侧皮瓣(Anterolateral Thigh Flap, ALTF)由 Song [32]等人于 1984 年首次引入，Koshima [33]等人随后推广，现目前 ALTF 已成为重建由肿瘤、创伤、炎症和其他疾病导致的四肢、头部和颈部软组织缺损的主要选择[34]。ALTF 用途广泛，优点有血管蒂长、管径粗、穿支丰富、可制备面积大、成活率高、不牺牲肢体主要血管、皮瓣切取后对供区功能和外形影响较小[35]-[37]等，其能够根据缺损具体情况来制备皮瓣、皮瓣 + 肌瓣的组合[38]，可根据需要提供足够的皮肤组织量和肌肉组织量，在复杂缺损三维重建中展现独特优势。相较于 RFFF，ALTF 可以通过股旋外侧神经神经化，在重建区域内提供感觉的潜力[39] [40]。且 ALTF 位于大腿处，供区隐蔽性使患者满意度提高[41]。同时，ALTF 制备后通常无需皮肤移植物来覆盖供体部位[42] (当切取宽度 < 8 cm 时)，可直接拉拢缝合。

然而，相比于 RFFF，ALTF 的技术敏感性更高，术中血管的摆放更为重要，血管蒂发生扭转、术中动脉痉挛的可能性更大[43]。同时，ALTF 的穿支血管变异大[44]，术前需通过血管造影等辅助检查行血管定位标记，皮瓣制备的难度更高，因此需要医生具有更加丰富的手术经验。目前，大多数文献表明游离皮瓣移植的存活率已超过 90% [34] [43]，Marco 等人[43]研究表明 ALTF 较 RFFF 用于头颈外科重建的成功率较高，但其需要的手术时间明显延长。对于肥胖患者来说，皮下脂肪层较厚是 ALTF 的主要缺点，过厚的皮瓣对口腔内软组织重建恢复相应功能不利。

3.3. 薄大腿前外侧皮瓣

薄大腿前外侧皮瓣(Super-Thin Anterolateral Thigh Flap, Super-Thin ALTF)是传统 ALTF 的先进改良技术，Super-Thin ALTF 定义[45]为在传统 ALTF 的基础上，去除浅筋膜层的多余脂肪，或在显微镜下精细解剖周围血管蒂脂肪，使得皮瓣厚度控制在 3~12 mm 不等，减薄后的 Super-Thin ALTF 较传统的 ALTF 更为纤薄且灵活，使其特别适用于颌面部和口腔内重建[46]，这种结构改良可以显著提升患者术后的功能性，尤其是在进行口腔相关活动时，同时还能改善患者的美观效果。

传统的 ALTF 应用于唇部等部位的重建时[47]，由于其厚度较大，常常导致效果不佳，显得臃肿，患者可能需要二次手术来进一步减薄，适应美观需求。Cigna 等人[48]比较了直接使用 Super-Thin ALTF 组和传统 ALTF + 二次减薄组用于头颈部重建的效果，结果表明 Super-Thin ALTF 组相较于传统 ALTF + 二次减薄组重复手术需求降低 6 倍(4% vs 28%)，具有显著的统计学差异，同时，两种方法在并发症发生率上无显著差异。此外，Super-Thin ALTF 组可使患者的恢复周期缩短，降低医疗成本。因此对于特定部位的修复以及肥胖患者来说，Super-Thin ALTF 是优于传统 ALTF 的选择。Super-Thin ALTF 结合了 RFFF 和传统 ALTF 的优点，如提供薄而柔韧的特性，无需二次减薄，同时具有较低的供区发病率、血管蒂长、可嵌合使用以及适合两组人员同时操作等[47] [49]。然而，Super-Thin ALTF 也存在一定的并发症风险，如皮瓣的薄度可能会限制供体区域的皮肤和血管供应，从而可能导致皮瓣坏死和血液循环不良等并发症[50]。同时也提示临床医生，并非所有患者都适合 Super-Thin ALTF，皮肤薄弱或血供不良的患者，可能不适宜使用 Super-Thin ALTF。

3.4. 腓肠内侧动脉穿支皮瓣

腓肠内侧动脉穿支皮瓣(Medial Sural Artery Perforator Flap, MSAPF)自 2001 年由 Cavadas [51]首次引

入后，逐渐发展为重建外科领域中一种重要的技术。Kao [52]等人首先将其应用于头颈部创面修复，证明了 MSAPF 在多种情况下的有效性和实用性。由于该皮瓣具有多项显著优势，包括质地薄、血管蒂长、管径粗大、不需牺牲主干血管、供区发病率低等特性[53] [54]，MSAPF 可携带相关的神经、肌腱和肌肉构建嵌合皮瓣以修复三维软组织缺损创面，使得 MSAPF 在创面修复中的使用愈发广泛，包括口腔、头颈、手部、膝关节、小腿及足踝等多个部位的重建。随着对 MSAPF 的研究深入，它被认为在修复头颈及口腔部位缺损方面具有继桡动脉皮瓣后成为主要选择的潜力[55]。此外，由于腓肠内侧动脉的供血，MSAPF 在术后常常展现出良好的血供和愈合效果。

