Laser versus bur and dentinal bonding

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_Introduction

In times of increased awareness of aesthetics, high quality ceramic restorations in dentistry are in great demand. Furthermore, demands for alternative dental preparation techniques like laser preparation which affords non-contacting and vibration-free working, increased. Therefore, laser research and laser application became more and more important in dentistry. However, constantly new developments and this concentrated flow of information can occasionally be a problem for the attending dentist, because it is hardly possible in clinical everyday live to review all new products and information that are given by manufacturers. The purpose of the present work is therefore to provide information about the stability of the adhesive compound between human dentin and ceramic using different laser and conventional preparation tools.

Erbium-based lasers are approved devices for cavity preparation in dentistry.[1-4] Er:YAG laser and Er,Cr:YSGG laser, hard tissue laser with a wavelength of 2,940 nm and 2,780 nm, respectively, offer a high surface effect with only a low depth effect on teeth. Due to the large proportion of water in carious tissue, caries will be removed particularly well. An auxiliary bactericidal effect exists. Furthermore the pulpal increase in temperature is not higher than 2,5 °C through an efficient water cooling system.[5-8] According to a study by Zach et al., temperature increases of less than 6,1 °C are considered to be inoffensive for the dental pulp.[9] All of those elements and other factors like patient-friendly treatment by a vibration-free and contactless preparation technique make Erbium-based lasers the ideal alternative to conventional preparation techniques.[1] Some researchers even suggest that additional acid etching before the adhesive ceramic fixation may not be necessary because of micro roughness, which is achieved by laser treatment.[6,10,11] In contrast, studies by Bahillo et al.,[12] Lee et al.[13] and others[14,15] advice additionally acid etching after laser treatment. Hence, there are still doubts about how laser-treated dentin can bond to adhesive systems. For this reason, we investigated both laser preparation with and without phosphoric acid etching.

Fig. 1_Bernhard Gottlieb University Clinic of Dentistry, Medical University of Vienna, Austria

As ceramic samples, Cerec®-blocks (VITABLOCS Mark II®), conventional feldspar ceramic were used. We used these CEREC®-blocs because the industrial sintering process under vacuum at 1,170 °C, which can be reproduced at any time, ensures a more homogenous microstructure with consistent material quality compared to laboratory sintered and lab-processed ceramic restorations. We were thus able to minimize interference factors from the ceramic that otherwise may influence our study results.[16] As adhesive material for gluing the dentin discs on the ceramic blocks we used Variolink® II plus Syntac® (Ivoclar Vivadent,

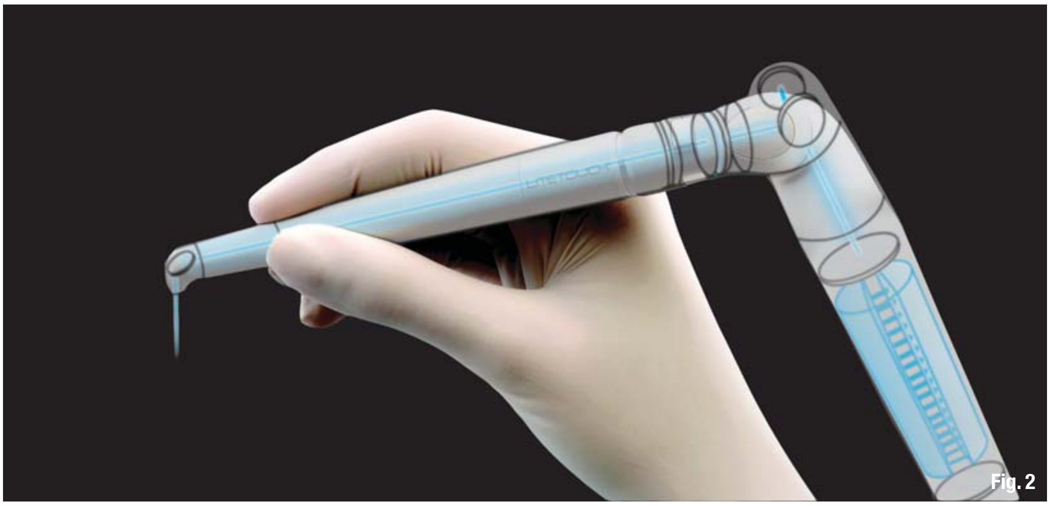

Fig. 2_LiteTouch™ Laser-in-the-Handpiece™: The laser energy is swiftly delivered to the tissue, providing supreme cutting power and precise incisions for hard tissue and bone.

Schaan/Liechtenstein), a classic etch and rinse adhesive system which acts very often as a gold standard.

