# 脉冲 Nd :YAG激光影响复合树脂修补烤瓷粘接强度实验研究

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**摘要** **目的**:评价激光进行瓷面预处理对复合树脂修补烤瓷的粘接效果。**方法**:分别用 8 %氢氟酸及 3 组能量参数的脉冲 Nd:YAG激光(15 Hz、40 mJ、0.6 W;15 Hz、60 mJ、0.9 W;15 Hz、80 mJ、1.2 W)对烤瓷牙粘接表面进行照射,照射时间均为 1 min,涂硅烷液及活化剂后,粘接复合树脂。应用电子万能试验机测试复合树脂–烤瓷的抗剪切粘接强度。采用扫描电镜观察瓷处理面的形貌特征。**结果**:激光 0.6 W组、0.9 W组、1.2 W组及酸蚀组的抗剪切粘接强度分别为 8.61、14.07、11.22 及 13.47 MPa,激光 0.6 W组明显低于酸蚀组,两者具有统计学差异,而 0.9 W组及 1.2 W组与酸蚀组则无显著性差异。扫描电镜显示经激光处理的瓷面粗糙不平,呈浅凹状及火山口状结构。**结论**:在适当能量参数下,脉冲 Nd:YAG激光可代替酸蚀进行烤瓷牙粘接面的预处理。

**关键词** 激光 烤瓷 复合树脂 抗剪切粘接强度 酸蚀 扫描电镜

## Effects of Pulsed Nd :YAG Laser Irradiation on Shear Bond Strength of Composite Resin Bonded to Porcelain

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**Abstract**

**Objective**: To evaluate the shear bond strength of composite resin bonded to pretreated porcelain surfaces by use of a pulsed Nd:YAG laser irradiation and by use of 8 % hydrofluoric ecthing. **Methods**: Surfaces of porcelain were roughened with coarse diamonds until the opaque body porcelains were exposed. The samples were divided into four groups. Samples of the first group were etched with 8 % hydrofluoric acid for 3min by following the manufacter′s instructions. Samples of the 2nd, 3rd and 4th groups were separately irradiated by a pulsed Nd:YAG laser of three energy parameters of 15Hz, 40mJ, 0 6W; 15Hz, 60mJ, 0.9W and 15Hz, 80mJ, 1.2W different respeetively, each specimen was irradiated for 1min. Then, silane coupling agent was equally placed on the treated surfaces for 3min, the activator was used on each surface. The adhesive was applied and light-cured. The composite resin material was finally bonded to the treated porcelain surface, forming a 3mm ×3mm ×2mm resin mass. Samples were then tested for shear bond strength between the treated porcelain and composite resin by using a SWD-10 electric universal testing machine with a crosshead speed of 1mm/min until fracture. At the end of testing, the data was evaluated by using a two-way analysis of variance (ANOVA) comparing the shear bond strengh. On the other hand, characteristic morphology of laser irradiated surfaces of porcelain was prepared and observed by a scanning electron microscopy. **Results**: The shear bond strength of laser groups of 0.6W, 0.9W, 1.2W and etching group was respectively 8.61, 14.07, 11.22 and 13.47MPa. There was no significantly difference among groups of laser 0.9W, 1.2W and the etching group. This suggested that irradiated on surfaces of porcelain by Nd:YAG laser at the above laser energy could attain the same effectiveness as hydrofluoric acid etching. But the shear bond strengh of laser 0.6W group was significantly lower than the etching group. It suggested that shear bond strengh would obviously decrease when laser energy was 0.6W or lower than this parameter, and had no use in treatment on porcelain surfaces compar-

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ing to acid etching. SEM showed that porcelain surfaces irradiated by Nd:YAG laser exhibited rough, umbilicate, lava crater-like structure. This structure helped to produce mechanical retention between resin composite and porcelain. **Conclusion**: The pulsed Nd:YAG laser could replace etching method to pretreat the fracture porcelain surfaces for bonding with composite resin at appropriate energy parameters.

