



## EFFECT OF ER: YAG LASER ON THE BOND STRENGTH OF NON-CARIOUS SCLEROTIC DENTIN IN ADULT

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### ABSTRACT

**Objectives:** To evaluate the effect of Er:YAG laser preparation on the bonding properties between composite resin and the sclerotic dentin of elderly subjects. **Methods:** 40 extracted premolars with cervical wedge-shaped defect and sclerotic dentin on the surface from 18-50 year-old people were randomly divided into 2 groups (n = 20). In the experimental group Er:YAG laser was used for cavity preparation, in the control group regular burs with high speed turbines was used for cavity preparation. The cavities of all teeth were filled with composite resin Filtek Z350. 15 samples in each group were cut into dumbbell-shaped specimens with a bonding area of 1 mm<sup>2</sup>. The micro-tensile bond strength (MBS) was tested on Instron 5848 Micro Tester. Each tooth of the remaining 5 samples in each group were divided into two parts along buccolingual directions parallel to the long axis of the tooth. The bonding interface was observed by SEM. **Results:** The MBS (MPa) of experimental and control groups was (35.24 ± 7.05) MPa and (27.56 ± 4.79) MPa respectively (P < 0.05). SEM observation showed that hybrid layer between sclerotic dentin and composite resin was thinner in experimental group resin tags and crystallizing column within dentinal tubules connected together tightly. **Conclusions:** Er:YAG laser preparation can improve the bond strength between adult non-cariou sclerotic dentin and composite resin.

**KEYWORDS:** Er: YAG Laser; micro-tensile bond strengths; adult; non-caries sclerotic dentin.

### INTRODUCTION

Wedge-shaped defects are caused by the slow consumption of hard tissues on the lips and cheeks of the teeth. The incidence is higher in adults and is one of the main diseases that cause adult dental defects. Due to the large amount of calcified salt crystals deposited in the dentin tubules at the wedge-shaped defect, non-caries sclerotic dentin (NSD) is often formed. In addition, the dentin tubules are blocked by mineralized crystals, which hinders the formation of resin protrusions to a certain extent, so the bonding strength of the resin to the non-cariou sclerotic dentin of the tooth neck is lower than that of normal dentin.<sup>[1]</sup> In the oral clinic, the treatment effect of wedge-shaped defects is not ideal, and the failure rate of composite resin bonding repair is high. At present, the high-speed turbine handpiece is commonly used for dental hard tissue cutting and preparation of holes in the clinic. After preparation, the surface of the dental tissue is often formed with a smear layer. This surface morphology of the dental tissue will inevitably affect its adhesion to the filling material. performance.

Erbium laser is a new generation of hydrodynamic

biological laser system, also known as water laser. At present, it is believed that the use of Er:YAG laser for tooth preparation can effectively remove the carious dentin and the smear layer and debris on the surface,<sup>[2]</sup> and the stimulation to the surrounding tissue and pulp is very small. It is a very safe and effective method of tooth preparation. In addition, the laser has a certain etching effect on dentin. Using Er:YAG laser for preparation can also increase the bonding strength between dentin and the filling material.<sup>[3-4]</sup> However, there is little research on the effect of Er:YAG laser on non-cariou sclerotic dentin and its bonding performance.

In this study, 18-50 year-old adult isolated teeth with wedge-shaped defects were used as experimental objects. Micro-tensile test and scanning electron microscope observation were used to compare Er:YAG laser and traditional high-speed turbine handpiece on the influence of the bonding performance between dentin and composite resin.

## MATERIALS AND METHODS

### 1. Materials and equipment

Adeper Easy One self-etching adhesive, Filtek Z350 composite resin (3M ESPE, USA); Er:YAG laser treatment machine (Fotona M002-3A/4, Fotona dd company, USA, wavelength 2940nm, frequency range 2-50Hz, pulse energy 20-150mJ, output guide spot with diameter 2-7mm, when irradiated there is an adjustable size around the fiber tip The water mist is sprayed out and the maximum power is 20w.); high-speed turbine handpiece (NSK Corporation, Japan); light curing machine (3M ESPE, USA); 5848 Micro Tester (Instron Corporation, USA); Scanning Electron Microscope (JSM-T300, JEOL Corporation, Japan); Digital Display Constant Temperature Water Bath (HH-4, Zhengzhou Dufu Instrument Factory, China); Electronic Vernier Caliper (Shanghai Measuring Tool Factory, China)

## 2 METHOD

### 2. 1 Selection of isolated teeth

40 premolars with wedge-shaped defects on the buccal neck were selected from adult volunteers aged 18-50 years who had been removed due to periodontal disease. The isolated teeth had no caries and no fillings; the visual classification of the hardened dentin on the defect surface is above grade 3 (graded according to North Carolina dentine sclerotic scale<sup>[5]</sup>). Immediately after extraction, all teeth were removed by ultrasonic to remove plaque and calculus on the tooth root surface, frozen at -20 and used for experiment within 1 month.

