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·临床研究·

下颌第一磨牙种植体解剖式愈合基台与成品愈合基台的临床应用对比研究

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【摘要】 目的　探讨下颌第一磨牙解剖式愈合基台对种植修复后牙龈软组织形态变化，以及对种植体周围牙龈成型、食物嵌塞、患者满意度等的影响，为临床上选择愈合基台提供依据。**方法**　选取湖南中医药大学附属口腔医院（长沙市口腔医院口腔）种植中心2020年9月至2021年9月期间下颌第一磨牙单颗缺失接受种植修复的患者26例，其中男性12例，女性14例，随机分为对照组（13例14颗种植体）和试验组（13例14颗种植体）；试验组应用解剖式愈合基台4周后行冠修复，对照组应用成品愈合基台4周后行冠修复；设定5个时间观测点（二期手术前、二期手术后4周、冠修复即刻、冠修复后4周、冠修复后12周），二期手术前和二期手术后4周分别采用3Shape口内扫描仪扫描下颌，对软组织的变化进行定量分析，比较两组愈合基台对牙龈成型的影响；比较冠修复后4周和冠修复后12周两组修复体食物嵌塞发生率；比较冠修复即刻、冠修复后4周和冠修复后12周两组患者的满意度。**结果**　种植二期手术后4周试验组牙龈近远中龈乳头向冠方增加值高于对照组，近中试验组为0.50（0.26，0.72）mm，对照组为0.27（0.24，0.38）mm，差异有统计学意义（P = 0.029），远中试验组为0.48（0.26，0.62）mm，对照组为0.23（0.13，0.39）mm，差异有统计学意义（P = 0.004）；颊舌向龈缘顶点向冠方成型差异无统计学意义（P > 0.05）；两组颊、舌侧龈缘中1/3顶点根方0、1、2 mm处颊、舌侧软组织的颊舌向的变化差异无统计学意义（P > 0.05）。对照组与试验组冠修复后4周、冠修复后12周观察的食物嵌塞发生率差异无统计学意义（P > 0.05）。冠修复即刻、冠修复后4周和冠修复后12周试验组满意度评分均较对照组高，组间差异有统计学意义（P < 0.05）。**结论**　下颌第一磨牙种植体的解剖式愈合基台在软组织塑形方面优于成品愈合基台，近端和远端龈乳头的冠状面均有所增加，患者满意度较高。

【关键词】 口腔种植；　解剖式愈合基台；　成品愈合基台；　牙龈成型；　口内扫描；　食物嵌塞；　种植体周围软组织；　软组织塑形；　龈乳头；　患者满意度
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A comparative study of the clinical application of anatomical healing abutments versus finished healing abutments for mandibular first molar implants

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【Abstract】 Objective　To evaluate the effect of anatomical healing abutments for mandibular first molars on the morphological changes of gingival soft tissue after implant restoration, as well as on peri-implant gingival molding, food ingrowth and patient satisfaction, to provide a basis for clinical selection. **Methods**　Twenty-six patients who received implant restoration for a single missing mandibular first molar between September 2020 and September 2021 at the Oral Implant Center of Changsha Stomatological Hospital were randomly divided into a control group (13 cases with 14 implants) and a trial group (13 cases with 14 implants), of which 12 were male and 14 were female; the trial group had anatomical

