

黏性骨在口腔种植及牙周领域中的研究进展

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[摘要] 黏性骨由自体血小板浓缩物与颗粒骨移植材料交联而成,具有良好的可塑性和稳定性,可以适应多种骨缺损区形态并维持成骨空间;同时,源于自体血小板浓缩物的白细胞和多种生长因子的释放促进了血管生成和组织愈合。目前,黏性骨已逐渐应用于口腔种植和牙周领域并取得了积极效果。本文阐述了黏性骨的组成、制备方式和作用机制,并对其在牙槽骨增量、即刻种植、牙槽嵴保存、上颌窦底提升以及牙周手术中的应用进行综述,旨在为进一步的机制研究和临床应用提供参考。

[关键词] 黏性骨; 血小板浓缩物; 颗粒骨材料; 骨增量; 牙龈退缩

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Progress of research on sticky bone in oral implant and periodontology

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[Abstract] Sticky bone comprises autogenous platelet concentrates and bone-particle grafts. It exhibits favorable plasticity and stability for fitting various bone defects and maintaining bone-regeneration space. Angiogenesis and tissue healing are promoted by the release of leukocytes and various growth factors from autogenous platelet concentrates. Sticky bone is currently being gradually applied in oral implantology and periodontology, and positive results have been obtained. This review briefly describes the composition, preparation protocol, and mechanism of sticky bone. Its applications in alveolar bone augmentation, immediate implant placement, alveolar ridge preservation, maxillary sinus floor elevation, and periodontal surgery are also outlined. This work can serve as a reference for further research on sticky bone and its clinical application.

[Key words] sticky bone; platelet concentrates; bone particle grafts; bone augmentation; gingival recession

因炎症、外伤、畸形和肿瘤等因素导致的牙槽骨缺损始终是当前口腔医学领域亟待解决的问题^[1]。骨移植材料已被广泛应用于牙槽骨缺损修

复,以满足种植义齿对牙槽骨量的需求^[2]。理想的骨移植材料应满足可操作性佳、低发病率等条件,并具备良好的血管生成潜力及成骨稳定性^[3-5]。目前临床上常用的骨移植材料主要包括自体骨、同种异体骨、异种骨、合成材料和自体血小板浓缩物(autogenous platelet concentrate, APC)等^[2],但作用于骨增量时均存在相应的局限性^[6]。更为关键的是,移植的骨替代材料需要具备在愈合阶段

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稳定维持在骨缺损区并形成必要的成骨空间的能力,防止材料移动降低骨增量效果。据此,发掘一种具有稳定机械性能、可长期维持成骨空间并促进牙槽骨再生的骨移植材料具有重要的临床意义^[3]。

基于自体血液制品的发展,2011年Sohn等^[7]提出了黏性骨(sticky bone)的概念并成功应用于牙槽骨增量。黏性骨是通过将颗粒状的骨移植材料与APC按照一定比例混合,混合期间自体血液中的纤维蛋白原被激活,形成具有一定三维结构的黏弹性支架材料。该材料可根据牙槽嵴缺损的形状整塑成相应的契合形态,并构建出稳定的成骨空间^[8]。同时,APC降解过程中游离出的多种生长因子有助于细胞黏附和血管生成,可促进新骨形成和组织愈合^[9]。此外,黏性骨的密集纤维蛋白网络可减少软组织的长入,避免成骨过程受到干扰^[7]。基于这些优势,黏性骨已经逐渐受到临床医师的关注,有望成为一种理想的骨移植材料。本文对黏性骨的组成、制备方式、作用机制及其在种植及牙周领域中的应用进行综述。

1 组成

黏性骨主要由APC和颗粒状骨移植材料两部分组成。

1.1 APC

APC是一组由自体血液制备的产品,旨在通过高速离心手段从自体血液样本中提取有助于改善愈合和促进组织再生的元素^[10],如血小板、纤维蛋白和细胞成分^[11]。基于不同的离心速率,已开发出的APC包括富血小板血浆(platelet-rich plasma, PRP)、富血小板纤维蛋白(platelet-rich fibrin, PRF)、浓缩生长因子(concentrated growth factor, CGF)及相应衍生物^[12]。