### 2. 2 Cavern preparation and filling

The above 40 isolated teeth were randomly divided into an experimental group and a control group (n = 20). The experimental group used the Er:YAG laser treatment machine to prepare the cavity at the wedge-shaped defect. During the preparation, the laser fiber head was 1-1.5 mm from the target tissue surface, the spot diameter was about 1 mm, and the power was used according to the instructions of the Er:YAG laser treatment machine. Set to 4 W (65% air pressure, 55% water pressure). The control group used a traditional high-speed turbine handpiece to prepare cavities for wedge-shaped defects under water cooling. After the preparation of the two groups was completed, each tooth was rinsed with water for 10 s. Then use self-etching adhesive Adper Easy One to evenly coat its surface for 10 s, air gun lightly blow for 5 s, and light cure for 20 s; Finally, the Filtek Z350 composite resin was filled in layers only at the defect, cured by light for 40 s. When filling, a plastic tube with an inner diameter of 5 mm was used to help shape, and the filling material was required to protrude from the tooth surface by about 4-5 mm. After filling, all samples were placed in distilled water at 37 for 24 h.

### 2. 3 Production and testing of micro-tension specimens

15 filled teeth were randomly selected from each group, which were perpendicular to the long axis of the tooth body under running water cooling, and the crown portion

of the filling was abraded; and then parallel to the long axis direction of the tooth body, along the cheek-tongue direction Cut each tooth into a sheet (d=1 mm), and trim it with a fine emery pin to form a dumbbell-shaped test piece with a bonding area of 1 mm × 1 mm; finally, use an electronic vernier caliper (accuracy of 0.02 mm) for measurement, And accurately calculate the bonding area of each test piece for micro-tensile testing.

10 complete specimens were selected from the experiment and the control group and fixed on the Instron 5848 micro-force testing machine (sensor 100 N) one by one, and tested at a loading speed of 1.0 mm / min; the filling material and tooth surface tension of each specimen were recorded separately The maximum load (N) at break, and calculate the micro-tensile bonding strength (MPa) of each test piece according to the following formula: MBS = maximum load (N) / bonding area (mm<sup>2</sup>).

4 Scanning electron microscope to observe the micro-morphology of the bonding interface

Take 5 sample teeth of each group and cut them longitudinally along the buccal tongue parallel to the long axis of the tooth body to expose the bonding interface; after grinding with water sand paper No. 240, 360 and 600 respectively, use 370 g / L phosphoric acid Solution treatment for bonding interface for 30 s; rinse with distilled water, blow dry, and then soak in 20 g/L sodium hypochlorite solution for 120 s; then place in 100 g/L formaldehyde solution for 24 h. After fixation, rinse thoroughly, dry and spray gold, and observe the micro-morphology of the bonding interface between non-carious hardened dentin and composite resin under scanning electron microscope.

### 2.5 Statistical analysis

The micro-tensile bond strength data ( $\bar{x} \pm s$ ) was statistically analyzed with SPSS 17.0 statistical software. The t test was used for comparison between the two groups, and the test level was  $\alpha = 0.05$ .

