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·临床研究·

隐裂牙根管治疗后二硅酸锂玻璃陶瓷高嵌体和全冠修复的效果比较

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【摘要】 目的 比较隐裂牙根管治疗后二硅酸锂玻璃陶瓷高嵌体和全冠修复的效果，为隐裂牙根管治疗后的修复提供参考。**方法** 本研究通过医院医学伦理委员会审批，患者均签署知情同意书。自2022年1月至2023年1月对在本院行根管治疗的隐裂牙患者，根据纳入排除标准，筛选入组患者60例，共60颗患牙。采用随机数表法，按2∶3比例分为高嵌体组和全冠组，24例高嵌体组患牙采用二硅酸锂玻璃陶瓷高嵌体修复，36例全冠组患牙采用二硅酸锂玻璃陶瓷全冠修复。术后第3、6、12个月复查，参考改良的USPHS标准对高嵌体组和全冠组的修复效果(修复体的美学、功能和生物学方面)进行评价及比较分析；对高嵌体组和全冠组患牙的存留情况进行生存分析。**结果** 术后第3、6、12个月，高嵌体组患牙达到A级的修复效果比例均在85%以上，全冠组患牙达到A级的修复效果比例均在80%以上，高嵌体组与全冠组患牙的修复效果差异无统计学意义($P>0.05$)；高嵌体组患牙12个月存留率达95.65%，全冠组患牙12个月存留率达94.12%，患牙的存留情况差异无统计学意义($P>0.05$)；年龄、性别、牙位、牙列、牙隐裂裂纹方向、牙隐裂裂纹累及边缘嵴数量和修复体类型对患牙的存留情况均无显著影响($P>0.05$)。**结论** 隐裂牙根管治疗后二硅酸锂玻璃陶瓷高嵌体的短期效果与全冠相当且短期效果均良好，高嵌体更符合微创原则，有望成为替代全冠的修复方式。

【关键词】 二硅酸锂玻璃陶瓷；高嵌体；全冠；隐裂牙；根管治疗；牙体预备；修复效果；微创原则
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Comparing the effectiveness of lithium disilicate glass ceramic onlays and full crowns in the restoration of cracked teeth that have undergone root canal therapy

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【Abstract】 Objective This study compares the effects of lithium disilicate glass ceramic onlays and full crowns in restoring cracked teeth that have undergone root canal therapy, providing a reference for the restoration method of cracked teeth that have undergone root canal therapy. **Methods** This study was approved by the hospital's medical ethics committee, and all patients signed the informed consent form. Patients with cracked teeth who underwent root canal treatment in our hospital from January 2022 to January 2023 were enrolled in this study. According to the inclu-

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sion and exclusion criteria, 60 patients were screened and enrolled, with a total of 60 affected teeth. The patients were divided into the onlay group and full crown group at a ratio of 2:3 using the random number table method. Lithium disilicate glass ceramic onlays were used to restore the affected teeth in the onlay group (24 cases), and lithium disilicate glass ceramic full crowns were used to restore the affected teeth in the full crown group (36 cases). At 3, 6, and 12 months after the repair, the restoration effect was evaluated and compared with the modified USPH Standard (the aesthetic, functional, and biological aspects of restorations). According to the biological definition of survival, survival analysis was conducted on the affected teeth in both groups. **Results** At 3, 6, and 12 months after the repair, 85% of cases in the onlay group achieved grade A, while 80% of cases in the full crown group achieved grade A. There was no statistically significant difference in the restoration effects between the onlay group and the full crown group ($P > 0.05$). The 12-month survival rate of cracked teeth in the onlay group reached 95.65%, and the 12-month survival rate of cracked teeth in the full crown group reached 94.12%. There was no statistically significant difference in the retention of the affected teeth ($P > 0.05$). There was no significant effect of age, gender, tooth position, dentition, direction of cracks, the number of marginal ridges associated with cracks, or the type of restoration on the survival status of cracked teeth. ($P > 0.05$). **Conclusion** For cracked teeth that have undergone root canal therapy, the short-term effect of lithium disilicate glass ceramic onlays is comparable to that of full crowns, and both have good short-term effects. Onlays are less invasive and are expected to become an alternative restoration method to full crowns.

【Key words】 lithium disilicate glass ceramic; onlay; full crown; cracked tooth; root canal therapy; tooth preparation; restoration effect; minimally invasive principle

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牙隐裂是口腔常见病，发病率可达9.67%～14.28%[1]，其已成为继牙周病和龋病之后引起后牙牙列缺损的第三大病因[2]。约半数隐裂牙需行根管治疗[3]，根管治疗后的隐裂牙，因髓腔通路的建立导致牙体完整性遭到破坏，牙体抗折性降低，同时因失去牙髓的营养供应，牙体组织脆性增加，更容易出现折断、劈裂。全冠和高嵌体是修复根管治疗后隐裂牙的两种常用的修复体，目前尚缺少隐裂牙根管治疗后高嵌体和全冠修复效果的比较研究。本研究通过比较隐裂牙根管治疗后二硅酸锂玻璃陶瓷高嵌体和全冠修复的效果，为根管治疗后隐裂牙的修复方式提供参考。

1　资料和方法

1.1　临床资料

本研究经遵义医科大学附属口腔医院医学伦理委员会审批通过（批准号：YJSKTLS-2021-2022-004H），患者均签署知情同意书。使用PASS 15软件计算本研究最小样本量：高嵌体组22例，全冠组22例，共44例。