PRP是初代APC,被激活后所含的血小板会释放出由生长因子、细胞因子和趋化因子等组成的颗粒内容物,参与到伤口愈合和组织再生过程^[13-14]。PRF是第2代APC,与PRP的不同之处在于制备过程中无需加入抗凝剂及凝血酶/氯化钙来激活血小板和聚合纤维蛋白^[15],并且含有更多的细胞因子和干细胞^[16-17]。通过改良制备程序,在PRF的基础上开发出多种衍生物,包括可注射型富血小板纤维蛋白(injectable platelet-rich fibrin, i-PRF)^[18]、富白细胞-富血小板纤维蛋白(leuko-

cyte-platelet-rich fibrin, L-PRF)^[15]和改良型富血小板纤维蛋白(advanced platelet-rich fibrin, A-PRF)^[19]等。CGF是第3代APC,其机械强度和降解速率与PRF相似,但含有更为丰富的生长因子和纤维蛋白基质^[20]。

1.2 颗粒状骨移植材料

在牙槽骨重建过程中,虽然不同类型的骨移植材料存在理化性能上的差异,但是都具备一定的结构支持作用^[21]。自体骨作为骨再生的“金标准”^[22],供体部位包括髂嵴、腓骨、颅骨以及下颌体和下颌支等^[23]。同种异体骨是异体骨组织在保留原有理化特性的基础上,经脱细胞处理形成的具备骨诱导性的骨移植材料^[24],可通过改变松质骨与皮质骨比例调整其在体内的吸收速率^[25]。异种骨结构成分与人体骨骼相似,具有优良的机械性能,但加工过程限制了其骨诱导和成骨性能^[26-27]。天然或人工合成的生物陶瓷和聚合物如羟磷灰石(hydroxyapatite)、硫酸钙(calcium sulfate)、 β -磷酸三钙(β -tricalcium phosphate)等具备良好的生物相容性,但延缓了组织愈合的进程^[28-29]。

研究^[30-33]表明:将不同理化特性的颗粒状骨移植植物与纤维蛋白支架构成的APC以一定规则制备并结合,不仅便于手术操作,而且可以协同发挥两者的积极效用。

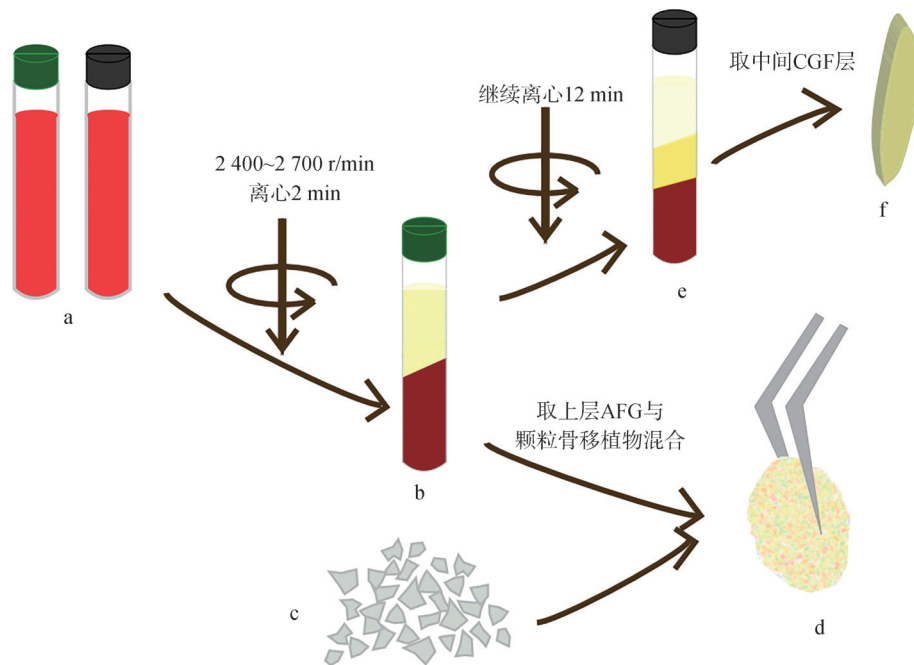
2 制备程序

自黏性骨的概念提出以来,Sohn等^[8]经过一系列临床试验,于2015年提出将CGF联合同种异体骨颗粒制备黏性骨的标准方案,具体流程见图1。抽取20~60 mL肘静脉血分配至1~2个无涂层真空采集管和2~7个无抗凝剂的二氧化硅涂层采集管中,以2 400~2 700 r/min的速度交替离心2 min后取出无涂层采集管,获取中上层的自体纤维蛋白胶(autogenous fibrin glue, AFG)备用;平衡剩余采集管位置并继续离心12 min,获取涂层采集管中的中间层(CGF层)并用金属盖压缩为CGF膜备用;随后将AFG与同种异体骨颗粒混合,在5~10 min的聚合过程后形成黏性骨。在此过程中可加入压缩CGF凝胶的渗出液(含有生长因子和自体凝血酶)以加快聚合过程。

