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·临床研究·

牛心包膜在美学区水平骨增量手术中的应用效果分析

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【摘要】　目的　探讨牛心包膜在美学区水平骨增量手术中的应用效果，评估其在引导骨再生术(guided bone regeneration，GBR)中的临床可行性。**方法**　本研究通过医院医学伦理委员会审查批准。29例前牙区缺牙伴唇侧骨缺损的患者，应用牛心包膜结合颗粒状或块状骨移植物进行水平骨增量手术。以术前设计中的虚拟种植体为中心，测量术前(T0)、术后即刻(T1)及术后6个月(T2)不同时期种植体颈部及其以下1～5 mm处种植体唇侧骨板厚度，评估骨再生效果。记录术后患者的疼痛、肿胀视觉模拟评分(visual analog scale，VAS)，以及是否有感染、伤口裂开等并发症发生。**结果**　术后即刻，所有患者种植体唇侧骨板厚度显著增加，平均骨增量大于3 mm；术后6个月，骨增量保持较好，特别是在种植体颈部下方3～5 mm处唇侧骨板厚度均大于3 mm。VAS评分显示，术后疼痛及肿胀在术后3 d达到峰值，随后逐渐减轻，术后10 d恢复良好。随访期间无感染、伤口裂开等并发症发生。**结论**　牛心包膜在美学区水平骨增量中具有良好的骨增量效果和生物相容性。

【关键词】　牛心包膜；　胶原膜；　引导骨再生术；　水平骨增量；　美学区；　唇侧骨板厚度；　并发症
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Efficacy analysis of bovine pericardium membrane for horizontal bone augmentation in the aesthetic zone

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【Abstract】　Objective　To investigate the application effect of bovine pericardium in horizontal bone augmentation surgery in the aesthetic area and to assess its clinical feasibility in guided bone regeneration (GBR). **Methods**　This study was approved by the Ethics Committee. A total of 29 patients with anterior tooth loss accompanied by labial bone defects were selected, and horizontal bone augmentation was performed using a bovine pericardium membrane combined with particulate or block bone grafts. Centered on the virtual implant in the preoperative design, labial bone thickness at the implant neck and 1-5 mm below it was measured at different time points: preoperatively (T0), immediately postoperatively (T1), and 6 months postoperatively (T2). The results were used to assess bone regeneration outcomes. Additionally, the visual analog scales (VASs) of postoperative pain and swelling were recorded, and whether any complications such as infection or wound dehiscence occurred were monitored. **Results**　Immediately after surgery, labial bone thickness of all implants significantly increased, with an average increase more than 3 mm. Six months after surgery, the bone augmentation was well maintained. Specifically, labial bone thickness 3-5 mm below the shoulder of the implant was greater than 3 mm. The VAS scores showed that postoperative pain and swelling peaked on the third day and then

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gradually decreased, with good recovery 10 days after surgery. No complications such as infection or wound dehiscence occurred during the follow-up period. **Conclusion**　Bovine pericardium shows good bone augmentation effect and biocompatibility in horizontal bone augmentation in the anterior aesthetic area, and it is suitable for various horizontal bone augmentation surgeries in the aesthetic area.

【Key words】 bovine pericardium membrane; collagen membrane; guided bone regeneration; horizontal bone augmentation; aesthetic zone; labial bone thickness; complications

