Effects of Various Laser Treatments on Surface Characterization and Repair Bond Strength of Zirconia-Reinforced Lithium Silicate Ceramics

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Purpose: To evaluate the effects of two different lasers and their use in combination with hydrofluoric acid (HF) etching on the surface roughness of zirconia-reinforced lithium silicate (ZLS) ceramics and their shear bond strength (SBS) to composite resin. Materials and Methods: The five study groups were as follows: (1) Group H = HF etching; (2) Group N = Nd:YAG (neodymium: yttrium-aluminum-garnet) laser; (3) Group NH = Nd:YAG laser + HF gel; (4) Group E = Er:YAG (erbium: yttrium-aluminum-garnet) laser; and (5) Group EH = Er:YAG laser + HF gel. Surface roughness was assessed using a noncontact profilometer, and SBS tests were conducted with a universal testing machine. Results: The mean SBS values were 16.23 ± 1.77 MPa for Group H, 17.1 ± 1.65 MPa for Group N, 16.65 ± 1.11 MPa for Group NH, 8.08 ± 1.12 MPa for Group E, and 11.58 ± 0.82 MPa for Group EH. There were significant differences between groups E and EH (P < .001), but no significant differences (P > .05) among the other groups. Conclusion: Clinicians may prefer Nd:YAG laser or the combination of Nd:YAG and HF to intraorally repair fractured areas.

The mechanical features of ceramic materials have been developed with the addition of the crystalline phase to their formulations, resulting in a novel material called zirconia-reinforced lithium silicate ceramic (ZLS). ZLS consists of 10% zirconia dissolved in a glass matrix and contains silicate crystals that are four times smaller than conventional lithium disilicate ceramic. However, fractures of restorations made from this material are still encountered. Therefore, establishing a reliable and durable bond between composite resins and dental ceramics is of great importance. The aim of this study was to evaluate the effects of two different lasers (Er:YAG [erbium: yttrium-aluminum-garnet] and Nd:YAG [neodymium: yttrium-aluminum-garnet]) and their use in combination with hydrofluoric acid (HF) etching on the surface roughness of ZLS restorations and the shear bond strength (SBS) between ZLS and composite resin.

MATERIALS AND METHODS

After 100 ceramic samples (4 x 6 x 3 mm) were obtained from ZLS blocks (Celtra Duo, Dentsply DeTrey, Bensheim, Germany) by using a diamond saw, all samples were embedded in acrylic molds with the adherent ceramic surfaces exposed.
Study groups (n = 20 per group) and the applied surface treatments were as follows:

1. Group H: HF (4.9%, IPS Ceramic Etching Gel, Ivoclar Vivadent) etching gel was applied to the sample surfaces, rinsed with distilled water, and air dried.
2. Group N: Surfaces were scanned with Nd:YAG laser beams (AT Fidelis, Fotona). Then, all surfaces were rinsed and dried. The applied laser specifications were as follows: 150 mJ (pulse energy), 20 Hz (repetition rate), 3 W (power setting), medium short pulse (MSP) mode (150 µs pulse duration), and 1,064 nm (wavelength).
3. Group NH: Surfaces were scanned with Nd:YAG laser with the same procedure as in group N and etched with HF gel as in Group H.
4. Group E: Surfaces were scanned with Er:YAG laser beams (AT Fidelis). Then, all surfaces were rinsed and dried. The applied laser specifications were as follows: 400 mJ (pulse energy), 10 Hz (repetition rate), 4 W (power setting), MSP mode (100 µs pulse duration), and 2,940 nm (wavelength).
5. Group EH: Surfaces were scanned with Er:YAG laser with the same procedure as in group E and etched with HF gel as in Group H.

After surface treatments, the surface roughness (Ra) values of the samples were determined using a 3D noncontact profilometer device and image processor software. The surface topography of each sample was evaluated with a scanning electron microscope (SEM).

After surface treatments, the ceramic surfaces to be repaired were coated with silane and air dried. Composite resin was applied and then cured. SBS tests were conducted with a universal testing machine (Instron) at a crosshead speed of 0.5 mm/minute until each sample fractured. For statistical analysis, paired t test was used to compare the Ra values for each group before and after surface treatments, and Pearson chi-square test was used to compare failure rates between groups. The significance level was set at P < .05.

RESULTS

SEM images showed that HF application led to a homogenous conditioning pattern, with a porous surface composed of bean-like crystals with nanometric size (Fig 1). The combination groups (groups NH and EH) revealed nonhomogenous surface patterns under the effect of both laser irradiation and HF. The mean surface roughness values of the study groups before and after surface treatments are presented in Table 1.

The mean SBS values were 16.23 ± 1.77 MPa for group H, 17.1 ± 1.65 MPa for group N, 16.65 ± 1.11 MPa for group NH, 8.08 ± 1.12 MPa for group E, and 11.58 ± 0.82 MPa for group EH (Table 2). These values
indicated a statistically significant difference between groups E and EH (P < .001) and no significant differences (P > .05) between groups H and N, groups H and HN, and groups N and HN.

**DISCUSSION/CONCLUSIONS**

The outcomes of this study indicate that surface roughening and intraoral repair bond strength between ZLS ceramic and composite resin can be improved by using an Nd:YAG laser or the combination of Nd:YAG and HF acid. However, compared to N and NH, HF treatment is more clinically feasible, requires less equipment, and presents lower costs than a laser approach. The disadvantage of HF alone is that it could present hazardous effects when used for treating a ceramic surface; since intraoral repair is the focus, the use of lasers would be safer for the patient and operator.

**ACKNOWLEDGMENTS**

The authors report no conflicts of interest.

**REFERENCES**