在此基础上,学者们根据不同的应用环境提出了多种改良的黏性骨制备方案,主要涉及多种

类型APC的制备和颗粒状骨移植材料的选择^[34-39]。Csöngé等^[39]在2021年研发出一种半自动生成黏性

骨的装置,在操作流程上进行简化和改良,进一步提高了椅旁效率。



a: 静脉血; b: 离心后获取AFG (上层); c: 颗粒状骨移植材料; d: AFG与颗粒状骨移植材料聚合形成黏性骨; e: 离心后管内分为血清(上层)、CGF(中层)和红细胞(下层); f: CGF压缩成CGF膜。

图1 黏性骨制备程序

Fig 1 The preparation process of sticky bone

3 作用机制

根据PASS原则,牙槽骨再生成功需要满足4个条件:无张力创口关闭(primary wound closure, P)、血管化过程(angiogenesis, A)、成骨空间的创建和维持(space maintenance, S)和骨移植材料的稳定(stability, S)^[40]。

在黏性骨的制备过程中,松散的颗粒状骨移植材料被APC中的凝胶状纤维蛋白原固定。二者接触后激活了凝血级联反应,期间纤维蛋白网络与移植颗粒迅速联结(<5 min),形成具有一定弹性和可塑性的稳定块状物,能够适应不同类型的牙槽骨缺损^[41]。由于黏性骨的纤维蛋白网络联结十分致密,该结构可限制移植材料移动,在一定程度上减少对骨块和钛网的需求;纤维蛋白网络与颗粒材料的密集交联形成屏障作用,限制了软组织向黏性骨内部生长,可不覆盖可吸收或不可吸收屏障膜;源于APC的转化生长因子- β 、血小板源性生长因子、胰岛素样生长因子、静脉内皮生

长因子和上皮生长因子等在愈合期中稳定地释放,持续促进骨缺损区的骨祖细胞迁移、血管生成和软硬组织再生^[42];此外,由于黏性骨具备良好的可塑性,术中可通过塑形和调整获得所需的黏性骨形态,有助于术区软组织关闭。综上,黏性骨在骨再生中的作用机制与PASS原则相一致,为临床应用提供了理论基础。

4 在口腔种植及牙周领域中的应用

4.1 牙槽骨增量

2015年, Sohn等^[8]报告了3例使用黏性骨对种植体周骨缺损、侧方牙槽嵴缺损和垂直牙槽嵴缺损进行骨增量的病例,发现未使用钛网固定的黏性骨在愈合期间维持了良好的牙槽嵴轮廓并形成稳定的新生骨。Joshi等^[43]发现:牙槽嵴缺损4个月后,应用黏性骨在水平向和垂直向可分别获得5.37 mm和4.21 mm的骨量。Cortellini等^[44]测量了10例水平牙槽嵴缺损应用黏性骨5~8个月后的嵴水平宽度和体积变化,结果显示:在牙槽嵴顶2、6、

10 mm处, 牙槽嵴宽度平均增加了(4.6±2.3)、(5.3±1.2)、(4.4±2.3) mm, 牙槽嵴体积平均增加了(1.05±0.7) cm³, 而移植物体积吸收率仅为15.6%±6.7%。该研究者认为: 黏性骨致密且稳定的结构性质在牙槽嵴增量过程中起到了关键作用。

鉴于APC在促进创面愈合和减少组织水肿等方面的优势^[12], 由APC组成的黏性骨同样具备这些特性。Iancu等^[45]与Barbu等^[46]比较了黏性骨与自体骨块在牙槽骨增量中的临床表现, 结果显示: 在骨增量上, 黏性骨与自体骨块无明显差异, 但无需开辟第二术区, 避免了供区术后神经感觉障碍、血肿和感染等发生。此外, 有学者^[47-48]提出在牙槽骨增量中应用黏性骨的同时覆盖APC膜, 可以更有效地发挥其效能。

4.2 即刻种植

在即刻种植位点, 种植体周骨缺损间隙内充填黏性骨可以有效防止软硬组织塌陷并促进组织愈合^[49], 尤其在前牙美学区域更有效果^[50]。即使是在伴有严重骨缺损的牙槽窝中进行种植体即刻植入, 黏性骨移植物仍可维持种植体植入后的软硬组织稳定, 降低种植体边缘骨吸收^[51]。此外, 有研究^[52]发现: 黏性骨可提高种植体植入时的初期稳定性, 有助于实现种植体的早期负重。Eid等^[53]和Cirmeni等^[50]在患有根尖周炎症的拔牙位点行即刻种植, 跳跃间隙内充填黏性骨, 术后3年的临床和影像学结果均证实了黏性骨有利于种植体周骨再生。