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healing abutments applied for 4 weeks and then underwent crown restoration, while the control group finished five time points (before the second stage surgery, 4 weeks after the second stage surgery, immediately after the crown restoration, 4 weeks after the crown restoration, and 12 weeks after the crown restoration). A 3Shape intraoral scanner was used to scan the jaw before and 4 weeks after the second stage surgery to quantify the soft tissue changes and compare the effect of the healing abutment on gingival molding between the two groups. The incidence of food impaction was recorded and compared between the two groups at 4 weeks and 12 weeks after crown restoration. Patient satisfaction was recorded and compared between the two groups immediately after crown restoration, 4 weeks after crown restoration and 12 weeks after crown restoration. **Results** Four weeks after implant surgery, it was observed that the gingival proximal and distal gingival papillae increased on the coronal side in the test group compared to the control group, 0.50 (0.26, 0.72) mm in the near-medium test group and 0.27 (0.24, 0.38) mm in the control group, with a statistically significant difference (P = 0.029), and 0.48 (0.26, 0.62) mm in the far-medium test group and 0.23 (0.13, 0.39) mm in the control group, with a statistically significant difference (P = 0.004). There was no statistically significant difference (P > 0.05) in the buccolingual to gingival margin apex to coronal molding or in the buccolingual to lingual soft tissue at 0, 1, or 2 mm of the root of the middle 1/3 apex of the buccal and lingual gingival margins between the two groups. Compared to the control group, there was no statistically significant difference in the incidence of food impaction observed 4 weeks and 12 weeks after crown restoration in the test group (P > 0.05). The satisfaction scores were higher in the trial group than in the control group immediately, 4 weeks, and 12 weeks after crown restoration, and the difference between the groups was statistically significant (P < 0.05). **Conclusion** The anatomical healing abutment for the implant mandibular first molar was superior to the finished healing abutment in terms of soft tissue contouring with an increase in the coronal aspect of the proximal and distal gingival papillae, resulting in high patient satisfaction.

【Key words】 oral implants; anatomical healing abutment; finished healing abutments; gingivoplasty; intraoral scan; food impaction; peri-implant soft tissue; soft tissue contouring; gingival papillae; patient satisfaction

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种植体愈合基台是种植体植入后，为防止食物残渣等进入种植体的螺孔而安装在种植体顶端的螺帽结构，对牙龈塑形具有重要作用[1]。在前牙区，种植冠修复的美观与牙龈袖口形成相关[2]，后牙区的牙龈袖口的形成影响牙冠颈部外形，对牙周健康具有重要意义，愈合基台穿龈高度、材料及形态均对种植义齿上部冠桥的健康、美观及功能产生重要影响[3]。本研究对下颌第一磨牙种植修复患者一期采用士卓曼或奥齿泰种植系统的骨水平种植并埋入式愈合，二期手术使用笔者自行研制的下颌第一磨牙解剖式愈合基台使下颌第一磨牙种植体穿龈袖口愈合和成型[4]，促进龈乳头成型，并且与成品愈合基台比较，观察其临床应用效果。

1　资料和方法

1.1　研究对象

选取2020年9月至2021年9月在长沙市口腔医院接受下颌第一磨牙缺失行种植术的患者为研究对象。本研究经长沙市口医院临床研究伦理委员会批准，所有患者均签署知情同意书。通过查找类似研究[3]、听取相关专家意见，同时考虑到实际条件，于http://powerandsamplesize.com/在线计算样本量，最终确定样本量为26例，把握度为0.810 7。

纳入标准：①年龄≥18岁；②下颌第一磨牙缺失（未见明显骨缺损、无需骨增量），行种植一期手术（士卓曼锥柱状常规种植体骨水平且种植体直径为4.1 mm、4.8 mm和奥齿泰常规种植体骨水平且种植体直径为4.0 mm、4.5 mm、5.0 mm两种种植体系统）后埋入式愈合的患者；③缺牙间隙近远中距离8～12 mm；④对颌牙无明显伸长，颌龈距离为6～8 mm；⑤牙龈无红肿；⑥邻牙牙周健康。排除标准：①连续多牙缺失；②邻牙明显倾斜与对颌牙明显伸长；③牙龈炎症明显；④中到重度牙周炎、进行性牙周炎患者；⑤重度吸烟者（每天吸烟超过10支）；⑥接受头颈部放疗的患者；⑦口腔黏

膜纤维化。共纳入26例病例，其中试验组13例，男7例，女6例，平均年龄（40.75 ± 15.92）岁，试验组应用解剖式愈合基台4周后行冠修复；对照组13例，男5例，女8例，平均年龄（40.08 ± 13.86）岁，对照组应用成品愈合基台4周后行冠修复。

