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·临床研究·

不同纤维桩表面处理方式对牙根修复后抗折裂强度的影响 *

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摘要 目的：探讨不同纤维桩表面处理方式对牙根修复后抗折裂强度的影响。**方法：**收集行正畸拔除的前磨牙 120 颗作为本研究样本，随机将 120 个纤维桩分为对照组、喷砂组和过氧化氢酸蚀组，每组 40 例。对照组纤维桩表明不给予任何处理，喷砂组给予氧化铝砂粒持续喷砂粗化处理，过氧化氢酸蚀组给予 10%过氧化氢溶液处理，均包埋于纤维桩道预备好的离体牙内，采用相同树脂制备成核，行全冠修复与黏固，再模拟口腔内部环境给予样本牙冷热循环处理，经相同环境加载后，置于电子万能实验机获取样本牙抗折裂强度数据。对比三组离体牙样本体型数据、离体牙断裂方式、抗折裂强度，对三组进行为期 24 个月的定期随访，统计三组修复体断裂率，并采用 Kaplan-Meier 曲线和 Log Rank 法分析三组的生存状况。**结果：**三组的离体牙样本关于牙齿长度、牙根长度、颈部颊舌径及颈部近远中径对比差异无统计学意义(P>0.05)；喷砂组和过氧化氢酸蚀组的离体牙抗折裂强度显著强于对照组(P<0.05)；喷砂组和过氧化氢酸蚀组的牙齿折裂总发生率分别为 20.00%和 22.50%，均显著低于对照组的 70.00%(P<0.05)。但两组间比较差异无统计学意义(P>0.05)。喷砂组、过氧化氢酸蚀组的生存状况显著优于对照组。**结论：**前磨牙修复过程中，对纤维桩表面进行喷砂或过氧化氢酸蚀处理均能提高牙根修复后抗折裂强度，改善修复体修复效果生存状况，且两种纤维桩表面处理方式对离体牙样本的断裂方式和抗折裂强度影响相当。

关键词：纤维桩；喷砂处理；过氧化氢酸蚀处理；牙根修复；抗折裂强度

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Effects of Different Surface Treatment Methods of Fiber Post on the Fracture Resistance after Teeth Root Repair*

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ABSTRACT Objective: To investigate the effects of different surface treatment methods of fiber post on the fracture resistance after teeth root repair. **Methods:** 120 cases of premolars with orthodontic extraction were collected, 120 fiber posts were randomly divided into the control group, sandblasting group and hydrogen peroxide etching group, with 40 cases in each group. The control group was not given any treatment on the surface of fiber post, the sandblasting group was given alumina sand granules for continuous sandblasting and roughening, and the hydrogen peroxide etching group was treated with 10% hydrogen peroxide solution, and then embedded in the isolated teeth of the fiber post, given the same resin to prepare nucleation for complete coronal restoration and adhesion, and then they were given thermal-cold cycling treatment of sample teeth by simulating internal environment of oral cavity, and placed on an electronic universal testing machine to obtain the fracture resistance data of sample teeth after being loaded in the same environment. The body shape data of isolated teeth samples and fracture modes and fracture resistance of isolated teeth were compared among the three groups. The three groups were given 24 months of routine follow-up, and the fracture rate of restorations was counted in the three groups. Kaplan-Meier curve and Log Rank method was used to analyze the survival status in the three groups. **Results:** There was no significant difference in the teeth length, length of teeth root, diameter of neck buccal tongue and mesio-distal diameter of neck among the three groups (P>0.05). The fracture resistance of isolated teeth in the sandblasting group and hydrogen peroxide etching group were significantly stronger than that in the control group (P<0.05). The total incidence rate of teeth fracture was 20.00% in the sandblasting group and 22.50% in the hydrogen peroxide etching group, which were significantly lower than that in control group (70.00%, P<0.05). However, there was no significant difference between the two groups (P>0.05). The survival status in sandblasting group and hydrogen peroxide etching group was significantly better than that in the control group. **Conclusions:** During the repair of premolars, sandblasting or hydrogen peroxide etching on the surface of fiber post can improve the fracture resistance after teeth root repair and promote the survival status of repair effects of restorations. And the two surface treatment methods of fiber post have similar influence on the fracture

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modes and fracture resistance of isolated teeth samples.