4.3 牙槽嵴保存

拔牙后牙槽嵴会经历显著的水平向和垂直向骨吸收, 可通过牙槽嵴保存术(alveolar ridge preservation, ARP)代偿吸收的牙槽骨体积^[54]。研究^[55]表明: 与仅充填颗粒状骨移植材料相比, 黏性骨能够降低结缔组织百分比, 这是因为PRF成分在降解过程中释放的多种生长因子能够早期促进细胞增殖和细胞外基质形成, 从而促进组织再生并减少炎症细胞活动。此外, Soni等^[55]报道了1例黏性骨联合PRF膜成功修复因阻生尖牙拔除而遗留的腭侧大面积缺损牙槽窝的病例, 移植术后3个月即观察到显著的骨再生表现。

值得一提的是, Andrade等^[56]和van Orten等^[36]将自体牙本质颗粒与APC混合制备黏性骨, 并将其称为“黏性牙齿”(sticky tooth)。由于牙本质和牙槽骨来自同一胚胎学来源, 有机物与无机物组成相似, 故形成的黏性骨相较于传统颗粒骨移植

材料具备更佳生物相容性和成骨特性。目前有关黏性牙齿的临床研究还很少, 需要更多证据评估其在不同缺损下的表现。

4.4 上颌窦底提升

因牙齿缺失、炎症疾病和上颌窦气化等导致的上颌后牙区牙槽嵴高度不足^[57], 临床上多采用上颌窦底提升术来扩增牙槽嵴垂直骨量^[58-59]。Mu等^[60]在动物试验中观察到, 与上颌窦内单独填充脱蛋白牛骨基质(deproteinized bovine bone matrix, DBBM)相比, 由DBBM与i-PRF制备成的黏性骨可以在上颌窦底提升早期促进窦内血管生成、骨形成以及DBBM的吸收。Shamami等^[61]采用随机对照试验比较上颌窦底提升并同期植入种植体中窦底移植异种骨材料(cerabone)和移植黏性骨(cerabone联合PRF)对种植体稳定性的影响, 结果发现: 术后1、4、8、12、16、24、28、32、36周, 移植黏性骨组的种植体稳定性分别为66.9±8.5、57.4±2.0、66.1±4.0、70.1±3.8、73.4±5.6、74.9±1.9、75.5±5.0、75.1±2.0、74.9±1.0, 仅移植cerabone组的稳定性分别为63.55±6.2、55.4±3.0、59.5±4.9、62.35±4.0、65.8±8.0、68.5±2.2、69.17±7.2、70.7±16.0、71.1±1.0, 各个时间点均观察到黏性骨组的种植体呈现出更高的稳定性。

4.5 牙周手术

根据目前的文献报道, 黏性骨在牙周领域中的应用主要集中在与冠向复位瓣等术式结合治疗牙龈退缩。Kapa等^[62]的病例系列报告尝试将同种异体骨与i-PRF制备成的黏性骨联合冠状复位瓣用于16例前牙区患有Miller I、II型牙龈退缩的患者, 术后6个月的临床和影像学结果显示所有患者的牙龈厚度和唇侧骨高度得到改善, 其中12例达到完全的根面覆盖。Mitra等^[63]的研究中, 将15名患者的30个患有Miller I、II型牙龈退缩位点随机分组, 分别接受单纯冠状复位瓣与冠状复位瓣结合黏性骨及CGF膜的手术方案, 观察两组在1、3、6个月的牙龈退缩深度、宽度、附着水平、角化龈宽度和黏膜厚度的疗效差异, 结果发现: 两组间的差异无统计学意义, 应用黏性骨后的改善效果有优于单纯冠状复位瓣的趋势, 需要进行更多的病例观察和研究。

作为冠状复位瓣的联合材料, 黏性骨在牙龈愈合过程中的作用主要是增强凝血稳定性、促进成骨细胞的增殖和软组织生长^[63]。迄今, 黏性骨治疗Miller I、II型牙龈退缩的临床研究仍不足,