自2022年1月至2023年1月对就诊于本院的因隐裂牙牙髓炎而行根管治疗的患者，在行根管治疗及牙周系统治疗后，观察1周，无临床症状。根据纳入及排除标准筛选60例患者（60颗患牙），年龄20～60岁，牙位均为磨牙。采用随机数表法，按2∶3比例分为高嵌体组和全冠组，24例高嵌体组患牙采用二硅酸锂玻璃陶瓷高嵌体修复，36例全冠组患牙采用二硅酸锂玻璃陶瓷全冠修复。两组一般资料比较差异无统计学意义（$P > 0.05$）。

纳入标准[4-10]：①患牙行根管治疗术前符合以下标准，a患者存在咀嚼痛、冷热刺激痛、自发痛等经历；b显微镜下观察到裂纹；c裂纹条数为1条；d裂纹宽度< 300 μm（CBCT分辨率为300 μm）；e裂纹方向为近远中向或颊舌向；f裂纹深度为髓室顶至髓室底（不含）且未累及根管壁；g咬棉签出现不适或“回弹性”疼痛；h用探针对裂纹施加压力时出现不适；i亚甲蓝、龙胆紫染色阳性；j牙髓温度测试敏感即牙髓状况为不可复性牙髓炎；k根尖周无异常；l排除引发牙体缺损及牙髓炎的非隐裂疾病。②患牙行根管治疗术后符合以下标准，a患者已进

行完善的根管治疗且根管治疗前为活髓牙；b患者已行牙周系统治疗，牙龈粉红色，探诊出血（bleeding on probing，BOP）（-），探诊深度（probing depth，PD）≤ 4 mm或附着丧失（attachment loss，AL）≤ 2 mm，生理性动度，无进行性病变；c叩诊（-），X线显示患牙根尖无透射区；d与对颌牙存在咬合关系。③患者身心健康，无重大全身系统性疾病。④对患者进行口腔卫生指导，使其学会保持口腔卫生的方法。⑤患者自愿配合12个月随访以及相关口腔检查和影像检查。

排除标准[7-11]：①牙髓反应正常者；②患牙存在龋病等其他牙体疾病者；③患牙裂纹较宽或裂至髓底或根管壁，无法保留；④患牙牙髓坏死或存在根尖周炎；⑤患牙根管形态复杂或属疑难病例；⑥患牙存在未经治疗或控制的牙周病；⑦不能有效维护口内卫生情况者；⑧存在磨牙症、紧咬牙和咬合干扰的患者。

1.2　主要设备及材料

比色板（VITA Toothguide 3D-Master，VITA，德国）；高嵌体备牙套装（FG0910D，Toboom，中国）；全冠备牙套装（FG1114D，Toboom，中国）；铸造瓷块（IPS e.max LS2，Ivoclar，列支敦士登）；椅旁CAD/CAM系统（CEREC SW5，Dentsply，美国）；排龈线（#00号/#000号，Ultradent，美国）；酸蚀剂（LL-Etch35 Gel，Longly Biotechnology，中国）；氢氟酸凝胶（IPS Ceramic Etching Gel，Ivoclar，列支敦士登）；硅烷偶联剂（Monobond N，Ivoclar，列支敦士登）；粘接套装（RelyX Ultimate Clicke，3M，美国）；光固化机（LED B，Woodpecker，中国）；咬合纸（型号100 μm / 40 μm，Bausch，德国）；矽离子（SILICONE OneGloss，Shofo，日本）；单反相机（D7500，Nikon，日本）。

1.3　研究方法

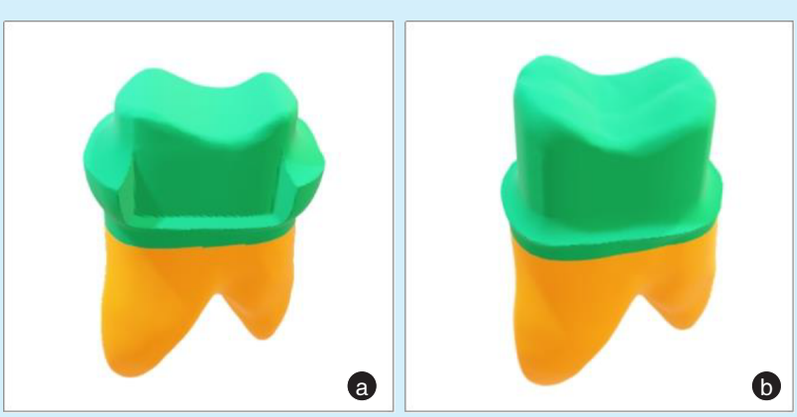
本研究中的根管治疗、比色、牙体预备、试戴、调𬌗、抛光和口腔卫生指导由同1名副主任医师完成；计算机辅助设计与制作由同1名中级技师完成；回访由同1名住院医师完成。在自然光条件下，采用Vita 3D Master比色板对牙齿的颜色进行比色。