Key words: Fiber post; Sandblasting; Hydrogen peroxide etching; Teeth root repair; Fracture resistance

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前言

根管治疗是修复牙体缺损最为有效、完善的治疗手段，桩核冠能提高修复固位力和美学效果[1-4]。临床牙科领域应用的主要辅助桩核为纤维树脂桩、金属桩和瓷桩，金属桩虽坚固耐用，但美观性不佳、生物相容性差，瓷桩虽可模拟天然牙的美观效果，但硬度大极易折断[5-8]。而纤维桩不仅兼备良好美观度，又具有耐腐蚀性、较好弹性模量、生物相容性好、易于取出及不易引根折等特点，广泛应用于牙齿残根的修复中[9]。目前，临床对纤维桩表面进行喷砂或过氧化氢酸蚀等处理以增强纤维桩和牙根间稳固性和抗折裂性[10]。但不同纤维桩表面处理方式对修复体的抗折裂程度影响尚存争议。故本研究主要探讨了喷砂和过氧化氢酸蚀的纤维桩表面处理方式对前磨牙修复后的抗折裂强度的影响。

1 材料与方法

1.1 样本选择与材料制备

1.1.1 样本选择 研究样本源于 2015 年 6 月～2017 年 6 月在本院行正畸拔除的前磨牙 120 颗。纳入标准：完 3 整下颌单根管前磨牙；前磨牙未发生楔形缺损、裂纹、内吸收和龋坏；无无氟斑牙；牙根形态与长度基本一致。

1.1.2 材料制备 准确定位离牙体，选择釉牙骨质界冠方 2 mm 处，选择沿袭牙长轴纵向垂直线方向进行截断，做常规根管预备，并交替冲洗根管，冲洗液为 5.25%次氯酸钠及生理盐水混合配制成溶液，选用 AH Plus 根充糊剂配伍牙胶(不含丁香粉)进行尖侧压填充处理；填充完毕，选用模型蜡封对根管口与根尖孔处进行蜡封，并放置于 37%生理盐水进行为期 1 周保存处理。

1.1.3 桩道预备 制备预留 120 个纤维桩 (3M RelyTM Fiber Post，尖端长 0.8 mm，尾端长 1.3 mm)和 120 个形态大小相近的离体牙，应用配套的专用预备钻在釉牙骨质界上 1 mm 处预留深 9.0 mm 桩道、高 2.0 mm 肩领和宽 1.0 mm 肩台，预备操作中使用 5.25%次氯酸钠 + 生理盐水混合溶液交替冲洗根管，离体牙内嵌固定纤维桩。

1.2 方法

1.2.1 不同纤维桩表面处理方法和黏固 将前磨牙 120 颗以 1:1:1 随机分为三组，即对照组、喷砂组和过氧化氢酸蚀组，每组 40 例。喷砂组：应用产自天津精工医疗技术设备有限公司的笔式喷砂机和 100 目氧化铝砂粒，设置喷砂压力为 0.28 MPa，喷砂头与纤维桩表面呈 90° 角，在离其表面 30 mm 处持续喷砂 15 s，再应用纤维桩超声机清洗其表面 5～10s，待纤维桩表面风干后备用。过氧化氢酸蚀组：应用无菌棉球蘸取 10%过氧化氢溶液擦拭、浸湿纤维桩表面 20～30 min，待其干燥后以作备用。对照组：纤维桩表面不给予任何处理。选用产自日本可乐丽公司的帕那碧雅树脂黏固剂将预备好的纤维桩黏固在根管内，并制成树脂核，保障纤维桩固定良好，将牙离体样本保存于 37℃的生理盐水中 1 周。