且应用于Miller III、IV型牙龈退缩或其他牙周疾病的临床证据尚少见报道,需要更多相关的研究来探究黏性骨在牙周领域中的效用。

5 总结与展望

由颗粒状骨移植材料与APC交联而成的黏性骨具有良好的可塑性和稳定性,不仅可以适应各种形状的骨缺损,而且致密的纤维蛋白网络有效维持了成骨空间并具有组织屏障作用。此外,APC富含血小板和白细胞,愈合期间可持续释放生长因子,有助于骨再生和软组织修复。黏性骨对于牙槽嵴增量、种植体周骨重建及牙周组织再生具有重要意义,具备广阔的应用前景和临床价值。

现有的研究大多聚焦于黏性骨在牙槽骨缺损的修复,但是黏性骨的组成成分和牙槽嵴缺损类型各不相同,难以评估何种颗粒骨移植材料与何种类型APC聚合而成的黏性骨能够达到最佳的骨再生效果。此外,黏性骨作用于牙周领域的适用范围较为单一,缺少治疗Miller各类型牙龈退缩和牙周炎的临床证据。在黏性骨制备方面,不同学者都在Sohn等^[8]提出的初步方案上进行了经验性改良,尽管都取得了积极的结果,但是需要制定一套共识性的黏性骨制备方案,包括APC类型、颗粒骨材料类型、成分配比等,利于黏性骨的临床应用和研究结果的统计对比。为此,还需要更多的体内外试验来进一步探索不同组合下的黏性骨在口腔种植和牙周领域中促进组织再生的作用机制和临床效果。

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6 参考文献

- [1] Elsalanty ME, Genecov DG. Bone grafts in craniofacial surgery[J]. *Cranio-maxillofac Trauma Reconstr*, 2009, 2(3): 125-134.
- [2] Zhao R, Yang RJ, Cooper PR, et al. Bone grafts and substitutes in dentistry: a review of current trends and developments[J]. *Molecules*, 2021, 26(10): 3007.
- [3] Bhatt RA, Rozental TD. Bone graft substitutes[J]. *Hand Clin*, 2012, 28(4): 457-468.
- [4] Wang WH, Yeung KW. Bone grafts and biomaterials substitutes for bone defect repair: a review[J]. *Bioact Mater*, 2017, 2(4): 224-247.
- [5] Haugen HJ, Lyngstadaas SP, Rossi F, et al. Bone grafts: which is the ideal biomaterial[J]. *J Clin Periodontol*, 2019, 46(Suppl 21): 92-102.
- [6] 龚佳明,张启航,苟萍,等.自体牙本质用于牙槽嵴增量的Meta分析[J].*华西口腔医学杂志*, 2022, 40(5): 566-575.
Gong JM, Zhang QH, Gou P, et al. Meta-analysis of application of autogenous dentin for alveolar ridge augmentation[J]. *West China J Stomatol*, 2022, 40(5): 566-575.
- [7] Sohn DS, Heo JU, Kwak DH, et al. Bone regeneration in the maxillary sinus using an autologous fibrin-rich block with concentrated growth factors alone[J]. *Implant Dent*, 2011, 20(5): 389-395.
- [8] Sohn DS, Huang B, Kim J, et al. Utilization of autologous concentrated growth factors (CGF) enriched bone graft matrix (sticky bone) and CGF-enriched fibrin membrane in implant dentistry[J]. *J Implant Adv Clin Dent*, 2015, 7(10): 11-18.
- [9] Yung YL, Fu SC, Cheuk YC, et al. Optimisation of platelet concentrates therapy: composition, localisation, and duration of action[J]. *Asia Pac J Sports Med Arthrosc Rehabil Technol*, 2017, 7: 27-36.
- [10] Bielecki T, Dohan Ehrenfest DM. Platelet-rich plasma (PRP) and platelet-rich fibrin (PRF): surgical adjuvants, preparations for *in situ* regenerative medicine and tools for tissue engineering[J]. *Curr Pharm Biotechnol*, 2012, 13(7): 1121-1130.
- [11] Dohan Ehrenfest DM, Del Corso M, Diss A, et al. Three-dimensional architecture and cell composition of a Choukroun's platelet-rich fibrin clot and membrane[J]. *J Periodontol*, 2010, 81(4): 546-555.
- [12] 龚佳明,赵瑞敏,张启航,等.自体血小板浓缩物用于上颌窦底提升的系统评价再评价[J].*中国口腔种植学杂志*, 2023, 28(2): 102-108.
Gong JM, Zhao RM, Zhang QH, et al. The autologous platelet concentrates for maxillary sinus floor elevation: an overview of systematic reviews[J]. *Chin J Oral Implantol*, 2023, 28(2): 102-108.
- [13] Liao HT, Marra KG, Rubin JP. Application of platelet-rich plasma and platelet-rich fibrin in fat grafting: basic science and literature review[J]. *Tissue Eng Part B Rev*, 2014, 20(4): 267-276.

