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· 临床研究 ·

渗透树脂修复磨牙-切牙矿化不全的美学效果评价

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【摘要】 目的 探讨渗透树脂修复磨牙-切牙矿化不全的美学效果,为临床应用提供参考。方法 筛选符合纳入标准的轻度磨牙-切牙矿化不全患者12例(36颗患牙),使用渗透树脂进行修复,于治疗前(T0)、1周复诊(T1)、6个月复诊(T2)时用Crystaleye比色仪拍摄照片,计算分析不同时刻病损区与周围正常釉质区的色差值 ΔE ;进行口内照相,使用Adobe Photoshop CS3软件对不同时刻图像的病损面积和患牙唇面总面积进行计算,得出相应的病损面积比(R)及治疗有效率(SR),通过比较不同时刻色差值(ΔE)、R值的大小,判断渗透树脂治疗磨牙-切牙矿化不全的有效性,评估其美学效果。采用重复测量单因素方差分析对结果进行统计分析。结果 轻度磨牙-切牙矿化不全患牙经渗透树脂治疗后色差值(ΔE)明显降低,病损面积比R值较治疗前明显缩小,差异有统计学意义($P < 0.001$),治疗有效率SR值可达86.02%,美学效果显著,且有利于保存天然牙体组织,符合微创医学的观点。结论 渗透树脂修复轻度磨牙-切牙矿化不全患牙,美学效果良好,推荐临床使用。

【关键词】 磨牙-切牙矿化不全; 渗透树脂; 微创; 病损面积; 折光率; 釉质矿化不全; 美学效果; 图像分析; Crystaleye比色仪

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Esthetic evaluation of resin infiltration for the treatment of molar - incisor hypomineralization GU Xi, ZHANG Liya, CHEN Ruixue, LI Ya, YANG Senhao, LI Chunnian. Department of Operative Dentistry and Endodontics, Hebei Key Laboratory of Stomatology, Hebei Clinical Research Center for Oral Diseases, School and Hospital of Stomatology, Hebei Medical University, Shijiazhuang 050017, China

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【Abstract】 **Objective** To evaluate the clinical effects of resin infiltration in treating molar-incisor hypomineralization. **Methods** Twelve patients (36 teeth) with mild molar-incisor mineralization imperfecta who met the inclusion criteria were selected and treated with penetrating resin. Before treatment (T0), at the one-week follow-up (T1) and at the six-month follow-up (T2), a Crystaleye spectrophotometer was used to take photos, and the color differences (ΔE) between the lesion area and the surrounding normal enamel area at different times were calculated and analyzed. The area of the lesion and the total area of the labial surface of affected teeth were calculated using Adobe Photoshop CS3 software. The corresponding area ratio (R) and treatment efficiency (SR) were obtained. The R value was used to judge the effectiveness of resin penetration in the treatment of molar and incisor mineralization imperfecta and to evaluate its aesthetic effect. The results were analyzed by repeated measures one-way ANOVA. **Results** The color difference of the lesion area vs sound adjacent enamel (ΔE) decreased significantly, and that of the lesion area decreased significantly after resin infiltration ($P < 0.001$). The success rate was approximately 86.02%, which means that the esthetic effect of resin infiltration in treating molar-incisor hypomineralization was remarkable. No important adverse events or side effects were observed. **Conclusion** The aesthetic effect of resin infiltration in the treatment of mild molar and incisor hypo-

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mineralization is good. This method is recommended for clinical use.

【Key words】 molar-incisor hypomineralization; resin infiltration; minimally invasive; lesion area; refractive index; enamel hypomineralization; esthetic effect; image analysis; Crystaleye spectrophotometer

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磨牙-切牙矿化不全是一种全身因素引起的特殊类型的牙釉质发育不良,表现为至少1颗第一恒磨牙矿化不全,常伴多颗切牙受累^[1]。受累切牙常表现为唇面白垩色到黄褐色的病损斑块,甚至出现釉质塌陷^[2],严重影响美观,给患者带来心理负担^[3]。

渗透树脂是近些年新兴的一种早期龋治疗方法,多项体外实验^[4-5]和临床研究^[6-7]已证实其用于釉质脱矿、正畸后白垩斑的治疗效果,且对比研究^[8-9]表明渗透树脂对牙体组织的损伤很小,在微创的前提下可以达到最好的美学效果。最新研究表明,渗透树脂用于轻中度氟斑牙亦可遮盖氟斑牙表面不均匀的黄白色斑块,明显改善患牙外观^[10-11]。