_Materials and Methods

Extracted third molars were cleaned and stored in physiological saline solution. Using a precision saw, cusps were removed and teeth were cut into uniform dentine discs of a thickness of 1 mm. After removal of enamel, dentine discs were randomly divided into five subgroups representing five different preparation techniques: (i) diamond bur and acid etching; (ii) Er:YAG laser (LiteTouch^{TM}, Syneron), 2,940 nm, 4 W, 20 Hz; tip of 0,8 mm; (ii) Er:YAG laser and additional acid etching; (iv) Er,Cr:YSGG laser (Waterlase MD^{TM}, Biolase), 2,780 nm, 2 W, 30 Hz with a conical tip of 600 µm (MC 6 Saphir); (v) Er,Cr:YSGG laser and additional acid etching. All laser irradiation settings were executed at an angle of inclination of 30° and with a feed rate of 1 mm per minute.

After treatment, dentine discs were fixed on CEREC® ceramic blocks using the system Syntac®/ Variolink® II (Syntac® etch & rinse adhesive and Variolink® II, Ivoclar Vivadent, Schaan, Liechtenstein). The system Syntac®/Variolink® II was applied according to the manufacturer's instructions. In addition, the application of human dentin discs on CEREC® ceramic blocks was performed following the manufacturer's instructions.

Sample size of each of the five subgroups was n = 15, resulting in a total of 75 dentine discs and 75 CEREC® ceramic blocks. All samples were subjected to thermocycling (10,000 cycles, 5 °–55° respectively) to simulate artificial aging. After thermocycling, a shear test was performed using the universal testing machine Zwick (Zwick/Roell, Ulm, Germany) at a crosshead speed of 0.8 mm per minute. The bond strength was registered in megapascals (MPa). Data were analysed using ANOVA with Tukey's post hoc test with a significance level of = 0.05.

_Results

The results of the shear bond strength tests showed the highest values for the group of the Er:YAG laser with and without additionally acid etching. The diamond bur and acid etching group as well as the Er,Cr:YSGG laser group with and without additionally acid etching showed similar but slightly lower values (Fig. 1 and Tab. 1). Overall, there was a trend towards stronger bonding with the Er:YAG-laser treated dentin with additionally acid etching; however, no statistically significant differences were exposed when comparing the five preparation methods ($p = 0.169$). These findings suggest that laser irradiation provides favourable conditions for bonding between dentin and ceramics.

_Discussion

The results of this study suggest that a laser-treated dentin surface provides favourable conditions for bonding. Our findings that laser treatment can provide coequal adhesive conditions to the diamond bur

Fig. 3_Class V – Cavity Preparation using LiteTouch™. (Courtesy of Dr Avi Reyhanian)

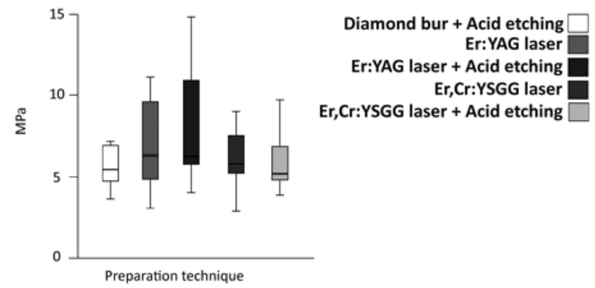

Fig. 3

more, the thickness and especially the size of the dentin discs are of crucial importance, because the bond strength is significantly influenced by the size of the discs.[26] Another important factor of the achieved bond strength is the storage medium in which the extracted molars have been stored pending further processing. While we used physiological saline solution to imitate the natural situation as well as possible, other studies applied distilled water, 0,5 % chloroform solution and other storage solutions.[27,28]

Fig. 4_Comparison of the five preparation techniques with regard to the bonding strength.

Table 1_ Means and standard deviations of shear bond strength tests (MPa)

	Diamond bur + Acid etching	Er:YAG laser	Er:YAG laser + Acid etching	Er,Cr:YSGG laser	Er,Cr:YSGG laser + Acid etching
Variolink®II Syntac®	6.84 +/-3.38	6.89 +/-2.7	8.11 +/-3.18	6.11 +/-1.65	5.85 +/-1.67

are not supported by the majority of similar studies. In comparable studies using human dentin laser treatment resulted in equivalent[17] or even lower[18–20] bond strength to ceramic or composite. However, these studies differed in other experimental aspects (e.g., the laser setting, angle of irradiation, storage conditions for the tooth samples, and the source and preparation of tooth discs).