- [14] Zhu Y, Yuan M, Meng HY, et al. Basic science and clinical application of platelet-rich plasma for cartilage defects and osteoarthritis: a review[J]. *Osteoarthritis Cartilage*, 2013, 21(11): 1627-1637.
- [15] Dohan Ehrenfest DM, Rasmusson L, Albrektsson T. Classification of platelet concentrates: from pure platelet-rich plasma (P-PRP) to leucocyte- and platelet-rich fibrin (L-PRF)[J]. *Trends Biotechnol*, 2009, 27(3): 158-167.
- [16] Ahmed TAE, Dare EV, Hincke M. Fibrin: a versatile scaffold for tissue engineering applications[J]. *Tissue Eng Part B Rev*, 2008, 14(2): 199-215.
- [17] Burnouf T, Goubran HA, Chen TM, et al. Blood-derived biomaterials and platelet growth factors in regenerative medicine[J]. *Blood Rev*, 2013, 27(2): 77-89.
- [18] Shashank B, Bhushan M. Injectable platelet-rich fibrin (PRF): the newest biomaterial and its use in various dermatological conditions in our practice: a case series[J]. *J Cosmet Dermatol*, 2021, 20(5): 1421-1426.
- [19] Ghanaati S, Booms P, Orlowska A, et al. Advanced platelet-rich fibrin: a new concept for cell-based tissue engineering by means of inflammatory cells[J]. *J Oral Implantol*, 2014, 40(6): 679-689.
- [20] Isobe K, Watanebe T, Kawabata H, et al. Mechanical and degradation properties of advanced platelet-rich fibrin (A-PRF), concentrated growth factors (CGF), and platelet-poor plasma-derived fibrin (PPTF)[J]. *Int J Implant Dent*, 2017, 3(1): 17.
- [21] Fillingham Y, Jacobs J. Bone grafts and their substitutes[J]. *Bone Joint J*, 2016, 98-B(1 Suppl A): 6-9.
- [22] Putters TF, Wortmann DE, Schortinghuis J, et al. Morbidity of anterior iliac crest and calvarial bone donor graft sites: a 1-year randomized controlled trial[J]. *Int J Oral Maxillofac Surg*, 2018, 47(11): 1474-1480.
- [23] Reiningger D, Cobo-Vázquez C, Rosenberg B, et al. Alternative intraoral donor sites to the chin and mandibular body-ramus[J]. *J Clin Exp Dent*, 2017, 9(12): e1474-e1481.
- [24] Benders KEM, van Weeren PR, Badylak SF, et al. Extracellular matrix scaffolds for cartilage and bone regeneration[J]. *Trends Biotechnol*, 2013, 31(3): 169-176.
- [25] Krasny K, Kamiński A, Krasny M, et al. Preparation of allogeneic bone for alveolar ridge augmentation [J]. *Cell Tissue Bank*, 2017, 18(3): 313-321.
- [26] Bracey DN, Seyler TM, Jinnah AH, et al. A porcine xenograft-derived bone scaffold is a biocompatible bone graft substitute: an assessment of cytocompatibility and the alpha-Gal epitope[J]. *Xenotransplantation*, 2019, 26(5): e12534.
- [27] Xu G, Guo RZ, Han LW, et al. Comparison of osteogenesis of bovine bone xenografts between true bone ceramics and decalcified bone matrix[J]. *J Mater Sci Mater Med*, 2022, 33(10): 75.
- [28] Zhang LY, Bi Q, Zhao C, et al. Recent advances in biomaterials for the treatment of bone defects[J]. *Organogenesis*, 2020, 16(4): 113-125.
- [29] Cheah CW, Al-Namnam NM, Lau MN, et al. Synthetic material for bone, periodontal, and dental tissue regeneration: where are we now, and where are we heading next[J]. *Materials*, 2021, 14(20): 6123.
- [30] Anitua E, Sánchez M, Orive G. Potential of endogenous regenerative technology for *in situ* regenerative medicine[J]. *Adv Drug Deliv Rev*, 2010, 62(7/8): 741-752.
- [31] Anitua E, Sánchez M, Orive G, et al. The potential impact of the preparation rich in growth factors (PRGF) in different medical fields[J]. *Biomaterials*, 2007, 28(31): 4551-4560.
- [32] Anitua E, Sánchez M, Orive G, et al. Delivering growth factors for therapeutics[J]. *Trends Pharmacol Sci*, 2008, 29(1): 37-41.
- [33] Xu Y, Qiu JL, Sun QF, et al. One-year results evaluating the effects of concentrated growth factors on the healing of intrabony defects treated with or without bone substitute in chronic periodontitis[J]. *Med Sci Monit*, 2019, 25: 4384-4389.
- [34] Mourão CF, Valiense H, Melo ER, et al. Obtention of injectable platelets rich-fibrin (i-PRF) and its polymerization with bone graft: technical note[J]. *Rev Col Bras Cir*, 2015, 42(6): 421-423.
- [35] Ponte JS, Pérez-Guerrero JA, Aragão FA, et al. Histomorphometric evaluation of human extraction sockets treated with autologous fibrin, sticky bone or biphasic calcium phosphate[J]. *Acta Odontol Latino-*