1.2　*方法*

1.2.1　解剖式愈合基台的制作　成品愈合基台直径比天然牙颈部直径小，导致最后修复基台颈部直径过小和修复冠颈缘内收过大而失去对牙龈的支撑和引导，使龈乳头降低或消失而形成黑三角间隙。牙龈成型后修复冠牙颈部与天然牙颈部形态相似，一定程度减少黑三角间隙形成而改善种植修复体的健康及美观[4]。

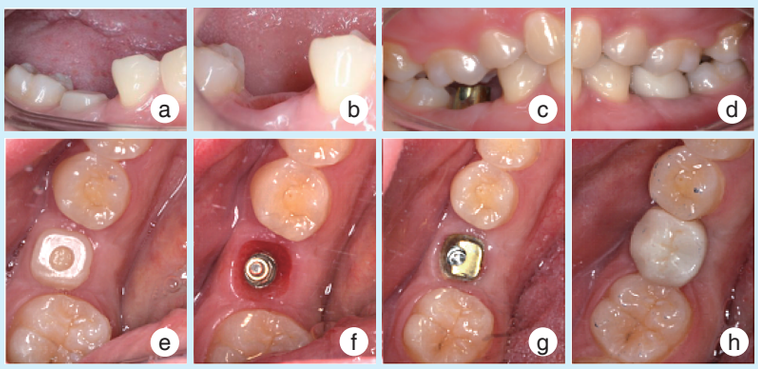
本研究使用笔者自行研制的下颌第一磨牙解剖式愈合基台，参照健康成人下颌第一磨牙牙颈部周围牙龈的解剖数据，牙颈部的临床健康牙龈龈沟深度为0.5 ~ 2 mm，龈沟的底部位于釉牙骨质界，釉牙骨质界（cementoenamel junction，CEJ）上方0 ~ 2 mm范围是牙龈成形的主要部位，天然牙CEJ上方0 ~ 2 mm范围的形态也是本研究解剖式愈合基台最主要的设计依据范围。由于年龄增长、牙周炎或各种损伤刺激致结合上皮向牙骨质表面下移，龈缘退向根方，龈沟底位于牙骨质表面，所以解剖式愈合基台设计高度增加1 mm。解剖式愈合基台设计高度为5.0 mm，愈合基台颈部形态的上端高度为3 mm，与天然牙颈部CEJ上0 ~ 2 mm及CEJ下0 ~ 1 mm的形态相似，下端2 mm为愈合基台与种植体衔接过渡部分。下颌第一磨牙牙颈部为冠方大、根方小的方圆柱形，根据测得的天然立体下颌第一磨牙牙颊舌径、近远中径平均值，以天然牙四轴面于牙颈部CEJ上2 mm至CEJ下1 mm与牙体长轴形成的角度为坡度来设计解剖式愈合基台周径大小、坡度形态[4]。

测得下颌第一磨牙离体牙CEJ向下1 mm近远中径均值为8.54 mm、颊舌径均值为7.87 mm，下颌第一磨牙牙冠近远中径稍大于颊舌径，将测得离体牙CEJ向下1 mm近远中径数值缩小42%、28%、18%，测得天然牙离体牙CEJ向下1 mm颊舌径数值缩小37%、24%、12%，获得解剖式愈合基台的3种不同周径，使设计的愈合基台釉牙骨质界的近远中径和颊舌径同时为5、6、7 mm 3种不同周径的解剖式愈合基台，应用EXO软件创建似天然牙颈部形态的解剖式愈合基台模型，构建出5 mm高度的不同周径方圆柱形下颌第一磨牙颈部解剖式愈合基台[4]。