1.2.2 离体牙包埋 选用医用胶布将范围在釉牙骨质界下 2 mm 至根尖处的牙根面进行包裹，并预留牙周膜位置，将预备好的圆柱形模具(高 20 mm，直径 17 mm)平行放置于将模型观测仪处，选用白凝树脂将样本牙黏固，保障牙体长轴平行于观测仪分析杆，于样本牙釉牙骨质界下 2 mm 进行凝树脂固定处理。

1.2.3 全冠制作和黏固 依据牙槽特点制备镍铬合金金属全冠，经试戴大小匹配合宜后，选用磷酸锌水门汀黏固全冠，再保存于 37℃的生理盐水内 24h。

1.2.4 循环加载 将上述所有样本牙内置于产自日本岛津公司的电子万能实验机中进行循环加载操作，控制频率在 2.33Hz，循环次数在 30 万次，循环载荷为 100N，再模拟口腔内部环境，设置 1 年的口腔咀嚼次数。在试件循环加载过程中注意力道垂直于其表面，此过程均在 37℃生理盐水中操作。

1.2.5 冷热循环 将上述所有样本牙分别放置于 4℃和 60℃的冷热水中进行冷热循环处理，循环次数在 5000 次，停留时间控制在 30s，传递时间控制 30s。

1.2.6 抗折裂强度测试 包埋离体样本牙的抗折裂强度测定选用电子万能实验机，自制不锈钢金属底座的柱形槽，将样本牙的自凝树脂放置其中，为模拟下颌磨牙的侧向受力方向，柱形槽与水平面成 30°，设置加载速度 1 mm/min，直至离体样本牙发生折裂，统计所有样本牙的折裂时力值和折裂方式。

1.3 观察指标

对比三组经处理后的离体牙样本数据(牙齿长度、牙根长度、颈部颊舌径及颈部近远中径)，游标卡尺测量牙根长度、近远中径及颈部颊舌径，根尖至颊侧釉牙骨质界最低点直线长度为牙根长度，釉牙骨质界处最大近远中径为近远中径，釉牙骨质界处最大颊舌径为颈部颊舌径；比较离体牙样本抗折裂强度；对所有患者进行为期 24 个月的定期随访，每 3 个月随访 1 次，观察并统计三组离体牙样本断裂方式，计算三组离体牙样本断裂率；对所有修复体的生存状况进行 Kaplan-Meier 曲线和 Log Rank 法分析，以离体牙样本断裂为终点事件，对比三组修复效果生存状况。

1.4 统计学方法

计量资料以($\bar{x}\pm s$)形式表示，组间比较采用单因素方差分析检验或 SNK-q 检验，计数资料以[n(%)]表示，组间比较采用 χ^2 检验，采用 Kaplan-Meier 曲线和 Log Rank 法分析三组修复体的生存情况，以 $P<0.05$ 为差异具有统计学意义。

2 结果

2.1 三组离体牙样本对比

三组的离体牙样本关于牙齿长度、牙根长度、颈部颊舌径及颈部近远中径对比差异无统计学意义($P>0.05$)，见表 1。

表 1 三组离体牙样本对比 ($\bar{x}\pm s$)

Table 1 Comparison of isolated teeth samples among the three groups ($\bar{x}\pm s$)

Groups	n	Teeth Length	Length of teeth root	Diameter of neck buccal tongue	Mesio-distal diameter of neck
Control group	40	22.26±0.59	14.26±0.42	6.29±0.26	4.58±0.21
Sandblasting group	40	22.36±0.55	14.08±0.49	6.23±0.21	4.62±0.23
Hydrogen peroxide etching group	40	22.14±0.62	14.15±0.45	6.30±0.23	4.67±0.21
t/χ^2		1.407	1.596	1.045	1.729
P		0.249	0.207	0.355	0.182

Note: [a]*P*<0.05 vs control group, [b]*P*<0.05 vs sandblasting group.