An explanation for the advantageous results in the laser group could be that we used a standardised process of laser treatment with a constant feed rate and irradiation angle of 30 degrees to the dentin surface. We already obtained promising results with this setting in preliminary tests. We suggest that the superficial part of the laser-irradiated surface is not affected and there are no micro fractures as described in studies with other laser settings.[14, 21, 22]

In this study we show that Er:YAG-laser treated dentin discs with and without additional acid etching revealed slightly higher mean values than Er,Cr:YSGG laser or bur-treated dentin discs. However, no statistically significant differences were exposed when comparing the different preparation methods. Differences between the results of this study and other studies, which seemed to be comparable at first sight, can be based on a small number of divergences in the study design. A very important factor is the quality and nature of the used adhesive materials and of the dentin discs.

While we used caries-free and mature third molars for the preparation of the dentin discs, other studies applied retained molars, teeth other than molars or enamel surfaces to compare laser preparation with conventional preparation techniques.[23-25] Further-

Our findings have to be interpreted with care because *in vitro* settings only partially reflect the *in vivo* performance. Further studies are necessary to understand if these *in vitro* findings translate into clinical practice. Moreover, the *in vitro* system may not necessarily represent the *in vivo* conditions, in which the temperature and humidity are closer to the physiological situation than in our room temperature setting. Other experimental conditions, such as bonding in a climatic chamber and simulation of mastication cycles or long-term storage, can change the bonding strength. Future studies need to consider these physiological situations. There is still room for maximising the bonding strength of dentin to ceramics by improving the laser protocols for the preparation of dental cavities.

_Conclusion

Taken together, our findings show that dentin surfaces prepared with the Erbium laser can provide a favourable dentin surface for binding ceramics, particularly when using Variolink®II/Syntac® as the adhesive system. Overall, Erbium laser can be an attractive alternative to the conventional preparation technique using a diamond bur._

_contact laser

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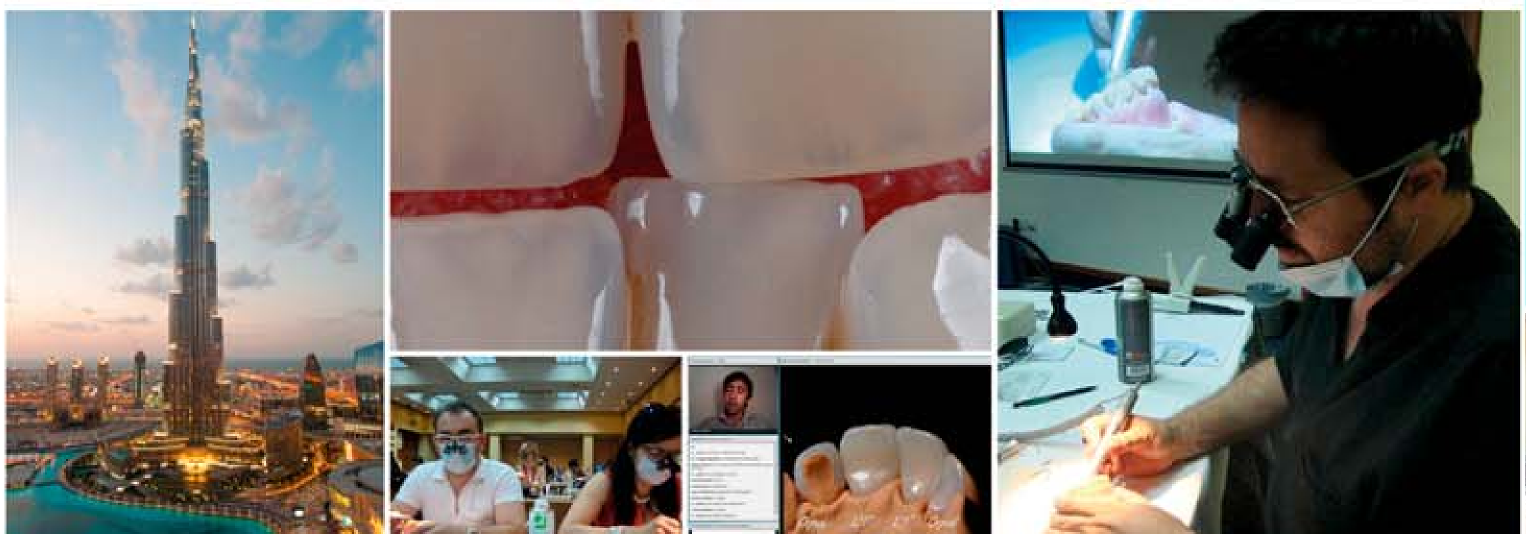

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