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前牙区由于唇侧骨板通常较薄，牙齿缺失后易发生严重的骨吸收，不仅增加种植修复的难度，还对美学效果提出更高要求[1]，如何在这一特殊区域实现有效骨增量并满足美学需求，成为临床面临的关键问题。引导骨再生术（guided bone regeneration，GBR）技术通过屏障膜隔离软组织细胞，为骨组织生长提供理想空间，已广泛应用于种植手术前骨量不足的情况[2-3]，在美学区的水平骨增量中具有重要临床价值[4]。近年来，来源于天然材料的可吸收屏障膜因其良好的生物相容性和避免二次手术的优势，逐渐成为水平骨增量的主流选择[5]。这类屏障膜在降解过程中能够为新生骨提供持续支持，但机械强度相对较弱，限制了其在复杂临床场景中的应用[6]。因此，寻找兼具良好生物降解性能与高机械强度的屏障膜材料，成为当前研究的重点方向。动物来源的胶原膜以其接近人体组织的结构和优异的生物学性能，受到广泛关注[3, 7]。其中，牛心包膜作为一种新兴的胶原膜材料，因其独特的双层结构表现出显著优势[8]。牛心包膜致密层可有效阻止软组织细胞的侵入，为骨再生提供稳定环境；粗糙表面则有助于成骨细胞的附着和增殖，从而促进新骨的形成[9]。牛心包膜的机械性能很大程度受其胶原纤维取向和排列结构的影响，其纤维取向与受力方向一致的区域具有显著的抗拉强度和较高的耐疲劳性能[10]，通过合理的结构设计和加工优化能够提升其整体力学性能，满足骨缺损修复对机械支撑和生物降解性能的双重需求。研究表明，牛心包膜在大鼠长骨缺损修复中表现出优异的生物相容性，其显著的力学强度有助于促进骨组织生长，并增强缺损部位的骨体积[11]。以上研究结果展示了牛心包膜在复杂骨缺损修复中作为优选材料的潜力。然而，目前动物来源胶原膜的研究多集中于猪皮或牛真皮材料[12-13]，牛心包膜在GBR中的研究尚属少见，在美学区水平骨增量中的系统研究几乎缺乏。

本研究旨在探讨牛心包膜应用于美学区水平骨增量手术后骨厚度的变化及骨再生效果，验证其在美学区骨增量中的可行性，为优化GBR材料选择提供新思路。

1　资料和方法

本研究经过四川大学华西口腔医院伦理委员会批准（审批号：WCHSIRB-D-2022-171）。所有研究对象均签署了知情同意书。

1.1　研究对象

选取2022年4月至2023年4月于四川大学华西口腔医院种植科就诊的29例前牙缺失要求种植修复治疗的患者。

纳入标准：①患者18～65岁，性别不限；②前牙区单牙或多牙缺失伴唇侧骨板水平骨缺损，需行GBR；③患者身体健康状况良好，能耐受种植手术；④ 无活动性牙周病或其他急性口腔感染疾病；⑤患者及其家属充分了解手术方案，签署知情同意书，愿意参与研究并接受随访。

排除标准：①患有严重心血管疾病、未控制的糖尿病（空腹血糖 ≥ 8.0 mmol/L）、肝肾功能异常，或其他不能耐受手术的全身性疾病；②存在未控制的牙周病、严重根尖周病变，或其他需要优先治疗的急性口腔问题；③吸烟量超过20支/d，且在过去6个月内未戒烟者；④正在或近期（3个月内）服用可能影响软硬组织愈合的药物，如长期使用非甾体抗炎药或糖皮质激素者；⑤患有骨质疏松症、骨软化症、骨硬化症等影响骨代谢的疾病；⑥曾在过去一年内接受过头颈部放射治疗或患有活动性恶性肿瘤；⑦患有免疫系统疾病或自身免疫性疾病，如系统性红斑狼疮；⑧妊娠期或哺乳期女

性；⑨受试者有凝血功能异常，或正在服用抗凝血药物且凝血检查结果异常。

1.2　治疗过程

1.2.1　术前准备　在所有手术开始前，研究人员详细向受试者解释研究目的、手术步骤、潜在风险、术后护理要求及随访计划，并获得受试者签署的知情同意书。术前每位受试者均接受锥形束计算机断层扫描（cone-beam computed tomography，CBCT）（3D Accuitomo 170，J. Morita Mfg. Corp.，日本）和口内扫描（PANDA P2，频泰科技，中国）、虚拟排牙（DentalCAD，Exocad，德国），并将上述数据导入专业种植方案设计软件（Simplant Pro 17.01，Dentsply Sirona，美国），以修复为导向，综合考虑解剖结构（如牙槽嵴宽度、邻牙根间距等）及修复需求（如种植体角度、植入深度及种植体轴线与修复体的关系），进行种植体理想位置及骨增量设计。术前设计文件保存为SPR格式，以便生成并制造术中使用的种植手术导板。此外，所有受试者至少在手术前1周接受了牙周基础治疗。