1.2.2　下颌第一磨牙人工种植牙修复　治疗前进行口腔健康宣教工作，排除口内牙结石、菌斑、食物等对种植修复过程的影响，一期手术在下颌第一磨牙植入适当的骨水平种植体，种植体平台平于牙槽嵴顶根向0.5 mm内，初始稳定性≥35 N·cm，上封闭螺丝，对位严密缝合，2周后拆线；3个月后行种植二期手术，术前拍摄X线片，局麻后种植术区嵴顶作“一”字水平切口，两侧邻牙近缺隙侧附加龈沟内切口，翻全厚龈瓣，取下封闭螺丝更换愈合基台，间断缝合两针。对照组采用同系统成品愈合基台进行牙龈成型，试验组采用根据下颌第一磨牙天然牙颈部形态设计、制作的临时冠桥树脂材料的下颌第一磨牙解剖式愈合基台进行牙龈成型，同植体系统中央螺丝固位，种植体与邻牙之间的水平距离 > 1.5 mm以满足生物学宽度形成后防止侧向的边缘骨丢失[5]。本研究种植一期手术均为自由手操作，愈合基台与邻牙间近远中应预留0.5 ~ 1 mm间隙，所以，缺牙间隙近远中径、颊舌径为8 ~ 9 mm、10 ~ 11 mm、12 mm时分别应用5、6、7 mm宽度的解剖式愈合基台。2周后，利用个性化转移杆、转移印模后送加工厂制作符合软组织形态个性化永久修复基台和冠修复体后戴入，2组基台均采用中央螺丝固位，冠与基台采用进口玻璃离子粘接固位后去除颈部多余粘接剂，戴入后检查种植修复体与邻牙的接触距离，以牙线具有一定阻力为宜。两组二期术后、修复后的情况见图1、图2。

1.2.3　时间观察点　观察时间点为二期术前、二期术后4周、冠修复后即刻、冠修复后4周、冠修复后12周。

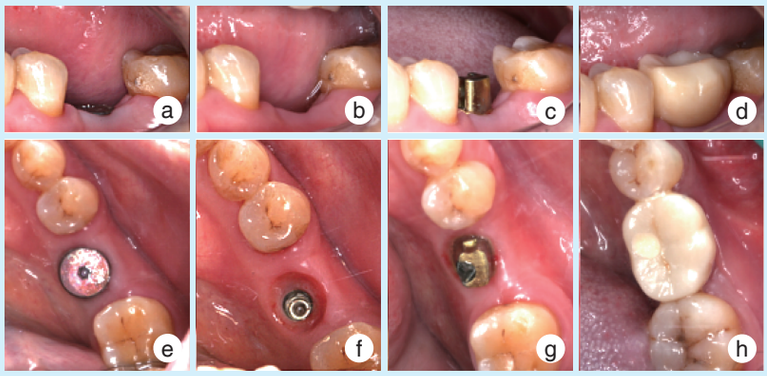
1.2.4　种植体愈合基台周围软组织三维变化的测量　使用口内扫描仪3shape（3ShapeTrios Color，3Shape，丹麦）对二期手术前、二期手术后4周的软组织进行扫描，扫描范围包含下颌牙列，修整会明显发生形态变化的解剖区域（如唇、颊系带等）。将下颌牙列口内扫描数据以Stl文件格式导入3Shape软件，分别在下颌牙列上选取相对无变化、突出的、同一解剖位置的3个位点使术前、术后牙列配准，构建出下颌第一磨牙种植体愈合基台周围软组织形态三维变化量模型进行分析。在愈合基台安装前后的下颌牙列配准后应用软件内置工具于缺失的下颌第一磨牙的近中龈乳头（图3）、远中龈乳头、愈合基台唇舌龈缘中1/3位置颊舌向纵切二维截面（图4）可得到愈合基台对牙龈成型前



a~d: buccal view; c~d: bottom for maxillofacial view; a&e: soft tissue profile; b&f: gingival cuff; c&g: installation of permanent abutment; d&h: wearing of full-crown restorations

Figure 1　Mandibular first molar anatomically healed abutment shaped gingival cuff posterior crown restoration