- am, 2021, 34(3): 271-281.
- [36] van Orten A, Goetz W, Bilhan H. Tooth-derived granules in combination with platelet-rich fibrin (“sticky tooth”) in socket preservation: a histological evaluation[J]. *Dent J*, 2022, 10(2): 29.
- [37] Tony JB, Parthasarathy H, Tadepalli A, et al. CBCT evaluation of sticky bone in horizontal ridge augmentation with and without collagen membrane—a randomized parallel arm clinical trial[J]. *J Funct Biomater*, 2022, 13(4): 194.
- [38] Rupawala TA, Patel SM, Shah NH, et al. Efficacy of sticky bone as a novel autologous graft for mandibular third molar extraction socket healing—an evaluative study[J]. *Ann Maxillofac Surg*, 2020, 10(2): 335-343.
- [39] Csöngé L, Bozsik Á, Tóth-Bagi Z, et al. Regenerative medicine: characterization of human bone matrix gelatin (BMG) and folded platelet-rich fibrin (F-PRF) membranes alone and in combination (sticky bone)[J]. *Cell Tissue Bank*, 2021, 22(4): 711-717.
- [40] Wang HL, Boyapati L. “PASS” principles for predictable bone regeneration[J]. *Implant Dent*, 2006, 15(1): 8-17.
- [41] Cortellini S, Castro AB, Temmerman A, et al. Leucocyte- and platelet-rich fibrin block for bone augmentation procedure: a proof-of-concept study[J]. *J Clin Periodontol*, 2018, 45(5): 624-634.
- [42] Pavlovic V, Ciric M, Jovanovic V, et al. Platelet-rich fibrin: basics of biological actions and protocol modifications[J]. *Open Med*, 2021, 16(1): 446-454.
- [43] Joshi CP, D’Lima CB, Karde PA, et al. Ridge augmentation using sticky bone: a combination of human tooth allograft and autologous fibrin glue[J]. *J Indian Soc Periodontol*, 2019, 23(5): 493-496.
- [44] Cortellini S, Castro AB, Temmerman A, et al. Leucocyte- and platelet-rich fibrin block for bone augmentation procedure: a proof-of-concept study[J]. *J Clin Periodontol*, 2018, 45(5): 624-634.
- [45] Iancu SA, Referendaru D, Iancu IA, et al. Immediate postoperative complications after lateral ridge augmentation—a clinical comparison between bone shell technique and sticky bone[J]. *J Med Life*, 2022, 15(4): 533-538.
- [46] Barbu HM, Iancu SA, Rapani A, et al. Guided bone regeneration with concentrated growth factor enriched bone graft matrix (sticky bone) vs. bone-shell technique in horizontal ridge augmentation: a retrospective study[J]. *J Clin Med*, 2021, 10(17): 3953.
- [47] Marwan Arnab A, Ghonaim I. Comparative study between using A-PRF membrane with sticky bone and traditional GBR procedure at the bone defected area[J]. *Clin Oral Implants Res*, 2018, 29(S17): 121.
- [48] Aboelela S, Fattouh H, Abdel Rasoul M. Ridge augmentation using autologous concentrated growth factors (CGF) enriched bone graft matrix (sticky bone) versus guided bone regeneration using native collagen membrane in horizontally deficient maxilla [J]. *Egypt Dent J*, 2021, 67(4): 3061-3070.
- [49] Aggarwal S, Rawat P, Jain S, et al. A Simplified approach for managing severe horizontal ridge atrophy using sticky bone enriched with autologous injectable PRF: a case report[J]. *Int J Sci Res*, 2021, 9(4): 27-28.
- [50] Cirmeni M, Fedele O, Giammarinaro E, et al. Immediate implant and socket preservation using sticky bone and leukocyte-platelet-rich fibrin in the anterior maxilla: a 3-year case report[J]. *Clin Adv Periodontics*, 2023, 13(3): 144-148.
- [51] Abdullah A, Abdelmabood AA. Autogenous bone ring transplant versus sticky bone in defective socket augmentation with simultaneous implant placement [J]. *Egypt Dent J*, 2020, 66(3): 1459-1507.
- [52] Sadighi Shamami M, Sadighi Shamami M, Safaralizadeh R, et al. The effect of sticky bone on implant stability in ridge splitting and simultaneously implantation[J]. *Clin Oral Implants Res*, 2018, 29(S17): 287.
- [53] Eid ME, Mohamed MA, Tawfik A. Immediate implant placement combined with sticky bone and enriched fibrin membrane for teeth exhibiting periapical pathosis[J]. *Al-Azhar Assiut Dent J*, 2020, 3(2): 106-112.
- [54] Kalsi AS, Kalsi JS, Bassi S. Alveolar ridge preservation: why, when and how[J]. *Br Dent J*, 2019, 227(4): 264-274.
- [55] Soni R, Priya A, Yadav H, et al. Bone augmentation with sticky bone and platelet-rich fibrin by ridge-split technique and nasal floor engagement for im-