1.2.2　手术过程　手术由同一位经验丰富的种植医生在局麻（使用4%阿替卡因与1∶100 000肾上腺素）下进行。在缺牙区牙槽嵴顶偏唇侧做横行切口，延伸至术区相邻1～2个牙位远中轴角做垂直附加切口或角形瓣，翻起全厚瓣暴露骨缺损区域，清除所有软组织以确保骨面的完全暴露。在受区骨皮质上使用球钻打孔穿透皮质层以增加血供。按骨缺损程度及术前设计方案在种植导板引导下同期或分期植入种植体。Terheyden1/4型骨缺损采用颗粒状异种骨移植物（Bio-Oss，Geistlich Pharma AG，瑞士）与同种异体骨移植物（Bio-DBM，湖北联结，中国）按1∶1比例混合后，填充至骨缺损区域，重建理想的骨结构轮廓。Terheyden2/4型骨缺损在上述基础上联合纯钛螺丝钉固定同种异体骨片或骨块（Bio-DBM，湖北联结，中国）。将牛心包膜（膜瑞，陕西瑞盛，中国）覆盖于骨移植材料表面，确保其完全覆盖缺损区域，并通过缝线（PROLENE™ Polypropylene Suture，Johnson & Johnson MedTech，美国）或膜钉（MatrixMIDFACE，Depuy Synthes，美国）固定，以确保稳定性。无张力严密缝合术区，确保软组织愈合良好。术后当天拍摄CBCT。分期种植患者在骨增量术后6个月进行CBCT拍摄及口内扫描，种植导板引导下植入种植体。典型治疗过程如图1所示。

1.2.3　术后护理　术后即刻为受试者施行局部冰敷以减少肿胀，并为患者提供详细的术后护理指导。包括使用0.12%的氯己定漱口液每日漱口2次以保持口腔卫生，同时为患者开具抗生素（阿莫西林胶囊500 mg，每日3次；奥硝唑分散片500 mg，每日2次；持续5 d）和止痛药（双氯芬酸钠缓释片75 mg，每日1～2次）。术后2周拆除缝线。

1.3　测量指标

本研究中的数据测量由一名经过校准的独立测量员完成，该测量员未参与研究的其他阶段。该测量者对29例患者进行了CBCT数据测量，两周后再次进行数据测量。对两次测量数据进行组内相关系数（intraclass correlation coefficient，ICC）检验，得到ICC为0.95。