图1　下颌第一磨牙解剖式愈合基台成型牙龈袖口后冠修复



a~d: buccal view; c~d: bottom for maxillofacial view; a&e: soft tissue profile; b&f: gingival cuff; c&g: installation of permanent abutment; d&h: wearing of full-crown restorations

Figure 2　Mandibular first molar finished healing abutment shaped gingival cuff posterior crown restoration

图2　下颌第一磨牙成品愈合基台成型牙龈袖口后冠修复

后软组织变化的对比图。

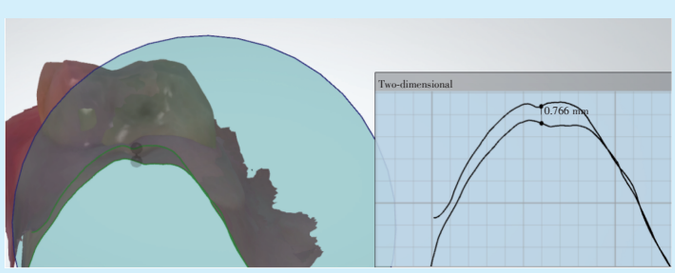
测量下颌第一磨牙种植体愈合基台近远中牙龈顶点的冠根向的变化，术后近远中牙龈顶点位于术前牙龈顶点冠方则为正，否则为负。愈合基台唇舌龈缘中点的纵切二维截面在唇舌侧由龈缘顶点的冠根方向测量，术后近远中牙龈顶点位于术前牙龈顶点冠方则为正，否则为负，并在截面内分别测量颊舌侧龈缘顶点根方0、1、2 mm处软组织形态的唇腭、舌向的变化距离。

1.2.5　食物嵌塞发生率　对纳入患者在下颌第一磨牙种植体冠修复后4周、冠修复后12周记录是否发生食物嵌塞的情况。

1.2.6　患者满意度　对纳入患者在下颌第一磨牙种植体冠修复即刻、冠修复后4周、冠修复后12周进行视觉模拟测量尺评分法(visual analog scale，VAS)的调查[6]。VAS具体做法是：在纸上面划一条10 cm的横线，最左端标注0，指非常不满意，记0分；最右端标注100分，指非常满意，记100分。

1.3　统计学分析

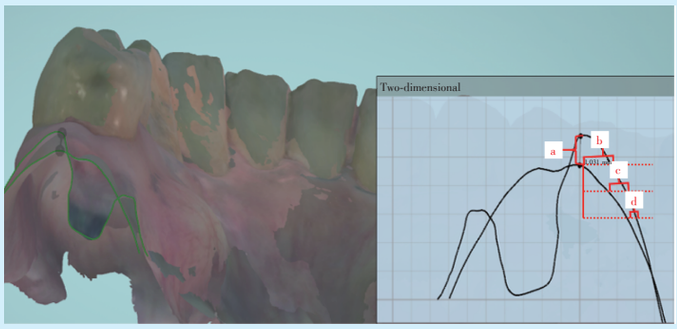
运用SPSS 26.0软件进行统计学分析，两组病例中的计数资料采用Fisher确切概率法进行分析，计量资料用Shapiro-Wilk检验各组数据的正态性，符合正态分布的数据用$\bar{x} \pm s$表示，采用独立样本t检验进行比较；不符合正态分布的两组间均数采用Wilcoxon秩和检验，检验水准$\alpha = 0.05$。



The change in the crown-root orientation of the proximal mesial gingival apex of the mandibular first molar implant healing abutment is measured in the two-dimensional screenshot of the intercepted model in the proximal mesial soft tissue

Figure 3　Longitudinal two-dimensional cross-section of the proximal and distal mesial gingival apexes of the healing abutment