## 3. RESULTS

Comparison of micro-tensile bond strength between two groups

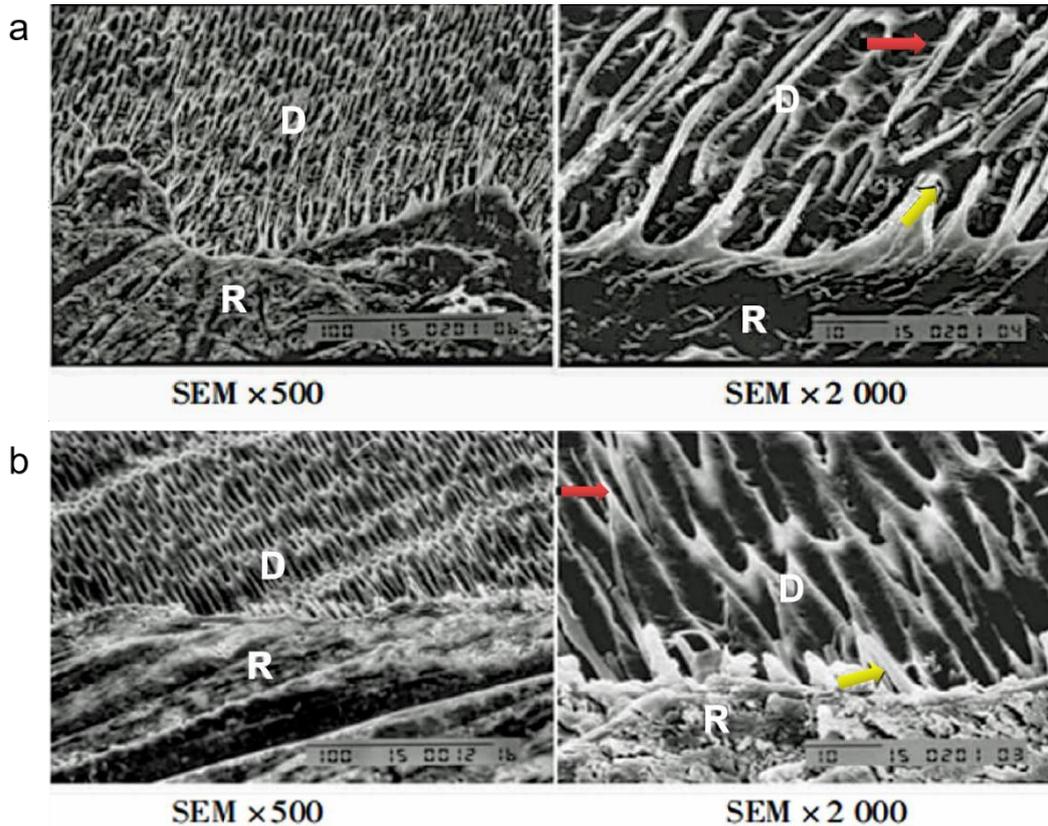
The results of the micro-tensile bond strength test showed that the bond strength of the Er:YAG laser preparation group was (35.24 ± 7.05) MPa, which was significantly higher than that of the high-speed turbine dental drill group (27.56 ± 4.79) MPa, the difference was statistically significant ( P < 0.05). Compared with traditional high-speed turbine handpieces, Er:YAG laser preparation can improve the micro-tensile bond strength between hardened dentin and Z350.

Comparison of the micro-morphology of the bonding interface

It can be seen under the scanning electron microscope that the bonding interface of the experimental group is uneven, the mixed layer is thin, and the resin protrusions

entering the dentin tubules are sparse and short. The mixed layer, resin protrusions and hardened columns in the dentin tubules are tightly connected together (a). In

the control group, the bonding interface was smooth, the mixed layer was thin, and the resin protrusions entering the dentin tubules were sparse and short (b).



Micromorphology of the bonding interface

a: Experimental group b: Control group

D: dentin; R: composite resin; ↑ resin protrusion; ↑ hardened column

#### 4 DISCUSSION

Wedge-shaped defects are common non-carious dental defects in oral clinics. They are chronic injuries of dental hard tissues. The incidence in adults is as high as 70%, and the number of affected teeth and the degree of defects also increase with age. Wedge-shaped defects can cause progressive loss of dental hard tissue, and further development can easily lead to Endodontic disease, periapical disease, tooth fracture, etc. The problem of wedge-shaped defects in adults is becoming more and more serious, and has become one of the adult dental diseases worthy of attention.