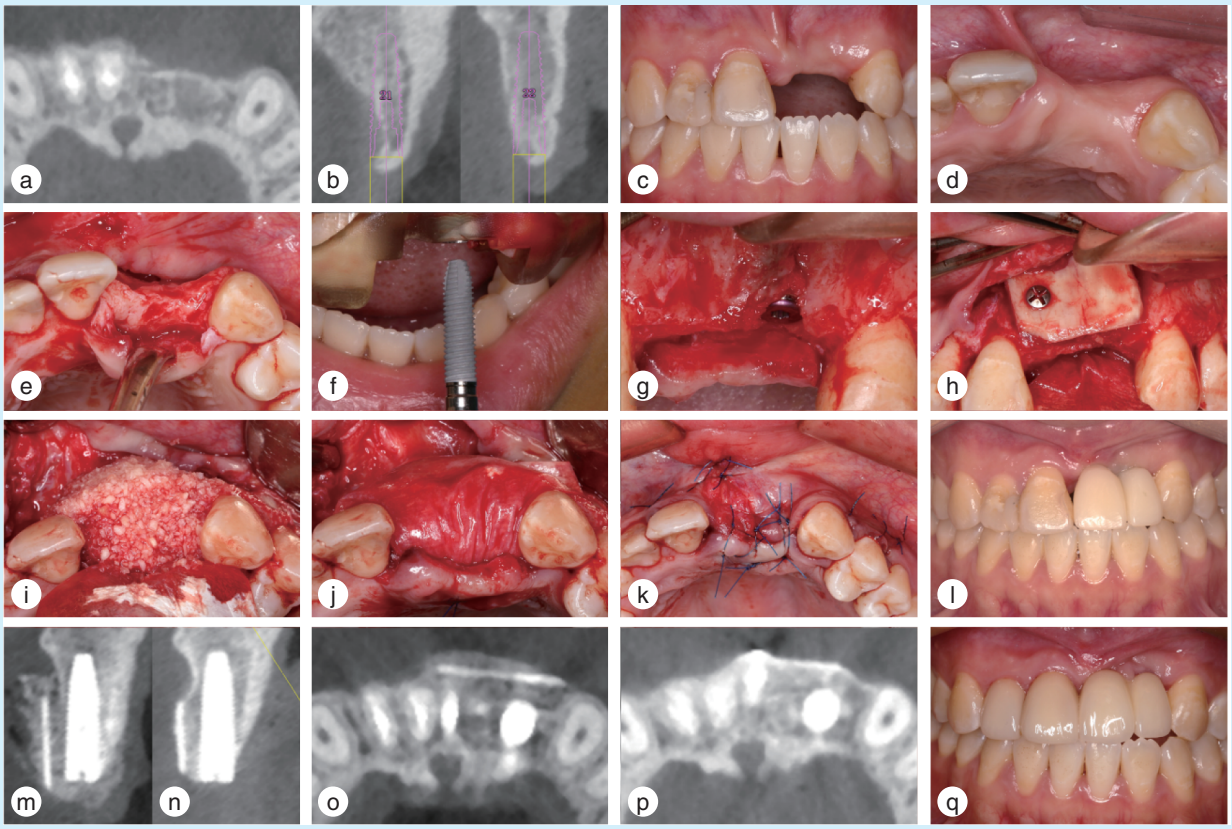
1.3.1　影像学数据测量　所有患者均在相同条件下完成CBCT扫描，包括术前（T0）、术后即刻（T1）以及术后6个月（T2），获取Dicom数据。将上述Dicom数据导入Simplant软件进行三维重建并重叠。以术前设计中的虚拟种植体为中心，测量不同时期种植体颈部及其以下1～5 mm处种植体唇侧骨板厚度（labial bone thickness，LBT）（图2）[14]。不同时间点的骨厚度变化定义如下。①植骨量（bone graft，BG）：LBT在T1和T0之间差值。②新骨形成（bone formation，BF）：LBT在T2和T0之间差值。③骨吸收量（bone resorption，BR）：LBT在T1和T2之间差值。当种植体唇侧有骨时，其差值为正数；当种植体唇侧没有骨时，其差值为负数，但记为0。

1.3.2　术后肿胀疼痛情况　通过视觉模拟评分（visual analogue scale，VAS）评估患者术后第1、3、7、10天的肿胀和疼痛情况。患者通过在一个10 cm长的直线上标记其肿胀及疼痛感受的位置来表示肿胀和疼痛的程度。左侧为“无肿胀”和“无痛”（0分），右侧为“最剧烈的肿胀”和“最剧烈的疼痛”（10分）。测量人员使用尺子测量患者标记位置与左端（0分）的距离，以厘米为单位精确到1 mm，换算为0～10的评分。

1.3.3　术后并发症　术后评估伤口愈合情况，记录是否出现感染、伤口裂开等并发症。

1.4　样本量计算

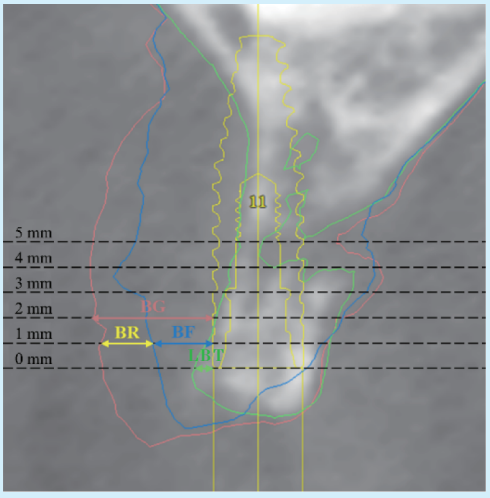
在本研究中，样本量计算使用PASS软件（PASS 15，NCSS，LLC. Kaysville，UT，美国）。将种植体肩部水平（$LBT_{0\ mm}$）硬组织的唇侧厚度视为主要结局。根据Benic等[15]的研究，标准差为0.80 mm，考虑到显著性值α= 0.05（I类错误）和把握度β=