图3　愈合基台近远中牙龈顶点纵切二维截面



Soft tissue changes were measured in a longitudinal two-dimensional section at the midpoint of the buccal gingival margin of the healing abutment of the mandibular first molar implant. a: measuring the change in the coronal root direction of the apex of the gingival margin on the labial side; b: measuring the distance of change in the buccolingual direction of the soft tissue pattern at the root of the apex of the gingival margin on the buccolingual side; c: measuring the distance of the change in the buccolingual direction of the soft tissue pattern 1 mm above the root of the apex of the buccolingual margin; d: measuring the distance of the change in the buccolingual direction of the soft tissue pattern at 2 mm from the root side; measuring the change in the lingual gingival tissue in the same way

Figure 4　Longitudinal two-dimensional cross section of the midpoint of the labiolingual gingival margin of the healing abutment

图4　愈合基台唇舌龈缘中点的纵切二维截面

2　结　果

2.1　愈合基台周围软组织三维形态变化值

种植二期手术后试验组对牙龈近远中龈乳头分别向冠方增加值均高于对照组，近中试验组为0.50(0.26,0.72)mm，对照组为0.27(0.24,0.38)mm，差异有统计学意义(P = 0.029)，远中试验组为0.48(0.26,0.62)mm，对照组为0.23(0.13,0.39)mm，差异有统计学意义(P = 0.004)；两组颊舌向龈缘顶点向冠方成型差异无统计学意义(P > 0.05)；两组颊、舌侧龈缘中1/3顶点根方0、1、2 mm处颊、舌侧软组织的舌颊向和颊舌变化差异无统计学意义(P > 0.05)。具体数据见表1、表2、表3。

2.2　食物嵌塞的发生率

试验组冠修复后4周和12周近、远中食物嵌塞发生率均为15.40%；对照组冠修复后4周和12周近、远中食物嵌塞发生率分别为30.80%、23.10%，30.80%、23.10%。试验组冠修复后4周和12周的食物嵌塞发生率，与对照组相比，近远中食物嵌塞发生率均低于试验组，但差异无统计学意义(P > 0.05，表4)。

2.3　患者满意度比较

试验组冠修复后即刻、冠修复后4周、冠修复后12周的满意度评分较对照组高，两组患者满意度差异有统计学意义(P < 0.05，表5)。

表1　种植二期愈合基台牙龈成型前后近远中龈乳头、颊、舌侧龈缘中1/3顶点垂直向变化值

Table 1　Vertical change values of the middle-1/3 apex of the proximal and distal gingival papillae, buccal and lingual gingival margins before and after gingival shaping of the implant stage Ⅱ healing abutment　$\bar{x} \pm s$/Median (P_{25}, P_{75}), mm, n = 13

	Mesial gingival papillae	Distal gingival papillae	Middle 1/3 of the buccal gingival margin	Medial 1/3 of the lingual gingival margin
Anatomical healing abutments	0.50(0.26,0.72)	0.48(0.26,0.62)	0.84 ± 0.62	0.13(−1.13,0.53)
Finished healing abutments	0.27(0.24,0.38)	0.23(0.13,0.39)	0.56 ± 0.27	0.27(0.22,0.43)
t/Z	−2.180	−2.846	−1.486	−0.487
P	0.029	0.004	0.156	0.626

表2　种植二期愈合基台牙龈成型前后颊侧龈缘中1/3顶点根方0、1、2 mm处软组织的颊舌向变化值

Table 2　Values of buccolingual variation of soft tissues at 0, 1 and 2 mm of the root side of the middle 1/3 apex of the buccal gingival margin before and after gingival shaping of the implant stage Ⅱ healing abutment　$\bar{x} \pm s$/Median (P_{25}, P_{75}), mm, n = 13

	Vertex of the middle 1/3 of the buccal gingival margin	1 mm above the middle 1/3 root of the buccal gingival margin	2 mm above the middle 1/3 root of the buccal gingival margin
Anatomical healing abutments	1.96(1.14,2.28)	0.86 ± 0.55	0.34(0.20,0.85)
Finished healing abutments	1.54(1.49,2.47)	1.03 ± 0.53	0.39(0.29,0.66)
t/Z	−0.077	0.810	−0.487
P	0.939	0.426	0.626