**Key words**: laser porcelain composite resin shear bond strength ectching scanning electron microscope

金属烤瓷既具有金属的强度又具有自然牙的色泽美观,是牙体、牙列缺损修复中深受医师和患者欢迎的修复体。由于临床上医技操作不当或患者使用不慎,瓷面在口腔内有可能发生破损。已粘接的金属烤瓷冠、桥发生破损,目前尚无简便易行、效果满意的修补方法。采用树脂修补其粘接强度受粘接前烤瓷面预处理方法的影响很大。本实验应用脉冲 Nd:YAG 激光照射经磨除处理的烤瓷牙粘接面,与 8 %氢氟酸酸蚀相比较,通过测定复合树脂和瓷面的抗剪切粘接强度及扫描电镜观察瓷面形貌,评价口腔内金属烤瓷瓷面破损后,激光对瓷面预处理的临床可行性。

## 1 材料和方法

### 1.1 材料

金属烤瓷冠(Vita VMK68 瓷粉,瓷牙由台湾定远陶齿厂制),8 %氢氟酸(Bisco,美国),硅烷(Bisco,美国),活化剂(Dentsply,美国),粘接剂(Primer & Bond 2.1,美国),光固化复合树脂(APH,美国)。

激光机为美国 PulseMaster 脉冲 Nd:YAG激光,波长 1.06 μm,功率 0.3～6.0 W,能量 30～200 mJ,脉宽 100 μm,光纤直径 0.3 mm,以 He-Ne 激光作靶瞄准光。SWD-10 电子万能试验机(长春试验机研究所)。扫描电镜(HITACHI S-450,日本)。

### 1.2 方法

1.2.1 抗剪切强度测试 分组:将 32 个烤瓷牙随机分成 4 组。第 1、2、3 组为激光组,照射能量参数分别为 15 Hz、40 mJ、0.6 W,15 Hz、60 mJ、0.9 W及 15 Hz、80 mJ、1.2 W。第 4 组为氢氟酸处理组。

用粗金刚砂钻将烤瓷牙瓷面磨出 4 mm ×4 mm、深至体瓷层的粗糙面。第 1、2、3 组分别以上述激光能量参数照射瓷面 1 min。第 4 组参照产品使用说明,以 8 %氢氟酸酸蚀瓷面 3 min,流水冲洗、吹干。各处理组瓷面均匀涂一层硅烷液,静置 3 min 后涂活化剂 3 min,再涂两层粘接剂,每层光照 10 s。在此粘接面上放置复合树脂,形成 3 mm × 3 mm ×2 mm 的树脂块,光照固化 40 s。

将以上所有试件置于室温生理盐水浸泡 24 h。取出置于 SWD-10 电子万能试验机上,将切刃对准复合树脂—瓷粘接界面正中,以 1 mm/min 的速度向下加压,直至树脂块折裂,计算各试件的抗剪切强度(MPa)。

1.2.2 扫描电镜标本制作 取烤瓷牙 8 个,分组同上,每组 2 个。同上所述,将瓷面磨除至体瓷层后,分别以氢氟酸、激光处理烤瓷牙的粘接面。再行临界点干燥、喷镀金膜,扫描电镜观察各组瓷处理面的形貌。

## 2 结 果

### 2.1 抗剪切强度测试

激光 0.6 W组、0.9 W组、1.2 W组与酸蚀组的抗剪切强度分别为 8.61 ±3.29、14.07 ±3.26、11.22 ±3.03 及 13.47 ±3.22 MPa。激光 0.6 W 组与酸蚀组有显著性差异,而激光 0.9 W组及 1.2 W 组与酸蚀组无统计学差异。上述结果经完全随机方差分析, $P < 0.01$。组间均数两两比较(LSD 法),结果见表 1。