a: preoperative CBCT occlusal view; b: alveolar bone classification: site 22 was classified as Terheyden 1/4 type, and the site was selected for implant placement using a 1∶1 mixture of particulate allograft and xenograft bone graft materials; site 21 was classified as Terheyden 2/4 type bone defect and treated with a 1∶1 mixture of particulate allograft and xenograft bone graft materials combined with pure titanium screws to secure the allograft bone block; c: intraoral frontal view; d: intraoral occlusal view; e: flap reflection revealing the collapsed contour of the alveolar ridge; f: implantation of NobelParallel® Conical Connection under the guidance of a surgical stent; g: exposure of the implant neck; h: fixation of the allograft bone block; i: placement of a 1∶1 mixed particulate allograft and xenograft bone graft material; j: fixation of the biomembrane (bovine pericardium); k: tension-free tight suturing; l: temporary restoration; m: immediate postoperative CBCT sagittal view; n: six-month postoperative CBCT sagittal view; o: immediate postoperative CBCT occlusal view; p: six-month postoperative CBCT occlusal view; q: final restoration

Figure 1　Allogeneic bone grafting at tooth missing positions 21-22 with insufficient bone volume under a bovine pericardium barrier with simultaneous implant placement

图1　21-22缺牙位点骨量不足在牛心包膜屏障下同种异体骨块移植同期植入种植体



BG (bone graft) = LBT_{T1}–LBT_{T0}. BF (bone formation) = LBT_{T2}–LBT_{T0}. BR (bone resorption) = LBT_{T1}–LBT_{T2}. LBT: labial bone thickness. T0: preoperatively (green outline); T1: immediately postoperatively (red outline); T1: 6 months postoperatively (blue outline)

Figure 2　Schematic diagram of measurement methods for bone graft, bone formation and bone resorption

图2　植骨量、新骨形成、骨吸收量测量方法示意图

0.20(Ⅱ类错误),1 mm为自身前后对比临床相关差异[16]和20%的脱落率,样本量至少为24例患者。本研究为病例系列研究,最终样本量基于实际收集的病例数量,确保大于最小样本量。

1.5　统计学分析

本研究使用SPSS 26.0软件(IBM Company, Armonk,美国)进行统计分析。所有变量的统计描述采用以下方法:对于所有连续变量,首先进行正态性检验(如Shapiro-Wilk检验)以评估数据是否符合正态分布。若数据符合正态分布,则使用均值和标准差进行描述,计算均值的95%置信区间(confidence interval, *CI*),并采用重复测量方差分析进行前后配对数据的差异检验。若数据不符合正态分布,则使用中位数和四分位数间距进行描述,并采用非参数检验(如Friedman检验)进行配对数据差异的比较。当重复测量检验显示组间差异具有统计学意义时,进行多重比较来确定哪些组之间存在显著差异,并采用Bonferroni校正以控制多重比较的错误率。对于分类变量,使用频数和频率进行描述。检验水准为 $\alpha = 0.05$。

2　结　果

2.1　患者基础信息

本研究纳入29例患者共65个植骨位点,所有患者均接受了牛心包膜结合骨移植材料的前牙美学区水平骨增量手术。所有患者的人口统计学信息和骨增量区域的特征如表1所示。

表1　牛心包膜屏障下美学区水平骨增量病例的临床特征

Table 1　Clinical characteristics of horizontal bone augmentation cases in aesthetic areas with bovine pericardium barrier