表3　种植二期愈合基台牙龈成型前后舌侧龈缘中1/3顶点根方0、1、2 mm处软组织的舌颊向变化值

Table 3　Values of lingual-buccal variation of soft tissues at 0, 1, and 2 mm root side of the middle 1/3 apex of the lingual gingival margin before and after gingivoplasty of the second stage healing abutment　$\bar{x} \pm s$/Median (P_{25}, P_{75}), mm, n = 13

	Vertex of the middle 1/3 of the lingualgingival margin	1 mm above the middle 1/3 root of the lingual gingival margin	2 mm above the middle 1/3 root of the lingual gingival margin
Anatomical healing abutments	0.54(0.38, 1.04)	0.70 ± 0.64	0.56±0.49
Finished healing abutments	0.76(0.61, 1.37)	0.65 ± 0.26	0.35±0.22
t/*Z*	−1.410	−0.264	−1.419
P	0.158	0.795	0.442

表4　应用种植体解剖式愈合基台与成品愈合基台冠修复后患者食物嵌塞的发生率

Table 4　Incidence of food impaction in patients after restoration with implant anatomical healing abutments versus finished healing abutment crowns　n = 13

	4 weeks after the crown restoration		12 weeks after the crown restoration	
	Mesial	Distal	Mesial	Distal
Anatomical healing abutments	15.40%	15.40%	15.40%	15.40%
Finished healing abutments	30.80%	23.10%	30.80%	23.10%
P	0.645	0.500	0.645	0.500

表5　应用种植体解剖式愈合基台与成品愈合基台冠修复后患者满意度比较

Table 5　Comparison of patient satisfaction after restoration with implant anatomical healing abutments versus finished healing abutment crowns　$\bar{x} \pm s$/Median (P_{25}, P_{75}), n = 13

	Immediately after the crown restoration	4 weeks after the crown restoration	12 weeks after the crown restoration
Anatomical healing abutments	93.69 ± 2.29	94.00(91.50, 96.50)	92.85 ± 1.86
Finished healing abutments	84.69 ± 5.48	82.00(81.00, 86.50)	85.00 ± 3.81
t/*Z*	−5.462	−4.352	−6.673
P	< 0.001	< 0.001	< 0.001

3　讨　论

3.1　数字化下的软组织定量比较

椅侧口腔扫描仪是一种数字印模系统，取代了传统的印模材料，并利用连续3D视频图像创建数字印模，包含由多个镜头和蓝色LED单元组成的光学系统。光学系统每秒可捕获约20个3D数据集或接近2 400个数据集以实现精确和高速扫描。

软组织形态在三维方向上的变化是不规则的，对其进行准确测量一直以来是研究的难点[7]。既往对软组织形态的评价多采用半定量主观分级指标[8-10]，使用数字模型的优点包括：易于处理和存储、时效性好、减手动错误。数字模型可通过口腔内组织扫描（创建虚拟模型）或研究铸型（创建数字铸型模型）获得。近年来，随着口内扫描系统的不断更新、升级，对口内软、硬组织的扫描精度不断提高[1, 11-12]，且临床操作简便，对患者无创、无辐射，通过口内扫描获得的测量结果的再现性得到改善，这将提高数据的有效性，并提高研究的质量[13]。更重要的是，口内扫描对软组织无压迫，可记录软组织的原始形态[14-15]。