2.2 三组离体牙抗折裂强度对比

三组离体牙抗折裂强度对比差异有统计学意义(*P*<0.05)，喷砂组和过氧化氢酸蚀组的离体牙抗折裂强度显著强于对照组(*P*<0.05)，见表 2。

表 2 三组离体牙抗折裂强度对比 ($\bar{x}\pm s$)

Table 2 Comparison of the fracture resistance of isolated teeth among the three groups($\bar{x}\pm s$)

Groups	n	Fracture resistance
Control group	40	0.77±0.06
Sandblasting group	40	0.79±0.07[a]
Hydrogen peroxide etching group	40	0.55±0.03[a]
t/χ^2		226.383
P		<0.001

Note: [a]*P*<0.05 vs control group, [b]*P*<0.05 vs sandblasting group.

2.3 三组离体牙断裂方式对比

三组牙齿总发生率对比差异有统计学意义(P<0.05)，喷砂组和过氧化氢酸蚀组的根颈 1/3 处折裂发生率和牙齿折裂总发生率均显著低于对照组(*P*<0.05)，但两组间对比差异无统计学意义(*P*>0.05)，表 3。

表 3 三组离体牙断裂方式对比 [n(%)]

Table 3 Comparison of fracture methods of isolated teeth among the three groups [n (%)]

Groups	n	Longitudinal fracture of teeth roots	Fracture at 1/3 of root collar	Fracture at 1/3 of root medium	Fracture at 1/3 of root tip	Post or post core fracture	Post core dislocation	Crown dislocation	Total number of teeth fractures
Control group	40	0(0.00)	18(45.00)	0(0.00)	0(0.00)	0(0.00)	5(12.50)	3(7.50)	28(70.00)
Sandblasting group	40	0(0.00)	5(12.50)[a]	0(0.00)	0(0.00)	0(0.00)	2(5.00)	1(2.50)	8(20.00)
Hydrogen peroxide etching group	40	0(0.00)	6(15.00)[a]	0(0.00)	0(0.00)	0(0.00)	3(7.50)	0(0.00)	9(22.50)
t/χ^2		-	36.815	-	-	-	1.527	3.621	27.093
P		-	<0.001	-	-	-	0.466	0.164	<0.001

Note: [a]*P*<0.05 vs control group, [b]*P*<0.05 vs sandblasting group.

2.4 三组修复体的生存状况分析

三组患者排龈后修复体经为期 24 个月随访，Kaplan-Meier 生存曲线显示不同纤维表明处理方法对修复体生存时间是有影响的，其中喷砂组、过氧化氢酸蚀组的修复体的生存状况优于对照组，见图 1。

3 讨论

牙髓炎、根尖周炎等疾病可造成牙齿大面积缺损或断裂，根管治疗是临床主要治疗方式，但在根管预备过程中，由于颈部牙体组织缺损严重，加之管壁牙本质被切削，可造成牙齿抗折负荷减小，导致牙体折裂和缺失[11-13]。因此，提高牙齿残根缺损修复后抗折裂性能在临床中显得十分重要。桩核冠是目前修复前牙缺损最为常见的辅助固位修复手段，既能避免牙根拔除所带来的咀嚼功能减退，又能提高口腔美观度，以降低甚至消除对患者日常生活饮食的负面影响[14-16]。随着牙体修复材料和修复技术的飞速发展，纤维桩因接近牙本质的弹性模量良、较

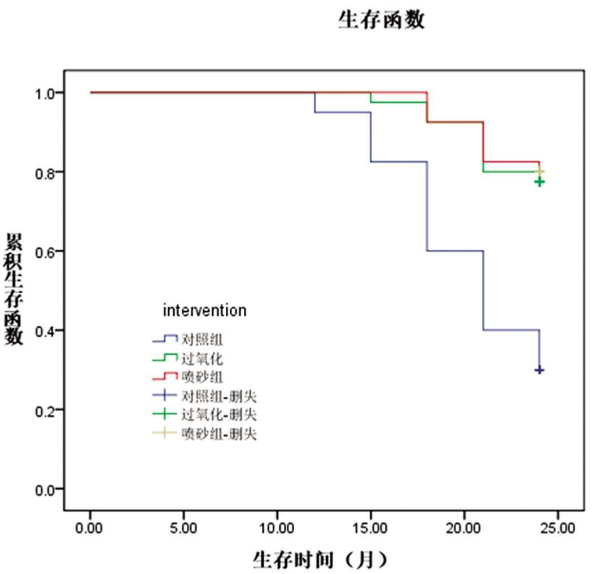

图 1 三组修复体随访 24 个月的 Kaplan-Meier 生存曲线

Fig.1 Kaplan-Meier survival curves of restorations at 24 months of follow-up among the three groups

注：喷砂组、过氧化氢酸蚀组的修复效果生存状况好于对照组。

Note: The survival status of repair effects in sandblasting group and hydrogen peroxide etching group is better than that in control group.