1.3.1　牙体预备　高嵌体组牙体预备，𬌗面：按原有解剖外形预备1.5 ~ 2.0 mm，确保牙尖交错位以及前伸、侧方𬌗运动时与对𬌗牙有足够的修复空间；裂纹方向轴壁：预备1.0 ~ 1.5 mm，聚合度2° ~ 5°，边缘在止于龈上1.0 mm并形成1.0 mm宽的浅凹状肩台；非裂纹方向轴壁：预备1.0 ~ 1.5 mm的外斜面并形成1.0 mm宽的浅凹状肩台（图1）。

全冠组牙体预备，𬌗面：按原有解剖外形预备1.5 ~ 2.0 mm，确保牙尖交错位以及前伸、侧方𬌗运动时与对𬌗牙有充足的修复空间；轴面：磨除量1.0 ~ 1.5 mm，颈部边缘线终止于龈上1.0 mm，同时形成约1.0 mm宽的浅凹形肩台（图1）。

1.3.2　计算机辅助设计与制作　通过扫描获得光学数据模型，对数据进行检测，根据检测情况修整至标准水平，利用配套的设计软件设计修复体并将修复体数据传输至切削机，切削机切削半结晶瓷块形成修复体，通过烤瓷炉烧结达到修复体完全结晶，获得最终的修复体。

1.3.3　试戴及粘接　检查修复体的色泽、外形、质地、就位、固位、边缘密合性、邻接关系和咬合并根



a: schematic diagram of tooth tissue after the preparation of the onlay group of cracked teeth that have undergone root canal therapy. The preparation of 1.5 - 2.0 mm on the occlusal surface, 1.0 - 1.5 mm on the axial surface consistent with the crack direction, and an outer inclined plane of 1.0 - 1.5 mm on the axial surface in the non-crack direction. b: schematic diagram of tooth tissue after the preparation of the full crown group of cracked teeth after root canal therapy. The preparation of 1.5 - 2.0 mm on the occlusal surface and 1.0 - 1.5 mm on each axial surface

Figure 1　Schematic diagram of tooth tissue after the preparation of the onlay group and the full crown group of cracked teeth that have undergone root canal therapy

图1　隐裂牙根管治疗后高嵌体组及全冠组预备后的牙体组织示意图

据情况修整至标准水平。5%氢氟酸酸蚀修复体组织面20 s,冲洗干燥并超声震荡5 min,吹干,涂硅烷偶联剂,静置;上橡皮障,35%的磷酸对牙体进行选择性的酸蚀30 s,生理盐水冲洗30 s;绿巨人粘接套装粘接,光照2 s,去除多余复合树脂,各个面再光照20 s。

1.3.4　调𬌗、抛光　使用咬合纸进行正中𬌗、前伸𬌗及侧方𬌗调整,确认无误后使用矽离子抛光。

1.3.5　口腔卫生指导及回访　指导患者学习巴斯刷牙法和使用牙线。第3、6、12个月对患者进行回访。

1.4　评价指标

参考改良的美国公共卫生署(United States Public Heath Service , USPHS)标准(表1)[12],对修复效果各方面进行评价;根据存留的生物学定义,对高嵌体组和全冠组患牙的存留情况进行记录。

1.5　统计学分析

所有数据采用SPSS 29.0进行统计学分析。等级资料进行Wilcoxon秩和检验;使用Kaplan-Meier法绘制生存曲线,通过Log Rank检验比较两组生存曲线的差异,运用Cox回归分析影响两组曲线的因素。$P < 0.05$为差异有统计学意义。

表1　改良的美国公共卫生署标准

Table 1　The modified United States Public Heath Service standard

Evaluation criteria	Degree	Content
Restoration integrity	A	The restoration is complete
	B	The restoration has fine cracks or defects, which do not affect the function
	C	The restoration has visible cracks or defects, which affect the function
Restoration retention	A	The restoration is no loosening or detaching
	C	The restoration is loose or detached
Restoration color match	A	The restoration matches in color and translucency to adjacent tooth structure
	B	The mismatch is within the acceptable range of tooth color and translucency
	C	The mismatch is outside the acceptable range of color and translucency
Anatomic contour of the restoration	A	The general contour of the restoration follows the contour of the tooth
	B	The general contour of the restoration does not follow the contour of the tooth
	C	The restoration has an overhang
Surface texture of the restoration	A	The surface of the restoration has no defects and is smooth
	B	The surface of the restoration has a slight roughness and small defects, but it can be trimmed
	C	The surface of the restoration has severe surface defects and cannot be trimmed
Marginal fitness of restoration	A	The marginal fitness of restoration is quite well, and there was no stuck probe phenomenon
	B	There is a gap between the restoration and the abutment, the dentin is not exposed, and the probe is stuck
	C	There are obvious cracks between the edge of the restoration and the abutment, and the dentin or tissue surface of the prosthesis is exposed
Adjacency	A	The dental floss passes through with resistance and there is no food impaction
	B	The dental floss cannot pass through or is relatively easy to pass through, and there is no food impaction
	C	The gap is large and there is food impaction
Secondary caries	A	No secondary caries in abutment teeth
	C	Secondary caries in abutment teeth
Tissue of tooth	A	The dental tissue is intact without any defect
	B	There are cracks or defects in the dental tissue that do not affect function
	C	There are cracks or defects in the dental tissue that affect function.
Gingiva health status	A	The gingiva condition is healthy.
	B	There is mild gingival inflammation and a small amount of bleeding is detected during probing.
	C	There is obvious redness and swelling of the gingiva, bleeding, and deepening of the periodontal pocket