Variables		Value
Age/years		34.79 ± 11.00 (30.61, 38.98)[a]
Gender	Male	15 (0.52)[c]
	Female	14 (0.48)[c]
Jaw	Maxilla	25 (0.86)[c]
	Mandible	4 (0.14)[c]
Number of operations	Simultaneous implantation (once)	17 (0.59)[c]
	Staged implantation (twice)	12 (0.41)[c]
Fixation of the bovine pericardium membrane	Suture	17 (0.59)[c]
	Titanium pins	12 (0.41)[c]
Average number of bone grafting sites		2, 2[b]
Alveolar bone defect classification	Terheyden 1/4	18 (0.62)[c]
	Terheyden 2/4	11 (0.38)[c]
Mean width of alveolar bone	0 mm	3.14, 2.57[b]
	1 mm	4.16, 2.64[b]
	2 mm	4.89 ± 1.69 (4.46, 5.31)[a]
	3 mm	5.19 ± 1.66 (4.77, 5.61)[a]
	4 mm	5.56 ± 1.70 (5.14, 5.99)[a]
	5 mm	5.86 ± 1.67 (5.44, 6.28)[a]

a: normal distribution, described using mean±standard deviation (95% confidence interval of the mean); b: non-normal distribution, described using median and interquartile range (*IQR*); c: categorical variables were described using frequency (rate)

2.2　不同时期唇侧骨板厚度

患者不同时间点的唇侧骨板厚度如表2所示。

基线时(T0):虚拟种植体颈部下方0~5 mm处唇侧骨板厚度中位数均小于0.5 mm,反映出基线时唇侧骨板厚度普遍较薄,符合进行骨增量手术的适应证。

术后即刻(T1):各测量水平的唇侧骨板厚度显著增加,95%*CI*较窄,表明术后骨增量效果显著且数据分布较为集中。其中,种植体颈部下方2~5 mm位置骨增量较为明显(均超过4 mm)。

术后6个月(T2):各测量水平的唇侧骨板厚度有所减小,中位数在2.28~3.33 mm,但整体仍保持较为稳定的骨增量,特别是在种植体颈部下方3~5 mm的位置,骨板厚度均大于3 mm,显示出术后骨增量的长期稳定性。

所有测量水平骨板厚度均存在术后即刻(T1)

表2　牛心包膜屏障下美学区水平骨增量病例在不同时期的唇侧骨板厚度

Table 2　Labial bone thickness at different stages in cases of horizontal bone augmentation in aesthetic areas with bovine pericardium barrier

Time	Different levels below the shoulder of the implant					
	0 mm	1 mm	2 mm	3 mm	4 mm	5 mm
T0	0.00, 0.71[b]	0.00, 0.94[b]	0.00, 0.86[b]	0.00, 0.95[b]	0.32, 1.19[b]	0.38, 1.37[b]
T1	3.63 ± 1.14 (3.34, 3.91)[a]	3.86 ± 1.11 (3.58, 4.14)[a]	4.10 ± 1.06 (3.83, 4.36)[a]	4.14 ± 1.07 (3.87, 4.41)[a]	4.39,1.49[b]	4.10 ± 1.13 (3.82, 4.39)[a]
T2	2.28, 1.76[b]	2.30, 1.57[b]	2.93, 1.50[b]	3.19, 1.55[b]	3.17, 1.70[b]	3.33, 1.99[b]
χ^2	92.571	101.556	103.968	103.238	94.317	93.536
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
$Z_{T0\ vs\ T1}$	−9.621	−10.067	−10.156	−10.156	−9.710	−9.532
$P_{T0\ vs\ T1}$[1)]	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
$Z_{T1\ vs\ T2}$	4.811	5.434	5.078	4.811	4.722	3.563
$P_{T1\ vs\ T2}$[1)]	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001
$Z_{T0\ vs\ T2}$	−4.811	−4.633	−5.078	−5.345	−4.989	−5.969
$P_{T0\ vs\ T2}$[1)]	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

a: normal distribution, described using mean±standard deviation (95% confidence interval of the mean); b: non-normal distribution, described using median and interquartile range (*IQR*); T0: preoperative; T1: postoperative; T2: 6 months postoperative. 1)Adjusted significance $\alpha = 0.05/3 = 0.016\ 7$