表 1 4 组抗剪切强度组间均数两两比较

| 比较组 | 均数差 | $t$ | $P$ 值 |
|---|---|---|---|
| X1-X2 | -5.47 | -3.42 | <0.01 |
| X1-X3 | -2.62 | -1.64 | >0.05 |
| X1-X4 | -4.86 | -3.04 | <0.01 |
| X2-X3 | -2.85 | -1.78 | >0.05 |
| X2-X4 | -0.61 | -0.38 | >0.05 |
| X3-X4 | -2.25 | -1.41 | >0.05 |

本实验结果表明,应用脉冲 Nd:YAG 牙科激光机处理瓷面,适合的能量参数为 15 Hz、60 mJ、0.9 W。少于 60 mJ 时抗剪切粘接强度则明显降低。

### 2.2 扫描电镜观察

酸蚀组:瓷面呈粗糙不平、形态不规则之凹凸结构,有倒凹形成,凹窝较深(图 1)。0.9 W 激光组:陶瓷表面粗糙不平,有许多大小不等的浅凹坑形成,有的呈火山口状,可见倒凹(图 2)。

## 3 讨 论

许多学者认为[1],有效的瓷面蚀刻是复合树脂

成功修复的必要步骤,酸蚀是形成瓷—树脂粘接面机械固位的最有效手段,甚至是唯一的瓷面预处理选择。氢氟酸蚀刻的机理在于选择性地与长石质瓷的硅相成分发生反应,破坏 Si-O 键,形成水溶性的氟化硅化合物,经水冲洗后即在瓷面形成不规则凹凸形态的机械固位结构。

图 1 酸蚀组瓷面呈粗糙不平、形态不规则之凹凸结构 ×1000

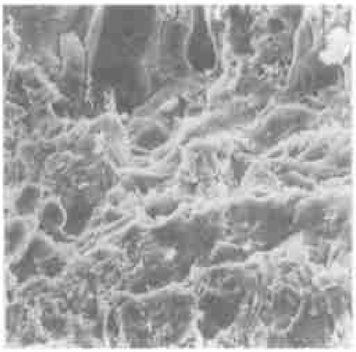

图 2 0.9 W 激光组陶瓷表面粗糙不平,有许多大小不等的浅凹坑形成,有的呈火山口状 ×1000

本实验 SEM 显示经 8 %氢氟酸作用的瓷面,表面形态呈形状不规则的凹凸结构。而经激光照射的瓷面则在不规则形态的基础上形成许多小凹坑,边缘不规则,有的呈火山口状,倒凹相对较浅。瓷面的不规则形态是由于激光照射前以金刚砂钻预备所形成,而分散的凹坑则是激光照射所致。笔者分析,可能当激光达到一定能量时,瞬间的高温或压强作用破坏了局部陶瓷颗粒晶体及基质,从而破坏了瓷面的致密结构。

比较各处理组的抗剪切粘接强度,激光 0.9 W 组及氢氟酸组最高,分别为 14.07 MPa 和 13.47 MPa,十分相近,两者无统计学差异。激光 1.2 W 组稍低,与前 2 组无统计学差异。而激光 0.6 W 组的抗剪切强度明显偏低,与激光 0.9 W 组及酸蚀组相差显著。提示在通常情况下,选用氢氟酸蚀刻破损瓷面,方法简便易行,不需特殊设备。而激光在某种情况下,则可替代氢氟酸蚀刻烤瓷面进行复合树脂粘接,但是必须选择合适的、足够的能量参数。应用激光进行瓷粘接面的预处理,术野清楚,可准确控制预处理面的范围。对于一些烤瓷破损区在龈边缘处、氢氟酸处理易损伤软组织者,应用激光处理尤为合适。

有报道认为[2,3],瓷—树脂的粘接强度不仅与所选用的陶瓷、复合树脂及粘接剂的种类有关,实验条件如耐水试验时间、冷热温差循环次数等均可影响其粘接强度。本实验观察到,无论使用氢氟酸或激光预处理烤瓷的粘接面,首先应用金刚砂钻研磨瓷的表面,使其粗糙,大大增加了粘接面积,不规则的形态和倒凹有机械的扣锁力形成,再在此基础上进行预处理,此步骤必不可少。

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