然而，MSAPF 在使用过程中也有不可忽视的缺点，如循环问题、穿支解剖结构多变及血管口径减小是影响其使用的主要因素[56]。由于 MSAPF 血管蒂在肌内走行，因此制备 MSAPF 对解剖技术要求较高，外科医生需在术前进行仔细评估，包括行术前超声多普勒、CT 血管造影以明确血管分型和走行，从而降低血管分离难度并减少术中风险[52]。也有学者尝试将内镜技术应用于穿支探查，旨在通过更精确的技术降低血管变异所造成的医源性损伤[57]。MSAPF 较 RFFF 和 ALTF 具有最低的供区发病率[17] [58]，根据目前的文献报道，当切取皮瓣宽度 ＜6 cm 时可直接关闭供区[59]，无需二次植皮；然而，在 Aakshay Gulati 等人的研究中表明，MSAPF 较 RFFF 和 ALTF 的总体并发症发生率更高[60]，如供区创口裂开、皮瓣血运障碍等，此外，有文献报道 MSAPF 切取后早期有发生腓肠肌内侧头坏死风险[61]，进而可导致约 10% 的弹跳力丧失[51]。

3.5. 旋髂浅动脉穿支皮瓣

旋髂浅动脉穿支皮瓣(Superficial Circumflex Iliac Artery Perforator Flap, SCIPF)是一种具有独特优势的软组织重建技术，最初是由腹股沟皮瓣演变而来，腹股沟皮瓣因其可以提供大面积的皮肤组织，同时可以直接关闭较隐蔽的供区，广泛应用于多种外科重建。但其解剖结构多变、厚度较大以及不易折叠等缺点[62] [63]限制了其在颌面部缺损重建中的应用。通过全面分析腹股沟皮瓣的解剖特点，旋髂浅动脉穿支皮瓣克服其固有缺点[64]，最大限度发挥其优势，提供更薄且更符合面部外形及轮廓的皮瓣，减小供区的发病率，且较 ALTF 具容易隐藏的疤痕。SCIPF 还可嵌合不同的组织[65]，如骨、肌肉、神经，甚至淋巴组织，从而提供更灵活的重建选择。

然而，SCIPF 具有解剖学上的可变性、血管蒂较短以及小血管直径的缺点[66]，这些都对其应用效果产生影响。术前结合超声多普勒检查及血管造影，既可以准确定位主要血管，又能识别其变异，为手术提供必要的信息，降低术后并发症的发生。同时，术中使用超显微外科技术可以更精细地操作，避免对周围组织的损伤，进而提升皮瓣的存活率和功能效果。Mario 等人[67]研究提出术中使用吲哚菁绿灌注血管造影辅助评估动脉供应及静脉引流，可以降低部分或完全皮瓣失败的风险，这一技术的运用为优化术中判断提供了新的方向。Terence 等人[68]的研究则探索了通过解剖深筋膜以外的血管，获得额外的 1~2 cm 的蒂长，同时也确保了更大直径的血管供应。根据 Michael 等人[15]的研究结果，SCIPF 相较于 RFFF 和 ALTF 具有较低的并发症发生率及总体住院时间减少，这些优势使得 SCIPF 在临床实践中逐渐获得更多关注和认可。目前关于 SCIPF 的文献报道主要集中在肢体缺损等受体血管位于浅表的情况[69]，关于 SCIPF 在头颈部的相关研究相对较少，因此对该皮瓣在这一领域的适应性和有效性仍需进一步探讨。

4. 总结

总体来说，口腔颌面部重建手术的成功与否取决于面部轮廓、皮肤纹理和功能表达的恢复。它不仅仅是填补缺损，而是提供功能和美容。理想的皮瓣应提供与周围皮肤厚度相近的薄皮瓣，同时应能够恢复其感觉。对于小到中等大小的缺损，使用局部或区域旋转皮瓣是迄今为止最好的选择。对于较大的缺

损或不能用局部皮瓣覆盖的缺陷，自由皮瓣是不可避免的。自体游离皮瓣重建口腔内软组织缺损可使大多数患者获得良好的语言、吞咽和生活质量，外科医生可选择的皮瓣类型有很多，但目前尚无确切证据表明某一种皮瓣具有绝对优势，在临床使用中需要综合考虑，根据软组织缺损的大小、部位、供区皮瓣的体积，仔细选择皮瓣是重建成功的关键。同时，在皮瓣移植术后，临床医生应密切关注皮瓣的一般状况，必要时行相关处理。在未来的研究中，探索新型修复材料和技术将显得尤为重要，如生物膜材料修复、3D 打印、再生医学等。综合考虑各类技术的优缺点，谨慎选择合适的修复方式，将是促进软组织缺损修复成功的关键。

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