mediate loading of dental implant after extracting impacted canine[J]. *Natl J Maxillofac Surg*, 2019, 10 (1): 98-101.

[56] Andrade C, Camino J, Nally M, et al. Combining autologous particulate dentin, L-PRF, and fibrinogen to create a matrix for predictable ridge preservation: a pilot clinical study[J]. *Clin Oral Investig*, 2020, 24(3): 1151-1160.

[57] Chen YH, Cai ZY, Zheng DG, et al. Inlay osteotome sinus floor elevation with concentrated growth factor application and simultaneous short implant placement in severely atrophic maxilla[J]. *Sci Rep*, 2016, 6: 27348.

[58] Boyne PJ, James RA. Grafting of the maxillary sinus floor with autogenous marrow and bone[J]. *J Oral Surg*, 1980, 38(8): 613-616.

[59] 龚佳明, 赵瑞敏, 潘宏伟, 等. 屏障膜对侧壁开窗式上颌窦底提升影响的Meta分析[J]. *兰州大学学报(医学版)*, 2022, 48(10): 24-31.
Gong JM, Zhao RM, Pan HW, et al. Meta-analysis of barrier membranes over the lateral sinus floor augmentation procedures[J]. *J Lanzhou Univ (Med Sci)*, 2022, 48(10): 24-31.

[60] Mu ZX, He QQ, Xin LJ, et al. Effects of injectable platelet rich fibrin on bone remodeling in combination with DBBM in maxillary sinus elevation: a randomized preclinical study[J]. *Am J Transl Res*, 2020, 12(11): 7312-7325.

[61] Shamami MS, Safaralizadeh S, Safaralizadeh R, et al. The effect of use of platelet-rich fibrin (PRF) mixed with bone graft (sticky bone) on implant stability in lateral approach sinus lift procedure and simultaneous implantation: a double blinded randomized clinical trial[J]. *J Clin Periodont*, 2018, 45 (S19): 326-326.

[62] Kapa BP, N K S, G V G, et al. Coronally advanced flap combined with sticky bone and i-PRF-coated collagen membrane to treat single maxillary gingival recessions: case series[J]. *Clin Adv Periodontics*, 2022, 12(3): 147-151.

[63] Mitra D, Kandawalla S, Potdar P, et al. Evaluation of the efficacy of sticky bone and concentrated growth factor membrane along with a coronally advanced flap as compared to coronally advanced flap alone in the treatment of Miller's class I and class II gingival recession defects[J]. *J Indian Soc Periodontol*, 2022, 26(6): 577-584.

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《自体牙移植手术图谱》出版发行

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内容简介：书中采用大量临床病例图片，附以详细注解说明，对自体牙移植手术进行了科学阐述。通过阅读本书，读者可以充分了解自体牙移植手术的术前评估、手术操作步骤和注意事项、术中和术后并发症、后期根管治疗的操作步骤和注意事项、不同类型手术的预后情况以及自体牙移植手术与口腔其他专业的相互关系等，所附病例的随访结果为口腔临床医师确定手术效果提供了可靠依据。本书内容包括：1) 自体牙移植简介；2) 自体牙移植术前评估及处理；3) 自体牙移植的手术步骤；4) 自体牙移植术并发症的原因及防治；5) 自体牙移植的预后及影响因素；6) 自体牙移植和其他牙科治疗的关系。