Grade A indicates that the restoration is ideal; Grade B indicates that the restoration is acceptable; Grade C indicates that the restoration is unacceptable

2　结　果

2.1　修复效果评价及比较分析

术后第3、6、12个月，高嵌体组患牙修复效果达到A级的比例均在85%以上，全冠组患牙修复效果达到A级的比例均在80%以上，高嵌体组与全冠组患牙的修复效果无统计学差异（$P>0.05$，表2）。

修复体完整性：如出现患牙折裂即患牙无法存留的情况则剔除对应例数。术后第6个月，全冠组出现1例患牙折裂，故剔除1例，全冠组总数为35例。术后第12个月，高嵌体组出现1例患牙折裂，故剔除1例，高嵌体组总数为23例；全冠组剔除前述术后6个月时牙折裂1例，全冠组总数为35例。

牙体组织情况：如出现修复体折裂即修复体无法存留的情况则剔除对应例数。术后第6个月，全冠组出现1例修复体折裂，故剔除1例，全冠组总数为35例。术后第12个月，高嵌体组出现1例修复体折裂，高嵌体总数为23例；全冠组新增1例修复体折裂，故再剔除1例，全冠组总数为34例。

其他修复效果：如出现修复体或患牙折裂即修复体或患牙无法存留的情况则剔除对应例数。术后第6个月，全冠组出现1例修复体折裂及1例患牙折裂，故剔除2例，全冠组总数为34例。术后第12个月，高嵌体组出现1例修复体折裂及1例患牙折裂，故剔除2例，高嵌体组总数为22例；全冠组新增1例修复体折裂、1例修复体伴患牙折裂，故再剔除2例，全冠组总数为32例。

表2　隐裂牙根管治疗后高嵌体组及全冠组患牙修复后第3、6、12个月的修复效果评价及比较分析

Table 2　Evaluation and comparative analysis of the affected teeth in the onlay and full crown groups at 3, 6, and 12 months after restoration of cracked teeth that have undergone root canal therapy　*n*(%)

Evaluation criteria	Follow-up visit time	Group	Degree			Total	*Z*	*P*
			A	B	C			
Restoration integrity	The third month	Onlay	24(100.00)	0(0.00)	0(0.00)	24	0.000	1.000
		Full crown	36(100.00)	0(0.00)	0(0.00)	36		
	The sixth month	Onlay	24(100.00)	0(0.00)	0(0.00)	24	−0.828	0.408
		Full crown	34(97.14)	0(0.00)	1(2.86)	35		
	The twelfth month	Onlay	22(95.65)	0(0.00)	1(4.35)	23	−0.616	0.538
		Full crown	32(91.43)	0(0.00)	3(8.57)	35		
Restoration retention	The third month	Onlay	24(100.00)	−	0(0.00)	24	0.000	1.000
		Full crown	36(100.00)	−	0(0.00)	36		
	The sixth month	Onlay	24(100.00)	−	0(0.00)	24	−0.828	0.408
		Full crown	34(100.00)	−	0(0.00)	34		
	The twelfth month	Onlay	22(100.00)	−	0(0.00)	22	−0.616	0.538
		Full crown	31(96.88)	−	1(3.13)	32		
Restoration color match	The third month	Onlay	22(91.67)	2(8.33)	0(0.00)	24	−0.419	0.675
		Full crown	34(94.44)	2(5.56)	0(0.00)	36		
	The sixth month	Onlay	22(91.67)	2(8.33)	0(0.00)	24	−0.360	0.719
		Full crown	32(94.12)	2(5.88)	0(0.00)	34		
	The twelfth month	Onlay	20(90.91)	2(9.09)	0(0.00)	22	−0.297	0.767
		Full crown	30(93.75)	2(6.25)	0(0.00)	32		
Anatomic contour of the restoration	The third month	Onlay	22(91.67)	2(8.33)	0(0.00)	24	−0.651	0.515
		Full crown	31(86.11)	5(13.89)	0(0.00)	36		
	The sixth month	Onlay	22(91.67)	2(8.33)	0(0.00)	24	−0.727	0.464
		Full crown	29(85.29)	5(14.71)	0(0.00)	34		
	The twelfth month	Onlay	20(90.91)	2(9.09)	0(0.00)	22	−0.388	0.698
		Full crown	28(87.50)	4(12.50)	0(0.00)	32		
Surface texture of the restoration	The third month	Onlay	23(95.83)	1(4.17)	0(0.00)	24	−0.240	0.810
		Full crown	34(94.44)	2(5.56)	0(0.00)	36		
	The sixth month	Onlay	23(95.83)	1(4.17)	0(0.00)	24	−0.288	0.773
		Full crown	32(94.12)	2(5.88)	0(0.00)	34		