轻度磨牙-切牙矿化不全的患牙病损区域的釉质结构与早期龋相似^[12],表层相对完整,表层下釉质矿化程度较低,其孔隙度较健康釉质明显增加,部分区域可达25%^[13],呈现多孔性。因其与早期龋的病理结构相似,推测采用渗透树脂治疗磨牙-切牙矿化不全亦可取得良好效果。回顾文献发现,2019年有学者进行体外模型测试证实了渗透树脂用于矿化不全患牙的有效性^[14],但此测试样本量很小,且为体外实验;而目前有关此方面的临床文章多为病例报道^[15-16],尚缺少分析渗透树脂治疗磨牙-切牙矿化不全美学效果的定量试验研究,对其美学疗效尚无清晰认识。

Crystaleye 比色仪由 OLYMPUS 公司研制开发,采用齿科专用多光谱图像系统,以标准 D65 光源作为光源系统,7 原色再现颜色,使拍摄到的牙齿图像更加真实可靠、灵敏度高;同时其配套专业的色彩分析软件,对 Crystaleye 比色仪得到的标准照片进行分析,可以对特定位置进行准确的颜色记录,获得确切的明度指数(L*)、色品指数(红绿轴)(a*)、色品指数(黄蓝轴)(b*)和色差值(ΔE 值)进行定量分析。多项研究表明 Crystaleye 比色仪是衡量牙齿颜色变化的重要指标^[17-18]。本试验拟采用

Crystaleye 比色仪和口内图像分析对渗透树脂用于磨牙-切牙矿化不全的美学效果进行联合评估、定量分析,为临床应用提供参考。

1 资料与方法

1.1 研究对象

选取2018年12月-2019年8月期间,于河北医科大学口腔医院牙体牙髓科门诊确定受试者12例,其中男5例,女7例,年龄12~31岁,共36颗患牙。受试者纳入标准为:①轻度磨牙-切牙矿化不全^[19];②上颌前牙,釉质白垩色斑块区域无明显塌陷,表面光滑,质地坚硬;③牙面无树脂充填物、贴面、烤瓷冠等修复体。排除标准为:①活动性龋齿、氟斑牙、四环素牙引起的牙齿颜色异常;②曾行渗透树脂或美白治疗;③伴有精神疾病或其他系统疾病。本试验纳入的患牙均为轻度磨牙-切牙矿化不全中的病损前牙。受试者及其监护人均经过良好沟通,对试验内容及复诊时间有充分了解,签署了知情同意书。本试验获河北医科大学口腔医院医学伦理委员会批准(批件号:[2019]015)。

1.2 试验设计

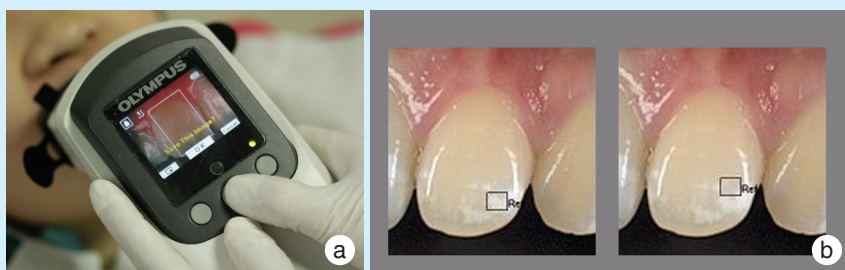
使用 Icon 渗透树脂套装 (Icon Caries infiltrant-smooth surface, DMG, 德国) 对患牙病损进行处理,具体处理方法如下:首先清洁患牙及邻牙,使用低速手机+橡皮杯配合不含氟牙膏清洁牙面,橡皮障隔离患牙;涂布 Icon-etch 酸蚀剂,涂布范围需覆盖病损区域及周围 2 mm,处理 2 min,酸蚀过程中需使用小毛刷来回移动,注意来回移动摩擦时间小于 6 min,以去除酸蚀产生的气泡,保证酸蚀剂与牙面接触良好;进行大量充分冲洗,至少冲洗 30 s;使用 Icon-Dry 干燥剂干燥牙面 30 s,同时对酸蚀效果进行检查,观察高度矿化的表层是否酸蚀干净,视检查情况可重复酸蚀步骤 1~2 次,以确保渗透通路的开放,总体酸蚀时间一般不超过 6 min;干燥后涂布足量的 Icon-infiltrant 树脂材料于酸蚀区域,渗透 3 min,注意渗透过程中应避免牙椅照明灯直射;