较基线(T0)增加，术后6个月(T2)较术后即刻(T1)减少的显著变化($P < 0.001$)。

2.3　唇侧植骨量、新骨形成及骨吸收情况

唇侧植骨量、新骨形成及骨吸收见表3。

在各测量水平上，植骨量均显示出显著增加的趋势，植骨量均值/中位数为3.10～3.78 mm。其中，种植体颈部至种植体颈部下方2 mm位置的植骨量呈正态分布，均值及95%*CI*较为集中，提示植骨量随深度的增加而逐渐增高。尽管在种植体颈部下方3～5 mm位置，存在分布异质性，中位数显著高于临床安全阈值(≥2 mm)，且*IQR*范围较窄，提示大部分患者仍显示出较高的植骨水平，

各个测量水平的新骨形成均保持较高水平，均值为2.00～2.66 mm。尤其在种植体颈部下方3～5 mm，新骨形成最为显著，均值超过2.5 mm，且95%*CI*较窄，表明骨形成效果良好且稳定。

不同测量水平的骨吸收量：种植体颈部及下方1～2 mm处骨吸收量较高，*IQR*为1.39～1.69 mm，表明此区域的骨量吸收较为明显。种植体颈部下方3～5 mm处骨吸收量较低，中位数为0.61～0.93 mm，说明此区域的骨量较为稳定，吸收程度较小。

表3　牛心包膜屏障下美学区水平骨增量病例种植体唇侧植骨量、新骨生成及骨吸收情况

Table 3　The amount of bone graft, bone formation and bone resorption on the labial side of the implant in cases of horizontal bone augmentation in aesthetic areas with bovine pericardium barrier

	Different levels below the shoulder of the implant					
	0 mm	1 mm	2 mm	3 mm	4 mm	5 mm
Bone graft	3.10 ± 1.53 (2.71, 3.48)[a]	3.29 ± 1.50 (2.91, 3.67)[a]	3.52 ± 1.52 (3.14, 3.91)[a]	3.78, 1.89[b]	3.75, 1.72[b]	3.51, 1.80[b]
Bone formation	2.02 ± 1.81 (1.56, 2.47)[a]	2.00 ± 1.66 (1.59, 2.42)[a]	2.47 ± 1.70 (2.04, 2.90)[a]	2.66 ± 1.68 (2.23, 3.08)[a]	2.56 ± 1.72 (2.13, 3.00)[a]	2.61 ± 1.77 (2.16, 3.05)[a]
Bone resorption	0.90, 1.69[b]	1.08, 1.46[b]	1.05, 1.39[b]	0.90, 1.20[b]	0.93, 1.22[b]	0.61, 1.40[b]

a: normal distribution, described using mean±standard deviation (95% confidence interval of the mean); b: non-normal distribution, described using median and interquartile range (*IQR*)

2.4　术后肿胀及疼痛VAS

患者术后10 d内肿胀及疼痛VAS如表4所示。患者的肿胀和疼痛均在术后3 d达到高峰，随后逐渐减轻，到术后7 d和10 d时明显改善。

2.5　术后并发症

随访期间未观察到感染、伤口裂开等并发症。

3　讨　论

屏障膜通过分离软组织和骨缺损在GBR中发挥重要作用[17]。与不可吸收膜相比，可吸收屏障膜的优点是无需后期手术去除[18]。除了单次手术的优点外，胶原膜在临床上还加速了早期伤口稳定和缺损的初步闭合[19-20]。胶原膜也显示出低暴

表4　牛心包膜屏障下美学区水平骨增量病例术后肿胀及疼痛VAS

Table 4　Postoperative swelling and pain VAS in cases of horizontal bone augmentation in aesthetic areas with bovine pericardium barrier