高美学价值、良好的生物学特性、不影响核磁共振检查和较强的抗折裂性能等优点，已取代传统金属桩核、瓷桩核，在牙齿残根修复中得以广泛应用[17-20]。

目前，已有多个学者研究指出对纤维桩进行表面处理能有效增强桩和树脂材料的黏结性好，提高离体牙的抗折裂性能，以提高纤维桩修复的成功率[21-24]。本研究对 80 颗前牙缺损的纤维桩进行表面粗化处理能获得满意的修复效果。本研究中，选择选择喷砂粗化处理的 40 颗纤维桩(喷砂组)和选择过氧化氢酸蚀粗化处理的另 40 颗纤维桩(过氧化氢酸蚀组)，两组离体牙抗折裂强度显著强于不给予表面粗化处理的剩余 40 颗纤维桩(对照组)，提示纤维桩进行喷砂法或过氧化氢酸蚀的表面粗化处理均能提高前牙缺损修复离体牙的抗折裂性能，但两种处理方式的修复效果差异无几。考虑其原因在于喷砂粗化处理是利用气压原理将混合喷料喷附于纤维桩表面，能有效提高纤维桩表面粗糙性和摩擦力，扩大表面粗糙面积，以便于纤维桩表面和树脂形成微机械固位，促使牙根更稳固地于粘接于根管桩道[25-27]。过氧化氢酸蚀粗化处理则是利用粗化处理过氧化氢溶液对纤维桩表面的酸蚀作用，使其表面形成无环氧树脂表层，增加粗化后纤维桩表面和有效黏结面积，增强黏结性，获得良好基桩力学性能和牙根抗折裂强度，且此操作过程中不会酸蚀暴露的纤维和内部纤维间空隙中树脂，保证纤维桩本身结构完整无损[28-30]。

本研究中，对三组进行为期 24 个月的定期随访，发现喷砂组和过氧化氢酸蚀组的牙齿折裂总发生率为 22.50%，均低于对照组，说明对纤维桩进行喷砂或过氧化氢酸蚀的表面粗化处理均增强前牙根抗折裂负荷，减少前牙齿折裂发生，且两种粗化处理方式的前牙根稳固效果相差无几，与罗毅等[2]报道结果相仿。而本研究对三组的牙齿折裂方式作进一步分析，发现三组的根颈 1/3 处折裂发生率存在明显差异，其中喷砂组和过氧化氢酸蚀组显著低于对照组，提示前牙根颈 1/3 处属于牙体受力薄弱区，考虑其此处牙体受力薄弱原因在于，在制备桩核和牙体预备过程中，能极大削弱颈牙体组织强度和承受正常的咬合力，造成根颈 1/3 处承受侧向载荷增加，形成应力集中区，导致此处折裂，而喷砂或过氧化氢酸蚀的粗化处理纤维桩表面能较大程度保护前牙根颈 1/3 处，减少此牙根处折裂风险。本研究对三组修复体的生存状况进行为期 24 个月定期随访观察，发现纤维桩进行喷砂或过氧化氢酸蚀的表面粗化处理能延长修复体的生存时间，提高前牙根稳固效果。

综上所述，在前磨牙缺损修复过程中，选择喷砂或过氧化氢酸蚀粗化处理纤维桩均能获得良好黏结强度，提高牙体抗折裂强度，并降低牙齿折裂发生风险，尤其是根颈 1/3 处折裂，以延长修复体的生存时间，但两种处理方法的修复效果相差无几。

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