去除多余树脂材料,光照40 s;重复涂布 Icon-infiltrant 树脂材料,渗透1 min,去除多余树脂材料,光照40 s;去除橡皮障,打磨,精细抛光。

1.3 数据采集

1.3.1 Crystaleye 比色仪 为了保证比色仪拍摄图像的可重复性和准确性,设定拍摄条件:①仪器校准:每次拍摄图像前需将 Crystaleye 比色仪放置在基座上进行校准,3 min 内若未完成拍摄应再次进行校准;②患牙准备:拍摄前应对患牙进行彻底清

洁,牙面保持湿润而无多余唾液。使用 Crystaleye 比色仪在治疗前(T0)、一周复诊(T1)、6个月复诊(T2)时对患牙进行拍摄,得到标准照片。采用专用软件 Crystaleye Application ver.1.4 对拍摄的图像进行分析,由术者之外的医师进行。手动模式下选定病损区域、周围正常釉质区域进行比较,得到 ΔE 值,每个患牙重复分析3次取平均值,作为其颜色的改变值,将不同时刻的色差值 ΔE 进行统计分析。见图1。



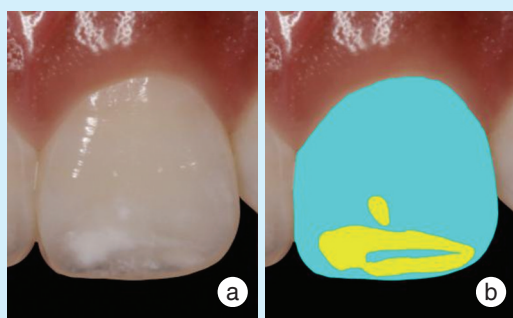
a: images of teeth taken with the Crystaleye spectrophotometer; b: selected lesion area (left part) and sound adjacent enamel area (right part)

Figure 1 Color difference of the lesion area and the sound adjacent enamel area of molar-incisor hypomineralization measured using the Crystaleye

图1 Crystaleye 比色仪分析磨牙-切牙矿化不全病损区与周围正常釉质区色彩数据

1.3.2 口内正面照相和图像分析 使用数码单反相机(EOS 5D, Canon, 日本)、环形闪光灯(MACRO RING LITE MR-14EX, Canon, 日本)配合微距镜头(MACRO LENS EF 100 mm, Canon, 日本)对患牙正面进行拍摄,拍摄条件设定:光圈(F) = 25,快门速度为 1/200 s,感光度(ISO) = 400,自动白平衡。每次拍摄前均抛光清洁患牙牙面,分别于治疗前(T0)、一周复诊(T1)、6个月后复诊(T2)时在同等条件下对受试患牙拍摄正面照片。照片打乱顺序后由术者之外的人员将 T1、T2 时刻的患牙图片与

T0 时刻进行比较分析,所有图像分析均在同一台显示器上进行以减小误差。使用 Adobe Photoshop CS3 软件对不同时刻图像的病损面积和患牙唇面总面积进行计算,见图2。根据以下公式可以得出相应的病损面积比(R)及治疗有效率(SR),通过比较治疗前后病损面积比R的大小,可以判断渗透树脂治疗磨牙-切牙矿化不全的有效性,评估其美学效果。病损面积比(R) = 病损面积/患牙唇面总面积 $\times 100\%$; Tn 时刻治疗有效率(SR) = $(R_{T0} - R_{Tn}) / R_{T0} \times 100\%$



a: front view of the tooth; b: Adobe Photoshop CS3 software was used to calculate the lesion area and the total area of the labial surface; yellow: lesion area; blue: labial surface area

Figure 2 Adobe Photoshop CS3 analysis of lesion area of molar-incisor hypomineralization