续表2
Continue table 2

Evaluation criteria	Follow-up visit time	Group	Degree			Total	*Z*	*P*
			A	B	C			
	The twelfth month	Onlay	21(95.45)	1(4.55)	0(0.00)	22	−0.266	0.790
		Full crown	30(93.75)	2(6.25)	0(0.00)	32		
Marginal fitness of restoration	The third month	Onlay	23(95.83)	1(4.17)	0(0.00)	24	−0.629	0.530
		Full crown	33(91.67)	3(8.33)	0(0.00)	36		
	The sixth month	Onlay	23(95.83)	1(4.17)	0(0.00)	24	−0.683	0.494
		Full crown	31(91.18)	3(8.82)	0(0.00)	34		
	The twelfth month	Onlay	21(95.45)	1(4.55)	0(0.00)	22	−0.266	0.790
		Full crown	30(93.75)	2(6.25)	0(0.00)	32		
Adjacency	The third month	Onlay	21(87.50)	3(12.50)	0(0.00)	24	−0.154	0.878
		Full crown	31(86.11)	5(13.89)	0(0.00)	36		
	The sixth month	Onlay	21(87.50)	3(12.50)	0(0.00)	24	−0.084	0.933
		Full crown	30(88.24)	4(11.76)	0(0.00)	34		
	The twelfth month	Onlay	19(86.36)	3(13.64)	0(0.00)	22	−0.121	0.904
		Full crown	28(87.50)	4(12.50)	0(0.00)	32		
Secondary caries	The third month	Onlay	24(100.00)	−	0(0.00)	24	0.000	1.000
		Full crown	36(100.00)	−	0(0.00)	36		
	The sixth month	Onlay	24(100.00)	−	0(0.00)	24	0.000	1.000
		Full crown	34(100.00)	−	0(0.00)	34		
	The twelfth month	Onlay	22(100.00)	−	0(0.00)	22	0.000	1.000
		Full crown	32(100.00)	−	0(0.00)	32		
Tissue of tooth	The third month	Onlay	24(100.00)	0(0.00)	0(0.00)	24	0.000	1.000
		Full crown	36(100.00)	0(0.00)	0(0.00)	36		
	The sixth month	Onlay	24(100.00)	0(0.00)	0(0.00)	24	−0.828	0.408
		Full crown	34(97.14)	0(0.00)	1(2.86)	35		
	The twelfth month	Onlay	22(95.65)	0(0.00)	1(4.35)	23	−0.252	0.801
		Full crown	32(94.12)	0(0.00)	2(5.88)	34		
Gingiva health status	The third month	Onlay	24(100.00)	0(0.00)	0(0.00)	24	0.000	1.000
		Full crown	36(100.00)	0(0.00)	0(0.00)	36		
	The sixth month	Onlay	23(95.83)	1(4.17)	0(0.00)	24	−1.007	0.314
		Full crown	30(88.24)	4(11.76)	0(0.00)	34		
	The twelfth month	Onlay	20(90.91)	2(9.09)	0(0.00)	22	−0.696	0.487
		Full crown	27(84.38)	5(15.62)	0(0.00)	32		

"0" indicates that the number of restorations or affected teeth corresponding to this item is 0."-" indicates that there is no corresponding grade in the evaluation criteria. In terms of restoration integrity, if the affected tooth is cracked (i.e., the affected tooth cannot be retained), the corresponding cases will be excluded. Six months after repair, one patient experienced tooth cracking in the full crown group, so one case was excluded. The total number of cases in the full crown group was 35. Twelve months after repair, one patient experienced tooth cracking in the onlay group, so one case was excluded. The total number of cases in the onlay group was 23. After excluding the case of tooth cracking at 6 months in the full crown group mentioned above, the total number of cases in the full crown group was 35. In terms of tooth tissue, if the restoration is cracked (i.e., the restoration cannot be retained), the corresponding cases will be excluded. Six months after repair, one patient experienced restoration cracking in the full crown group, so one case was excluded. The total number of cases in the full crown group was 35. Twelve months after repair, one patient experienced restoration cracking in the onlay group, so one case was excluded. The total number of cases in the onlay group was 23. One new patient experienced restoration cracking in the full crown group, so another case was excluded. The total number of cases in the full crown group was 34. In terms of miscellaneous restoration effects, if the restoration or the affected tooth is cracked (i.e., the restoration or the affected tooth cannot be retained), the corresponding cases will be excluded. Six months after repair, one patient experienced restoration cracking and one patient experienced tooth cracking in the full crown group, so two cases were excluded. The total number of cases in the full crown group was 34. Twelve months after repair, one patient experienced restoration cracking and one patient experienced tooth cracking in the onlay group, so two cases were excluded. The total number of cases in the onlay group was 22. One new patient experienced restoration cracking and one patient experienced both restoration and tooth cracking in the full crown group,so two more cases were excluded. The total number of cases in the full crown group was 32.

2.2　生存分析

高嵌体组患牙和全冠组患牙的Kaplan-Meier生存曲线如图2所示。高嵌体组患牙12个月存留率达95.65%，全冠组患牙12个月存留率达94.12%；通过Log-Rank检验发现，高嵌体组与全冠组之间的存留率差异无统计学意义（$P > 0.05$）。

通过对可能影响患牙存留情况的因素：年龄、性别、牙位、牙列、裂纹方向、裂纹累及边缘嵴数量、修复体类型进行Cox多因素回归分析，结果显示以上因素对患牙的存留情况均无显著影响（$P > 0.05$，表3）。