本研究采用口内扫描记录软组织轮廓、数字化三维重叠比较软组织变化，保证软组织记录的精准性，直观、清晰、真实地检测软组织变化，提高试验可信度。龈乳头退缩、缺失会影响种植修复的美观与功能，在临床上是种植修复中难处理的常见并发症。本研究结果显示：两组近远中龈乳头均有所增量，试验组大于对照组，表明下颌第一磨牙种植体解剖式愈合基台达到预期临床疗效；两组均观察到近中龈乳头增加值高于远中龈乳头增加值，可能原因是：近中与双尖牙相邻，邻间隙明显小于远中，而在愈合基台近远中相近的挤压作用下，使远中龈乳头高度增量小于近中。当牙槽嵴顶骨距离邻牙触点下方距离小于5 mm时，高概率可以实现牙龈乳头的充盈，但距离＞7 mm时出现黑三角的概率将大大增加；对于单牙种植体，邻牙的临床附着水平影响种植体和邻牙之间的牙龈乳头高度[16-17]。本研究中，种植位点邻牙牙周组

织健康、牙槽嵴未见明显吸收，牙槽嵴高度对牙龈乳头高度无明显影响。试验组中冠修复后食物嵌塞发生率低于对照组，但差异无统计学意义，解剖式愈合基台对预防种植修复后食物嵌塞作用不明显，这可能和食物嵌塞发生的原因复杂有关。导致种植冠修复后食物嵌塞的原因除了龈乳头退缩、缺失外，还包括邻牙倾斜、对颌牙伸长和邻面接触区位置及形态异常[18]。

3.2　解剖式愈合基台的设计

目前钛材质的成品愈合基台常用于进行种植体周围软组织愈合和塑形，其形态多为圆形，可满足大部分临床应用要求，但是存在美学区穿龈塑形与邻牙不协调的风险。采用树脂愈合基台进行牙龈塑形较少，更多是采用树脂临时修复体对牙龈塑形[4]。树脂临时修复体可提供高生物相容性和低细胞毒性[19-20]。目前，未发现不同材质愈合基台对牙龈塑形存在明显差异性[21]。

修复基牙的选择影响种植体周围软组织的生物学表现和长期健康状态，即宽轮廓基牙将有利于更厚结缔组织以及更多倾斜和垂直方向纤维的形成，当软组织受到咀嚼产生的机械力时，防止连接上皮顶端迁移，而凹基牙会减少结缔组织的厚度和倾斜、垂直纤维的数量，这会减少结缔组织向根尖移动的阻力，降低对机械咀嚼力的抵抗力[22]。当角化龈厚度不同时，对外界刺激的抵抗也不同，种植体颊侧龈袖口处水平向软组织厚度每增加1 mm，骨吸收量减少0.345 mm，颊侧骨板厚度每增加1 mm，骨吸收量减少0.303 mm，垂直向龈袖口软组织厚度、冠边缘位置与边缘骨吸收未观察到明显相关性[23]。本研究所有患者软组织成型期间未出现明显的炎症或牙龈退缩坏死的情况，解剖式愈合基台出龈部位加宽并未使牙龈退缩，但其远期效果仍需观察。

3.3　局限性与展望

本项研究通过口内扫描方法与三维软件分析种植二期手术前后愈合基台对软组织形态变化的简单规律，也存在一定局限性。病例观察时期相对较短、观察样本量未完全充足，尚无法得出软组织形态变化的长期影响；解剖式愈合基台和成品愈合基台对软组织薄龈型或厚龈型牙龈的成型效果影响尚未确认，有研究表明薄龈型的牙龈成型效果较厚龈型差，薄龈型牙龈的远期稳定性较厚龈型不足；不同种植体系统对软、硬组织的影响尚未确定；前庭沟的牙槽黏膜动度较大，这些位置的软组织形态变化难以准确评估。今后仍需更大样本量以及更长周期的研究以确定种植体周软组织形态三维变化的长期规律。下颌第一磨牙解剖式愈合基台的形态与天然牙颈部无法完全一致，且存在个体差异，本研究制作的解剖式愈合基台高度单一，并不能对每一位患者达到完全的个性化制作与成型，有研究表明立即修复可以对种植体周围的软组织产生积极的临床效果，因为它可以将软组织塑造成一个看起来像自然人的跨黏膜轮廓[24]。未来研究仍需研制更多的个性化愈合基台，在后牙种植体修复不进行立即修复程序的情况下为软组织提供充分的支持。

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