图2 Adobe Photoshop CS3 分析磨牙-切牙矿化不全病损面积示例

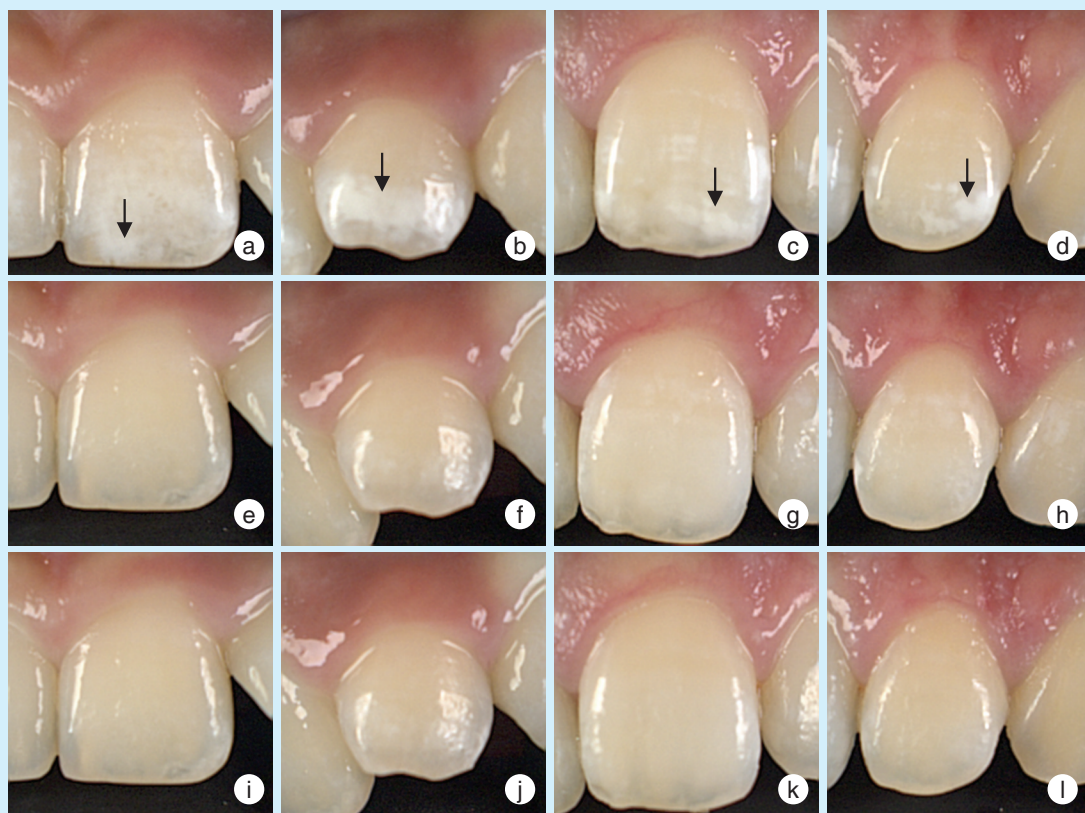
1.4 统计学分析

使用SPSS 19.0软件对数据进行分析,计量资料符合正态分布,用均数 \pm 标准差($\bar{x}\pm s$)表示;采用重复测量单因素方差分析比较T0、T1、T2不同时刻病损区域与周围正常釉质区的色差值 ΔE 、病损面积比R值及治疗有效率SR值的变化。当 $P < 0.05$ 时认为差异有统计学意义。

2 结果

治疗前可见患牙唇面散在分布白垩色斑块;治疗后一周复诊,白垩色斑块基本消失,患牙呈现自然透亮的正常釉质色;6个月后复诊,牙面未见明显染色,牙齿颜色更加自然美观。见图3。

治疗前(T0)、治疗后1周复诊(T1)、6月复诊(T2)时的色差值(ΔE)、病损面积比(R)和治疗有效



a-d: images before infiltration (T0), chalky plaques were scattered on the labial surface of the affected teeth (as shown by the arrow); e-h: one week after infiltration (T1), the chalky plaques essentially disappeared, and the appearance of the teeth was naturally bright, similar to normal enamel; i-l: six months after infiltration (T2), no obvious staining was found on the tooth surface, and the color of the teeth was more natural and beautiful; a,e,i: left upper central incisor; b, f, j: left upper lateral incisor; c, g, k: left upper central incisor of another case; d, h, l: left upper lateral incisor of another case

Figure 3 Comparison of resin infiltration before and after treatment for molar-incisor hypomineralization

图3 渗透树脂用于磨牙-切牙矿化不全治疗前后对比

率(SR)见表1。采用单因素方差分析(ANOVA)对不同时间点组内比较得出:①色差值(ΔE):T1、T2时刻与治疗前T0时刻比较, ΔE 值明显降低,差异有统计学意义($P < 0.001$),说明渗透树脂可以明显降低病损区域与周围正常釉质区的颜色差异,改善患牙外观,美学效果可以肯定。但T1、T2之间差异无统计学意义($P > 0.05$),说明治疗后6个月疗效保持稳定;②R值:T1、T2时刻与治疗前T0时刻比较,

病损面积比R值明显减小,差异有统计学意义($P < 0.001$)。相较于T1时刻,T2时刻R值略微下降,但差异无统计学意义($P > 0.05$),与Crystaleye比色仪分析所得结果一致;③SR值:T2与T1时刻相比,T2时刻有所升高,但差异无统计学意义($P > 0.05$),即渗透树脂治疗MIH患牙后疗效稳定,经过6个月随访期后,未出现明显波动。在治疗过程中及整个观察期内,未有患者出现敏感不适等不良反应。