Wedge-shaped defect surfaces often form hardened dentin. Due to the particularity of its structure, the use of existing dentin adhesives or filling materials cannot achieve a very ideal bonding effect. In addition, the surface of this non-carious hardened dentin will form an over-mineralized layer. There is a large amount of mineralized crystals in the intertubular, peritubular dentin and dentin tubules, which leads to the reduction of the diameter of the dentin tubules and occlusion of the lumen,<sup>[6]</sup> and accompanied by mineralization of collagen fibers around the tube. The mineralized deposits on the

surface will interfere with the penetration of the etchant and the resin infiltration, and make the hardened dentin stronger in acid resistance.<sup>[7]</sup> A good acid etching demineralization effect cannot be obtained, and it is difficult to form in the dentin tubules. Resin protrusion with mechanical retention<sup>[8]</sup> Ultramicromorphological studies have found that the mixed layer formed after the bonding of hardened dentin is relatively thin, the resin protrusion is short and few or even no,<sup>[9-10]</sup> and the same bonding strength as normal dentin cannot be obtained. Yoshiyama *et al.*<sup>[11]</sup> believed that when the existing adhesive is used to bond non-carious hardened dentin, the micro-tensile bond strength is 25% to 40% lower than that of normal dentin.

Current research believed that using Er:YAG laser to prepare holes can significantly increase the roughness of the dentin surface and its bonding area, thereby enhancing the resin-dentin bonding strength,<sup>[12]</sup> Some studies found that the surface of dentin prepared by Er:YAG laser was rough, clean and free of smear layer, and there was no thermal damage such as melting, carbonization and cracking. Peripheral dentin could be removed more.<sup>[12-14]</sup> Sung *et al.*<sup>[15]</sup> reported that because

Er:YAG laser had an effective etching effect on dentin, simply using Er:YAG laser to prepare dentin can obtain the same effect as traditional high-speed turbine preparation + acid etching. Celik *et al.*<sup>[16]</sup> believed that Er:YAG laser irradiation could effectively improve the micro-tensile bonding strength of self-etching bonding system.

Jin *et al.*<sup>[17]</sup> after Er:YAG laser irradiation, the sclerotic dentin surface would form a honeycomb structure, which was conducive to its bonding with resin. The results showed that the micro-tensile bond strength between the sclerotic dentin prepared by Er:YAG laser and the composite resin Z350 was significantly higher than that of the control group; it was suggested that the preparation of hardened dentin with Er:YAG laser could effectively enhance dentin bond strength with resin. In the bonding of dentin and composite resin materials, the quality and quantity of the mixed layer and the resin protrusion that penetrates into the dentin tubule were closely related to the bonding effect of dentin. Pashley *et al.*<sup>[18]</sup> believed that a tight bond between the resin protrusion and the tubule wall of dentin was a prerequisite for good bonding performance.

In this study, the length and number of resin protrusions in the Er:YAG laser preparation group were not much different from the control group; the possible reason was that the laser preparation could not produce demineralization<sup>[19]</sup> which could not increase the dentin for hardened dentin. The exposure of the tubules could not increase the formation of resin protrusions. In addition, due to the demineralization of dentin and the exposure of collagen fibers during the laser preparation process, coupled with the demineralization of the self-etching adhesive was also poor, resulting in a thin or even mixed layer at the bonding interface of the group.

In this study, the self-etching bonding system was used to fill the composite resin. Compared with the full-etching bonding system, the dentin demineralization treated by the self-etching adhesive was shallower and the mixed layer formed was thinner. However, the thickness of the mixed layer has no significant effect on the bond strength.<sup>[20]</sup> After the self-etching adhesive treatment, the stain layer is not completely removed, but is dissolved or modified, and a mixed junction layer is formed at the bonding interface. When the acidic monomer enters the dentin tubule, it can form a resin protrusion by demineralization, combining the dentin tubule wall and the emboli in the tube. Some studies have found that, regardless of the bonding of normal dentin or hardened dentin, the bonding strength of self-etching bonding system is not worse than that of full-etching bonding system<sup>[21]</sup> For sclerotic dentin, due to the poor demineralization ability of the self-etching binder, the mineralized crystals in the surface stain layer and the dentin tubules cannot be effectively removed, so the Er:YAG laser + Z350 group can be seen under the scanning electron microscope. The mixed layer, resin

protrusions and hardened crystalline columns in the dentin tubules are tightly connected together. This may be because the Er:YAG laser can remove the smear layer on the surface of the hardened dentin and etch the surface, which is conducive to the penetration of the acidic monomer from the acid etching binder and produces a partial demineralization, which causes the acidic monomer to enter the hardened crystalline column. With the gap between the dentin tubule wall, the resin protrusion is connected with the hardened crystalline column to obtain a good binding force.

This result suggested that using Er:YAG laser to prepare adult teeth with wedge-shaped defects could help improve the success rate of cemented repair.

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