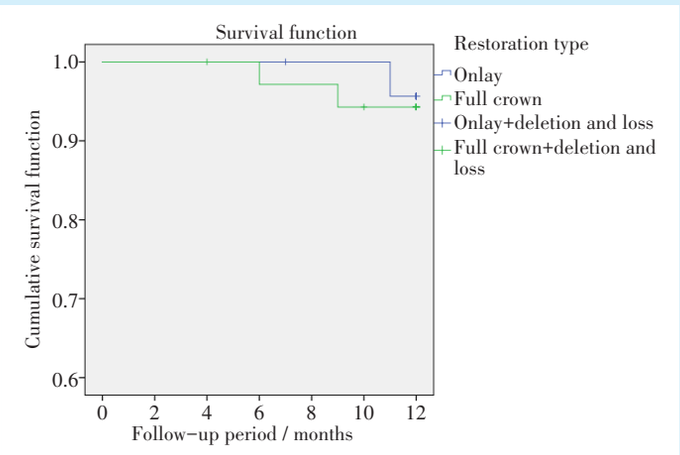


Figure 2　The Kaplan-Meier survival curves of the affected teeth after restoration in the onlay group and the full crown group of cracked teeth that have undergone root canal therapy

图2　隐裂牙根管治疗后高嵌体组和全冠组患牙修复后的Kaplan-Meier生存曲线

表3　隐裂牙根管治疗后高嵌体组和全冠组患牙修复后第12个月的Cox多因素回归结果

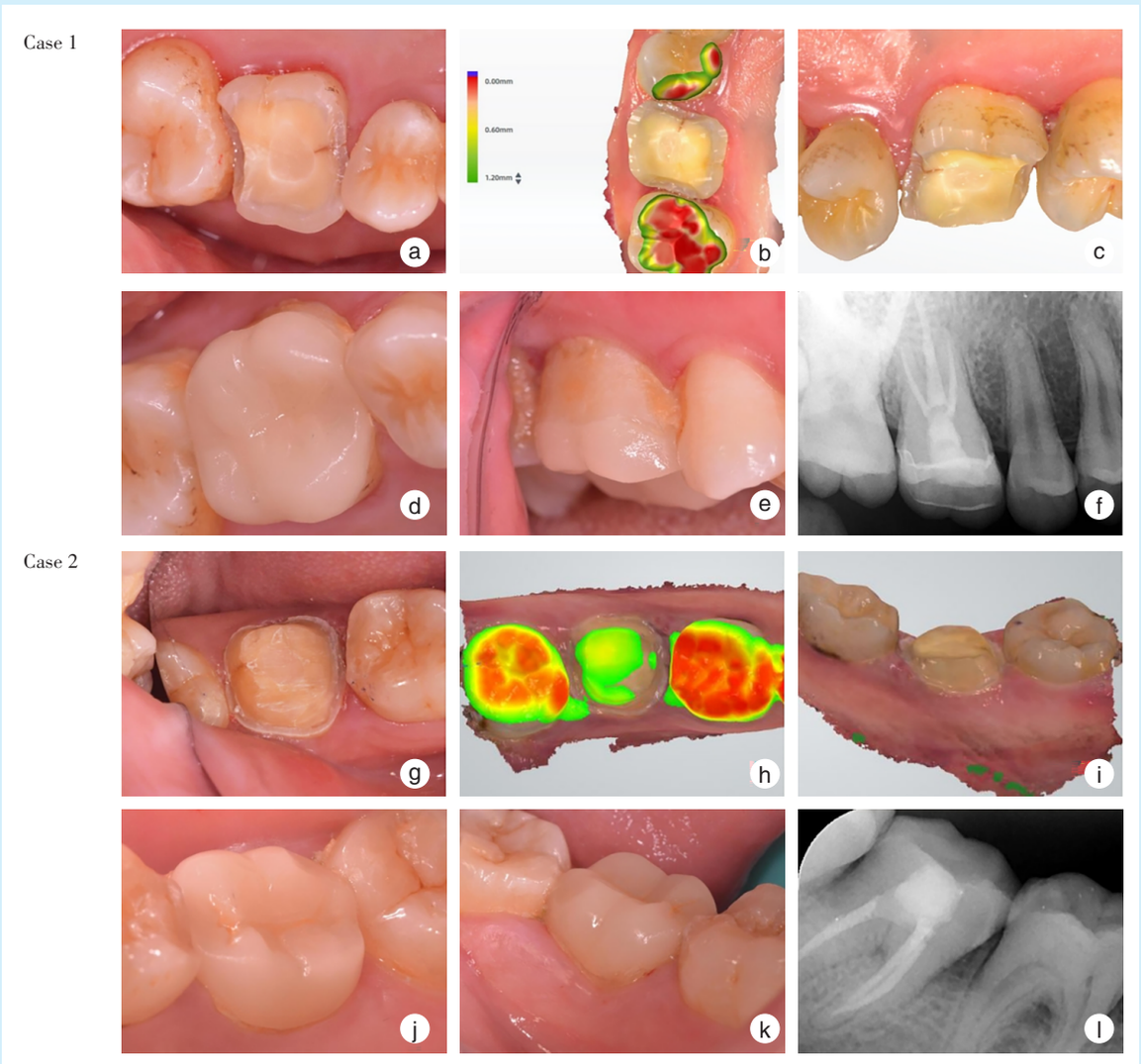
Table 3　The results of Cox multivariate regression 12 months after restoration of the affected teeth in the onlay group and the full crown group of cracked teeth that have undergone root canal therapy