表1 渗透树脂修复磨牙-切牙矿化不全不同时刻的 ΔE 、R值和SR值比较Table 1 Comparison of ΔE , R and SR values at different time points using resin infiltration for the treatment of molar-incisor hypomineralization $\bar{x} \pm s$

| Parameters | Time | | | P | | |
|------------|------------------|-------------------|-------------------|-----------|-----------|-----------|
| | T0 | T1 | T2 | T0 vs. T1 | T0 vs. T2 | T1 vs. T2 |
| ΔE | 7.63 \pm 1.39 | 2.08 \pm 0.63 | 1.72 \pm 0.41 | < 0.001 | < 0.001 | 0.362 |
| R(%) | 37.71 \pm 5.42 | 6.84 \pm 2.17 | 5.35 \pm 2.09 | < 0.001 | < 0.001 | 0.453 |
| SR(%) | - | 82.86 \pm 12.51 | 86.02 \pm 10.63 | - | - | 0.317 |

T0: before treatment; T1: one week after treatment; T2: six months after treatment; R: ratio of lesion area; SR: success rate, SR = $(R_{T0}-R_{Tn})/R_{T0} \times 100\%$

3 讨论

健康的牙釉质由96%无机物(羟基磷灰石)和4%有机物组成,因其羟基磷灰石的含量很高,健康牙釉质内部的折光率基本均匀一致,光线穿过牙釉质层传播到下方的牙本质时并不发生明显的散射,牙釉质层表现为均匀透亮的半透明色;然而在磨牙-切牙矿化不全患牙中,表层下釉质矿化不全导致釉柱间孔隙增加,空气含量增加,这些釉质矿化不全的区域散布在正常矿化的釉质中,导致釉质层折光率不再均匀一致,光线通过折光率不同的物质交界面时发生多次路线偏移,出现散射,在临床上呈现出白垩色外观。随着病损严重程度的增加,釉质的矿化不全和发育不全会进一步加重,导致釉柱间孔隙进一步增大,使表层釉质呈现多孔性,增加色素分子吸附的几率,形成黄色或棕褐色的斑块。

轻度磨牙-切牙矿化不全的病损表面完整,表层釉质矿化程度很高,表层下釉质矿化不全,与早期龋损结构类似。去除这一矿化程度高的完整表层后才能进入下方的矿化不全区域,研究发现临床常用的37%磷酸对于过度矿化表层的处理效果不佳,酸蚀深度只有7~10 μm ^[20];本试验中采用渗透树脂治疗磨牙-切牙矿化不全,首先使用酸性更强的15%盐酸对患牙表层进行处理,2 min的酸蚀时间可以达到34 μm 的深度,随着酸蚀时间的延长,8 min的酸蚀时间最多可达到深度约79 μm ^[21],确保了渗透通路的开放;但需要注意,临床应用过程中要严格控制酸蚀时间,以防丧失过多牙体组织,一般不超过6 min^[22],可以在操作过程中采用Icon-Dry干燥剂对表层的酸蚀处理效果进行检测。随后使用高渗透性的树脂材料对下方的多孔性矿化不全区域进行渗透,在毛细虹吸的作用下渗透树脂可以进入釉质的多孔性结构,研究发现其进入病损的深度可达(0.67 \pm 0.39) mm^[23]。这一材料的折光率为1.475,与正常釉质更为接近,渗透

树脂进入釉质矿化不全区域后占据了病损釉质中增大的孔隙,减少了空气的含量,使釉质重新恢复为折光率较为均一的质地,光线通过时减少路线偏移,从而釉质重新恢复透亮,改善患牙外观。本试验采用Crystaleye比色仪和口内图像分析对治疗效果进行联合评估,结果更加准确可靠,发现渗透树脂用于轻度磨牙-切牙矿化不全可以明显提升患牙外观,治疗有效率达86%,美学效果显著。

磨牙-切牙矿化不全的患牙,由于表层下釉质矿化不全,内部孔隙较多,龋坏风险较健康釉质高,同时其硬度较健康釉质低,在咀嚼过程中由于咀嚼力量的作用可能出现釉质崩解塌陷,出现牙体缺损。渗透树脂治疗后,树脂材料占据了病损釉质的孔隙,形成树脂-釉质混合层^[24],隔绝了外界酸性物质的进入,在一定程度上降低了龋坏发生的风险;而且树脂材料本身的硬度可以增加病损釉质区的机械强度,有利于保持牙体组织完整性,这与以往研究结论一致^[25-26]。

综上,渗透树脂用于轻度磨牙-切牙矿化不全的美学效果显著,且有利于保存天然牙体组织,符合微创医学的观点。但目前尚需要更长期的临床研究来观察渗透树脂的颜色稳定性。

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