Time	VAS of swelling	VAS of pain
Day 1	3.03 ± 0.34[a]	2.96 ± 0.45[e]
Day 3	6.58 ± 0.65[b]	5.21 ± 1.05[f]
Day 7	4.09 ± 0.54[c]	1.93 ± 0.49[g]
Day 10	0.96 ± 0.36[d]	0.50 ± 0.26[h]
$P_{\text{Mauchly's Test of Sphericity}}$	0.013	< 0.001
$F_{\text{Greenhouse \& Geisser}}$	833.033	314.143
$P_{\text{Greenhouse \& Geisser}}$	< 0.001	< 0.001

a-d: groups with different letters are significantly different from each other. e-h: groups with different letters are significantly different from each other. VAS: visual analogue scale

露率,特别是与不可吸收的膜相比,它们在暴露后的快速吸收也有效地消除了细菌感染的微环境[21-22]。同时,作为细胞外基质的主要成分,胶原蛋白由于其结构支持和再生特性而表现出优异的生物相容性[23]。因此,胶原膜因其良好的生物相容性和生物降解性而成为优选的生物材料[24]。

不同来源的胶原蛋白在结构和组成上存在较大差异,这直接影响了胶原膜在体内的降解模式和机械强度[25-26]。本研究探讨了牛心包膜在GBR中的临床应用效果,特别是在美学区水平骨缺损修复中的表现。研究结果显示,使用牛心包膜后种植体唇侧骨板厚度平均增加超过2 mm,这一增量水平与现有系统评价中报道的2~4 mm增量范围一致[27-28]。牛心包膜来源于心包组织,具有天然多向胶原纤维结构,使其在抗拉强度和抗撕裂性能方面优于猪皮膜和牛真皮膜[29-30]。体外研究显示,牛心包膜在润湿状态下的抗拉强度保持率高,展现出较大的杨氏模量和空间保持能力[31]。同时,心包膜的胶原纤维束直径较粗,天然交联程度较高,使其在体内具有较强的耐酶降解能力和延长的屏障功能[25, 32-33]。这使牛心包膜在复杂骨缺损修复中能够长期保持空间稳定性。

虽然牛心包膜具备优异的结构优势,但单独使用可吸收膜仍存在机械性能较弱的局限性[34]。在缺乏足够支撑材料的情况下,屏障膜可能在软组织压力下塌陷至缺损区域,影响骨增量效果[35-36]。因此,临床上常将胶原膜与块状或颗粒状的自体骨、同种异体骨或异种骨材料联合使用,以提高术区的支撑性和稳定性[37-38]。此外,在使用胶原膜作为屏障膜时,膜钉和缝合线的适当固定能够提供额外的支撑,降低伤口愈合环境不稳定的风险[39-40]。本研究使用牛心包膜与颗粒状或块状骨移植物联合进行手术,结合适宜的膜固定技术,减少了膜移位及术后塌陷风险,提高了骨增量的稳定性,展现出牛心包膜在美学区水平骨增量中的良好临床效果。然而,但对于大范围垂直骨缺损,其效果仍需进一步评估。

尽管研究结果令人鼓舞,但本研究也存在一些局限性。首先,本研究样本量较小且随访时间仅6个月,难以全面评估牛心包膜在长期骨再生中的效果和稳定性。其次,材料来源不一致,包括颗粒状异种骨、块状同种异体骨和国产牛心包膜,可能影响研究结果的可重复性及不同材料间的协同作用。此外,患者群体涵盖单颗牙及多颗牙缺失病例,且包含同期植骨和单独植骨两种方案,未对不同治疗策略进行细分分析,可能影响结果解读。研究中未设置对照组,限制了对牛心包膜独立性能的评估。未来需通过扩大样本量、延长随访期、标准化材料选择及细化分组设计,提升研究的科学性和普适性,并通过多中心研究验证其在复杂骨缺损中的应用价值。同时,优化膜材料的机械性能和生物降解特性,有望进一步提高其临床效果和经济性。

本研究初步显示了牛心包膜在美学区骨再生中的潜力,通过与颗粒状或块状骨移植物联合使用,可获得显著的种植体唇侧骨板厚度改善。术后短期随访结果表明,牛心包膜在美学区骨增量中的应用具有良好的临床可行性和初步效果。

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