Factor	Regression coefficient（*B*）	Standard error（*SE*）	*HR* (95% *CI*)	*P*
Age	−0.173	1.481	0.841(0.046, 15.342)	0.907
Gender	0.456	1.437	1.577(0.094, 26.374)	0.751
Tooth position	0.868	1.440	2.382(0.142, 40.066)	0.547
Dentition	−0.004	1.390	0.996(0.065, 15.194)	0.998
Crack direction	1.504	1.579	4.499(0.204, 99.421)	0.341
The cracks involve the number of edge ridges	2.143	1.472	8.526(0.476, 152.623)	0.145
Restoration type	0.804	1.391	2.235(0.146, 34.132)	0.563

2.3　典型病例

病例1，男，29岁。主诉：右上后牙反复疼痛1个月。口腔检查：16𬌗面隐裂纹自中央窝越过近中边缘嵴，裂纹处探诊加力不适，湿棉签咬诊不适，叩（−），牙不松，BOP（−），PD=3 mm，AL=1 mm。CBCT示：16冠方及根方无明显异常，根尖周及牙槽骨无明显异常。诊断：16慢性牙髓炎急性发作（牙隐裂）。治疗计划：16行RCT+高嵌体修复。复查：参考改良的USPHS标准，第3、6、12个月修复效果各方面均为A级，修复体和患牙均存留。详见图3a-3f。

病例2，男，34岁。主诉：右下后牙反复疼痛3 d。口腔检查：47𬌗面隐裂纹自中央窝越过远中边缘嵴，湿棉签咬诊不适，叩（−），牙不松，近中PD = 4 mm，AL = 2 mm。CBCT示：47冠方及根方无明显异常，根尖周无明显异常，近中牙槽骨吸收至根颈1/3。诊断：47急性牙髓炎（牙隐裂）。治疗计划：47行RCT+全冠修复。复查：参考改良的USPHS标准，第3、6、12个月修复效果各方面均为A级，修复体和患牙均存留。详见图3g-3l。



a: intraoral photo of the occlusal surface of tooth 16 prepared with onlay restoration. b: oral scan photos of the occlusal surfaces of tooth 16 prepared with onlay restoration. c: oral scan photos of the palatal surfaces of tooth 16 prepared with onlay restoration. d: intraoral occlusal surface photo 12 months after onlay restoration of tooth 16. e: the intraoral buccal surface photo 12 months after onlay restoration of tooth 16. f: X-ray films were reexamined 12 months after onlay restoration of tooth 16. g: intraoral photo of the occlusal surface of tooth 47 prepared with full crown restoration. h: oral scan photos of the occlusal surfaces of tooth 47 prepared with full crown restoration. i: oral scan photos of the palatal surfaces of tooth 47 prepared with full crown restoration. j: the intraoral occlusal surface photo 12 months after full crown restoration of tooth 47. k: the intraoral buccal surface photo 12 months after full crown restoration of tooth 47. l: X-ray films were reexamined 12 months after full crown restoration of tooth 47

Figure 3　Photographs of the restoration process and the 12-month follow-up results of the affected teeth in the onlay group and the full crown group of cracked teeth that have undergone root canal therapy

图3　隐裂牙根管治疗后高嵌体组和全冠组患牙修复过程及第12个月回访结果

3　讨　论

3.1　修复材料和修复方式

二硅酸锂玻璃陶瓷具有良好的美学性及生物相容性，目前尚无其对口腔组织产生不良反应的报道[13-14]。二硅酸锂晶体均匀分布于玻璃基质中，形成互锁微结构，可阻止修复体裂纹的扩展，力学性能明显提高，同时其弹性模量较氧化锆与牙本质更接近[15]，且对隐裂纹表面的应力较优韧瓷和复合树脂更低[16]，更适合隐裂牙。

全冠修复需磨除大量牙体组织，特别是磨除了承受矜力较大的颈部牙体组织，剩余牙体组织较少，降低了牙体抗折能力，但它可以减少应力集

中，将矫力较均匀分布至整个牙体组织。与全冠相比，尽管高嵌体的侧向分力更大，但高嵌体承受矫力的剩余牙体组织较多，特别是保留了更多的颈部牙体组织，增加了牙体抗折能力。针对不同修复方式对隐裂牙抗力影响的三维有限元分析均显示，高嵌体和全冠与嵌体等其他修复方式相比，均能有效减少裂纹处的应力集中[17-18]。Shi等[19]针对不同修复方式对隐裂牙抗力影响的三维有限元分析显示，纤维增强带结合高嵌体比全冠更能增加隐裂牙的抗折性。Naka等[20]对24颗离体隐裂牙的体外研究发现，高嵌体增加了患牙的抗疲劳强度。

3.2　高嵌体与全冠修复效果

研究显示，在修复体完整性方面，对于根管治疗后的患牙，高嵌体及全冠均能取得良好的效果[21-24]，与本研究结果一致。本研究术后第3个月无修复体折裂，术后第6个月全冠组1例修复体折裂，术后第12个月高嵌体组1例修复体折裂，全冠组3例修复体折裂。修复体折裂的原因：隐裂牙患者存在矫力较大及咀嚼硬物矫力突然增大的可能；修复体折裂的部分均为受力较大的功能尖；2例修复体断面显示厚度欠均匀导致应力分布欠均匀及修复体抗力性降低，而修复体厚度欠均匀可能与牙体预备不足、修复体设计和制作过程的误差及调矫相关；1例修复体伴牙体折裂，如牙体组织先折裂会对修复体产生拉应力并引起应力集中。尽管本研究选取的二硅酸锂玻璃基陶瓷具有较大的硬度，但仍具有玻璃陶瓷脆性较大的缺点。这提示在整个治疗过程中通过减少各个环节产生的误差来控制修复体厚度有助于维持修复体的完整性。

研究显示，在修复体固位方面，对于根管治疗后的患牙，高嵌体及全冠均能取得良好的效果[21,25-26]。本研究第3、6个月未观察到修复体脱落，第12个月观察到1例全冠脱落。修复体脱落的原因：过大的侧向力、基牙牙体预备不当及粘接失败。脱落修复体内侧粘接剂厚薄欠均匀及隐裂牙患者较大的矫力是脱落的原因，故对脱落的修复体进行了清洁及重新粘接。这提示粘接剂合适的厚度有利于修复体固位。

3.3　修复后患牙的生存分析

研究显示，对于不同牙髓状况的隐裂牙，全冠均能取得良好的效果。de Toubes等[27]对全冠修复的60颗未区分牙髓状态的隐裂牙的研究发现，患牙的1年存留率达100.00%。Lee等[28]对全冠修复的34颗牙髓状态为可复性牙髓炎的隐裂牙的研究发现，患牙牙髓的4年存留率达91%。Nguyen等[29]对48颗隐裂牙根管治疗后全冠修复的研究发现，患牙的5年存留率达97%。

研究显示，对于活髓隐裂牙，高嵌体能取得良好的效果。Banerji等[30]对树脂高嵌体修复的151颗活髓隐裂牙的研究发现，患牙牙髓的3个月存留率达86.75%。Zhao等[31]对全瓷高嵌体修复的27颗活髓隐裂牙的研究发现，患牙牙髓的22个月存留率达92.59%。王春红等[32]对128颗活髓隐裂牙的研究发现，全瓷高嵌体组牙髓的2年存留率为87.50%，全冠组牙髓的2年存留率为85.94%，且全瓷高嵌体组术后疼痛评分均低于全瓷全冠组。

本研究发现，患牙修复后第12个月高嵌体组22例(95.65%)患牙存留，全冠组32例(94.12%)患牙存留。本研究观察到1例高嵌体和2例全冠修复的隐裂牙缺失，分析隐裂牙缺失的原因：过大的矫力及修复体下牙体组织抗力性不足。1例高嵌体组为上颌第二磨牙发生折裂，近远中向完全裂开，尽管高嵌体组保留了更多的牙体组织，增加了牙体组织的抗力，但不足以抵抗隐裂牙患者可能存在的较大矫力、远中无第三磨牙及贯穿牙体组织的裂纹导致的抗力降低产生的影响。2例全冠组牙体组织折裂，其中1例全冠组为上颌第二磨牙近中裂开，尽管仅为部分牙体组织裂开及全冠下应力分布较均匀，但其增加的抗力不足以抵抗较高嵌体更少的牙体组织、隐裂牙患者可能存在的较大矫力及远中无第三磨牙产生的影响；另1例全冠组牙体组织折裂为下颌第一磨牙，尽管患牙有分担矫力的邻牙且全冠下应力分布较均匀，但其增加的抗力不足以抵抗较高嵌体更少的牙体组织、隐裂牙患者可能存在的较大矫力及贯穿牙体的裂纹产生的影响。

本研究显示，年龄、性别、牙位、牙列、裂纹方向、裂纹累及边缘嵴数量和修复体类型均未对患牙存留情况产生显著影响。对于这些因素中的裂纹累及边缘嵴数量对存留情况是否存在显著影响仍存在争议。Krell等[33]对363颗隐裂牙为期1年的研究发现，裂纹是否贯穿牙体组织对生存结果存在显著影响。Krell等[34]对796颗隐裂牙为期6年的研究发现，裂纹是否贯穿牙体组织对生存结果无显著影响。支持者认为这些显著影响与裂纹贯穿牙体组织的患牙抗力性更差、位于末端的牙

位承受更大的矜力且无共同承担矜力的远中牙相关。

3.4　创新性和临床价值

目前隐裂牙根管治疗后高嵌体和全冠修复效果的比较研究较少，故此研究有一定的创新性，且对隐裂牙根管治疗后修复方式的选择有一定参考价值。在牙体修复领域，微创原则为临床方案选择提供了重要指导。微创原则是指根据牙列咬合受力情况和治疗牙剩余牙体组织情况，优先选择保存牙体组织多、不易造成牙体无法修复的折裂[35]。高嵌体较全冠对牙体组织的预备少，约为全冠预备量的一半，其中高嵌体预备牙体组织量约34%，全冠预备牙体组织量为67%～75%[36]，故高嵌体更符合微创原则。

4　结　论

本研究显示，隐裂牙根管治疗后二硅酸玻璃陶瓷高嵌体的短期效果与全冠相当且短期效果均良好，高嵌体更符合微创原则，有望成为替代全冠的修复方式。

【Author contributions】 Zhang H designed the study, performed the experiments, analyzed the data and wrote the article. Tian Y, Li ZZ, Zhang M analyzed the data, designed the research study and revised the article. Zhou HL, Liu JG conceptualized and reviewed the article. All authors read and approved the final manuscript as submitted.

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